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TABLE OF CONTENTS

		Page
Acknowledgements		i
Table of Contents		ii
List of Tables		ix
List of Figures		xvi
Synopsis		xviii
CHAPTER I :Introduction and background		1
1.0	The problem, approaches and outcomes	1
1.01	The problem	1
1.02	Approaches to the problem	1
1.03	Outcome of the research	2
1.04	The rich picture of the Cyprus Hotel Energy Management	3
1.1.1	Cyprus-The country	4
1.1.2	The development of the economy	6
1.1.3	Tourism-An insight view to a major energy consumer	11
1.2.1	Current energy policies	19
1.2.2	The Hotel Industry as an important energy consumer	29
1.3.1	Energy consumption: a wider perspective	40
1.3.2	The Energy Scene	49
CHAPTER II: The methodology of the research		60
2.1	The Soft Systems Methodology	60
2.1.1	The development of the rich picture	63
2.1.2	Selection of issues and model building	65
2.2	The field survey	68

2.3 Analysis of questionnaires and other energy related data 71
2.3.1 The hotel guest questionnaire 72
2.3.2 The manager's questionnaire 73
2.3.3 The chief engineer's questionnaire 73
2.3.4 Analysis of data 74
2.3.5 Adopting a case study "bottom up approach" 75
2.3.6 Construction of an energy data base 76
2.4 Analysis of the situation 77
2.5 Limitations and problems 79
2.5.1 Problems of the data gathering techniques 82
2.5.2 The series data on energy use 85

CHAPTER III : Systems analysis and conceptual models 88

3.1 The existing problem situation 88
3.1.1 The main actors of the problem situation 89
3.1.2 Selecting issues from the problem situation 103
3.1.3 Relevant systems related to the main issues 104
3.2 The conceptual model of the primary task 106
3.2.1 The comparison stage 110
3.3 A practical illustration of Soft Systems Methodology 111

CHAPTER IV : Investigating the problem situation (I)
-Energy Audits- 117

4.1. Energy Audits 122
4.1.1 Disaggregation 122
4.1.2 An audit procedure plan 124

4.2 Discussion of the findings 129

4.2.1 Description of the detailed energy audit in Hotel A 130

4.2.2 The energy scene 131

4.2.3 The timing of energy demand 145

4.2.4 Remarks concerning soft problems 150

4.2.5 Remarks concerning hard problems 156

CHAPTER V : Investigating the problem situation (II)

- Questionnaires- 174

5.1 Managers questionnaire 174

5.1.1 The objectives of the questionnaire 175

5.1.2 The sample for the interviews 177

5.1.3 Discussion of the results 178

5.2 Guest questionnaire analysis 191

5.2.1 The objectives of the questionnaire 193

5.2.2 Discussion of the results 194

5.3 The chief engineer questionnaire 200

5.3.1 The objectives of the questionnaire 202

5.3.2 Discussion of the results 205

CHAPTER VI: The role of the energy consultants 216

6.1 General considerations 216

6.2 Attitudes of the consultants 220

6.2.1 Guidelines of achieving good consultant-client relationship 223

6.3 Proposed procedural plans 226

CHAPTER VII : Analysis of energy related factors 232

7.1 General correlations 232
7.2.1 The Hotel Industry as a whole 233
7.2.2 The five star class hotels 236
7.2.3 The four star class hotels 238
7.2.4 The three star class hotels 240
7.2.5 The two star class hotels 242
7.3 Multiple regression analysis of energy related parameters 244
7.3.1 The whole industry 245
7.3.2 The five star class hotels 246
7.3.3 The four star class hotels 246
7.3.4 The three star class hotels 246
7.3.5 The two star class hotels 247
7.3.6 Multiple regression of the energy related parameters 248
7.4 The wider implications 249
7.4.1 Fuel substitution patterns 251
7.5 Understanding and improving the mechanism of energy usage at the level of hotel management 254

CHAPTER VIII: Energy Technologies within the Hotel System .. 257

8.1 Heat recovery or heat reclamation 257
8.1.1 A case study analysis 259
8.2 Hot water Solar Systems 264
8.2.1 A case study analysis 266
8.3 Solar heated swimming pools 271

8.3.1 A case study analysis 274

8.4 Passive cooling 278

8.5 The technology of BEMS 283

8.5.1 The BEMS situation in the Hotel Sector of Cyprus ... 286

8.5.2 A case study analysis 290

CHAPTER IX : Approaching the system modelling-choise of meta modelling scenarios 292

9.1 Technological sub systems-interactions and efficiency 294

9.1.1 Building Energy Management Systems 296

9.1.2 Heat Recovery Systems 296

9.1.3 Solar Hot water Systems 297

9.1.4 Solar heated swimming pools 298

9.1.5 Passive energy saving techniques 299

9.1.6 Cogeneration 300

9.1.7 Wind Energy 300

9.2 Broad consideration for technological integration ... 301

9.2.1 The sector of electricity 305

9.2.2 An alternative demand side approach 307

9.2.3 Creating alternative scenarios 309

9.3 Additional considerations 334

9.4 Sampling the energy demand across the economy. The need for systematic analysis in other sectors .. 338

CHAPTER X : Using computer tools for energy demand modelling. 341

10.1 Micro computer modelling 341

10.1.1 The system variables 342

10.1.2 The simulation process 343
10.1.3 The first stage analysis 343
10.1.4 The second stage analysis 347
10.1.5 The simulation results 352

CHAPTER XI: Recommendations and recommended further work. 358

11.1 General recommendations 358
11.1.1 Changes in policy 360
11.1.2 Changes in attitude 361
11.1.3 Changes in use of energy 361
11.1.4 Changes in structure 363
11.1.5 Education and training needs 364
11.2 "Reality" versus "ideals" 367
11.3 Adopting a realistic Action Plan -
Initiating Change 368
11.4 Recommended further work 377
11.5 General conclusions 378

APPENDICES 382

Appendix A: Appendix to Chapter I 383
Appendix B: Appendix to Chapter II..... 391
Appendix C: Appendix to Chapter III 397
Appendix D: Appendix to Chapter IV 419
Appendix E: Appendix to Chapter V 461
Appendix E 1: Sample manager's questionnaire 462
Appendix E 2: Sample guest's questionnaire 469
Appendix E 3: Sample chief engineer's questionnaire 477

Appendix F : Appendix to Chapter VII 488

Appendix G : Appendix to Chapter IX 491

Appendix H : Appendix to Chapter X 496

Appendix I : Self criticism and retrospective 498

Publications 502

Bibliography 504

LIST OF TABLES

Page

Table 1.2.1: Current retail price of fuels in Cyprus 26

Table 1.2.1: Number and size of Hotels and Tourist Apartments 34

Table 1.2.2: Location of Hotels and Tourist Apartments ... 34

Table 1.2.3: Energy related facilities in Hotels 35

Table 1.2.4: Energy related facilities in Tourist Apartments 35

Table 1.2.5: Percentage of Hotels utilising solar energy .. 35

Table 1.2.6: Percentage of Hotels utilising BEMS..... 36

Table 1.2.7: Number of tourist and bednights and energy and electricity consumption (1983-1989) 37

Table 1.2.8: Total energy and electricity consumption per tourist and bednight (1983-1989) 38

Table 1.2.9: Percentage contribution of fuels for the Hotel Industry 39

Table 1.2.10: Energy consumption indices for the Hotel Industry of Cyprus 39

Table 1.3.1: Percentage of energy cost to total cost for Hotels and Tourist Apartments 43

Table 1.3.2: Percentage of energy cost to direct production cost for the Hotel Industry 44

Table 1.3.3: Percentage of energy cost to total operating cost for Hotels and Tourist Apartments 45

Table 1.3.4: Percentage of water cost to direct production cost for Hotels and Tourist Apartments 46

Table 1.3.5: Comparison of total energy cost to total operating cost for Hotels internationally 47

Table 1.3.6: Energy cost per available room per year for Hotels in Cyprus (1988) 47
Table 1.3.7: Energy cost per available room internationally 48
Table 1.3.8: Petroleum imports, domestic exports and total imports in Cyprus 51
Table 3.2.1: Activities of conceptual model level 2 109
Table 4.1.1: Procedure plan for performing energy audits .. 128
Table 4.2.1: Electricity consuming equipment in Hotel A ... 138
Table 4.2.2: Lighting fixture details for Hotel A 139
Table 4.2.3: Room temperature and time elapsed to achieve 157
Table 4.2.4: Boiler combustion efficiency results-Hotel A 159
Table 6.3.1 Procedure plan for energy consultants for evaluating an energy audit/study project 227
Table 6.3.2: Procedure plan for hotel owners/managers for evaluating/selecting/cooperating with energy consultants 228
Table 7.1.1: Basic correlations between total energy and tourism and electricity 233
Table 7.2.1: Single factor correlation matrix for the whole Hotel Industry 236
Table 7.2.2: Single factor correlation matrix for all variables for the 5 star sample hotels 237
Table 7.2.3: Single factor correlation matrix for all variables for the 4 star sample hotels 240
Table 7.2.4: Single factor correlation matrix for all variables for the 3 star sample hotels 241
Table 7.2.5: Single factor correlation matrix for all variable for the 2 star sample hotels 244

Table 7.3.1: Multiple regression coefficients for the interrelationship between energy sources 245
Table 7.3.2: Interrelationship of different energy consumption factors 247
Table 7.3.3: Multiple regression coefficient for fuel use in different hotel categories 248
Table 9.1.1: Financial indices for three scenarios for a heat recovery investment 263
Table 9.1.2: Results of sensitivity analysis of discount rate to NPW for a heat recovery investment ... 263
Table 9.2.1: Occupancy and hot water requirements for a solar hot water system design 269
Table 9.2.2: Financial indices for six scenarios for solar hot water system investment 270
Table 9.2.3: Sensitivity analysis of NPW with varied discount rate on a solar hot water system investment 270
Table 9.3.1: Financial indices for various energy price scenarios for a solar heated swimming pool investment 277
Table 9.3.2: Sensitivity analysis of NPW on the effect of different discount rate and fuel prices 278
Table 9.4.1: Percentage monthly contribution of radiative cooling to cooling load 282
Table 9.5.1: Financial indices for a BEMS investment 292
Table 9.5.2: Sensitivity analysis for the effect on NPW of different fuel prices and discount rates 293
Table 11.1.1: Samples of demand patterns used in the simulation runs 344

Table 11.1.2: Ten year discounted NPW for a chp investment 346

Table 11.1.3: Effect of incorporating four separate 3 month sampling periods into data 346

Table 11.1.4: Results of simulation runs for various configurations 348

Table 11.1.5: Combination of cogeneration units with some wind generators 349

Table 11.1.6: Results of cogeneration simulations without auxiliary energy sources 354

Table 11.1.7: Results of various simulations utilising auxiliary sources of energy 355

Table 11.1.8: Results of simulations in which chp capacity was substituted with wind and solar input 356

Table 11.1.9: Sensitivity analysis on NPW for configuration A 357

Table A.D.1: Monthly electricity consumption and occupancy for Hotel B 426

Table A.D.2: Hourly electricity consumption for Hotel B .. 427

Table A.D.3: Power factor recording for Hotel B (DAY 1) .. 428

Table A.D.4: Electricity consumption, maximum demand and occupancy for Hotel C 432

Table A.D.5 : Monthly LPG and gasoil consumption for Hotel C 432

Table A.D.6: Electricity consumption and maximum demand Hotel D 454

Table A.D.7: LPG and gasoil consumption-Hotel D 454

Table A.D.8: Room occupancy-Hotel D 455

Table A.D.9: Electricity consumption and maximum demand Hotel E 455

Table A.D.10: LPG and gasoil consumption-Hotel E 456

Table A.D.11: Room occupancy-Hotel E 456
Table A.D.12: Electricity consumption and maximum demand Hotel F 457
Table A.D.13: Room occupancy-Hotel F 457
Table A.D.14: Electricity consumption and maximum demand Hotel G 458
Table A.D.15: LPG and gasoil consumption-Hotel G 458
Table A.D.16: Room occupancy-Hotel G 459
Table A.D.17: Electricity consumption and maximum demand Hotel H 459
Table A.D.18: LPG and gasoil consumption-Hotel H 460
Table A.D.19: Room occupancy-Hotel H 460
Table A.E.1: Personal profile of hotel managers 466
Table A.E.2: Implementation of energy conservation measures 466
Table A.E.3: Attitude of managers on energy issue 467
Table A.E.4: Opinion of managers on energy use and waste 467
Table A.E.5: Tabulated results of various questions 468
Table A.E.6: Response rate of guests questionnaire 474
Table A.E.7: Country of residence of guests 474
Table A.E.8: Time spent by guests in hotel areas 475
Table A.E.9: Guest responses to questions number 3-10 ... 476
Table A.E.10: Professional experience of chief engineers 480
Table A.E.11: Educational background of chief engineers 480
Table A.E.12: Staff supervised by chief engineers 480
Table A.E.13: Chief engineers'opinion on energy consumption level (3 star hotels) 481
Table A.E.14: Chief engineers'opinion on energy consumption level (4 star hotels) 481

Table A.E.15: Chief engineers'opinion on energy consumption level (5 star hotels) 481
Table A.E.16: Chief enginners'opinion on energy consumption level (all hotels) 482
Table A.E.17: Chief engineers' opinion on energy waste level (3 star hotels) 482
Table A.E.18: Chief engineers' opinion on energy waste level (4 star hotels) 482
Table A.E.19: Chief engineers' opinion on energy waste level (5 star hotels) 483
Table A.E.20: Chief engineers' opinion on energy waste level (all hotels) 483
Table A.E.21: Chief engineers' ranking of energy waste centres 483
Table A.E.22: Chief engineers' opinion on prospects for energy conservation (3 star hotels) 484
Table A.E.23: Chief engineers' opinion on prospects for energy conservation (4 star hotels) 484
Table A.E.24: Chief engineers' opinion on prospects for energy conservation (5 star hotels)..... 485
Table A.E.25: Chief engineers' opinion on prospects for energy conservation (all hotels) 485
Table A.E.26: Chief engineers' opinion on suitability of technologies for hotels (3 star hotels) 486
Table A.E.27: Chief engineers' opinion on suitability of technologies for hotels (4 star hotels) 486
Table A.E.28: Chief engineers' opinion on suitability of technologies for hotels (5 star hotels) 487

Table A.E.29: Chief engineers' opinion on suitability of technologies for hotels (all hotels) 487

Table A.F.1 : Principal variables-analysis of variance 489

Table A.F.2 : Important factors-multiple regression analysis 490

Table A.H.1 : Real heat and electricity demand data used in the second stage of simulation runs 497

LIST OF FIGURES

Page

Figure 1.1.1: Gross income from Tourism 15

Figure 1.1.2: Revenues from Tourism and exports and cost of imports 15

Figure 1.1.3: Gross output of Hotel Sector 16

Figure 1.1.4: Value added for Hotel Sector 16

Figure 3.2.1: Primary task based conceptual model (level 1) 106

Figure 3.2.2: Conceptual model level 2 108

Figure 3.2.3: Conceptual model of example activity "Gather data" (level 3) 112

Figure 3.2.4: Conceptual model of example activity "Gather data" (level 4) 113

Figure 4.2.1: Variation of maximum demand-Hotel A..... 134

Figure 4.2.2: Variation of electricity consumption-Hotel A 134

Figure 4.2.3: Room occupancy-Hotel A 136

Figure 4.2.4: Sankey Diagram for Hotel A-Energy Cost 141

Figure 4.2.5: Sankey Diagram for Hotel A-Energy Use 142

Figure 4.2.6: Hourly electricity consumption-Hotel A 144

Figure 4.2.7: Hourly gasoil consumption-Hotel A 144

Figure 4.2.8: Hourly ambient temperature-Hotel A 146

Figure A.B.1: Soft system methodology for tackling unstructured problems 395

Figure A.E.1: Hours spent in rooms 470

Figure A.E.2: Hours spent in dining rooms 470

Figure A.E.3: Hours spent in public spaces 471

Figure A.E.4: Combined presentation of hours spent in hotel areas 471

Figure A.E.5: Guests' preference to shower-bath 472

Figure A.E.6: Frequency of shower-bath taking per day 472

Figure A.E.7: Average percentage of guests taking shower-bath at certain time 473

SYNOPSIS

The present research has investigated the problem of energy management and conservation in the Hotel sector of Cyprus; one of the most important and most dynamic sectors of the island's economy.

The methodology of the soft systems approach was considered as the most appropriate method for tackling the complexities involved in the problem situation. The outcome of the research demonstrated that the adoption of this methodology is suitable for investigating problems of energy management and conservation and can indeed be extended by use of "systemic" interactive computer simulation methods.

The existing problem situation in the Hotel industry was investigated through design and execution of questionnaires addressed to the main human actors, energy audits, site visits, discussions and statistical analysis of energy related factors. Serious deficiencies were found at all levels.

Energy consumption and use patterns were analysed with respect to quantity, quality and timing of energy use. Existing and new technologies were evaluated using life cycle cost-effective analysis methods. Evaluation of alternative energy supply "mixes" using computer simulation techniques were made, which demonstrated the viability of cogeneration, wind and solar collection approaches in some situations.

The research concluded that:

(a) there is good scope for energy conservation (in the range of 10-20%) by modifying user habits, hotel energy demand, remodeling of existing technology and introduction of new energy efficient technology.

(b) there is an immediate need to provide training and education to all human factors involved

(c) there is a need to modify existing energy policies

(d) there is need to introduce new energy management infrastructure at National level and below

(e) there is real need for changing the attitudes towards energy conservation of all "actors" involved.

(f) there is need for further investigation of the energy supply and demand patterns of hotels

Recommendations concerning the introduction of training and education, and changes in policy, attitudes, practice and energy use, and infrastructure are made. All recommendations are based on conceptual models developed following the application of the soft systems methodology.

CHAPTER I

INTRODUCTION AND BACKGROUND

1.0. The problem, approaches and outcomes

1.0.1 The Problem

The management of energy resources in Cyprus - all of which are imported - provided the focus of attention of this thesis. In particular, the work centered on the problems of one of the largest energy consuming industries of Cyprus: the Hotel sector and the management of its energy consumption processes.

1.0.2 Approaches to the problem

Recognising the systemic nature of the problem situation - e.g. the dynamic relationships between National and local energy consumption patterns in Cyprus (as exemplified by the important Hotel sectoral energy demands) - has lead to the use in depth of the Soft Systems methodology (P.Checkland 1981, Checkland and Scholes 1990). The development of the "rich picture" of the problem as illustrated on page 3 was the central essence of the use of the Soft Systems methodology to clarify the important issues and influences at work.

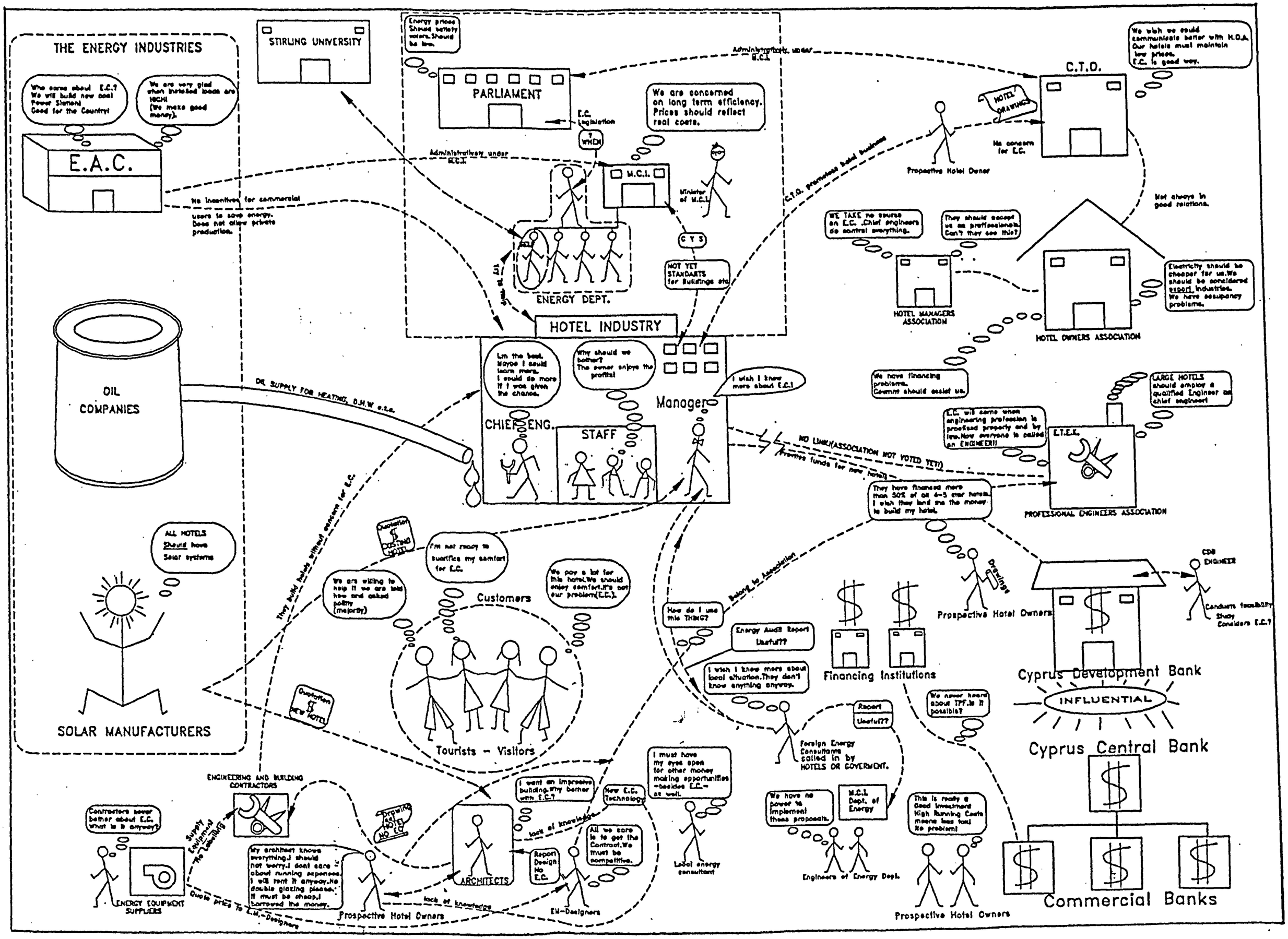
Individual sub-systems from the "rich picture" have received detailed field work and analysis. For example, energy audits (Chapter IV), the role of various influential groups (e.g. hotel managers, engineers, hotel guests, external consultants) and analysis of energy technologies within the hotels (Chapter VIII).

Analysis of technical inputs to hotel energy consumption and detailed use of computer simulation tools, employing the earlier field data, were used to model some alternative scenarios of importance to the Hotel sector and to individual hotel owners (Chapters IX and X).

1.0.3 Outcome of the research

In addition to the specific scenario meta models developed on Chapter IX, the research enabled strong recommendations for the future management, information systems, management structure, National and local industry training and education needs. These recommendations were extended to include both sectoral and Government energy policy levels, and are wholly relevant also to other industries than the Hotel sector. These recommendations are detailed in Chapter XI.

1.04 : The rich picture of the Cyprus Hotel Energy Management.



1.1.1 Cyprus-The Country

Cyprus is an island in the Northeastern Mediterranean Sea. It lies at 33 degrees east of Greenwich and 35 degrees North of the equator. Situated at the crossroads of three continents, Europe, Asia and Africa and having an area of 9,251 sq.km Cyprus is the third largest island in the Mediterranean after Sicily and Sardinia.

Though the last official census was in 1960, it is estimated that the de jure population of the island is close to 680,000 of which 77% are Greeks, 18% are Turkish and the remainder are mainly Armenian, Maronite and Latin minorities. The capital of the island, Nicosia, with a population of some 150,000 is a major banking and financial centre. Limassol, with around 107,000 inhabitants besides being a very important tourist resort is the main port and industrial centre of the island. Paphos with a population of 21,000 and Larnaca with a population of 48,000 are two other important tourist resorts.

Due to its important strategic position, Cyprus, which is a country of a civilization of 9000 years old, has through the ages been occupied by several different races. The long list of occupants includes the British, the Romans, the Venetians, the Turks, the French and the Egyptians. The language, the culture and the religion of the island was influenced no more by any one than the Greeks, who originally settled on the island on the 14th century BC. The population was entirely hellenized, and maintained its Greek character through the centuries.

Richard the Lionheart who conquered the island in 1191 was followed by the British, the French the Venetians and the Turks. In 1878 Cyprus passed under British administration again and remained so until a struggle of the people for union with Greece led in 1960 into the declaration of a sovereign independent Republic which chose to remain a member of the British Commonwealth. The rapid economic and social progress that the hard work of the people of the island managed to achieve was violently halted in 1974. The consequences of the unjustified Turkish invasion on the island were tragic and tremendous. Besides the loss of lives, the drama of the people still missing today and the forceful abandoning of the houses of 200,000 people, there were also economic consequences. Thus 70% of the country's natural and economic resources were seized.

Though up to the present time, no permanent solution to the Cyprus problem has been found, the island has managed to recover from the "invasion shock" " to that extend that several remarks of an "economic miracle" that has taken place in Cyprus are being made.

Today's standard of living is quite high and the quality of life can be described as much better than that simply reflected by the annual per capita Gross Domestic Product and the notion that Cyprus is a European country in the Middle East is well justified.

Although the Turkish occupied Northern parts of the island have been poorly developed since the invasion, with hotels and resorts closed down, there are some very recent reports of minor activity. Thus, a large hotel in already operating successfully in Famagusta, and it can not be too long before the local competition becomes more significant. This provides all the more impetus for the businessmen of the Republic to be efficient in their uses of resources-such as energy, that they may the more readily meet the new competition.

1.1.2 The development of the economy

The problem of efficient energy management in the hotel sector should not be considered as an isolated problem. The systemic approach of this research necessitates an analysis of the problem situation in the context of its interactions with other problems and situations.

In addition to being a major technical and management of resources problem, the adequate supply and efficient use of energy in the hotel sector must also be viewed as a major economic problem as well. We believe that a description of the most important phases of the economy of Cyprus will provide the required framework within which the specific energy problems investigated is placed.

During the 28 years of Cyprus's life as an independent country, its economy had to overcome many serious constraints and adversities. Today, the island enjoys the fruit of a

relatively advanced economic and social development. In 1988 the GNP per capita in the free part of the island was 3,588 Cyprus pounds. With respect to unemployment, which was 2.9% in 1988 the island is even ahead of some advanced economies.

The adequate supply of energy has been closely related with the development of the economy.

The early times

In 1960, the newly established state of Cyprus was faced with the immense task of revitalizing an underdeveloped and stagnated economy. Per capita income was very low and the entire economy was relying on very unstable factors.

Agriculture was the sector upon which economy was relying most since it was at that time employing more than 45% of the island's working force. However its contribution to the Gross Domestic Product was only 18%. There was no touristic infrastructure and the contribution of industrial exports to total foreign exchange was only 18%. Unemployment and migration levels right after independence were at very high levels and less than 45% of the children between 12-17 years of age were attending high school education. In addition 93% of the houses in the country were not supplied with water and only 28% of them were provided with electricity.

Though an effort to prepare and launch a Development Planning Program was undertaken by the Colonial Government as well after

the Second World War, it was only after Independence that a real planning effort aiming at an efficient utilization of all human, physical and financial resources, was undertaken. (Malaos, 1985). Energy management was certainly not an issue at those times!

The Economic Development Plans

The First Five Year Plan was designed to cover the economic developments for the years 1962-1967. Though the Plan had set some very ambitious investment targets, it was, for various reasons, largely concentrated on the public sector.

In the agricultural sector, the Plan laid emphasis mostly on land reclamation, increased productivity, extension of irrigation and use of machinery and fertilizers. It also provided for heavy investments in the development, proper utilization and conservation of water. The emphasis on the industrial sector was concentrated on technical training, provision of incentives and the establishment of credit institutions.

A new airport terminal building, and an extension of the road network were some of the goals of the Plan in the infrastructure area. In the energy scene the major development had been the expansion of the electricity grid. Great emphasis was also given to the sector of tourism, for which the program envisaged among others, promotion of the island abroad, building of additional hotel accommodation and training of the

working force.

The lack of knowledge on efficient building design and the absence of sensitivity on the issue of energy conservation and management resulted in the build up of hotels that offered great opportunities for energy management and conservation. The same attitude followed during the next two Five Year Plans as well. The importance however of the contribution of the sector of hotels to the economy continued to increase.

Right after the expire of the First Five Year Plan the Second Five Year Plan, which was to cover the period between 1967 to 1971 was launched. An entirely new approach was used in the design of this Plan. Based on the economic progress recorded during the First Five Year Plan and the experience gained, a more detailed analysis of the problems was now developed. The Plan focussed on both the social and the welfare aspects of development. At the same time the plan attempted to spread the benefits of economic growth among the various parts of the island and among the various income groups.

In this respect, the philosophy of the plan was to assist in the restructuring of the economy, speed up the process of growth and increase general welfare. A unique characteristic of this Plan was that in its design the development of the economy, the legal, administrative and regional aspects of the economy were all included.

The Third Five Year Plan, was designed to cover the period of 1972-1976, intensify the implementation of the policies adopted by the Second Five Year Plan and stress the importance of both the extension of social benefits and of a more uniform spread of the national income.

The experience and the economic progress of the first decade was very carefully evaluated in order to attain the maximum benefit. When comparing the Second with the Third Five Year Plan one notes a definite commitment of the new plan towards restructuring and modernization. Since Cyprus was expected to be exposed to stronger foreign competition a drive towards efficiency was inevitable.

However, energy efficiency was not included within the "efficiency measures" undertaken. Furthermore, no specific energy efficiency directions were given in the next economic plan as well. Incidentally, it was during this period that both the first energy crisis and the Turkish invasion to Cyprus took place.

The Plan incorporated programs, policies, and measures in order to generate both external economies and economies of scale. It also aimed towards increasing the productivity and reducing diseconomies of any kind. The Third Plan is also to be praised for containing the first real attempt for physical and spatial planning. However The Turkish invasion of 1974 turned everything upside down. Besides its tragic human aspect, the

invasion had tremendous consequences on the economy of the island as well. Forty per cent of the island's area was occupied and 1/3 of its population was forced to abandon their houses, jobs and properties. Most of the country's productive capacity was turned under occupation. This included among others natural resources, tourist land, mines, water resources and hotels which constitute the focus of this research.

It is regretful that this research project is unable to include hotels from the occupied part of the island. The value of land and other fixed investments occupied was estimated to be around 2.5 billion Cyprus pounds. Just before the invasion (1974) all these resources were estimated to contribute by 70% to the total Gross Output of the island. In order to face these tremendous problems, the Government was forced to abandon its Third Five Year Plan (1972-1976) and adopt what was called the "First Emergency Economic Plan".

A series of Economic Plans (see Appendix A) were developed through the years covering up to 1993 which have had indirect impact on a number of energy related issues such as the development of manufacturing , agriculture and tourism. This latter has a direct bearing on the development of the hotel industry of course and is therefore described in more detail.

1.1.3 Tourism-An insight view to a major energy consumer

The interest of this research is focused on hotels. However

hotels constitute the core of the tourism industry, one of the most vital and dynamic sectors of the economy of the island.

Among the first people that had developed tourism were the were the Sumerians, the Egyptians, and the Greeks. Though contemporary tourism is in general considered a British phenomenon, earlier development of tourism, for many centuries is attributed to the Greeks. The island of Cyprus has been enjoying tourism since the Neolithic and even the Paleolithic ages. During the Greek-Roman period the island enjoyed a nice touristic development that was violently interrupted by the period of Arab invasions that followed.

The first appearance of tourism on the island took place at Paphos following perhaps Aphrodite who, according to mythology was born there. From Paphos tourism was spread to Amathus, Idalio, and Salamis. During the domination of French (1200-1489 A.D) the largest number of hotels as well as the best hotels i the Mediterranean were found in Famagusta (now under Turkish occupation). The decay of tourism in Cyprus began during the first Turkish occupation of the island (1570) Tourism was to flourish again only after the British occupation that followed (1878-1960). There are written testimonies that in 1882, three thousand British tourists were enjoying their holidays in the Troodos area. The development of the famous Cypriot resorts such as Platres, Pedoulas and Kalopanayiotis took place at that time. According to other testimonies in 1905 every single town in Cyprus had its own hotel. However, one can only talk of a

high quality of the Cypriot touristic product only after the building of various hotels such as Dome, Seaview, Coeur De Lion, Forest Park, Berengaria and Sovoy (Andronikou,1987).

The inauguration of the "Cyprus Airlines" in 1947 and the government run Office of Tourism in 1949 were major points for the development of tourism on the island.

The first research study on tourism was done in 1950 and included a questionnaire of 1000 questions.

Another major study done in 1957 made several suggestions for the training of the working force, on the improvement of the transportation network, the provision of loan to the Hoteliers and for the way advertising ought to be approached.

A remarkable effort can be attributed to those few members that had worked for the "Tourist Office" of Cyprus during the last ten years of the British rule on the island (1950-1960). It was this Tourist Office that had set the foundations for the spectacular progress that followed in the years 1969-1979, after the Independence. When the country became independent, the Cypriot development planners set the development of tourism as one of the most important priorities of the new state. Today, there is no doubt that the rapid growth of tourism has been one of the most important factors contributing to the recent success of the Cypriot economy. According to the 1968 SNA, value added to the economy resulting from tourism

activities is distributed among various sectors of the economy, the main ones being restaurants, hotels, transport, communication, retail trade and real estate.

Figures 1.1.1 and 1.1.2 present valuable information concerning the contribution of tourism in the economy. The gross output and the value added of the hotel sector itself 11 are shown in Figures 1.1.3 and 1.1.4 respectively.

The rapid growth of tourist arrivals in Cyprus over the past decade (18.4% annually compared to 4.8% for the world during 1977-1985) was accompanied by a rapid growth of accommodation.

The high demand of energy related services of the sector makes it not only a major contributor to the economy but at the same time a major energy consumer.

Even though not directly related with energy uses, the major problems faced by the tourist sector today have been outlined here. Energy is not an isolated issue and must always be addressed in the context of other issues in an economic sector.

The systemic approach of this research necessitates a reference to the interactions with other problems as well.

Problems in the tourism sector

It is a fact that the rapid growth of accommodation on the island while helping the economy to operate at practically full

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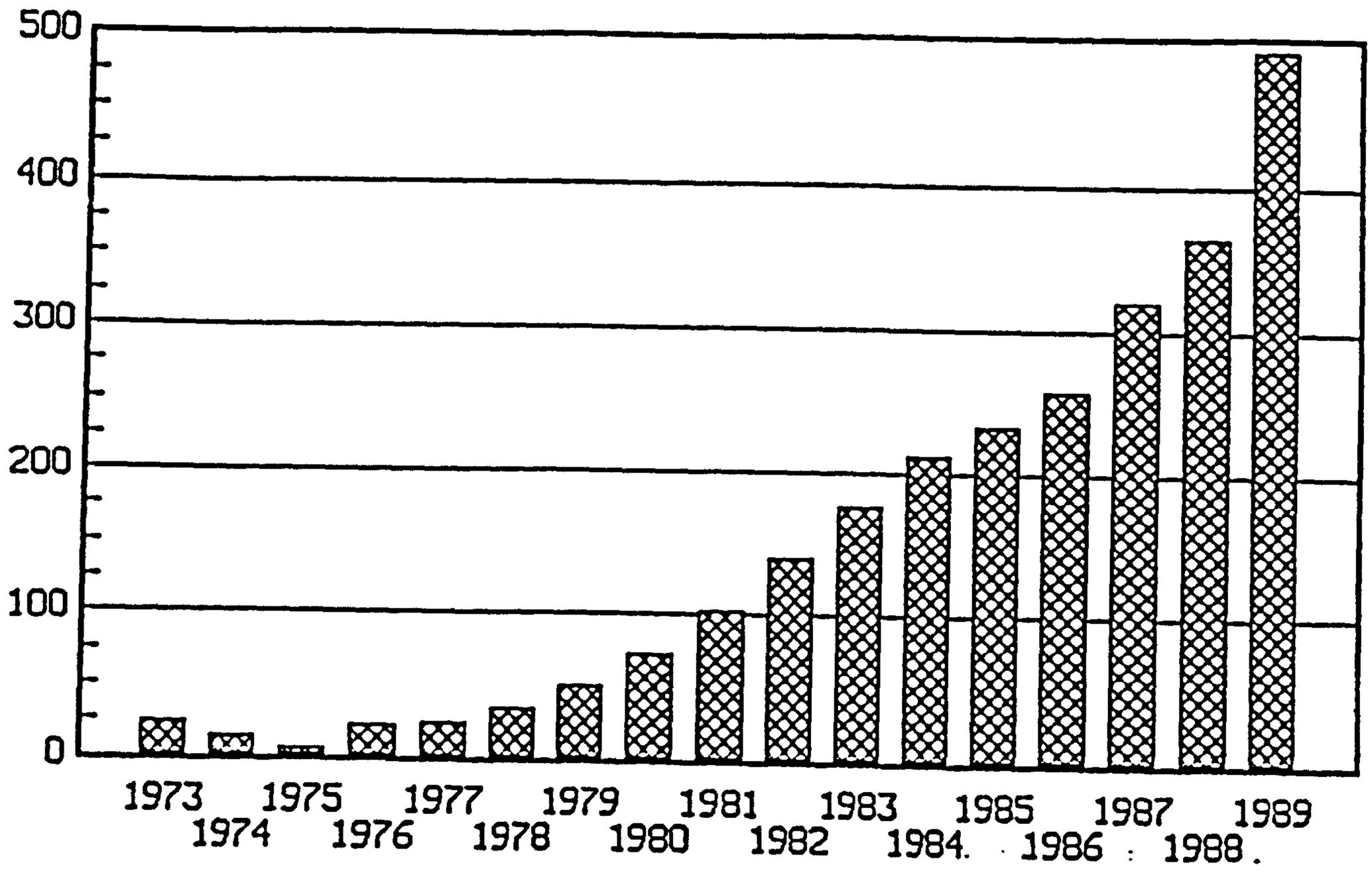

Figure 1.1.1: Gross income from Tourism in million Cyprus pounds

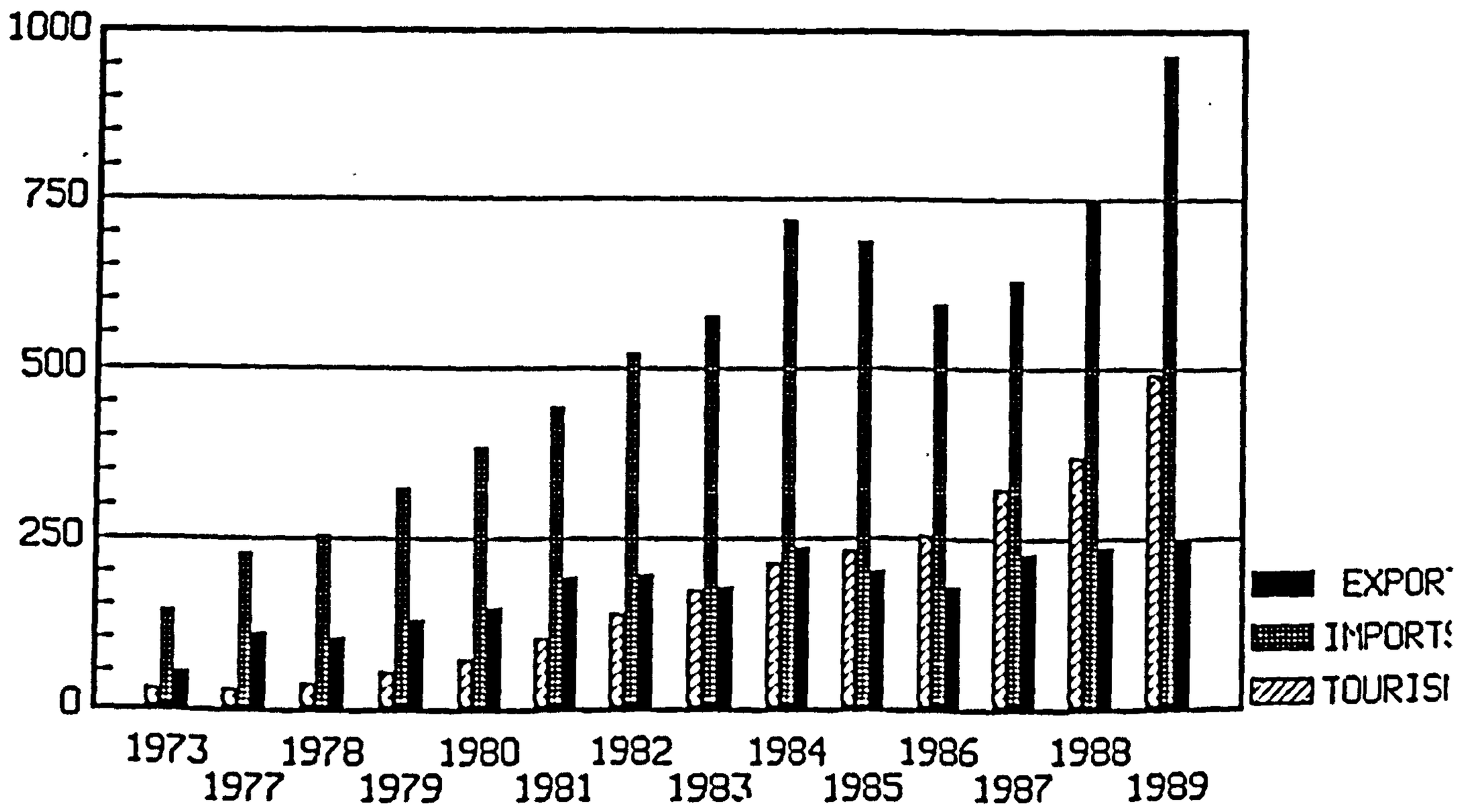

Figure 1.1.2: Comparison of revenues from Tourism with revenues from exports and cost of imports in million Cyprus pounds.

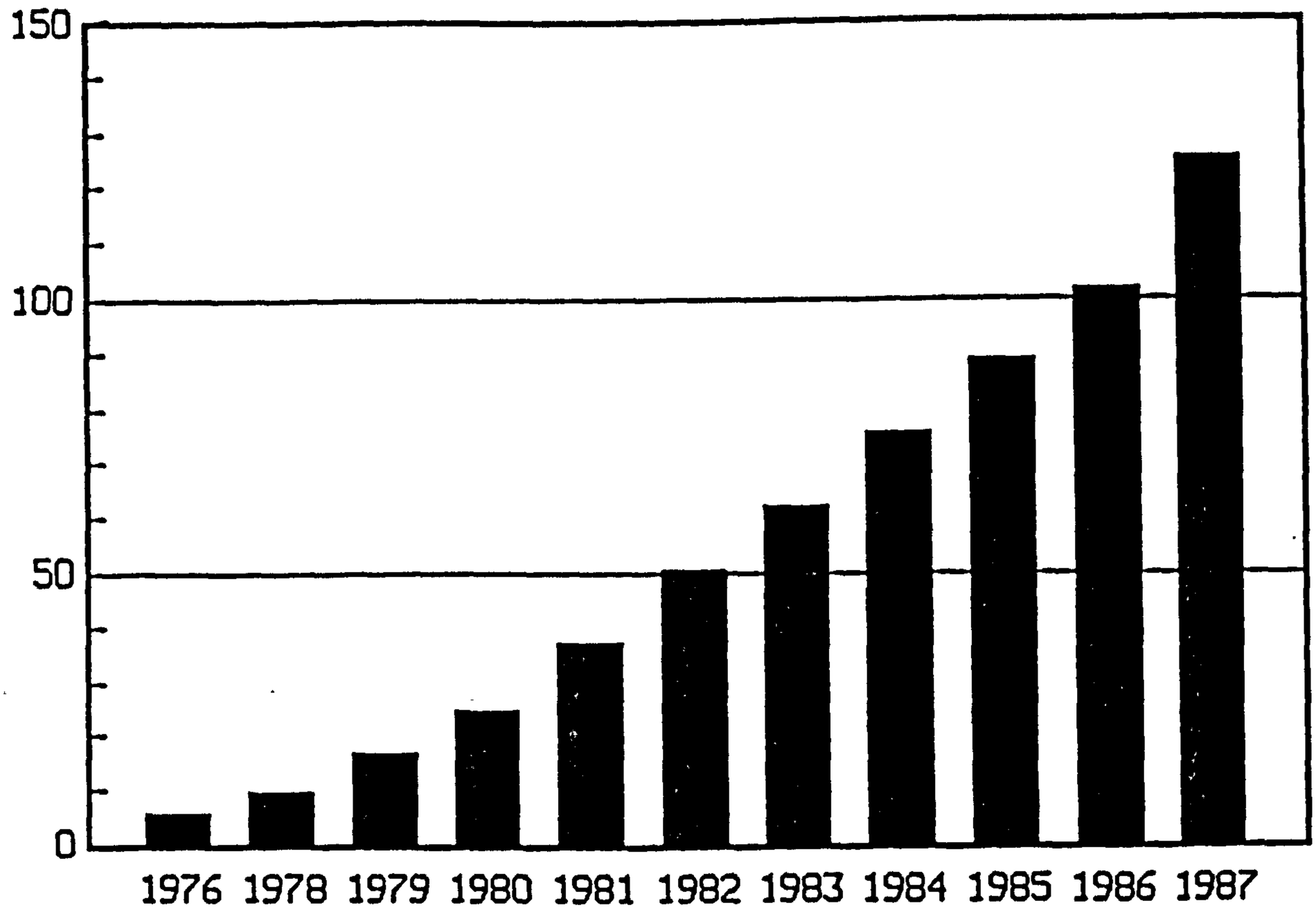

Figure 1.1.3: Gross output of Hotel Sector in million Cyprus pounds (current market prices)

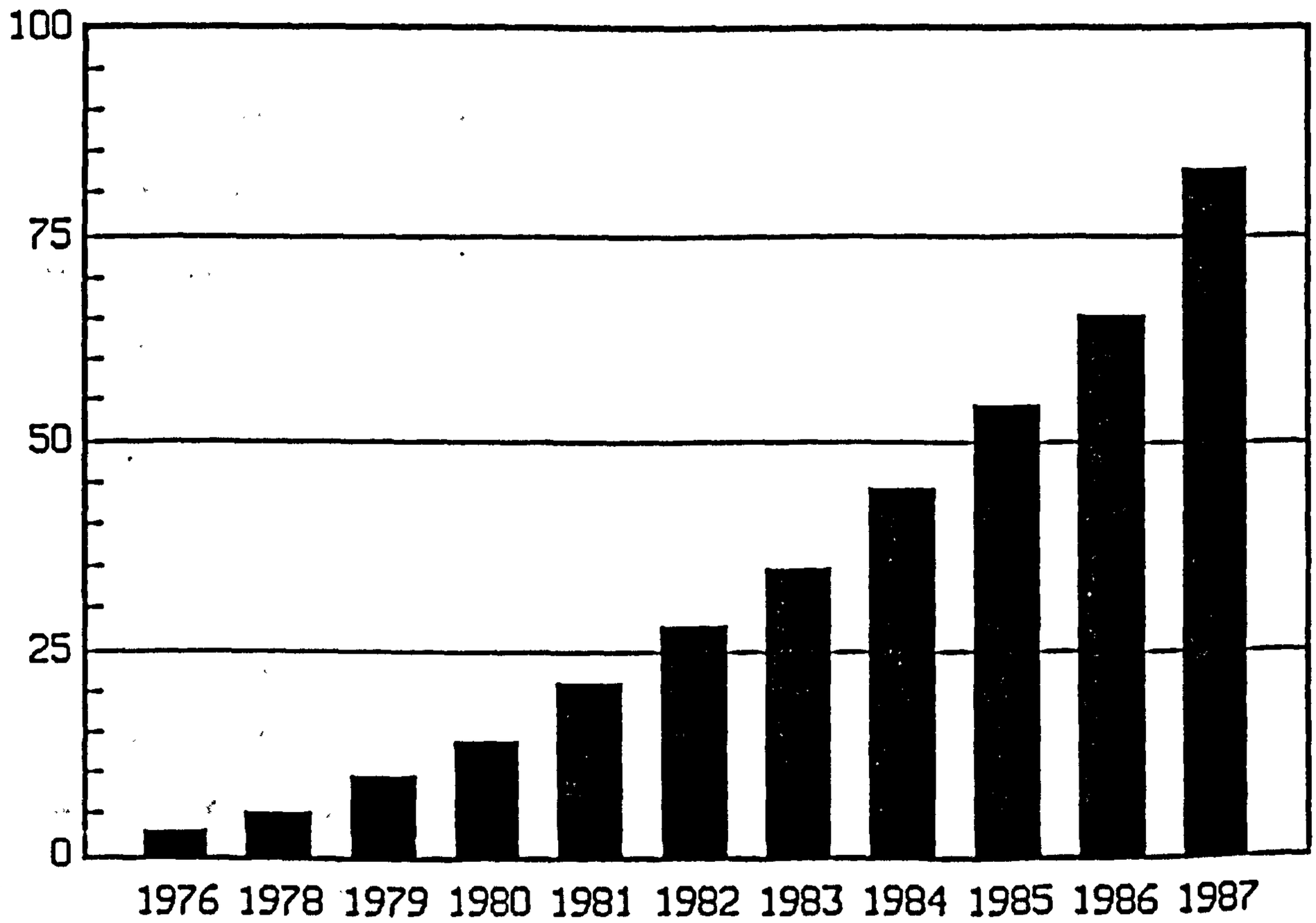

Figure 1.1.4: Value added for Hotel Sector in million Cyprus pounds (current market prices)

employment since 1978 it has also created several problems. It now appears that the solution of these problems will prove crucial for the future development of the sector. Some of the most important of these problems will be briefly outlined.

1.Inadequate supplementary facilities

Because of the concentration of tourism development solely on the island's beaches the majority of which have limited carrying, over crowding has already taken place on some beaches. On the other hand, water skiing, wind surfing and diving, which are the major water sports, are not well developed. In addition there appears to be lack of tennis courts and golf courses as well as air conditioned sports halls.

2. Inadequate infrastructure

Due to problems in the road network there appears to be an almost constant congestion and conflict between road users and pedestrians. It is however true that the road network was never designed to handle such a high volume of traffic resulting from intensive building of tourist facilities.

Another major problem is the lack of centralized sewage services and shortage of water. The lack of adequate water supplies forces, during the peak summer months to resort to purchasing and tracking water from remote boreholes. Proper management of the limited supplies of water is therefore of vital importance to hotels owners. This activity is closely

related to the efficient management of energy as well (need for pumping, purification etc).

3. Lack of product variety

It is a fact that Cyprus has developed as a "beach product" which constitutes the main offer to the tourists. However, as competition increases, a tourism industry that will be offering and depending on a single product will become vulnerable. There is a need for other natural and historical assets of the island to be "presented" and developed in a significant way. Many of these are likely to imply additional energy requirements.

4. Relatively high prices

From the outcome of an analysis of the retail price that holiday makers pay, it appears that Cyprus is on the high side of the scale. A recent study compared the cost of a one week packaged tour using a four star hotel on half board arrangement.

It must be noted that despite the relatively high prices being paid by the tourists, hotel owners do not seem to get their deserved share. It appears that the main reason for this "strange" phenomenon is the behaviour of tour operators who take every advantage of the existence of very hard competition. Though wholesale rates to tour operators are not supposed to be reduced by more than 20-25%, there may be reasons to believe that rebates in the range of 33-48% of regulated published minimum rates are actually given to tour operators.

5. Seasonality

Last but perhaps the most important of all is the problem of seasonality. With the exception of the ski resort in the Troodos region and some other specific areas of the island very little tourism occurs in the period November to February. Marketing efforts should therefore be enhanced in order to attract larger number of tourists during these periods.

The highly competitive environment in which the industry operates does not allow any waste of resources. As costs are reduced profit increases and more financial resources can be allocated to other needs such as development of new facilities, product variability and price reduction. Energy management is one effective tool for obtaining results in this direction.

Energy consumption is not a function of the number of beds occupied and therefore, though revenues are less during this period, the same does not hold for the consumption of energy. (see Chapter VII also). A relation between energy consumption and the number of tourists arriving in the country was developed and the resulting regression model is shown in Table 7.1.1.

1.2.1 Current energy policies and regulations

Energy policy has been traditionally defined as "a set of decisions taken to provide the energy requirements of a country in order to satisfy the needs of the various groups of

consumers". The same definition applies, at a micro level, to a large individual consumer be it a hotel a manufacturing or a commercial company.

For many years the main concern of the government of Cyprus, like most other governments, has been taking the necessary measures/actions in order to secure the quantities of energy "required. The role of the government has therefore been limited to negotiating with energy producers the price of the fuels and buying them for the country. These kind of policies were inevitably dominated by the oil producing countries and were correctly defined as being "supply-oriented policies". Energy suppliers were thus in a position (being in absolute control of this situation) to create their own forecasts, and set oil prices according to their own will claiming an ever growing-according to their forecasts-demand.

It was only after the first oil crisis in 1973 that these one sided energy policies began to change. The resulted increase of oil prices forced energy policy makers to reconsider their supply oriented policies and try to identify their major drawbacks. Phrases such as "energy conservation" and "energy efficiency" were introduced. The need to change consumption patterns that would result to a reduction of energy use and thus energy imports became apparent. The new energy conservation policies have been very effective for various countries. For example, the overall energy consumption of the OECD countries increased only by 4% between 1973 and 1985 while

the GNP for the same period rose by more than 30%.

As a first reaction to the energy crisis the government of Cyprus requested, in 1977, the assistance of the United Nations in order to develop a project on "Energy Conservation and Development". One of the major objectives of that project, which began in 1978, was the establishment of an overall energy development policy for the country. The project lasted until 1983 when a new project was initiated with the assistance of the World Bank.

However eighteen years after the major oil crisis and twelve years after the first major energy project Cyprus continues to have a purely supply oriented energy policy. While there is a well declared energy policy aiming at energy conservation and exploitation of renewable energy sources no measures seem to be taken. There is therefore an immediate need for the government to move from a declared to an implemented energy policy.
A policy that will escape from the supply oriented policy.
Related legislation, regulations and standards will have to be produced and implemented.

Energy related investments at the national level continue to be planned and implemented without any consideration for the potential of energy conservation. A major example of this attitude has been a study for the construction of a coal fired electricity plant in which the potential for energy conservation, was never taken into consideration (when

forecasting energy demand).

The overall responsibility for formulating the energy policy of the country rests with the Ministry of Commerce and Industry. The Energy Unit of this Ministry is assigned with the task of formulating and presenting proposals related to energy matters to the Council of Ministers, through the Minister of Commerce and Industry. The two other major institutions that play a vital role in the formulation of energy policy are the Electricity Authority of Cyprus (EAC), and the Cyprus Petroleum Refinery (CPR). EAC is a semi-autonomous government company under the Ministry (administratively) of Commerce and Industry. The government owns 50% of the CPR shares with the remaining owned by the oil companies operating on the island (Mobil 20% British Petroleum 15% and Shell 15%).

The focus of the energy policy of the Cypriot government right after the second energy crisis of 1979 concentrated on energy conservation, and diversification of fuel sources. These policies aimed at reducing dependency on imported oil supplies, and emphasis on solar energy.

Various consultants have visited the country through UNDP (United Nations Development Program) and World Bank programs mainly to advise on energy conservation prospects and methods in various sectors of the economy and investigate the possibilities of exploiting renewable energy technologies and especially solar energy. The efforts of the Government towards

improving solar energy use concentrated on assisting the manufacturers of solar collector to improve the quality of their solar panels.

The fuel pricing policy

The current (1989) retail prices of fuels in Cyprus compared with Economic Levels are shown in Table 1.2.1.For several years in the past, petroleum products and especially LPG have been sold below economic levels. Currently, most petroleum products (see Table 1.2.1) are sold above their costs. This is not due to any modification in the existing pricing system (which has been the same for many years) but due to the current relatively low oil prices. The only fuels priced lower than their economic cost are the Heavy Fuel Oil produced by the Cyprus Petroleum Refinery and sold to the EAC and the aviation fuel sold to the Airline company of the country.

The retail prices of oil products are fixed by the government after negotiations with the oil companies. However, according to a 1984 law, these prices, have to be approved by the House of Representatives which has the final word. In many cases, for political reasons, the house of Representatives reject the recommendations of the Government and lowers the retail price of fuels.

The income of oil companies is determined after negotiations between the government and the oil companies operating on the island. The negotiations are based on the annual balance sheets

of the oil companies known as the "Price Negotiation Balance Sheets" (PNBS). The main elements of the PNBS are the cost of oil products and crude oil, refining costs, marketing expenses of companies, freight costs, port dues, insurances, bank charges and taxes. Each of these elements is negotiated between the two parties. This negotiation usually takes place once a year. The final PNBS agreed is modified accordingly depending on whether the companies have shown profits or loss. When oil companies show profits, the government may decide, depending on the amount of the profit, to revise retail prices downwards or increase excise duties. If profits are made at the end of the budget year they be subject to the usual taxation of revenues (Sema Metra vol.1,1985).

An arrangement is also made for the case of losses. The government may decide in this case to increase retail prices. However as already stated, any agreement is subject to the final approval of the House of Representatives.

There are several drawbacks in the fuel pricing system described. The major of these drawbacks are listed below:

(a) The fact that the frequency of negotiations is not satisfactory leads to the absence of targets by the oil companies.

(b) As a rule the negotiation starting point is done by the companies. Because the basis for negotiation is proposed jointly by all companies there is always the possibility of the proposed average cost to be much higher (the least

efficient company is included). It is obvious that since the whole of the negotiations begin at a higher point it will result to a higher energy cost for the consumer.

(c) The fact that the negotiation of the PNBS includes all products introduces disparities between the oil companies because they do not all have the same products.

From the brief description made above the need for improving the present fuel pricing system becomes widened. The fact that prices have to be approved by the House of Representatives has complicated further the issue. In reality the government, which is supposed to have its own energy pricing policy, does not have the power to implement it. In Chapter XI recommendations for improving fuel pricing policies are made.

Regulations-standards-codes of practise

Although there are certain requirements that have to be fulfilled before a permission to proceed with the construction of a hotel, there are absolutely no regulations related to energy efficiency.

(1) Product	(2) Retail price (t)	(3) Economic level (t)	(2)/(3) Percent
Premium gasoline	356	81	440
Regular gasoline	330	73	452
Kerosene	117	73	133
LPG	120	88	79
Jet Fuel	70	94	128
Gasoil	110	75	147
Light fuel oil	47	43	109
Heavy fuel oil (local refinery)	25	38	66
Heavy fuel oil (imported)	38	38	100

Table 1.2.1 : Current retail prices of fuels in Cyprus pounds

Unfortunately there has been no change to the old practice of traditional building methods in which building regulations were unnecessary. This was due to the fact that earlier building practises on the island provided a combination of a large thermal mass and the required shading appropriate for the island's climatic conditions. In these times great consideration to the mass of the fabric, that provided the

insulation of the building was given. Earlier building practises were also taking advantage of solar passive contribution that was providing comfortable conditions by reducing solar gains in the summer and allowing solar radiation to penetrate in the winter.

However, the raise of the standard of leaving on the island introduced greater demand on better living and working environment. The hotel sector could not be an exception to this rule. The availability of new building material and construction practices and the development of new technology that enabled better temperature control led to the abundance of earlier building methods. This situation resulted to a greater demand for energy. When energy was cheap and a taken for granted source, no one would think of regulations, standards and codes of practice. The greater demand for energy should normally lead to a serious consideration of introduction of certain minimum regulations.

This was not the case in Cyprus. As a result, all of the hotels and hotel apartments have been built without any compliance to any energy efficiency regulations.

Though a great number of hotels in Cyprus are fully air conditioned (heating and cooling) there is no single regulation pertaining to the efficient energy design and operation of these facilities.

There is therefore an urgent need for the country to develop its own fabric and services design and operation parameters that should be made compulsory, especially for large hotels. These regulations should definitely include thermal insulation and solar shading and use. These and other recommendations are made in the recommendations section in the lighting of the findings of this project.

The impact of correct energy policies on the hotel sector

The fact that current fuel retail prices do not always represent real costs combined with the total absence of codes and regulations on the energy efficient construction and operation of hotels has considerable negative effects.

Subsidised or unrealistically (usually for political reasons) priced fuels (i.e gasoil, LPG, light fuel oil) send the wrong messages to hotel owners, and managers that result to waste and discouragement from energy related investments. As a result hoteliers are mostly concerned with satisfying their established user pattern and no effort is made in modifying (reducing) their demand pattern.

Another major drawback to energy efficiency in the hotel sector is the fact that (according to a 1985 law), hotels enjoy a "benefit" of a 15% reduction on their electricity bill. The aim of this act was to assist the industry in becoming more competitive in the international market. We believe that the act sends the wrong messages again. We think that by providing

hotel owners with an effortless reduction of their energy bills they are spared with the opportunity of making any effort to save energy.

There is no doubt that the absence of regulations and codes leads to the construction of non energy efficient hotels. Electricity and fuel demand could be considerable lower (lower peaks also) if efforts are made for proper construction and operation of hotels (utilising passive active solar methods and following standards) were made at the early stages.

1.2.2 The Hotel Industry as an important energy consumer

In order to produce an energy audit of the hotel industry of the island and thus determine the quantity and type of energy used both by the industry as a whole and the various groups of hotels (mainly by class), a representative sample of hotels was selected and analysed.

The sample included hotels of the 5,4,3,and 2 star class. No hotels of the 1 star class hotels were included in the sample mainly because of the negligible, compared to the total energy consumption of the sector, quantities of energy they use, the non availability of energy consumption data and the considerably different way by which they are managed. As far as the number of beds is concerned, hotels of the 1 star class constitute only 6.5% of the industry's total number of beds.

The aim of the survey was to construct a sample that would be

as large and as representative as possible.

The most important factors that were taken into consideration during the sampling process of hotels, in the light of preliminary "pre judgements" were the following:

(a) the age of the hotel

(b) the class of the hotel

(c) the location of the hotel

(d) the function of the hotel

(e) the availability of historical energy consumption data

(f) the willingness of the management of the hotel to cooperate

The final number of hotels included in the sample was 51 hotels and represented 30% of all hotels and more than 50% of the total number of beds.

Because of the small number of hotels of the 5 star class, all hotels in this category in operation during the period of the survey were included in the sample: i.e. 100% of the population.

The hotels of the 4 star class were represented by 53% of their population whereas those of the 3 star class were represented by 52%.

Hotels of the 2 star class were represented by 20% only. The relatively lower representation of the 2 star hotels is

partly attributed to the relatively increased difficulty of obtaining historical energy consumption data and securing the commitment of the management for cooperation as well as the larger population in the category.

The survey covered a period of five years (1985-1989) and resulted to the formation of an extremely useful energy data base for the hotel industry. It is the first time that an energy data base of this extent has been created. Data were collected by personal visits, contacts and inquiries rather than the more usual "mail shot" approach. Additional electricity data were provided by the Electricity Authority of Cyprus. Data were also obtained from the Ministry of Commerce, the Cyprus Tourism Organisation and the Goverment's Department of Statistics.

Before presenting the results of the analysis of the data contained in the energy data base obtained, it was considered appropriate to present a brief description of the industry. This description will be helpful in setting up the energy scene. Various tables and will be used in order to present this information.

Table 1.2.1 presents the number and size of hotels as well as tourist apartments by class. The Table is valid for the year 1990. The location of hotels as well as that of the tourists apartments is shown in Table 1.2.2.

In order to identify the energy related facilities available by the Hotel Industry of the island it was consider appropriate to obtain data related to the number of hotels utilising air conditioning systems, central heating systems, solar energy systems, energy management systems etc. This information is summarised in Tables 1.2.3, 1.2.4 and 1.2.5.

Table 1.2.6 refers to the use of "computerised energy management systems". The use of this relatively new technology has been expanding, rapidly in Cyprus as in many other parts of the world, rapidly in Cyprus. A more detailed reference to the use (and abuse) of these systems as well as that of solar energy is made in Chapter VIII.

The total energy consumed by the hotel industry in 1989 was estimated to be 806 million MJ. This amount included 101 million kWh of electricity. These figure were based on information derived from the analysis of the sample and data provided by the Electricity Authority of Cyprus. Whenever reference to the total energy consumption is made this includes both hotels and tourist apartments as well. The same holds for the total number of bednights as well.

Table 1.2.7 presents data related to the total number of tourists arrived in the country, the total number of bednights the total energy and the total electricity consumed for each year for the years 1983-1988.

Table 1.2.8 presents energy and electricity consumption per tourist and per bednight for each year as well as the average values for the whole six year period.

An analysis of the energy data of the 51 sample hotels showed that electricity is the fuel used mostly by the hotel industry reaching a level of 45 per cent of the total energy used.

The percentage of fuel used by type for each class of hotels is shown in Table 1.2.9. As it can be seen from Table 1.2.9 the percentage use of electricity is higher for the hotels of the higher class .

This is explained by the fact that hotels of higher class are much more electricity intensive since they offer more functions, more and of higher quality air conditioning and various other electrically driven services on a "convenience" basis. The level of percentage use of liquified petroleum gas is at the same level for all classes of hotels.

Hotels

Class	Number	Average Number of Rooms
5	10	210
4	30	155
3	61	90
2	46	35
1	37	25

Tourist Apartments

Class	Number	Average Number of Apartments
A	77	60
B	131	30
C	28	24

Table 1.2.1 : Number and Size of Hotels and Tourist Apartments (1990)

HOTELS		
On the beach	: 27%	(51)
On the seafront	: 17%	(31)
In other locations	: 56%	(104)
TOURIST APARTMENTS		
On the beach	: 7%	(17)
On the seafront	: 17%	(41)
In other locations	: 76%	(180)

Table 1.2.2 : Hotels and Tourist Apartments location (1990)

Central Air Conditioning System	:	60%
Partial Air Conditioning System	:	26%
Central Heating System	:	25%
Heated Swimming Pools	:	68%

Table 1.2.3 : Energy related facilities for hotels (1990)

Central Air Conditioning System	:	10%	(23)
Partial Air Conditioning System	:	76%	(181)
Central Heating	:	19%	(46)
Heated Pools	:	4%	(6)

Table 1.2.4 : Tourist apartment energy related facilities (1990) (Total : 238)

All hotels	:	59
Five Start	:	43
Four Star	:	73
Three Star	:	61
Two Star	:	54
One Star	:	50

Table 1.2.5 : Percentage of Hotels utilizing Solar Energy

Middle East	:	14.3
Southern Africa	:	8.5
Australia	:	43.6
Far East	:	24.6
Asia	:	12.1
Canada	:	15.2
Continental Europe	:	21.1
Scandinavia	:	50.0
U.K.	:	29.2
Mexico	:	13.8
Caribbean	:	21.0
South America	:	3.8
CYPRUS *	:	14

Table 1.2.6 : Percentage of hotels utilising computerised Energy Management Systems (1987).

* It concerns a percentage on the total number of a 4 and 5 star hotels since they are the only hotels comparable in size with the hotels included in the sample for the other parts of the two

Note : Source for other parts of the world : 1988 Worldwide Hotel Industry Report by Horwarth & Horwarth International.

Year	Tourists Arrived	Total Number of Bednights	Total Energy Consumption (million MJ)	Total Electricity Consumption (million kWh)
1983	620,726	3,200,000	357	44.9
1984	736,973	3,750,000	406	51.1
1985	813,607	4,370,000	460	57.9
1986	827,937	4,810,000	509	64.0
1987	948,551	5,690,000	580	72.8
1988	1,111,818	7,430,000	708	88.6
1989	1,377,636	8,173,000	806	101.1

Table 1.2.7: Number of Tourists and Bednights and total energy and electricity consumed for the year 1983-1989.

Year	Energy MJ/Tourist	Electricity (kWh) per Tourist	Energy per Bednight (MJ)	Electricity per Bednight (kWh)
1983	575	72	111	14.0
1984	551	69	108	13.6
1985	565	71	105	13.2
1986	614	77	106	13.3
1987	611	77	102	12.8
1988	637	80	95	11.9
Average	592	74.3	104	13.13

Table 1.2.8 : Total Energy and Electricity Consumption per tourist and per bednight for the Hotel Industry (includes Tourist Apartments)

Hotels	Electricity %	gasoil %	LPG %
All hotels	45	42	13
5 Star	50	37	13
4 Star	44	43	13
3 Star	40	46	14
2 Star	32	54	14

Table 1.2.9 : Percentage Contribution of fuels for the Hotel Industry

Hotel Class	Energy GJ/m^2	Electr kWh/m^2	Energy GJ/bocc	Electr kWh/bocc	Energy kJ/m^2-bocc
5	1	132	0.2	28	14
4	0.8	100	0.2	18	23
3	0.7	78	0.13	14	36
2	0.5	42	0.07	5	46

Table 1.2.10 : Energy consumption Indices for the Hotel Industry of Cyprus.

The percentage use of gas oil is higher for the case of the hotels of lower class. This can be attributed to various factors the most important of which being the following :

(a) the absence of total air conditioning in a number of hotels

(b) the oversizing of their heating systems (less efficient).

An analysis of the total energy consumption and the electricity consumption of all sample hotels with respect to their occupancy and area resulted to the derivation of valuable energy indices. The results of this analysis are shown in Table 1.2.10.

1.3.1 Energy consumption : a wider perspective

While reduction of the energy consumption was the main concern of this research, it was considered appropriate to focus on the cost of energy and its relation to the total production and operation cost of the industry and of the hotels of each class separately.

A comparison with the corresponding data from hotels in other parts of the world was also performed. The data obtained from the hotels through the survey of this project were set aside other similar data obtained by the Department of Statistics.

Energy cost represents a larger percentage cost of the total cost for the case of the tourist apartments. This is attributed to the difference of operation mode, the variability of the functions of the buildings and the way they are operated. Energy consumption for cooking is considerably less for most of

the tourist apartments as they usually provide no breakfast and meals for their guests. In addition their staff expenses are much lower.

The percentage of energy cost for the hotels of the 3,4 and 5 star class lies in the same levels (between 3.9% and 4.1%) whereas the percentage of the same cost for the 2 star hotels is larger (4.4 %).

Table 1.3.1 shows a summary of this information for three separate years (for comparison purposes). In the year 1985 the percentage of energy cost with respect to total energy cost was much larger than the corresponding figures of the latest years. The decrease of this percentage can not be attributed to a more energy efficient operation of the hotels but rather to a considerable decrease to the price of electricity. This decrease of the result of a fall of the price of oil used for the production of electricity generation, in the international market.

The percentage of energy cost to the total direct production cost for Hotels and Tourist Apartments for the same period (1985-88) is summarized in Table 1.3.2 .

The cost of water is not included in Tables 1.3.1 and 1.3.2. However, because of the importance of this vital resource separate data were collected and analyzed. The information obtained is summarised in Tables 1.3.3 and 1.3.4. In these two tables a comparison is made between the cost of the water and

the total operating and total direct production cost respectively.

In order to appreciate the situation on a global basis, Table 1.3.5 is provided which presents a comparison of the ratio of the total energy cost to the total operating cost for Hotels internationally.

The sample of the hotels from Cyprus included only Hotels of the 4 and 5 star class since these are the only hotels that have a comparable number of rooms with the hotels included in the international survey.

In order to obtain a wider view with respect to the overall distribution of expenses and revenues for the hotels, an analysis that covered the case of the 4 and 5 star hotels was performed.

As it can be seen from Table 1.3.5 the percentage of energy cost to total operating cost for the hotels in Cyprus is higher in almost all other parts of the world (with the exception of Africa and the Middle East).

Class		1985 %	1987 %	1988 %
Five Star	:	7.3	4.1	3.9
Four Star	:	7.5	4.6	4.0
Three Star	:	7.5	4.7	4.1
Two Star	:	7.3	4.3	4.5
One Star	:	6.4	3.9	3.8
Tourist Aptm A	:	6.9	5.7	5.0
Tourist Aptm B	:	10	6.2	5.5

Table 1.3.1: Percentage of energy cost to total cost for Hotels & Tourist Apartments in Cyprus

Note : Energy cost does not include cost for water

Class		1985 %	1987 %	1988 %
Five Star	:	22.0	14.7	12.2
Four Star	:	24.2	14.9	13.2
Three Star	:	24.0	15.8	14.0
Two Star	:	24.0	15.2	15.0
One Star	:	18.0	14.4	11.0
Tourist Aptm A	:	30.2	22.1	21.4
Tourist Aptm B	:	39.6	24.5	22.1

Table 1.3.2 : Percentage of energy cost to direct production cost for the hotel industry of Cyprus

Note : Energy cost does not include cost for water.

Class	1985	1987	1988
	%	%	%
Five Star :	0.5	0.4	0.6
Four Star :	0.9	0.7	0.7
Three Star :	0.8	0.9	0.7
Two Star :	1.2	0.6	0.8
One Star :	0.6	1.0	0.9
Tourist Aptm A :	0.8	1.0	1.1
Tourist Aptm B :	1.4	1.6	1.2

Table 1.3.3 : Percentage of water cost to total operating cost for Hotels & Tourist Apartment in Cyprus

Class	1985 %	1987 %	1988 %
Five Star :	1.5	1.4	1.8
Four Star :	3.0	2.7	2.4
Three Star :	2.8	3.0	2.5
Two Star :	4.0	2.1	2.8
One Star :	1.6	3.7	2.5
Tourist Aptm A :	3.6	3.9	4.8
Tourist Aptm B :	5.6	6.3	4.8

Table 1.3.4 : Percentage of water cost to direct production cost for Hotels and Tourist Apartments in Cyprus

International	:	4.0%
Asia & Australasia	:	4.4%
North America	:	3.9%
Latin America/Caribbean	:	4.2%
Africa & Middle East	:	5.4%
Europe	:	3.5%
Cyprus	:	4.9%
(8.1% in 1985)		

Table 1.3.5 : Comparison of total Energy cost to total operating cost for Hotels internationally (1987)

* Source : 1988 Worldwide Hotel Industry Report by Horwath and Horwath International Energy cost includes cost of water (Data on Cyprus added).

Hotel Class	Cost (Cyprus Pounds)
5	500
4	350
3	255
2	240

Table 1.3.6 : Energy Cost per available room per year for Hotels in Cyprus (1988)

Norther Africa	1406
Southern Africa	1239
Middle East	1362
Asia	1464
Far East	1348
USA	1192
Canada	852
Australia	1114
Continental Europe	1370
Scandinavia	941
U.K.	1026
Mexico	570
Caribbean	1910
South America	1028
Cyprus :	1015

Table 1.3.7 : Energy Cost in US dollars per available room (1987)

Note : 1988 Worldwide Hotel Industry by Horwath & Horwath International. The cost includes cost of water as well. For the purpose of this comparison only hotels of the 4 and star class from Cyprus are included.

The percentage of Cyprus is more than 20% higher than the average international value. The Cyprus figure becomes much more dramatic when the figure in parenthesis representing the year 1985 (before the drop of oil and electricity prices) is considered.

The choice of the hotels of these class was based on the fact that it would enable a comparison with the hotels internationally for which data were available.

An attempt to relate the cost of energy per room available was also performed. The results shown in Table 1.3.6 show that hotels of the 2 and 3 star class lie in the same range, whereas the difference between the energy per available room of 3 and 4 class and 4 and 5 class is around 40% higher for the hotels of the upper class.

Table 1.3.7 presents a comparison of energy cost per available room between Cyprus and many other parts of the world. As it can be seen from Table 1.3.7 energy cost per room for Cyprus is less (!) than most of the other parts of the world (only higher than Canada and Mexico).

1.3.2 The energy scene

The systemic approach employed in this thesis requires that the problem of energy conservation and management in the hotel industry of Cyprus is addressed within the content of the overall energy situation.

There is no doubt that the benefits of the introduction of energy conservation measures in the hotel sector will have positive effect on both the sector and the economy. At the national level the benefits will result from the reduction of oil imports for which considerable amounts of foreign exchange is spent every year.

The importance of concentrated efforts towards energy savings in the hotel sectors is much better appreciated if an overall view of the energy scene is realised. A brief description of the main characteristics of the energy scene is therefore given below.

Characteristics of the energy scene

The main characteristic of the energy situation in Cyprus is the total absence of exploitable local energy sources. The island was unfortunately not blessed with any conventional energy sources of its own. While there is no oil, gas, or coal there is also no possibility of exploiting other forms of energy such as hydroelectric or geothermal energy. There are certainly the options of renewable energy sources such as solar, wind and biomass. However the contribution of these sources, at least in the near future, is not expected to provide real relief to the island's energy problem. As a result, the island is totally depended on imported energy (oil) for covering its energy needs.

Year	(1) Petroleum Imports	(2) Domestic exports	(3) Petroleum Imports	(4) Ratio (1)/(2)
1973	8.8	51.4	698,305	0.17
1974	19.0	46.8	568,356	0.40
1975	18.0	49.0	534,508	0.37
1976	26.7	85.7	609,962	0.31
1977	35.1	111.2	672,387	0.31
1978	30.9	106.4	727,669	0.29
1979	44.4	135.1	779,937	0.33
1980	78.4	157.0	785,282	0.50
1981	105.2	200.6	785,116	0.52
1982	117.0	204.9	840,607	0.57
1983	119.8	189.0	876,729	0.63
1984	142.9	244.0	821,450	0.58
1985	134.3	210.7	847,498	0.64
1986	81.2	181.1	931,634	0.45
1987	84.2	226.0	1,071,052	0.37
1988	76.2	235.7	1,131,366	0.32
1989	105.9	246.9	1,160,746	0.43

Table 1.3.8: Petroleum imports, domestic exports and total imports in Cyprus. (Column 1,2 and in million Cyprus pounds and column 3 in metric tonnes).

Huge amounts of valuable foreign exchange is paid every year in order to satisfy the energy needs (see Table 1.3.8).

Another characteristic of the energy situation of Cyprus is the rising need for energy which is mainly due to the improving nature of the island's developing economy. As it can be seen from Table 1.3.8 there has been a steady rise in the consumption of energy for the period 1982-1988.

Therefore, while in 1982 the total energy consumption was 840,607 metric tonnes in 1988 it reached 1,131,366 metric tonnes. This corresponds to a mean annual rate of increase of the order of 7.1% compared to a 4.6% during the period of 1978 to 1981.

A third characteristic of the energy scene in Cyprus is the fact that not only is the country depended on imported energy but is also heavily depended on a single form of energy. That is, oil and the various oil products in liquid forms. It is only recently (1985) that a relative diversification of the energy supply sources took place. This diversification concerns the recent use of coal by the two cement factories of the country.

The almost total dependance on a single product such as oil creates additional problems to the existing huge problems caused by the absence of local energy sources. A major problem is the fact that the energy supply system is very sensitive to various world events such as wars (for example the Iran-Iraq

war) the decisions of the OPEC, the exchange rate of the dollar etc.

A fifth characteristic of the energy scene in Cyprus is the following. A great portion of the primary energy imported is used for the production of electricity through steam generators. This electricity production process is certainly inefficient since only 30% of the fuel input is converted into usable electricity.

Besides the huge quantities of oil required for the production of electricity one must also consider the quantities required by the EAC (Electricity Authority of Cyprus) in order to satisfy the needs of an ever increasing demand for electricity. In the period 1980-1984 EAC had invested for the production of new units and the reinforcement of the distribution system more than 43 million Cyprus pounds while for the period of 1985-1989 the corresponding expenses reached 78.4 million Cyprus pounds. The planned investments for the period 1990-1994 include the construction of a new power station that will operate on coal and will cost around of 166.7 million Cyprus pounds.

An additional characteristic of the energy situation in Cyprus, which is related to electricity, is the fact that EAC has for almost 20 years been supplying the occupied part of the island with electricity which was never paid for. As a consequence, electricity charges have been constantly higher than those they should be since prices charged include the cost

of the electricity supplied to the occupied part of the island.

Energy Consumption by sector

A brief discussion on the consumption of energy by the various sectors of the economy is essential in order to understand the various characteristics of the energy situation of Cyprus.

The total energy consumption in Cyprus was distributed in 1989 among the various sectors of the economy as follows.

Transport	:	46.5%
Industry	:	23.2%
Domestic sector	:	14.1%
Commercial & Tourist sector	:	10.5%
Agriculture	:	5.7%

Despite the small area of the island the sector of transport absorbs very large quantities of energy. A breakdown of this consumption is given below:

Private transport	:36%
Airplanes	:32%
Taxis and Buses	:11%
Commercial Transp	:10%
Ships	: 7%
Others	: 4%

A great portion of the total energy consumption is absorbed by the sector of Industry.

The major consumers of this sector are : the cement factories, the mines, the brick factories and food industries.

The smallest quantity of the energy consumed in Cyprus is absorbed by the Agricultural Sector. 75% of this energy is absorbed by irrigation and heating of greenhouses while the remaining 25% is used by various agricultural machinery.

Energy : a major cost

Undoubtedly energy is one of the major economic problems facing the country. One way to appreciate the extend of the economic problem is to relate the cost of imported energy (oil) with the revenue from the country's exports. Table 1.3.8 presents the cost of energy for various years and the revenue from exports. In the last column the percentage of energy cost to the total revenue from exports is also given. As it can be seen from Table 1.3.8 , this ratio varied from a high value of almost 64% to a low value of 17.1%.

Solar Energy

The island of Cyprus enjoys a sunny climate that favours the application of solar energy. In fact, in the central plain and the eastern lowlands the island enjoys sunshine for more than 75% of the time the sun is above the horizon. Over the whole Summer period the island receives an average of almost 12 hours of bright sunshine per day. Even during the cloudiest

months of December and January there is at least 5 hours of bright sunshine per day. Today, more than 90% of the island's houses are equipped with solar collectors corresponding to an area of 500,000 sq.m of installed solar panels. This number places Cyprus perhaps to the first place in the world among countries exploiting solar energy for domestic purposes. The index used for this comparison is the area of solar collectors installed per capita which for Cyprus is around 0.8.

In addition, more than half of the country's hotels and almost all of the refugee housing are equipped with solar collectors systems.

Impressive as may look however , solar energy's contribution to the total energy needs of the island (including that of the exploitation of wood) does not exceed 4% of the island's total energy consumption.

Additional Energy Problems

The fact that the country is an island and of considerably small size creates additional problems to the energy situation. Several energy alternatives which are currently employed in most industrialized countries con not be adopted by Cyprus. For example importing natural gas does not appear economically attractive because of the high cost of laying and maintaining the submarine pipeline which would be needed and the very small quantities of gas flows required. At the same time nuclear energy is generally not envisaged for capacities below 1000 MW whilst the electricity grid of Cyprus could not absorb more

than 400 MW.

Even the study which is presently under serious consideration aiming at investigating the possibility of coal conversion of electricity power plants does not appear very favourable for Cyprus as the cost per tone of oil replaced will be higher than in larger industrialized countries.

One should add to these problems the problem of the political situation which among other has its energy implications also. As has already been mentioned, the electricity supply to the occupied areas has brought no revenues since 1974 causing electricity prices for the Greek consumers to be at least 20% higher in order to cover for these unbilled quantities of electricity. In fact the issue is quite complicated and despite occasional protests from citizens, the government guided by political reasons appears reluctant to either demand payment from the consumers of the occupied part or interrupt the supply of electricity .

The Energy requirements

The total energy requirements of the country are of the order of 1,207,000 tones of oil equivalent (including the contribution of the renewables). This figure makes an average of 2.16 toe per capita (for a population of the free part of the country of 548,000). While the figure appears to be low when compared for example with the USA (7.1 toe per capita) and the EEC countries (3.2 toe p.c) it compares favorably with other Mediterranean countries such as Spain (1.9 toe p.c) and

Greece (1.6 toe p.c).

The relatively low global energy consumption level is partly explained by the fact that there is a limited development of any energy intensive industries. The two major energy intensive industries of the island are the two cement plants. The relation between energy consumption and economic development can be expressed by the ratio Energy/GDP. In Cyprus the GDP/capita is of the order of 3500 Cyprus pounds and therefore the ratio of Energy/GDP is 0.74 toe per 1000 of GDP. This ratio is close to the European (for example in France it is around 0.7).

The Sector of electricity

The energy consumption of the electricity sector represents 35% of the total energy requirements of the country. This share is comparable to those of other industrial countries. However it must be mentioned that the high primary energy need of electricity is also due to the low efficiency of the electricity production and supply system (0.34 toe per 1000 kWh delivered by the plants while this ratio is 0.22 to 0.23 toe per 1000 kWh in most developed countries).

Another very particular feature of Cyprus is the fact that electricity is produced only from oil products and therefore 35% of the energy balance means 35% of the oil imports of the country.

It is mainly due to this reason that each kWh of electricity

saved will make a significant contribution to primary energy 54 savings.

All economic calculations on comparison between electric and non electric energy alternatives should always take into account the ratio of electricity/primary energy.

When the nature of the energy scene described above is properly evaluated the importance of efficient energy management in the sector of hotels (a major electricity consumer) is highly appreciated.

CHAPTER II

THE METHODOLOGY OF THE RESEARCH

2.1. The Soft Systems Methodology

There are undoubtedly several ways by which a researcher can tackle a particular problem. The method and approach used for the investigation and solution to a problem may well influence the style of solutions or set of alternatives. In an attempt to avoid to rigid a perspective for the defining of the particular problem investigated, the Soft Systems Methodology (SSM), developed by Professor P. Checkland of the University of Lancaster (Departments of Systems), has been used widely in the development of this research. In a very recent description of the new refined version of the methodology the following description is given:(Checkland, 1989 after von Bulow)

"SSM is a methodology that aims to bring about improvement in areas of social concern by activating in the people involved in the situation a learning cycle which is ideally never-ending . The learning takes place through the iterative process of using systems concepts to reflect upon and debate perceptions of the real world, taking action in the real world, and again reflecting on the happenings using systems concepts. The reflecting and debate is structured by a number of systemic models. These are conceived as holistic ideal types of certain aspects of the problem situation rather than as accounts of it. It is taken as given that no objective and complete account of a problem situation can be provided".

The systems approach and in particular SSM has been considered appropriate for the present research since the subject under investigation, the management of energy conservation in the hotel industry of Cyprus, was thought to be quite a complex problem. Indeed the complexity is most probably paralleled in the energy use of hotel industries elsewhere, and some outcomes of the research are expected to be readily transferable.

The Soft Systems Methodology has been considered appropriate for this research for the following major reasons:

(a) It enables the researcher to put energy conservation management in the proper perspective by assisting in properly "fitting" the energy issue in the overall picture of hotel's business, and more widely, in the overall picture of the hotel industry and the economy of the island.

(b) It enables the researcher to investigate the way by which energy investments and energy conservation are faced by top management and hotel owners in relation to other expenses and necessary investments.

(c) It allows for an evaluation of the problem as it applies to smaller units in larger systems. Thus we can separately consider :

(1) Hotels of a certain standard /class (i.e 5 star and 4 star hotels) in the system of total number of hotels in the area.

(2) Hotels of an area and the way they and their energy usages fit in the system of total number of hotels in the country.

(3) The system of the Hotel industry and the way it fits in the larger economic system of the country including its interactions and relations with other economic parameters.

(d) The methodology enables the researcher to identify specific issues and tasks within the situation which could be dealt with, either separately or together, in order to achieve an overall improvement in the current situation faced.

(e) The methodology was further considered appropriate because it was thought that it would enable the researcher to perform a more thorough analysis by breaking the problem into several "pieces", analysing them separately and putting them together again possibly in a new way and thus forming a new set of relationships. Further illumination and insight may thus have been achieved.

(f) The construction of conceptual models, according to the methodology, and their comparison with the perceived real world situation, was considered an excellent way for the systematic drawing of conclusions and formulation of recommendations.

(g) The fact that the methodology had been put into practise and tested, in contrast to other methodologies, was considered a considerable advantage for its use in this research. A recent publication (Checkland and Scholes, 1990) describes several

successful cases in which the methodology was employed in order to tackle ill-structured, ill-defined problems involving both the private and the public sector.

We believe that the complex problem of the management of energy conservation is an excellent candidate for approach with the Soft Systems Methodology. The dynamic structure of the problem and the great involvement and influence of the human element are major strong points in favour of the selection of its use.

A brief description of the Soft Systems Methodology as refined recently by P.B. Checkland is presented in Appendix B.

2.1.1 The development of the rich picture

An important element of the SSM analysis of this research involved the construction of the so called rich picture of the problem situation.

A rich picture in the language of SSM is a free-hand drawing on a large blank piece paper. All "actors" of the problem situation (government departments, related associations, individuals etc) were drawn on this picture in an effort to describe the situation by emphasising such elements as structure, climate and process.

Arrows, phrases describing important elements of situation, boxes, symbols and colour were employed in order to design a picture that would represent the perceived problem situation as

accurately as possible.

Extensive research work preceded the first drafting of this picture in order to obtain the information required. However the picture continued to be modified for a long time as more accurate information became available. Reliable information concerning attitudes of actors, and processes were in many cases identified only after in-depth analysis of the individual elements concerned.

Once the draft picture was completed we were equipped with a very powerful means that enabled us to :

(a) Identify possible problems
(b) Select relevant systems
(c) Construct conceptual models of the relevant systems
(d) Compare the conceptual models with the perceived real situations in order to propose feasible and desirable recommendations.

It is emphasised here that the success of later stages in the SSM, closely related with the effort put in developing a good detailed and descriptive rich picture.

The availability of the whole, perceived, real situation in the form of a handy colourful picture was extremely valuable. The importance of this picture can not be overemphasised. Isolated information, knowledge and perceptions presented in the rich picture provided an excellent means for a spherical

systemic appreciation of the whole existing situation.

2.1.2 The selection of issues and model building

The problem situation as described by the rich picture was used in order to select issues that ought to be examined. As a first step, a list of all issues deriving was constructed.

Following thorough examination of the list, it was observed that several issues were part of other more general issues and therefore it was decided to delete them from early consideration.

A relevant (issue based) system was defined for each of the issues derived from the rich picture in order to carry the methodology through all its steps for each one of them.

However the majority of these relevant issue-based systems were already included in the primary-task relevant system and the main conceptual model.

The primary task of the research was defined as follows:

"To understand, manage and improve the energy use in the Hotel Industry of Cyprus".

After numerous iterations, the following root definition for the primary task relevant system was chosen :
"A global and ongoing system to understand, manage and improve the energy use in the Hotel Industry of Cyprus for the

benefit of the economy of the country".

The multiple levels of problem analysis required, are immediately apparent.

The "CATWOE" mnemonic (according to P. Checkland) for the primary task root definition was satisfied as follows :

C (customer): Individual hotels, the hotel industry of Cyprus, and the economy of the island (3 different levels).

A (actors): All actors in the problem situation shown in the rich picture: Hotel managers, owners, engineers, guests (4 different levels).

T (Transformation): Understand, manage and improve energy utilisation processes with a view to greater effectiveness and economy (at each major level).

W (Weltanschaung): Cyprus is too dependent on foreign suppliers and at the mercy of oil price variations. However it has certain energy resources of its own (such as energy conservation) and the engineering skills to develop effective energy conservation devices and means (2 different levels, National and local).

O (Owner): Government Energy Department on behalf of all parties concerned and Hotel engineers charged with energy economy on behalf of the owners. (2 levels)

E (Environment): Attitudes, abilities, capability to invest in proposed measures, legislation, regulations.

According to the very recent applications of the methodology, (Checkland and Scholes, 1990) it was found, that any conversion of input to output (see Appendix B) can be judged successful or unsuccessful on the three different counts of **Efficacy, Efficiency and Effectiveness.**

Based on the root definition described above and the satisfaction of the "3Es" criteria a conceptual model was developed.

Most activities of the model were required to be developed up to a fourth level in order to arrive at the final conceptual model.

The need to know and to understand the existing situation as accurately and as comprehensively as possible can not be overemphasised since it gives the basis for constructive model building.

Besides studying the existing situation, a literature survey was also undertaken in order to acquire essential background both on the energy issues to be examined and the application of the Soft Systems Methodology.

In order to facilitate the comparison stage of the SSM, detailed investigation of the existing situation (mainly in 63

the form of audits and questionnaires) was performed.

The comparison of each activity of the conceptual model with the real situation as described in the rich picture resulted in important recommendations that were considered to be both feasible and desirable.

In order to arrive at recommendations regarding the need for change, all similarities and differences between the activities in the real situation and the activities of the conceptual model were listed, as a primary step.

2.2 The Field Survey

In order to perform a thorough analysis of the existing problem situation, a sample of eight hotels was chosen for detailed investigation. The number of hotels chosen was determined following consideration of the number of hotels in each category (class) and the possibility of performing a thorough, representative and high quality analysis within the time span and capabilities of this research project.

The major factors considered when chosing hotels to be audited were :

(a) Geographic location

(b) Function of operation (i.e business or pleasure)

(c) Size of hotel (number of rooms)

(d) Class of hotel

(e) Willingness of the management to cooperate (using

professional judgement about the sense of debates with persons involved).

Every effort to avoid the inclusion in the sample of non typical hotels either in the sense of their modes of operation or in the sense of their energy consuming systems and energy forms used was taken. (However, this was not to eliminate special lessons which might be learned from such "non typical" examples).

Using a systemic approach and utilising the energy audit method for buildings, developed and proposed by the International Energy Agency (IEA), energy audits were performed in each of the eight hotels included in the sample. Chapter IV contains detailed information regarding the methodology employed during the auditing process.

It was not the intention of the audits to make use of sophisticated and expensive instrumentation for measuring the consumption or monitoring the performance of various energy consuming equipment in the hotels. The adoption of such a purely applied (engineering) approach was well beyond the scope of this research.

However, it is believed that the methods employed provided vital inside information on the patterns of use and the identification of energy saving opportunities. Though the importance of detailed sophisticated monitoring equipment is well appreciated, it is advocated that to the eyes of an

experienced observer random systematic "quality" observations and simple measurements can produce information of comparable value at lower cost.

Among the simplified methods extensively used in the audit process in this research were the following:

(a) Monitoring of electricity consumption and power factor by monitoring electricity meters utilising a simple stop watch.
(b) Monitoring and recording the temperature in various area by the use of a simple thermometer.
(c) Personal observations for the recording of the frequency of operations of boilers (utilising a simple stop watch).
(d) Personal observations for the monitoring of operation of energy consuming equipments.
(e) Identifying areas of waste by personal observations during sudden visits (sometimes on a 24 hours basis).
(f) Observation of the behaviour and way of execution of duties of staff.
(g) Extensive use of simple "behind the envelope" type calculations in an effort to verify results or observations.

The level of success of each of the above simplified methods were always a function of the amount of effort put prior each visit in studying various related topics (usually technical) and the amount of quality time spent in each hotel. The issue of "quality time" must be underlined here in order to

distinguish it from the time spent without producing real worthy observations.

Historical energy consumption data for quite extensive time periods, for all forms of energy employed by each hotel were collected and analysed. The data collected were on a yearly, monthly daily and in two cases even on an hourly basis.

The collection of detailed energy consumption data were necessary in order to establish accurate information regarding the quantity, quality and timing of demand (QQT) of energy use in each hotel (Jacques, Lesourd and Ruiz, 1989).

The concept of QQT analysis is an extremely important strategic energy planning tool. Detailed reliable data on QQT of demand for both heat and electricity are necessary in order to asses the real (actual) energy needs and proceed to the next important step. This step concerns the evaluation of various energy supply sources (both conventional and renewable) in order to arrive to optimum mixes that will satisfy the specific needs of each hotel. The very same approach applies for the satisfaction of needs at the national level as well.

2.3. Analysis of questionnaires and other energy related data

Before providing further details about the questionnaires it is important to consider their value and their usefulness as research tools.

The analysis of the results of the questionnaires addressed

to the main actors of the problem situation (managers, guests and chief engineers) may well influence both the strategic and the tactic development of energy planning for the hotel sector of the island.

The outcome of these questionnaires yielded much valuable information. The finally adopted method of obtaining the required data (i.e interviewing instead of mailing the questionnaires) has contributed significantly to the fulfilment of expectations from them.

The influence of the results of each questionnaire is very briefly discussed in the sections following.

2.3.1 The Hotel Guests Questionnaire

As guests are the main energy users in hotels, it is very important for the management to have a feedback from them with respect to the quality of the energy related services provided.

Also the unnecessary supply of energy of higher quality than that required could be avoided by studying and evaluating the replies of the guests to the questions related to their perceived level of comfort.

Information concerning the amount of time spent in specific areas of hotels is also of vital importance in determining the emphasis that ought to be placed on the duration of supply.

Individual hotels can be assisted by this information in developing individual strategies tailored to their own specific needs.

The supply strategies of the Electricity Authority (EAC) could also be influenced. Once an "accurate" demand pattern for the individual hotels, and the sector in general, is established, EAC could proceed by adjusting its supply pattern accordingly in order, if possible, to match it. Special arrangements could in that case be made between hotel owners and the public supplier, with tariff implications also.

2.3.2 The Managers Questionnaire

The information related to the knowledge, attitude and sensitivity of these important actors (decision makers) to the issue of energy use and management can, if properly evaluated, provide useful hints to any systematic and integrated effort for improving the problem situation. There is no doubt that without proper evaluation of the "quality" of these decision makers any program is bound to be at least ineffective.

The output of the questionnaire also provided the grounds for identification of "weaknesses" of hotel managers with respect to energy management. Concentrated effort on providing the means for alleviating these problems should be a major task of any strategic plan.

2.3.3 The Chief Engineers Questionnaire

The information obtained from the analysis of the chief

engineers questionnaire shed considerable light on the quality and characteristics of one of the most important actors in the problem situation.

Information on the expertise level, attitudes and perceptions of chief engineers is absolutely necessary before any strategic decision for implementing measures, initiating training programs or providing incentives can be taken.

The information obtained from the analysis of the data obtained form the chief engineers questionnaire could be used by all major actors involved such as the Government, the Hotel Owners Association and the hotel managers.

Chapter V contains further details regarding the development of the methodology used during the questionnaire stage of the research.

2.3.4 Analysis of data

Non parametric tests were attempted for the analysis of a number of answers obtained from the various questionnaires. These tests such as the "chi-square" test were considered as one possible approach appropriate to establish relations between various important parameters and characteristics of the data obtained.

Problems faced with statistical analysis because of the small size of the sample (for the non parametric tests) are not uncommon in a research based upon small study samples.

Following several attempts at data grouping it was seen that, mainly because of the small size of the sample, "chi-square" tests were not suitable for providing reliable comparative information. It was therefore considered necessary to proceed with the analysis of the questionnaires utilising a "case-by-case" judgmental approach . Results were therefore interpreted on the basis of personal judgement guided by knowledge and information obtained from background study observations during extensive site visits and discussions with persons involved.

2.3.5 Adopting a case-study, bottom up approach

There were important reasons for employing a "case study" approach in this research. The main points in favour are summarised below.

It was considered that the systemic approach of the research would be more effective in appreciating the existing situation by the utilization of "bottom up approach" that would examine in detail issues at various, normally non investigated, levels. For specific cases, this "bottom up approach" would certainly provide first hand experience and in depth analysis of the functions and interactions of all the actors described in the "rich picture".

This approach would undoubtedly require the in depth personal involvement of the researcher in all data collection phases. It would be practically impossible to perform a high quality "bottom up" analysis for a large sample of hotels within a

reasonable time.

In several instances the need for collecting additional follow-up data became apparent. This was done by visiting the various sites repeatedly or by telephone communication. Cross examination of the accuracy of data collected was also necessary on various occasions in order to confirm or modify earlier assertions made by staff.

2.3.6 Construction of an energy data base

Data on historical energy consumption of various energy sources (for both hotels and tourist apartments) were analysed in an effort to establish consumption patterns for the various classes (see Chapter I). This work was performed on a much wider sample of hotels.

Utilising a statistical analysis software package ("Statplan") the contents of the extensive energy data base achieved (51 hotels) were analysed and relations among the various energy related parameters involved were established. The regression analysis resulted in the production of very interesting findings about relations among the various parameters (see Chapter IX). The energy related variables studied were :

(a) Number of rooms

(b) Area

(c) Class (category)

(d) Number of occupied beds

(e) Oil consumption

(f) LPG consumption

(g) Electricity consumption

(h) Degree days for heating

(i) Degree days for cooling

2.4 Analysis of the situation

The role of each of the various actors of the rich picture was thoroughly examined and proposals for change were made. This involved an extensive range of actors ranging from policy formulating and implementing agencies, such as the appropriate government authorities, to foreign and local consultants.

Cost effectiveness evaluation models and simulation techniques were extensively employed to explore the appropriateness of a number of energy technologies as well as other technologies (such as cogeneration) that are entirely new in the Cyprus energy scene.

The life-cycle cost effectiveness analysis aimed at selecting suitable technologies which would have possibilities of wide applicability. Emphasis was given to seeking an optimum mix of appropriate conventional and renewable energy technologies. Technologies examined included:

(a) Heat Recovery

(b) Building Energy Management Systems

(c) Combined Heat and Power

(d) Solar energy for domestic hot water supply

(e) Solar energy for swimming pool heating

(f) Passive solar heating and cooling

(g) Wind energy

A number of permutations and combinations of these technologies were also examined.

Creative exploration has been a major issue during the examination of the present energy use patterns. Every effort was taken in order to use "fresh/new" ideas utilising such techniques as lateral thinking (Edward de Bono, 1987). Examples of the systematic effort to apply creative thinking are presented in Chapter VIII.

Considerable emphasis has been placed in thinking about the feasibility of "rearrangement" of the distribution of energy use over time. This might be achieved, for example, by the use of lower quality of input energy which will be supported by local sources of lower quality energy as well. By a critical evaluation of the energy consuming activities such as heating, cooking, lighting, laundry, over time periods, the researcher can establish related user patterns. Then, the justification of reasons for which a certain activity is performed at a specific time must be assessed. If only a poor justification exists, the particular activity may have to be "shifted" to a period of lower demand for high quality of energy. Removing "peaks" for demand for electricity, for example, is highly desirable in order to avoid excessive capital generator requirements.

A mixture of "locally" available forms of energy (such as wind and solar) might be used in combination with other high

quality expensive sources such as electricity, in order to minimize total cost as well as reducing demands for high quality energy source.

2.5 Limitations and Problems

There are certainly limitations to the methodology and the techniques employed in this research. The methodology employed presented both advantages and disadvantages.

A major limitation of the research has been the fact that the number of hotels audited as well as the number of hotels for which detailed energy consumption data were collected (at the level of hour consumption), eight and two respectively, has been relatively small.

Despite the fact that every effort was taken to obtain a sample that would be as representative as possible, we believe that a larger number might provide further insights to the overall problem situation. It is not however possible to evaluate the degree of usefulness of this additional information, but we may well suppose that the classical "80 : 20" rule applies here as in many other types of field trial experiments (Pareto).

There is certainly no guarantee that an investigation of a much larger sample would produce more "issues" for examination. It might just as well produce a repetition of problems faced in the examination of the initial smaller sample. It would however reinforce the importance or otherwise of the issues identified

and demonstrate how widespread they are.

The number of the sample hotels had to be selected taking into consideration the problems of geographical dispersion of hotels and the need for extensive repeat visits in order to obtain first hand information from the various sites.

In addition securing the willingness of the management of hotels for cooperation was not an easy task. The researcher was in many cases considered as an invading outsider seeking free access to their premises (accounts departments, maintenance departments, rooms etc). Several hotel owner were even more reluctant because they knew that the researcher was also a government official in another capacity! These perceptions may well have introduced biases in the sample finally selected, in favour of "friendly" and /or "enthusiastic " managers!

Major problems were also faced during the collection of data from hotel owners. The problem of identifying sources of data and information and the problem of avoiding the risk of collecting unsubstantiated derivative data were faced at the initial stage of the research.

Despite difficulties, a lot of useful data and information were collected and utilised for the very first time (i.e degree days for various geographical locations, hotel water consumption figures).

Most of the island's hotels did not possess, or were not

willing to provide historical energy consumption data for their business. Even in the cases for which data were provided, cross examination (through other sources such as the EAC) was always performed in order to verify the overall impression of accuracy of the figures. The same double verification process was followed throughout the data collection phase using other sources as well (such as the Department of Statistics, the Cyprus Tourist Organisation etc).

The necessary search of related literature, also presented various problems. It has been quite difficult to locate sources for similar types of research in other countries. Indeed very little work at such level of detail has previously been attempted. Such information was sought since it would be useful in understanding and comparing methods and approaches used by other researches (either individual consultants or public or professional agencies) for tackling similar problems in other parts of the world. Information from similar but non academic work was finally located in countries such as Japan, the United States, the EEC countries and the United Kingdon (Lawson,1983).

The search of the international scene also provided information on a major international accounting firm (Horwath 1985,1986 etc) that collects and publishes data on the International Hotel Industry. These publications also include several energy related data.

Problems were also faced during the initial stages of applying the Soft Systems Methodology. This is the stage in

which the researcher attempts, according to P.Checkland, to draw the "rich" picture of the perceived problem situation.

The role of each actor in the picture was clearly established only after consultations with the many agencies, authorities and individuals involved.

The almost entire absence of related legislation stating the purpose and authority of existing agencies and institutions was an additional obstacle. These problems were indeed very revealing of the need for new institutions and services in the Cyprus energy context. Furthermore, in order to establish elements of "climate" in the picture, extensive repetitive discussions with "actors" involved were carried out. Elements of "process" also presented several problems. Repetitive personal observations were in many cases necessary in order to identify their elements correctly and position them appropriately in the picture. Of course on the positive side the attempt to construct the "rich picture" was invaluable in providing early, clear vectors for this research and for possible further work.

2.5.1 Problems of the Data Gathering techniques

Almost all available data gathering techniques were used extensively during the research. Questionnaires, interviews, personal observations and actual experimental measurements (related to measurement of power factor, temperature, fuel consumption etc.). Each of these techniques presented its own problems.

A major problem for the attempted mailed questionnaires (for managers and chief engineers) had been the extremely low response (less than 6%). Several reasons could be identified to justify this low response level. The most important of these reasons are listed below.

(a) The questionnaires were mailed at a period of high (Summer) occupancy and therefore hotel managers and chief engineers had been very busy.

(b) There may have been problems of clarity perceived in some of the questions.

(c) Respondents were unable to provide answers due to lack of knowledge on the topics involved.

(d) The respondents might have felt that they should not reveal various facts and figures pertaining to the operation of their hotel for commercial reasons.

(e) The respondents might have underestimated the importance of the research and its potential contribution towards improving the cost effectiveness of operation of their own hotel.

Following the very low response to the mailed questionnaire survey, a decision to proceed with an adequate number of interviews, that would provide the required information, was taken. A larger sample was chosen from the entire hotel population taking every effort in considering parameters such as class, number of hotels in each class, number of rooms, facilities offered, geographical location and mode of operation.

All managers of hotels chosen were contacted personally in an effort to explain the importance of their cooperation and hopefully arrange for personal meetings. The strategy developed aimed at securing the involvement and cooperation was twofold.

Firstly, managers had to be convinced that the outcome of the research would benefit their own hotels as well. Secondly, managers had to be assured that strict confidentiality would be maintained during and after the project and that the major purpose of the research was to expose problems and not persons or hotels. The strong emphasis paid to these points during personal communications resulted in a positive response by the interviewees although still with difficulty, and slowly.

Problems were also encountered in the attempt to perform the questionnaire survey for the guests in the hotels of the smaller sample. Hotel owners and managers appeared to be quite reluctant in giving permission for the execution of this tasks in their hotels. The first method of conducting this survey was to randomly select and "interview" guests in a hotel. Several hotel managers felt that this method was disturbing their guests by allowing "outsiders" to waste their holiday time. After consultation with several managers this method was abandoned.

Certain questions were rephrased and questionnaires were reprinted on a much better quality and more attractive paper. A brief polite letter explaining the purpose of the survey was written on a complimentary hotel paper and attached to each

questionnaire. A questionnaire was then put in each of the occupied rooms and the customers were (through the accompanying letter) kindly requested to return the completed questionnaires at the reception desk.

This new method of collecting data described above presented several advantages and proved to be very effective. The most important of these advantages are listed below.

(a) Guests were able to complete the questionnaire in their rooms without wasting time from their sun bathing, swimming or relaxing with their friends in the cafeterias or restaurants of the hotels.

(b) Guests could discuss the questions of the questionnaire with other members of their family in their rooms (thus, responses may not be the work of single individuals at all).

(c) Guests felt free to complete the questionnaire at any time under no pressure and in absolute privacy and anonymity.

(d) Researcher's time and embarrassment could be saved by avoiding cases in which guests would possibly refuse to answer the questionnaire.

2.5.2 <u>The series data on Energy use</u>

Time series data related to energy consumption for the small (detailed sample) as well as for the larger 30%, greater sample were obtained for several years at various level of accuracy.

Occupancy figures for hotels involved were also obtained for the corresponding periods. Energy consumption figures included monthly data for electricity, fuel and liquid petroleum gas.

Some problems were faced during attempts to draw economic conclusions from this data which was often poor, incomplete or imperfect (e.g. poor reliability). The interpretation of these data, will certainly influence the investment recommendations, the estimation of savings for the particular case, the potential benefits for the sector and the economy as a whole.

In certain cases, data had to be collected repetitively in order to decide on whether a particular hypothesis ought to be accepted or rejected.

At the level of hourly measurements, the problem of establishing relatively acceptable data was tackled by the method of 30-50% random sampling of all events. Personal observations have been of invaluable assistance whenever "strange" readings of electricity and fuel use had been provided by management.

The cost economics of energy use in the sector is primarily governed, at present, by individualistic management decision of the owners and possibly the managers of hotels. It is therefore extremely difficult to generalise economic conclusions for the economic performance of the sector (due to proposed measures) by examining a sample only (even of considerable size) of the businesses in the sector.

When drawing economic conclusions from the investigation of sample hotels the researcher is forced to make assumptions about various "non measurable" and unpredictable factors; for

example, that there is a common model underlying the operation of all hotel businesses. This is not however the case. The way energy is managed affects considerably its final consumption. Energy use, consumption and monitoring are strong functions of the human (user) elements of each particular hotel.

The level of "acceptability" of proposed measures is also an unpredictable and important factor affecting the reliability of economic conclusions drawn from the investigation of the sample hotels. The researcher might assume that his proposed recommendations would be accepted by the majority of businesses concerned, or that one of a number of near-optimal solutions would be taken up by some owners and managers. This however is not the real situation. Whereas some businesses, depending on individual policies and sensitivity to energy matters, will accept and adopt at least some of the proposed measures, others, assumed to have an economic interest in accepting and adopting measures, may not. This is why the provision of support measures, in the form of guidelines, legislation motivation and incentives alongside recommendations will be needed in order to achieve industry-wide adoption of such economic investments.

Every effort was taken in this research to arrive at specific proposed measures that are described in detail and in a form which will make their adaptation to local needs, feasible.

CHAPTER III

SYSTEMS ANALYSIS AND CONCEPTUAL MODELS

3.1 The existing problem situation

As explained in the methodology Chapter, the construction of a so called rich picture provides a valuable model for describing the existing problem situation. This picture, does not necessarily have to be completed prior to the beginning of a research. For example in the case of this project as more information became available, it was added to the rich picture. This process was repeated until it was considered that no important aspects of the situation were missing.

As the research progressed there were cases in which certain roles and attitudes of actors in the picture had to be modified. All changes were based on the grounds of more accurate information and in some instances on a better understanding of the situation. According to SSM, emphasis was placed on identifying elements of, structure, climate and process (Checkland,1981).

Structure concerns the physical layout, the power hierarchy, the reporting structure and the pattern of communications (both formal and informal). Process involves the basic activities of deciding to do something, doing it and monitoring it. Climate refers to the relationship between structure and process and is the core characteristic of the problem situation.

The importance of establishing a good rich picture that would closely represent the situation has been emphasised; at this stage the drawing of the picture does not aim at expressing the problem but the problem situation and its environment.

3.1.1 The main "actors" of the situation

A study of the rich picture created revealed that there are several important actors in the existing problem situation. A list of the most important actors is given below :

(a) The Cyprus Tourism Organisation (C.T.O)

(b) The Cyprus Development Bank (CDB)

(c) The various commercial banks

(d) The Cyprus Hotel Owners Association

(e) The Cyprus Professional Engineers Association

(f) The Cyprus Hotel Managers Association

(g) The Department of Energy

(h) Designers of electromechanical services

(i) Architects

(j) Tourists

(k) Chief Engineers

(l) Hotel Managers

(m) The suppliers of energy consuming equipment

(n) Building and Engineering Contractors

(o) The Cyprus Organisation for Standards

(p) The House of Representatives

(q) The Electricity Authority of Cyprus

A brief description of the role and function of these actors is given below.

The Cyprus Tourism Organisation

The Cyprus Tourism Organisation is a semi public organisation governed by a Board appointed by the government and has as a main objective the promotion of the tourism industry. Under the Director General, who is subordinate to the Board, there are four departments. These departments are the following:

(1) Administration and Accounting

(2) Marketing

(3) Planning

(4) Tourist Services

Several of the activities in the last two departments have either direct or indirect relation with the efficient management of energy.

The activities which fall under the Department of Planning are the collection and analysis of statistical data, the implementation of research studies and the establishment of policies on tourism. In the Department of Tourist Services, the two directly or indirectly energy related activities are the classification and provision of permit for the operation of hotels and the approval of drawings for their construction.

CTO is also responsible for setting the prices of the tourist product and is therefore sometimes in conflict with

hotel owners. The Organisation produces its own data regarding occupancy, revenues etc for the Hotel Industry. These data are not always in agreement with the data provided by the Hotel Owners Association.

There is evidence that there are several communication problems between CTO and the Hotel Owners Association. There are also elements of mistrust. In spite of these differences, we believe that the two establishments could and should cooperate closely since their objectives ought to be in the same direction. There is however a certain conflict of interests deriving from the fact that CTO addresses the issue of tourism from the macroeconomic point of view whereas hotel owners tend to concentrate on the benefit of their individual business entity only.

At the moment there are no coordinated efforts from the two establishments with respect to the efficient use of the industry's energy resources. The results of such successful efforts would allow C.T.O to set, with the consent of hoteliers, more competitive prices for the tourist product.

The C.T.O is also authorised for granting permission for the construction of new hotels. This authority could easily be extended to include certain energy conservation features for proposed hotels, before the drawings are finally approved.

Administratively, C.T.O. falls under the Ministry of Commerce and Industry with which is in close cooperation.

The Energy Department of this Ministry has in many cases cooperated with the Organisation mainly for the dissemination of information concerning energy management and conservation in the hotel industry.

The unique role of the Cyprus Tourism Organisation is underlined by the fact that it has close relations and interactions with major actors in the situation such as the tourists, the hotel owners and the government.

The Cyprus Development Bank

The Cyprus Development Bank, founded in 1963 and staffed with some sixty professionals of various backgrounds is another major actor in the situation. The Bank is a development institution whose primary objective is to accelerate the pace of economic and social development on the island through the mobilisation and allocation of scarce resources. The main activities of the Bank include the provision of loan and equity finance, venture capital, consultancy services and specialised support to small businesses. In addition, CDB also promotes capital and institutional projects.

From the very early years of the operation of the Bank, emphasis was placed on the development of the tourism industry. As a result, loans were granted for the construction of several hotels totalling presently more than 10,000 beds. More than half of the 5 and 4 star hotels have been financed by the Bank which is also a shareholder in many of them. It is mainly because of this unique role that the Bank could promote

efficient energy use and management. Being a financier and a shareholder is quite a good reason for making efforts in this direction.

There is no doubt that the Bank is a very influential and dominating institution. It is not however presently established that energy management and efficiency, or investments in capital energy equipment are among its priorities.

For example the Bank's engineers could be more energy conscious in the various studies they undertake. In fact the Bank could possibly set up its own energy unit to promote and sell services related to energy efficiency and also consider financing energy investments.

Though the bank, as a public development institution, follows the overall government development policy, it has a considerable degree of autonomy in its operations. The Ministry of Commerce and Industry, which is responsible for formulating and implementing energy policy is represented with its Director General in the Board of the Bank but does not in any way impose its policy. We believe that there is great scope of cooperation in the energy sector between the Bank and the Ministry.

Commercial Banks

Commercial banks provide loans for energy related investments at a certain fixed rate (9%). However, none of the banks has any specific plans for promoting energy saving investments. The Central Bank of Cyprus governs the operation

of the commercial banks and sets the borrowing and lending rates. A special fund made by deposits of the commercial banks is allowed to be used only for special listed purposes. Among them are energy conservation investments and studies. The borrowing rate is however the same.

The Cyprus Hotel Owners Association

The Cyprus Hotel Owners Association has also a dynamic role in the situation. Most of Hotel and Tourist Apartment owners are members of this Association. The Association maintains close, though not always good, relations with the C.T.O and the Ministry of Commerce and Industry. The Association could play a very important role in energy efficiency in the hotel industry. However, hotel owners are not well aware of the opportunities and certainly not willing to invest in energy conservation. It is almost always declared that hotels face financial problems and that they face "low" occupancy problems.

In addition the Association demands from the Government that their hotels be considered as export industries in order to enjoy the accompanying benefits.

The information provided by people concerned shows that it is extremely difficult for prospective hotel owners to be convinced to invest in energy conservation at the initial stages of construction. The majority of the hotel owners claim that such investment would increase the initial capital required (originating from a loan).

According to a statement by one of the Hotel owners "higher operating costs that include energy costs are not a problem since in the end they result in ... less taxable income" (This is a remarkable view of profit maximization!).

There is an additional important aspect of hotel ownership which relates to attitudes on energy efficiency. Several hotel owners lease their hotels to companies that undertake their operation and management. This relieves hotel owners from the headache of energy management as well and from related investments. Again, such a hands-off approach is severely likely to maximize income and profit.

The Cyprus Professional Engineers Association (CPEA)

CPEA, founded in 1960, has as members qualified engineers of all disciplines. It is well known that engineers play a vital role in the management of energy in all countries. However, in Cyprus, at least up to this moment, there is no compulsory registration or formal competence requirement before being allowed to practise as an engineer.

This fact creates several problems in the economy of the country, and energy efficiency in the hotel sector is certainly one of them consequences.

For example, large hotels and certainly many other large industries are not obliged by law to employ qualified engineers as is the practice in many other developed countries.

The Association believes that energy efficiency will benefit when the importance of the profession is recognised by law. Most of the practising engineers are members of the Associations. However, several others, mostly non qualified, are allowed to design hotels, specify energy consuming equipments carry out their maintenance and monitor their operation.

The Cyprus Hotel Managers Association

Qualified hotel managers are members of this Association which promotes the interests of its members and organises activities that enhance their knowledge and abilities.

Energy management as a taught subject is not included in the curricula of most of the Hotel Management Schools. This is an additional reason for including energy management seminars in the programmes organised by the Association.

However, hotel managers do have a lot of serious problems themselves. One of the most important problems they face is the fact that, like professional engineers, their profession is not controlled by law and thus several unqualified people hold the position of a hotel manager. In addition, there are no uniform salary scales and professional experience is not always properly assessed. Most of these problems result in demotivation of the managers with serious consequences in the management of energy and conservation as well.

The Department of Energy

The Department of Energy is one of the most important actors in the problem situation. The Department of Energy is a small unit which employs only four engineers supervised by a senior officer in charge with other duties as well. The Department, is responsible for advising the Minister of Commerce and Industry on matters of energy policy, providing advise on energy conservation and implementing programs for energy conservation and the exploitation of new and renewable sources of energy.

The Department has been involved in many projects organised by such organisations and institutions as the United Nations and the World Bank. The staff is well trained and has good international exposure through international training programs and seminars attended.

Assistance to the hotel sector was offered on many occasions by the staff of the energy unit. However, the small number of staff and the heavy work demand involving a variety of tasks does not allow the unit to function properly at the consultative level.

Unfortunately decision makers maintain an attitude of appreciating the importance of the Energy unit only in periods of high oil prices. Despite recommendations by foreign consultants, new staff was not employed and the future of a recently completed Applied Energy Centre under the Ministry of Commerce & Industry now under construction still remains unclear.

Designers of electromechanical Services

The work of this group is especially important. Their services include the air conditioning system, the hot and cold water supply system, the lighting, the kitchen and other equipment. These are the professionals responsible for the design and specification of all energy consuming equipment. There is no doubt that designers can contribute considerably to the efficient use of energy in this industry.

However, there are several problems in the design area as well since several of the designers are not qualified for the job they do.

Others are bound by proprietary financial interest and thus specify certain types of equipment that are not always suitable for the case. For example many chillers installed in hotels are oversized. It is obvious that the task of energy conservation becomes extremely difficult when vital equipment such as boilers and chillers are oversized. Visits and discussions with members of this group provided evidence that a lot of the designed task is performed empirically. The design of solar collectors systems follows the same pattern.

Another problem is that recently consultants specify expensive computerised energy management equipment the cost effectiveness of which is not always demonstrated.

Architects

Architects are responsible for designing the structure of the hotels and the tourist apartments; the design of the building is extremely important for its future energy efficient operation. By employing several well known and proven techniques, (i.e. passive heating and cooling) architects could design hotels that would require considerably less energy. Proper orientation, natural ventilation, and insulation are only some examples of suitable techniques.

Discussions with architects who had designed hotels, highlighted their important involvement in the problem situation. However, the majority of architects are not sufficiently energy conscious. The discussions held provided evidence that the major concern of most architects is to design an impressive building and try to increase the number of rooms by efficiently exploiting all space available. Most of the architects maintained that it is the hardware that will consume the energy and not the.. envelope of the building! They also claimed that whenever they had attempted to specify energy efficient measures (e.g.insulation), it was not accepted by their customers.

Despite efforts to conceal the fact, there are certainly knowledge gaps among architects that relate to efficient energy design of buildings. This became evident during detailed scientific discussion. It is for this reason that the organisation of seminars and short courses on this subject is necessary. Today, there is enough evidence that the application

of good solar passive techniques, preferably at the initial stage of construction, can significantly reduce the energy required for its operation. Because of the importance of this issue a separate section related to this topic was devoted in this research (see Section 10.1.5).

The Tourists

The other important actors in the situation are major energy users themselves; these are the tourists or (as called by many hotels) the guests. It is important that the needs and habits of these people are taken into serious consideration. The ultimate goal should not be the supply of various forms of energy (electricity, LPG, oil) at predetermined quantities but the provision of facilities and comfort levels that would satisfy specific needs. This approach necessitates knowledge of the exact needs and required comfort levels. In addition, since the provision of energy services is closely related with the satisfaction of the guests that provide the revenue for the hotels, it is extremely important that guests are kept as satisfied as possible. The timing of the guests demands may be just as important as the type and quality of energy related services which they demand.

A recent example serves to describe the negative side and the consequences of not providing the comfort levels required: A foreign consultant, working for the Ministry of Commerce and Industry complained to the researcher that he wanted to move to another hotel because his room was very cold.

The reply of the management of the hotel to the consultant's complaint was that they did not want to turn on the heating in order to save energy! The customer did leave the hotel, only to find out that in the new hotel the temperature of the room was unbearably high !!

The importance of the needs of tourists was taken very seriously into consideration in this research mainly by the design and analysis of specific questionnaires that were addressed to them.

Chief Engineers and Hotel Managers

The questionnaires that were used as the basis for conducting interviews for these group aimed at examining in detail the attitudes and knowledge that relate to the use of energy and its management. Detailed reference to these important actors in made in Chapter V. Chefs under the control of managers are also very important energy users within the hotel environment.

Suppliers of Energy Consuming Equipment

Suppliers of energy consuming equipment have also an important role in the situation. This is the group that provides the hotels with the equipment that utilises energy. However, because of lack of control of this profession and the absence of qualified personnel there are severe problems. The import of energy consuming equipment should, for example be controlled by the Ministry of Commerce and Industry which could sanction importation of energy efficient equipment only.

Building and Engineering Contractors

The situation with the building and engineering contractor is similar to the case of the suppliers of equipment. Absence of control or firm quality standards and inefficient energy use because of lack of qualified staff are the most important characteristics in this case.

The Cyprus Organisation for Standars

The Cyprus Organisation for Standards, responsible for the construction of standards and testing of quality, could play a more active role in the situation. It could for example accelerate the process of establishing standards for the construction and operation of buildings. At present there are no standards and regulations related to the construction and operation of buildings (i.e. insulation, maximum temperatures, ventilation rates etc).

The House of Representatives

The House of Representatives is the Body that votes for legislation and sets the price of oil products proposed by the government. This is the body that is supposed to send the correct messages to consumers by adopting the right energy pricing policies. However, this is not always the case in Cyprus. Members of the House are not actually concerned with long term pricing objectives but rather with maintaining the minimum of oil prices for the satisfaction of their voters. This is usually done by the method of subsidizing certain fuels with consequences for the economy.

The Electricity Authority of Cyprus (EAC)

EAC is a semi public non profit institution responsible for the production and supply of electricity for the island. Based on a legislation dating from the times of the British authority (1947) when there was a need to protect it from competition, (because of large investments made), the Authority has the monopoly for the generation and sale of electricity on the island. According to this law no other person is allowed to produce electricity without the permission of the ... Minister of Commerce and Industry, who requests always the opinion of EAC before deciding.

3.1.2 Selecting issues from the problem situation

The detailed and careful study of the situation presented in the rich picture led to the selection of various important issues indicative for detailed study. Relevant systems that would eliminate the problems within each of the issues and support the primary task were thus formed.

The initial stage involved the selection of some thirty issues. However during detailed examination the number was reduced to sixteen. The reason was because several of these issues were judged to be components of other major issues.

The main issues selected from the rich picture

The selected main issues (in no particular order) were the following :

(1) Energy Policy

(2) Lack of awareness of energy conservation opportunities

(3) Lack of education and training of persons involved in the design and operation of hotels at all levels.

(4) Lack of clear line of authority and responsibility for the implementation of energy conservation measures

(5) Lack of progressiveness of the financial institutions in their loan policies.

(6) Lack of energy data and information at all levels.

(7) Communication problems within hotels and between various actors at all levels.

(8) Energy management problems in the hotels themselves

(9) Parliament and Government conflicts about policy and special group interests.

(10) Lack of motivation and incentives for the implementation of energy conservation measures.

(11) Improper and inaccurate measuring of energy consumption

(12) No testing facilities for the life cycle efficiency of solar collector systems.

(13) Lack of research and development on new technologies that are relevant to the hotel industry needs.

(14) Lack of legislation and regulations pertaining to energy conservation and equipment quality.

(15) Lack of professional control (engineers, hotel managers)

(16) Lack of interest and priority in the energy issue.

3.1.3 Relevant Systems Related to the Major Issues

The relevant systems that were developed in order to eliminate the issues above were the following:

(a) A system to form and promote policies on energy use and

energy related investments.

(b) An education system to inform and increase awareness on energy matters.

(c) A system to establish a centre or a body that will be responsible for the efficient use of energy.

(d) An information system for the collection, analysis and provision of regular and ad hoc information on energy matters to all parties concerned.

(e) A system to promote new methods of financing for energy conservation investments.

(f) An information system to inform relevant parties within a hotel on matters related to energy efficiency and provide a channel to ease communication difficulties.

(g) A system to establish and facilitate links between isolated parties concerned with energy conservation

(h) A management system to plan and organise energy efficiency activities within a hotel.

(i) A system to encourage energy conservation through the provision of incentives.

(j) A system to support research and development in relevant technologies for the Cypriot Hotel Industry.

(k) A control system aimed at installing professionalism into the procedures related to energy use and investments (e.g engineers, consultants).

(l) An informal system aimed at informing and encouraging interested parties about energy conservation developments and opportunities.

(m) A system to lobby for and encourage the recognition of energy efficiency as an important issue.

3.2 The conceptual model of the primary task

The next stage involved the development of the conceptual model based on the primary task. All relevant systems were included in this conceptual model. The first level of this conceptual model is shown in Figure 3.2.1.

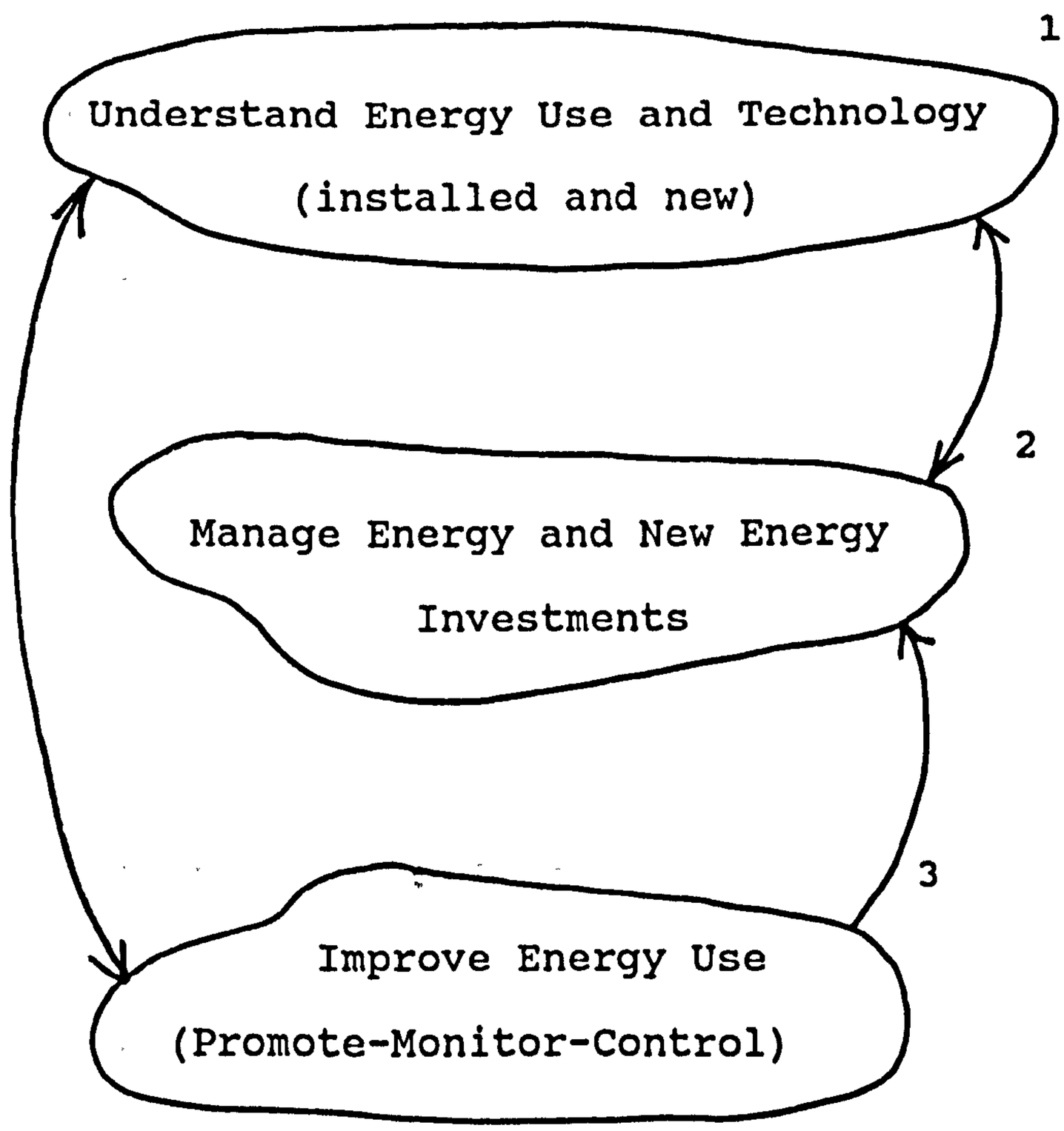

Figure 3.2.1: Primary task based conceptual model (Level 1)

The three important activities are connected with arrows, the direction of which shows the interaction between them. Arrows in both direction denote interaction and interdependence.

The importance of understanding energy use and technology is denoted by activity number 1. This understanding is achieved by determining the quantity the quality and the timing of energy supply and demand. Understanding technology involves both old (installed) and new technology. New technology concerns technology that though it may be available is not yet adopted by the hotel industry.

The second activity (number 2) of the primary task conceptual model involves both the management of energy and new energy related investments. This activity involves a detailed study of the attitudes, awareness and knowledge of individuals and organisations involved.

Activity number 3 is concerned with the improvement of energy use and involves the promotion of proper practices, correct monitoring and controlling energy consumption.

Following P.Checkland's soft systems methodology the conceptual model of level 1 (see Figure 3.2.1) was further developed to level 2. This model consisted of a total of thirty five activities. The activities of level 2 were further developed to level 3 and in many cases to level 4 bringing the final number of activities for the whole model to three hundred and forty four (344). The development of an activity to further levels was halted only when it was proved that further development would not have any real contributing effect on the model. The conceptual model of level 2 is shown in Figure 3.2.2. Table 3.2.1 lists the names of all activities

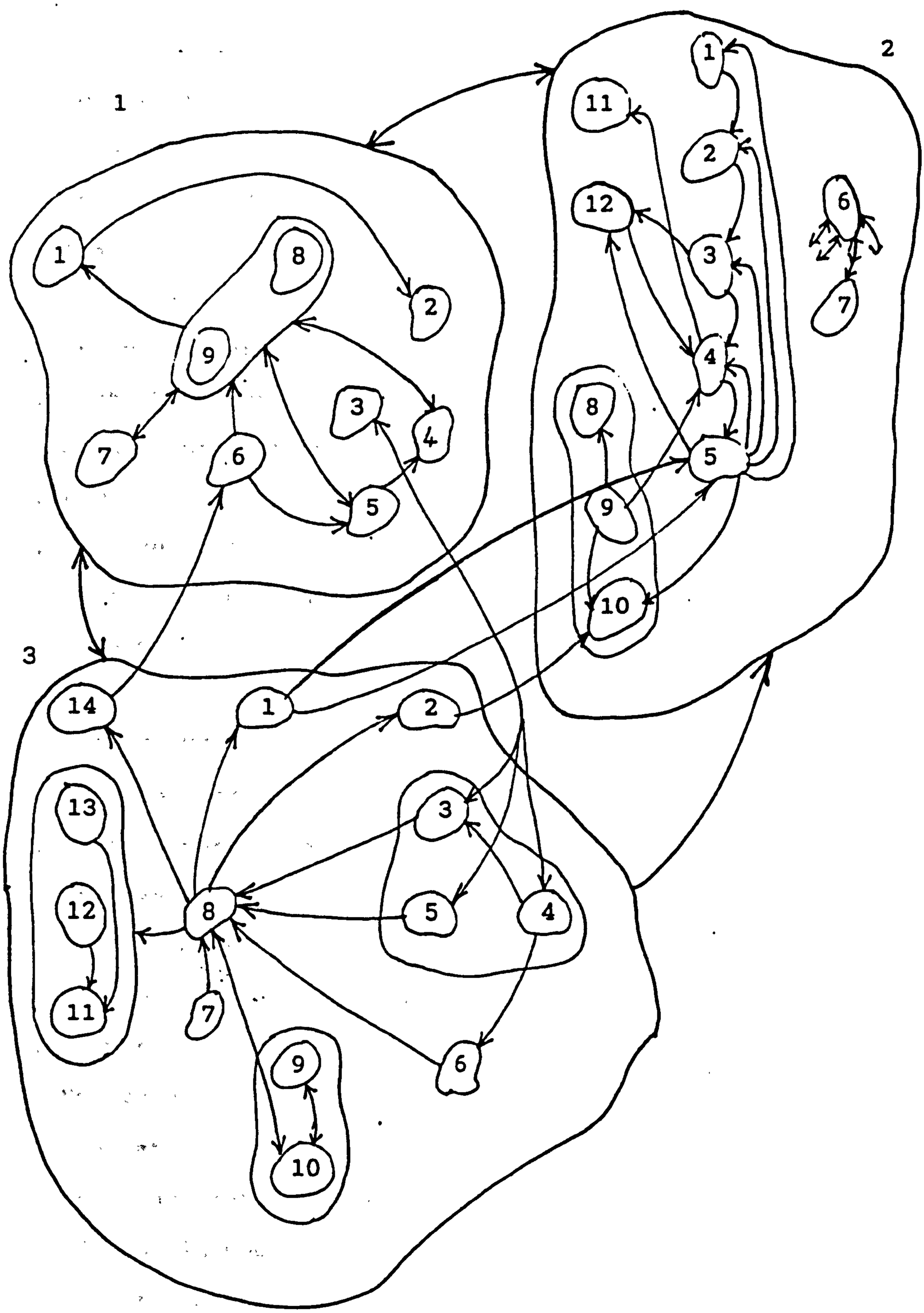

Figure 3.2.2 : Conceptual model level 2

included at level 2 analysis.

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1. UNDERSTAND ENERGY USE AND TECHNOLOGY

1. Train
2. Increase Awareness
3. Analyse information
4. Distribute information
5. Gather information
6. R&D
7. Provide information
8. Aggregate information on energy use
9. Develop data base

2. MANAGE ENERGY USE AND TECHNOLOGY

1. Measure energy use
2. Record energy use
3. Analyse energy use
4. Monitor energy use and new investments
5. Follow guidelines and legislation
6. Communicate with relevant people
7. Motivate people
8. Evaluate various technologies
9. Introduce optimum energy "mixes"
10. Invest in new technology
11. Control energy use
12. Set targets

Table 3.2.1: Continues to next page

3. IMPROVE ENERGY USE

1. Introduce guidelines for measuring, targeting and monitoring
2. Provide incentives for energy conservation
3. Monitor international developments on energy use and cost
4. Monitor energy use in industry and economy
5. Monitor energy cost in hotel industry
6. Evaluate benefits for industry and economy
7. Consider/monitor other benefits
8. Propose system changes
9. Establish responsibilities for energy conservation
10. Form policies on energy conservation and use
11. Introduce legislation and regulations
12. Propose legislation to control practising of related professions
13. Propose and canvas legislation and regulations related to energy use
14. Encourage R&D of relevant technology

Table 3.2.1 : Activities shown in conceptual model level 2

3.2.1 The comparison stage

The final conceptual model was set aside the real situation (as presented in the rich picture) in order to identify differences and similarities between the activities of the model and the real problem situation. Based on the results of the comparison stage the research proceeded to the next intermediate stage. This stage involved focussing on recommendations. Attention was drawn to recommendations that

were developed at a later stage. Every effort was taken so that recommendations would be both feasible and desirable. It is totally unnecessary to proceed with the development of recommendations that would be non feasible and even undesirable for the people concerned. This is the principal reason why extensive discussions with people concerned preceded the final write up of recommendations.

Furthermore, an additional stage defined as "guidelines for recommendations" was also included for each and every case. This stage was considered necessary in order to provide practical guidelines for the persons that would attempt to implement these recommendations. There are many real life cases in which the absence of this final stage constitutes a major obstacle to the implementation of recommendations. Though the stage is extremely important it does not necessarily have to appear as a separate one. Once the researcher is aware of the need of this stage he can (as in this research) incorporate the guidelines in his main body of recommendations.

All recommendations in this research project are the result of the systematic application of the soft systems methodology. The recommendations are presented in Chapter XIII.

3.3 A practical illustration of Soft Systems Methodology

In Appendix C selected conceptual models of various activities are presented. However, in order to demonstrate the application of the methodology in detail for all stages, an example activity was selected to serve as illustration.

The activity selected is the one named at conceptual model of level 2 as "Gather Information ". Figure 3.2.3 presents the conceptual model of level 3 for this activity.

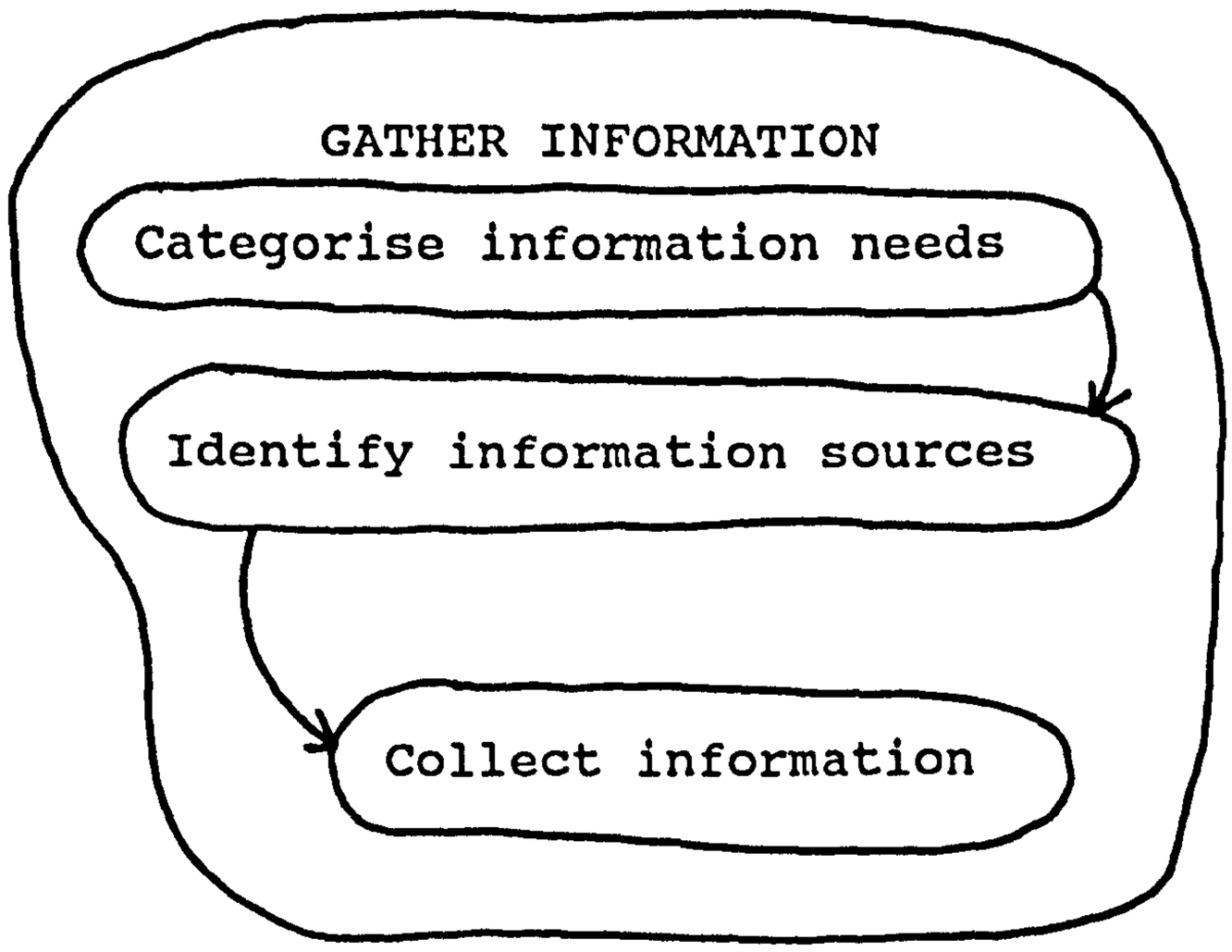

Figure 3.2.3 : Conceptual model of example activity "Gather Information (level 3)

Figure 3.2.4 presents a conceptual model of the same activity at level 4.

The description of the detailed application of SSM in this research proceeds with the comparison stage of one of the three main activities of the example activity shown in Figure 3.2.3. The comparison is shown below.

Letters S and D denote similarities and differences respectively between the conceptual model and the real situation.

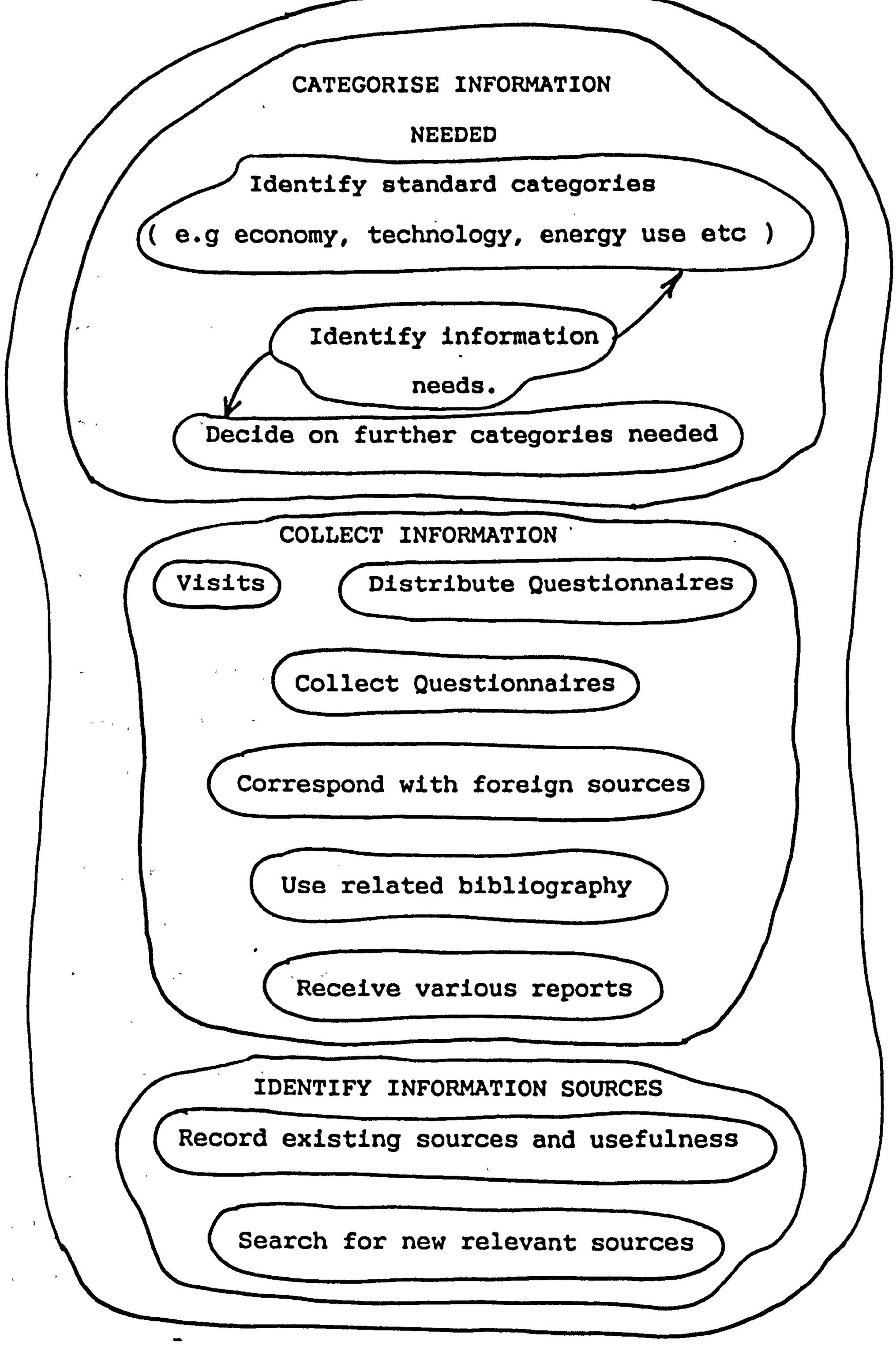

Figure 3.2.4 : Conceptual model of example activity "Gather information" - level 4

A. CATEGORISE INFORMATION NEEDS

1. **Activity: "Identify data needs"**

S: Current research considers such needs.

D: The need for further data, to provide the material for generating decision-making information, is highlighted.

2. **Activity: "Identify standard categories"**

S: The Department of Energy and the Department of Statistics do collect some information. The Department of Statistics collects data about imports of oil and the Department of Energy collects, through the EAC, information on consumption of electricity.

D: Presently there is no coherent and integrated collection of standard information on energy use and technology.

3. **Activity : " Decide on further categories needed "**

S : None

D : Presently there is no vehicle for information response to specific energy related problems which are new or "surprising".

Based on the above comparison between the conceptual model and the existing situation the following foci for action recommendations were drawn.

FOCI FOR RECOMMENDATIONS

A. Categorise information needed

There is a need to consider, coordinate and manage information and provide a vehicle for information response to

specific needs, including "new" situations.

B. Identify data needs (to "feed" the information requirements).

There is a need to search, record, assess and establish data sources.

C. Collect data

There is a need to establish information flows and links between interested parties.

Recommendations

The recommendations that were formed based on the foci for recommendations above were the following :

(A) Set up a centre for the management of energy related data so that information needs are comprehensively considered and coordinated.

(B) Establish a comprehensive set of data sources both locally and internationally.

(C) Establish data flows between interested parties with a new of increasing awareness and access to relevant information.

In order to assist the process of implementing the recommendations above certain guidelines, shown in the next pages, were developed.

Guidelines for the implementation of recommendations

1. Centre for the Management of Energy Related Data

It is envisaged that the only feasible Centre would be within the Energy Department of the Ministry of Commerce and Industry, in the absence of an energy specific initiative by the Hotel Industry itself (!). The major tasks of this Centre

should be :

(a) To consider information needed by all parties and develop a set of standard categories for regular data collection.

(b) To evaluate data already collected by individual bodies and consider the exchange and/or access of the resulting information.

(c) To provide a facility for information response to specific energy related problems.

2. Establishment of Data Sources

(a) Record all existing resources

(b) Assess the usefulness of data sources

(c) Search for new sources

(d) Establish regular sources of Data

3. Establish information flows

(a) Provide an official channel (via the Centre) to search for data and receive results data processing (information)

(b) Provide a comprehensive library facility with general access to books and journals on energy related subjects.

(c) Advertise the data and information resources and advise facilities available.

(d) Establish regular links with overseas experts and Centres of energy related research.

(e) Establish personal links and encourage information flows through regular visits.

(f) Set up written data flows through the distribution and collection of carefully focussed questionnaires.

CHAPTER IV

INVESTIGATING THE PROBLEM SITUATION (I)

4.1 Energy Audits

Energy auditing is a recent term and there is no single and precise definition for it. The term is used by some to define a specific activity and by others to encompass a wide range of activities in the accounting of energy usage (Watt Committee Report No 6, 1979).

Prior to the 1973 oil crisis some professionals had began developing techniques for the systematic examination of industrial and other energy intensive facilities with the aim of finding practical ways to reduce energy consumption (Turner, 1982).

The incentive was to save money on purchased fuel and electricity. According to Turner the term energy audit must have been introduced by some professionals at that period. It is further advocated that the term audit, is a mistaken and not very descriptive term with negative implications. The negative implications derive from the widely accepted fact that usually an audit takes place for the purpose of revealing cheating and dishonesty in a purely "historical" context.

Some alternative terminology could be "plant energy study" "energy utilization analysis", and "evaluation of energy conservation potential". Irrespective of the history and the connotations of the term "audit", once its managerial

objectives are appreciated and accepted by both the "auditor" and the energy user the whole process of improving the situation (in the systems management sense) has already been initiated".

In order to produce enough evidence of the "real world" situation, in the soft systems sense, with respect to energy use and management in the hotel sector, energy audits were performed in a sample of eight hotels. The process of selecting these hotels was explained in Chapter II.

The methodology recommended by the International Energy Agency (IEA), was used as a basis for all audits performed. According to IEA energy auditing is taken to "entail a series of actions aimed at the evaluation of the energy saving potential of a Hotel and the identification and evaluation of energy conservation opportunities".

The IEA approach has been considered the most appropriate for the complexities of the Hotel Industry because of its systemic philosophy and because it seeks to minimize the cost of auditing, maximise its effects and pass as quickly as possible to recommendations for energy saving measures. It was not possible during the energy auditing phase of this research to utilise sophisticated and expensive equipment. The audits were based on the use of the scientific and systems methodology, personal observations and first hand collected data. The collected data provide evidence for important conclusions regarding the behaviour of the system and

facilitated the formation of useful recommendations.

A hotel is a dynamic system and several factors need to be taken into consideration when attempting to perform a detailed audit. Variations occurring in various parts of the hotel, and occupancy differences and patterns, are some of the most important of these factors. In addition, there are the important factors of the quality of the human elements and their ability to conduct regular and proper "husbandry" of the various energy sub-systems present.

An energy audit can be considered as a process seeking the solution to a problem. The problem of achieving energy efficiency. Though formulae and instruments can not be a substitute for experience and knowledge, the evidence obtained in this research points to the fact that the effectiveness of the audit can be considerably improved if it is carried out systematically and if information is organised and used in a structural manner. There are various additional words supplementing the phrase "energy audit" and aiming at describing the type of audit concerned. For example, the term "walk through audit" used quite extensively is employed to describe a relatively brief audit carried out during a cursory examination of a building.

This is not the type of audit performed in this research project. The eight hotels audited were visited repeatedly during all seasons and at different times of the day. This was necessary because of the need to establish correct quality,

quantity and timing of use patterns for each individual hotel. In general, audits can be characterized by three major characteristics: The level of detail, the scope and the focus of the audit. Focus refers to the different depth and purposes set up to be examined during the audit.

For example, audits addressing the needs of national or community energy planning will have a different purpose than audits addressing the goal of reducing energy consumption on a hotel by hotel basis. The level of detail is closely associated with the focus of an audit. In this sense different purposes demand different level of detail. Scope refers to the number of aspects of energy use addressed. Audits often address a limited number of aspects of energy user (building, industry etc). It is often common for an audit to concentrate on one or two aspects of a building but encompass a large number of buildings. The focus of this research has been to acquire enough evidence on the Quality, Quantity and Timing of energy demand (QQT).

A further step involved the evaluation of the data in conjunction with other data obtained with other research tools within the context of the systemic analysis (such as questionnaires). All audits addressed almost every aspect of energy use in each hotel audited. The level of detail of the 8 audits has been quite high and included personal observations and detailed data collection on a yearly, monthly, and hourly basis.

The design, the material used, and the equipment utilised in a hotel are some criteria that normally would have to be evaluated before including a hotel in the sample. However, in the context of this research this task appeared to present several problems.

The most important of these problems were the following:

(a) There was lack of previous energy performance data for all hotels. Because of the absence of these data no comparison could be made between hotels with respect to their energy efficiency (and thus the sample may include those performing poorly).

(b) There was no coordinated data base on the design, material and equipment used by the hotel industry.

(c) There was a necessity to carry out the audits simultaneously with other phases of the research as a matter of time efficiency of the overall project.

Because of the reasons listed above all hotels audited were chosen based only on the parameters mentioned earlier (see Chapter II) i.e. size, location, type of business performed, willingness of the management to cooperate.

An effort to rate hotels with respect to their energy efficiency will certainly facilitate future selection of hotels for auditing purposes.

One method that could be used for this purpose is the method of "energy indicator". An energy indicator is simply the number obtained when the total energy consumption in a certain period (usually a year) is divided by one or more normalisation factors. These factors can be the conditioned floor area, the volume, or any other geometrical feature. Indicators will then have to be compared to reference values that would define the "acceptable" performance for the various types of hotels.

The energy rating of a hotel can also be made on a cost basis. The amount of money that can be saved through energy conservation can be calculated by subtracting the cost of actual energy consumption from the corresponding cost of targeted energy consumption. It must be emphasised that energy indicators will have a certain value as long as proper care will be taken to consider that only hotels belonging to the same category with respect to function, mode of operation, age, geographic location, will be compared. Energy consumption can also be normalised with respect to occupancy.

4.1.1 Disaggregation and energy cost centres

Disaggregation is a very important stage of the energy auditing process. This stage is valuable because it provides the means for concentrating the efforts to the meaningful and important energy consuming centres of each hotel. In addition, dissagregation can also serve as a simple energy model which can be quite useful when evaluating energy conservation opportunities. It can also be used for the verification of the

results of various theoretical calculations and models.

One of the best ways of presenting dissagregation results is through the use of a so called Sankey diagram. The easiness of their construction and the quality of the visual feeling of the energy situation they provide are their main advantages (see Figures 4.2.4 and 4.2.5).

Depending on the extend of the audit and the complexity of a hotel, the level of detail of dissagregation of energy use can vary from the analysis of only a very few energy utilising components to a quite extensive analysis. Examples of these components are: space heating with all related losses, ventilation, infiltration, conduction and humidification, fan energy for heating and cooling separately, exhaust system, pump energy, lighting, space heating (with all related gains, losses and loads), various other equipment and machinery such as elevators, laundry, kitchen equipment etc. It was not the intention of the majority of the audits of this research to proceed into an analysis of such extend. However in two of the hotels audited an analysis of considerable depth was performed.

Disaggregation is usually (as it has been the case during this research) a very interactive process. As more refined data became available, the process was repeated until a balance between individual components and equipment and overall consumption was established.

Some of the sources that provided data during the audit phase of the research were: utility records, plant and building drawings and specifications, on site observations and personal discussions. The value of the personal discussions and observations can not be over emphasised. In this research, extremely valuable information was obtained from both casual and planned discussions with concerned hotel staff at all levels.

Although, as mentioned earlier, the level of dissagregation can vary considerably (very simple to very elaborate) the evidence of this research points to the fact that simple dissagregation backed up by considerable input from personal observations and discussions can produce results quite comparable to those obtained by other sophisticated methods. The use of simple graphs drawn by the utilisation of data easily available was extremely useful in obtaining a comprehensive visual understanding of the situation. However, several problems were faced in some of the audits of this research. Some of the problems arose from the fact that the same system was used for both space heating and for the heating of water for domestic use. Variations of occupancy and pattern of use between Summer and Winter were also the cause of dissagregation problems.

4.1.2 An audit procedure plan

A recommended procedure plan for performing energy audits based on the recommendations of the IEA is presented in Table 4.1.1.

This plan was only used as a guide to the execution of the audits rather than followed precisely. The reason is that the auditing process in the content of this research was only a means of appreciating the "real world situation". In this sense several stages of the procedure plan (e.g conclusions etc) were the object of other parts of the research.

In stage 1 the auditor obtains from technical literature a list of opportunities applicable to similar type of buildings with the hotel to be audited. The auditor will most probably be in a position to add other opportunities deriving from his own experience.

During stage 2 several measures on the list obtained may have to be deleted as being not applicable to the particular case. The decision to discard any of these measures will be mainly based on background information (e.g low projected savings), differences between the type of system of hotel examined and the system used as a reference in the list of stage 1 and specific reasons imposed by the owner of the hotel or the auditor (not withstanding potential benefits of the measure).

Energy saving opportunities that are not discarded are set up during stage 3 in the three categories shown in Table 4.1.1 (3a, 3b, 3c). It is very important to note that classification of the various opportunities in this stage is done using readily available data and observations from a very preliminary audit. Detailed in-depth analysis is only

performed for opportunities included in stage 3c.

During stage 4 the auditor proceeds to detailed measuring and collection of all necessary data regarding the efficiency, suitability and cost of proposed investments. The data required in stages 5 and 6 include :

(a) Method of securing capital

(b) Interest rates, inflation rates and depreciation rates.

(c) Investment and other special tax allowances. The output of this analysis is the Net Present Value (NPV) and Internal Rate of Return (IRR) of each candidate investment.

There are various factors that need special consideration when attempting to rank opportunities according to their potential value. For example, it is always necessary to investigate whether the management of a certain hotel has its own threshold values for investments. A promising measure in the eyes of the researcher does not always appear as promising to the eyes of hotel the management. Difficulties in implementing/adopting a certain technology is another crucial factor to be considered in stage 6. Though a technology may be financially and technically sound there may be problems when an attempt is being made to adopt it.

Lack of expertise, lack of capabilities to perform proper maintenance, lack of qualified personnel, and unwillingness of personnel to cooperate in the adoption of the specific

technology are some of these problems. Problems of this sort were discussed in relation to replication potential of energy conserving technologies by U.K. breweries (Fawkes and Jacques, 1987).

Stage 7 is the stage proceeding the strategic implementation plan. Overall plans of hotels, policies, budget and other limitations, alternative actions, combinations and interactions of various proposals must be taken into consideration during this stage. No final proposals for specific investments can be made without prior discussion with the owner and manager of the hotel concerned.

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1. From a relevant source obtain a list of energy saving opportunities for similar buildings.
2. Discard opportunities not applicable for specific hotel.
3. From readily available data and preliminary analysis sort remaining opportunities to following three groups.
   (a) Opportunities to be implemented immediately (usually operational or minor maintenance)
   (b) Opportunities to implement without further evaluation (mainly maintenance and small works)
   (c) Promising opportunities requiring further evaluation (mainly equipment, building modification or replacements)
4. Proceed with detailed audit and evaluation of promising opportunities in stage 3 c above.
5. Gather related financial data and proceed to detailed cost effective analysis.
6. Consider specific factors (i.e accepted investment criteria, suitability of technology) and rank opportunities according to their potential value.
7. Discuss with hotel owners: company overall plans, policies, budget limitations, choise of alternatives, combinations and interactions of proposed investments.
8. Cooperate with hotel owner, and manager and chief engineer on implementation of strategy plan showing time of implementation of each proposed measure.

Table 4.1.1: Proposed procedure plan for performing energy audits (based on IEA recommendations).

4.2 Discussion of the findings

The results of one of the detailed audits performed are presented in detail in this Chapter in order to demonstrate the methodology employed. The major findings of the rest of the audits are presented in condensed form, in Appendix D.

Detailed discounted cash flow analysis that would provide information on the viability of energy conservation opportunities was performed only for those representative technologies with wider applicability. In all of these cases a description of the technologies examined is also presented (see Chapter VIII).

It was not the intention of this work to substitute a fully instrument supported audit that would normally be undertaken by a professional engineering team with more limited systemic objectives.

The purpose of the audits was rather to obtain insight valuable information that would assist in two important respects :

(a) Assist in appreciating the "real world" situation in the soft systems sense of the methodology employed in this research.

(b) Provide the supporting background knowledge required for the recommendations stage that were made following the comparison stage between the "real world" and the conceptual models developed.

In this sense the remarks and information obtained from the audits of this research are not necessary similar to those of typical engineering audits of buildings.

4.2.1 Description of the detailed energy audit in Hotel A

Hotel A is a three star beach hotel located in one of the touristic cities of the island. The main volume of its tourists originates from the United Kingdom and it enjoys a very good occupancy (see Figure 4.2.3).

The hotel was built in 1982 and in its 114 rooms it can accommodate 228 guests. The hotel is run by one of the major hotel operators on the island, operating nine other hotels and tourist apartments.

The management of the hotel is quite progressive and the manager is very sensitive on the issue of energy management.

The three-person staff of the maintenance department is responsible for the hotel gardens and all other property as well.

There is no permanent chief engineer in the hotel. The task is undertaken by the chief engineer of the hotel operating company who is also responsible for the maintenance of the other nine hotels and tourist apartments. The chief engineer visits the hotel at least once a week and he is, according to his claims, in constant communication with his staff on the hotel to which he gives the necessary directions

according to needs. The chief engineer is a holder of a University degree in Mechanical Engineering with five years experience.

The hotel is of rectangular shape and consists of a basement, a ground floor and six typical floors. The front view (entrance) orientation is towards south east.
The basement includes the plant room the store rooms, two cold rooms and a staff room. The reception area, a bar a living room, a dining room and the management's office are located in the ground floor. The six typical floors consist of 19 rooms each. The area of each room is approximately 22 sq.m.
A veranda of approximately 3 sq.m for each room is also provided.

The building envelope is made of concrete frame structure with thick plastered brick walls. External doors and windows are made of 4 mm thick single glazing.

The glazed portion of the building is approximately 40% of the wall area. Most of the glazed area faces towards. Summer shading is provided through internal curtains (unfortunately short enough to enable considerable amount of sun penetration during Summer!).

4.2.2 <u>The energy scene</u>

In order to evaluate the energy situation in the hotel several visits at various times of the day and during all seasons were performed. A brief description of the most

important findings of these visits is given below.

The building is fully air conditioned, and therefore both heating and cooling is provided. Besides the rooms all common areas are also air conditioned. The common areas are served through several air handling units and each room is equipped with its own individual fan coil.

Two air cooled chillers, of a capacity of 120 kW each, mounted on the roof, provide the cooling during the Summer period. As it was observed, the two chillers share the working load on a daily basis by operating several hours independently (one on duty and the other on stand by mode).

Heating is provided by two oil fired operated boilers. According to observations made during various times of the day in the plant room the two boilers operate simultaneously for a considerable amount of time in order to satisfy the heating load of the winter period.

The boilers supplement the heating required for the hot water needs as well. Each of the hot water boilers is rated at 400 kW and heat the water supplying the fan coils and the air handling units to 60 degrees Centigrade.

The hot water needs, at an estimated 85%, are satisfied by a solar hot water system installed on the roof of the hotel. The area of the solar panels installed on the roof is 138 sq.m. (74 panels each of 1.86 sq.m).

LPG (liquified petroleum gas) is the fuel utilised for the satisfaction of the cooking needs of the hotel. This fuel is used for the operation of the various cookers, ovens, grills etc in the kitchen.

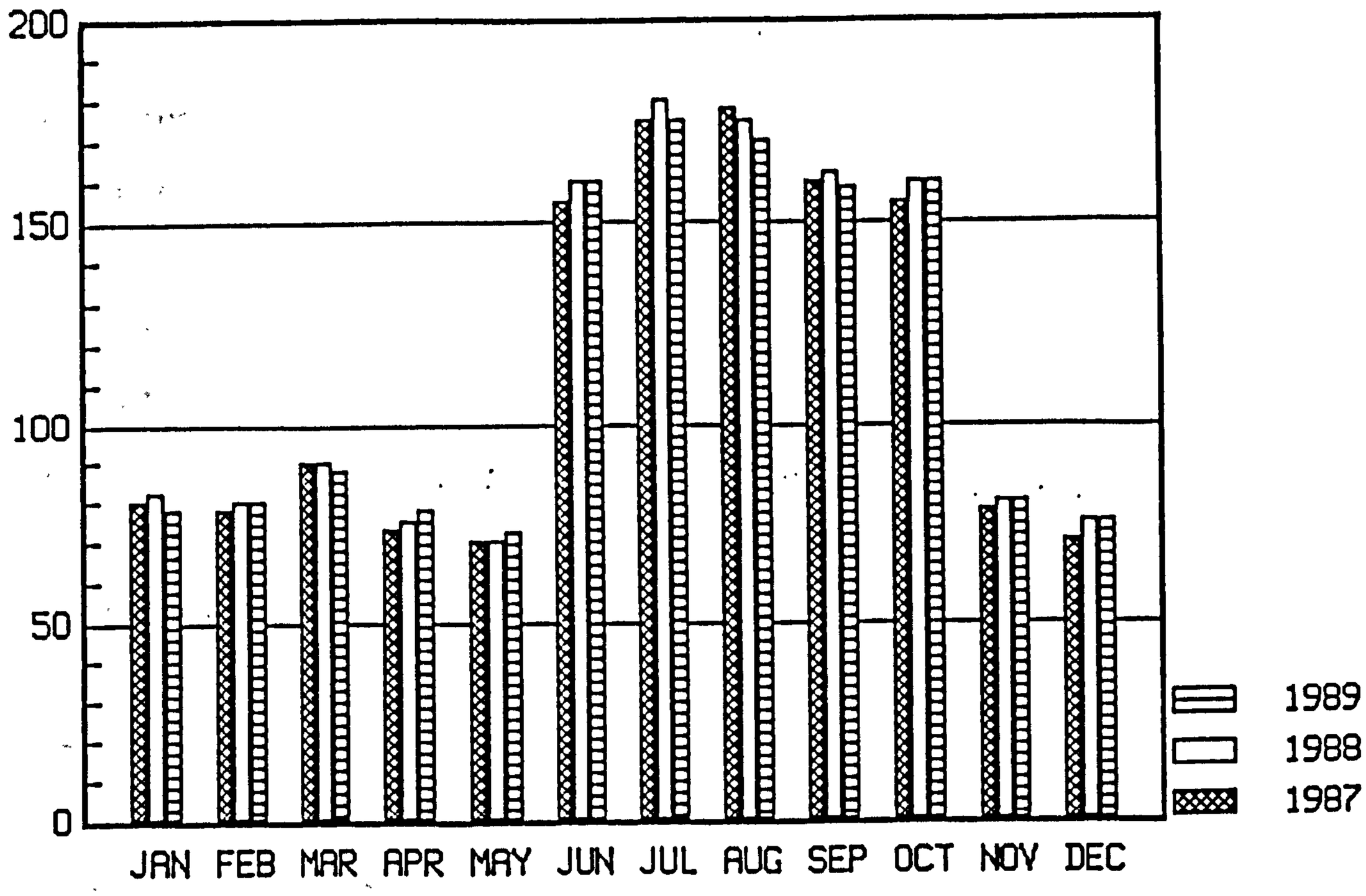
Unfortunately, as is the case for the vast majority of the hotels in Cyprus, there were no monthly consumption records of either the gasoil or the LPG. It was therefore very difficult to establish the exact percentage of the gas oil actually used for heating. However delivery records and cost records were available from which useful estimations were made.

The analysis of the electricity usage was relatively easier (at least at the monthly level) since detailed consumption data were available.

The monthly variation of electricity consumption and maximum electrical demand for the years 1987-1989 are presented in Figures 4.2.1 and 4.2.2 respectively. The occupancy for the same period is shown in Figure 4.2.3.

Analysis of similar data for other hotels shows that Figure 4.2.1 is a typical curve of electricity consumption for hotels in Cyprus. The major characteristic of this typical curve is its normal distribution shape and the rise of consumption that starts in the month of June, peaks in the month of August and reduces again in September and October.

The maximum demand curve (Figure 4.2.2) is also of typical



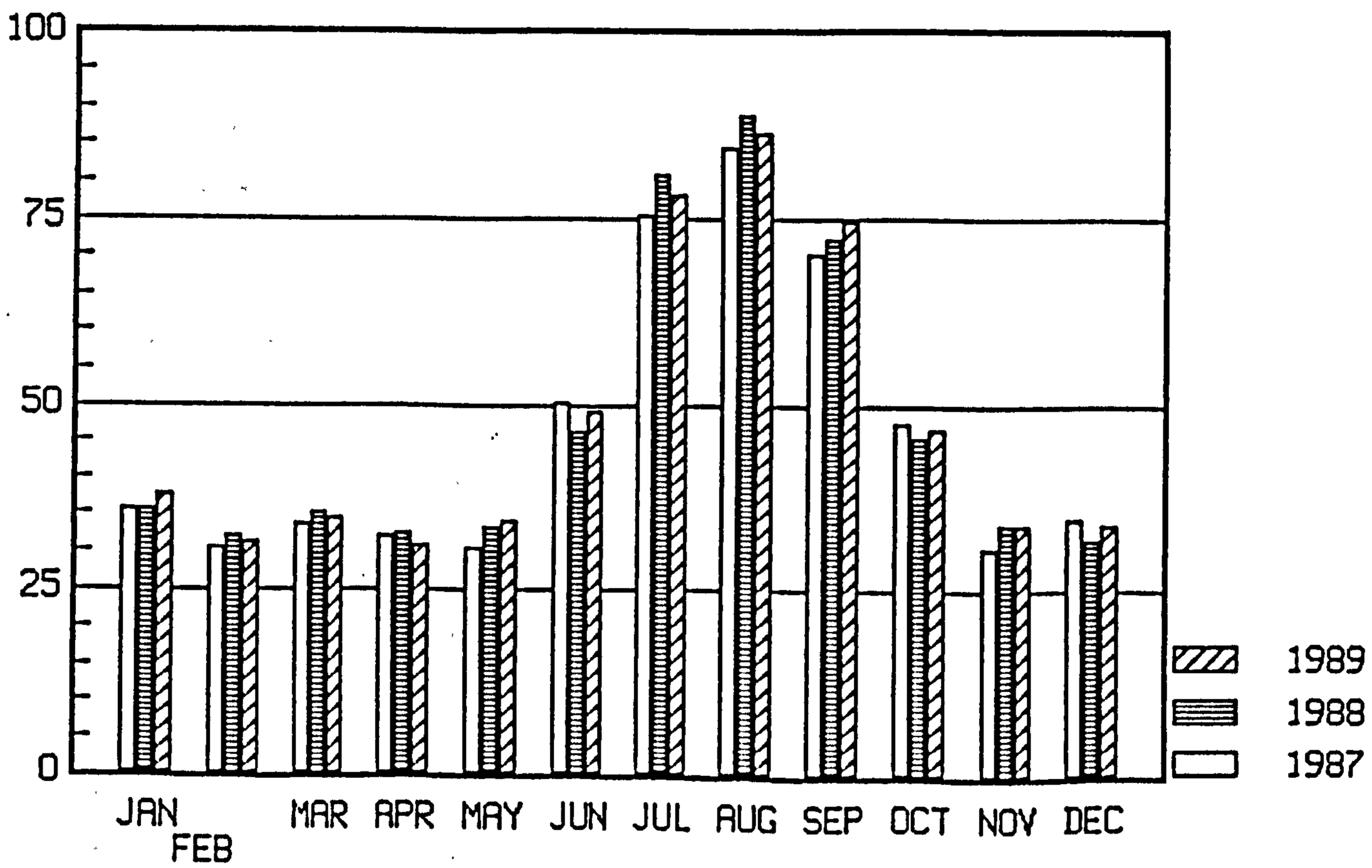


Figure 4.2.1 (below): Monthly variation of maximum demand for Hotel A (kVA)

Figure 4.2.2 (above): Monthly variation of electricity consumption for Hotel A (MWh)

shape and shows that once the air conditioning system is set on (June to October) the maximum demand rises dramatically.

The occupancy figures presented in Figure 4.2.3 are also typical of the occupancy figures pertaining in hotels of the particular area. A detailed analysis of correlations among electricity and other energy related parameters is presented in Chapter VII.

There are several factors that affect the shape of the electricity consumption and maximum demand curves. These factors are in fact much more significant than occupancy. and include the variation in the mode of operation of the air conditioning system during the summer period. The 1989 energy bill of the hotel amounted to 29500 Cyprus pounds. This cost was divided as follows :

(a) Electricity : 22000 Cyprus pounds (74.5%)

(b) Gas oil : 6000 Cyprus pounds (20%)

(c) LPG : 1500 Cyprus pounds (5%)

With respect to the total energy used in the hotel (in GJ) the percentages presented below are representative.

(a) Electricity :40%

(b) Gas oil :45%

(c) LPG :15%

In an effort to identify the percentage of electricity consumption by the various electricity consumption equipment

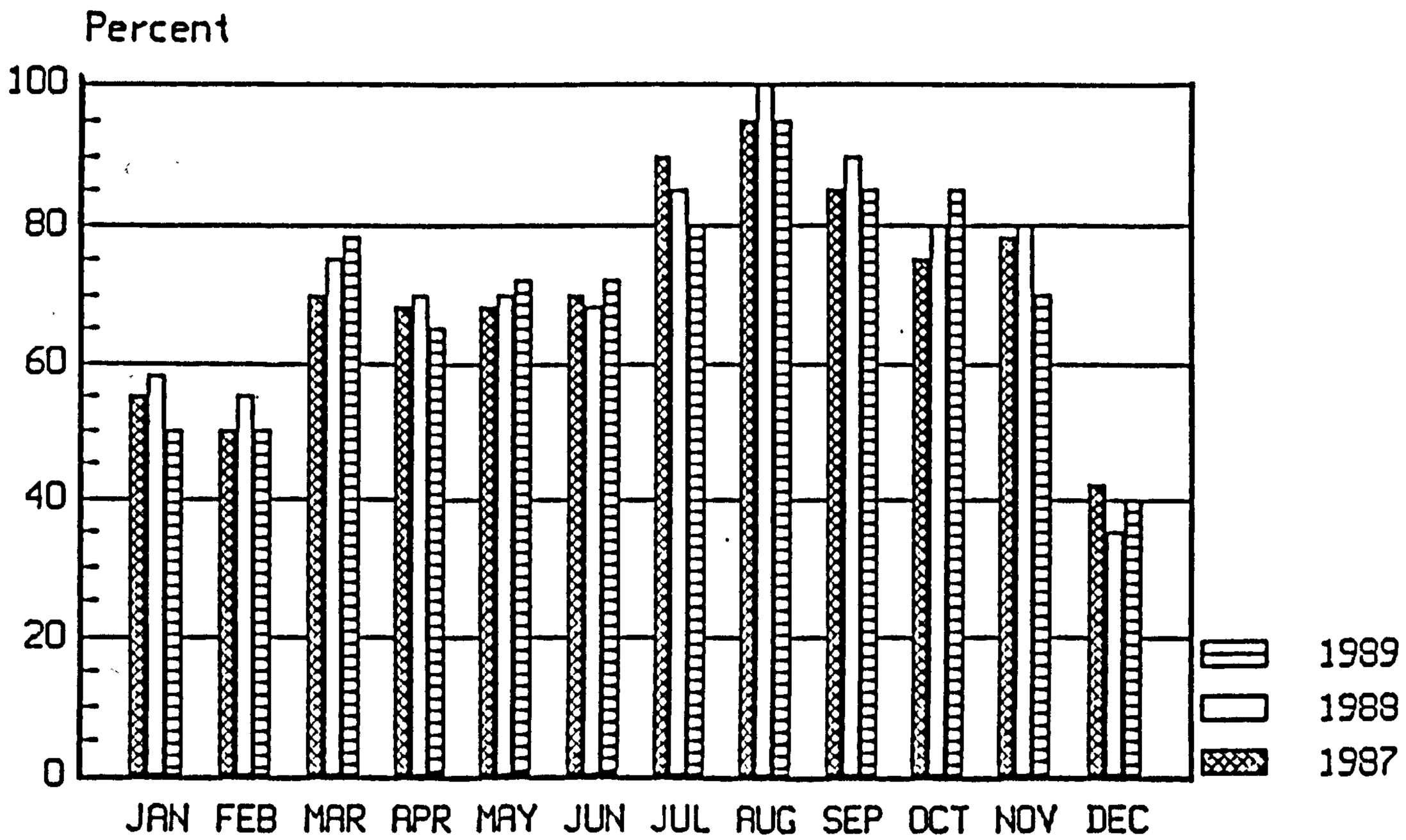


Figure 4.2.3: Room occupancy for Hotel A

with respect to both cost and energy, an analysis was performed. This was considered appropriate because of the extreme importance of electricity both as a cost (as proved by the data presented above) and as an energy resource.

The electricity analysis necessitated a detailed survey for the production of a list of all electrically driven equipment, their capacity and the number of hours the are operated per year. Extensive observations and discussions were required in order to achieve this task that produced very interesting results.

Established daily figures were integrated in order to arrive to monthly, seasonal and annual figures.

Table 4.2.1 presents a list of the major electricity consuming equipment of Hotel A, their rating, and the estimated period of operation (based on personal observations and discussions with hotels staff). Utilising this data and an average electricity cost per unit the related consumption and the cost for each case were calculated. An estimated load factor was used for each individual equipment. Lighting fixtures are not included in this table.

Table 4.2.2 presents information regarding the type, the numbers installed, the estimated hours of operation and the electricity consumption of each lighting fixture.

Figures 4.2.4 and 4.2.5 present the so called Sankey

Equipment	Rating (kW)	Number	Hours	Days	Load Factor	Total (kWh/year)
Circulators	1.1	1	24	365	0.60	5782
Press. set	5.7	2	24	365	0.07	6990
Solar circ.	1.5	1	8	300	1.00	3600
H.W Circul.	1.1	2	24	365	1.00	19272
Burner	0.4	2	24	365	0.25	1752
Heating Pump	4.1	1	11	150	1.00	6765
Heating AHU	0.75	3	11	150	1.00	3712
Chiller	68	1	18	150	0.75	137700
Chiller Pump	5.5	1	18	150	1.00	14850
Cooling AHU	0.75	3	8	150	1.00	2700
Dish Washer	12	1	4	180	0.80	3072
Refrigerator	0.4	2	24	180	0.25	864
Coffee mach.	2	1	8	180	0.35	1008
Toaster	1.5	1	8	180	0.50	1080
Refrigerator	0.15	1	24	180	0.25	162
Ice machine	3	1	8	365	0.25	2190
Coffee mach.	1	1	24	365	0.35	3066
Blower	3	1	24	365	1.00	4680
Pumps	0.35	1	24	365	1.00	3066
A/C Units	1.6	2	15	180	0.75	6480
Equipment	0.5	1	24	365	0.20	876
Fan Coils	0.12	120	6	150	0.55	7128
Fan Coils	0.07	108	6	150	0.80	5443
Cofee maker	3	1	8	365	0.35	3066
Ice machine	1	1	24	365	0.25	2190
Circulators	3.5	1	24	340	1.00	28560
Guest Lift	12	2	24	365	0.15	31536
Staff Lift	12	2	24	365	0.15	31536
Exhaust Fans	0.15	10	6	340	1.00	3060
Fan	4.5	1	4	365	0.80	5256
Mixer	0.75	1	2	365	1.00	547
Potato peeler	0.75	1	1	365	1.00	273
Veget. Slicer	0.5	1	2	365	1.00	365
Coffee mach.	7	1	18	365	0.40	18396
Dish Washer	13	1	10	180	0.80	18720
Microwave	0.65	1	2	365	0.65	308
Toaster	3	1	4	365	0.50	2190
Refrigerators	0.25	3	24	365	0.25	1642
Sandwich mach.	3	1	5	365	0.75	4106
Dish Dryer	2	1	3	200	0.80	960
Refrigerators	0.25	3	24	365	0.25	1642
Electric Oven	12	1	6	365	0.50	13140
Refrigerator	0.25	1	24	365	0.25	547
Mixer	0.5	1	1	365	1.00	182
Mincing mach.	0.5	1	2	60	1.00	60
Meat tender.	0.15	1	1	60	1.00	9
Total	:					386701

Table 4.2.1: Electricity consuming equipment in Hotel A

Place	Type	Rating (W)	Number	Hours Operated	Total (kWh/year)
Balcony	B	40	60	4	3504
Rooms	B	40	570	5	41610
Service	C	9	12	12	473
Roof	B	400	1	2	292
Pool	B	40	19	2	555
Pool	A	52	3	2	312
Pool	C	9	14	2	252
Pool	D	300	3	2	567
Pool	B	40	7	2	204
Corridor	B	40	12	7	1226
Parking	C	9	17	7	390
Corridor	A	40	15	7	1533
Basement	A	52	12	9	2050
Kitchen	A	52	4	22	1670
Kitchen	A	84	12	16	5887
Restaurant	A	9	60	7	1380
Lobby	C	9	27	9	798
Reception	C	9	13	22	940
Bar	C	9	56	9	1656
Dining R.	B	40	40	3	1752
Staircase	B	60	15	2	657
Toilet	A	84	7	24	2207
Toilet	B	40	8	24	2803
Corridor	A	25	114	24	24966
Total	:				97684

Table 4.2.2 Lighting fixtures details of Hotel A.

Note

Type A: Florescent Lamp
Type B: Filament Lamp
Type C: Energy Efficient Lamp
Type D: Tungsten Lamp

Diagrams for the energy cost and the energy used respectively. These figures include all forms of energy used in Hotel A (gas oil, electricity and LPG) and are based on 1989 values for both energy consumption and cost .

Though most values presented in this thesis are based on approximate calculations it is believed that the information derived is well within reasonable accuracy limits and thus conclusions and recommendations based on them can be considered quite reliable. This is made clear by comparing the estimated electricity consumption of electrical equipment and lighting fixtures (see Tables 4.2.1 and 4.2.1) with the actual annual electricity consumption (see Figure 4.2.5). Estimated electricity consumption is only 10% lower than the average actual consumption.

Hourly energy consumption

In order to identify possible energy saving opportunities and malfunctions of the energy supply system and appreciate the energy demand it is extremely important to appreciate the energy consumption on an hourly basis for "typical" winter and summer conditions.

For example an unusually high electricity consumption at a specific time may lead to an investigation of the situation with possible findings of unnecessary equipment operation.

In order to obtain reliable data of such accuracy it is necessary to utilise sophisticated electricity and gasoil

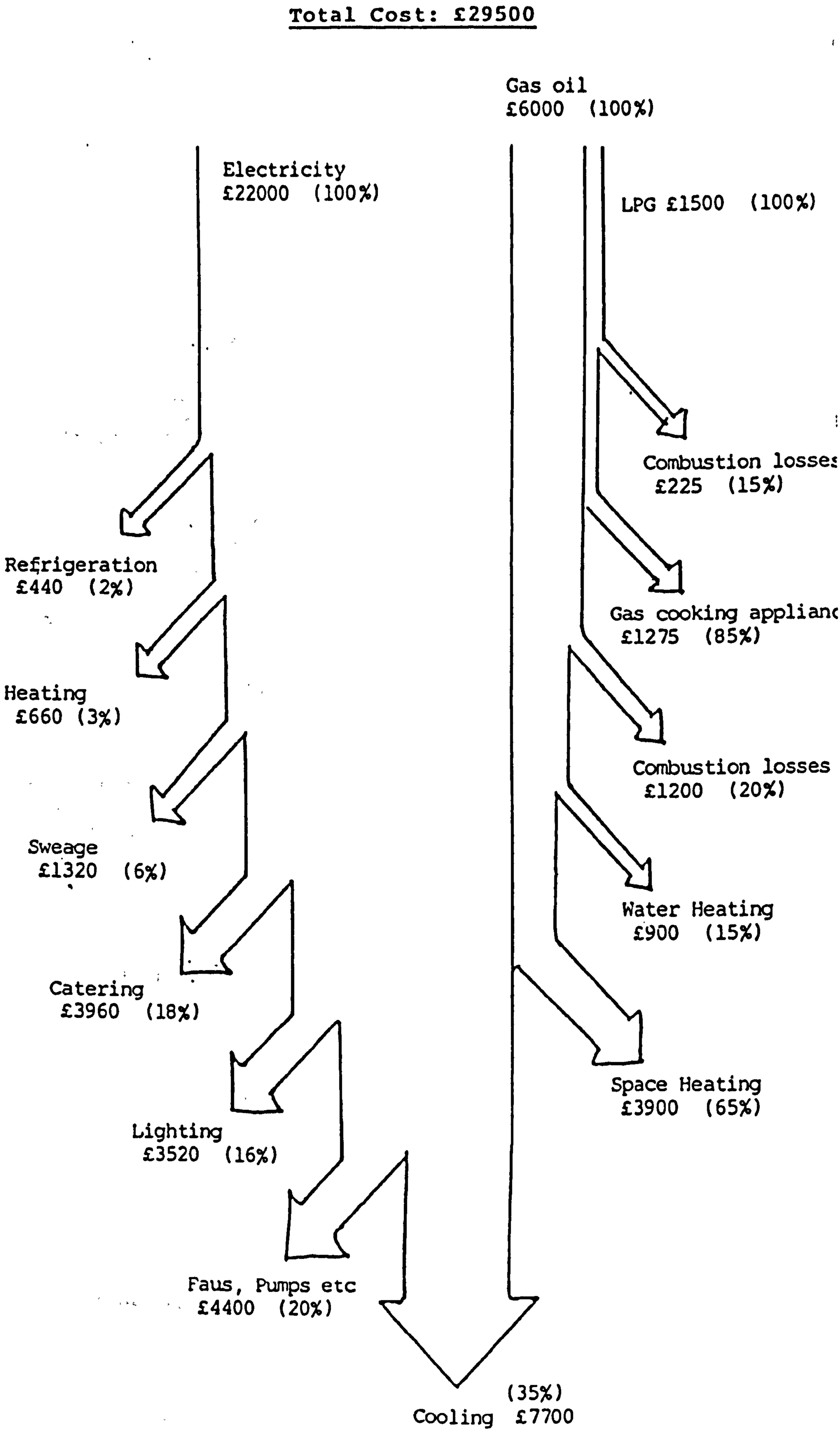


Figure 4.2.4: Sankey Diagram for Hotel A - Energy Cost

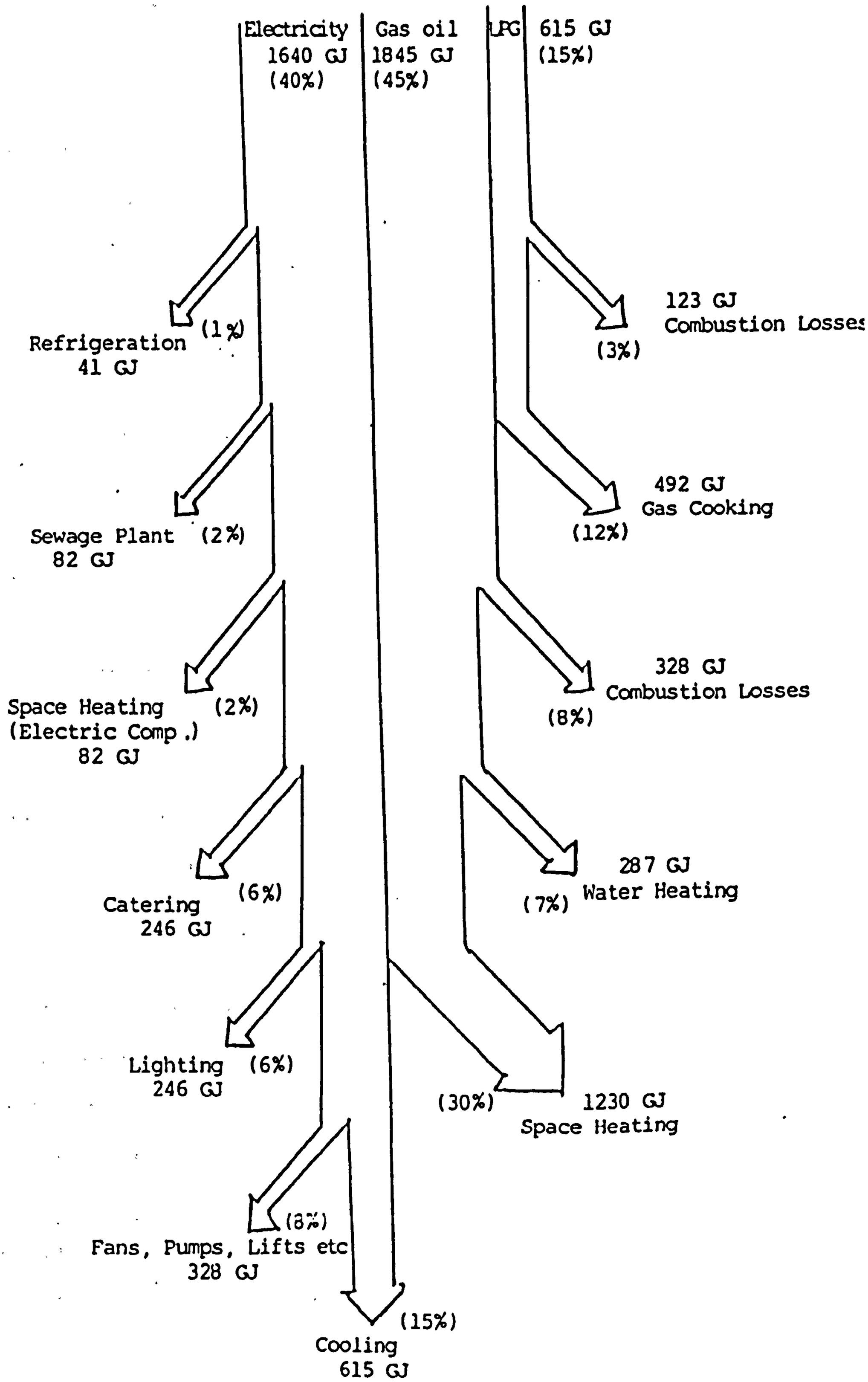


Figure 4.2.5: Sankey Diagram for Hotel A - Energy Use

metering devises that will monitor consumption continuously. This however was neither the case nor the intent of this research. The purpose of the investigation was to draw approximate but useful and usable conclusions by observations that would require the minimum of sophistication with respect to the hardware employed.

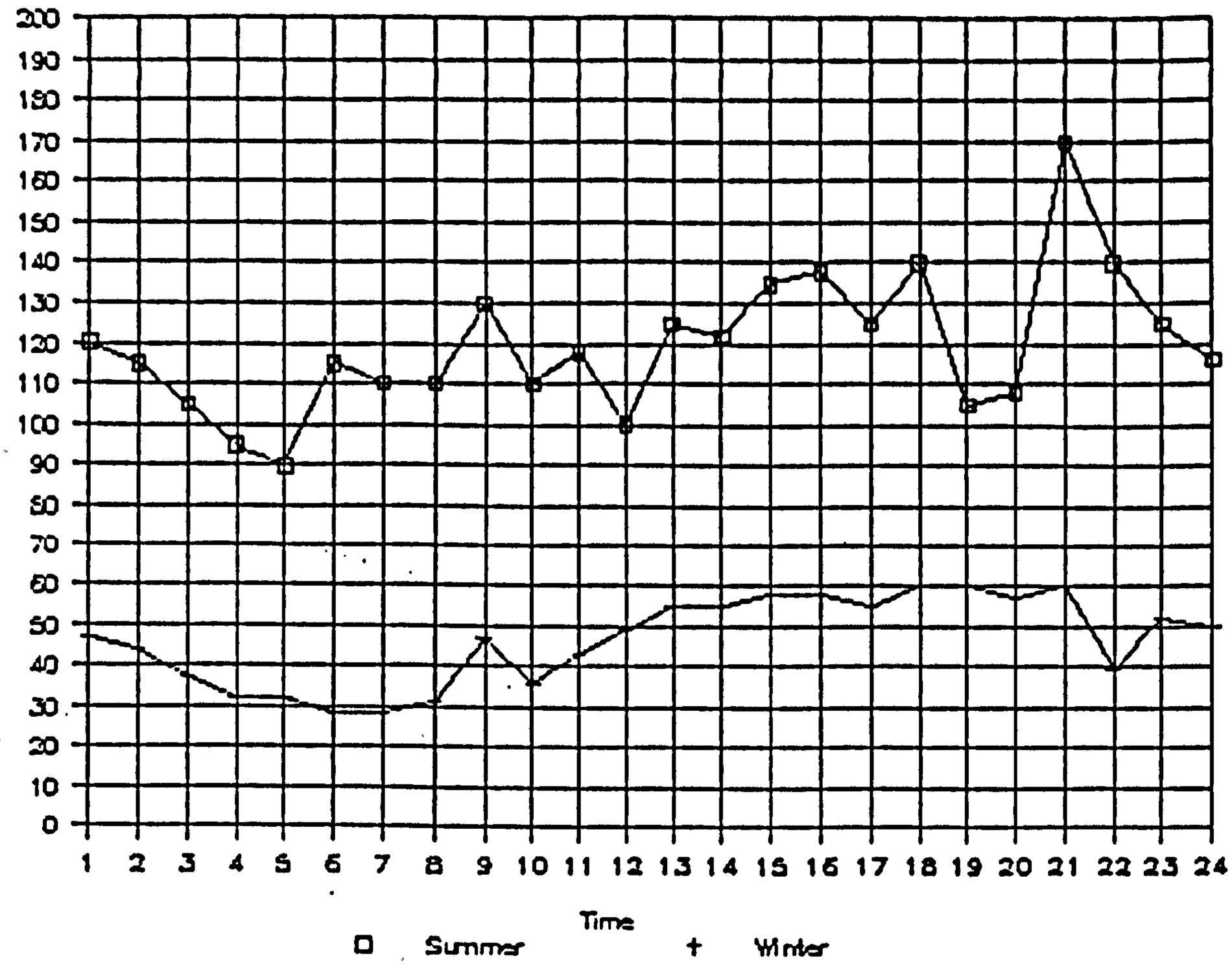
Two "typical" seasons were identified as Summer and Winter and data of three (non consecutive) days of electricity and gas oil consumption were collected on an hourly basis.

The electricity consumption was monitored by monitoring the electricity meter whereas the gas oil consumption was monitored by the time of operation of the boiler and its specific consumption provided by the manufacturers catalogues.

While no absolute accuracy is claimed, it is believed that the average consumption of those typical Summer (August) and Winter (January) days is quite representative and indicative of the existing situation.

Figure 4.2.6 presents the results of the three day average hourly electricity consumption for hotel A and Figure 4.2.7 presents the hourly average gas oil consumption. The average hourly temperature at those days are shown in Figure 4.2.8.

The hotel utilises a solar hot water system and the demand on the boilers in the Summer (August) is very small. It is therefore very extraordinary for the boilers to operate during



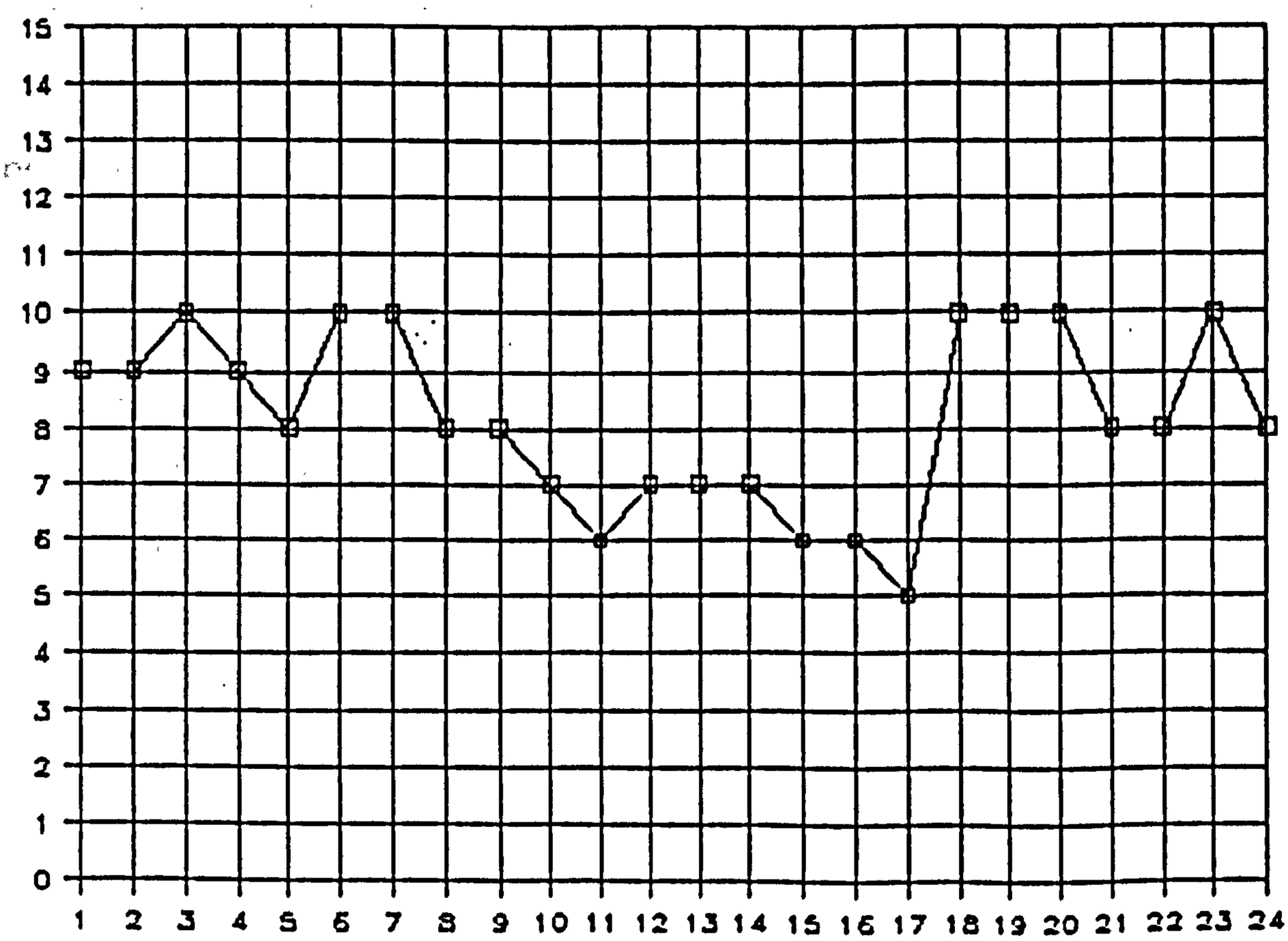


Figure 4.2.6 (above): Hourly electricity consumption for Hotel A (kWh)

Figure 4.2.7 (below): Hourly gasoil consumption for Hotel A (litres)

this month. Therefore no Summer data were collected for the hourly gas oil consumption.

It is worth noting in Figure 4.2.6 that the minimum consumption occurs at 6.00 a.m and the maximum at 9.00 p.m.

The Summer maximum consumption at the above time (9.00 p.m) can be attributed to the reasons listed below whereas the minimum (at 6.00 a.m) to the opposite reasons.

(a) Most of the hotel guests are occupying their rooms during this early (for Cyprus) part of the evening and therefore all room air conditioning facilities are utilised.

(b) Hotel lighting comes at this time

(c) Kitchens, dining rooms and various functions are at their peak during this time.

4.2.3 The "timing" of energy demand

This section focuses on the importance of the concept of "timing" of energy demand. Following a brief reference to the opportunities for energy savings (mostly electricity) an illustration of the idea of shifting loads from the peak demand period in the case of sample Hotel A is made.

The importance of quality, quantity and timing of energy demand (QQT) has been emphasized several times in this thesis (Jacques, Lesourd and Ruiz, 1988). Operating equipment longer than actually required and heating water at higher

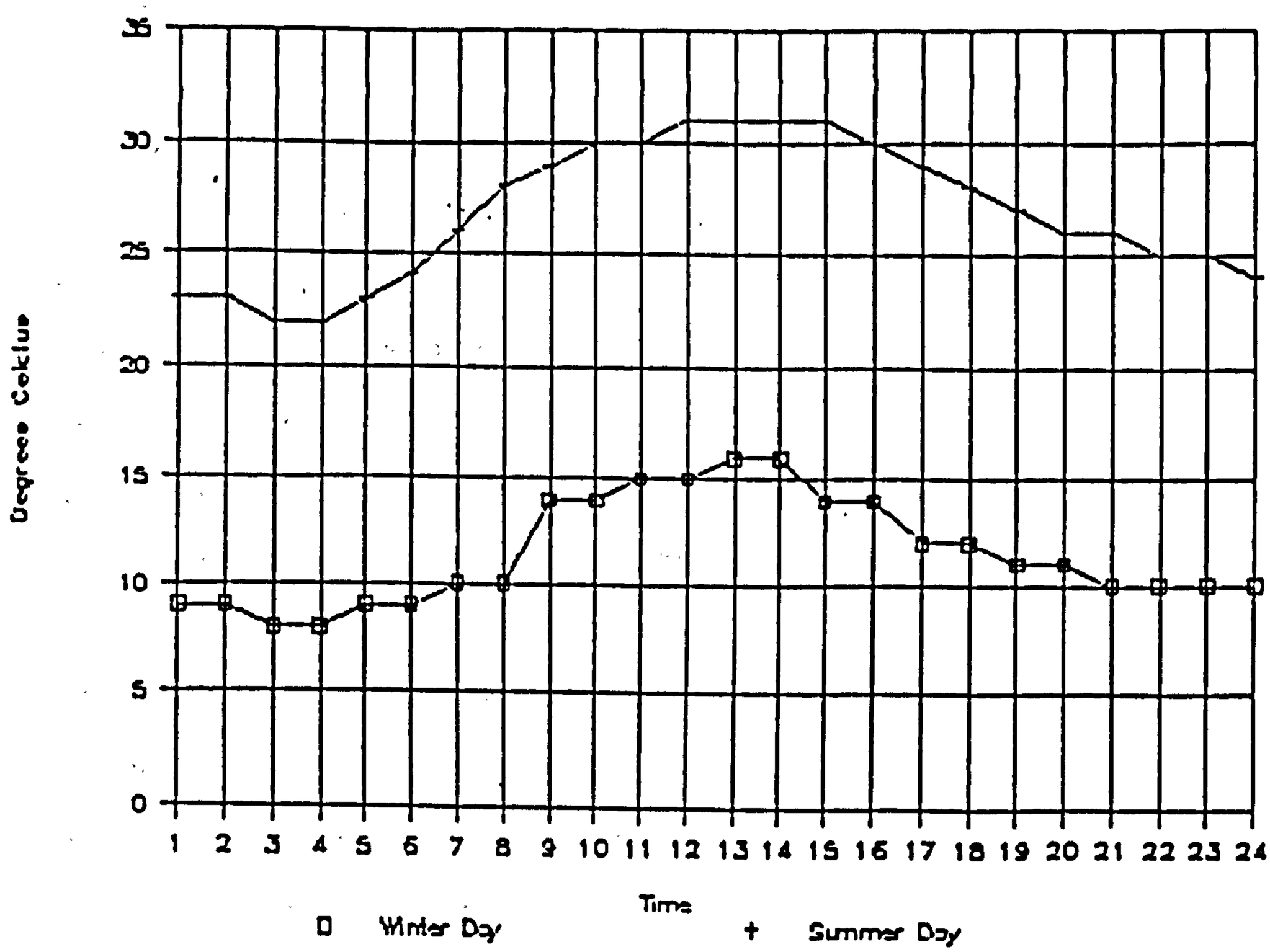


Figure 4.2.8: Hourly ambient temperature at location of Hotel A

temperatures are good examples of misuse of the concepts of quantity and quality of energy requirements. Both of these cases were encountered repeatedly during the field work of this thesis.

Electricity demand costs can be controlled or reduced by turning off (shedding) low priority electrical loads when high priority loads are causing an increase in kW draw. A good candidate to be shed during periods of high demand is an air handling unit. In this case, savings can be obtained by turning off the air system fan and (provided they are on) the compressor, the condenser fan and the electric reheat.

The turning off of energy consuming equipment in order to reduce costs (load control) typically applies to electrical equipment. However, the principles can also be applied to non-electrical energy consuming equipment.

Load control can result in the reduction of both electricity consumption and demand costs. Consumption costs can be reduced either by turning an equipment off when there is no reason for it to operate (time reduction), or by reducing its operation time when it is required to operate (duty cycling).

Demand limiting provides great scope for energy savings as well. The operation of each and every equipment within the hotel during peak periods of electricity demand (around 9 p.m for most of the hotels in Cyprus) will have to be well justified. As electricity charge is based on maximum demand

recorded every twenty minutes, unnecessary loads can contribute significantly to the energy costs. It is for this reason that the potential of installing the necessary controls (not necessary sophisticated and expensive!) will have to be evaluated. A preliminary analysis of this investment will have to be based on the historical record of demands, the annual cost of demand charges and the projected savings.

A detailed analysis of the prospects of timing controls is certainly more involved and includes the following steps.

(a) Determination of the pattern of load demand
(b) Listing of major electrical equipment that could be turned off for short periods (if necessary).
(c) Listing of important data for each equipment (e.g load, period allowed to be turned off, additional kWh savings).
(d) Estimation of cost of providing a demand control system (starting with the equipment with the largest annual demand).
(e) Calculation of economic benefits of the control system investment.

It is obvious than any attempts to modify the timing of the energy demand pattern will have greater effect during the Summer period (see Figure 4.2.2) and at the peak clock times shown in Figure 4.2.6. For example in Hotel A, a 10% reduction of the maximum demand in the 5 Summer months (June to October, when air conditioning operates) will result to savings of

500 Cyprus pounds whereas a more ambitious 20 % reduction will result to savings of around 1000 Cyprus pounds.
These savings is the result of reduction of demand and electricity consumption cost. In fact demand charges represent around 28% of the savings and electricity consumption around 72% of the savings.

The calculation is based on the average electricity consumption and maximum demand values shown in Figures 4.2.2 and 4.2.6 and on the existing kVA electricity charge tariff. According to this tariff, each of the first 200 units of electricity consumption for each kVA of demand is charged at 5.59 cent and each of the next 100 units per kVA of demand at 5.04 cent. Each additional electricity consumption unit is charged at 3.8 cent. The charge per kVA for these months (June to October) is 1.33 Cyprus pounds.

From the example presented above, even for the Summer period only, it is shown that considerable savings can indeed be achieved. A careful look at Tables 4.2.1. and 4.2.2 will reveal several candidates for which timing of demand could possibly be changed. The most important of these energy consuming equipment for the Summer period discussed, are the cooling air handling units, the swimming pool circulator (operating on a 24 hour basis) and various lighting loads (e.g. in the kitchen, corridors, and toilets).

4.2.4 Remarks on the energy scene for Hotel A

Before proceeding into a discussion on the energy conservation opportunities identified, several important remarks that were made during repetitive visits and discussions in the hotel are made below. The remarks concern both "soft" and "hard" problems. Simple calculations were in several cases used in order to support arguments related to possible energy savings.

4.2.4 Remarks concerning "soft problems" for Hotel A

(A) The manager of the hotel appeared to be quite sensitive on the issue of energy. However, it was easily observed, during extensive discussions, that the manager lacked the necessary background that would enable him to appreciate the complexity of the energy issue and thus organise and motive his staff accordingly.

The answers to the extensive questionnaire, on the basis of which the manager of the hotel was interviewed, revealed several important issues. The most important points of this interview are listed below.

(1) Though the manager had stated that he considered the issue of energy management in his hotel as being very important he was not following up the energy costs personally and was thus unable to provide even approximate information regarding the energy cost of his hotel.

(2) The manager had a strong conviction that most of the

energy in his hotel was wasted in the rooms by the guests. Discussions revealed that there was indeed a lot of pressure put by the management on both the housekeeper and the staff. The manager repeatedly instructed the staff to turn lights, radios and heating and cooling systems off while cleaning rooms and also report any waste or malfunctioning of equipment. However, no interest was shown on behalf of the management for other energy consuming centres (such as for example the kitchen !).

(3) It appeared that there was a kind of "friction" between the manager and the chief engineer. While the manager repeatedly praised the good work of the chief engineer, he also made it clear that he would rather see him spending more time in his hotel and less time in other hotels operated by the company. Furthermore, it was noticed that there were also communication gaps between the two men. This was made obvious by comparing the answers to the same questions posed independently to them. For example the answers of the manager to the two questions given below were positive while those of the chief engineer were negative. (a) "Do you discuss technical issues with your manager/chief engineer ?" (b) "Do you have regular meetings with your manager/chief engineer ?"

(4) The manager stated that he was willing to attend training seminars on the issue of energy and specifically on the operation of the hardware and on ways for evaluating prospective investments. The manager stated: "In many cases I am being visited by representatives of companies that promote

energy saving equipment. Though I do respect the opinion of our chief engineer I would also like to be in a position to evaluate a proposal before I make a recommendation to the owners!". These remarks demonstrate clearly the need for training. The fact that the chief engineer was not always available to the hotel on a permanent basis was a negative factor for the issue of energy management and conservation. We believe that the absence of clear responsibility for various tasks, the lack of communication and the incomplete preventive maintenance program observed are the results of this situation. It was not that there was a need for a "full time" energy manager, but rather that the "part time" status of the engineer enabled "excuses" for omissions and communication problems.

(B) The most important remarks obtained from the analysis of an extensive questionnaire for the chief engineer are listed below.

(a) The chief engineer was very sensitive on the issue of energy management. There appeared however a need for further training which the chief engineer was willing and anxious to have. The most important training needs identified were related to monitoring and targeting techniques, knowledge of basic electricity conservation opportunities (such as power factor improvement) and energy efficient operation of heating and cooling system.

(b) An important gap, noticed in many other hotels as well, was the total absence of a simple and understandable "Targeting and Monitoring" system. This does not necessary imply a sophisticated computerised system but rather a simple method by which the consumption of the various forms of energy are recorded, normalised and used to set feasible and regularly monitored targets.

There is also a need for training on the use of basic statistical analysis techniques. The use of these techniques will enable both the chief engineer and the manager to derive useful indices and relate energy consumption and costs to various important parameters (e.g weather, occupancy and operation mode).

(c) The chief engineer had a very good knowledge of the way energy was used in his hotel and had recommended several energy saving measures. The majority of these measures were accepted. The measures concerned the installation of energy efficient lighting fixtures, the installation of magnetic switches on the balcony doors and the insulation of the plant room piping.

(d) The chief engineer was not in favour of several technologies on which he was asked to express his opinion. These technologies included combined heat and power, heat recovery and solar space heating. As it was observed, the chief engineer was unable to support his views with strong arguments (mainly because of lack of knowledge).

(C) Extensive discussions were conducted with the room cleaners of the hotel and the chef. The main points of these discussions are listed below.

(a) The vast majority of the room cleaners (90%) claimed that lights, air conditioning and radio were very rarely found on when they enter a room.

In addition most of the room cleaners were, according to their claims, at some point officially instructed by the management to turn unnecessary operating devices off. However there is a possibility that room cleaners may have given the answers that their manager would like to hear.

(b) The chef appeared quite energy conscious and said that he always instructed his staff to avoid energy waste. In addition, he said he was willing to learn more on ways to conserve energy in the kitchen and that he would favour the installation of a separate electricity meter in the kitchen. The principal cooking fuel however was LPG.

(D) The behaviour of the guests and the staff play an important role in any effort for energy management. Detailed questionnaires were designed and addressed to the guests of all hotels (see Chapter V). However it is only through on site continuous observation and cooperation with various members of the staff that the real situation was appreciated.

An attempt of this nature in this specific hotel revealed

the following:

(i) Room thermostats were consistently set out of the designed set values. It appears that guests, for psychological reasons, were setting the room thermostat temperature above normal in Winter and below normal in Summer. This yields higher cooling or heating loads and hence increase fuel/ electricity consumption, and strongly suggests that the supply limitations did not accord fully with guests requirements.

(ii) Ceiling lights were left on by the staff continuously despite the fact that there was sufficient daylight to do the work.

(iii) Room lighting was found on after (!) the rooms were cleaned by room cleaners.

(iv) Ceiling exhaust fans in the bathrooms were in many cases left on consistently thus venting warm indoor air to the exterior (in Winter) and consuming unnecessary electricity.

(v) Balcony doors were left open while the air conditioning system was operating. This information was obtained from the Reception desk to whom regular complaints for the interruption of the air conditioning (through magnetic switches installed on the balcony doors) were made.

(vi) Kitchen equipment (like toasters) were found to operate unnecessary continuously (very late in the night!).

4.2.5 Remarks and Recommendations concerning "hard" problems

The most important remarks concerning the efficient operation of the hardware of the hotel are listed below. For reasons of clarity and simplicity, whenever possible, estimated costs and savings follows each remark and recommendation.

Life cycle cost effective analysis was only performed for important energy saving investments and technologies with potential application to a wider range of hotels (see Chapter IX). Furthermore it is emphasised that it was not the intention of the soft systems analysis of this research to proceed into the details of each possible energy saving opportunity.

(a) Room Temperature and Fan Coil Operation

Rooms are equipped with fan coil units. The motor speed of the fan coils is controlled by a four positions manual switch, that is : OFF, LOW, MEDIUM and HIGH. The three-way valve is controlled by a thermostat. As a result guests have the capability to control through the adjustment of the thermostat both the final temperature of their room and the speed at which this temperature is achieved.

Once the final temperature is reached, the three position motor speed control becomes useless. In fact only the LOW position is useful. If the switch remains on the medium or HIGH position there is a waste of energy.

In order to investigate the reliability of the control system in the fan coil of rooms a simple test using a stop watch and a thermometer was performed.

The results of these measurements for a requested temperature of 20 degrees Centigrade are shown in Table 4.2.3 The parenthesis contains the time elapsed (minutes) in order to reach these temperatures for an initial temperature of 27 degrees Centigrade.

Position	Room 1	Room 2	Room 3
	Degrees Centigrade		
LOW (8.5)	24.8	24.7	24.8
MEDIUM (5.0)	23.7	24.0	23.8
HIGH (4.0)	23.5	23.8	23.6

Table 4.2.3: Room temperature and time elapsed to achieve it

The installation of a more accurate and simpler ON-OFF control system in each room is recommended. The estimated cost for this investment will be around 1250 Cyprus pounds but savings are very difficult to estimate. The primary concern here would seem to be the quality of comfort level provided rather than energy cost rationalization; guests satisfaction is clearly vital in a competitive market!

(b) The Boiler room

(1) A first "walk- through" observation proved that there was need for reinsulating certain pipes and equipment (such as the hot water tanks). This action would halt losses and contribute to energy savings.

(2) As is the case in many hotels in Cyprus, the early American rather than the more energy efficient European approach was used to boiler sizing. According to the American practice, instead of having three boilers each one capable of satisfying 1/3 of the heating load, two boilers, each one capable of satisfying the total load are used. As the sizing is based on the peak demand, which rarely occurs and for a very short time, the boilers operate inefficiently at part-load conditions.

(3) In order to evaluate the combustion efficiency of the two boilers, a combustion efficiency test was performed. This was achieved through a boiler efficiency test kit. Borrowing of the combustion efficiency test kit was unfortunately necessary as this hotel, like the majority of the hotels in Cyprus, do

not posses such a kit. This is certainly a very basic lack of equipment and can only be attributed to ignorance on both the savings that can be achieved and the cost of the kit (around 300 Cyprus pounds). The findings of the combustion efficiency test are shown in Table 4.2.4.

With very simple unsophisticated and "no cost involved" adjustments, the oxygen content of the flue gases could be reduced to the level of 5% and the efficiency of the boilers could rise to near the 90% level. The expected savings for an average present gas oil consumption of 56,000 litres would be around 6,000 litres/year .

Boiler	Oxygen Content %	Flue gas temperature Degrees Centigrade	Combustion Efficiency %
1.	9.9	181	83.3
2.	14.4	230	75.3

Table 4.2.4 : Boiler combustion efficiency test results for Hotel A

The expected money savings from this simple combustion test (using a gasoil price of 9 cent per litre) would be around 540 Cyprus pounds .

(4) There are three calorifiers in the boiler room. The first of these calorifiers is connected to the boilers whereas the other two are connected to the solar panels. These two calorifiers (hot water tanks) provide preheated water for the third calorifier that serves the needs of the hotel.
It appears that this design is not energy efficient since it necessitates the operation of the boiler on sunny days as well. It would be better if the all three calorifiers were connected to the solar panels and water boiler as well.

(c) <u>The swimming pool</u>

The swimming pool of the hotel has an exposed area of 100 sq.m. The pool is not heated during the winter months though a heat exchanger for this purpose is installed.

The most important heat loss from the pools is by evaporation. The use of a night cover (estimated cost around 2000 Cyprus pounds) would certainly contribute to energy savings and would pay for itself in around a years time. The use of low temperature solar panels (see Chapter IX) can not be considered as a feasible option mainly because of lack of the required space.

However, the possibility of another opportunity for energy saving (electricity) does exist. The swimming pool is equipped

with two water circulators (one duty and one standby). Each of these circulators is rated at 3.4 kW. Observations during various times of the day and for various days through all seasons proved that the duty circulator operates continuously throughout the year.

The 24 hour continuous operation requires a yearly consumption of around 29,784 kWh or a cost of around 1300 Cyprus pounds. As the pool is not used during the night it would be possible to reduce the running hours of the circulators while maintaining the high quality level of water in the pool. By reducing the number of hours of operation per day of the duty circulator by an average of 9 hours (from 10 p.m to 6 a.m in the high season and from 8pm to 6 am during the low season) it the electricity consumed will be reduced to 11,170 kWh representing money savings of the order of 487 Cyprus pounds. As the cost of this investment is not expected to be more than 50 Cyprus pounds this appears to be an excellent investment paying for itself in just over a month! (36 days). The quality of the swimming pool water should be checked regularly to ensure no deterioration.

(d) <u>The Kitchen</u>

(1) <u>The dishwasher.</u>

It was observed that there are two electric dishwashers operating in the hotel. One of these dishwashers serves the needs of the kitchen throughout the year and operates, according to observations and discussions with the kitchen staff, for around 10 hours per day. The second dishwasher is

installed at the pool bar and operates for around 4 hours a day only during the Summer season (around 180 days per year). The capacity of these dishwashers is 12 kW each. The required hot water, at a temperature of around 70 degrees Centigrade is produced by electric elements. The water enters from the mains supply at an average temperature of 24 degrees Centigrade in the Summer and 15 degrees Centigrade during the other months. The two dishwashers consume around 52,440 kWh per year at an annual average cost of 1900 Cyprus pounds per year.

Other less expensive means could provide the required water at the desired temperatures. For example instant gas water heaters operating on LPG could be used and the electric dishwashers could be used in case of emergency only. The difference in the cost between an electricity and an LPG kWh is so great (3.05 cent) that the investment can certainly be justified. The money savings will be of the order of 1600 Cyprus pounds per year whereas the installed cost of two instant gas water heaters is not expected to exceed this amount. It is therefore clear that in one year the investment will most probably pay for itself.

(2) <u>The pastry oven</u>

According to the information provided by the chef and his staff, the 12 kW electric pastry oven operates for an average of 6 hours per day. The remarks expressed for the dishwashers above hold for this case as well since an LPG operating pastry oven for this period would save annually 400 Cyprus pounds (a load factor of 0.5 is assumed). It is not however certain that

the fuel change would be feasible without the total replacement of the electric pastry oven with an LPG operated one. A search in the market showed that the cost of such an LPG operated pastry oven would be around 1100 Cyprus pounds.

Even in this case, the change to an LPG operated pastry oven appears to be a wise investment since it could repay itself in less than three years (two years and nine months)!

(3) Electric coffee machine

A similar case exists for the kitchen electric coffee machine that operates, according to observations and information provided by the kitchen staff, for 18 hours per day. A modification of this 6.9 kW machine, undertaken as found out willingly by the equipment suppliers, would save (assuming a load factor of 0.4) around 530 Cyprus pounds. The required modifications are not expected to exceed this amount and the investment is anticipated to pay back for itself in one year!

In all of the cases above the LPG units could by supplied from the main LPG storage tank of the hotel.

(e) Lighting

As it can be seen from the Sankey diagrams developed (see Figures 4.2.4 and 4.2.5) lighting is a significant energy consumer in the hotel, accounting to almost 13% of the total energy bill. However today's technology enables the replacement of existing lamps with other lamps that provide

the same illumination while they consume much less electricity. The cost effectiveness of this energy saving investment depends on the following important factors :

(1) The cost of the energy efficient lamp

(2) The hours of operation of the existing lighting fixtures

(3) The difficulty of replacing the existing lamps and the labour cost involved.

It is therefore not cost effective to replace all of the hotel's bulbs as the hours of operation for a large number of them would not justify the investment. However it should be the intention of the management to replace as many of the light bulbs situated in the common areas (lounge, dining rooms, bars, corridors and reception). The analysis below shows how the above three factors are integrated in order to find the overall cost per operating hour for both an ordinary and an energy efficient lighting fixture. A 40 Watt lamp is used for the calculations of this analysis. All costs are in Cyprus pounds.

Energy efficient lamp

Life expectancy	:	5000 hours
Rating	:	10 Watt
Replacement Cost per lamp	:	0.10
Light bulb cost	:	2.50
Cost per kWh (4.3 cent/kWh)	:	0.000430
Life depletion cost/hour	:	0.000500
Replacement cost (labour)	:	0.000020
Total cost per hour	:	0.000950

Existing (ordinary) lamp

Life expectancy	:	1000 hours
Rating	:	40 Watt
Replacement Cost per lamp	:	0.10
Light bulb cost	:	0.25
Cost per kWh (4.3 cent/kWh)	:	0.001720
Life depletion cost/hour	:	0.000250
Replacement cost (labour)	:	0.000100
Total cost per hour	:	0.002070

The difference between the two amounts (0.00112 Cyprus pounds) would be the savings from the use of the energy efficient lamp per hour of operation.

In general, the higher cost of the energy efficient lamps is offset by the higher life expectancy. The initial cost of installing an energy efficient PL lamp is around 5 Cyprus pounds (because it includes the control gear) but the replacement cost is only 2.5 Cyprus pounds.

The replacement of 650 ordinary lamps with energy efficient PL lamps would result to an electricity reduction in consumption of approximately 21,000 kWh costing around 900 Cyprus pounds. The investment required (at 5 Cyprus pounds per lamp plus labour cost for replacement) is estimated to be around 3315 Cyprus pounds. The repayment period for the investment is therefore around 3.5 years (3 years and 7 months).

(f) Hot water supply system - Secondary circulators

During repetitive visits in the plant room of the hotel the following remarks concerning the secondary circulators was made: There are three secondary circulators installed each rated at 1.1 kW. Two of the circulators operate while the other one is standing by. The purpose of the circulators is to ensure the supply of hot water at the draw off points.

The control of the operation of these pumps is done through a contact thermostat that senses the temperature of the return temperature. Observations however proved that the thermostat does not (as usually happens in hotels) function properly. As a consequence, the circulators operate continuously for 24 hours a day and for 365 days per year. The electricity consumed under these circumstances is estimated to be around 19,272 kWh per year costing around 835 Cyprus pounds every year. However, the installation of a simple time switch control costing no more than 50 Cyprus pounds would result in significant savings.

For example if the total number of hours is reduced to 50%, 9,636 kWh or 417 Cyprus pounds every year can be saved (a pay back period of just over one month!).

Care should however be taken in order to ensure the supply of adequate quantities of hot water to the guests.

(g) The Solar System

The following observations were made regarding the solar system of the hotel.

(1) It appears that no proper calculation were made within the design stage for the proper distance between the rows of the panels. This is not an uncommon case and it has been observed in other hotels as well. As a result shading of the panels occurs at the time when solar energy is at its maximum. Observations showed that at noon time, almost 1/3 of many panels were in shade. This certainly reduces the efficiency of the system.

(2) Several of the panels were observed to be coated with a delicate layer of oxide that reduces the transmissivity of the panel glass considerably. It was impossible to remove this layer of oxide that had penetrated the inside of the glass as well. A special liquid (available in the market) should be used in order to remove this layer. If this proves impossible it is recommended that the glass of all panels affected should be replaced. The glass cost is certainly very small and the important cost component would be the labour cost.

However, boosting the performance of the systems should certainly offset the cost.

(h) Change of fuel

The boilers of the hotel operate on gas oil which is priced at 9 cent per litre. However an alternative fuel, light fuel oil is priced at only 4 cent per litre.

By replacing the two burners of the boilers with similar ones suitable for atomising and burning light fuel oil the hotels heating bill (6000 Cyprus pounds) will be reduced to around 50%.

The cost of this investment, including two light fuel oil operated burners, an oil heating system to preheat the oil for better combustion and fluidity, and labour charges is not estimated to exceed 3000 Cyprus pounds. It is obvious that such an investment will be paying for itself in one year only! In addition, the higher calorific value of this fuel will result to a higher output of the boilers.

(i) Roof insulation

As in the majority of hotels in Cyprus, no insulation is used on either the roof, the floor or the envelope. However, the studies by various engineering consultants suggest that it is very worthy to insulate at least the roof of buildings.

The addition of insulation in the form of 50 mm polyurethane foam covered with a protective asphalt membrane could reduce

the U value of the concrete slab from 3.5 W/sq.m.K to around 2.0 W/sq.m.K.

The savings expected for coastal hotels could reach 8% of the air conditioning load during the cooling season and 8% over the heating season.

In the case of Hotel A the savings would total 745 Cyprus pounds whereas the total investment (at a price of 3.5 Cyprus pounds/sq.m including labour) would be 1785 Cyprus pounds. Thus the investment could pay for itself in less than 2.5 years!

(k) Chiller Water Reset Temperature

Savings can also be obtained by resetting the chilled water temperature in response to the demand for cooling of the hotel. The vast majority of the chiller systems today operate with a constant chilled water supply temperature. This is the temperature required to meet the building's design cooling conditions.

However, cooling costs can be reduced by allowing the chilled water temperature to increase as the cooling load of the building decreases. The temperature difference between the constant supply temperature and the actual supply temperature (after reset control has been applied) is known as the "Average Degrees of Chilled Water Reset".

The annual savings in cooling energy costs in Cyprus pounds per year can be calculated by the relation :

$$CS = TS \times AD \times 0.015 \times EL \times CH \quad \text{.....(A)}$$

(Barber & Coleman,1985)

where :

CS = Annual savings in cooling energy cost

AD = Average degrees of chilled water reset (Degrees Centigrade)

0.015 = Normal expected percent savings for each degree of chilled water reset (%/C)

EL = Cost of electrical consumption per kWh

CH = Chiller efficiency (kW/ton)

TS = Rating of machine in tons x hours per year of operation x percent average chiller load

The calculations performed using relation (A) show savings of 120 Cyprus pounds per year. The chiller capacity used is 20 tons, the load factor 0.75 the hours of operation 2700 and the average degree of temperature reset 5 degrees Centigrade. The efficiency of the chiller was estimated to be 8 kW per ton.

(1) Demand limit control

In general, the chiller constitutes a substantial portion of a hotel's power consumption and therefore adds considerably to the demand level. A method for achieving savings and consequently reducing demand exists for this situation. This is achieved by partially reducing chiller energy consumption during peak demands. Usually this can be accomplished with the

minimal effect on the comfort of the hotel.

The savings in annual demand can be calculate by relation (B) given below.

$$DS = CHC \times CHE \times MPY \times DER/100 \times DC \quad \text{.....(B)}$$

(Barber & Coleman,1985)

where :

DS = The demand savings in Cyprus pounds per year

CHC = Chiller capacity in tons

CHE = Chiller efficiency (kW/ton)

MPY = Months per year of demand reduction

DER = Percent average demand reduction per month

DC = Demand cost in Cyprus pounds per kW

The estimated savings calculated with relation (B) are 58 Cyprus pounds. In relation (B) the following data were inputed:

(a) the percent reduction of maximum demand used was 15%

(b) the chiller efficiency 0.8kW/ton

(c) 6 months per year of demand reduction

(d) the price per KW was 4 Cyprus pounds

The total savings from "opportunities" k and l above are 178 Cyprus pounds whereas the investment will be in the range of 600 Cyprus pounds offering a straight pay back period of less than 3.5 years.

(m) Temperature equalisation and reduction in Winter

During various visits in the Winter time large temperature differences were observed in various parts of the hotel. Temperatures in the corridors varied between 24 and 25 degrees Centigrade when even 22 degrees would be satisfactory. Low temperatures were recorded in the various parts of the ground floor as follows :

Lobby	:	19 degrees	Centigrade
Bar	:	20 "	"
Restaurant	:	20 "	"

Temperatures were low mainly because the entrance of the hotel was unnecessarily kept open. A permanent close up of the door would certainly increase the temperature of the space to the required level. In public areas temperatures could be set lower (around 22 degrees Centigrade) but staff should be instructed to make sure that doors do remain closed. This would certainly reduce space heating gas oil consumption in Winter.

The other hotels

Appendix D presents the major findings of the audits contacted in the other seven hotels of the sample. Following the naming pattern of Hotel A, described above, the hotels described in Appendix D are referred to in alphabetical sequence.

In order to facilitate the process of describing the major findings of the audits in the seven hotels and allow easy

comparison it was decided to adopt the following pattern:

The description of each audit was divided in 5 major sections which were considered as being quite adequate in providing a picture of the pertaining "real situation" in the soft system analysis sense.

These sections are the following :

(a) Building

(b) Plant

(c) Major human actors

(d) Energy consumption

(e) Possible energy saving opportunities within the existing systems.

Finally, it is worth recalling what this collection of "domestic" detail and simple energy saving recommendations achieves, relative to the overall systems plan : It provides a sound basis of understanding of the underlying demand requirements after correction of gross errors of approach within the existing system of supply and demand. To this extend we have so far only been concerned with "Level 1" and Level 2 " aspects of energy management.

CHAPTER V

INVESTIGATING THE PROBLEM SITUATION (II)

5.1 Managers'questionnaire Analysis

The answers of the managers' questionnaire analysed in this Chapter are expected, to contribute significantly to the overall development of a rational energy planning model.

There is no doubt that the managers of hotels play a vital role in the whole hotel system. Both as a decision maker during the every-day running of the hotel and as the important "link" between the hotel and its owner, the manager has a unique role to play. His ability to appreciate situations and to motivate his subordinates are of vital importance to the energy management effort; So too might be his relation to his guests/clients.

There is not much hope for the successful implementation of any energy conservation program without the commitment of the manager of the hotel. A hotel manager should be knowledgeable, well informed and sensitive to energy issues.

In order to understand and appreciate the "quality" and the characteristics of this vital human resource of the island's hotel industry a questionnaire was designed and employed as a useful research tool.

The questionnaire included 32 questions of the "fill the blank" and the multiple-choice type. One question required

the managers to draw a draft organisation chart of their hotel.

5.1.1 The Objectives of the Questionnaire

The main objectives of the questionnaire were the following:

(a) To assess the knowledge, attitude and sensitivity of managers on energy management and utilization.

(b) To obtain detailed information related to the age, the experience and background of the managers.

(c) To identify the interest and knowledge of managers in energy use and management as well as determine their training needs.

(d) To establish the existing level of communication between their department heads and more importantly with their chief engineer.

(e) To establish the acceptable threshold for energy saving investments.

(f) To identify on whether an energy audit had been undertaken and in the case of a positive reply by whom and when was it undertaken.

(g) To obtain information on the way the hotel is run by means of an organisation chart.

Following the design of the questionnaire, a test on a sample of three hotels was performed in order to identify possible drawbacks and problematic questions. The very useful remarks obtained from the three managers of the micro sample were taken into consideration while redesigning the final

questionnaire which was sent by mail with an attached letter to all 5,4 and 3 star hotel on the island.

Because of differences in management pattern and the relatively lower importance given to energy matters in these hotels, no questionnaires were mailed to 1 and 2 star class hotels.

The response rate of the questionnaires mailed was extremely low (less than 6%) and was considered unacceptable as no reliable conclusions could be drawn. Despite telephone follow-up and the assurance of a large number of managers that the questionnaires would be promptly completed and returned, the response rate continued to be the same.

This behaviour of managers might be attributed to the following causes :

(a) Managers were very busy and could not allocate the time required for completing and mailing the questionnaire.

(b) Managers were not confident enough that they should "reveal" the information requested by the questionnaire.

(c) Managers were not in a position to answer the questions.

(d) Managers did not feel "comfortable" with the questions and kept procrastinating.

(e) Managers were misguided by the relatively large (32) number of questions included in the questionnaire and thought that they needed a long time to complete it.

Since data sought was considered extremely valuable for this research, alternative methods for obtaining them were considered. Finally direct interviewing was chosen. The major disadvantage of this method is that it is quite time consuming as it requires arranging (and often cancelling) meetings as well as travelling. There are however several important advantages which are outlined below.

(a) There is a guaranteed response of the individual manager.

(b) There are certain questions that are much better off if they are answered "on the spot" rather than allowing time for consultation of other sources. Certain questions aimed at testing the managers own knowledge. In fact there were occasions during this research when manager requests to have the questionnaire mailed to them prior the interview were politely turned down, in order to deter from the possibility of using the services and knowledge of another source (subordinate, accountant etc).

(c) The appointment can be set well in advance.

(d) The reaction of the managers during a specific question is appreciated better.

(e) Usually the opportunity of extending the reply to a useful discussion arises from which important information can be obtained.

5.1.2 <u>The sample for the interviews</u>

A sample of 22 hotels was chosen from the entire 5,4 and 3 class hotels of the island representing 50% of the hotels of these categories. Proper care was taken so as to include in this sample hotels of all size, locations, and nature

(function). Five hotels of the 5 star group representing 60% of these hotels, 8 hotels of the 4 star hotels group representing 25% of the hotels of this group and 9 hotels of the 3 star group representing 17% of this group were included in the sample.

A major assumption of this sampling procedure was that the replies of the managers not included in this sample would not be significantly different from those of the managers not included in the sample.

5.1.3 Discussion of the results

The data obtained from the questionnaires are summarised in Tables A.E.1 to A.E.5 in Appendix E1. Table A.E.1 presents data related to the age, the experience, the years of service in the present post and the ownership of the hotel.

As it can be seen from the data on the "weighted average" column of Table A.E.1 the "typical" hotel manager in Cyprus is 40 years old, has been holding his position for 7 years and has an average experience of 13 years. Only 18% of the managers stated that they are also the owners of their hotel. The relatively young age of the hotel managers can be considered as a very encouraging factor for the future of energy management. Younger managers may well be more adaptive to new ideas.

The fact that the average tenancy in the present post is as high as seven years is also encouraging. Managers holding

their position for that long have a better possibility of understanding the human and material resources they manage. In addition, in the case of initiating an energy management program, it is always easier to implement and monitor it under the same management that had initiated it.

There had been occasions in which energy management programs initiated had to be abandoned or given less priority under a new management.

Since energy is the main subject of this research, it was considered appropriate to include in Table A.E.1 data related to the relevant educational background of the managers.
It might be encouraging to note that according to the managers interviewed 41% had been exposed to a special course on energy conservation or hotel maintenance. However as no such courses are offered in Cyprus it is concluded that they must have been taken some 13 years ago (their average experience). This fact raises the need for training in order to update the knowledge of the managers that have been exposed to these subjects and educate those that never had the opportunity. A very positive factor is the willingness of the vast majority to receive training.

Table A.E.1 also shows that none of the managers of the 5 star hotel group stated that he is the owner of the hotel, whereas on the average 18% of the total number of managers interviewed said that they were also the owners.

Table A.E.2 presents information related to the implementation of energy conservation measures. According to the data obtained, 96% of the managers said that measures of some kind were already undertaken in their hotel. These measures were not taken in the context of a formal energy audit and were not suggested by a foreign or local consultant. Proper care was taken during the interview at this point in order to clarify the term "energy conservation measures". It was only after the term was clarified that replies to this question were recorded. The clarification was considered necessary after discussions that revealed that managers tended to confuse maintenance and other measures with energy conservation measures.

More than half of the managers asked (54%) stated that energy audits had already been undertaken in their hotel. According to these managers 42% of the audits were conducted by local firms, 18% were conducted by hotel staff and 18% by local firms in collaboration with foreign consultants. Foreign consultants had undertaken the audits in 23% of the cases. It is interesting that for the case of 5 star hotels, all audits were undertaken by foreign firms alone or in collaboration with local firms. The complexity of the functions and hardware of the hotels of this class and the contacts of their managers with foreign firms are the main reason for the non utilisation of the services of local consultants (see also Chapter VI).

On the other hand, none of the lower class hotels (3 star) utilised the services of a foreign consultant. In these hotels

85% of the audits performed were undertaken by either hotel staff (25%) or by a local firm. The remaining of the hotels (15%) had audits undertaken by local firms in collaboration with foreign consultants.

In the case of the 4 star group of hotels, 70% of the audits were conducted by either hotel staff (20%) or by a local firm (50%).

It is very interesting to note that according to the statements of the managers all measures recommended were implemented and that their performance was considered satisfactory.

This particular reply raises certain questions. How were the measures recommended implemented and how was their performance evaluated? Why should all of the measures recommended be implemented?

The interpretation seems to be that certain measures recommended (most probably the least expensive) were implemented and that, according to their knowledge (most probably from their chief engineer) these did perform satisfactorily. However, chief engineers are usually involved in the decision process and that once measures are adopted (with their advise and consent) it would be quite extraordinary for them to admit that the measures are not performing well.

In addition, it is very rare for a hotel to continuously monitor and record the performance of measures and thus have valuable inside information obtained from an historical life cycle cost analysis. More than half of the managers (57%) stated that they had attempted to convince the owner of their hotel to approve a certain energy saving investment. According to the data obtained, all 5 and 4 star hotel managers had succeeded with their attempts whereas only 20% of the 3 star hotel managers did. Management proposals for the case of the 5 and 4 star hotels were usually better documented, addressed to a board rather than to a single person, and their costs constitute a smaller percentage of the turnover of the hotel. The opposite holds for the case of the 3 star hotels.

Table A.E.3 presents the results of the managers opinion on the issue of energy in general and energy conservation measures in particular. The attitude of managers is quite important as they are the decision managers that can halt or approve recommendation of a certain energy investment proposal.

Encouragingly 96% of the managers interviewed consider energy as an important issue. All of 4 and 5 star hotels said that they consider energy as an important issue in the operation of their hotel. Only one of the managers of the 3 star hotels said that he does not consider energy to be an important issue. This unique particular case is therefore well remembered as is the argument of the particular hotel manager. According to this manager, the percentage cost of energy

to his hotel's total operating cost and turnover was very small. Therefore, according to his opinion, he should not be bothered with "such minor details". Furthermore, he considers energy conservation measures as being "very expensive". The fact that such costs represent a large fraction of his controllable (manageable) costs, seems to have escaped this respondent!

The majority of the managers (82%) said that energy conservation measures deserve every effort. A small minority (5%) said that the measures cost too much and 4% did not give any comment. While the majority of the 5 star hotels (80%) said that energy conservation measures deserve every effort, 20% of them also said that these measures affect the comfort of their guests. Of the total number of 4 star hotel managers, 12% said that the measures affect the comfort of their guests also but 76% said that the measures deserve every effort within that (guest comfort) constraint.

Table A.E.4 presents the results of the questions related to the managers opinion on energy use and waste. These questions are very important as people tend to be guided by their perceptions (not always correct) when deciding or judging something. The perception of managers as to where energy is used and wasted in their hotel is very important. To all managers it was made clear that the question addressed the total energy used or wasted in their hotel (electricity, gasoil, LPG). The majority of the hotel managers (68%)

considered the rooms as utilising and wasting most of the energy in their hotels. According to 27%, public areas consumed most of the energy and only 5% (!) stated that most of the energy is used by the kitchen.

Most of the energy waste, according to the 5% of the managers is wasted in the public areas whereas 27% of them said that the kitchens were the greatest, waster.

Only one manager from the 4 star group (13%) said that the kitchen utilised most of the energy. Interestingly, none of the managers of the 5 star group indicated the kitchen as utilising most of the energy in their hotel. The same result holds for the 3 star group of hotels.

The vast majority of the 5 star group of hotels (80%) considered the rooms as the largest consumers of energy in their hotel. A very similar figure (78%) was obtained for the 3 star hotels whereas only half of the 4 star group said that rooms are the largest energy users. However, when it comes to waste of energy, 75% of that group had felt that most of the energy is wasted in rooms.

None of the 4 and 3 star hotel managers indicated the public areas as being considerable energy "wasters" whereas only 20% of the 5 star group of managers said that most of the energy is wasted in public areas.

It must be underlined that the perception of managers with regard to the main energy users and wasters is not entirely born out by direct observations. Energy consumption in the kitchen is often seriously underestimated. Had there been submetering in any of the hotels the opinion of the managers might have been entirely different. The absence of submetering and wrong perceptions may lead to wrong decisions and wrong investments. As far as the kitchen specifically is concerned one should consider that it utilises energy for cooking, water heating, catering and refrigeration as well. In addition kitchens consume energy for lighting, cooling and some times heating as well.

Improper planning for the works to be carried out in a kitchen, as well as improper maintenance, can lead to considerable waste, on a much greater scale than that anticipated by hotel managers.

Public areas also use and waste considerable amounts of energy. The over-riding perception among managers that rooms are the largest energy users and "misusers" in hotel is considered to be the main reason for the relatively wide spread of energy saving devices adopted by hotels aiming to save energy in rooms. The main devices in this category are the key fob system, a system that disconnects electricity supply (except one lamp and the refrigerator) when the guest leaves the room, and a magnetic switch on the balcony doors that interrupts the operation of the air conditioning when the guest opens his balcony door.

Table A.E.5 presents tabulated results of various questions addressed to the sample of managers. The vast majority of the managers (90%) stated that they follow up their energy bills personally. The percentage of the 5 and 4 star group (80% and 86% respectively) was lower than for the 3 star group of hotels, in which all of the managers said that they monitor their energy bills personally. The lower percentages for the 4 and 5 star hotels might be attributed to the fact that these usually have a heavier load of general management tasks associated with a wider variety of staff and other functions to perform.

However only 77% of the managers were able to provide reasonably accurate figures for their energy bill of the last two months. It is apparently strange that the lowest percentage of the managers that could provide figures belonged to the 3 star hotel group. This is the same group that claimed (all managers) that they monitor their energy bills personally. This can be attributed to either a misunderstanding of the term or to an attempt by the managers to create a false impression. The researcher was able to verify the replies of the managers since data, at least for their electricity consumption, were available independently.

The results of question 3 of raises the important need for the proper utilisation of the energy-related data collected. From Table A.E.5 it can be seen that only 54 % of the managers claimed that they use their energy data in any way. Only 44% of the managers of the 3 star group said that they do

use their data whereas the results for the 5 and 4 star group were 60% and 62% respectively.

The need for training on methods for evaluating and analyzing data techniques is obvious. Monitoring and collection of data is entirely useless as an end in its self.

A characteristic case of unnecessary production of data that was not being used, was the case of a 5 star hotel with an installed Building Energy Management System. This system was programmed to produce data every 15 minutes on the electricity consumption, the peak demand, and the air conditioning temperatures at various parts of the hotel. When the engineering assistant was asked "what use do you make of these data?" the reply was: "well, I am not sure, but when they get to be to much, we throw all this paper away"!

The result of question 4 related to the managers' knowledge of the proportion of energy cost on their total operating costs are exactly the same with those of question number 3. It is obvious that managers do not have a global understanding of their operating cost, and the share in that cost of energy factors.

Questions number 5 and 6 aimed at establishing the communication levels between hotel managers and their department heads and especially (question number 6) with their chief engineer.

All of the 5 star hotel managers said that they discuss energy matters with their department heads and that they have regular meetings with their chief engineer. Regular meetings with the chief engineer were also claimed by all of the managers of the 3 star hotel group.

However, only 62% of the 4 star group of managers said they discuss energy matters with their department heads and 88 % of them said that they hold regular meetings with their chief engineers. Almost 90% of the 3 star hotel managers said that they do discuss energy related matters with their department heads.

The most popular topic among the sample of managers interviewed relates to the knowledge of energy conservation techniques. On the average, 54% of the managers have declared that they are interested in this topic. New technology is the subject which comes second in the interest of the managers, since 36 % of them have indicated it. None of the managers has indicated functioning of equipment as their favourable subject for training. This result was more or less expected as managers should not necessarily be expected to have detailed knowledge of the technical functioning of the equipment of their hotel (however an understanding of the operational capabilities might be expected).

The result which comes as a surprise is the considerably low percentage given to the subject of methods of analysing

prospective investments. It is even greater surprise that none of the 5 star managers has indicated any great interest in this subject.

Arguably, it is essential for managers to have personal knowledge of these methods and especially the implications of life cycle cost analysis methods.

During the personal interviews, it became obvious that the problem of evaluating prospective energy related investments is quite serious. Several managers had expressed their concern on the issue of lack of knowledge on this matter. Some 12 and 13% respectively of the 3 and 4 star hotel managers did express interest for training on this subject!

The results of the questions related to the issue of the provision of incentives to the hotel employees in order to motivate them to conserve energy are quite interesting as they reveal a certain local (and international?) mentality that pertains to the management of this industry. The remark concerns the attitude of underestimating the human factor and the unwillingness to provide motivation and incentives. Some managers did not even appreciate the need for providing any kind of incentives at all!

The case of the group of 5 star hotels can serve as an excellent example for demonstrating this remark. None of the managers of this group has indicated any willingness to offer any kind of incentive. Bonus was considered as a possible

incentive by 27% of the managers interviewed whereas only 4% said that they would consider providing various sorts of discounts. Only 5% of the managers said that they were willing to consider other kinds of incentives (such as recognition as employee of the month). None of the managers expressed any willingness to consider the offer of extra leave as an energy saving incentive. This fact can be attributed to the severe shortage of manpower faced by the industry.

The option of offering certain discounts was mentioned by 12% of the 4 star group hotel managers only. Of the 3 star hotel managers, 44% said they would consider offering bonus, compared to a 25% of the 4 star hotel group.

The majority of the hotel managers interviewed (86%) stated that they have been visited by companies promoting energy saving devices.

All of the 4 and 3 star hotels stated that the reason for not implementing energy conservation measures was their cost which was considered very high. The reply of the 5 star group of hotel managers was divided. Half of them stated that they would not adopt energy conservation measures because of their high cost whereas the other half said that the reason was that they were not in a position to evaluate savings claimed by the suppliers. Both of these groups again confirm the lack of thorough appreciation of how investment appraisals are conducted and with what fundamental criteria of success and failure (Nett worth over time, for example).

A sample questionnaire addressed to the managers is given in Appendix E1.

5.2 Guest questionnaire Analysis

The literature survey for this research, failed to locate any studies in which the views of guests were taken into consideration during the analysis of the energy situation of hotel establishments. However, (as explained in Chapter II), it is believed that the analysis of such data can be valuable in the development of rational energy planning. It is for this reason that all "reluctance" to "bother" hotels guests with questions had to be overcome.

The ultimate aim of the energy system of a hotel is closely related to the provision of services and comfort to the guests. These services include air conditioning facilities (heating and cooling), hot water for sanitary purposes, swimming pool heating and lighting not to mention catering provision.

It is extremely important for the management to have an accurate feedback from its guests with respect to their appreciation of the quality of energy related services provided. No fixed (standard) level of energy quality need be required. The necessary yardstick should be the maintenance of satisfactory (according to the guests) standards that will provide them the comfort levels and the services required. There is clearly no need to produce energy at higher quantities and qualities than those demanded (i.e lower

cooling temperatures or higher heating temperatures), and such provisions may themselves, be sub optimal to customer requirements.

In order to understand the way guests use energy, and thus obtain a feedback of their perception with respect to their real needs a questionnaire was designed. The questionnaire included ten questions and was administered in 8 hotels of different location, size and function. This number of questions was considered as the maximum that could be "tolerated" by hotels guests. The number was considered adequate for covering the most important objectives of the survey.

The questions included were modified slightly in order to accommodate remarks of guests of a micro sample on which it was tested (utilising an interview method) and to overcome certain difficulties (e.g. avoiding guest embarrassment or interfering with their "holiday experience").

Having secured the willingness of the management of the 8 hotels participating in the survey, an attempt to administer the questionnaire was made. This was not successful mainly for the following reasons :

(a) It was not easy to obtain answers to the questions during their "relaxing" time as most of them were either on the beach or in the public spaces of the hotels (restaurants, cafeterias, lounges etc).

(b) Most of them felt quite embarrassed when interviewed during the time period described in (a). (c) A large number of the guest appeared to be in a hurry to finish the questionnaire as soon as soon as possible and continue .. enjoying their holidays.

(d) Most of the guests could not concentrate and provide accurate answers to the questions.

Following this failure it was considered much more appropriate to place the questionnaires in each occupied room in which the guests would have the privacy, the time and the comfort required to fill the questionnaire.

Once the permission of the management was secured the content of the questionnaire was modified accordingly in order to include an explanatory paragraph with instructions for the guests. A complimentary slip of the hotel was attached to each questionnaire and they were placed one in each occupied room. This method worked very well and the response rate was quite satisfactory.

5.2.1 The objectives of the questionnaire

The questions of the questionnaire aimed at achieving the following objectives.

(1) Understand the way guest feel about the energy (comfort and facilities) provided by the hotel.

(2) Understand the relation (if any) of guest habits (country of residence for the last 2 years) and energy comfort levels and pattern of use.

(3) Establish the time and sequence of energy use by the guests.

(4) Find out on whether guests can handle effectively the energy control devices in their room.

(5) Establish the preference of guests with respect to taking shower or bath in order to relate it with the timing and the quantity of the hot water consumption and the energy required to produce it.

(6) Identify the time spent in various parts of the hotel in order to draw conclusions on the timing and the emphasis that ought to be placed in the supply and quality of energy to the various parts of the building.

(7) Establish the sensitivity of the guests on energy conservation and their possible cooperation in the management's effort to promote it.

5.2.2 Discussion of the results

Table A.E.6 presents the response rate of the questionnaire as a whole and to each specific question. As it can be seen the response rate ranged between 25% and 42 %. The highest response rate involved a business hotel (hotel number 4) located in Nicosia. The majority of the guests provided answers to all of the questions. Question number 2 (concerning the number of hours spent at different parts of the hotels) received the lowest number of answers. This can be attributed to the fact that this particular question was rather elaborate and required some moments of thinking and calculation (could not be answered instantly). The business hotel provided the least replies to this question. Relatively lower response

was obtained (in sample hotels 1, 2,and 7) for question number 6 related to the sequence of bath/shower taking. Considering the relatively discrete character of the question the response can be considered quite satisfactory. The relatively lower response to question number 10 (regarding the use of stickers in rooms) can be attributed to a possible not clear understanding of the question by the guests. Comments on the results of each question are given below.

Question 1

The results of this question (see Table A.E.7) firmly agree with the statistics of the Cyprus Tourism Organisation in which the majority of the tourists visiting the island come from the United Kingdom. It can therefore be concluded that the user habits of tourists from this particular country must be seriously considered. France and Germany were the countries from which most of the other guests originated. It is obvious that the large percentage of tourists from these countries is due to the organised visits of groups. The guests of sample hotel number 4 (a mainly business hotel) contained representatives of 15 nationalities. Though no reliable conclusions can be drawn, the presence of so many nationalities in this specific hotel can be used to make some comparisons. For example in one reply to question number 7 (regarding the temperature of the public spaces) a guest from Japan said that he found it too high, whereas a guest from Iraq found the temperature to be too low! There is thus no generally accepted satisfactory temperature!

Question 2

Table A.E.8 presents the results for this question which concerns the time guests spend in the rooms, the public spaces and the dining areas.

The average time spent in the hotel during the evening (between 6.00 p.m-8 a.m) is 8 hours and this pattern is followed by almost all hotels. The pattern of the business hotel (number 4) varies slightly. For example, guests of the business hotel appeared to spend more time in the hotel during the period 8.00 a.m-6 p.m (possibly due to later departure in the morning and more relaxing time during noon), less time in the public spaces in the same period (time spent outside the hotel for business and in room) and considerably less time in the dining areas between 6.00 p.m and 8 a.m (possibly due to business and meeting arrangements elsewhere).

Figures A.E.1, A.E.2 and A.E.3 present graphical presentations of the time (hours) guests spend in rooms, dining areas and public spaces respectively. Figure A.E.4 presents a combined graphical presentation of time spent in all of these areas. The purpose of this Figure is to enable direct comparison of time spent in all spaces at all times.

Question 3

The large majority of the guests (average 93%) stated that their room temperature was comfortable and only 3% and 4% respectively stated that the temperature was either too low or too high. The case of the business hotel situated in Nicosia

(the hottest part of the island) is again interesting. Only 76% of the guests of this hotels (compared with 100% in some cases) stated that their room temperature was comfortable. The variety of habits (possibly national backgrounds), the higher temperatures of the city and the more heavily (formal) dressing of the businessmen guests) may be some of the reasons of this result.

Question 4

The answers to this question (Table A.E.9) ranged from 57% to 100%. It is interesting to note that sample Hotels 1 and 2 (which had the largest percentage of people that said controlling the room's thermostat was not easy) were the hotels in which real air conditioning control was done from the plant room (and not from the thermostat as it appeared). As a result guests could not feel the effort of their attempts to control their room temperature (through the thermostat) and therefore concluded that they could not do it satisfactorily.

Question 5

The results of this question are also shown graphically in Figure A.E.5. On the average 62% of the guests have declared that they take shower and only 13% said they prefer a bath. Based on this high (75%) shower utilization it would be extremely easy to control the consumption of water in hotel rooms by the utilisation of water flow restriction in the shower.

Question 6

The results of this question are also presented graphically in Figure A.E.6. The range of the response for the guests stated that they prefer shower once a day was 22%-78%. Only 8% (average) of the guests stated that they take a shower more than twice a day, whereas 38% (average) said that they take a shower or a bath twice a day. The combination of results of this question with question 5 can provide useful conclusions with respect to water consumption by guests.

Question 7

The vast majority of the guests (90% average) stated that they considered the temperatures of the public areas of their hotels to be comfortable. The results of sample hotel number 4 are again interesting. In this case almost 30% of the guests stated that the temperature was either too low or too high. This can be mainly attributed to the difference in the background of the guests and their "personal feeling" of temperature. In sample hotel number 6, 30% stated that they found the temperature in public areas to be very high, and thus suggest a significant over-supply.

Question 8

The vast majority of the guests (average 97%) stated that the hot water temperature was good whereas in two cases (sample hotel number 4 and 8) said that the temperature was too high (14% and 5% respectively). There were also two cases (hotels 1 and 3) in which a number of guests (4% and 11% respectively) said that the temperature was too low.

Question 9

The results of this question are quite interesting. On the average 47% of the guests stated that they take their shower/bath in the evening only, whereas 36% stated that they take it in the morning and in the evening. This means that the hot water demand is very high when the supply of solar energy is minimum. Therefore well insulated hot water storage facilities is essential and hot water back up systems must always be available. This limitation of solar energy use in hotels may well be significant in the "total system" design (see Figure A.E.7).

Question 10

The range of positive responses to this question concerning the use of "energy saving" stickers varied between 45%- 100%. For the case of those who reacted negatively to this idea the corresponding range was 0- 43%. On average 86% gave favourable replies. Guests tended to be quite sensitive on the issue (at least they claim to be so) when they were asked politely.

It is interesting that some of the guests had additional remarks that they thought appropriate to write on the questionnaire. For some of the respondents the idea of having stickers in their rooms urging them to conserve energy, (even very politely) was considered as a kind of "insult" since, as they stated, they did not have to be reminded of "such an obvious thing" and that they "knew how to do it"!

Another interesting remark was that certain guests felt that they should be "royalty" during their "glorious holidays" and

that they should not be bothered with such "trivialities". After all, according to their view, they pay for their holidays and they can enjoy the comfort and perhaps the luxury of energy wastage (this view was sometimes reciprocated by managers, especially in the high-charging 5 star category).

A sample guest questionnaire is given in Appendix E2.

5.3 Chief Engineer's Questionnaire

As discussed in Chapter II, the evaluation of the answers given by the chief engineers played a very important role in the formulation of the recommendations of this research. It is also believed that any further action towards improving the "problem situation" would have to take serious consideration of these findings.

Chief engineers constitute the "hidden" heart of the human system of the hotel industry. Their unique role and function is dominated by the fact that they are the persons bearing the responsibility for the proper operation of the hardware of the hotel and the provision of comfort and facilities that enable the guests to enjoy a pleasant stay either for business or for pleasure.

It is quite impossible for the hotel to function and provide any kind of services without the involvement of the chief engineer and his staff. Since all of the services for which the chief engineer is responsible involve the use of some form of energy (electricity, LPG, gasoil etc.) he is also the key

person in the energy management of the hotel.

Air conditioning, catering, lighting, pool heating, refrigerating, and hot water production are all major energy consuming functions of the hotel that fall in the sphere of the chief engineer's responsibility.

Chief engineers are also, at least for the larger hotels, department heads and as such participate in meetings with other department heads and the manager. Because of this function they are in a unique and sensitive position to express their views and influence decisions that concern energy management. There is therefore no doubt that chief engineer's knowledge and sensitivity on the issue of energy and its management as well as his ability to promote within his staff and within his colleagues energy conservation is of vital importance to any serious attempt to implement an energy management plan.

In order to understand and appreciate the quality and the characteristics of this important human resource, a questionnaire was designed and employed.

The questionnaire included 21 questions of the "fill-in-the blank" type, and the rating type. In the questions that involved rating, chief engineers were requested to express their opinion on a certain issue by stating how strongly they felt with the statement using a scale of 1 to 5. Number 5 was used to express strong feelings or total agreement whereas

lower numbers (with number 1 being the minimum) to state less emphasis accordingly.

5.3.1 The objectives of the questionnaire

The main objectives of the questionnaire addressed to chief engineers were the following:

(a) To asses the knowledge the attitude and the sensitivity of chief engineers on energy use and management.

(b) To obtain detailed information related to the experience and the educational background of chief engineers.

(c) To establish the existing communication levels between chief engineers and their managers.

(d) To identify the level of interest and knowledge of chief engineers in energy use, waste and management and determine their interest to learn more about these things .

(e) To obtain information on monitoring and targeting of energy consumption in each hotel and the methods employed by chief engineers.

(f) To obtain information on chief engineers opinion regarding energy conservation prospects for various functions within their hotel.

(g) To obtain the opinion of chief engineers on the applicability of various energy saving technologies for their hotel.

(h) To establish whether chief engineers have proposed energy saving investments and whether their proposals had been accepted or not.

Following the design of the questionnaire a test on a sample

of three hotels was performed in order to identify any modification needs. Useful remarks were obtained from all three chief engineers of this micro sample. All of these remarks were seriously considered when the final questionnaire was redesigned.

The new questionnaire, incorporating the remarks of the chief engineers on the micro sample on which it was firstly tested was mailed with an accompanying cover letter to all 5, 4 and 3 star hotels. Because of various differences on the management pattern, the relatively lower importance given to energy matters (no chief engineer available at least on a full time basis), the low consumption levels and the smaller size of the hotels, no questionnaires were mailed to any of the 1 and 2 star hotels.

As was the case of the questionnaire mailed to the managers of the hotels, the response rate was extremely low (4%). This response rate was considered unacceptable and not reliable for drawing useful conclusions. Despite telephone follow up and the assurance, of several of the chief engineers that they would respond to the questionnaire the response rate remained considerably low for a long period. A similar problem had been experienced with the hotel managers' response rate.

The low response rate of the mailed questionnaires to the chief engineers is attributed to the following reasons:

(a) Chief engineers were very busy and could not therefore allocate the time required.

(b) Chief engineers were not confident on whether their managers would approve of their responses.

(c) Chief engineers might have been instructed by their managers not to reply to the questionnaire.

(d) Chief engineers were not in a position to provide answers to all of the questions and thus felt embarrassed in mailing the questionnaire back.

As was the case of the managers of the hotels, the replies of the chief engineers were considered absolutely necessary for this research and alternative ways of obtaining the information were considered.

The main reasons for which the answers were considered necessary were :

(a) To assess the skill suitability for innovative energy equipment planning and operating.

(b) To asses the interest, motivation and commitment to energy conservation.

As a result a decision to proceed with the method of interviewing was taken for the case of chief engineers as well. The advantages and disadvantages of the method were already analysed in Chapter II.

In order to facilitate the execution of the interviews it was decided to interview the chief engineers of the same sample for which interviews for hotel managers were planned.

The synthesis of the sample and the major assumption was

explained earlier in the analysis of the questionnaire conducted for the hotels managers.

However, it was not always possible to execute the two interviews on the same day, mainly because of different obligations of the two men. It was often therefore necessary to conduct repeated visits to the hotels.

5.3.2 Discussion of the results

Table A.E.10 and A.E.11 in Appendix E3 present tabulated data related to the professional experience and the educational level of chief engineers. This information was considered as being extremely useful in order to asses the "quality" of this vital human resource.

As it can be seen from these tables, chief engineers of all hotel categories have an average experience of 16 years. The range of this experience however is quite large and varies from 3-40 years. There is not much difference between the average number of years of experience of the chief engineers of the various hotel classes.

The maximum number of years of experience for the 3 star class of hotels is considerably lower.

The highest level of education for most of the chief engineers in the hotels was that of the High school. Table A.E.11 shows that almost half of the chief engineers interviewed (48%) were graduates of High schools. Chief

engineers with college level of education constituted 7% whereas those with University Diplomas (B.Sc.level) 27%. It is interesting to note that on the average 16% of the chief engineers had only attended elementary schools. Only 1% of the chief engineers had post graduate degrees(M.Sc. level). The largest percentage of chief engineers with University qualifications concerns, as expected, hotels of the higher categories (4 and 5 star) whereas there was no university graduate chief engineer working for the 3 star hotels. At the other side of the scale the highest percentage of high school graduates involved the same (3 star) class of hotels .

It is extremely important to have background information on the educational "quality" of this vital human source in order to communicate effectively with it and promote energy efficiency effectively.

As far as the academic subject of studies was concerned the majority of the chief engineers (65%) had studied mechanical engineering, 15% had attended a curricula of electrical engineering, 10% refrigeration and air conditioning and an other 10% had attended a course for plumbers.

At least from their statement to the question on energy conservation, it can be concluded that all of the industry's chief engineers are sensitive to the issue. All of the chief engineers of the sample had replied that they consider energy conservation as being an important issue! If this is the case then there is a serious problem of "feeding" chief

engineers with the right methods and knowledge required to attempt and achieve energy efficiency.

Questions 5 was included in order to appreciate the responsibilities of the chief engineers and evaluate the number of people they manage in order to see the level of assistance and the degree of difficulties they have. The average number of personnel supervised was 10 whereas, as expected, the highest number of staff involved was in the 5 star hotels (17), and the lowest in the 3 star hotels (2). The number of people supervised varied considerably and ranged from 0-21 people. Table A.E.12 shows the detailed data obtained from this question.

Question number 6 was included for the purpose of establishing information on whether chief engineers have or are implementing any energy conservation measures in their hotels. The question aimed also at identifying these measures and to test in a way their knowledge on various technologies. All of the chief engineers responded that they have implemented various measures. The measures varied considerable both by function and by cost. These measures include lighting controls, key fob systems, door magnetic switches, BEMS and power factor correctors.

The intention of question 7 regarding measuring and controlling instruments was to establish the level of control of energy consumption. Since nothing can be controlled if it can not be measured, measuring the consumption of energy is

extremely important. However hotels equipped with anything more than the standard electricity and water meters constituted a mere exception (3%). It is believed that separate electricity meters in the various parts of hotels are very useful in both measuring, controlling and motivating for energy conservation. These electricity meters do not cost much and can be easily installed.

The system of rating was employed for four questions (questions 8,9,10 and 13). This system was considered more appropriate because chief engineers could demonstrate how strongly they felt about each statement.

Numbers in between meant feelings of relative degree of agreement. The results of each of these questions were tabulated in four tables; one table for each of the hotel categories and a fourth table in which the data of all responses were combined.

Tables A.E.13 ,A.E.14, A.E.15, and A.E.16 present the tabulated results of question number 8 that concerns the opinion of chief engineers on the level of energy consumption of various energy consuming centres in their hotels.

In order to rank the various consumption centres with respect to the importance placed on them by the chief engineers, a weighted sum (point score x percentage of each reply) was evaluated, (overall rating = final column). No credit was given for a "no" reply or for "no opinion".

Table A.E.16 presents the ranking of these perceived consumption centers for each class of hotels and for the overall average as well.

All of the chief engineers seemed to understand the huge consumption levels of the kitchen compared to all other energy consumption centers. With the exception of the 4 star group of hotels all 5 and 3 star and in overall average, the kitchen ranks first. In the overall average, the kitchen is followed by the rooms, the pubic areas the bar/restaurant and "other areas", in rank order.

Chief engineers of the 5 star hotels have rated the public areas as second in importance. It is a fact that the size, the function and the various energy consuming facilities of these areas are much more energy intensive than for other (lower) classes of hotels. It is also much more important with respect to energy quantities used than rooms, bar/restaurants and other areas of the hotels. It is considered that the evaluation of the chief engineers is quite right, and the difference between this opinion and the opinion of hotel managers is notable (see previous section).

Question number 9 aimed at obtaining the opinion of the chief engineers regarding the waste level of the various energy consuming centers within their hotel.

Tables A.E.17, A.E.18 and A.E.19 present the percentage of responses to the rating of each energy center, according to

the opinion of the chief engineers for the case of the 3 star, 4 star and 5 star hotels respectively. Table A.E.20 presents the weighted average results whereas Table A.E.21 presents the ranking of energy waste level of the various energy consumption centers.

It is seen from Table A.E.21 that the kitchen is considered by the majority of the chief engineers as being the energy consumption center in which most of the waste takes place. This however should not be taken as being absolute since there exists a tendency to assume that large consumption relates to large waste.

Since chief engineers consider the kitchen as being the largest consumer they do consider it as the greatest "waste point" as well, usually without much proof. This fact is also underlined by a comparison of Table A.E.16 related to energy consumption levels and Table A.E.20 related to the level of waste. When we compare the two columns labelled "overall" we see that the evaluation is similar. That is the perception, not necessarily correct, is "large consumer means large waste and that small consumer means small waste". In several cases chief engineers (mostly at the lowest class of hotels) were not able to rate the level of waste at the various energy consuming centers of their hotels. This underlines the necessity of providing training and education and possibly measuring "tools" for the chief engineers, in order to enable them to know and understand their hotel better.

Question number 10 aimed at obtaining the opinion of chief engineers regarding the prospects of energy conservation for the most important energy consuming equipment and systems. Tables A.E.22, A.E.23 and A.E.24 present the results of this question in percentages of the chief engineers that gave a specific rate to each question and Table A.E.25 presents the weighted average results of all chief engineers in all hotels. From this analysis it is obvious that both for the case of specific class of hotels and for all of them as a group, air conditioning presents, the greatest prospects for energy conservation. During discussions it was concluded that this rating by chief engineers underlines their concern over this vital energy consumption centre .

Lighting is also of major concern to all chief engineers as they rate it second in importance. It is however surprising to see that chief engineers do not consider the laundry as presenting good prospects for energy conservation. Laundries are undoubtedly large energy consumers and there are certainly very good prospects for energy conservation. However not many chief engineers have any experience with laundries since not many hotels have their own laundries.In fact 55% of the chief engineers of the three star hotels (none of them have laundries) did not express any opinion on this question.

Question number 11 aimed at identifying whether chief engineers had taken the initiative of suggesting any energy conservation measures. All of the chief engineers stated that they had, at various times, suggested conservation measures.

The measures varied from case to case, and the most important of them are given below :

(a) Introduction of energy efficient lamps

(b) Power factor control units

(c) Solar energy system for hot water

(d) Double glazing

(e) Building Energy Management Systems

(f) Key Fob Systems

(g) Exhaust fan control

All of the chief engineers stated that their suggestions had been accepted and adopted by the management of their hotel.

Question number 13 aimed at obtaining the opinion of chief engineers on the suitability of a number of the most important technologies for the hotels. Chief engineers were asked to rate nine of these technologies according to their own evaluation. The question served at establishing the awareness, the level of knowledge and the interest of chief engineers on new technologies. Tables A.E.26, A.E.27 and A.E.28 present the results obtained from the analysis of the questionnaires for the 3, 4 and 5 star class of hotels individually whereas Table A.E.29 shows the weighted average values of these data. It is obvious that the most "popular" technology among chief engineers is the technology of the magnetic switch. This is a magnetic switch installed on the balcony doors of hotels which interrupts the operation of the fan coil in the hotel room as soon as the balcony door is open.

Insulation is also highly rated among chief engineers and therefore ranks 2nd among all measures followed by the key fob system, the heating of water by solar energy, the BEMS heat recovery, solar cooling and chp.

From this analysis it is derived that "unknown" technologies are rated very low. However this is not necessary correct. Unknown (to the chief engineers) are most probably non tested technologies and thus no objective judgement regarding their suitability can be made. We believe that chief engineers should be "educated" in the performance and suitability of new technologies in order to be able to recommend them to their employers. For example heat recovery and chp option could have very good prospects despite the extremely low rating given to them by the chief engineers.

The need for continuous updating of the knowledge and level of education of chief engineers is well underlined by the results of question number 13 for the case of the three star hotels (see Table A.E.26). As can be seen from this table, an extremely large percentage of chief engineers were not in a position to express an opinion on various technologies such as BEMS, Solar HWS, Solar cooling, heat recovery and even insulation. This percentage decreased for higher classes of hotels. The technology for which the largest number of chief engineers were unable to express an opinion was that of combined heat and power (Tables A.E.26, A.E.27 and A.E.28) which rose to the 67 % level for the case of the 3 star group of hotels.

It is interesting to note that chief engineers of the 5 star class of hotels have rated heat recovery technology quite highly, (third).

All of the chief engineers interviewed (questions 14,15) stated that they attend regularly meetings with the management of their hotels. All of the chief engineers were able to provide details of consumption (question 16) for the various forms of energy utilized in their hotel.

Question number 17 aimed at :

(a) establishing on whether chief engineers knew exactly what power factor meant

(b) identifying on whether chief engineers were satisfactorily monitoring their power factor and the level of their hot water temperature.

These two parameters were chosen because of their importance and the relatively easiness of memorizing their value. The value of the hot water temperature given varied considerably (between 40-70 degrees Centigrade). Chief engineers always claimed that the value they had chosen to set the operation of their boilers was the "correct" one. This fact underlines the necessity of providing specific guidelines and training to the chief engineers in order to avoid energy waste.

The replies of some of the chief engineers to the question of the power factor were overwhelming! From their replies it

was obvious that they had no clear idea of what power factor was. Replies included: 250 kVA, 100 hp etc ! Though these outlandish replies were not the rule but the exception (only 3%) the need for training is again underlined.

Only 10% of the total number of chief engineers interviewed stated (question 18) that they had taken any specific training on energy conservation.

All of the chief engineers (question 19) stated that they are interested to learn more about ways of conserving energy. Since the willingness is there the need for education, to be provided by either the public or the private sector, is emphatic.

All of the chief engineers claimed (question 20) that they do set targets for energy conservation and their targets were said to be based on (question 21) either a percentage reduction of last years consumption on the total energy consumption or on results shown on monthly graphs of previous years.

A sample questionnaire addressed to the chief engineers is found in Appendix E 3.

CHAPTER VI

THE ROLE OF ENERGY CONSULTANTS

6.1 General Considerations

The findings and remarks of this research tend to support and develop the conclusions of Jacques and Wood (1982,1984) in their work on models of energy consultancy.

Despite the increasing importance of the role of energy consultants, we were not able to locate any in depth analysis of their role, the problems they face, their contribution and drawbacks of their efforts.

This Chapter develops the tactical themes required for achieving success in the overall strategies of energy consultancy (Jacques and Konis, 1991).

Energy consultants could play a vital role in the overall hotel energy system of a country. Their ability to cope with their specific assignments, the depth of knowledge of their specialized subjects and the level of the success of their attempt to convince hotel owners for the need of implementation of their recommendations, are basic factors of their important mission.

This mission becomes considerably more serious when carried out in a developing Mediterranean country. The reason for this is that countries such as Cyprus, striving for reduction of energy imports and energy efficiency, can not

(more than most) afford the luxury of wrong investments, poorly targeted efficiency measures and policies, nor the adoption of inappropriate technologies. All of these problems can be the consequence of poorly managed energy consulting services. However, efficient consultants, submitting proper site-adequate proposals and recommendations, can contribute significantly towards the achievement of energy efficiency and the establishment of a cost effective operation of a business.

Energy management is a relatively new field. Though Cyprus has one of the highest rates of University graduates in the world (including hundreds of engineers and architects) there are very few holders of energy related degrees. The practice of professional energy consulting is even more limited and there are not more than two companies performing actual energy consulting work on the island.

The two professional energy consulting firms do not operate in a particularly "friendly" market environment. The fact that most of the hotel owners and hotel managers are not aware of their energy problems, combined with the absence of any background on the subject, does not allow them to appreciate the services of a professional energy consultant. Consultants are, therefore, burdened with the task of convincing hotel owners and managers of the expected benefits. Very rarely will a Hotel owner or manager, on his own initiative invite, an energy consultant to perform an energy audit in his premises.

Energy consultants hired by the government have, almost

always, been appointed and compensated through a foreign loan (usually the World Bank or other Agencies or Institutions). In some case the loan may be part of an assistance through a development program. The selection of the consultants by a local committee is always approved by the Agency providing the loan. A local committee evaluates applications from local and foreign consultants as well as from "joint ventures". A major problem identified at this stage is the fact that the local committee, though well qualified, is assigned with the task of, selecting a foreign energy consultant based on the resume of himself and his company. This is not an easy task. There is always a great risk of placing too much emphasis on points with less real value, while ignoring others of considerable importance.

One example of a usually not well evaluated item is the consultant's previous working experience in a foreign country and his ability to communicate and cooperate well with others. The selecting committee will have to consider heavily two major factors. These are <u>related</u> experience and previous overseas assignments. Experience has shown that very often committees tend to overemphasize the importance of impressive experience while failing at the same time to differentiate and appreciate that impressive experience is not always related experience.

It is not uncommon for a consultant with an extremely impressive experience to perform poorly in an unrelated or unfamiliar assignment. The ability of a consultant to work, communicate, cooperate and perform in a sometimes entirely

different than he is used to environment, in a foreign country, must never be underestimated.

Another major point of caution when selecting energy consultants to work for both government or private assignments is the vital necessity of a personal interview. This is considered absolutely essential. In the case of government agencies it is advocated that they should insist on a personal interview even if it has to be carried out on public budget. The benefits of such a meeting far supersede the cost involved. It is during this meeting that several vital points concerning the proposed assignment are cleared. Government committees will have the opportunity, if they are well prepared, to assure correct communication between the two parties.

Job descriptions and job terms constitute a very important element of the client-assignment-consultant system. In the case of public projects these descriptions are in general written by a foreign expert in collaboration with government officers. It is of vital importance that the author of the job terms be a member of the selecting committee. In a particular case with which the Author was involved job terms were written by a foreign consultant who never had the opportunity to participate in the selecting procedure. It is imperative that there will be a direct person to person discussion on each term of the assignment between the members of the selecting committee and the prospective consultant. Only then will the two parties feel confident that there is a common understanding of the expected output of each task. In this specific case there were serious

communication problems between client and prospective energy consultant. There were several points where the understanding of the consultant was entirely different from that of the client. In another case the client was unable to provide detailed answers regarding expected tasks since the persons present at the meeting had not personally been involved in the preparation of the terms of the assignment. Explicit understandings are, from the outsets, essential.

There are several important points that derive from the experience of working with foreign and local Cypriot energy consultants. The most important of these points along with recommended actions for improving the situation are now discussed.

6.2 Attitudes of the consultants

Besides problems of improper interpretation of job terms there appeared to be other problems, mainly relating to attitudinal and communicational difficulties :

(a) The first type of consultant's attitude is termed the "no challenge attitude". This attitude derives from the fact that foreign energy consultants, being aware that energy management is a relatively new subject in Cyprus, tend to overestimate their experience and knowledge while at the same time seriously underestimate the spirit of enquiry of their local collaborators.

As a result, consultants assume that there is no

possibility of their recommendations, methods and findings being challenged by anyone. When finally they are challenged they tend to resume a defensive stand which results to the formation of an unpleasant and sometimes non cooperative atmosphere. This "no challenge attitude" may also result in the preparation of a report that will contain unjustified recommendations and proposals, both for the technical and the financial suggestions and procedures employed. Thus, in one case, consultants held a very defensive stand when they were asked to perform their cost effectiveness analysis (of proposed major investments) using the life cycle cost analysis method in addition to the customary crude pay back period method. No concept of risk analysis was offered. We therefore believe that while there is a real need on behalf of clients to know as much as possible about their consultants, there is also a need for the consultants to know as much as possible about their local collaborators. This knowledge should involve the country, the educational and technological level, the energy infrastructure and the particular economic sector in which they will be working. In fact all these "background" factors will contribute to mutual understanding and sound team-work.

(b) The second attitude identified, which is valid for both foreign and local consultants, is termed as the "rush attitude".

This attitude refers to the fact that consultants appear, almost always, to be in a hurry to complete specific tasks as soon as possible and without spending much time and effort to

appreciate systemic and interactive difficulties.
This behaviour is most probably initiated by the fact that their financial cost will be reduced if they finish their assignment ahead of schedule. It is not implied that it is the practise of consultants to submit their final report earlier than their planning (budgetary) deadline; rather, in many cases, energy consultants do not allow sufficient time for site visits, discussions with persons involved, actual on the job observation and collection of primary data. It is not uncommon for consultants to appear quite satisfied once the collection of basic data is completed. Immediately after that, they appear to be in a rush to work on their data doing mostly office work from which an impressive and often weighty report results.

It is not advocated that a consultancy assignment can be completed without the required office work. The intention of the remarks is to underline the risks involved from rushing to the write up phase too soon and without a fully systemic analysis of the overall hotel problem environment.
This "rush attitude" of energy consultants usually leads to mistaken observations and conclusions. At the same time the attitude does not allow the energy consultant to employ a systemic approach and thus consider all factors involved. Thus sub-optimisation often results.

(c) A third problem concerns communication and cooperation with staff in each hotel audited. It has been observed that even in the cases in which hotels volunteer to participate in energy audits, the staff assigned to work with the consultants feels

quite threatened by the presence of the consultant. The consultants and his collaborators were usually faced as "invaders" since their actions and possible findings were thought as having the possibility of having negative consequences for them. The ability of the consultant to create a cooperative atmosphere using sensible tactical and diplomatic approaches is of vital importance.

A good climate of cooperation has to be maintained for the whole period of the audit. In one recent case, an audit which had been under way had to be abandoned because at a certain point the management of the hotel became totally unwilling to cooperate further with the consultants. This fact caused considerable delay to the execution of a large public project of which this was a component, and an entirely new site had then to be found in order to start a new, unbiased, audit.

6.2.1 Guidelines for achieving good consultant-client cooperation and communication

A good approach recommended for consultants in order to avoid the problems is discussed is the following:

(i) Try to give credit for any good work being carried out by so far (with respect to energy conservation) to the hotel staff involved.

(ii) Indicate, in a friendly and tactful way, possible omissions and wrong doings to the staff concerned, never failing to add that these mistakes are typical and that they

have been seen in other places as well.
Statements of this nature do contribute considerable to the establishment of a good working atmosphere.

(iii) The following remarks concern the oral presentation of findings of the audits to the hotels concerned.

(a) In many cases there is a problem of communicating the findings to the management of the hotel concerned. It is imperative that simple everyday language is used avoiding technical and financial jargon. The problems have to be stated clearly and simply. The proposed solutions must be presented in a clear and practical way and be supported by a summary of all relevant benefits (financial and other benefits). Possible drawbacks should be stated. While a detailed cost-effectiveness analysis is highly preferable for the final written report, a simple brief reference is more appropriate for these verbal presentations. We believe that other measures, which the consultant believes are worth considering (despite long "payback" periods) should also be presented. An effort should be made to explain tactfully to the management and sometimes to the head of the technical department that the crude pay back method is not the best financial criterion. Too often consultants use the crude "payback" criterion because they believe that this is what the client expects. It is the duty of the consultant to extent his client's horizons to long term thinking and not to ignore potential risks over the time horizon (created for example by changed fuel prices and/or availabilities or changed use patterns (e.g.business/tourist).

(b) The management of most hotels appears very anxious to hear about low cost solutions but were very hesitant to consider investments that involved investments of more than one or two thousand pounds. An additional task for the consultant would be to explain that an investment that costs less is not necessarily better than an investment that costs more. Again, the remit goes properly beyond the narrowest interpretations of the contract, in the interest of widening the client's appreciation of the larger problems and their systemic solutions.

(c) The management of many hotels appears reluctant to consider proposed measures that had not already been implemented by others in the country. This derives possibly from a local mentality that requires first hand evidence and testimony before proceeding with the adoption or the acquisition of anything. It is however wholly in line with general problems of innovative adoption.

The typical question demanding an answer from the energy consultant in these cases is the following: "Who else has invested in this measure and how satisfied is he ?". Consultants will have to be prepared to give possible indirect answers to this questions but reference to closely related demonstration schemes (cfl, ETSU/Harwell publications) could be helpful, despite the acknowledged problems of "replication potential" ideas (Fawkes and Jacques 1987).

(d) Most consultants, while having a good knowledge of the technical aspects of their subject appear to have considerable lack of necessary analytical and communication skills.
We beleive that knowledge of these subjects is a necessary prerequisite in order to perform a complete and thorough energy audit.

6.3 Proposed procedural plans

Table 6.3.1 and 6.3.2 present two procedure plans developed for the purpose of assisting clients (government officials or hotel owners/managers) and consultants in their collaborative tasks. The models of these tables serve to summarise some of the key issues of consultancy illustrated in this Chapter.

Table 6.3.1 presents a procedure plan that assists energy consultants to consider evaluate and accept an energy audit contract. Table 6.3.2 presents a procedure plan aiming in assisting clients to evaluate, select and cooperate with energy consultants.

Though the two models assume a public agency as being the client it is believed that the procedures apply equally well for the case of individual hotel owners/managers as well. These schemes represent recent developments, based on real experience of the conditions in Cyprus, in comparison of earlier models of Jacques and Wood (1982). Table 6.3.1 represents a new model deriving from a need demonstrated well during real life experience. The major differences of the model shown in Table 6.3.2 with earlier models are denoted with an asterisk.

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1 Understand job terms - Ask for necessary clarification

2 Evaluate Project and establish whether interested

3 Obtain general information on country and hotel

4 Establish knowledge for : country's energy infrastructure, sector concerned, technological level, human element involved

5 Evaluate analysis of phases 2, 3, 4 together and decide whether to proceed

6 If decided to, proceed, design strategic plan and include in the quotation/proposal

7 Seek to present strategic plan and proposal in person to the client

8 Modify strategic plan accordingly and list specific tactical approaches to be tested

9 Secure clients cooperation

10 Proceed with signing of the contract

Table 6.3.1 : Procedure plan for Energy Consultants for Evaluating an Energy Audit/Study Project

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1 Evaluate applications-Consider cost and related experience

2 Arrange for personal interview with prospective consultants

3 Ensure common understandability of job terms

4* Evaluate consultants knowledge of: country situation, sector concerned, technological level, infrastructure, human elements

5* Request strategic plan

6 If satisfied with stages 2, 3, 4 and 5 proceed with negotiation of tactical methods, prior to signing of contract.

7 Discuss strategic plan in detail and suggest modifications to this and to tactical requirements

8* Introduce consultant's collaborators and establish sound communication and cooperation levels

9 Monitor progress and assure execution of works according to the proposed tactical plan and time schedule

10 Discuss content of consultant's final report, ensure complete understanding of report content in both its tactical and strategic aspects

11*Decide on measures to implement, and seek consultant's assurance for "out of contract" advice/assistance

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Table 6.3.2 : Procedure plan for Hotel Owners/Managers for Evaluating/Selecting/Cooperating with Energy Consultants

Notes on Tables 6.3.1 and 6.3.2

Table 6.3.1

Stages 1 to 4 were discussed above. The designing, presentation and modification of a strategic plan (stages 6 and 7) are of most importance. Experience has proved that in many cases the absence of a strategic plan by which the consultant intents to tackle the various tasks of his assignment causes serious problems while carrying out an energy audit. It is also very important that the strategic plan be presented (stage 7) to the client in person. The reason for the personal presentation advocated is that the consultant will be given an opportunity to answer questions, listen to the remarks of the client and modify his plan accordingly (stage 8). A mutual agreement on this plan is very important since in contracts of this nature consultants and clients have to work as a team.

Table 6.3.2

Stages 1 to 7 were discussed above. Stage 8 concerns both the case of a consultant being employed either by the government or by an individual hotel. It is the responsibility of the client to make every effort so as to feel confident that the person assigned to work with the consultant will be cooperative. Stage 9 refers to the obligation of the client to monitor the progress of the work and assure that there will be no serious deviations from the strategic plan mutually agreed (stage 7). Experience has shown that the feeling of being monitored leads to a better and more disciplinary work by consultants.

Stage 10 underlines the importance of the client discussing the context of the report with the consultant and assuring its content is well understood. This will avoid problems during the implementation phase in which, most probably, consultants will not be available for assistance and clarifications.

In many cases clients fail to understand the importance of the content of the energy audit report submitted to them. In fact this is the main reason that so many reports are left on the shelves of the executives never finding their way to the implementation stage.

In many cases clients never have the opportunity to have thorough discussion with the consultant. This can be mainly attributed to lack of time and/or lack of background on behalf of the client to carry out such a discussion. As a result clients also do not feel confident to decide to implement a recommended measure in the future without the assistance of an expert. However, most consultants appear willing to provide no cost advise or assistance long time after the completion of their contract.

Stage 11 aims at underlying the above facts and urge clients to decide on measures during the presence of the consultants and thus taking advantage of his presence and personal guidance.

Unless proper attention is given to the problems described in this section the effectiveness of the services of energy

consultants can be considerably reduced. This is not only bad for the individual hotel, but also, in the long run, is likely to be bad for the reputation of consultants.

The field work of this research shows that consultants and hotel managers in Cyprus have still not digested the lessons of the work reported in earlier studies (Jacques and Wood 1984) nor are they working to general good practices of consultancy in the team-context, as discussed by several authors (Belbin,1981; Tisdall, 1982; Greiner and Metzger, 1983; Kubr, 1986).

CHAPTER VII

ANALYSIS OF ENERGY RELATED FACTORS

7.1 General correlations

This Chapter presents the results of various attempts to establish the degree of correlation between the energy related factors. The results are based on an analysis performed utilising a statistical software package ("Statplan") of the data contained in the energy database created during this research.

The first analysis attempted to establish relations between the number of tourists arriving each year, the number of bednights, and the total energy and total electricity consumed, by the sector as a whole.

The following is a summary of the results of the statistical analysis performed (further detail is provided in Appendix F).

(a) Ho: There is a strong correlation between the number of tourists arriving in the country and the total energy consumed by the hotel industry.

(b) Ho: There is a strong correlation between the electricity consumed by the hotel industry and the total number of bednights.

(c) Ho: There is a strong correlation between total energy consumed by the hotel industry and the number of bednights.

(d) Ho: There is a strong correlation between the number of tourists arriving in the country and the total electricity consumed by the hotel industry. The parameters of the linear equations (Y=ax+b) yielded for each of the hypotheses above with the related correlation coefficient, all significant at the 99.5% confidence level, are shown in Table 7.1.1 below.

Ho	Y	x	a	b	r^2
a	Energy (million MJ)	Tourists (thousands)	66.457	270.73	0.959
b	Electricity (million kWh)	Bednights (millions)	8.277	34.266	0.961
c	Energy (million MJ)	Bednights (millions)	66.45	270.33	0.959
d	Electricity (million kWh)	Tourists (thousands)	8.277	34.247	0.961

Table 7.1.1: Basic correlations between tourism, electricity and total energy useage (Years 1983-1989).

7.2.1 <u>The Hotel Industry as a whole</u>

As far as the industry as a whole is concerned (not considering individual classes of hotels) an attempt to

establish the degree of correlation between energy related variables was performed. These variables were: number of rooms, hotel class, number of occupied beds, hotel area, oil consumption, LPG consumption, electricity consumption, total energy consumption, number of degree days for heating and number of degree days for cooling. The correlation analysis performed for all of the variables above resulted to the Correlation Matrix shown in Table 7.2.1. From Table 7.2.1 it can be seen that there is significant correlation at the 99.5% confidence level between the number of rooms and the variables of total energy, electricity and LPG consumption respectively. Correlations at the same level of significance with each of the last three variables (total energy, electricity and LPG consumption) and the variables of hotel class and occupancy were also established.

No correlation was established between the consumption of gasoil and the number of degree days heating. This is attributed to various factors the most important of which are likely to be:

(a) Inaccuracy of data. Gasoil consumption is not actually metered.
(b) Low occupancy during Winter (parts of hotels may not be heated while unoccupied).
(c) Gasoil in most of the hotels is used for heating sanitary water as well.
(d) There is extreme complexity and variation to the use of the spaces and the functions taking place in each hotel.

Large areas of hotels may or may not be used (and thus not heated) according to the specific requirements.

(e) Gasoil heated systems may be run "flat out", or in a non-responsive way.

Significant correlation at the 99.5% level of confidence was also established between the electricity consumed and the area of a hotel and between electricity and the number of beds occupied each year. This result would accord with the considerable amount of "fixed" lighting in corridors and social spaces. No correlation was established between the number of degree days cooling and the electricity consumption (r^2=0.032). In practice we have observed oversizing of the air conditioning systems, inefficient controls and lack of consideration for zoning as the most likely explanations for this situation. In other words the supply system is run in a non-responsive (un-managed) mode.

	Rooms	Oil	Elec	Energy	LPG	Area	DDH	DDC	Class	Bocc
Rooms	----	.798	.874	.885	.770	.991	-.017	-.007	.791	.851
Oil	.798	---	.828	.950	.783	.816	.077	.129	.692	.586
Electr	.874	.828	---	.957	.713	.896	-.054	.032	.766	.708
Energy	.885	.950	.957	---	.820	.906	.003	.074	.780	.693
LPG	.770	.783	.713	.820	----	.790	-.031	.010	.738	.649
Bocc	.851	.586	.708	.693	.649	.823	-.092	-.240	.610	---
Area	.991	.816	.896	.906	.790	---	.013	.004	.843	.823
DDH	-.017	.077	-.054	.003	-.031	.013	---	.593	.076	.092
DDC	-.007	.129	.032	.074	.010	.004	.593	---	.003	-.24
Class	.791	.692	.766	.780	.738	.843	.076	.003	---	.61

Table 7.2.1: Single Factor Correlation Matrix for the whole industry (N=51, DDH=Degree Days Heating, DDC=Degree Days Cooling, Bocc=Bed occupacity)

7.2.2 The 5 star class hotels

Table 7.2.2 presents a correlation matrix which is the result of a correlation analysis for the population of 5 star hotels. The most important correlations established for this class of hotels (six hotels in all) which were significant at the 99.5 % level of confidence are the following:

(a) A significant correlation was established between the total area of the hotels and the degree days heating. In contrast with failed attempt to correlate significantly

these variables for the larger total sample, this correlation this correlation can be attributed to the existence of better heating controls and usually better design of the building and its heating system in this high-class group.

(b) A significant correlation was established between the total area of hotels and the total energy consumed. The same correlation of area holds for the consumption of oil as well but not for the consumption of electricity. This emphasises the use of oil in non- variable applications (water heating especially).

	Rooms	Oil	Elec	Energy	LPG	Bocc	Area	DDH	DDC
Rooms	---	.731	.672	.836	.077	.469	1.00	.388	.332
Oil	.731	---	.499	.892	.089	-.128	.731	.830	.856
Electr	.672	.499	----	.833	-.580	.364	.672	-.020	.080
Energy	.836	.892	.833	---	-.200	.150	.836	.503	.566
LPG	.077	.089	-.580	-.200	----	.092	.077	.294	.174
Bocc	.469	-.128	.364	.150	.092	----	.469	-.508	.587
Area	1.00	.731	.672	.836	.077	.469	----	.388	.332
DDH	.388	.830	-.020	.503	.294	-.508	.388	----	.973
DDC	.332	.856	.080	.566	.174	-.587	.332	.973	---

Table 7.2.2: Single Factor Correlation Matrix for all variables for the sample 5 star hotels (N=6)

Surprisingly enough no significant correlation was established between occupancy and the overall consumption of energy.

Occupancy was not even correlated with the consumption of LPG which is directly and solely used for cooking. This can be attributed to the fact that the pattern of use of the catering services is usually the same irrespective of the number of guests in the hotel or the individual usage of facilities. (Particularly in 5 star hotels the services offered are widespread and frequently 24-hour available, but with few clients in some of them).

There are also cases in which efficiency is sacrificed for effectiveness (best service of the guests). An example is the case of large toasters, and coffee makers which were often found to be operating continuously in order to accommodate sudden customer demands at all times.

No correlation was found between the number of cooling degree days and the consumption of electricity. This result strongly suggests a lack of control over air conditioning utilities within hotels .

7.2.3 The 4 star class of Hotels

Table 7.2.3 presents a correlation matrix for all the variables related to energy consumption for the group of fifteen hotels of this class included in the sample.

The most important correlations that were established as significant at the 99.5% level of confidence are the the following :

(a) There is significant correlation between the number of rooms of a hotel (and its area) and the total energy consumed. These variables were also correlated with the total electricity and the total gasoil consumed. The correlation is attributed to the need for larger energy supply systems for increasing size of hotels.

(b) In contrast with the group of 5 star hotels there is a significant correlation between total energy consumed and and the number of occupied beds per year.

This can be attributed to the fact that in the 5 star hotels,the considerably higher number of social functions taking place (conferences, dances, receptions etc) consume much higher quantities of energy than the 4 star hotels.

As in the case of the 5 star hotels no correlation was established between occupancy and LPG consumption, gasoil consumption and degree days for heating and electricity consumption and degree days for cooling. The reason for this is the fact that provision of heating and cooling to unoccupied areas is not, as observed, cut off, mainly due to lack of controls.

	Rooms	Oil	LPG	Elec	Energ	Bocc	Area	DDH	DDC
Rooms	-----	.591	.435	.747	.684	.891	.997	-.264	-.198
Oil	.591	----	.818	.811	.954	.438	.589	-.306	-.145
LPG	.435	.818	----	.726	.853	.417	.431	-.248	-.076
Electr	.747	.811	.726	-----	.943	.602	.731	-.467	-.093
Energy	.684	.954	.853	.943	----	.542	.675	-.395	-.121
Bocc	.891	.417	.602	.542	.542	----	.876	-.442	-.265
Area	.997	.589	-.431	.731	.675	.876	----	-.217	-.232
DDH	-.264	.306	-.248	-.467	-.395	-.442	-.217	----	-.378
DDC	-.198	-.145	-.076	-.093	-.121	-.265	-.232	-.232	---

Table 7.2.3: Single Factor Correlation matrix for all variables for the sample 4 star hotels (N=15)

The lack of correlation between LPG consumption and occupancy is explained by the fact that the actual energy used for cooking is not directly related to the number of meals prepared. In addition, as it was seen during site visits, a large number of cooking appliances is left continuously in operation as meals are offered on a 24 hour basis.

7.2.4 The 3 star class of Hotels

Table 7.2.4 presents a correlation matrix for all the variables related to energy consumption for the hotels of this class included in the sample (24 hotels). The correlations significant at the 99.5% level of confidence established are shown in the next page.

(a) There is a significant correlation between the number of rooms (and the hotel area) and the total energy, electricity gas oil and LPG consumption individually. The correlation is explained by the need for larger systems (for heating and cooling) with increasing size of hotels.

	Rooms	Oil	LPG	Elec	Energ	Bocc	DDH	DDC	Area
Rooms	-----	.511	.628	.867	.751	.779	-.168	-.005	1.00
Oil	.511	----	.728	.608	.908	.576	-.028	-.001	.509
LPG	.628	.728	----	.733	.863	.531	-.118	.025	.625
Electr	.867	.608	.733	----	.877	.694	-.141	-.007	.865
Energy	.751	.908	.863	.877	----	.693	-.095	.000	.749
Bocc	.779	.576	.531	.694	.693	----	.138	-.260	.780
DDH	-.168	-.028	.118	.141	-.095	.138	---	.459	-.169
DDC	-.005	-.001	-.025	-.007	.000	-.260	.459	----	.007
Area	1.00	.509	.625	.865	.749	.780	-.169	----	.007

Table 7.2.4: Single Factor Correlation matrix for the sample of 3 star hotels (N=24)

(b) In contrast with the 5 and 4 star hotels there is a significant correlation between the consumption of LPG and the occupancy of the hotels. The explanation for this correlation is the following. In the hotels of this class meals are not offered on a 24 hour basis but only on fixed pre determined periods. Therefore the need for continuous operation of cooking appliances is eliminated. In addition, in contrast with

the hotels of the 5 and 4 star class, meals are usually served for hotel occupants only.

(c) There is, in contrast with the 5 and 4 star hotels significant correlation between the number of occupied beds in a year and the consumption of total energy, electricity and LPG individually. Since, as observed during the field work of this research, these hotels do not have better energy control systems than the 4 and 5 star hotels, the correlation can be explained by the absence of energy requirements for social activities. Furthermore, the energy consumed in public spaces in these hotels, compared to the energy used by hotel guests in rooms is much lower than the corresponding 5 an 4 star hotels.

No significant correlation was established between the number of degree days cooling and the consumption of electricity. This emphasises that air conditioning is perceived as a fixed cost in a wholly uncontrolled sense.

7.2.5. <u>The 2 star class of Hotels.</u>

Table 7.2.5 presents a correlation matrix for the six hotels of this class included in the sample. The most important correlations, significant at the 99.5% level of confidence are shown in the next page:

(a) There is a significant correlation between electricity consumption and the number of rooms of a hotels (and its area) This is attributed to the small size of common areas and the

very limited number of energy consuming social events taking place in these hotels. Furthermore, the size of the plants is primarily depended on the number of rooms.

(b) There is a significant correlation between occupancy (total number of occupied beds in a year) and electricity consumed. The correlation is explained by the fact that most of the hotels in this class are equipped with individual room air conditioning units. In addition common spaces are usually not air conditioned. As these hotels usually offer only breakfast there is no heavy electricity demand on the kitchen.

No significant correlation was established between occupancy and LPG consumption. It must be beared in mind that hotels of this class usually offer no meals and that LPG consumption is very small and not always used for satisfying direct cooking needs.

The absence of significant correlation between the number of heating degree days and oil consumption and the number of cooling degree days and electricity consumption can be attributed, like hotels of other categories, to the lack of energy consumption controls.

	Rooms	LPG	Oil	Elec	Ener	Bocc	Area	DDH	DDC
Rooms	-----	-.356	.551	.950	.717	.930	1.000	.622	-.177
LPG	-.356	----	.197	-.268	.022	-.149	-.356	.073	-.722
Oil	.551	.197	----	.552	.947	.573	.551	.437	-.340
Elec	.950	-.268	.552	----	.764	.931	.950	.812	-.277
Energy	.717	.022	.947	.764	----	.742	.717	.632	-.362
Bocc	.930	-.149	.573	.931	.742	----	.930	.626	-.435
Area	1.000	-.356	.551	.950	.717	.930	----	.622	-.117
DDH	.622	.073	.437	.812	.632	.626	.622	---	.434
DDC	-.117	-.722	-.340	-.277	-.362	-.435	-.117	-.434	---

Table 7.2.5 : Single Factor Correlation matrix for the 2 star sample hotels (N=6)

7.3 Multiple regression analysis of energy related parameters

In order to establish more accurate relations between the dependant energy consumption parameters and the other variables, (number of rooms, number of occupied rooms etc) an extensive multiple regression analysis was also performed.

The analysis was performed for the hotel industry as a whole (all hotels of the sample included) and separately for each individual class of hotels. The results of this analysis are presented below.

7.3.1 The whole industry

The variables chosen to be considered in the regression analysis each time were the variables that showed a significant degree of correlation in the correlation analysis.

The four equations (A-D) yielded concerning the whole of the industry are given in tabular form ($Y = ax + bz + cw + d$) in Table 7.3.1. In these equations x is the number of rooms, w is the number of occupied beds and z is the class of a hotel.

Equation	Y	a	b	c	d	r^2
A	Oil cons.	194	1502	- 0.14	- 6399	0.67
B	Energy cons.	69	1020	- 0.031	- 4150	0.80
C	LPG cons.	83	4799	- 0.024	- 11696	0.64
D	Electr.cons.	8907	146727	- 2.18	- 691381	0.78

Table 7.3.1 : Multiple regression coefficients for the interrelationship between energy sources.

7.3.2. The 5 star class of hotels

For this class of hotels only one multiple regression analysis was performed relating the consumption of gas oil with the number of rooms and the number of degree days for heating.

The relation obtained is given by equation (E) shown in the next page.

$$Y = 225.437\ (R) + 180.54\ (DDH) - 145983 \quad \ldots\ldots\ldots\ldots (E)$$

$(r^2=0.89)$

where : Y is the consumption of oil

R is the number of rooms and DDH is the number of degree days for heating

7.3.3 The 4 star class of hotels

Two multiple regression equations were established for this class of hotels. The first one (equation F), relates the consumption of electricity with the number of rooms and the number of occupied beds in a year and the second (equation G) relates the total energy consumed by a hotel of this class with the number of rooms and the number of occupied beds in a year.

The two relations, in which R is the number of rooms and B is the number of occupied beds are given below.

$$Y = 9467\ (R) - 5.778\ (B) - 120528.5 \quad \ldots\ldots\ldots\ldots\ldots\ldots (F)$$

$(r^2=0.58)$

$$Y = 69.05\ (R) - 0.05\ (B) + 75 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (G)$$

$(r^2=0.49)$

7.3.4 The 3 star class of hotels

Four equations were established for this class of hotels. These models relate the consumption of total energy, electricity, LPG and gasoil each time with the number of rooms, and the number of occupied beds in a year. The equations (H,I,J,K) are given in tabular form (Y=ax + bz + c) in

Table 7.3.2 below. Variables x and z represent the number of rooms and the number of occupied beds respectively.

Equation	Y	a	b	c	r^2
H	Energy cons.	46.97	- 27.24	10025	0.59
I	Electr. cons.	5563	0.519	- 112049	0.75
J	Oil cons.	26.16	0.1175	1957	0.34
K	LPG cons.	100.1	0.0305	404.4	0.40

Table 7.3.2: Interrelationship of different energy consumption factors (multiple regression for 3 star hotels).

7.3.5 <u>The 2 star class of hotels</u>

One equation was established for this class. Equation (L) relates electricity consumption with the number of rooms and the number of occupied beds in a year.

$$Y = 1348.6\ (R) + 1.59\ (B) - 14.2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (L)$$

$$(r^2=0.92)$$

where : Y is the consumption of electricity

R is the number of rooms

B is the number of occupied beds in that year

7.3.6 Multiple regression of the energy related parameters

In order to identify the linkage between the three energy parameters (gasoil, LPG and electricity) and examine whether direct substitutes of one fuel for another is significant among hotels using these resources, a multiple regression analysis was performed.

The parameters of the relations yielded (equations M,N,O,P and Q) from the multiple regression analysis are presented in tabular form in Table 7.3.3. In the resulted equations ($Y = ax + bz + c$), Y represents the consumption of electricity x the consumption of gasoil and z the consumption of LPG.

Equation	Hotel class	a	b	c	r^2
M	All industry	39.33	9.88	-2748	0.70
N	5 star	26.89	-52.18	285519	0.64
O	4 star	32	8.59	134618	0.67
P	3 star	6.43	22.65	77553	0.55
Q	2 star	17.61	- 5.5	46929	0.45

Table 7.3.3: Multiple regression coefficients for fuel use in different hotel categories.

Appendix F present a summary of the most important factors of all equations yielded (equations A-Q).

7.4 The wider implications

A detailed analysis of the causes and effects of these relationships can lead to fruitful conclusions and to specific actions at three levels of importance. These are: the level of individual hotels, the level of the hotel sector and the level of the economy as a whole.

While it is accepted that neither the total number of hotels examined (and that of the various classes) nor the data obtained were ideal, it is believed that useable conclusions can be drawn.

Energy planners may thus utilise several of the relationships established. For example,it has been well established (see equations A,B,C,D,E) that the total energy consumed by the hotel sector as well as the consumption of individual energy resources such as electricity and gasoil are highly correlated with both the number of tourists arriving in the country and the number of bednights.

These facts should send the message to energy planners that there is a need for coordinating public policies. Thus the declared policy of the Tourist Organisation aiming at attracting as many tourists on the island as possible must be examined in relation to the consequences of the increased demand of energy from public utilities.

There is certainly no doubt that increasing the number of tourists arriving in the country will have "positive"

effects on the economy. However, on the other hand, problems in the energy supply system, and especially electricity, could be as serious as creating a need for speeding up the construction (already decided !) of the new power station. One must also take into consideration the fact that presently, the Electricity Authority of Cyprus (EAC) faces serious problems in satisfying electricity peak demand.

It is within this context that very recently EAC has notified hotels that it reserves the right to disconnect (!) power supply to the air conditioning whenever this is considered necessary (mainly because of high peak demands).

There are however other benefits as well from the proper use of the relations developed for the individual hotels as well. For example it has been shown that for the group of 5 star hotels total energy consumption is not a function of occupancy. Since this group of hotels are major energy consumers efforts must be made to modify their user patterns so that consumption should relate as much as possible to occupancy. The highest degree of correlation between the variables of electricity consumption and occupancy exists for the case of the 2 star class hotels. The explanation is the following. The percentage of oil contribution in the total energy consumption of the 2 star hotels (see Table 1.2.9) is much higher than those of other classes (54%) and therefore its effect is greater in the total energy consumption. As 2 star hotels are equipped with central heating systems, their consumption is not a function of the number of guests staying in the hotel.

However, many 2 star hotels are not equipped with central air conditioning systems but with individual units installed in each room and rarely in common spaces. It is for this reason that in this class of hotels, electricity is highly correlated with the occupancy level (r=0.93).

Occupancy is directly related to the revenues and thus when occupancy is low energy consumption (which is a cost) should also be lowered where possible.

7.4.1 Fuel Substitution Patterns

From the multiple regression models it can be seen that in many cases there is a linkage between the usages of the various energy resources.

For example it was shown that the correlation coefficient for the case of the hotel industry as a whole between electricity and oil consumption was 0.87 whereas that of electricity and LPG consumption was 0.71. In both cases the correlation was positive.

The lowest correlation coefficient exists for the case of the hotels of the 5 and 2 star class respectively.

Equations M,N,O,P and Q show the relationship between electricity consumption and LPG and oil consumption.

From the analysis of the consumption data of the sample

hotels, it was shown that the contribution of electricity and gasoil in the total energy consumption of the hotel industry is approximate the same (45% and 42% respectively). The contribution of LPG is of the order of 13% only. The user pattern of the energy resources by the hotels, with some very isolated exceptions is generally similar.

Thus, in general energy resources are used for the satisfaction of various demands as follows :

(a) Electricity is used for lighting, operation of various appliances, cooking and air conditioning.

(b) Gas oil is used for heating and the production of hot water.

(c) LPG is used almost exclusively for cooking. It is obvious that electricity, being the most expensive and least efficiently produced resource, should be given high priority in any fuel substitution effort.

However, despite the encouragement of the authorities concerned (Electricity Authority of Cyprus, Department of Energy) for the substitution of electricity with other energy sources there are several important technical and financial obstacles. While the substitution of electrically operated cooking appliances is debatable and perhaps feasible (though not always cost effective) there is presently no practical and cost effective way for the substitution of the electricity required for the operation of the air conditioning and the lighting. The controllability of electrical appliances is also a perceived benefit.

In addition, substituting gasoil required for heating with LPG would not prove to be cost effective (the price of the two fuels are similar). Problems of storage, safety and system modification and maintenance will also need consideration.

The social factors involved must also be taken into consideration. It must be underlined that the price of LPG is consistently kept to a minimum, after being subsidised for many years, because of the fact that this is the fuel used mainly for domestic cooking on the island. The government may therefore have good reasons not to promote the use (by fuel substitution) of this low cost fuel to the commercial and industrial sectors.

While the prospects of fuel substitution, as briefly described above, may not appear good, there may be other ways by which efficiency of the energy supply system at both the level of individual hotels and the national level can be increased. One such possibility is the utilisation of the stand-by generators with which every hotel is equipped. These expensive units are considerably under-utilised when they could be contributing, at least to some periods of high demand, with very simple alterations to the current system.

We therefore advocate that substituting grid electricity by electricity produced by on-site generators is an option that has to be given serious consideration.

7.5 Understanding and improving the mechanism of energy usage at the level of hotel management

The usefulness of the correlation models is not only confined to their direct predictive power (i.e policy issues) A further use, probably even more valuable, concerns the help that the correlation models developed can provide in understanding the mechanism of energy usage. This is extremely useful at the level of Hotel management. By understanding the mechanism of energy usage within their hotels, managers and chief engineers can take the necessary steps towards improving the energy situation. These steps may include either or both of better utilisation and management of existing resources (including attempts to modify the user patterns) and proposals for energy conservation investments.

However, interpreting the correlation models described on a "stand alone" basis is quite risky and can lead to conclusions that might be very distant from reality. It is for this reason that the attempted brief explanations of the correlation in earlier sections were made on the basis of real personal observations and accurate related information obtained through reliable sources, (i.e interviews of related staff), in order to support the purely statistical evidence.

In fact this is the only way to establish confidently the mechanistic realities in the linkages between the various energy related factors.

While it was possible to develop general models correlating

energy related parameters for both the hotel industry as a whole and the various classes of hotels, the mechanism of energy usage within individual hotels could not be generalised. Both the field work (energy audits) and the questionnaire analysis of this research revealed that even at the individual hotel level the mechanism of energy use must be explored in a systemic and systematic way. Statistical results may indeed only be secondary support to such observational analysis.

The energy supply system will have to be examined with respect to its interaction with the human factors (including hotel guests) involved. It is only after such detailed study that steps toward improving the situation in individual hotels should be made.

Correlation models are certainly valuable tools. However, it must be remembered that correlations are made to be used rather than to be believed. The term "be used" emphasises the need for the use of the models as a basis for corrective action.

A good example for applying corrective action is the lack of correlation between LPG consumption and occupancy in the case of 5 and 4 star hotels. This situation exists despite the relatively good monitoring practices in these hotels and the appreciation by their chief engineers of the fact that kitchens are major energy consumers (see Table A.E.21). Proper use of the models in this case certainly means intensifying efforts towards improving the situation (modifying the existing model).

Another example is the lack of correlation (in all classes of hotels!) between electricity consumption and the variable of degree days cooling. The statement of the chief engineers interviewed regarding the prospects of energy conservation in air conditioning was clearly emphasised with this correlation model (see Table A.E.25). All of the chief engineers said that air conditioning has the best prospects for energy conservation in their hotels!

The use of the model can therefore provide the opportunity for strengthening the efforts in this direction (e.g better control systems). The result of the efforts could be seen in an alteration of the model in each individual hotel as the degree of correlation will be increasing.

CHAPTER VIII

ENERGY TECHNOLOGIES WITHIN THE HOTEL SYSTEM

This Chapter is largely concerned with the direct application of various energy supply technologies. The application of these energy supply technologies is examined mostly in their direct "retrofit" modes within the existing systems.

8.1 Heat Recovery or Heat Reclamation

The technology of heat recovery has been well known for several years. The theory behind its operation is simple. Most refrigeration and air conditioning systems extract heat in the evaporator coil by evaporating liquid refrigerant. The refrigerant vapour thus formed is extracted by the compressor which then increases its pressure and temperature. The superheated refrigerant vapour then passes to the condenser where heat is extracted and the refrigerant changes back into liquid ready for re-use. Heat reclaim units are fitted between the compressor and the condenser. The heat reclaiming units are designed so as to recover a large portion of the condenser heat which is normally wasted (Turner, 1982).

However, the quantity, quality and timing of supply of this, otherwise wasted heat, should match to the best possible extent the demand. An additional important factor is that the heat should be recovered in a cost effective way and by the utilisation of a technology that would "fit" well with the other energy supply system of a hotel and its (national/local).

infrastructure.

Furthermore this energy supply sub system should be accepted by the staff responsible for carrying out these operations.

The opportunities of utilising this technology vary with the size and the functions of the specific hotel. In Cyprus, very few hotels are equipped with a laundry that provides good heat recovery opportunities. There are also opportunities for recovering heat from exhaust air; these are, with the possible exception of swimming pool/sauna and kitchen areas, more theoretical than economically practical.

The evidence of this research shows that the most prominent opportunities of heat recovery lie with the extraction of heat rejected to the condenser of air conditioning systems and refrigeration plants. The vast majority of hotels are equipped with central air conditioning systems and large refrigerators.

The major disadvantage of the technology of heat reclamation from chillers of air conditioning plants for heating water is that the extracted heat is available only during the cooling period (Summer). This is in contrast to the option of installing solar systems that could provide, hot water for the year around, albeit at lower levels in Winter.

On the other hand, the availability of heat recovery opportunities in the summer coincides with the period of highest occupancy for which the highest demand for hot water

exists.

For the extraction of the available heat, heat exchangers manufactured commercially in many countries (not in Cyprus) can be utilised. The capacity of these heat exchangers vary from 3/4 of a refrigeration ton to more than 1000 tons.

Various manufacturers deliver individually sized and computer designed units that aim at satisfying the specific customer needs.

Units of the latest technology can operate with ammonia, freon or air compressors and require very simple maintenance since most of them have no movable parts.

There are however several other advantages claimed by manufacturers of heat reclaim systems. The most important of these advantages are the following:

(a) Reduction in maintenance cost of existing compressors.
(b) Reduction of electrical consumption
(c) Improvement of the efficiency of the refrigeration system especially when ambient temperatures are high.

8.1.1 A case study analysis

In order to evaluate the prospects of the heat recovery technology a cost effective analysis of a case study for a 3 star coastal hotel was performed. The analysis utilises real occupancy, chiller capacity and manufacturers cost data.

The calculation procedure for this analysis was the following :

(1) Utilising real occupancy data for a 3 star coastal hotel (52 rooms and 104 beds) the energy required to heat 100 litres of water for each guest from 24 to 55 degrees Centigrade was calculated to be 1100 MJ/day. This period is for 6 months or 180 days (May to October).

(2) The hotel is equipped with two 60 kW air cooled chillers of which one in is operation and the other is in a stand by mode. The calculated water demand for an average of 84 guests per day is 84,000 litres per day.

The available refrigeration tons is 60 kW x 0.75 = 45 RT Assuming that 10.9 MJ/RT-hr (or 45 litres/RT-hr of hot water, from 18 degrees Centigrade to 54 degrees Centigrade) can be produced, it is obvious that even with an minimal operation of the chiller of 3 hours the total load required can be covered and far exceeded (14.74 MJ/day).

Therefore the total contribution of the heat recovery system is 180 days x 1100 MJ/day= 198,000 MJ which corresponds (utilising a 70% boiler efficiency) to savings of 7 tons of oil or, in money terms, to 700 Cyprus pounds .

Assuming a 10 hour daily operation of the chiller and a 5% reduction in electricity consumption there is an additional savings of 5,400 kWh or 216 Cyprus pounds.

From manufacturers data the heat recovery system cost in Cyprus pounds is :

Heat exchanger	: 3200
Pumps, thermostats, installation	: 550
TOTAL	: 3750

The following financial data were used in the analysis:

(a) Depreciation : 10% over the total investment

(b) Gasoil price : 100 Cyprus pounds per ton

(c) Life of project : 15 years

(d) Income tax : 20%

(e) Investment credit:30% for the first year.

Because the investment involves saving of two forms of energy (electricity and gasoil) three different scenarios were used in the sensitivity tests in each of which the price of electricity and gasoil was as follows :

<u>Scenario 1.</u>

Gasoil price	: 100 Cyprus pounds/ton
Electricity price	: 4 cent/kWh

<u>Scenario 2.</u>

Gasoil price	: 110 Cyprus pounds
Electricity price	: 5 cent/kWh

<u>Scenario 3.</u>

Gasoil price	: 120 Cyprus pounds
Electricity price	: 6 cent/kWh

Table 8.1.1 presents the calculated pay back period the internal rate of return and the Net Present Value estimated for each scenario. Table 8.1.2 presents the results of a sensitivity analysis of varied discount rates on the NPW of the investment.

From the analysis presented it becomes obvious that under all three scenarios examined a heat recovery installation is a sound and cost effective investment.

Financial Indices	Today's Prices	10% higher Prices	20% higher Prices
P.B. Period	2.96	2.76	2.60
I.R.R	30.03	32.57	35.01
N.P.W (Cyprus pounds)	2357	2851	3345

Table 8.1.1 : Financial indices for three scenarios for a heat recovery investment (15% discount rate).

Energy prices	Discount Rates		
	10%	20%	30%
Today's	3916	1302	4
10% higher	4580	1683	252
20% higher	5244	2064	499

Table 8.1.2: Results of sensitivity analysis to discount rates of NPW of a heat recovery investment (in Cyprus pounds).

8.2 Hot Water Solar Systems

Solar energy for the production of hot water has been utilised by the hotel industry in Cyprus for many years. Almost half of the Hotels and Tourist Apartments on the island are equipped with these systems (see Table 1.2.5). With the exception of solar panels, all other equipment (pumps, pipes, valves etc) are imported. There are several hotels that utilise imported solar panels as well. This however was an early practice. As the quality of the locally manufactured panels increased and their cost was competitive the vast majority of the hotels utilised locally manufactured panels.

The spread of the solar systems in the hotel industry can be attributed to the very wide social acceptance of the technology (almost 90% of the houses are equipped with these systems) and the encouragement of the Government.

However several problems are associated in the effort of exploitation of this renewable resource for the hot water needs of hotels.

One of the most important of these problems has been the absence for a very long time of an appropriate authority that could test the efficiency of the panels and the whole systems and assist the manufacturers in improving the quality of their products. Consultants could also benefit from such facility. The efforts of the small Energy Unit of the Ministry of Commerce and Industry though considerable, are not providing a

total solution to the problem.

Another major problem is the fact that consultants are not conversant with solar technology and are thus not in a position to properly design and size a system for the particular needs of the specific hotel. Discussions with designers revealed that very often very important factors such as utilisation pattern, tilt angles, hotel needs and weather data are not taken into account during the design phase. The availability of very efficient and proven designing tools such as the "Fchart" software package, that assist in the design of various solar systems are hardly known by local consultants.

However, it is extremely important to size the systems correctly since oversized systems add considerably to the initial capital cost of the system. The fact that the only financial criterio utilised today by hotel managers in Cyprus is the crude pay back period is another important reason for paying considerable attention to correct sizing.

Another major factor which worths mentioning is the objection of several owners to the installation of solar systems, (in some cases backed by their consultants) on the ground of... aesthetic reasons.

A cost effective analysis of a solar hot water system was performed and is presented in the pages following.

8.2.1 A case study analysis

The hotel is a 3 star coastal hotel with 52 rooms and 104 beds. The hotel's boiler operates on gasoil.

In order to estimate the amount of energy required to heat the water, the amount of water needed was determined as follows:

(a) Hotel guests hot water requirements were taken as 100 litres per day (Source Book for Energy Auditors, 1987)

(b) Average monthly occupancy data for the last five years were provide by the hotel. These data and the calculated hot water requirements are shown in Table 9.2.1

(c) Based on the meteorological and occupancy data the following three distinct periods (seasons) were established

1. December to March
2. April and November
3. May to October

The cold water temperature (average) for each period and the hot water temperature required for each of the three periods above (1 to 3) were taken as:

1. CWT (cold water temperature) : 13 degrees C
   HWT (hot water temperature) : 60 degrees C
2. CWT : 17 degrees C
   HWT : 55 degrees C
3. CWT : 24 degrees C
   HWT : 55 degrees C

The heat load for each period was found to be :

Period 1 : 802 MJ/day

Period 2 : 1050 MJ/day

Period 3 : 1100 MJ/day

The mean solar radiation for the three periods is :

Period 1 : 15 MJ/sq.m

Period 2 : 20 MJ/sq.m

Period 3 : 21 MJ/sq.m

Utilising a system efficiency of 40% and a collector area of 71 sq.m (0.7 sq.m/guest) the solar contribution for each period was found to be :

Period 1 : 428 MJ/day

Period 2 : 563 MJ/day

Period 3 : 603 MJ/day

The total yearly solar contribution was calculated to be: 198,966 MJ or 55.12 MWh. Assuming a boiler efficiency of 70% the total solar contribution was estimated as 6.9 toe.

The economic analysis that was performed utilised the following input data :

a. Investment cost : 7100 Cyprus Pounds

b. Maintenance : 100 Cyprus Pounds/year for the life time

c. Depreciation : 10% per year over the total investment

d. Gas oil price : 100 Cyprus per ton *

e. Life of project : 20 years

f. Income Tax : 20%

g. Investment Credit: 30% of the total investment value for the first year

* Three different scenarios were examined with respect to the price of the energy substituted (gasoil). The first scenario utilised the current gasoil price whereas the other two scenarios used 10 and 20% higher price for each case over the 20 years. These prices were 100, 110 and 120 Cyprus pounds respectively.

Results

From the analysis presented it becomes obvious that despite the technical viability of the solar water heating systems, the financial return are poor and do not appear unless fuel prices are at least TWICE as expensive (see Table 8.2.2,last scenario) .

Table 8.2.3 presents a sensitivity analysis of varying discount rates on the NPW of the investment for each scenario.

Month	Guests/day	Occupancy %	Hot Water requirements million litres/month
January	37	36	0.15
February	42	41	0.12
March	56	55	0.17
April	63	62	0.19
May	75	74	0.23
June	84	82	0.25
July	87	85	0.27
August	93	91	0.29
September	86	84	0.26
October	83	81	0.26
November	69	68	0.21
December	28	28	0.09
TOTAL			2.49

Table 8.2.1: Occupancy and hot water requirements for a solar hot water system design

Financial Indices	Today's Price	Increase in fuel price 10%	20%	50%	100%	200%
P.B.Period (years)	7.99	7.33	6.77	5.51	4.2	2.85
I.R.R (%)	9.42	10.79	12.06	15.77	21.34	34.49
	(0)	(0)	(0.7)	(6)	(13)	(26)
N.P.W	-1533	1180	-830	222	1975	5480

Table 8.2.2: Financial indices for six scenarios for a solar hot water system investment. Values in parentheses correspond to the 7th year of the life of the system (15% discount rate, N.P.W in Cyprus pounds).

Energy prices	Discount Rate 10%	20%	30%
Today's	205	-2392	-3431
10% higher	272	-1960	-3245
20% higher	749	-1847	-3060
50% higher	2179	-1029	-2503
100% higher	4563	335	-1574
200% higher	9331	3062	283

Table 8.2.3: Sensitivity analysis of NPW (Cyprus pounds) with varied discount rates on a solar hot water system investment.

8.3 Solar heated swimming pools

The technology of solar heating of swimming pools has reached very good levels of development in many countries of the world. The European Community's Energy Demonstration Programme had included a sub program on solar heated pools because it was considered as "an almost ideal way of harnessing solar energy as a source of low temperature heat via relatively simple collectors"(Dickinson, 1980). However, the financial results are still relatively poor (see Table 9.3.1).

It was considered useful to refer briefly to the findings of the EEC large demonstration sub program on solar heated pools which consisted of an area of 25,726 sq.m of installed absorber plates. The main conclusions of this program were the following: :

(a) It is not uncommon to find solar installations covering 90% and more of the energy requirements of outdoor swimming pools.

(b) Appropriate energy saving measures such as pool covers or energy recovery installations reduce pool energy requirements. However, their use must be carefully studied and planned.

(c) Even distribution of pool water currents in the absorber area is a major factor in optimum energy exploitation.

(d) The installation must be operated in such a way so as to make optimum use of the solar energy collected.

(e) In Central Europe the ratio between absorber area and water area should be between about 0.5-0.7.

(f). A well designed and well run absorber installation of an outdoor pool can be expected to produce an energy gain of 250-300 kWh/sq.m of absorber area during the bathing season.

There is no doubt that the increased demands for high quality service for the hotels in Cyprus imposes the need for the availability of heated swimming pools during the Autumn and Winter months. However, the majority of the Hotels and Tourist Apartments with heated pools on the island utilise their gasoil fired boilers. This is done despite the availability of very good solar radiation and large sunshine duration even during the Winter months.

The main obstacles to a wider spread of solar heated swimming pools in the hotel industry of Cyprus are the following:

(a) Lack of space

(b) Unwillingness of hotel owners to "damage" the aesthetics of the hotel.

(c) Lack of knowledge on the design and evaluation of the cost effectiveness of the technology.

The field survey of this research revealed that there is a real need for disseminating information on this technology. The available literature and the results of the EEC Demonstration sub program provide an excellent basis on which good foundations can be built. There is also an additional need for training on the management of solar heated pools. Understanding the parameters permitting optimum management of

swimming pools as well as the provision of information and training for managers and pool staff of solar heated pools are vital.

There are several important characteristics that a solar collector for swimming pool heating should have. Among the most important are the following:

(a) Collectors should not be expensive to manufacture
(b) Collectors should be suitable for direct contact with swimming pool water. The need for a heat exchanger reduces significantly the efficiency of the collectors.
(c) Collectors should be durable and require little or no maintenance.
(d) The efficiency should be acceptable (1.8-2.0 kWh/sq.m-day)

Research carried out for a variety of absorber types shows that for lower temperatures, unglazed collectors have better efficiencies. However for higher temperatures (over 26 degrees Centigrade) glazed and insulated collectors have higher efficiencies. In Cyprus there is currently no company that manufactures plastic unglazed collectors. Since the cost of the glazed and insulated type of collectors (with higher efficiency) is not considerably higher, the analysis presented in this thesis involves ordinary glazed, locally manufactured and tested solar collectors.

Caution should be taken with respect to the material used as well. Ordinary available plastics upon exposure to combinations

of heat, pool water chemicals and the ultraviolet rays of the sun may last only 2 to 4 years. Specially manufactured swimming pool plastics may last for up to 15 years.

A detailed analysis of the cost effectiveness of solar heated swimming pools is quite involved and requires availability of several data. In these calculations, the pool's temperature is estimated by calculating an energy balance for a typical day for each month of the year. This is done be equating the heat gains to the heat losses from the pools temperature (Dickinson, 1980). However for the purpose of the present analysis several basic assumptions, (close to reality) were made.

In addition there are today software packages that perform analysis of swimming pools (like for example the "Fchart" program developed at the University of Wisconsin)

A final note should emphasise the importance of utilising pool covers. It can be shown analytically that most of the losses in a swimming pool are due to evaporation from their open surface (more than 65%). The use of a pool cover must therefore be considered when utilising solar heated pools. The reduction of losses will result to the requirement of smaller solar collector area and thus lower initial investment.

8.3.1 A case study analysis

The analysis concerns a 3 star coastal hotel with 52 rooms or accommodation facilities for 104 guests.

Assuming a simultaneous use of the pool by 40% of the maximum hotel occupancy, the design of the pool can be based on 40/100 x 104 guests = 42 guests.

According to specifications of swimming pool designers it is required that each guest has 3 sq.m of pool area available. Therefore the pool should have an area of 3mx42guests=126 sq.m Assuming an average depth of 1.5 m, the volume of the pool will be 1.5 m x 126 sq. m = 189 cu.m

According to the EEC experiments and findings the absorber to the pool area ratio for Central Europe should be between 0.5-0.7. The lowest ratio is chosen and therefore the required area of collectors is 0.5 x 126 sq.m = 63 sq.m

The energy collected from a swimming pool solar system per square meter and day according to the EEC research is between 1.8-2.0 kWh.

Assuming 180 days of heating period then the total energy saved will be 360 kWh/sq.m. For an area of 63 meters the total energy collected for a season will be 63m x 360 kWh/sq.m or 22,680 kWh. Assuming that there is a gasoil boiler with 70% efficiency then the total energy saved will be 22,680 kWh/0.70 = 32,400 kWh (or 3.8 tons of gasoil). Since the price of a gasoil kWh is 1.2 cent then the savings in money will be 1.2 x 32,400 kWh = 388 Cyprus pounds per year. The cost of the system (pump, check valve, gate vales, pressure relief valve, solar glazed panels and installation)

is estimated to be around 4,000 Cyprus pounds.

The financial data used in the analysis were the following :

(a) Discount Rate : 15%

(b) Corporation Tax : 20%

(c) Investment tax allowance (only for the first year): 30%

(d) Depreciation : 10% on total investment

(e) Life of the investment : 15 years

The results of the analysis shows that despite the technical viability and general environmental desirability of the solar heated swimming pools, the financial returns are poor except under conditions where real fuel prices (relative to other factors of equipment cost etc) are significantly greater than those currently being experienced. That is, the narrowly defined benefits do not appear unless fuel prices are at least (as seen in Table 8.3.1) twice their current values.

Table 8.3.1 presents the results of the analysis for various scenarios of fuel prices. Table 8.3.2 presents the results of further sensitivity analysis of the effect of different discount rates.

Energy Prices (15% discount rate)	P.B Period	I.R.R. %	N.P.W Cyprus pounds
Today's	7.14	12.74 (0) *	-209
10% higher	6.69	14.4 (1.5)	- 54
20% higher	6.3	16.1 (3.7)	102
50% higher	5.11	22.6 (12.1)	703
100% higher	4.2	30.2 (21.6)	1480
200% higher	3.22	44.78 (38.8)	3033

Table 8.3.1: Financial indices for various energy price scenarios for a solar heated swimming pool investment

* Note: The values in parenthesis correspond to the I.R.R at the 7th year of the life of the investment. All other values refer to the 15th year.

Energy Prices	Discount Rate		
	10%	20%	30%
	N.P.W. in Cyprus Pounds		
Today's	319	-539	-887
10% higher	528	-419	-809
20% higher	737	-299	-731
50% higher	1506	190	-377
100% higher	2550	939	240
200% higher	4640	1988	793

Table 8.3.2 : Sensitivity analysis of the effect of different discount rates and fuel prices on the NPW

8.4 Passive Cooling

Passive cooling can be defined as the dissipation of heat from buildings by the natural processes of radiation, convection and evaporation (Wright, 1984).

Considerable research activity has been undergoing for many years in the area of active solar cooling systems. However, despite international efforts, active solar cooling techniques (vapour compression, vapour absorption, vapour jet, dehumidification) have not until now proved to be cost effective when compared with conventional cooling systems. This can be attributed to the fact that active solar cooling systems have low coefficients of performance, high initial costs and considerable energy requirements. It is for these

reasons that passive cooling has a very important value especially in the hotels of the sunny Mediterranean area. As it has been shown in other sections of this thesis, a considerable quantity of electricity is utilised for the cooling needs of hotels during the extensive summer seasons. Cooling is therefore a priority and constitutes a necessary and important part of the service package offered to hotel guests. It is obvious that exploiting the potential of passive cooling in the hotel industry will have a positive effect on both the electricity consumption and the peak demand of individual hotels and the national grid.
These processes do not require the expenditure of non renewable energy sources.

The efficiency of passive cooling systems can be considerably enhanced by the use of other motor driven equipment that consume very little quantities of electricity. In this case passive cooling systems are called "hybrid" systems.

The most important passive cooling techniques are :

(a) Internal curtains
(b) Internal and external venetian blinds
(c) Natural cross ventilation
(d) Radiative cooling
(e) Permanent and movable shading devices
(f) High thermal insulation
(g) Reduction of south openings
(h) Buried pipes

(i) Direct and indirect evaporative cooling

The field survey of the research revealed that internal curtains, permanent shading devices and in rare occasions high thermal insulation are the techniques mostly used in the hotel industry of Cyprus. However, the application of these, seemingly simple techniques was not always the result of a thoughtful design and a life cycle cost analysis.

Most of the hotel designers were found to be not aware of the real capabilities and prospects of passive cooling technologies. Extensive discussions with a large number of architects revealed that passive cooling was not a major concern for them. Designers appeared to concentrate on the issue of designing hotels that would impress their customers architecturally rather than incorporating energy efficiency in their designs. However aesthetics and energy environment ought to be one single "system" concern.

One of the major problems we faced when we attempted to promote passive cooling technologies to the "actors" of the problem situation was the lack of real data that would justify savings claimed. It is for this reason that most energy saving calculations rely on simulations performed by software designed for this purpose, or on test-cases from other countries where analogous climatic conditions prevail.

In the European geographical area most of the tested passive

cooling systems are at the prototype stage. The reason is that so far the emphasis had been placed solely on passive heating systems.

Specifically in the area of hotels, the application of passive cooling techniques have been well demonstrated in Greece within the context of the EEC project "Building 2000".

A brief summary of the applications and results of passive cooling techniques in 2 hotels in Krete, latitude 35 N is given below. Because of the similarity with Cyprus in latitude and weather we believe that the results can be of value to the hotel industry of Cyprus as well.

Hotel (I)

This is a south oriented hotel complex composed by six individual buildings having a total area of 1120 sq.m. Both passive and hybrid systems are used. The south exterior glazed areas are shaded by overhangs. Both internal and external venetian blinds and internal curtains are installed.

Results

The contribution of the hybrid system to the annual cooling load is as follows :

For 10 sq.m collectors : 17%

For 20 sq.m collectors : 20%

For 30 sq.m collectors : 40%

Table 9.4.1 presents the monthly percentage contribution of radiative cooling to the monthly cooling load.

Month	Collector area		
	10 sq.m	20 sq. m	30 sq.m
May	100	100	100
June	34	63	90
July	15	30	43
August	36	17	54
September	65	100	100

Table 8.4.1: Percentage monthly contribution of radiative cooling to cooling load

However, the analysis performed for the hotel A showed that when the radiators are installed together with a full capacity conventional cooling system the overall design is not cost effective.

When the installed capacity of the conventional system is reduced, according to the expected contribution of the radiators, the investment becomes slightly more cost effective. According to the designers, the overall cost effectiveness of the system needs further investigation.

Hotel (II)

This is a hotel complex of 17,750 sq.m composed of 237 double rooms and 28 suites.

The passive cooling techniques utilised are:

(a) permanent and movable shading devices

(b) high thermal insulation

(c) night ventilation

(d) an array of 30 PVC buried pipes, 30 m long

Present results show that the mean annual contribution of the buried pipes is close to 15%. Night ventilation proved to be able to drop the temperature between 0.5 and 1 degree C when 5 air changes per hour were applied.

It appears that the design would be a more cost effective if passive cooling technologies were applied at the construction phase of the hotel. In this case equipment of less capacity , and therefore less cost, could be installed.

The problem of applying passive cooling techniques in the hotel industry of Cyprus is twofold. The first aspect of the problem, which is also the main obstacle, is the lack of sensitivity on behalf of designers on the issue of energy efficiency in general. The second aspect of the problem which underlines the need for training is the issue of lack of knowledge.

8.5 The technology of BEMS

Building Energy Management Systems is a relatively new and fascinating technology. More and more commercial and industrial building owners and managers, in their effort to manage their

energy consumption in a more efficient way, tend to the adoption of these systems.

The most important reasons for the continuous increase of popularity of these systems are :

(a) The increase of energy use

(b) The reduced costs of computers and electronic control which enables the systems to regulate more building functions for less.

(c) The fact that recent installations of direct digital control systems have resulted in improved comfort levels with reduced manpower and reduced operations and maintenance costs.

<u>The technology</u>

A BEMS is an energy monitoring and control system which employes minicomputers or microcomputers, associated peripherals, instrumentation, control equipment and application programs. The software programs are written in high level languages such as Fortran or Pascal configured into a network with control functions at multiple locations and a central point of operator control and supervision.

The most important ways by which a BEMS can reduce the energy cost of hotels are listed below:

(a) By minimising unnecessary energy use

(b) By optimising the efficiency of the operation of various

energy consuming sub systems.

(c) By the improvement of standards of operation and maintenance of a building.

(d) By the provision of various energy related data that can be used for monitoring and targeting.

(e) By encouraging higher levels of energy awareness.

BEMS are today used in many hotels to effect energy and manpower savings for heating, ventilating and air conditioning process equipment, lighting, chillers and boilers.

Reliability, expendability and state of the art design are the most important advantages of the modern BEMS systems. The so called, third generation systems are today capable of handling the part load conditions which exist in most hotels. Commonly used application software programs, can use adaptive control techniques that allow them to monitor their past performance and automatically adjust parameters for optimum performance.

The most important of these application programs are :

(1) Optimum start up and shut down of systems and equipment

(2) Duty cycling

(3) Power demand control

(4) Outdoor air enthalpy control

(5) Lighting control

(6) Night Purge

(7) Chiller optimisation

(8) Boiler optimisation

(9) Temperature reset

8.5.1 The BEMS situation in the Hotel Sector of Cyprus

With the exception of a handful of other buildings the hotel sector is the major user of BEMS on the island. All of the systems were installed during the last five years.

A very important characteristic of the use of the BEMS technology in the hotel sector is that almost all of the systems (which are of the latest technology) were installed at the initial build up of the hotels. This can be mainly attributed to the fact that at this stage funds are usually available (through loans) and that the total cost of the systems, though not inexpensive at all, is quite small when compared with the total cost of the whole investment. All of these hotels are of the upper class (4 and 5 star category).

Because of continuous extensions (unreliable data) to the only hotel on the island that was equipped with a BEMS many years after it was built, and the unavailability of "pre BEMS data" no cost effective investment analysis could be made. However, in order to evaluate the use and misuse of this important technology a series of meetings/interviews were arranged with the most important actors of the situation. These actors included the owners of the hotels, the consultants that specify the systems, and the operators of the systems. The chief engineers were considered as the operators of the systems since they are the persons responsible for their operation.

A survey of nine hotels representing almost 70% of hotels with installed BEMS at the time of the research was performed and discussions with all related actors were conducted.

In order to perform a systematic analysis of the situation a list of possible topics for discussion with each of these actors was prepared before each meeting. Though discussion varied depending on the individuality of each case the following items were included in all interviews.

A. Hotel owners

(1) Cost of the system

(2) The reason for the decision to install a BEMS

(3) The person that recommended the installation (i.e architect, engineer, self, other)

(4) Whether the owner was satisfied and if not what problems were faced.

(5) Whether any savings were quantified.

B. BEMS operators

(a) The date of the installation

(b) The level of difficulty of the BEMS operation

(c) The facilities provided by the system

(d) The problems faced

(e) The participation of the chief engineer in the decision process for installing the system.

(f) The operators opinion on the suitability of this technology.

C. Consultants of BEMS

(a) Details of the system

(b) Factors considered when designing the system

(c) Effort required to convince owner to install system.

(d) Cost effectiveness of the system

(e) Special training required in order to operate the system.

Discussion of results

The installations were shared by the only three representatives of these systems on the island. The general conclusion was that the technology of BEMS irrespective of its suitability or not had intruded the market without previous establishment of its cost effectiveness. We believe that this is a classical case of an adoption of a technology based on the fact that it was available and that it was claimed to provide savings. The information provided by the consultants was based on information from the suppliers.

Consultants were never involved in a cost effective analysis of the investment themselves. Furthermore a detailed cost effective analysis was never presented to any of the customers who could hardly understand the technical jargon referred during presentations. The main argument of the consultants that had specified the systems was that: "they were installed overseas producing lots of savings"!

The fact that the total investment was in several cases considerable (over 50000 Cyprus pounds) did not seem to be a major problem, as the largest portion of the investment

originated from a loan of which the BEMS cost was only a very small fraction ! Here lies one danger of not treating each separate "hardware item" as a subject for incremental benefit and discounted cash flow analysis.

In all of the cases, the proposal to install the system originated from the consultants (of the electro-mechanical services). Future operators were never consulted as in most of the cases they were not even employed at the time. Because of lack of knowledge of the technicalities of the matter all of the owners were unable to have a "contact" with the system after it had been installed. While none of the actors was able to provide evidence of savings, everyone felt satisfied with the service of the suppliers and the savings (?) enjoyed.

Another major obstacle to the proper operation of the BEMS is the fact that in the majority of the cases the suppliers of the systems had not provided the required training to the operators of the system. On the other hand the operators of the systems did not posses the necessary background (educational and technical) that would enable them to understand the operation of the systems and thus take full advantage of the services provided.

A percentage of hotels and hotel apartments utilising this technology and a comparison of use of the technology between other parts of the world is given Chapter I. The opinion of the chief engineers on the suitability of the BEMS technology for hotels is discussed in Chapter V.

8.5.2 A case study analysis

Because of lack of data, due to the fact that almost all installations were done at the build up phase, it was not possible to perform a cost effective analysis using real energy consumption figures.

However, following extensive discussions with BEMS contractors and using the energy consumption data of sample hotel "E" an analysis was performed. After extensive discussions with BEMS contractors concerning cost and expected savings, the following were decided:

(a) Two scenarios were to be examined.

In the first scenario (pessimistic) the evaluation would be based on 10% expected savings for the gasoil and 10% savings on the electricity consumption.

In the second scenario (optimistic) the evaluation would be based on 30% expected savings for the gasoil and 20% for the electricity .

(b) The cost of the system would be 15000 Cyprus pounds and would perform the following functions : Weather compensation for the boilers, optimum start/stop for the boilers, maximum demand control, chiller optimisation, optimum start/stop for the chillers and analog duty cycling.

(c) Existing installation and equipment to be used

(d) Energy consumption figures for the year 1989 for gasoil and electricity to be used (see Appendix C).

Table 8.5.1 presents the results of the analysis under the two scenarios. The table shows also a sensitivity analysis for the effect of changes in the price of fuels used. Table 9.5.2 presents further sensitivity analysis for the effect on the NPW of different discount rates. Though no generalisations can be made, the particular case examined appears to be a sound investment.

Scenario	P.B Period (Years)	I.R.R %	NPW
Pessimistic	1.65	57.18 (54.64)	32299
10% lower price *	1.76	51.71 (48.78)	26439
20% lower price	1.92	45.65 (42.24)	20580
Optimistic	0.96	88.43 (87.45)	53875
10% higher price	0.96	97.31 (96.44)	65901
20% higher price	0.96	105.42 (104.3)	77926

Table 8.5.1: Financial indices for a BEMS proposed investment. Values are for 15 years. Values in parentheses are for the 7th year of the investment (NPW in Cyprus pounds).

* Naturally, low fuel prices imply smaller nett energy cost savings.

Discount Rate Scenario	10%	20%	30%
	Net Present Worth in Cyprus Pounds		
Optimistic	73477	40747	24856
Pessimistic	45933	23170	12130
10% lower	38050	18647	9188
20% lower	30167	14124	6247
10% higher	89656	50020	30893
20% higher	105834	77926	36930

Table 8.5.2 : Sensitivity analysis for the effect on NPW of different fuel prices and discount rate.

CHAPTER IX

APPROACHING THE SYSTEM MODELLING CHOICE OF META MODELLING SCENARIOS

While Chapter VIII has dealt mainly about retrofit and savings (e.g.via re-timing and re scheduling of certain demands), at the hotel level, this Chapter extends the vision to the next higher level of concern for system-subsystem interaction and potential synergy.

9.1 Technological sub-system interactions and efficiency

Within the content of the systematic approach adopted in this research it was considered necessary to investigate the possibilities of integrating the technologies examined in Chapter VIII into what can be considered as a seamless system of near optimal use, in conjunction with a modified supply system approach : - Reducing and re-timing demand, modifying existing supplies, providing alternative supplies and finally systematizing the whole.

As mentioned elsewhere, this thesis does not advocate that the solution of the energy problems of the hotel industry can rely on the application of technological "fixes" alone. There are the human aspects of the problem and furthermore the important system/subsystem interactions to consider.

It is therefore necessary to underline the fact that each individual technological "fix" (sub system) analysed in Chapter VIII is a potentially important component of an energy efficient "supply and demand system". The group of

technologies analysed is illustrative, not comprehensive, and does not include all the available technologies.

The purpose of this analysis was rather to analyse a representative sample of technological "fixes", demonstrate the method of analysis and the way it should lead to an integration of each technology into an efficient energy utilisation system. Other possible technologies, with perhaps less potential for immediate exploitation such as photovoltaics and solar air conditioning might certainly have been included, but might seem less credible in terms of current costs, especially in the "retrofit" situation.

The first principles of energy demand planning should be to reduce demands (total and by time/sector) prior to matching needs with supply systems (Jacques, Lesourd and Ruiz, 1988). That has been exactly the intention of this thesis so far.

The ways in which the possible inclusion of energy efficient supply technologies in the system can assist the minimization of demand "pressures" and supply requirements have been the subject of modelling efforts (see Chapter X).

A brief description of the contribution of each of these technologies in an efficient energy demand plan and the various sub-systems and system interactions, will follow. No reference to the financial aspects is made here since all relevant data were already presented earlier (see Chapter VIII).

Clearly however, all "optimizing" solutions will be strongly affected by real costs and prices in the local (Cyprus) environment.

9.1.1. Building Energy Management Systems

This is itself an "integrating" technology in the sense that it can operate, monitor and control all other sample technologies (chp, heat recovery, hot water solar system, solar heated swimming pool) adopted by a hotel. In fact the technology links data on the energy environment to the preferred set of energy supplies.

The direct interaction of this technology (sub-system) with the total energy supply system and the other sub-system components is very important. While this technology is called to monitor the efficiency of the total system, the efficient operation of each sub-system is also very important. For example BEMS can control the optimum start time of the heating system but it can not improve the efficiency of this sub-system.

By doing this, the technology of BEMS contributes to a reduction of heat (gasoil) and electricity demand and thus may reduce the requirement of large quantities of primary energy inputs.

9.1.2 Heat Recovery Systems

This technology, as clearly shown in the case analysed in Chapter IX, presents good potential for being integrated within

the energy system of hotels. By taking advantage of the opportunities for heat recovery, energy demand (eg for gasoil) can be (cost effectively) reduced.

The importance of the interactions between this sub-system and other system components must be underlined in this case as well. For example, efforts should be taken not to affect the efficiency of the cooling system (chiller) because of the resulting reduction of the temperature of the cooling fluid. Any errors in the design and installation of this sub-system will have negative effects on the overall performance of the energy supply system.

9.1.3 Solar hot water systems

The technology of solar hot water systems utilising flat plate collectors has been well established for many years. Savings are considerable in the long run (pay back periods between 6-8 years) and it is advocated that incorporating a solar system in the hot water production system of a hotel can be quite beneficial.

Provided that incentives by the Government, for the wider use of solar energy in the sector are given, the incorporation of an efficiently designed and operated solar system in each hotel of the island should be considered a priority.

However, the installation of a solar hot water system must be the result of detailed study of the timing, quality and quantity of the hot water requirements. The interactions of the

solar sub-system with the back up hot water system will have to be carefully evaluated. Oversising or undersising of each of these sub-systems will have negative consequences on the overall energy supply system.

Furthermore the relationship between solar collection (frequently at its peak in the early afternoon) and the counter active need for air conditioning form an early part of the system planning approach.

9.1.4 Solar heated swimming pools

Despite practical installation problems, mainly because of local space limitations, and the relatively high cost of this sub-system, we believe that swimming pool solar heating should be given serious evaluative consideration because of the likely level of savings.

The high cost of heating a pool with conventional means (gasoil) the low quality of heat requirements, the social, economic and environmental benefits are all strong reasons for including a solar heated swimming pool in the energy supply system of a hotel. We therefore believe that it would be worthwhile to consider the integration of this sub-system in the energy supply system of a hotel. At an early design stage, efforts could be taken for the integration of this technology in the solar hot water producing sub-system.

9.1.5 Passive energy saving techniques

If there is a case for which we could take an absolute position as far as potential benefits are concerned, (at least for the case of new hotels) it is in the exploitation of the knowledge available, about solar passive heating and cooling techniques. The incorporation of this technology in the overall design of hotels should be thoroughly examined.

It certainly makes no sense to struggle for the energy efficient operation of the air conditioning system of a hotel (operating on expensive electricity) without prior consideration for the reduction of the cooling load.

Evaluating the exploitation of solar passive techniques prior to the sizing of the heating and cooling sub-systems is a wise step towards the reduction of cooling and heating loads. However, the interactions with other sub-systems will have to be considered, especially when attempting applications of the technology in existing hotels. There is no point in introducing extra heat (solar-collected) into the building if:

(a) the demand does not coincide in the time with the supply (not withstanding possible storage modes) or

(b) extra cooling capacity (air conditioning) is required to "combat" surplus heat leaking into the atmosphere within the building.

9.1.6 Cogeneration

The application of the technology of cogeneration has been analysed, through simulation and life cycle, evaluation techniques elsewhere in this thesis (see Chapter XI).

Despite this technology's very demanding site specific requirements, the complexity of the fuel pricing policies and the local monopolistic legislation related to the production of electricity, we advocate that cogeneration should be given serious consideration when forming the energy supply mix at the hotel level.

However, cogeneration itself should not be seen as a "single" technology but rather as a group of related technologies with very specific boundaries and limitations. In fact, the concept is much more widely applicable than merely "an electricity generator with waste heat provision". Usually this sub-system will not be designed to cover the total needs of the hotel, and every care should be taken for its proper integration in the energy supply system (see Chapter XI).

9.1.7 Wind energy

The possibility of exploiting wind energy has been examined in Chapter XI of this thesis in which it was attempted to incorporate it in various energy supply "mixes". Irrespective of the technoeconomic feasibility of this technology, we believe that the interactions of other sub-system components, such as technical problems with the grid electricity sub-systems should be thoroughly examined before major

installation decisions are taken.

The major point of the discussion concerning each and every one of the technologies above is that there are no "stand alone" " technologies. All of the sub system components should be efficient and properly integrated if overall system energy efficiency is to be achieved.

9.2 Broad consideration of technological integration

It is often argued that the cost of reducing energy consumption and demand in a sector, such as the hotel sector, is considerably lower than the investment required to provide this energy through a new power station.

For example, the Association for Conservation of Energy (A.W.Warren, London, 1984 onwards) frequently asserts that the cost of reducing domestic energy demand in the UK by about 30%, would be much less than the cost of the 4-6 large scale power stations which, according to the Association, would be made redundant.

There are several important reasons for which the argument described above has strong resonances in the case of Cyprus. The most important reasons which necessitate a discussion of this argument are the following:

(a) The government of Cyprus has already taken a decision for the construction of a new power plant. The construction of the power plant is only being delayed because of arguments related

to the proposed location of the erection and the type of fuel that will be used. There are thus, strong environmental constraints already acting on this proposed supply source.

(b) No serious efforts for adopting demand oriented energy management strategies was made during the planning of the proposed power station.

(c) The systemic "bottom up" approach adopted in this research project can provide exemplary grounds for drawing useful modelling conclusions and recommendations on the issue.

The experience gained from this research and its results have greater applicability while the methodology employed is certainly suitable for tackling the energy problems of other sectors of the economy as well.

Because of the huge investment and the environmental consequences involved, the erection of a new power plant in Cyprus (as in other parts of the world) is certainly an act requiring more than a supply-side decision.

While there are no implied criticisms for omissions or neglects in the work of local and foreign professionals involved, it is necessary to underline the risk of specifying a power plant based on inadequate data and improper evaluation of the real prospects of energy management conservation, and overall environmental impacts.

One consequence of ignoring energy management prospects would seem to be the erection of a power plant of much larger capacity and certainly higher financial and capital costs for the economy. Such a case will make later efforts for energy conservation not entirely meaningful since huge amounts of (borrowed) money will have already be spent without total justification, and the door will be effectively closed on more cost effective approaches.

Capital rationing is a necessary and prudent management tool even when supposed "surpluses of funds" exist. Since the economy of Cyprus is not an exception to this general situation, every effort should be taken to allocate its financial resources in the most efficient way.

The argument certainly holds for the allocation of financial resources for the supply (through a power station) of expensively produced electricity to a (most probably) non efficient end user, and the wastage of hot effluents at the power station, however well designed (e.g by use of combined cycle systems).

It is for this reason that we argue that the first step of a decision for major investments of this nature should be to ensure that the users are as efficient as possible and that the potential of improving the situation is thoroughly evaluated.

The evidence provided in this research in the form of data collected, case studies presented, sample simulation runs and

technological "fixes", points to the fact that there is a great scope for improving the current energy use situation in the hotel sector. Similar arguments apply to other large energy users, if preliminary evidence is to be believed (see Section 8.3 and Appendix G).

It is only after serious consideration of the prospects and the potential of such improvements in all the major user sectors that decisions regarding the construction and the capacity of new power plants should be made.

We might therefore argue that it may be more cost effective to supply expensive (high grade) energy in smaller quantities to a relatively efficient targeted integrated-user system, than to supply larger amounts of lower primary cost energy to a relatively inefficient user system.

The fact that the hotel industry energy user system investigated in this research is not efficient, has been clearly demonstrated. The main characteristics of the inefficiency of the hotel energy supply and demand system are summarised briefly below for the sake of the discussion that will follow.

(a) Lack of training and knowledge

(b) Lack of efficient monitoring and targeting systems

(c) Lack of motivation and incentives for energy conservation

(d) Lack of an efficient energy infrastructure

(e) Lack of proper exploitation of new and existing technology

(f) Lack of correct energy pricing policies

(g) Lack of justification of use of the specific fuels for each assigned purpose (fuel supply pattern)

(h) Lack of understanding of management modelling approaches to conservation

(i) Lack of an appreciation of the interactiveness of the sub-systems of energy supply and demand (related to h above)

Most of the reasons for these characteristics have already been discussed in other parts of the thesis (see Chapters II,VI and VII). Furthermore in Chapter XI recommendations based on the results of the research are given for the improvement of the situation. Here, a brief discussion of the electricity generation sector will be made. Following this, an attempt is made to put together sensible meta models of alternative scenarios that are based on the data and output of this research.

9.2.1 The Sector of Electricity

The Electricity Authority of Cyprus (EAC) is an independent, non profit making Semi-Government Corporation established under a 1952 Law (before the island gained its Independence in 1960). According to this Law, the Government, through the Minister of Commerce and Industry, is empowered to give directions to the Authority on matters pertaining to the general interest of the Republic. On the other hand, EAC advises the government, through the Minister of Commerce and Industry, on all matters connected with the generation, transmission and use of

electricity. It is clear, that the ultimate power and responsibility for establishing those policies which will benefit the country rests on the Government. Therefore, it is the Government's responsibility to direct the efforts of EAC in the right directions.

The fact that EAC is a non profit making corporation imposes additional obligations for supplying the public with electricity in the most efficient and cost effective way. Any investments made by EAC must be guided by these principles. Investing in the construction of a major power station implies the need for great attention and concentration on the National benefits.

But is this the case? Unfortunately the answer is not directly positive. What actually happens is that EAC whenever being critisised for actions or policies, argue that, according to the law by which it was established, it has the responsibility for uninterruptedly supplying all consumers with electricity. EAC thus concludes that it is within this responsibility that it plans for the expansion of its installations and the built up of new power stations.

This however is a pure application of the traditional "supply oriented approach". While it is true that EAC is burdened with the responsibility of the uninterrupted supply of electricity, it has also an obligation, as a semi public non profit making institution, to look on the demand side of the equation. Therefore, the aim should be the minimisation of demand so that

the required quantities will be reduced and the overall dependence on imported fuels minimized.

9.2.2. An alternative demand-side approach

Modifying the demand side of the equation can be illustrated in three ways. The first way does not require investments or incentives but requires the total cooperation of the consumer who will be asked, provided this is feasible, to reduce consumption and demand and perhaps change the time of his demand.

The second way is through investments on energy management and conservation. Where will the capital be provided from? First of all it should be established that energy management and conservation, being in line with its interest, should fall within the priorities of the EAC. Then the capital resources would be found. According to the 1989 balance sheet, EAC showed a surplus transferred to reserves of 17 million Cyprus pounds. Some of this surplus could certainly provide the basics for an energy conservation programme.

The third way arises from massive shifts in consumer technologies which might totally avoid the need for certain classes of energy resource.

Provided that the importance of looking at the demand side of the supply and demand equation (i.e., modifying /reducing supply and/or demand) is given the priority it deserves, the question naturally emerging is: Should EAC invest part of its

surplus (and indeed part of its scarce capital resources) to provide incentives to its consumers to reduce their consumption and demand for electricity? The answer should undoubtedly be yes. This is certainly a wise act that has been done by several electricity producing companies in the world. In the United States for example (Washington D.C), a local power company found that it was a better investment for the company to provide incentives and promote energy conservation of electricity than building a new power station for satisfying the demand. The investment was successful and the erection of a new power plant was avoided. The same issue is frequently rehearsed in the United Kingdom context (A.Warren, 1984).

However, the main issue of the discussion is to suggest feasible ways by which modification of the demand side of the equation might be achieved. It must be noted that it is an absolute necessity that demand side evaluation should be based on quality, quantity and timing criteria, taken together.

9.2.3 Creating alternative scenarios

While it is certainly possible to design several alternative scenarios, for the purpose of this discussion two major scenarios aiming at reducing energy demand will be targeted.

The discussion and the data provided in these two basic scenarios are based on the findings and the experience gained of the present research.

The first of these scenarios (Scenario I) involves an

attempt to reduce the energy demand without proceeding to major investments or the introduction of new technology . A first glance at the potential benefits suggests savings of 400000 Cyprus pounds and capital costs as little as 50000 Cyprus pounds.

The second scenario (Scenario II) involves the modification of the energy mix or resources through the introduction of new technologies. A first glance at the benefits and capital cost is more complex and interactive here, but possible benefits of 1.2 million Cyprus pounds and capital costs of less than 200000 Cyprus pounds would certainly justify a progression to more detailed analysis. For both scenarios anticipated benefits are given.

Scenario I

This alternative scenario is based on the following modifications that will have to be attempted:

(a) Modifying user habits and attitudes to energy conservation.
(b) Introduction of monitoring and targeting techniques
(c) Use existing energy resources in the most efficient and cost effective way (quantity, quality and timing wise)

It is advocated that by introducing the changes proposed in Scenario I savings in the range of 10-15% can be expected in individual hotels. The reduction of demand and consumption on the national grid will also be considerable and is estimated

around 10%.

All of the changes involved in Scenario I can certainly be incorporated in Scenario II. It is for this reason that expected savings for individual hotels and their impact on the sector and the economy, are much greater (see below). A brief analysis of the most important issues of each of the above proposed modifications is now presented.

(a) Modifying user habits and attitude to energy conservation

An examination of the various case studies and the analysis of the questionnaires demonstrates a great need and scope for modifying user habits and approach to energy conservation. These modifications can become a reality only by providing hotel staff (at all levels) with education and training. Education and training will certainly involve both technical and managerial issues and undoubtedly topics on monitoring and targeting which are discussed below.

Lack of knowledge and understanding of the complexities of the issue of energy conservation was well demonstrated during interviews with both hotel managers and chief engineers of the hotels.

Improving the understanding and knowledge of hotel managers and engineers on energy matters will undoubtedly have positive consequences in the energy demand of each hotel. Managers will be more sensitive on the energy issues and will

be more inclined to approve energy related investments whereas chief engineers will be able to manage, monitor and control energy use more efficiently.

Providing real incentives will undoubtedly contribute in the change of the staff's attitude. Considerable electricity savings (mainly from reduction of lighting load) will be realised once the staff, will be trained and motivated to strive consciously for energy efficiency.

Guests could certainly contribute to a more efficient energy use within a hotel. As it has been shown by the analysis of the related questionnaire the majority of the guests are willing to contribute towards energy saving in the hotel provided the management makes the effort to ask them to (see Chapter V). Provided the majority of the guests will react favourably, the energy for lighting, heating and cooling of rooms can be expected to be reduced by 5%-10%. However, according to the remarks of the guests, they expect to be asked politely and the request should not have consequences on the quality of service and comfort they are supposed to be enjoying.

There are good examples from the experience of other countries related to the positive effect of these measures. (Energy Management, AHMA, 1984).

(b) Introduction of monitoring and targeting techniques

The issue of monitoring and targeting has been given high priority within in this research. This is because it is

believed that the general axiom of "one can not control what he can not measure" has been literally adopted. In order for the measurements to have any value they will have to be consistently made and be used as a basis for taking corrective actions (controlling) and setting performance standards.

In almost all of the cases examined during this research the need for adopting monitoring and targeting techniques was overwhelming. It was only in very rare occasions that proper monitoring techniques were identified in hotels. Targeting was even more rare. Even in the cases where signs of these functions existed, there was always an apparent need for finding ways to evaluate and utilise the data gathered so that they would be turned into useful information upon which corrective measures would be based. It is for these reasons that this important issue is raised as a vital component of efficient Scenario I.

The need for sophisticated monitoring and targeting techniques is certainly not advocated. By adopting simple, usable and useful monitoring and targeting methods, a hotel makes a grand step towards energy efficiency. It is estimated that a typical hotel (such as sample Hotel A) can save at least 15% of its electricity consumption (around 82,000 kWh) in addition to electricity demand savings by the adoption of simple monitoring and targeting techniques.

(c) Use energy resources in the most efficient and cost effective way (quality, quantity and timing of demand: QQT).

The third energy efficiency component constitutes the core of the alternative Scenario I. The importance of establishing accurate information regarding present quality, quantity and timing (QQT) of energy demand in a hotel establishment (as in other energy consumers as well) can not be over emphasised. It is only after having obtained such information that decisions for corrective action can be taken. The existing maximum demand based tariffs for electricity makes it very expensive to operate equipment at times of peak demand (see Section 4.2.3). Extra capital equipment to provide the "peak" services should also be considered.

The adopted "bottom up" approach of this research was useful in establishing some of this vital information. The analysis of the data obtained throughout the research points to the fact that there are good reasons for challenging and reconsidering the righteousness of the present QQT patterns employed by several hotels.

Operating the air conditioning system in unoccupied or partly occupied zones is a good example of supplying the hotel energy system of comfort, through high grade expensively produced energy, inappropriately or at the wrong time.

There is also scope for improving the situation concerning the quality of energy required in several of the hotel premises examined. As it was observed during visits, discussions and

observations, there were cases in which "high quality electricity" was used unnecessarily. While lighting, exhaust fans, and motor driven equipment are virtually unavoidable electricity demands, there were cases, (for example in the kitchen, the sauna and the swimming pool bars and barbecue areas) where high quality electrical energy was used for heating water more for perceived "convenience" than for real need of the higher temperature available. For example an instant gas water could supply the required hot water at the point of use in sample Hotel A (at 60-75 Centigrade) much less expensive (1.1 cent/kWh) than the existing electric element (6 cent/kWh at peak demand period) resulting to reduction of electricity demand and savings of more than 1500 Cyprus pounds per year!

In other cases, hot water circulating in the space heating system was heated to much higher levels than the temperatures required while chillers were supplying chilled water to the air conditioning system at much lower temperatures than those required. All of these activities contribute significantly to costly peak loads and over consumption of electricity and other fuels. For example the COP (Coefficient of Performance) of a chiller with a centrifugal compressor increases by approximate 3% for each degree C of temperature rise of the leaving chilled water. Therefore a 100 kW compressor chiller with a COP of 3 operating for 18 hours a day during the summer period (150 days) will save 8,100 kWh for each degree C rise of its chilled water temperature.

The issue of quantity of energy used is extremely important. As in the case of establishing the quality and timing of energy use, identifying on whether the "correct" quantities of energy are used can be found out through relatively ease and non sophisticated audit methods. It was observed during visits and the analysis of the sample audits that in several cases excessive energy quantities were used. A good example of this situation is the operation of several hot water boilers each one well below its nominal capacity with a consequent low efficiency, resulting in a waste of gasoil. Electricity and LPG were also used wastefully when, for example, appliances (kitchen equipment, fans, air conditioning systems etc) were left to operate unnecessarily.

General Remarks

Adopting the measure described in Scenario I will result in a modification of the demand pattern of individual hotels by lowering the total energy requirements by at least 10-15% (around 80 millions MJ). At the individual hotel level, it is estimated that a typical seaside 3 star hotel with 90 rooms and average annual bed occupacity of 75% will be in a position to save around 70,000 kWh of electricity, 12,000 litres of gasoil and 1,000 kg of LPG or in money terms around 4,300 Cyprus pounds per year. While no investments are generally required, the aggregated benefit for the sector will be significant. Positive consequences will also be enjoyed by the national grid (reduction of costly peak demands) and the economy in general (reduction of oil imports).

Scenario II

Before proceeding to a description of the proposed attempts to design possible alternative energy supply scenarios it is necessary to explain briefly the logic and the procedure followed prior to arriving at this phase.

The various stages involved were as follows. The first stage involved the evaluation of the technical capabilities and limitations of the most important energy supplying technologies suitable for the sector investigated.

Decision modelling techniques (investment appraisal, simulations etc) were used to evaluate these technologies. The second stage involved the collection of data that would be used in understanding and establishing demand patterns. The third stage concerned the evaluation of these data in order to establish representative demand patterns.

Scenario II involves the last stage of this process in which attempts are made to over lay a supply "mix" that will match as possible the pertaining demand pattern. Various options of energy supply mixes are presented.

While major elements of the proposed "outcomes" are certainly very "site constrained", we believe that the alternatives provide an excellent range of feasible solutions with real applicability in specific situations.

Necessarily, any final decision to adopt any of the proposed

alternative "solutions" of Scenario II will have to be based on additional detailed analysis and investigation, beyond the estimates of costs and benefits used in this work.

Scenario II (a)

This scenario concerns attempts to modify the existing supply pattern so that the primary fuel and grid electricity cost of the supply energy mix is minimised. It is noted that the systemic nature of the analysis requires that benefits for individual hotels will have to be viewed in conjunction with the benefit of the sector, the economy in general, the infrastructure and the human aspect of all elements involved.

This scenario involves an increase in the contribution of solar energy and the exploitation, during peak demand periods, of the stand by generators of hotels. The average percentage of hotels equipped with solar systems on the island is 59%, the maximum percentage (73%) being in the hotels of the 4 star class, and the minimum (54%) for the hotels of the 5 star class.

There is certainly great scope for increasing the contribution of solar energy in the existing overall energy supply "mix". The use of solar energy should be extended for both the production of hot water and the heating of the swimming pools.

Without underestimating the practical difficulties of the installation of the systems, and especially that of individual

solar swimming pool system installations, it is believed that once a policy is set aiming at the maximum exploitation of this generously available resource, considerable benefits for both the sector and the economy will be realised. Imported gas oil currently used for these activities will be saved.

However, emphasis should be given to the correct design and installation of solar hot water systems and to the systemic interaction of the technology with other energy conservation measures. For example collecting solar heat in the peak of the Summer can work against the simultaneous efforts to cool the hotel if uninsulated hot water pipes emit heat to the environment. In fact around 70 W of heat will be emitted in the hotel from each meter of uninsulated copper pipe (28 mm in diameter) carrying solar heated water at a maximum of 75 degrees Celsius (ambient temperature around 25 degrees Celsius). This leakage generates roughly 25 kWh of unwanted heat, (assumed pipe length 45 m) extra demand on air conditioning plant each day. By taking a systemic approach to the design and operation of the energy consuming equipment many problems will be avoided.

Solar heated swimming pools

As has been shown in the case study of the swimming pool analysis the gasoil savings from this typical solar heated swimming pool are of the order of 3.8 tons of gasoil per year. However, the case analysed involves a relatively small hotel (52 rooms) when the average room number for 5, 4 and 3 star hotels are 210, 155 and 90 respectively. It is therefore quite

reasonable to assert that the savings for larger hotels will be much larger (average savings per hotel 7 tons of gas oil) per annum.

From the data collected it is shown that almost 70% of hotels heat their swimming pools in the Winter. Therefore (excluding 2 and 1 star hotels) the number of heated pools are approximately 70 and the expected savings from the application of solar heating on these swimming pools will be in the range of 490 tons of gasoil per year or in money terms around 50000 Cyprus pounds per year.

Solar hot water systems

A solar hot water system can supply a hotel with around 85% of its hot water requirements. As it has been shown in the relevant case study, (see Chapter VII) the savings in energy per square meter of solar panel installed (assuming a boiler efficiency of 70%) is 0.097 toe.

Assuming that motives will be given for the installation of solar hot systems in the majority (95%) of the hotels that are not currently equipped then the expected energy savings will be around 815 toe. In money terms the gasoil savings will be representing around 81500 Cyprus pounds. This estimation assumes that 8400 sq.m. will be installed (0.7 sq.m of solar collectors for each hotel bed). The solar hot water system efficiency was assumed to be 40%.

Stand-by generators

Exploiting the capabilities of the stand by generators, at least during the hours of daily peak air conditioning demand will have several positive effects on the energy supply system of the hotel sector. This component of Scenario II can certainly be included in any other scenario since it might, subject to technical and legal obstructions, become major part of the energy supplying policy of the industry. The major advantages of the exploitation of the stand by generators are listed below :

(a) Electricity consumption of individual hotels and the sector in general will be reduced
(b) The peak demand of the hotels and the total demand on the national grid will be reduced.
(c) Hotels will be exploiting otherwise sunk capital and thus contributing to the profitability of their capital investments.
(d) Considerable money savings will be enjoyed by all hotels involved through reduction of maximum demand cost. Typical savings in the range of 500-1000 Cyprus pounds per summer season (June-October) for a typical hotel can be expected (see also Section 4.2.3).

It is quite difficult to quantify exact savings from the adoption of this component of the scenario, mainly because of lack of knowledge on the total number of existing generators, their capacity, the number of operating hours and their efficiency. However some general conclusions on the effect

of this measure to the electricity supply system can be made.

According to the Cyprus Tourism Organisation (C.T.O) regulations, all five and four star hotels are obliged to have stand by generators. However, evidence obtained in this research shows that most of the two and three star hotels are also equipped with generators. Though the C.T.O regulation makes no provision for the required capacity of the stand by generators, their capacity usually far exists the installed air conditioning load.

The peak load of the hotel sector is around 15 MW and 56% on a peak day is due to air conditioning (EAC, Load Research Report ,1988). Assuming that stand by generators will be allowed to cut in at peak hours (around 8.30 p.m), the peak electricity load will be reduced to around 7 MW resulting to a 2% reduction on total network peak electricity demand over the adjoining one hour period.

Scenario II (b)

This scenario involves the use of chp micro systems for the production of both heat and electricity for the needs of individual hotels. As shown in the analysis performed (see Chapter X) using simulation techniques, optimum heat to power ratio was likely to be in the range of 0.5-1.0, given overall demands for the two types of energy.

Provided regulation, legislation and financial barriers are overcome considerable benefits could be expected form the wide

application of cogeneration in the sector. The technology of combined heat and power production could well be applied to both existing and new hotels. Though savings for new installations will be high, the cost of installing expensive boilers will be avoided and plant sizing might be more accurately planned.

It is certainly expected that the technology will have wider prospects for cost effective application in the case of larger hotels in which demand for both electricity and heat is greater.

However the possibility of sharing a chp system between two or more nearby hotels certainly exists. There are several occasions in Cyprus, usually at the beaches, in which hotels, are situated quite close to each other. For example at Paphos, half (5) of its 3 and 4 star hotels lie around 70 metres away, of each other, whereas in Larnaca the vast majority of its hotels and tourist apartments lies (in groups of 2 or 3) closer than 100 meters away from each other. Provided the willingness of the owners of hotels exists the sharing of energy supply facilities could easily become a reality. The theoretical possibility of "selling" energy (both heat and electricity) to other neighbouring hotels does exist.

The concept could even be extended to at least one step further. This remark concerns the possibility of a group of hotels, owning their own heat and power station .However, this option is discussed under Scenario II (c).

The optimum capacity of the chp systems suitable for installation in the hotel sector in Cyprus (based on the cases examined) lies in the range of 100-120 kW. Micro systems of 40-60 kW ratings for smaller hotels may also be viable in specific instances (see for example Fawkes, Linnell, Jacques and Watkins, 1987). The major obstacle when trying to generalise on the likely economics of chp in the hotel sector is the fact that viability of chp installations is always very site specific. For this reason an analysis of the actual heat and power demand based on QQT criteria must always precede a major decision of installing a chp system.

The analysis performed in this research did not include a large enough sample of hotels that would provide confidence for generalising conclusions for the whole sector; however assuming that the majority of the coastal hotels in Cyprus have a heat and electricity demand pattern similar to that of the hotels examined (see Chapter IV) it can be argued that there are good prospects for energy savings.

It is a fact that the peak electricity demand of the hotel sector, coincides with the peak demand on the national grid (EAC Load Research Report, 1988). The commercial sector has a contribution of approximately 25% on the total daily national electricity peak demand. We must also consider the fact that hotels are the major electricity consumers in the commercial sector, although geographically they might not be expected to be sited in the "industrial suburbs" of the major towns and villages.

All of the above underline the fact that any effort to reduce electricity demand on the hotel sector (like for example the installation of chp systems in large hotels) should have significant effects on the reduction of the peak demand.

However there are some important constraining issues. The most important of these constrains are discussed below.

(a) Although economies of scale do have a certain effect, smaller installations can be expected to be more cost effective than larger installations. This is because smaller installations can be expected to use a greater proportion of their output. It is not cost effective to attempt to size the chp installation for a specific hotel to meet the maximum demand, but rather to meet 65-85% of maximum, or 60% of average demand (Ove Arup and Partners, 1988).

(b) The most likely chp fuel is LPG, because, as explained earlier, its price is kept artificially low, mainly for social reasons. However, a decision may be taken to increase the price of LPG for industrial consumers. In this case the cost effectiveness of a chp installation operating on chp would have to be re examined (see also Section 10.1.5).

(c) Consideration should be given to the fact that domestic water heating is a relatively small load and space heating is only seasonal.

(d) There may be possible "conflicts" between policies

promoting wide use of chp and policies promoting the wide use of solar energy since both technologies attempt to satisfy hot water requirements. However policy makers will have to consider the fact that the application of solar systems supports a local industry (solar manufacturers).

(e) An option which bears detailed consideration is the investigation of the possibilities of converting existing stand by generators. Since there is apparently no serious technical problem, the cost effectiveness and the regulatory aspects should be examined. The fact that the greatest portion of the cost involved will have already been allocated (for the purchasing of the stand by generator) should be considered as an important advantage.

A cost effective analysis of various options of chp capacity based on actual heat and electricity demand data was performed in Chapter X. While it was not possible, for the reasons explained above, to generalise the benefits of wider applications of chp in the hotel industry, with any great precision, preliminary calculations indicate that a potential in the range of 2 to 5 MW does exist. We therefore believe that the issue should be seriously evaluated by the authorities concerned. The further evaluation of the prospects of the technology in the sector should be given high priority mainly because of the decision for the erection of a major power station.

Scenario II (c)

Scenario II (c) involves the satisfaction of heat and electricity needs of the hotel sector through a power station owned and operated by the hotel owners themselves.

Despite the fact that the scenario appears to be purely theoretical it was considered important to express some thoughts on the issue and certainly include it in the list of the possible alternative energy supply scenarios.

One current constrain upon the idea of the sector owning and operating its own heat and power station is the fact that according to pertaining legislation only EAC has the right to produce electricity on the island. However, the Law states that the Minister of Commerce and Industry can issue a permit for this purpose provided that the application is properly justified and that it does not work against the interests of the EAC.

Legislation barriers should therefore not be considered as a major obstacle since both the Government and the EAC have in the past expressed willingness to consider proposals for the production of electricity mainly through biogass and wind generators installations.

There are several issues that will need consideration when examining the possibilities of such an approach. The most important of these issues are listed below.

(a) Proper consideration should be given to the energy supply

source or energy "mix" that will be used. This can be a large chp plant, a conventional oil or coal (!) operated plant, a solar thermal or photovoltaic plant, a wind power plant or a "mix", at an optimum rate to be established, of these or perhaps other possible resources.

(b) Because of the distance between the touristic areas of the island and the expensive electricity transmission, line installations (heat supply to these distances is not practical at all) it may be more cost effective to construct four smaller energy supply plants that would satisfy the demands of each major touristic area of the island (Paphos, Limassol, Larnaca, Ayia Napa). By taking a close look on the map showing the location of hotels on the island, one easily observes that in all locations the majority of the hotels are very closely located to one another.

(c) The annual electricity bill of the Hotel Industry (in the range of 5 million Cyprus pounds) is a significant reason for the consideration of the idea of the sector becoming self sufficient.

(d) The government should consider positively such a proposal since it will provide substantial benefits to the consumption and demand of electricity on the national grid. This may also work to the benefit of the domestic consumers who are the principal concern of the current social policy on electricity supply. The benefits, at the economy level, will even be more if the energy supply "mix" of the proposed plants includes, a

high proportion of renewable energy sources. The renewable energy participation will contribute to the reduction of imported oil quantities.

(e) The adoption of this scenario will contribute to the diversification of electricity production sources.

In fact, energy planners should evaluate the possibility of encouraging the production of electricity by individual consumers and sectors against the need for the capital required to built, operate and maintain a new power station that would satisfy total national demands.

(f) The possibility of obtaining grants and contributions for foreign international organisations might be enhanced if the proposed supply "mix" contain renewable energy sources. In such a case the justification for the provision of the funds will be the fact that the plants could be considered as prototypes, and thus as a learning experience for other countries.

Scenario II (d)

This scenario involves the simultaneous adoption of a mix of energy technologies constituting of chp, wind generation, and solar energy. In order to evaluate the cost effectiveness of this scenario various simulation runs, based on real demand and weather data were performed (see Chapter X).

The details of the configuration of each run and the results

of the cost effective analysis for each case are presented in Table 11.1.7. The discussion in this section will revolve around the difficulties and the prospects of the wider applicability of this energy supply mix.

While there are obvious benefits when enriching the energy supply mix at the level of the hotel sector and the economy in general, for the case of existing hotels the situation is not exactly the same; "retrofit" policies require special care and often a certain number of extra site-specific costs.

That is, whereas for newly designed buildings the designer is free to adopt the most cost effective energy supply mix, in the case of existing hotels there are various constraints that reduce the effectiveness of the approach.

The most important disadvantages when attempting to adopt the particular energy mix in existing hotels are listed below.

(a) The evaluation of the energy needs and measures for improving the situation will have to consider seriously existing technology and the possibility of integrating it with the new supply mix in the most efficient and cost effective way.

(b) The problem of adopting new technology in an existing hotel will have to be taken seriously into account. Human resistance to change can be a major drawback for any attempt to introduce new technology. As it was shown during discussions in

the questionnaire phase of the research, there is general lack of knowledge and willingness to adopt new technology. The total cooperation of all staff is therefore necessary; The problem is, that the current evidence shows that there is no guarantee of such full cooperation.

(c) The problem of securing the required capital will certainly be raised by hotel owners. Discussions revealed that it is always much easier to convince hotel owners to invest at the initial build up of the hotel than afterwards. The reason for this, as explained by hotel owners, is the fact that sums allocated at the beginning are small parts of a large loan which will be paid over a long period whereas investments after the operation of the hotel will have to come from earnings and which are not always tax deductible. One should also consider a remark, made by a number of hotel owners and managers, which constitutes a major obstacle to energy efficient technology that "higher energy operating costs mean .....less tax !!" Energy management per se is clearly not the only gap in the education and training of managers!

Introduction of Variable Alternative Supplies

Despite the technical viability of the technology, the participation of wind electricity supply in the energy mix imposes three major problems that will need specific attention.

The first problem concerns the risk of having, (depending on the type and the capacity of the wind generator) unacceptable noise levels with serious consequences on the stay of the

guests. The second problem concerns the location of installation of the wind generating system. The third problem concerns the variability of the supply, and its phasing with demand patterns. In any case, detailed site specific wind velocity measurements must precede all major installation decisions.

The reference to the disadvantages above should not by any means be interpreted as limiting the prospects of promoting this specific energy supply "mix" in the hotel sector. As is shown in chapter XI there are good prospects of adopting this energy "mix".

It is quite difficult to estimate the overall energy savings from the adoption of this scenario. The contribution will depend on the degree of acceptability and the specific contribution of this energy supply mix for each individual case. The basic benefits for the sector and the economy, as mentioned elsewhere continue to apply. Mainly the reduction of electricity consumption and demand on the sector and the national network and the more efficient overall use of energy resources. A major benefit can be expected from the reduction of imports. The potential lies in the range of 2-3 overall MW demand and around 1 MW peak load reduction.

Scenario II (e)

This scenario concerns the adoption of measures by the majority of hotels aiming at modifying both the electricity and the heat demand of the sector. The installation of chp systems

is not included in this scenario since it was examined in an earlier model.

Reduction of electricity consumption and demand, under this scenario, is achieved by the adoption of passive cooling techniques whereas reduction of heat demand is achieved through heat recovery. In this case wasted heat from the chillers, heats water for domestic use. A hot water solar system, sized correctly, adds support for the heat supply requirements of the system.

The benefits of passive cooling, heat recovery and solar system technologies have been described in earlier sections of this thesis. The discussion in this section concerns a wider approach aiming at an attempt to evaluate the prospects and limitations of a general adoption of this energy supply "mix". Considerable energy savings (in the range of 15%-25%) can be expected from a systematic industry wide adoption, (based on thorough evaluation of each particular case) of this scenario.

At a first glance, the participation in the energy supply "mix" of both solar hot water systems and heat recovery technology for the production of hot water appears to be "contradicting". The reason, is that both technologies have the same objective, so that "normally" a decision is expected to be made in favour of one of them. This however should not be the approach. Every new design should aim at the most effective utilisation of both the limited capital resources and the available means and technology for the satisfaction of the

energy demand of the system as a whole. It is within this content that the energy supply "mix" should be addressed.

Therefore, unless an overall government policy, and the accompanying incentives, impose the adoption of solar hot water systems, the procedure for establishing the energy supply "mix" should be as follows.

(a) Every effort should be taken during the build-up of the building envelope for the exploitation of solar passive techniques. Estimation of cooling load and sizing of air conditioning equipment should consider this contribution. Even in the case of existing hotels, measures for adopting passive cooling techniques (shading, insulation etc) should be taken, but rationally, retrofitting is often more costly than primary installation because of its structural constraints.

(b) The second step should be the evaluation of the prospects of heat recovery from the chillers that will be specified in step (a) above. Since the vast majority of hotels are equipped with central air conditioning systems, much of the capital investment for the chillers is unavoidable. Enquiries to chiller suppliers revealed that several units offering heat recovery possibilities are available and can be ordered at the initial construction phase of the hotel.

(c) The third step of this scenario involves the evaluation of the hot water heating load that was not possible to be met from the exploitation of the heat recovery potential from the

chillers. It is this part of the load which might be satisfied through the installation of a solar hot water system. The above procedure is only indicative and does not exclude other approaches.

For example, the cost of the heat recovery system may prove to be prohibitive in which case step (b) will have to be entirely excluded and solar systems will have to satisfy most of the hot water needs.

According to the result of prototype applications of passive and hybrid cooling systems, the reduction of cooling load in new buildings and therefore of the electricity consumption and demand can be of the order of 15-50%. However most of the hotels are already built and therefore passive cooling techniques can only be used as retrofit measures.
The application of several of the techniques (shading, reflective painting etc) is still possible but savings should normally be expected to be in the lower part of the above range (10-20%).

9.3 Additional Considerations

The current experience indicates that the problem of energy management in the island's hotel sector has several unique characteristics. At the same time several other characteristics are not specifically sector related but are rather of a general nature within Cyprus. That is, they are related to the mentality of the people and their cultural characteristics.

In this sense it is advocated that there are no "universal solutions" to the problem of energy management and that local conditions affect the "solutions" dramatically. It is for this reason that the systems approach is perhaps the best available approach to the problem. While utilizing important universally accepted principles, it resorts to tailor-made recommendations for improving the situation, rather than for solving the problem "absolutely" in an unattainable "ideal" situation.

The importance of synergy of proposed and adopted energy solutions should be thoroughly considered in each individual hotel establishment. Taking the correct decisions for the appropriate "mixture" of energy saving investments at the right time not only results to the benefits of each individual investment but to additional benefits of the synergy (Jacques, Lesourd and Ruiz, 1988) effect of the solutions (for example: the solar collection/ air conditioning case; boiler sizing for best overall occupacity/efficiency).

While technology can be made universally available, its use and management is always a function of the human factors involved. This will also imply attitudes of the suppliers of capital funds to risk taking and capital rationing (see below).

There is no possible way by which one can attempt any remedial action without seriously considering the human element. It is for this reason that so much emphasis has been given in this research to this factor. It has been stated (Pearson, 1985), that energy management is 80% attitude and 20%

technology; the present thesis fully supports this view.

Furthermore, energy management must compete with numerous other objectives for hotel owners. While it certainly deserves a good place in the priority list of hotel executives, finally, it is only through competition that it will take its proper place in the agenda of the decision takers.

These facts have been well demonstrated during discussions, execution of the questionnaires and carrying out of the sample audits. A major problem faced was the fact that once a perceived value, justified or not, was established by the major human actors (managers, chief engineers, architects etc) it was extremely difficult to change it. This has considerable consequences on the decision making process since certain, perhaps good, solutions are excluded without real consideration. Willingness to learn is a major characteristic of the human actors of the system which has been well demonstrated on during the analysis of the questionnaires. However it was always very difficult to determine cases in which lack of knowledge was admitted.

The general characteristic, perhaps cultural, of the population, according to which "everybody claims to be expert on everything" was not an exception in the hotel sector. On several occasions chief engineers, and even managers, would pretend that they were familiar with the subject of discussions (see for example in Chapter V the response of some chief engineer's response regarding power factor).

In large hotels, we observed that the chief engineer is almost constantly under pressure to keep the hotel "running". At the same time he is faced with a complex pattern of changing priorities and even in some cases responsibilities. It is within this environment that most chief engineers are called to implement and maintain a proper energy management system.

Another major problem of energy management identified is the absence of an energy management "ethos". On several occasions the absence of real energy management ethos was obvious despite efforts to hide it and the lack of serious, specific endeavour.

A fundamental requirement for proper energy management, which has to be established in each and every hotel involved, is total management commitment. Unless the owner of the hotel the manager and all department heads are willing to commit time, money and resources, the energy management program will never be implemented.

Involving employees is at present one of the greatest unexploited sources for making a major contribution to the energy management effort. There are always members of the staff who have an intimate knowledge of the function and role of energy systems but do not have a mechanism for contributing to the program.

Managers of Cypriot hotels have been shown not generally willing to provide "worthy" incentives to their staff for conserving energy. No matter how energy conscious the staff may

be the management should consider seriously the provision of incentives.

Lack of knowledge must be recognised as a major problem for the development of energy management ideas. Many members of the staff simply do not know what to do or the priority of doing so, according to the questionnaire responses.

9.4 Sampling the energy demand across the economy of Cyprus The need for systemic analysis in other sectors

The Hotel industry has been the core industry of this research and its energy performance has been examined in detail in order to arrive at useful recommendations for the improvement of the situation.

However the systemic approach adopted in this research necessitates the view of the industry within the larger energy consumer, the economy. Important decisions, especially at the micro economic level (like for example the construction of a major power plant) should only been taken after detailed, bottom up, systemic investigation of the existing situation (in the soft systems methodology sense).

Within this context it was decided to proceed into a general sampling of the energy demand of the economy. The purpose of this investigation was to evaluate the nature of energy management and planning processes in sample industries in order to draw useful comparative conclusions for the existing

situation.

The related data for this investigation originated from a dairy industry, a canning industry, a wine, liquor and soft drinks producing industry, a hospital and the premises of a local bank.

The data were obtained from sources such as the EAC, the Department of Statistics, the MCI, and the staff of the energy consumers themselves. Valuable information was also obtained during discussions with related executives and officials.

The evidence obtained from this investigation indicates the presence of symptoms of both inappropriate and inadequate energy management practices and planning across all sectors.

Despite the brief examination of the existing energy scene in these consumers, it became obvious that there is certainly scope for better energy management and planning. Lack of monitoring and targeting techniques, as well as education and training of staff concerned was apparent in all energy consumers examined. In addition we observed a need for better management of existing technology as well as awareness of the existence and the need for adopting new more efficient technology.

The management of the three productive/industrial consumers seemed to be entirely occupied with the implementation of their production policies and production targets. While the contrary

was always stated it was obvious that the problem of energy management was quite low in their list of priorities.

In the case of the public hospital there appeared to be no clear line of responsibility for energy management. Hospital officials would state other government departments as being responsible, whereas officials of those departments claimed that they were only responsible for the maintenance of the hospital.

The bank manager quickly appreciated the situation and requested further information on possible remedial actions. However he was very keen to state that it should be the responsibility of the related government department to inform consumers on ways to conserve energy.

A brief description of the existing situation in the energy consumers examined and the most important conservation opportunities identified is given in Appendix H.

There is therefore an urgent need for proceeding into detailed studies, (utilising the approach and the methodology of this research) of the energy situation in other sectors of the economy as well. Considering the evidence of the present work in the hotel sector, nothing less than a fully systemic approach would be appropriate. We believe that it is extremely important that this work precedes any implementation, in the short run, of the decision already taken to proceed with the construction of a new major power plant.

CHAPTER X

USING COMPUTER TOOLS FOR ENERGY DEMAND MODELLING

10.1 Micro computer modelling

The solution of the problem of finding cost effective "mixes" of energy and the adoption of new techniques and patterns that will make maximum use of various alternative energy sources (i.e wind, solar) ought to be extremely beneficial for the whole of the hotel industry. Furthermore the application of the experience gained should lead to wider application in other industries as well.

In this Chapter the results of systematic attempts to satisfy diurnal energy demand patterns of heat and electricity (real and highly stochastic) utilising a new simulation software package will be presented.

The objective of these attempts was to demonstrate some of the problems of design-choice for cogeneration and other alternative energy sources under conditions of considerable demand variability. Preliminary studies were reported earlier (Jacques and Konis, 1989).

The need for having good, detailed sample data on quantity, quality and timing of energy demands (QQT) is extremely important in these decision modelling.

The software language employed by the model was Turbo Pascal

versions 3 and 4. The model allows for realistic variation of the three sets of system variables to meet the intermediate test requirements of the system designer. These are: engineering equipment configurations, fuel input costs and opportunity costs and detailed diurnal and seasonal energy consumption patterns. The three sets of variables are briefly described below.

10.1.1 The system variables

(a) The engineering design parameters of a proposed configuration such as maximum power rating, heat to power ratio, capacity of auxiliary boilers and other supplementary electricity supplies such as wind generators. System efficiency data and capital cost estimates are also included.

(b) Fuel input costs and opportunity costs of the energy outputs including the possibility of "selling" surplus electricity to the National grid (or to other consumers).

(c) The diurnal patterns of electricity and heat demand for the user of the system ("stochastic" variables). A complete 365 day year is represented by up to 12 monthly patterns.

The model also includes subroutines which take care of the variability in the supply potential of alternative sources of energy. A complete description of the model is available in the literature (Jacques and Muir, 1988).

All earlier studies in this field point to the importance of

testing the robustness of any proposed CHP scheme to random fluctuations in the demand pattern. The simulation research phase in this project was therefore composed of two stages.

(1) the simulation of random demand patterns on the economics of a "straight-forward" chp scheme and
(2) the effect of introduction of "mixed stochastic supply" options.

10.1.2. The simulation process

The first stage involved the testing of the model and the simulation of random occurrences. The effect of the simulated supply and demand patterns on the overall economic performance of a proposed micro-chp application was then evaluated.

The second stage involved the investigation of various options for satisfying the hotel's energy demand patterns with "mixes" of energy supplies (cogeneration, wind energy, solar energy) of different capacity . The results of the analysis of the first stage were evaluated and taken into consideration during the second stage of the investigation.

10.1.3. The first stage analysis

Samples of the data for the four demand patterns collected (for both heat and electricity) from a large seaside hotel are given in Table 10.1.1. The data were collected for three non consecutive days for each of four season patterns on an hourly basis.

Hour (24 hour clock)	Heat Mean	Heat Deviation	Electricity Mean	Electricity Deviation
Pattern 1	(February-April)			
10	3576	2213	306	18
21	6522	4377	546	25
Pattern 2	(May-July)			
10	1026	527	305	15
21	1314	327	487	49
Pattern 3	(August-October)			
10	100	1.0	766	65
21	100	1.0	1164	202
Pattern 4	(November - February)			
10	250	2.5	305	15
21	250	2.5	580	29

Table 10.1.1: Samples from demand patterns of the Hotel used in the simulation model (All values in MJ per hour)

Table 10.1.2 presents a test of the stability of conclusions about the discounted nett worth of the proposed chp configurations to varying degrees of randomness in the electrical demand data. As can be seen from this table the design choice becomes more sensitive under conditions of widened demand variation. The robustness of 100 kW and 60 kW choices with minimal heat-to electricity ratios (on 0.5:1) is evident.

It is also observed that a ten-fold increase in electrical demand variability around the observed sample means creates only 3-4 fold decrease in the discounted 10 year nett worth. The pay back period rises from 2-3 years to 6-7 years at 20% test discount rate. The choice of capital equipment is, thus, reasonably robust under most conditions.

The influence of seasonal patterns, based upon a combination of occupancy and weather data, was also examined. The results of this simulation are shown in Table 10.1.3. It is obvious from this table that there are improved economic savings from using low ratio cogeneration systems. This can be attributed to the fact that at least three of the four "season patterns" on the island are "hot" and there is a very heavy demand on electrical supply for air conditioning, relative to hot water demand.

However, when the simulation is required to accommodate wide seasonal variations of mean demand pattern and a large ten fold hourly electricity demand deviations, the consequences

Electrical Power (kW)	Heat : Power Ratio	NPW based on original spread of data	Electricity deviation increased 5 times	10 times
100	2:1	-7844	- 8600	-10917
	1:1	7523	6088	2329
	0.5:1	22700	20521	16351
60	2:1	-6152	-6500	-7686
	1:1	3036	2405	361
	0.5:1	12213	10734	7100
40	2:1	1870	-	- 686
	1:1	4195	-	1250
	0.5:1	5416	-	1648

Table 10.1.2: 10 year discounted Nett Worth (Cyprus pounds) for a chp proposal

Elec Power (kW)	Heat:Power Ratio	Single data set (original)	4 period sets original deviations	10 fold deviations
100	1:1	680	-2778	6067
	0.5:1	2329	12273	7230
60	1:1	-	1225	-2935
	0.5:1	62	6543	4040
40	1:1	-6767	-3097	-4079
	0.5:1	- 2467	1856	-350

Table 10.1.3 : Effect of incorporating four separate 3 month "sampling periods" into the data.

become much more significant.

The results shown in Table 10.1.4 indicate that the "optimal" size for cogeneration in the case of the particular hotel lies between 100 kW and 120 kW. The best choice of heat to power ratio, as illustrated in Table 10.1.4 lies between of 0.5-0.6.

The final phase of this stage included the addition in the simulation of a 20 kW wind generator. The benefits of the partial substitution of cogeneration power by some wind generated electricity despite its very variable characteristics are shown in Table 10.1.5.

All of the conclusions summarised in Tables 10.1.1 and 10.1.5 are very sensitive to fuel costs relative to current grid electricity prices and to relative costs of installed chp and wind generator units. The results are also dependent on local variability of heat and power demands on an hour by hour basis.

10.1.4 The second stage analysis

This stage of the analysis involved the extensive use of the simulation model in order to experiment with various mixes of energy supplies (cogeneration, solar energy, wind energy). The aim of this experiment was the drawing of useful conclusions concerning both optimum capacities and possible mixes of these supplies.

Real hourly heat and electricity demand data from typical

Electrical Power from chp	Units	H/P Ratio	Capital Cost	Annual Maint.	10 Year NPV *
40 kW	40	1:1	16000	1200	-4079
		0.5:1			350
60 kW	60	1:1	20000	1500	-2935
		0.5:1			4049
100 kW	100	1:1	30000	2500	-6067
		0.6:1			2025
		0.5:1			7230
120 kW	2x60	0.75:1	40000	2800	-2943
		0.6:1			1009
		0.5:1			4590
140 kW	80+60	0.7: 1	46000	3300	-4050
		0.5:1			3982
180 kW	3x60	0.75 :1	60000	4500	-12875
		0.5:1			-1018
200 kW	2x100	0.6:1	80000	5600	-20234
		0.5:1			-14840

Table 10.1.4 : Results of simulations for various possible configurations (* 20% test discount rate)

Total input (kW)	Units	Heat : Power Ratio	Capital Cost	Annual Maint Cost	Nett Worth 20% TDR
120	100 chp	1:1	49300	3500	-3600
	+ 20 wind	0.7:1			4316
		0.5:1			10935
80	+ 60 chp	1:1	39300	2800	-2713
	+20 wind	0.7:1			1517
		0.5:1			5027
80	80 chp	0.7:1	32000	2200	-1265
(no wind generator)		0.5:1			2805

Table 10.1.5: Combination of cogeneration units with some wind generators

weather patterns were collected and analysed.

The hourly heat input in the model by the various solar system configurations was calculated using hourly global radiation data for the specific hotel location. The solar data for surfaces tilted at 50 degrees were provided by the Meteorological Service of Cyprus.

A solar panel efficiency of 70% (typical of good locally manufactured systems) and a system efficiency of 40% were used in the calculations.

Wind velocities for the specific hotel area available at a height of 10 meters a.s.l were transferred, using an appropriate relation, to that of the proposed system shaft height utilising data from wind generator manufacturers and the Meteorological Service of Cyprus.

Hourly electricity produced for each season pattern was then calculated and inputted to the model.

The collection of data of hourly heat and electricity consumption was one of the most vital, difficult and time consuming activities of the whole investigation. The importance of the existence of adequate and reliable data for the model building process can not be overemphasised.

Seven different cogeneration systems of varied capacity and heat to power ratio of 0.5 : 1 were analysed. The decision to

investigate the particular heat to power ratio was based on the analysis of the first stage. The results of the first stage analysis were reconfirmed. During these simulations no other auxiliary sources of energy were added.

Following experimenting with three different energy "mixes" (configurations) which included cogeneration, solar systems and a wind generator, the effect of varying the capacity of the cogeneration system (between 40 and 140 kW) while maintaining the same wind generator (60 kW) and solar system (250 sq.m) was investigated. The effect of varying the heat to power ratio was also investigated on a specific configuration.

The established ratio of 0.5 during the first stage analysis was reconfirmed.

For the optimum configuration established for the specific hotel (100 kW chp + 15 kW wind generator + 150 sq.m solar system) a substitution of the chp generated electricity with wind generated electricity and solar produced heat was performed. Four new configuration were thus produced and examined. The final phase of the analysis included a sensitivity analysis of the resulted "optimum" configuration. The sensitivity analysis aimed at investigating :

(a) the effect of changes in the quality of heat and electricity input by the specific energy "mix" and

(b) the effect of changes in the cost of the system.

10.1.5 The simulation results

Table 10.1.6 presents the results of seven cogeneration configurations without any auxiliary energy inputs (i.e solar energy or wind energy). The calculated yearly benefit and Nett Present Worth for each proposed investment are given.

Table 10.1.7 presents the results of five simulation runs. In configuration No 4 we allowed cogeneration input to vary while solar and wind input was kept constant. In this way five new configurations were created. Configuration No 5 presents the results of varying the heat to power ratio of the cogeneration system for a specific configuration.

Table 10.1.8 presents the results of the substitution of cogeneration capacity with auxiliary sources of energy (solar and wind) on the configuration that produced the best financial return.

Table 10.1.9 presents the results of a sensitivity analysis performed on the "optimum" configuration. The cost sensitivity test included only the optimistic case (more close to reality) of reduction in the cost of all equipment involved.

The results of the second stage of the simulation process confirmed overall the simulation results of the first stage and it was shown that for the specific demand patterns and needs of the hotel examined the "optimum" range of cogeneration capacity is in the range of 100-120 kW and the "optimum" heat to power ratio is 0.5. The results of these simulations proved that when

energy "mixes" are used the configuration is more cost effective when the largest electricity and heat supplier is the cogeneration system. It was also shown that when the participation of auxiliary energy sources in the energy "mix" increases, the configuration becomes less cost effective. This result must of course depend on both the demand for heating and the price of heating fuels conserved by cogeneration modes.

The best of the configurations tested was the one that included a cogeneration unit of 100 kW, a solar system of 150 sq.m and a wind generator of 15 kW maximum power.

The sensitivity analysis proved that the "optimum" solution is very sensitive to a possible reduction of both the energy collected and the energy produced. A future drop of equipment cost (especially for wind machines) will prove very beneficial to the adoption of this integrated approach of energy "mixes". The financial analysis performed can be considered to be on the "tough" side since possible tax allowances (against depreciation) for these investment were not included in the analysis.

However in order to draw more reliable and general conclusions for the whole industry further simulation runs with weather and energy data from more hotels will be necessary. Again, the optimal solution will differ in each specific case, but the analytical approach will not change.

Capacity (kW) :	40	60	100	120	140	180	200
Cost (000's) :	16	20	30	40	46	60	80
Heat:Power :	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Efficiency :	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Availability :	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Maintenance :	1200	1500	2500	2800	3300	4500	5600
Yearly Benefit:	6859	10243	16697	19750	22246	26327	2780
NPV :	-21288	-12088	4796	13881	16756	17511	848

Table 10.1.6 : Results of cogeneration simulations without auxiliary energy sources.

Note : The following financial data were used :
Own capital 40000 Cyprus pounds, borrowing interest rate 9%, loan repayment 5 years, depreciation period 5 years and tax rate 42.5%.

Configuration 1 : Yearly Benefit = 19051, NPV = 8030

100 kW chp + 15 kW Wind + 100 sq.m. Solar
Cost : 30000 (chp) + 16500 (Wind) + 15000 (Solar) = 61500
Maintenance : 1500, Own capital : 30000

Configuration 2 : Yearly Benefit : 19725, NPV = 81

100 kW chp + 30 kW Wind + 150 sq.m Solar
Cost : 30000 (chp) + 19500 (Wind) + 22500 (Solar) = 72000
Maintenance : 2500, Own capital : 30000

Configuration 3 : Yearly Benefit = 20883, NPV = -7005

100 kW chp +45 kW Wind + 200 sq.m. Solar
Cost : 30000 (chp) + 22000 (Wind) + 30000 (Solar) = 82000
Maintenance : 3000, Own capital : 30000

Note: Interest = 9%, Depr.Plan = 10%, Discount Rate = 20%

Configuration 4 :60 kW Wind + 250 sq.m. Solar and chp as follows:

40 kw :Cost :99100, Maint.:1000,Yearly Benefit =13752,NPV=-31493
60 kw :Cost :103100,Maint.:1500,Yearly Benefit =16866,NPV=-25940
100kw :Cost :113100,Maint.:2000,Yearly Benefit =23272,NPV=-14982
120kw :Cost :123100,Maint.:2500,Yearly Benefit =25965,NPV=-14073
140kw :Cost :129100,Maint.:2500,Yearly Benefit =28382,NPV=-10546

Note : For all cases own capital assumed was 55000,depr. time 5years,loan repayment 5 years, discount rate 20%, H/P =0.5 efficiency=0.85 and availability 0.95

Configuration 5 :75 kW Wind + 300 sq.m. Solar + 100 kw chp

Cost :128000, Availability 0.95, Efficiency 0.85, Maint. 1500
H/P :0.5 , Yearly Benefit = 24470, NPV = -20982
H/P :0.6 , Yearly Benefit = 23668, NPV = -23152
H/P :0.75, Yearly Benefit = 22479, NPV = -26374
H/P :1.0 , Yearly Benefit = 20949, NPV = -30513

Note : Depreciation plan 5 years, discount rate 20%, repayment plan 5 years and own capital 64000

Table 10.1.7: Results for various simulations utilising auxiliary sources of energy

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Configuration A : 100 kW chp + 15 kw Wind + 150 sq.m. Solar

Cost: 30000 (chp) + 16000 (Wind) + 20000 (Solar) = 66000
Maintenance: 2000, Own capital : 33000
Yearly Benefit = 20063, NPV = 10113

Configuration B : 80 kW chp + 30 kw Wind + 200 sq.m Solar

Cost : 25000 (chp) + 19000 (Wind) + 27000 (Solar) = 71000
Maintenance : 2000, Own capital : 35500
Yearly Benefit = 17409, NPV = -1875

Configuration C : 60 kW chp + 60 kw Wind + 250 sq.m Solar

Cost : 20000 (chp) + 48000 (Wind) + 31000 (Solar) = 99000
Maintenance : 2000, Own capital : 49000
Yearly Benefit = 17422, NPV = -1759

Configuration D : 40 kW chp + 75 kw Wind + 300 sq.m. Solar

Cost : 16000 (chp) + 53000 (Wind) + 41000 (Solar) = 110000
Maintenance :2000, Own capital : 55000
Yearly Benefit = 14980, NPV = -14990

Table 10.1.8: Results of simulations in which chp capacity was substituted with wind and solar input.

Note: For all configurations above the following financial data were used : Discount Rate 15%, Depreciation Plan 10 years and Loan Repayment 5 years

Scenario	Yearly Benefit	NPW
10% more heat and electricity	19775	10204
20% more heat and electricity	20096	10633
10% less heat and electricity	19250	7583
20% less heat and electricity	18728	5928
10% more cost	17455	8798
20% more cost	16950	8090
10% less cost	22700	11529
20% less cost	24276	12135

Table 10.1.9: Sensitivity analysis on NPW (Cyprus pounds) for Configuration A (optimum configuration)

Note : For all financial analysis the following data were used : (a) electricity cost = 4 cent/kWh, (b) off peak electricity cost = 4 cent/kWh, (c) boiler fuel cost = 1.25 cent/kWh and (d) chp fuel cost = 0.95 cent/kWh.

CHAPTER XI

RECOMMENDATIONS, AND RECOMMENDED FURTHER WORK

11.1 General recommendations

The drawing of the general recommendations followed the methodology of the soft systems approach. A detailed step by step example of the procedure followed for arriving at these recommendations was presented in Chapter III.

The large number of activities involved in the conceptual models, and the corresponding recommendations, necessitated a simplification of their presentation. In order to facilitate their use, general recommendations were grouped into five major categories, which contained the majority of the most important subcategories.

The five major recommendation categories with the relevant subcategories are the following :

A. CHANGES IN POLICY

(1) Energy pricing policy

(2) Energy conservation policies

(3) Infrastructure policy (see D below also)

(4) Codes, regulations and standards

(5) Establishment of an Energy Conservation and Management Fund (ECMF)

(6) Introduction of R & D to establish cases for systemic change.

(7) Introduction of legislation for the practising of the engineering profession

B. CHANGES IN ATTITUDE

(1) Increase and promote awareness for energy conservation.

(2) Promotion of good communication

(3) Provision of incentives

C. CHANGES IN USE OF ENERGY

(1) Introduction of workable management information systems

(2) Introduction of performance review and target setting techniques.

(3) Application of quantitative design modelling approaches

(4) Remodeling of existing technology

(5) Adoption of new technologies and energy conservation measures

D. CHANGES IN STRUCTURE

(1) Establish Centre for collecting and disseminating information

(2) Establish Training Body for the needs of the Hotel Sector

E. EDUCATION AND TRAINING NEEDS

(1) Training of the staff of the Energy Unit

(2) Training of architects and engineers

(3) Training of hotel staff at all levels

(4) Training of energy consultants

11.1.1 A. CHANGES IN POLICY

1. Energy pricing policy

An immediate detailed study is recommended in order to establish flexible energy pricing formulas. The new energy pricing system, which should not exclude any radical approach, should reflect real cost of fuels.

2. Energy conservation policies

Current energy conservation policies should be reviewed and re-evaluated. The modification of existing and the adoption of new energy conservation policies should be examined.

3. Infrastructure policy

The Energy Unit, now operating within the Ministry of Commerce and Industry, should be given an autonomous status of operation in order to proceed with the application of energy conservation programs and cooperate with the Hotel sector (and other sectors) beyond bureaucratic government boundaries. The Unit should also be provided with additional staff.

4. Codes, regulations and standards

It is recommended that energy related codes, regulations and standards concerning the construction and operation of hotels should be established.

5. Establish an Energy Conservation and Management Fund (ECMF)

An Energy Conservation and Management Fund (ECMF) should be established to provide grants, low interest loans and other energy conservation incentives for the hotel industry and for

other industries as well.

6. Introduction of R & D

It is recommended that R & D be conducted on specific energy use and management problems with wide applicability and interest. Research should be undertaken in both hardware (e.g performance of solar systems, air conditioning systems) and soft problems (e.g hotel guest and staff attitude towards energy conservation).

7. Introduce legislation for the practising of the engineering profession and monitor its impact on the Hotel Sector

11.1.2 CHANGES IN ATTITUDE

(a) Introduce activities to increase and promote awareness at all levels between all actors involved.

(b) Introduce processes and institutions to promote communication at all levels for all actors involved.

(c) Introduce incentive schemes which will have a positive impact on the motivation of all actors towards energy efficiency.

11.1.3 CHANGES IN USE OF ENERGY

1. Introduce Management Information Systems

(a) Establish an Energy Data Base for the Hotel Sector. Besides its main use for performance review and target setting the data base will also be helpful for establishing regulations, and forecasting energy demand. Considerable effort should be given to the identification of the data

categories and the sequence by which they will be collected. The data categories should include energy consumption of various fuels, ambient temperature, number of rooms, occupancy levels and details of operation.

(b) Establish a "Technological Data Base" for the Hotel Sector related to cost and availability of energy efficient hardware and technology. Information should be collected from foreign and local manufacturers. Hotel related information should be made available to both hotels and engineering consultants.

(c) Hotels should be encouraged to use inexpensive computerised data collection and monitoring and targeting tools. Simple non expensive spreadsheets and data base software packages should be easily acquired and used.

2. Introduce performance review and target setting techniques in all hotels.

3. Introduce the application of quantitative design modelling approaches among engineering designers.

4. Remodeling of existing technology

It is recommended that efforts are made for the remodeling of the present energy supply mix in order to enable a more cost effective utilisation of energy resources. Arrangements for the effective occasional use of stand by generators, (see Chapter X) extraction of heat from the chillers, and efficient

use of solar energy (see Chapter IX) should be given priority.

5. Adoption of new technologies and energy conservation measures

Hotels should be guided for the adoption of new technology and energy conservation measures which best suit their individual needs. Among those recommended for serious consideration are the following:

* Insulation of the building envelope (priority to the roof)
* Combustion efficiency of the heating system
* Installation of energy efficient lighting fixtures
* Installation of power factor correction equipment
* Passive cooling techniques (e.g shading, curtains)
* Adoption of regular maintenance program
* "Wise" operation of energy consuming equipment
* "Correct" thermostat setting
* "Correct" hot water supply temperature
* Installation of occupancy switching equipment
* Improvement of energy use controls
* Utilisation of BEMS technology
* Utilisation of heat recovery technology
* Utilisation of the technology of solar energy for the heating of domestic water and the swimming pools.
* Utilisation of small combined heat and power systems

11.1.4 CHANGES IN STRUCTURE

1. Establish Centre for collecting and disseminating information

Set up a Body for collecting and disseminating energy

related information. This activity should be the responsibility of the Energy Unit and the Hotel Owners Association

2. Establish Training Body for the Hotel Sector.

Set up a Training Centre for the satisfaction of the training needs of all actors involved. It is envisaged that gradually this activity will be a major component of the training activities of the Applied Energy Centre of the Ministry of Commerce and Industry.

11.1.5 EDUCATION AND TRAINING NEEDS

1. Training of the Energy Unit (MCI) staff

Training for the staff of the Energy Unit should be provided. The knowledge of the staff should be enhanced on both technologies installed (e.g operation and control of air conditioning, heating and solar systems) and new technologies (e.g cogeneration, photovoltaics, solar air conditioning).

2. Training of architects and engineers

Training for architects and engineers should be provided. The training should aim at both enhancing awareness and sensitivity on energy conservation and increasing knowledge on techniques aiming at the minimisation of energy use in hotels. Recommended areas for training include:

(a) Application of passive solar heating and cooling techniques in the design of hotels

(b) Integration of solar energy and other renewable energy sources in the energy supply system of hotels

(c) Energy efficient design of electrical and mechanical services of hotels (e.g heating and cooling systems, lighting)

(d) Cost effectiveness analysis techniques of proposed energy consuming equipment

(e) Application of quantitative design modelling techniques

3. Training of hotel staff at all levels

The training of hotel staff should be directed to the following major groups:

(a) Hotel managers

A "direct to the point" approach, aiming at emphasising the importance of proper energy management and use and its effect on improving profit levels should be adopted. There should be no effort to provide detailed in depth information on either technical or financial matters.

(b) Chief Engineers

Training efforts (e.g seminars and short courses) should seriously consider both the individual needs of chief engineers and the diversity of the group's educational background (see also Section 13.3).

(c) Hotel Department Heads

It is expected that the main energy efficiency related education of hotel department heads will originate from their participation in the proposed Energy Management Committee.

It is also recommended that all Department Heads attend brief courses related to the development of communication and motivation skills. The development of these skills will enable Hotel Department Heads to use their staff more effectively.

(d) Hotel Department Staff

It is recommended that in house training courses for Hotel Department staff are organised. Common session should include topics on "motivation" whereas other topics (e.g the energy efficient operation of kitchen equipment) should be addressed to the individual staff members concerned.

The staff of the maintenance teams should be encouraged by the management to attend specific courses of interest organised by various authorities (e.g The Cyprus Productivity Centre).

(e) Training of Energy Consultants

It is recommended that existing energy consultants acquire, through tailor-made courses, the necessary analytical skills that will assist them in their tasks. Recommended topics include : statistical methods and techniques, cost effective analysis techniques, monitoring, targeting and forecasting techniques.

The Government should investigate the possibility of organising training courses (lasting from 4-6 months) for persons interested to join the energy consultancy profession.

11.2 "Reality" versus "ideals"

Though the general recommendations presented in Section 13.1 are the result of the systemic analysis, we believe that existing limitations, which are the result of systemic interactions, will prevent their full implementation. The most important of these limitations are presented below.

(a) Severe conflicts of interest are not expected to allow an easy change of energy pricing policy.

(b) Due to existing attitudes and Government budget considerations, the scope and role of the Energy Unit, the major public agency in the energy scene, is not expected to be enhanced. In addition, general Government policy is not expected to allow the hiring of any additional staff.

(c) At the expense of energy efficiency and the economy in general, Government and political parties appear reluctant to initiate energy efficiency measures that may have a possible political cost.

(d) Energy conservation is a low priority issue for the majority of the hotel owners who appear unwilling to allocate the necessary capital and human resources.

(e) It is anticipated that bureaucracy and other priorities will prevent the Cyprus Organisation for Standards from proceeding with the introduction of energy efficiency regulations in the required fast pace.

(f) The limited Government budget for the National Energy Conservation Campaign is not expected to increase.

(g) The severe shortage of qualified energy consultants and trainers for energy management and conservation will be a negative factor to the efforts for energy efficiency in the Hotel Sector.

(h) There are important limitations in the existing legislative and regulatory environment for the production of electricity.

(i) There is total absence of any real pressure on the Government for energy efficiency from any organised "pressure group" (e.g the professional or scientific community or the general public).

11.3. Adopting a realistic " Action Plan " - Initiating change

The specific recommendations contained in this two year "Action Plan" are based on the general recommendations derived from the soft systems analysis of the problem situation (see Section 13.1). However, in order to design a practical and realistic "Action Plan", all limitations described in Section 13.2, which are the result of existing systemic interactions, were seriously considered. Therefore, the specific recommendations of the "Action Plan" are the result of a screening process in view of these limitations.

The minimisation of bureaucracy at all levels and the

relative shift of the capacity of the "change initiator" from the public to the private sector were basic considerations of the "Action Plan". The private sector has been considered as a more appropriate "change initiator" since it is generally more flexible in its decision making process, is less bureaucratic and has generally more incentives to strive for efficiency. In addition, every effort has been taken in order to mobilize as many major actors of the problem situation (e.g HOA, Banks, Professional Associations).

The Action Plan

1. Establish an Energy Management and Conservation Fund (EMCF)

While the Hotel sector will be benefited from the establishment of the proposed ECMF as well, the objective of the Fund should be the promotion of energy efficiency for the whole economy. The main source of revenues of the proposed ECMF will be a slight increase on the retail price of petrol and gasoil. It is estimated that (1990 data) an increase of 0.8% on the retail price per litre of petrol and a 0.3% for gasoil will secure for ECMF around 500000 Cyprus pounds per year. Tax deductible contribution of the private sector to ECMF (eg. oil companies) should also be encouraged. Grants, soft loans and coverage of cost for energy audits will be among the main services to be provided by ECMF. The responsibility for the operation of the ECMF is recommended to be placed with the Cyprus Development Bank.

2. Initiation of an energy efficiency campaign for the hotel sector

The HOA, as the direct beneficiary of the implementation of energy efficiency measures in the sector, should be active in all efforts. It is recommended that HOA undertakes an energy efficiency campaign that will last for at least a continuous 6 month period. The official journal of the Association should be used to announce the decision for the campaign and the forthcoming events (e.g lectures by experts, round table discussions, dissemination of related published material).

3. Increase and promote awareness for energy conservation

Four half day briefings for hotel owners and managers aiming at improving their sensitivity on energy conservation and management, should be organised within the framework of the HOA campaign. During these half day briefings (one in each major city) officers of the Energy Unit should emphasise the importance of energy efficiency in improving hotel competitiveness through increased profit margins. It is advocated that the possibility of a successful initiation of the change process towards energy efficiency will be higher if the commitment of these important decision makers is secured. No major additional cost are expected to be involved in these activities.

4. Energy Committees within individual Hotels.

The Hotel Owner Association, through a circular to its members, and its official Journal should promote the establishment of an Energy Efficiency Committee within

each individual member hotel. Membership of senior staff in the Committee should be on a rotating basis (e.g 3 months) in order to allow more persons to be benefited from participation.
The details of the establishment of these important Committees should be discussed during proposed seminars and short courses as well (see 9d and 9e also).

5. Provision of incentives

In addition to related activities of ECMF the following should also be considered.

(a) Establish an annual Energy Efficiency Prize for Hotels. It is proposed that the prize be sponsored jointly by the Hotel Owners Association, the Cyprus Tourism Organisation and the Ministry of Commerce and Industry.

(b) The Central Bank should modify its lending policy in order to encourage commercial banks to establish special schemes, for directing funds in the adoption of energy efficient technologies. The concept of the "third party financing" should be promoted within the financial community.

6. Construction of an Energy Data Base for the Hotel Sector

Four one day seminars (one in each major city) should be organised for chief engineers of hotels. During these seminars, officers of the Energy Unit should explain the importance of the proposed energy data base, and the system of collection and dissemination of data. The importance of the cooperation of chief engineers should be properly emphasised. Since existing

hardware, software and human resources of both the Energy Unit and the HOA are expected to be utilised, no major costs for the construction of the data base will be involved. It is recommended that at least 3 review meetings be organised during the first year between officers of the Energy Unit and the chief engineers.

7. Codes, Regulation and Standards

The Cyprus Organisation for Standards should, in cooperation with the Energy Unit, consider the implementation of regulations concerning both the construction and operation of hotels. These regulations should include :

(a) Minimum and maximum summer and winter temperature levels
(b) Ventilation rates
(c) Maximum hot water supply temperature
(d) Minimum insulation levels
(e) Inclusion of passive heating and cooling techniques during the design phase
(f) Partial use of solar energy for the satisfaction of hot water needs and the heating of swimming pools.

Local conditions should be considered seriously when forming these regulations and mistakes of other countries should be avoided. Regulations (a), (b) and (c) should be implemented within the first 3 months of the initiation of this Action Plan whereas (d), (e) and (f) can be expected to be implemented within the first 2 years.

8. Remodeling of existing technologies

It is recommended that the quantity, quality and timing of demand (QQT) of all forms of energy of four selected hotels, be monitored for a two year period. The close cooperation of the four chief engineers with the Energy Unit will have to be secured. The results of the evaluation of this detailed analysis and the prospects of remodeling existing technology should be announced to hotel managers and chief engineers in a specific seminar. No major cost will be involved in this important activity.

9. Training

(a) It is recommended that all officers of the Energy Unit attend (on a rotating basis) specific short courses organised overseas and lasting no longer that 4-5 weeks. The cooperation of the UNDP and the Energy Directory of the EEC should be sought. The cost of these courses is expected to be covered, through existing cooperation agreements, by either UNDP or the EEC (Energy Directory). Bilateral agreements with other developed countries could also be used. In addition to the training areas stated in Section 13.1.5 the following topics should also be included.

(1) Energy management

(2) Energy auditing techniques

(3) Monitoring and targeting techniques

(4) Communication and presentation skills

(5) Statistical analysis and the use of computer data bases

(6) Investment appraisal methods

(b) Four 2 day short courses for Architects, one in each city, should be organised on the topic of "Solar Passive and Cooling Techniques". The organiser of the course should be the Cyprus Architects Association with the assistance of the Energy Unit. The courses, which should run 3 times during the first year, should be practical and contain real case examples. Architects should be provided with the opportunity to appreciate the benefits of these techniques through hands on experience on user friendly software packages. It is anticipated that approximately 240 Architects will take advantage of these courses. It is estimated that the total cost of each of these courses (16 hours of actual teaching) will be around 1200 Cyprus pounds. The subsidisation of the Industrial Training Authority (ITA) for the 16 hours of actual teaching of the course is expected to be in the range of 240 Cyprus pounds. Therefore the participation cost for each participant (assuming 20 persons in each course) will be around 50 Cyprus pounds.

(c) Four 2 day courses (one in each city) should be organised for the needs of electrical and mechanical engineering designers. The course (16 hours of actual teaching) should focus on energy efficient system design, life cycle cost effectiveness analysis and application of quantitative cost design techniques. The course should run twice during the first year of the Action Plan. It is expected that around 120 engineers will take advantage of these courses. The total cost and the subsidisation of each course is expected to be like (b) above and therefore the actual participation fee for each engineer (assuming 15 persons in each course) will be around

65 Cyprus pounds. Emphasis should be given on the practical applications of energy efficient design. The theory content of the course should be kept to a minimum.

(d) Hotel managers

Three seminars of 2 half day duration should be organised for the needs of Hotel Managers. In order to facilitate the participation of Hotel managers, the seminars should be conducted 3 times during the year in different time periods in Larnaca, Limassol and Paphos. Managers should thus be requested to state in advance preferred period and location of participation. All seminars should be sponsored by the Cyprus Hotel Managers Association which should encourage (e.g with a circular) the participation of its members. The intensive afternoon seminars (total duration of approximately 10 hours) should focus on the following topics:

(1) Energy conservation as means for increasing profit
(2) Performance review and monitoring and targeting techniques
(3) New energy efficient technology and energy conservation measures-cost effectiveness evaluation
(4) Motivating and effective communication techniques
(5) Principles of operation of hotel energy consuming equipment
(6) The importance of establishing an Energy Committee and the principles of its operation

Provided that good motivation and publicity is given, it is expected that between 90-120 hotel managers (mostly from the 3,4 and 5 star hotels) will attend the nine seminars during the

whole year. The total cost of each seminar (8 hours of actual teaching) will be around 800 Cyprus pounds. The ITA contribution for each seminar is expected to be around 150 Cyprus pounds. Therefore the cost for each participant will be around 45 Cyprus pounds.

(e) Three short courses, for the needs of the chief engineers each of a duration of three full days, should be organised in the same locations, sequence and arrangements with the seminars of hotel managers (see (d) above). The courses should be sponsored by the HOA with the assistance of the Energy Unit. The courses, which are expected to be taught by local experts, should focus on the following topics:

(1) Operation, efficient use and maintenance of both existing and new energy related technology.
(2) Cost effectiveness analysis techniques of prospective energy efficient investments.
(3) Energy monitoring and targeting techniques
(4) Use of statistical methods and data base management in energy management and conservation.
(5) Communication and motivation skills.
(6) The role of the chief engineer in the Energy Committee of the Hotel.

It is expected that 70-90 chief engineers will be attending these course. The total cost of each course (24 hours of actual teaching) will be around 1500 Cyprus pounds, 360 of which can be expected to be covered by ITA subsidisation. Therefore the

cost for each participant (assuming a minimum of 10 participants) will be around 115 Cyprus pounds.

The estimated cost of each of the above courses (and 9a, 8b, 9c, and 9e also) includes course design, overhead expenses, fee of local trainers, coffees and meals (where appropriate), venue cost and handout material.

10. Energy Committee

An Energy Committee should be formed with the task of monitoring the progress of all efforts towards initiating the change process in the Hotel Sector. The Committee should record both achievements and problems faced. We believe that the experience gained will be valuable for further forward planning both in the Hotel Sector and other sectors as well. The Committee should be small in order to keep its flexibility and effectiveness and should meet at least quarterly. It is recommended that the Committee is made up of three persons representing the Energy Unit, the HOA and the Cyprus Development Bank.

13.4 Recommended further work

The recommended further work can be divided into two major areas. The work in each of the two areas could be carried out either independently or separately.

The first area concerns the so called "soft" problems of the Hotel Sector. The management of new and existing energy consuming technology, as well as the management and motivation

of the human resources of the hotel system are the major issues for examination. Another challenging issue for further examination is the attitude of major decision makers on energy conservation and its effect on the efficient utilisation of energy resources in the hotel sector.

The second area concerns "hard" problems and refers to the efficient utilisation and maintenance of the energy consuming technology installed in the Hotel Sector. The major issue recommended for further work here, is the detailed monitoring of the use and performance of representative installed technologies in a sample of hotels in order to establish the actual level of their efficiency and suitability for the assigned task (with respect to quantity quality and timing of specific energy demands). Similar work could be carried out for other new (for the Cyprus Hotel Sector) technologies.
A combined heat and power unit or a wind generator are good candidate technologies for this work.

For the purpose of the development of further work the Author has included a self criticism and retrospective section in Appendix I.

11.5 General Conclusions

The present research has investigated the problem of energy management and conservation in the hotel sector of Cyprus; one of the most important and most dynamic sectors of the island's economy. The methodology of the soft systems approach was considered as the most appropriate method for tackling the

complexities involved in the problem situation. This was extended to the utilization of interactive simulation modelling in cogeneration supply and stochastic demand situations.

(1) It has been demonstrated that the adoption of a systemic approach for tackling complex problems is well suited for problems of energy management and conservation.

The use of the soft systems methodology approach employed in this research proved to be an excellent means of both understanding the problem situation of the Hotel Industry of Cyprus and proposing feasible and desirable changes for its improvement. No hesitation should therefore exist in applying the methodology for the investigation of the energy problems of other micro sectors of the economy.

(2) Existing problems in the energy situation investigated are systemic by nature. As a result there is always a need for systems interactive models for preparing feasible economic solutions. The reduction of current energy consumption level of the hotel sector by 10-20% through the application of the systems work is both possible and realistic.

(3a) There is a real need for changing the attitude of all "actors" of the system towards the issue of energy management and conservation (see 6 below).

(3b) The detailed investigation of the research points to the fact that there is a pressing need for introducing a new

energy management infrastructure at National level and below. This includes both changes in the overall Government system responsible for energy, and the hotel industry itself.

(4) There is a need to modify existing energy policies and adopting new more efficient policies and strategies. This conclusion concerns energy policies and strategies at the macro economic level, the hotel industry level and even at the level of individual hotels and the managerial staff.

(5a) There is a need for further investigation of the energy supply and demand patterns of the Hotel industry of Cyprus in order to arrive at accurate cost effective proposals for optimum energy supply mixes in individual hotels or small clusters of hotels.

(5b) Considerable energy savings can be realised by modifying user habits and hotel energy demand patterns (reducing energy consumption and peak electricity demand) through improved utilisation and management of installed technology. There is also good scope for energy conservation through both remodeling existing technology and introducing new energy efficient technology. The sequence of progression of these stages is also important to achieving maximal benefits.

(6) There is an immediate need for the provision of training and education of all human actors involved in the problem situation. This fact has been well demonstrated from the analysis of the questionnaires of the major "actors" of the

hotel industry (chief engineers, hotel managers, guests) and from the discussions held with hotel staff, architects, engineers, hotel owners and energy consultants.

(7) A general sampling of the energy demand of the economy, necessitated by the systemic nature of the research, proved the presence of inappropriate energy management practices and planning in several representative industries. This fact underlines the need for undertaking systemic investigations of all other energy consuming sectors prior to major energy planning decisions (such as the construction of a new power plant). It is believed that there is good scope of energy conservation in other sectors, of a magnitude comparable to that of the hotel sector examined.

APPENDICES

APPENDIX A

(Appendix to Chapter I)

The First and the Second Emergency Economic Plans

The First Plan was designed to cover only for the two year period between 1975-1976. The Plan should be short in time in view of the consultations for the solution of the Cyprus problem and to facilitate for quick re-adjustments and revision of targets. However the design of both this and the Second Emergency Economic Plan (1977-1978), considered seriously the long term economic developments and prospects.

Both the First and the Second Emergency Economic Plans aimed at easing major problems that were created by the Turkish invasion. The most important of these problems were the following:

(a) The dependance of thousands of people for their subsistence on Government funding
(b) The reduced level of incomes and the lowering of the standard of living
(c) The problem of unemployment and under employment
(d) The housing problem
(e) The low level of private investments
(f) The deprivation of considerable foreign exchange sources
(g) The considerably reduced level of public revenue

Considering the disastrous situation that the Turkish invasion had created, the progress achieved by the First and the Second Emergency Action Plans can be considered remarkable. As a result the economy was reactivated and to a certain extent reconstructed. The annual rate of increase of

goods realigned during the period of 1975-1978 and reached an average of 32.5%.

In 1978 the level of exports rose to 122 million Cyprus pounds and surpassed by about 110% the corresponding level of 1973. The sectors which achieved the greatest increase in that period were Construction (37.2% annually), Manufacturing (18.3% annually) and Wholesale and Retail Trade (16.2% annually). The annual rate of increase of the Gross Domestic Product at constant prices achieved during the period was of the order of 12%.

The Third Emergency Economic Action Plan (1979- 1981)

The problem of restructuring and modernizing the productive economy appeared more pressing after 1978. At that time there was a need of extending efforts towards the direction of larger and better organized capital-technology intensive units in order to achieve high rates of productivity growth.
The "Third Emergency Economic Action Plan" was set to be the means for the orientation of the economic policy towards these new directions. The main economic objectives of the Third Emergency Action Plan were the following:

(1) The maintenance of relative internal and external monetary stability
(2) The achievement of more productive and more remunerative employment of the labour force
(3) The implementation of a series of structural changes in the economy in order to avert the dangers of

distabilisation of the economy

(4) The attainment of the highest possible rate of growth without endangering the stability of the economy

(5) The maintenance of the country's foreign exchange reserves at satisfactory levels

(6) The maintenance of industrial peace

Among the social objectives of the Plan were included:

(1) The increase in the provisional qualitative improvement of social services

(2) The attainment of a minimum acceptable income for all citizens

(3) The promotion of a policy of a fairer distribution of national income groups

(4) The relief of refugees from the housing problem

(5) The further expansion and improvement of social services

The implementation of the Third Emergency Action Economic Plan can be considered successful. In contrast with the international situation a high rate of growth was achieved. The average rate of growth in this period had reached 5.5% in comparison with the Plan's target of 5.2%. Productivity (value added per person employed) increased at an average rate of 3.9% per year in comparison to the planned 3.3%. However, in contrast to the targets set, the rate of inflation was accelerated and reached, over the three year period of 1979-1981, 11.2% compared to 7.3% for the period 1977-1978 and 4.2% which was the average annual rate of inflation between

1967-1973.

The Fourth Emergency Economic Action Plan (1982-1986)

A major characteristic of this period was the fact that despite economic achievements, the economy had to go through a difficult transitional stage. Two conflicting objectives, that of continued economic growth and that of economic stability had to be simultaneously achieved.

The development strategy of this Plan aimed at diminishing the negative factors that had developed during the last years so that the economy could continue its upward trend. The main characteristics of the strategy adopted in the design of this plan were the following:

(a) The great emphasis given to the modernization of the economy through the creation of the appropriate institutions for the transfer of technology
(b) The improvement of the methods of production and organization
(c) The attraction of foreign investments
(d) The expansion of exports and especially those of high quality industrial goods
(e) The exploitation of the favourable geographic position of Cyprus as a centre for providing services to the Middle East area

The main objectives of the Fourth Emergency Economic Action Plan are listed in the next page.

(1) The achievement of the highest rate of growth

(2) The maintenance of conditions of full employment and full utilization of the labour force, and the securing of more remunerative employment for the working force

(3) The restructuring of the economy with emphasis on the modernization of enterprises both with respect of technology and management

(4) The attainment of a more equitable distribution of the generated income both by income group and by region

The favourable international economic situation and especially the fall of oil prices combined with the proper policies that were followed by the authorities during this period let to a stability of prices and to the balance of payments. The most important of these measures included intensification of efforts to reduce inflation and government debt, promotion of productive and more rewarding employment and introduction of new investment plans and production methods. At the same time, there were conditions of almost total employment and the rate of increase of inflation was reduced.

The average rate of increase of the Gross National Product (at constant 1980 market prices) rose to 5.6% compared to the target of 4.4%. Another positive aspect of this period has been the tremendous development of the services sector beyond the traditional tourism sector. This fact underlined the great potential for exporting these services and for properly utilizing the island's trained labour force in these sectors.

The New Five Years Development Plan (1989-1993)

Though individual targets vary, the long term objectives of this Plan remain similar to those of previous Plans.

More specifically the Plan aims at structural improvement and technological development. There are no obvious differences between the strategy of the "Fourth Emergency Economic Action Plan" and this Plan. However, certain variations will have to be made in order to account for the new conditions arising from the agreement signed recently for the customs union with the EEC. Heavy emphasis is also given to the development of better social condition for the people (Planning Bureau, 1975-91). The major objectives of this Plan are the following:

(a) The adjustment of the economy in order to meet successfully the challenge of the Cyprus-EEC customs union agreement
(b) The attainmnt of high rates of economic growth under conditions of stability
(c) The creation of conditions of full employment
(d) The reduction of dependance on imported oil for covering the country's energy needs
(e) A more fair distribution of the national income

The fourth of the above objectives is certainly of vital importance in this research since it is an indication of the determination of the government to take action on the issue of energy efficiency.

One of the basic elements of the strategy to be adopted by this Plan is the establishment of new large production units that are expected to produce new products for export. Unlike previous plans, which were focused mainly on short term responses to the situation created by the Turkish invasion, this Plan is placed within a long term framework and strategy. It is expected that the main emphasis will be given to the maximum development of the sectors of tourism, manufacturing and agriculture.

APPENDIX B

(Appendix to Chapter II)

Brief Description of Soft Systems Methodology

(after Checkland, Checkland and Scholes)

As can be seen from Figure A.B.1 in this Appendix, the methodology is divided into activities that involve the "real world", in which the problem under investigation (in this case "the management of energy conservation for the hotel industry of Cyprus") belongs, and the "systems world" or the "systems thinking" activities.

In stages 1 and 2 an attempt is made to understand and express not the problem but the problem situation. Effort is taken, during these stages, not to impose a pre conceived structure on the description of the problem. A so called rich picture of the situation is drawn as freely as possible in which elements of climate, structure and process are identified.

In stage 3 relevant systems are named and a root definition for each of these systems is constructed. The object of these root definitions is to get an explicit statement of the nature of the systems that will be used subsequently in order to improve the problem situation.

The next stage in the systems thinking part of the methodology is stage 4, in which conceptual models are developed. These models refer to the human activity systems that are defined and named in the root definition of stage 3. Though quite simple, this stage is extremely powerful. Chosing among all verbs of the English language, a structured set of

verbs is chosen so that it describes the minimum number of activities required in the human activity system described by the root definition of stage 3. Stages 4a and 4b are mutually supportive and allow the usé of a general model of any human activity in order to improve the conceptual models built. Modification or transformation of the models, for the same purpose, can also be performed within these supportive stages.

Stage 5 belongs to the activities of the "real world". Within this stage the conceptual models developed are set aside the real situation of stage 2. The objective of this comparing stage is to induce a debate with persons involved in the problem situation. This debate will hopefully result in recommendations for possible changes of the situation.

The changes will have to be proposed taking under serious consideration the existing attitudes, the power structures and the history of the situation. According to the methodology all changes recommended, which fall under stage 6, will have to be both feasible and desirable.

The last stage, stage 7, is the stage in which action is taken so that the situation will be improved. All actions taken are based on the measures recommended in stage 6.

Checkland and Scholes (1990) present the development of the SSM, described above, during the last decade. In the new publication a description of the development of the ideas of SSM through practical use in industry, the civil service and

the National Health System of the U.K. is given.

In particular the concept of the "3 E's" is developed, emphasizing the critical importance, and essential distinction between these in relation to input-output processes.

The first check examines on whether the chosen means actually work in order to produce the desired output. The name given to this check is **"Efficacy"**. The second check considers whether the transformation processes are being carried out with the minimum use of resources. This was called the **"Efficiency"** check. The last criterion investigates on whether the transformation, that may fulfil the first two criteria, achieves the long term aim and is termed as the **"Effectiveness"** criterion.

It is emphasised that it is the researcher (model builder) who defines, after thorough examination, of the proposed transformation process, the above three criteria for which the mnemonic of "3 E's" is used. In order to satisfy the "3 E's" requirements certain specific activities were included in the model (see Chapter III).

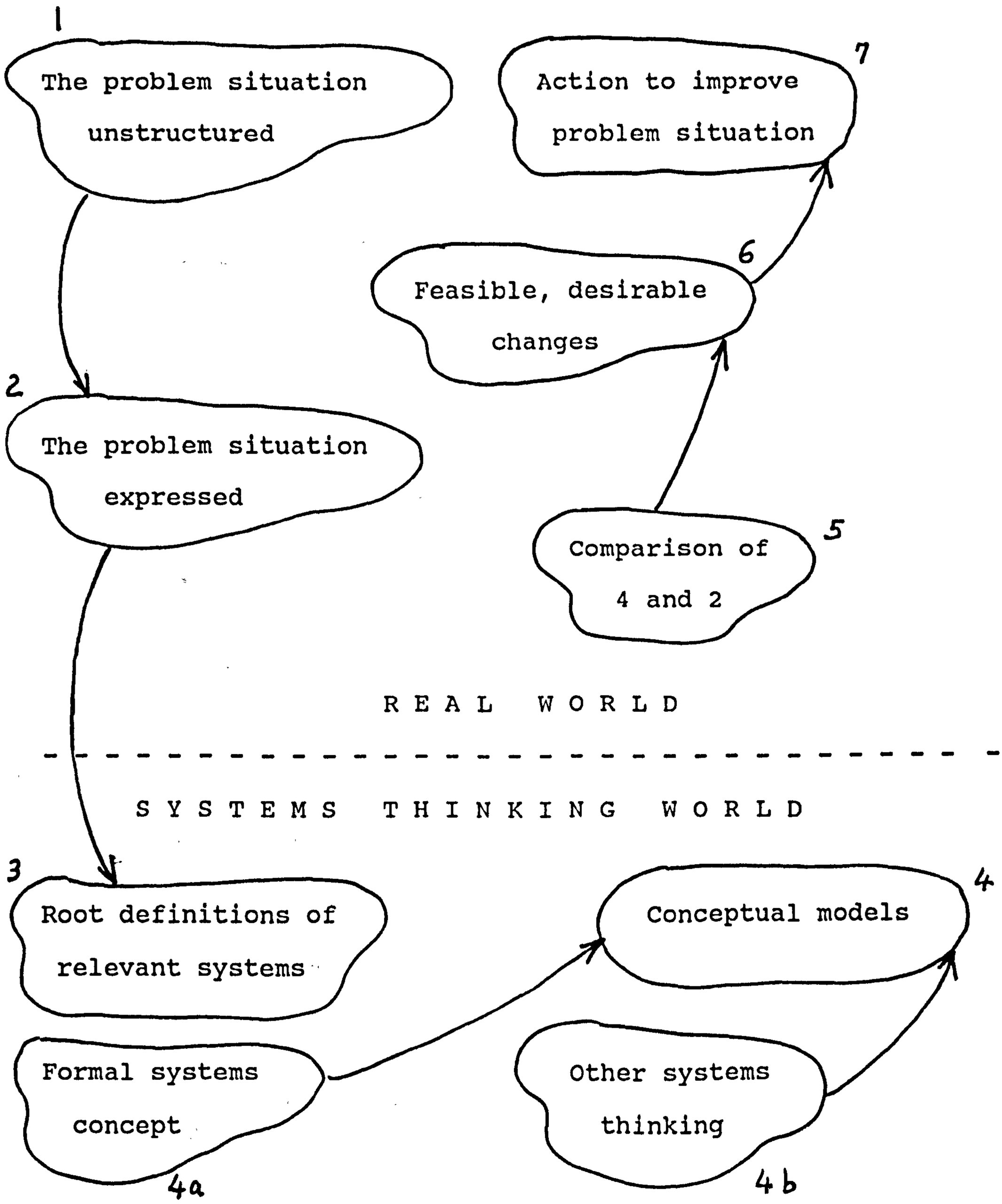
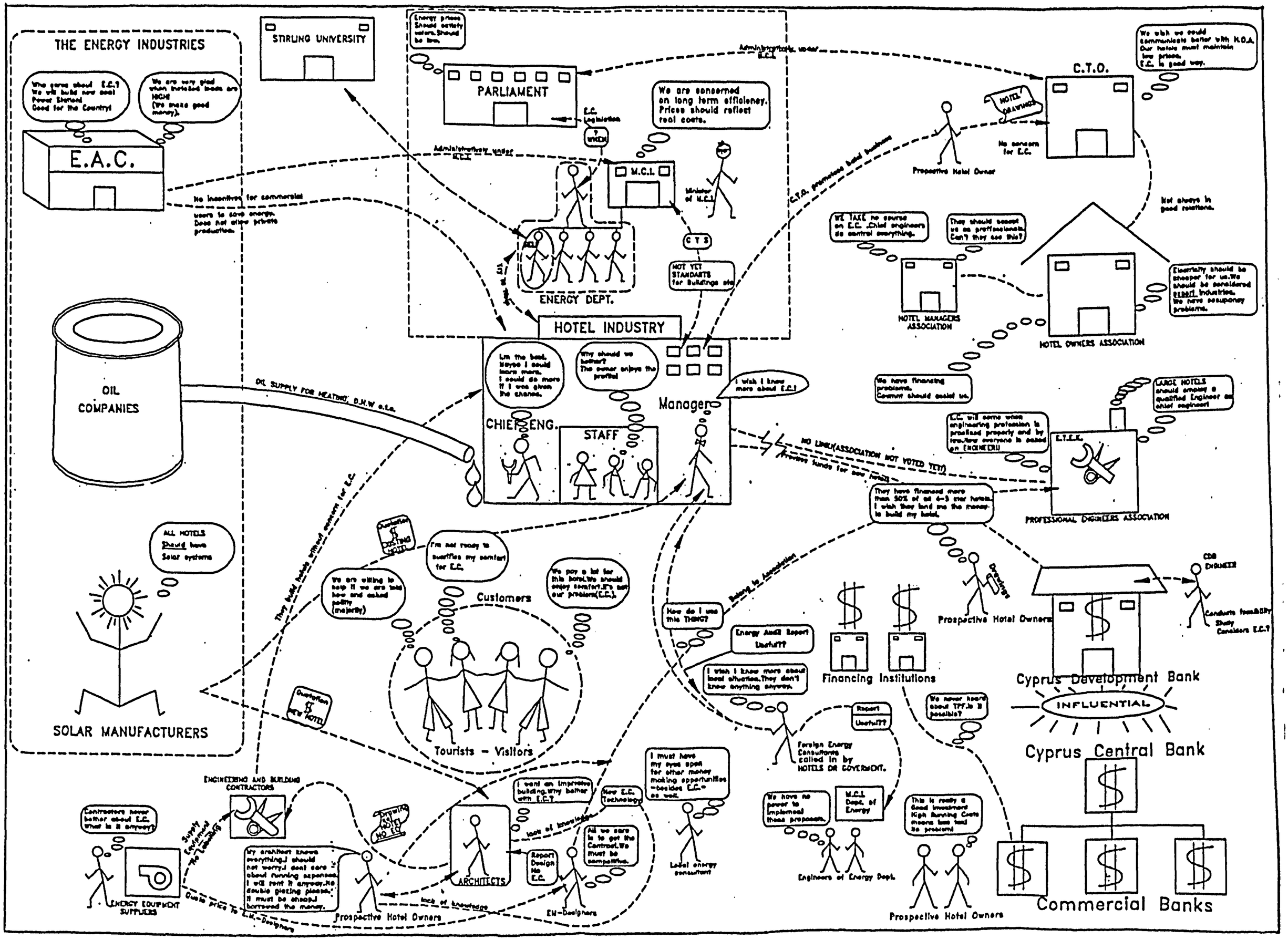


Figure A.B.1 : Soft Systems Methodology for tackling unstructured problems (after Checkland, 1975)

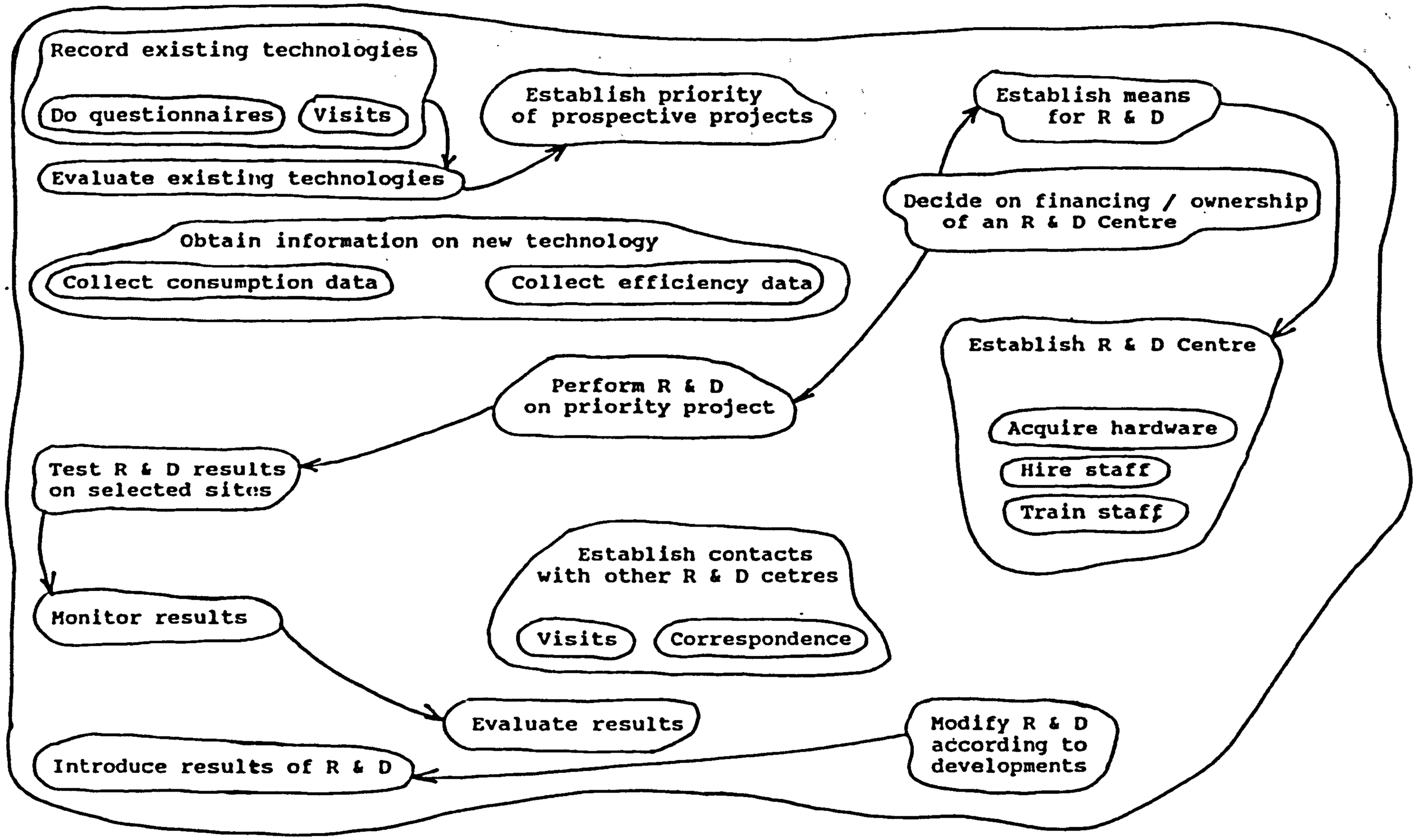
The rich picture of the Cyprus Hotel Energy Management.

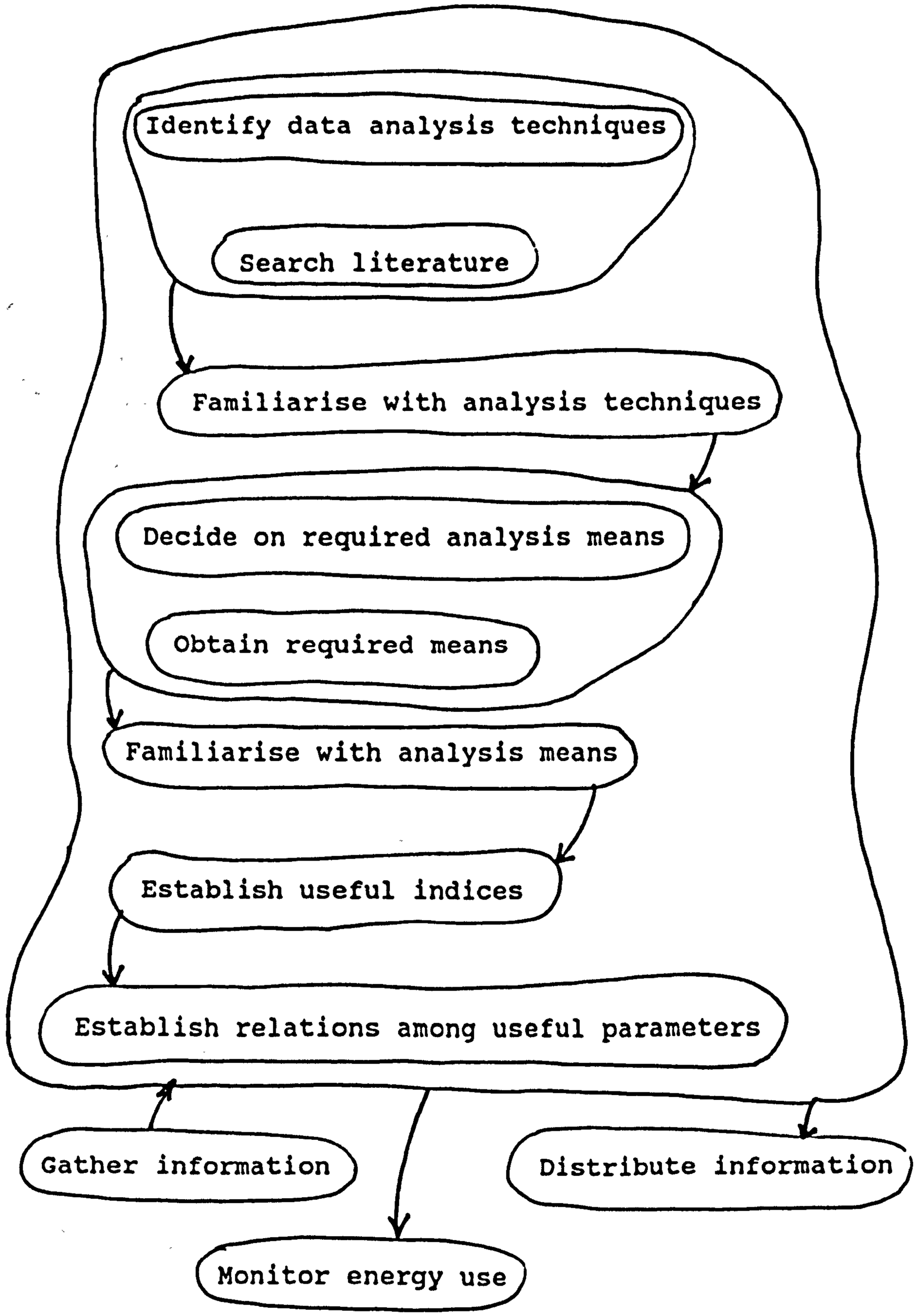


APPENDIX C

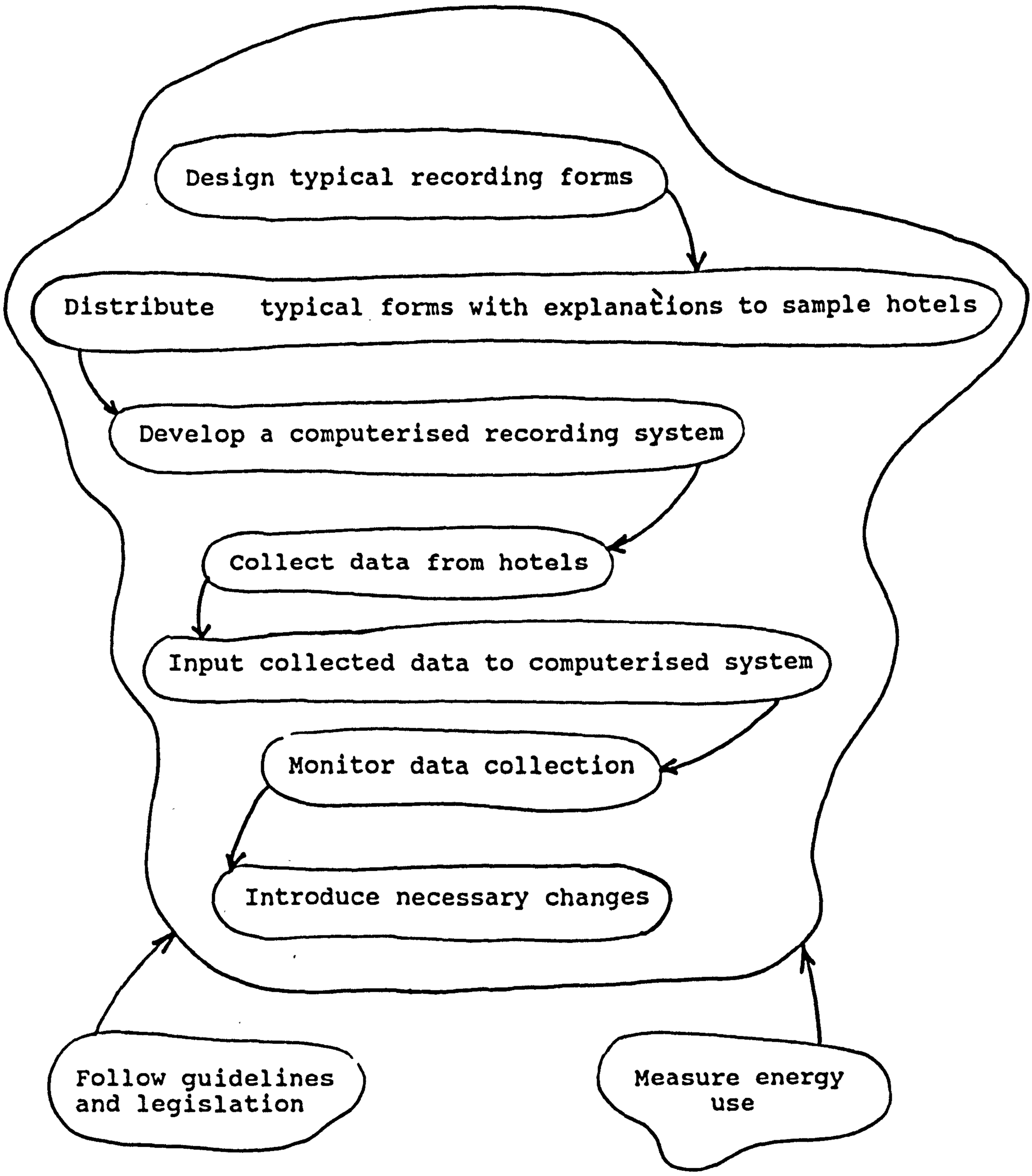
(Appendix to Chapter III)

Conceptual model of activity : " Research and Development "

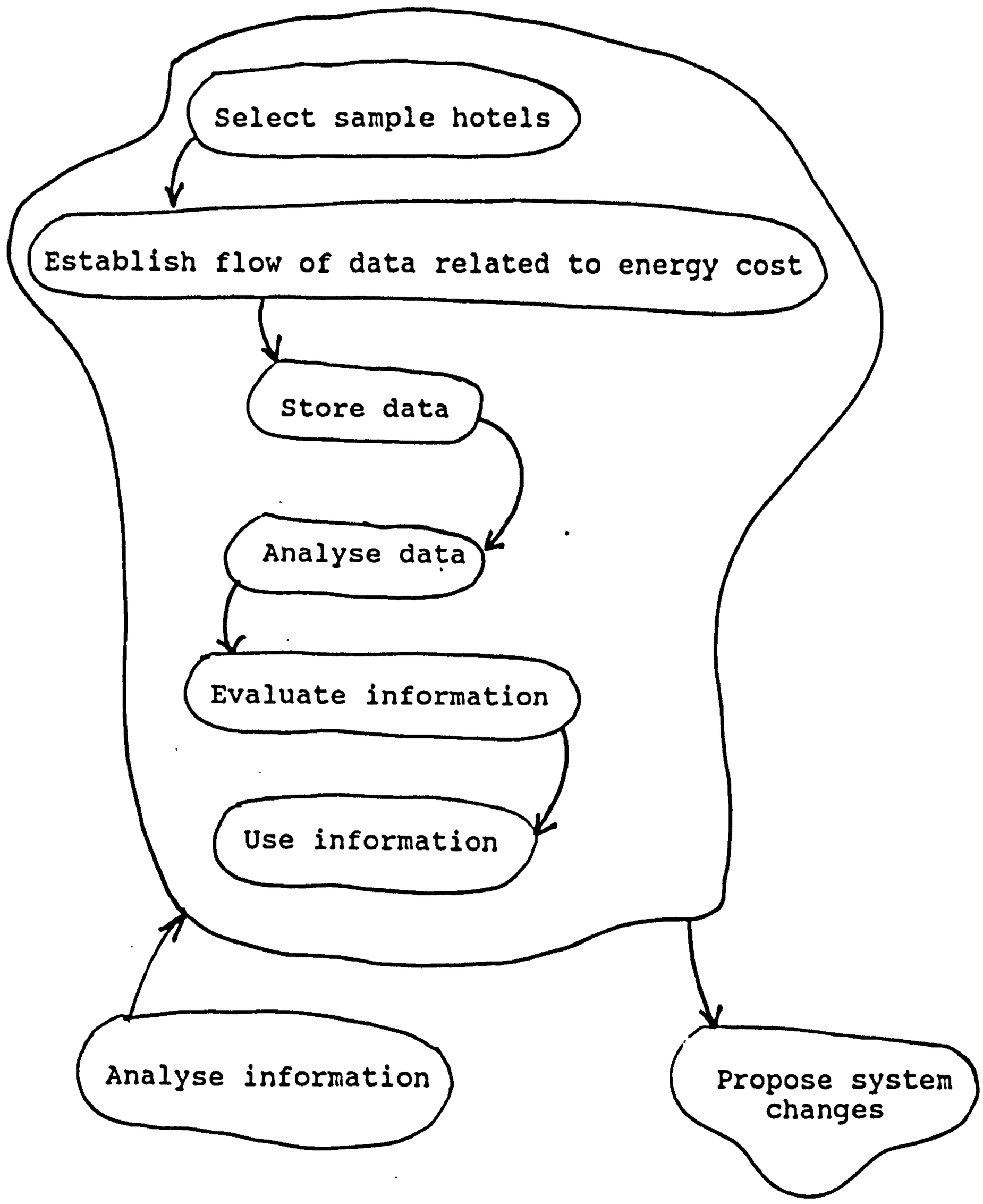




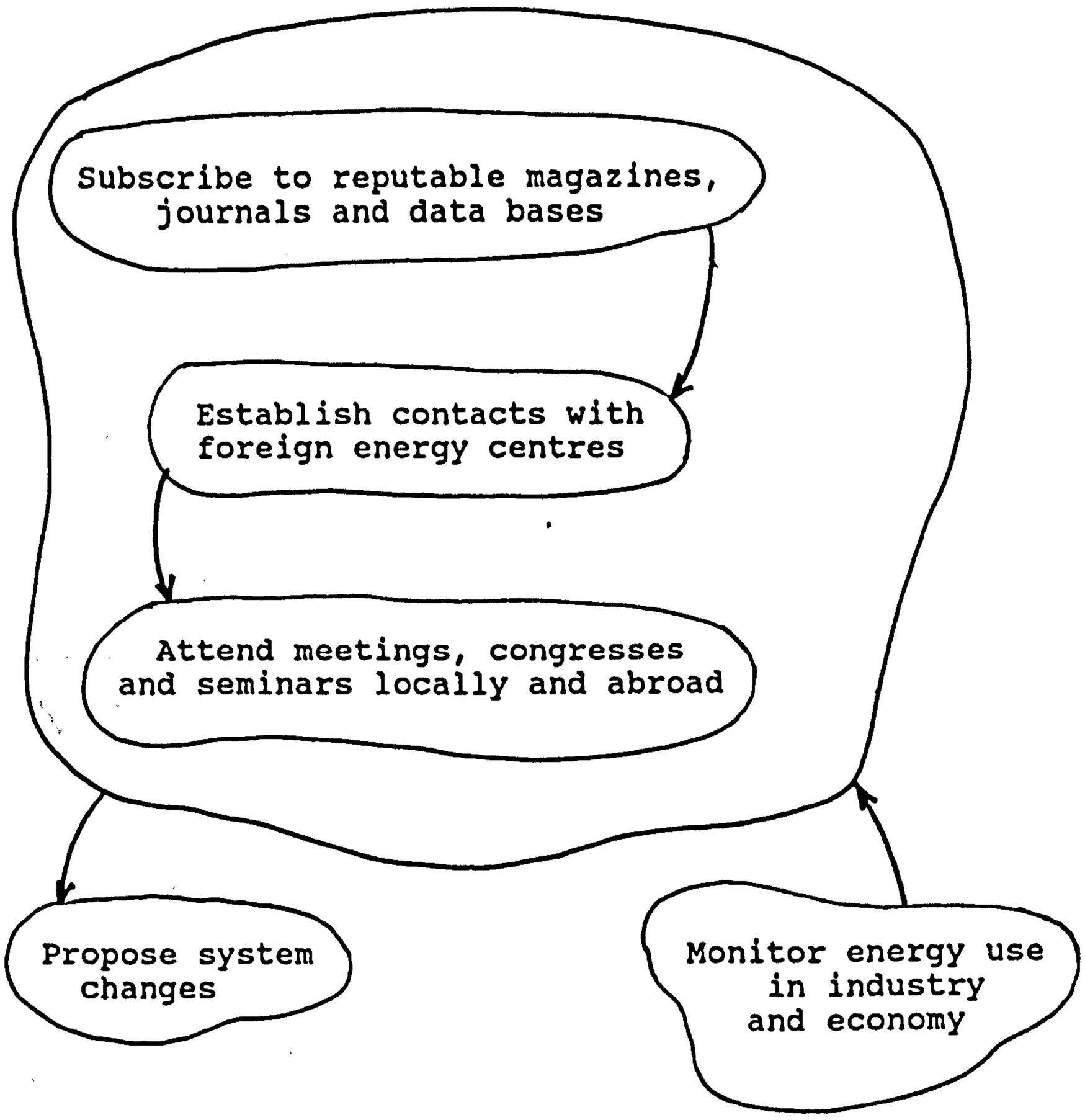
Conceptual model of activity: " Analyse information "



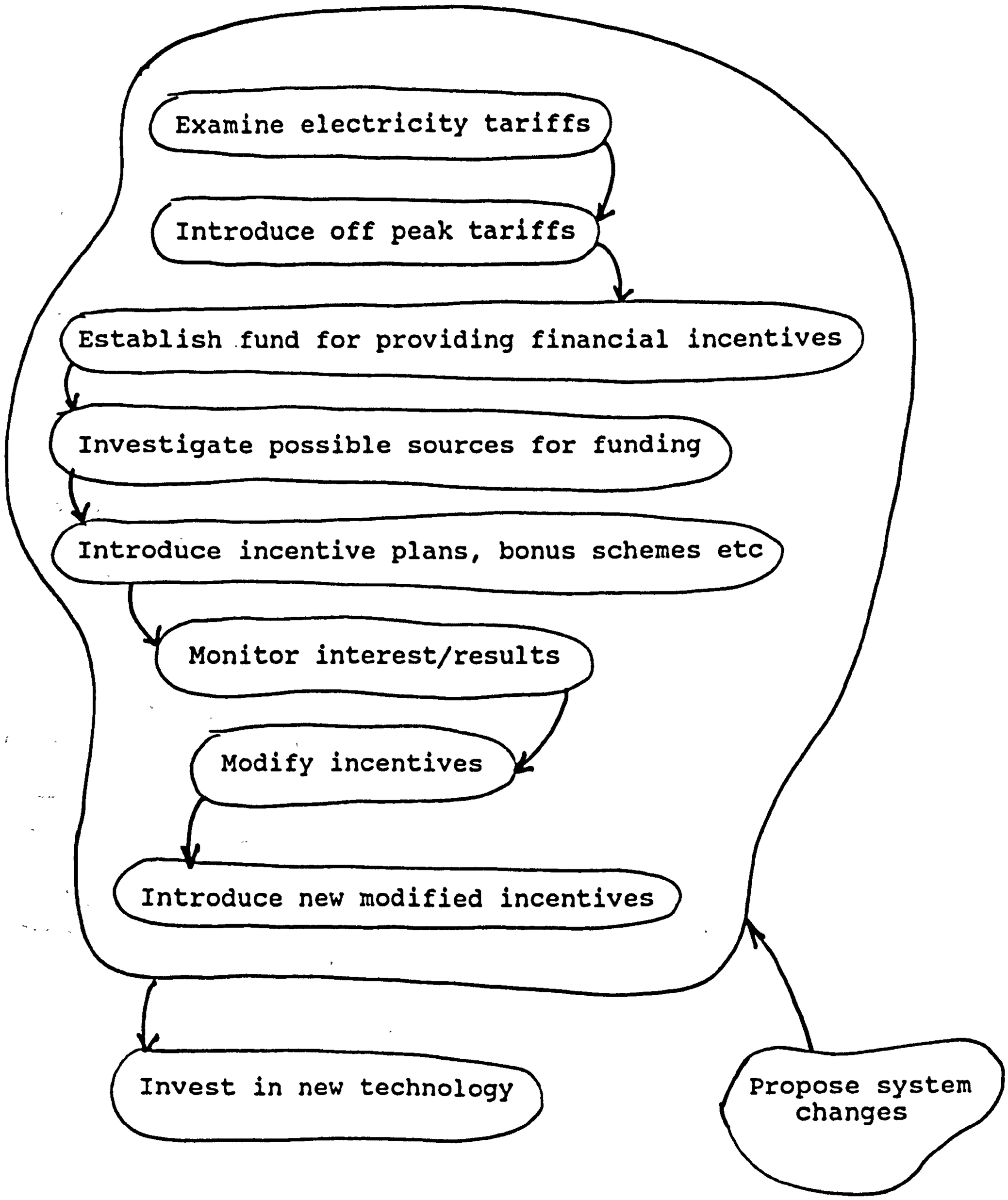
Conceptual model of activity : " Record Energy Use "



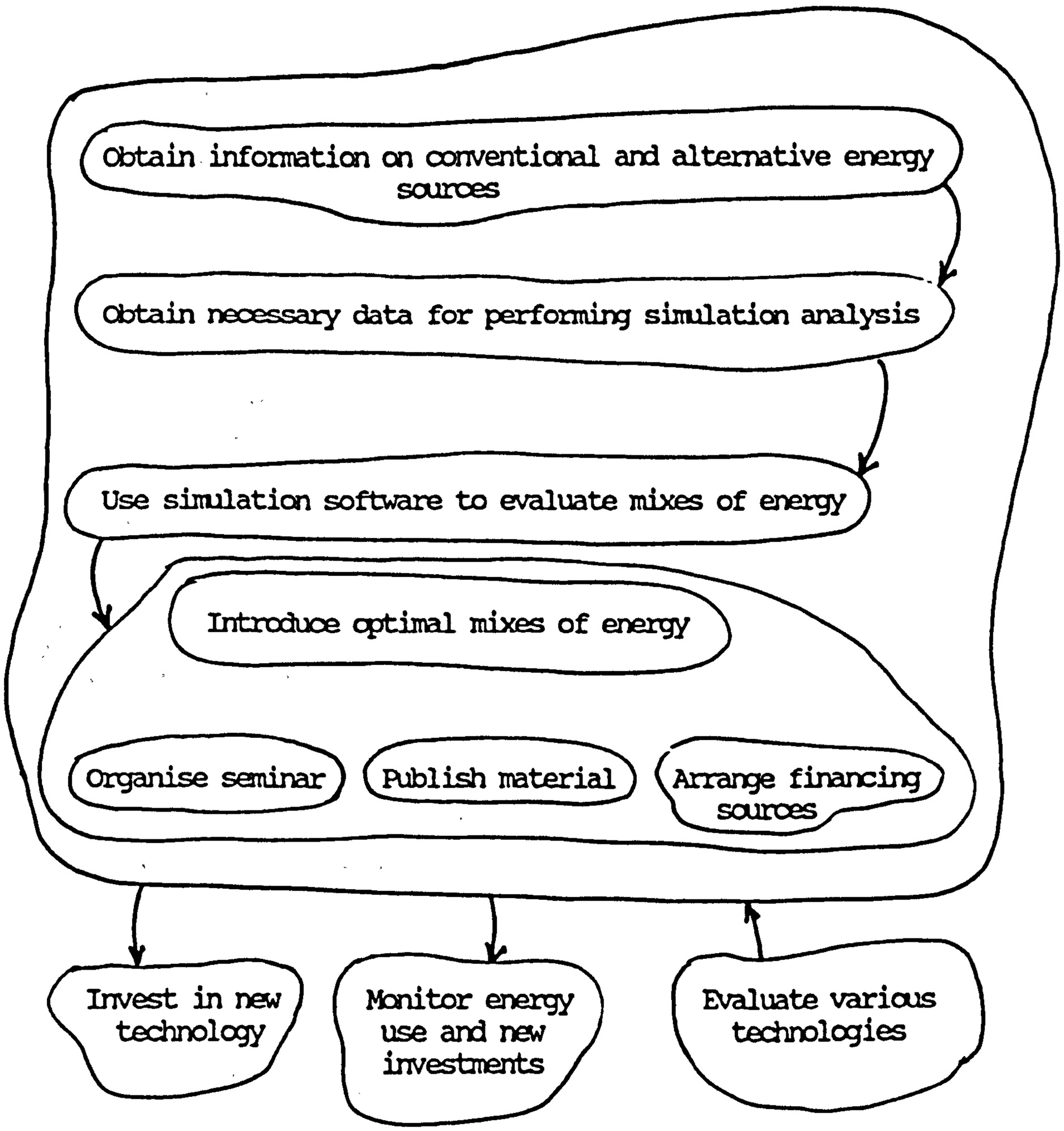
Conceptual model of activity : " Monitor energy cost in hotel industry "



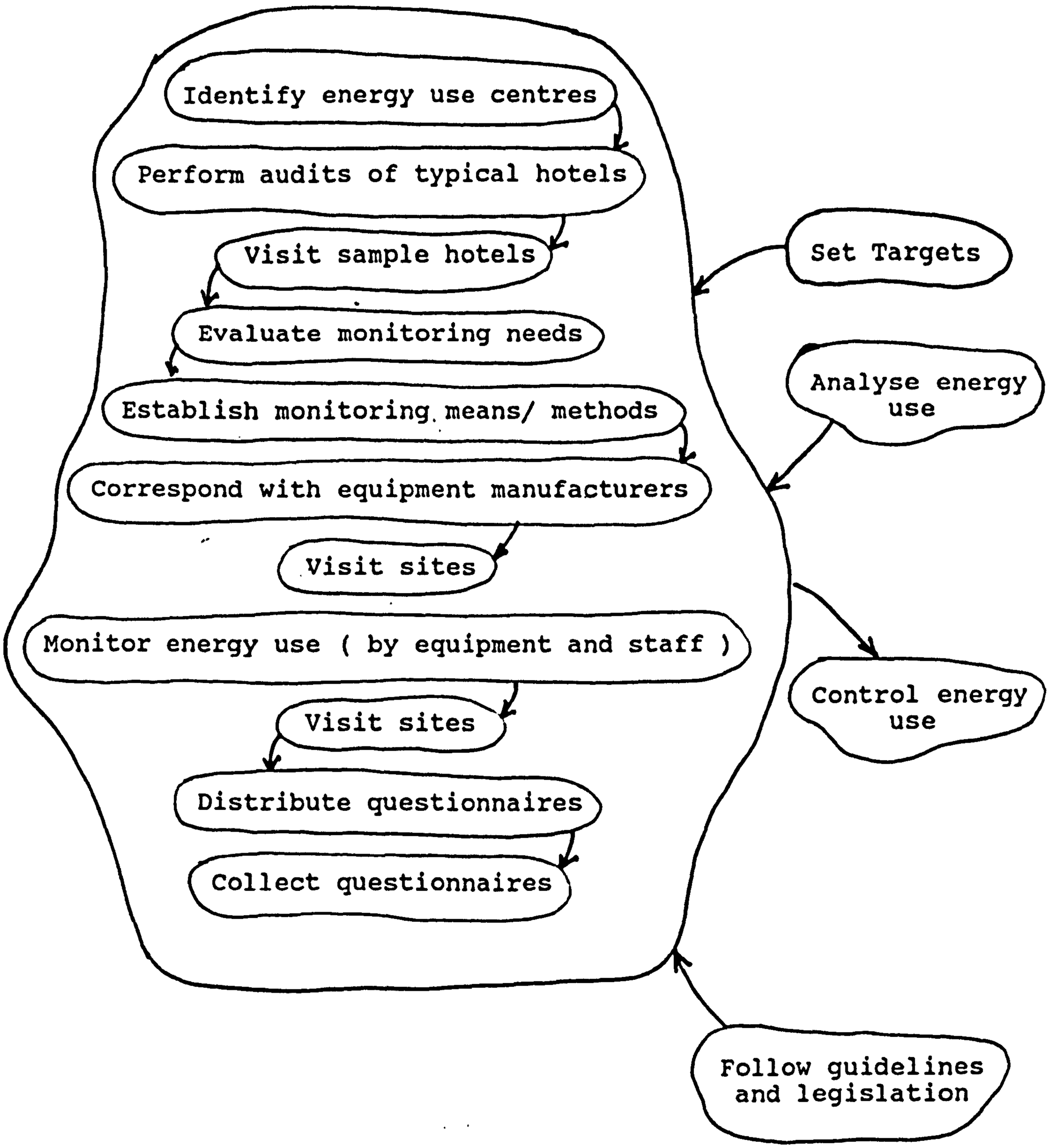
Conceptual model of activity : " Monitor international developments on energy use and cost "



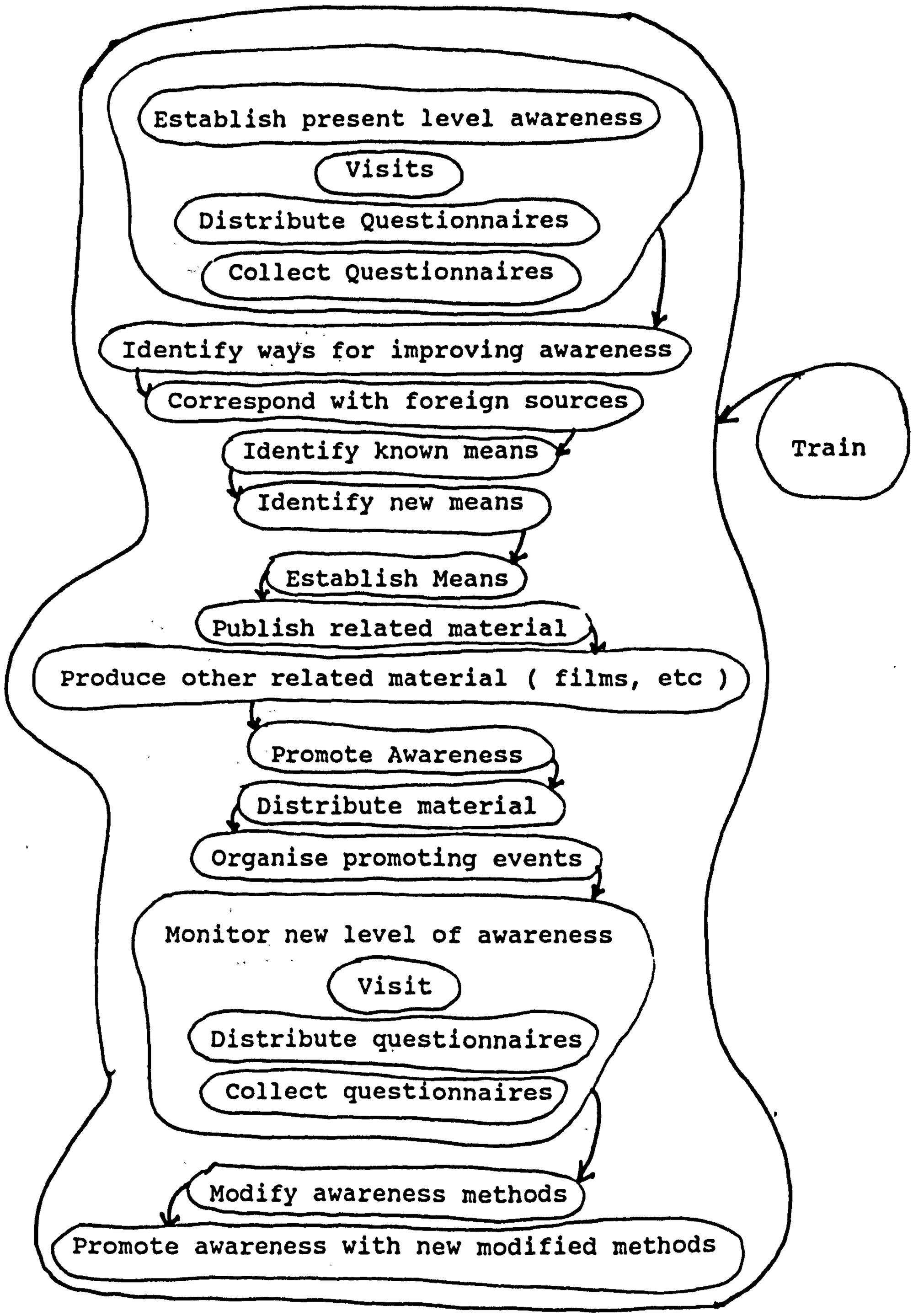
Conceptual model of activiry: " Provide energy conservation incentives to hotel owners "



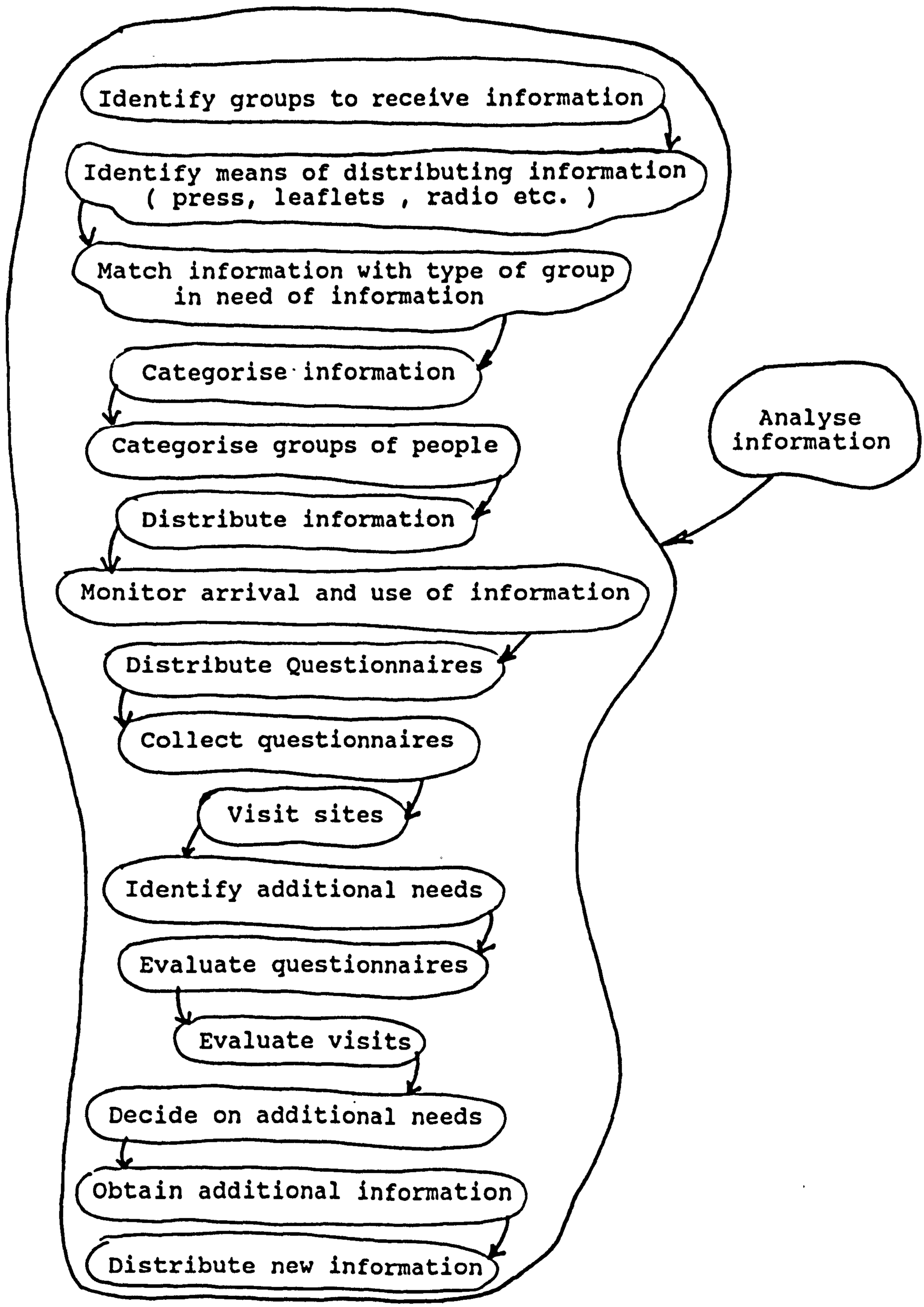
Conceptual model of activity : " Introduce optimal sources and mixes of energy "



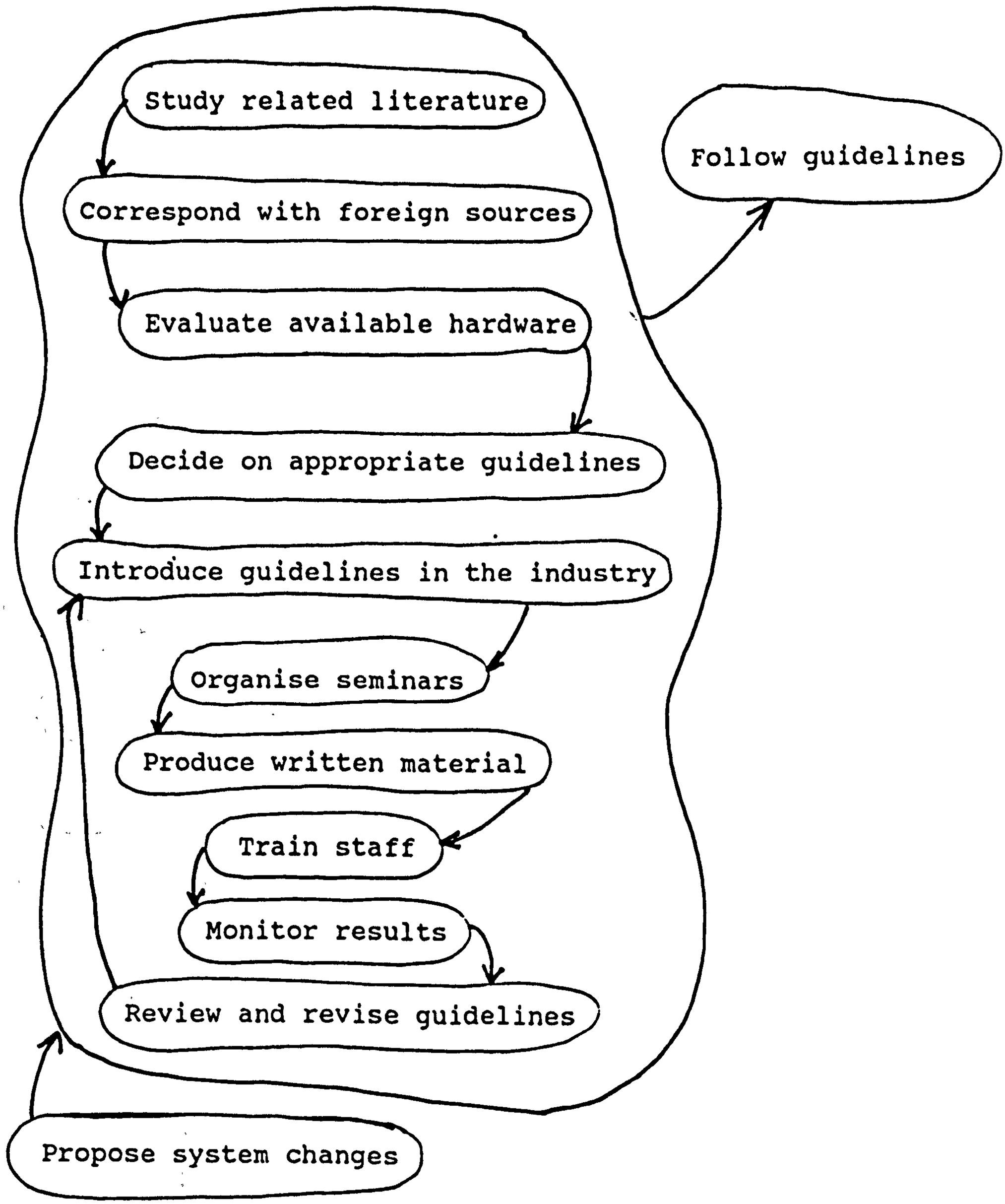
Conceptual model of activity: " Monitor Energy Use and New Investments "



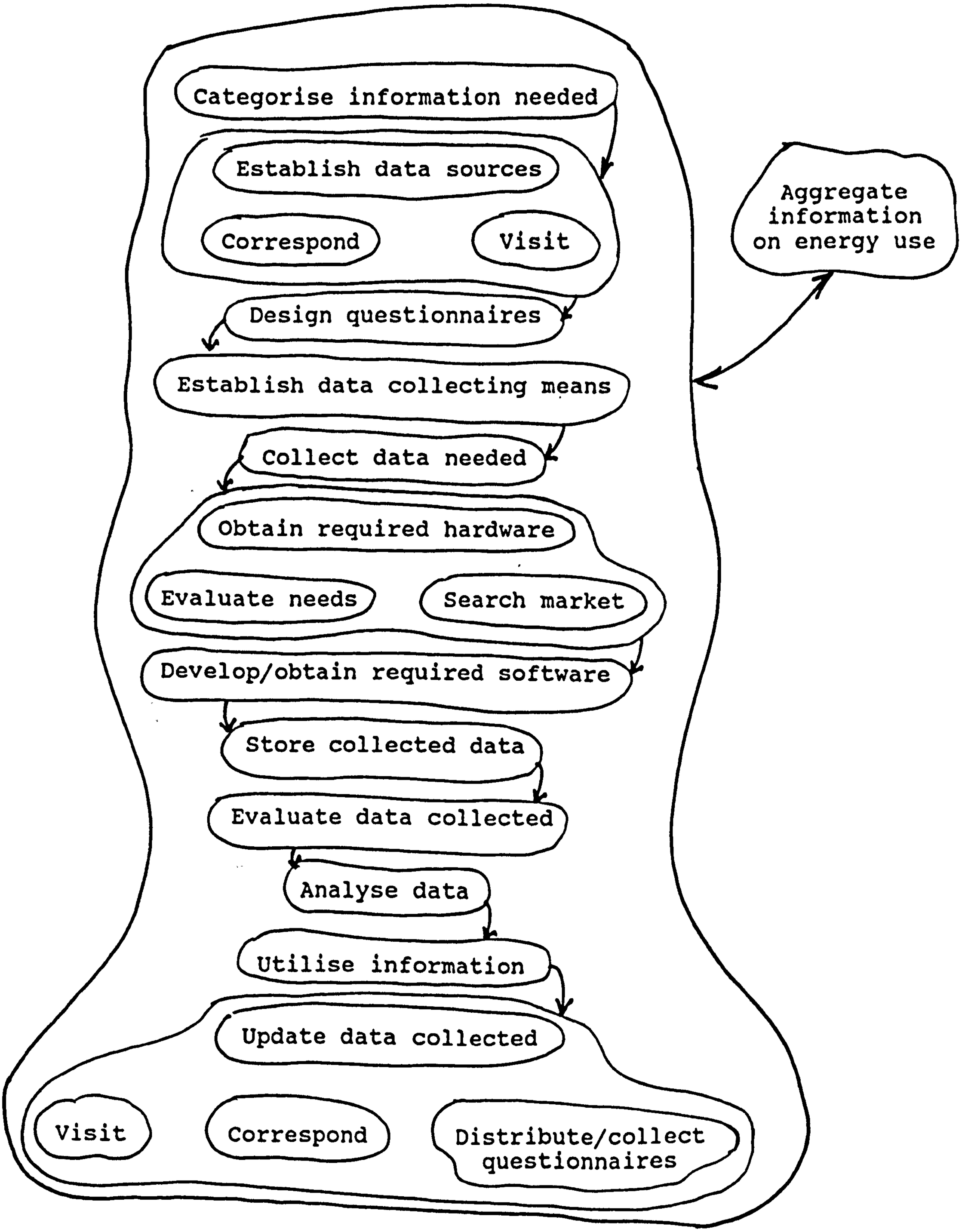
Conceptual model of activity : " Increase Awareness "



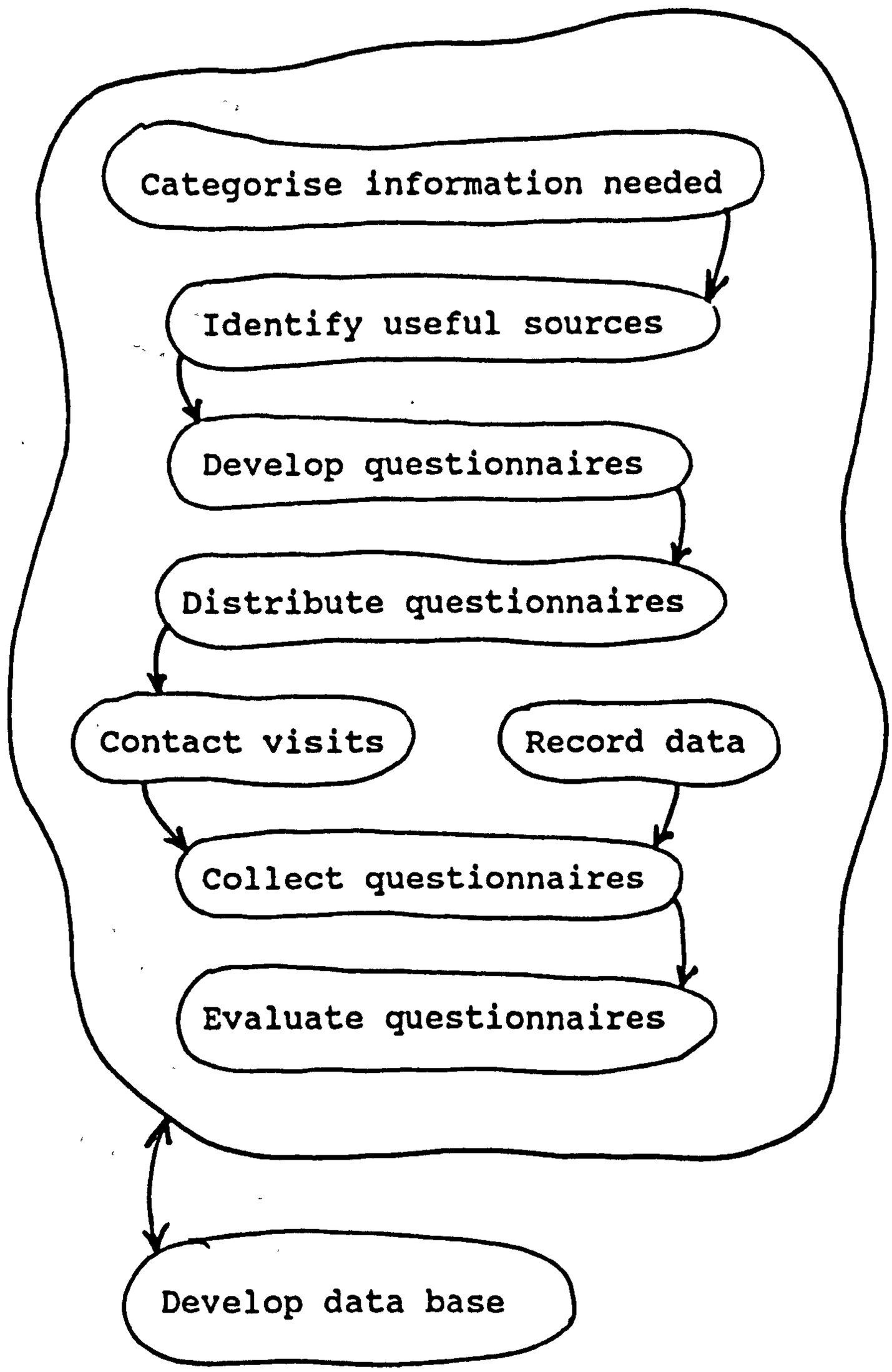
Conceptual model of activity: " Distribute information "



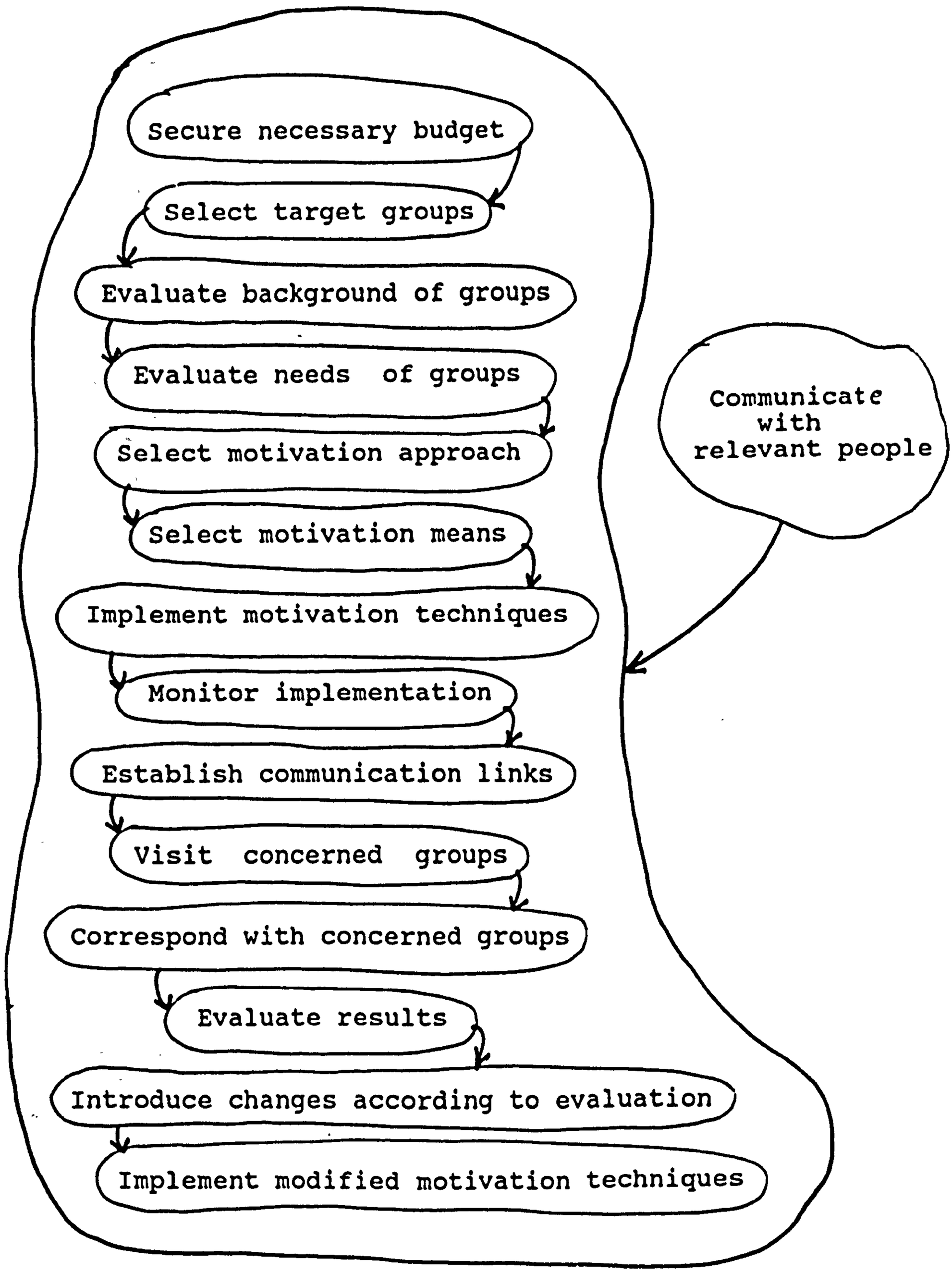
Conceptual model of activity : " Introduce guidelines for measuring and targeting "



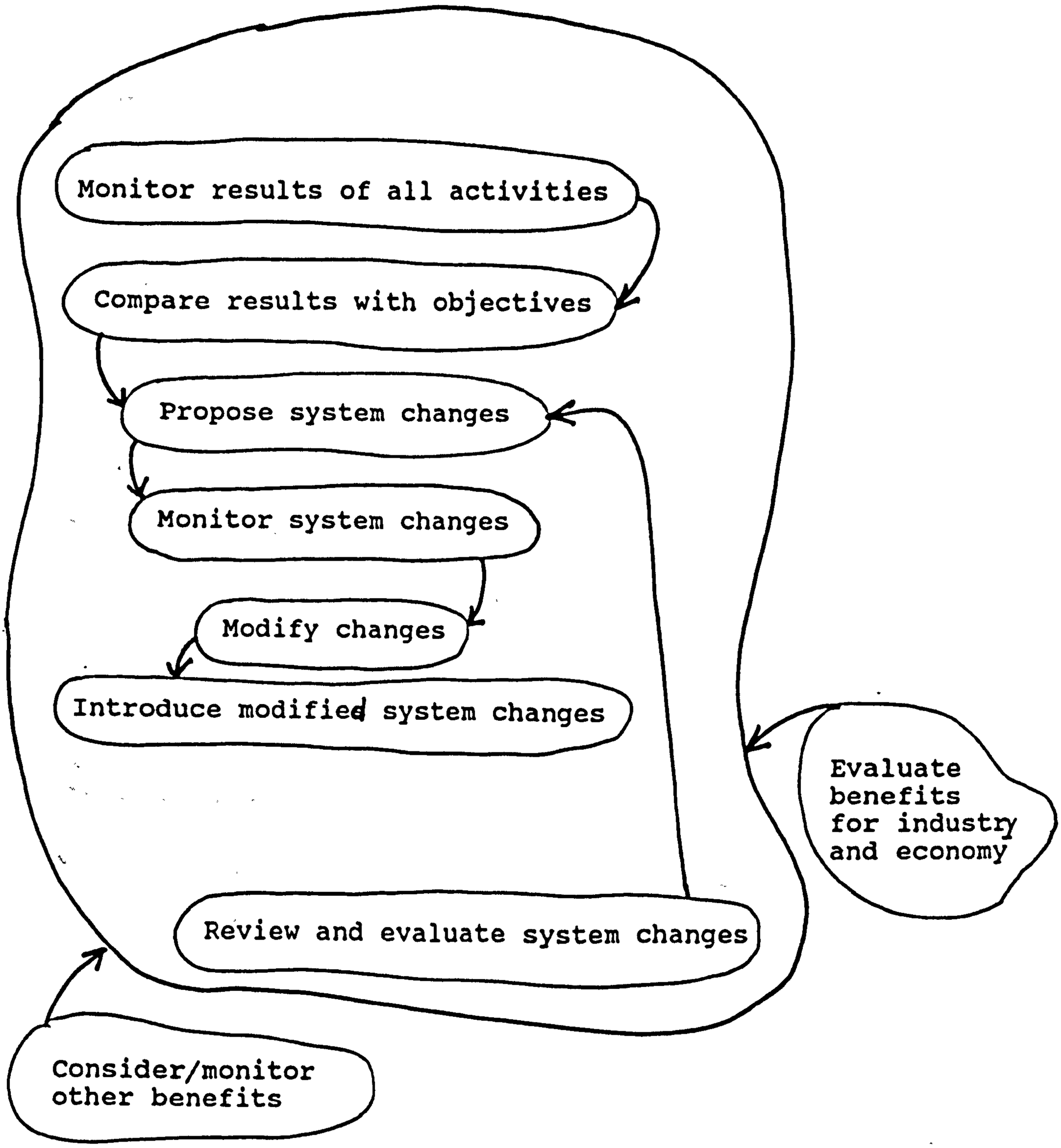
Conceptual model of activity : " Develop data base "



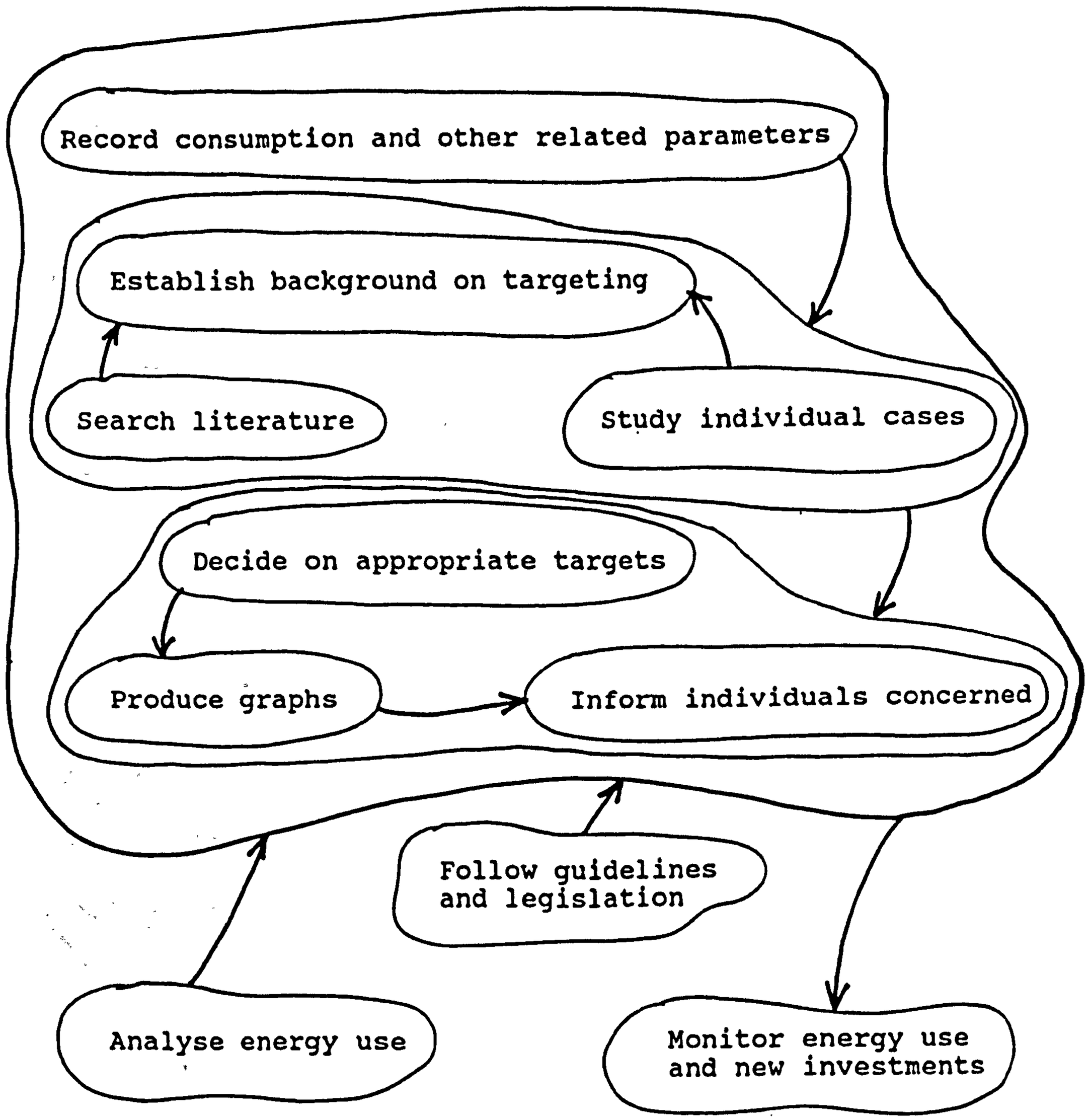
Conceptual model of activity : " Aggregate information on energy use "



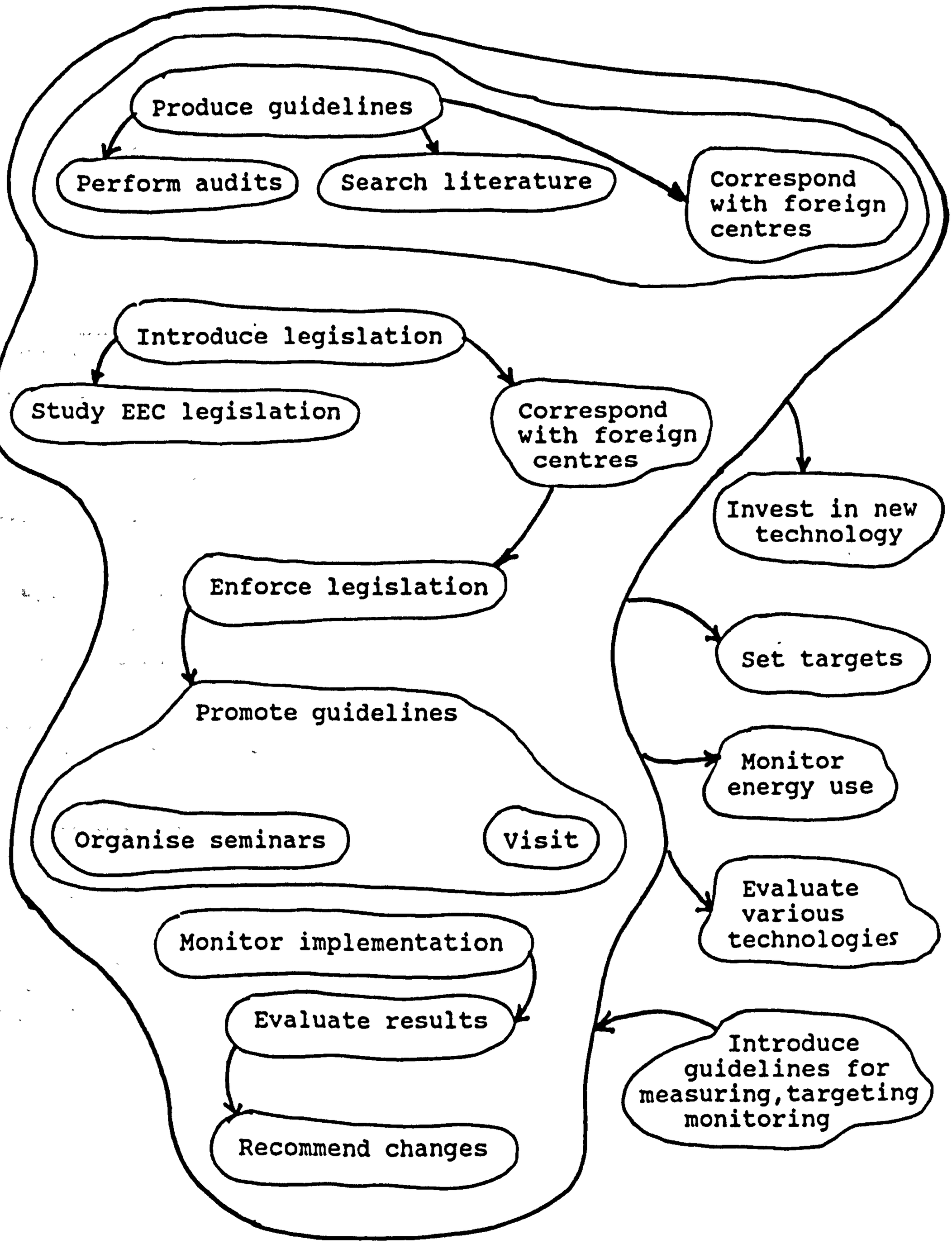
Conceptual model of activity : " Motivate People "



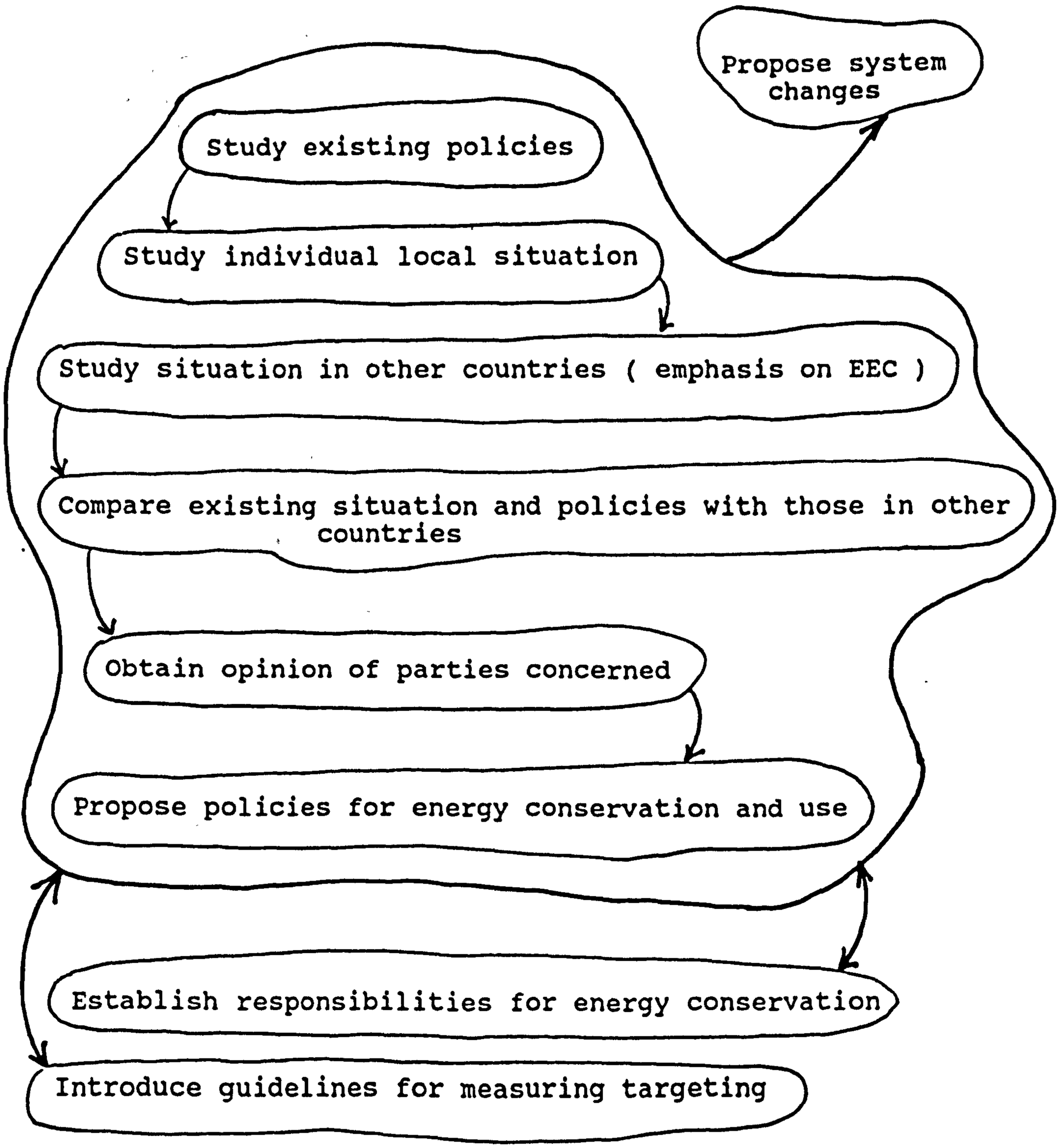
Conceptual model of activity : " Propose system changes "



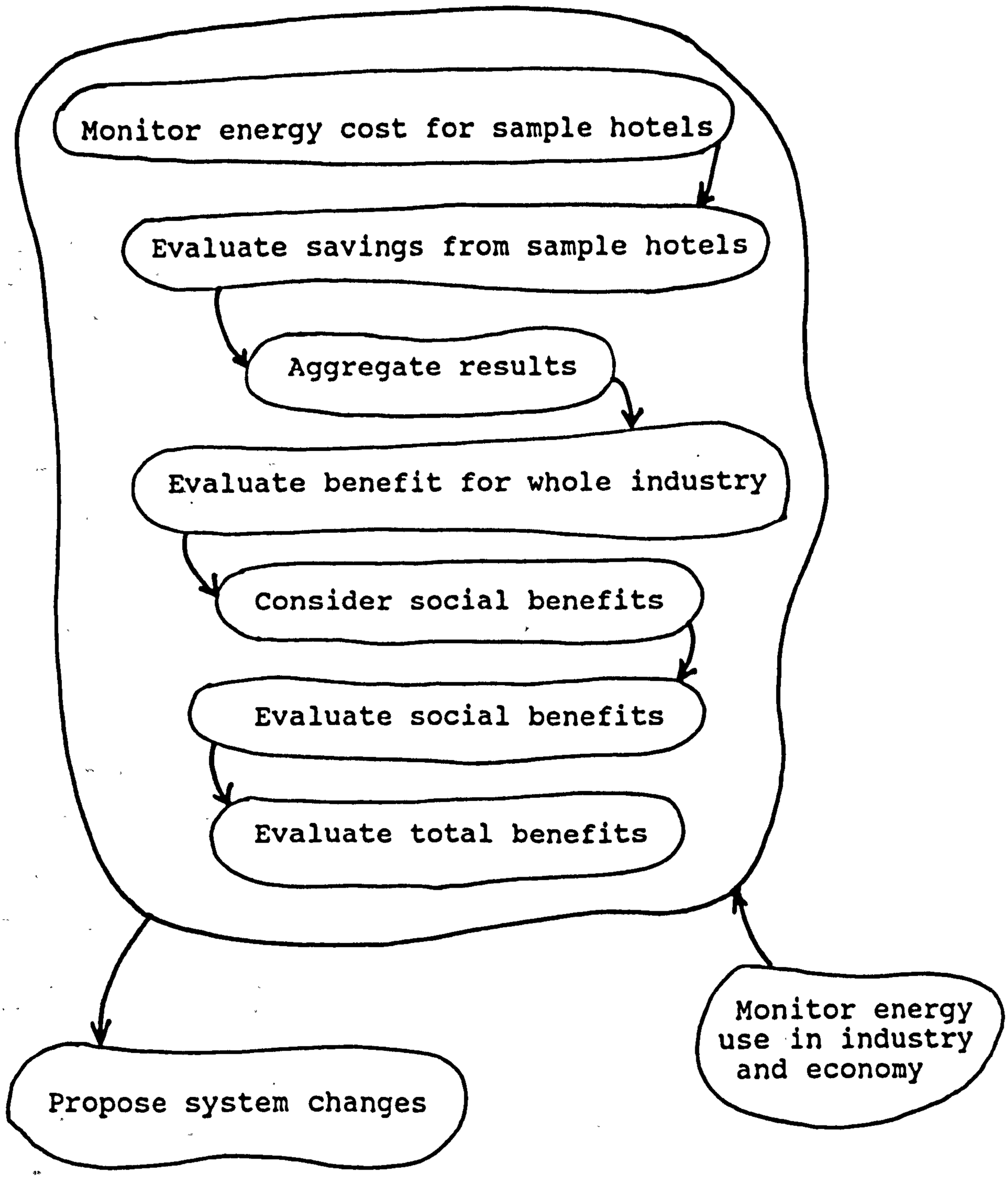
Conceptual model of activity : " Set Targets "



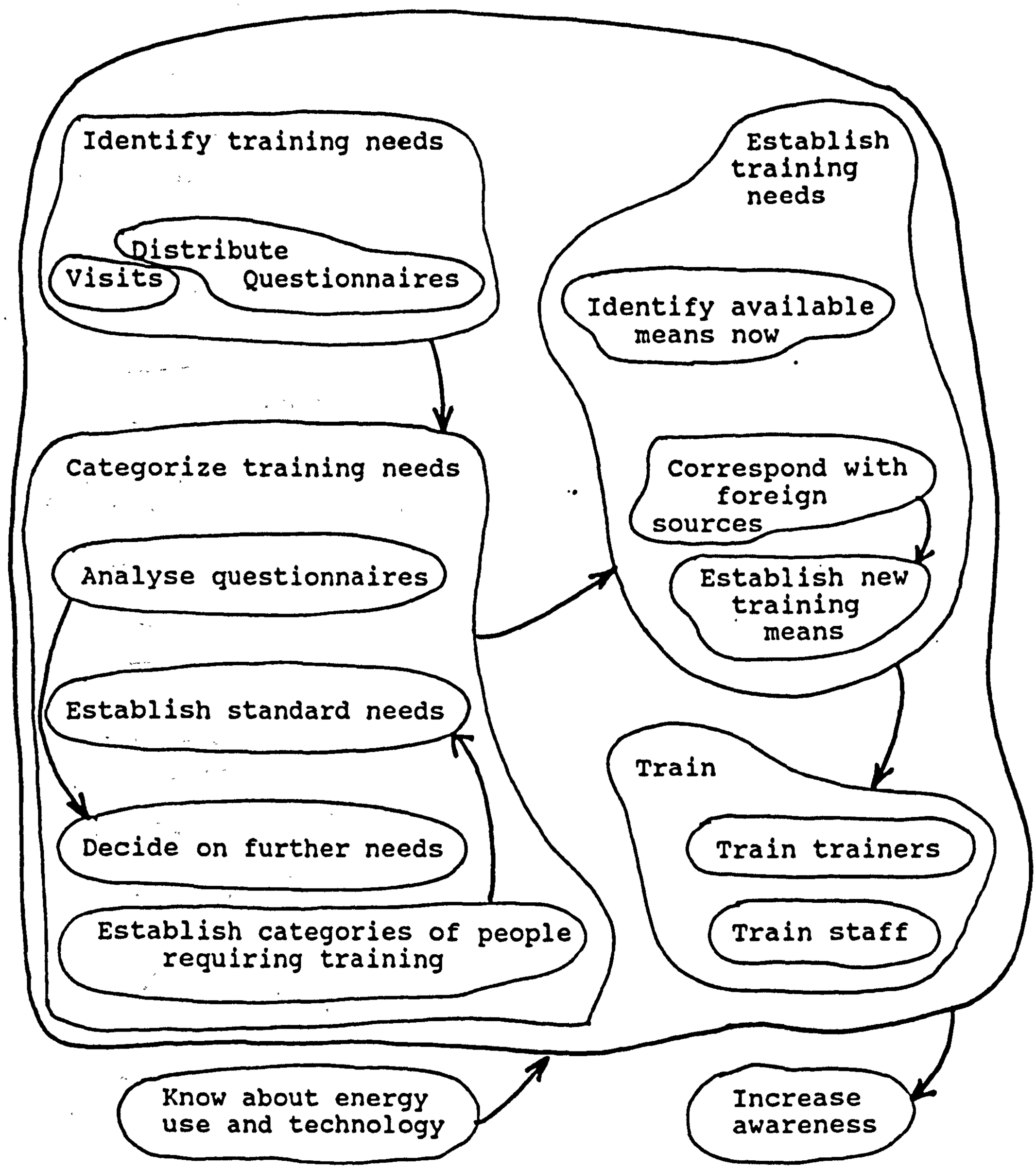
Conceptual model of activity : " Follow guidelines and legislation "



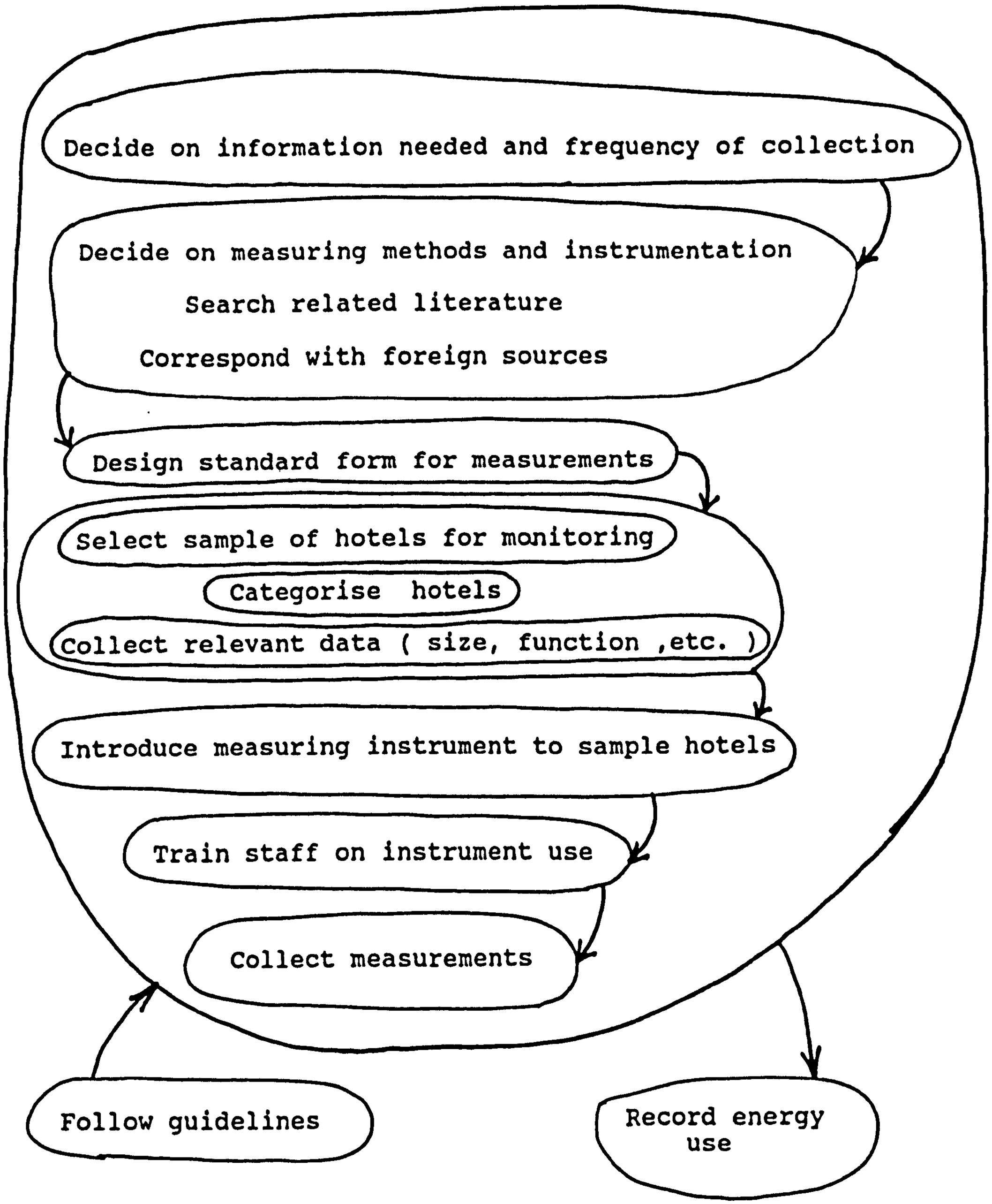
Conceptual model of activity : " Form policies on energy conservation and use "



Conceptual model of activity : " Evaluate Benefits for Industry and Economy "



Conceptual model of activity : " Train "



Conceptual model of activity : " Measure Energy Use "

APPENDIX D

(Appendix to Chapter IV)

Hotel B

A. The Building

Hotel B is a 3 star sea side hotel located at the south west region of the island. The hotel has 52 rooms and can accommodate 104 guests. The hotel front view is oriented towards south east and consists of a basement, a ground floor, a mezzanine and four typical floors occupying a total plan area of approximately 3200 sq.m.

The basement consists of a staff room, two store rooms, three cold rooms, a plant room and a parking place. The ground floor consists of a reception area, a bar, a living room, a dining room and two management offices. In the mezzanine there is a cafeteria, a small conference room and another office. There are 13 guest rooms on each typical floor each having an area of 18 sq.m. and a veranda of around 3 sq.m.

The hotel is made of a concrete frame structure with 20 cm thick plastered brick walls. All external doors and windows are made of single glazing approximately 4 mm thick. About 40% of the external wall area which is around 1500 sq.m. is made of glass. Most of this glazed area faces south-east and north west. The roof occupies an area of around 450 sq.m. and is made of two layers of concrete (250 mm and 100 mm thick) and a 50 mm cork layer between them.

B. The Plant

The space heating and hot water requirements (partly) are served by two hot water boilers each having a nominal capacity

of 280 kW. The boilers serve as a back up system to the supply of hot water from a solar water system installed on the roof and made of 50 panels each having an area of 2 sq.m. The hot water circulates through two hot water circulators operating sequentially.

Two 2.2 kW pumps operating sequentially feed the cold water tank from a concrete reservoir. The cold water is distributed from the plant through a pressurised system made up of two 2.2 kW pumps.

Heating is provided through hot water supplied from the boilers to fan coils in the rooms and to three air handling units serving the cafeteria, the bar and the dining room.

Two 3 kW chilled water pumps operating sequentially supply the chilled water produced by an air cooled 75 kW chiller to the fan coils and the air handling units.

Two exhaust fans provide ventilation for the kitchen and bath rooms through a duct system.

Three condensing units are installed in the basement to provide cooling for the two cool rooms. One freezer is also available.

The kitchen is equipped with two 3 kW toasters, a microwave two refrigerators, a potato peeler and dishwasher. LPG operated ovens are used for cooking.

Two 6 kW elevators are used to serve the guests and the staff of the hotel.

C. Major human factors

The manager of the hotel, who is in his late thirties and also the owner, has studied and worked overseas and is a very well organised and energy conscious person. During extensive discussions and interviewing on the basis of the research questionnaire, the following major conclusions were drawn:

(a) Energy issue both as a cost and as an improvement area enjoys high priority.
(b) There is considerable knowledge and awareness on both the management and the technical aspects of energy issues.
(c) There is willingness to consider energy conservation measures, introduce incentives for energy conservation (non financial) and learn more on energy conservation techniques.

The hotel does not employ a permanent chief engineer. The task has been contracted to a local maintenance company which in turn has assigned a technician with the responsibility of visiting the hotel regularly (once a week), providing maintenance and monitoring its operation. In case of emergency the technician is called in by the manager or the staff of the hotel. Discussions with the thirty year old high school graduate chief engineer proved that he is a very energy conscious and hard working individual. There is however great scope for improving his energy management knowledge on

technical matters and monitoring and targeting techniques.

The energy consumption recording task is assigned to the accounts department which is doing a very good job. All information is provided to the manager and the part time chief engineer upon request.

The hotel staff is very energy conscious as it is regularly instructed to be so by the management of the hotel.

D. Energy use and consumption

The three forms of energy used are gasoil (space heating and hot water production), LPG (cooking) and electricity (lighting, air conditioning, equipment).

The energy bill of the hotel for 1989 was 12630 Cyprus pounds and was made up as follows :

(a) Electricity : 9030 Cyprus pounds (71%)

(b) Gas oil : 2100 Cyprus pounds (17%)

(c) LPG : 1500 Cyprus pounds (12%)

The percentage contribution of the various energy forms is: Electricity :37%, Gasoil: 36% and LPG: 27%

Table A.D.1 presents electricity and occupancy data for 1988 and 1989. The accounts department was only recording purchasing dates and cost of both LPG and gasoil. Because these energy forms are not metered they are not shown in this

table.

In the case of this hotel hourly electricity consumption (at two hour intervals), maximum demand and power factor were recorded for five days during the month of April. The electricity consumption for the five days are given in Table A.D.2 and the power factor and the occupancy level for day 1 in Table A.D.3. The room occupancy for the five days for days 1-5 were 30, 45, 32, 20, 45 percent respectively.

E Energy conservation opportunities

The major energy conservation opportunities identified in the hotel were the following:

(a) The hotel could be benefited from a permanent trained chief engineer.

(b) A recording, monitoring and targeting system should be introduced. Necessary training must be provided.

(c) Boiler combustion efficiency tests should be performed regularly.

(d) The operation of a softening plant (available but never used) will result to energy savings.

(e) The possibility of changing the 75 kW chiller compressor with two 40 kW compressors should be examined. Better load conditions will be achieved with savings in electricity.

(f) Solar panels should be regularly cleaned and new insulation should to be added to several pipes.

(g) Lighting load will be reduced considerably resulting to

less electricity consumption if old fashioned GLS lamps are changed with modern energy efficient lamps.

(h) Power factor should be monitored for various times of the year.

(i) The possibility of installing a "key fob system" (keeps electricity supply off until guest puts his key in the slot) for the hotel rooms should be examined.

(j) The possibility of adding insulation to the building envelope should be examined (possibly under a false ceiling).

(k) An organised maintenance program should be introduced.

Month	Electricity MWh		Max Demand kVA		Occupancy %	
Jan	12.25	(11.33)	36	(32)	58	(53)
Feb	9.01	(8.02)	33	(31)	66	(62)
Mar	12.4	(2.1)	40	(38)	86	(84)
Apr	8.45	(8.2)	25	(22)	45	(45)
May	8.50	(8.0)	75	(73)	65	(65)
Jun	20.93	(20.6)	75	(75)	52	(50)
Jul	32.84	(31.1)	75	(76)	50	(48)
Aug	30.71	(30.1)	80	(78)	42	(42)
Sep	23.71	(22.0)	78	(75)	50	(50)
Oct	13.25	(12.3)	75	(75)	70	(65)
Nov	11.3	(11.0)	30	(28)	60	(60)
Dec	10.2	(10.0)	38	(30)	58	(55)

Table A.D.1: Monthly electricity consumption and occupancy data for Hotel B for the year 1989. (Data for 1988 are in parenthesis).

Time	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
8 a.m	22	23	25	23	20
10 a.m	30	33	31	33	32
12 a.m	26	22	21	22	22
2 p.m	26	26	23	22	24
4 p.m	17	27	25	25	23
6 p.m	20	19	20	21	20
8 p.m	34	31	32	32	32
10 p.m	35	40	38	36	35
12 p.m	35	36	35	35	35

Table A.D.2: Hourly electricity consumption for Hotel B

Time	kWh	kVah	P.F.
8.00 a.m	22	24	0.92
10.00 a.m	30	31	0.97
12.00 a.m	26	27	0.96
2.00 p.m	26	26	1.00
4.00 p.m	17	18	0.94
6.00 p.m	20	22	0.91
8.00 p.m	34	36	0.94
10.00 p.m	35	36	0.97
12.00 p.m	35	36	0.97

Table A.D.3: Power factor recording for Hotel B (DAY 1)

Hotel C

A. The building

Hotel C is a 3 star hotel located in a touristic area. The hotel operated for the first time in 1981 and is a five story building that can accommodate 140 guests in its 70 guest rooms. The hotel has an air conditioned area of approximately 3850 sq.m. and is located on the beach and is North South oriented. On the north and south sides of the building there are no open areas.

The concrete building envelope is made of standard single brick walls of 20 cm locally manufactured bricks. No part of the building envelope is insulated. The building is not well

protected against the sun since there is virtually no protection (shading) on the East and West sides.

B. The plant

Space heating is provide by two gasoil fired water boilers each one rated at 186 kW. The boilers produce water at 60 degrees Centigrade. Combustion gases are let to the air through an exhaust duct of 20 m high. The same boilers back up the production of hot water by an installed solar system composed of 34 panels each having an area of 2 m.

Space cooling is provided by fan coils in the rooms and air handling units in the public areas in the ground floor (lobby, restaurant, bar). The two air cooled chillers have a capacity of 15 kw and 18 kw and one is operational while the other is in a standby mode.

During the Winter season the hotel's swimming pool is heated by a heat exchanger provided with hot water from the gasoil operated boilers.

C. Major human factors

The manager of the hotel is a very intelligent person in his early forties with almost twenty years of experience in his field, eight of which in Hotel C.

Discussions and interviewing with the manager revealed that energy conservation and management ranks quite high among his priorities. This finding is underlined by the fact that the

manager had, during his service in Hotel C, requested the assistance of both a local and a foreign energy consultant. The major recommendations of both consultants were, (as personally observed), adopted. The manager had an excellent knowledge of the financially related energy matters of his hotel.

In addition, credit must be given to the manager's ability to establish perfect communication channels between himself and his chief engineer. As stated repeatedly during discussions the manager was very anxious to learn more on how to handle his hotel's energy matters.

The chief engineer of the hotel is a graduate of a technical high school who has attended several technical seminars and has 15 years of experience. Extensive discussions proved that there is both space for more learning and a willingness to do so.

The chief engineer must be given credit for recommending the installation of gasoil meters and LPG meters in addition to the electricity meters for monitoring the consumption of energy. There is however space for improving the use of these data.

Discussions with the staff of the hotel revealed that they were never officially instructed by the management to pay attention to energy management. Several members of the staff complaint that energy was wasted by guests. However the

conclusion of the staff was that: "there is nothing we can do about it".

D. Energy use and consumption

As is the case in the other hotels the three forms of energy used are electricity (air conditioning, lighting equipment gasoil (space heating, pool heating, hot water) and LPG (cooking).

The energy bill for the hotel in 1989 was 25800 Cyprus pounds and was made up by the following components:

(a) Electricity	:	20400 Cyprus pounds	(79%)
(b) Gas oil	:	4070 Cyprus pounds	(16%)
(c) LPG	:	1330 Cyprus pounds	(5%)

With respect to total energy used the percentage input of each energy source is as follows :

(a) Electricity : 45%

(b) Gasoil : 41%

(c) LPG : 14%

Table A.D.4 presents the electricity consumption, the maximum demand and occupancy figure for the year 1989 and 1988 (in parenthesis). Table A.D.5 presents the gasoil and LPG consumption for the same years.

Month	Electricity Mwh		Max Demand kVA		Room Occ %	
Jan	26.2	(25.4)	62	(56)	36	(33)
Feb	25.3	(21.5)	62	(62)	40	(40)
Mar	29.9	(25.7)	61	(64)	54	(52)
Apr	25.0	(26.9)	60	(62)	62	(60)
May	32.3	(30.8)	100	(98)	73	(70)
Jun	50.7	(42.4)	110	(122)	82	(80)
Jul	68.4	(63.6)	140	(138)	85	(82)
Aug	66.3	(62.5)	139	(138)	91	(91)
Sep	51.6	(55.8)	118	(122)	84	(84)
Oct	41.2	(37.4)	92	(110)	81	(78)
Nov	28.8	(25.4)	65	(64)	68	(68)
Dec	29.6	(26.1)	70	(72)	28	(25)

Table A.D.4: Electricity consumption, maximum demand and occupancy for the years 1988 and 1989 for Hotel C (1988 data in parenthesis).

Month	LPG (kg)		Gasoil (l)	
Jan	700	(800)	7425	(6300)
Feb	800	(850)	7430	(5580)
Mar	900	(1520)	6525	(7650)
Apr	1000	(800)	1575	(3060)
May	900	(900)	1800	(1800)
Jun	1100	(800)	1800	(730)
Jul	1110	(900)	1125	(740)
Aug	1150	(800)	1130	(720)
Sep	1010	(1000)	350	(1147)
Oct	800	(1000)	1780	(1575)
Nov	1000	(900)	5400	(2475)
Dec	800	(900)	6000	(6525)

Table A.D.5: Monthly LPG and gasoil consumption for the years 1989 for Hotel C (data for 1988 in parenthesis)

E. Energy conservation opportunities

The most important energy conservation opportunities identified are the following:

(a) Though the monitoring system was quite good, benefits will be obtained from the establishment of a clear targeting system

(b) Training for the management and staff on energy related

matters should be provided

(c) Regular boiler combustion efficiency tests should be performed

(d) The possibility of insulating at least the roof should be investigated

(e) The power factor should be monitored and corrective measures to be taken accordingly

(f) Plant room piping must be insulated

(g) Swimming pool night cover must be purchased

(h) Room thermostats must be reset to lower temperature in the Winter and higher in the Summer

(i) Peak electric demand can be reduced by staggering the starting time of equipment

(j) Separate electricity meter for the kitchen must be installed in order to monitor consumption

Hotel D

A. The building

Hotel D is a 3 star hotel located by the beach in a touristic part of the island. The hotel has 52 double rooms and can accommodate 118 guests. The hotel has four typical floors each having 13 rooms and is east west oriented.

The building envelope is made of single plastered walls made of locally manufactured bricks having a width of 20 mm.

The hotel is also equipped with an uncovered swimming pool which is not heated in the winter.

B. The plant

The building is fully air conditioned (heating and cooling) including all common areas.

Space heating and hot water is provided by two gasoil fired water boilers each rated at 200 kW. One of the boilers is in operation while the other one is in most of the time stand by and cuts in only to cover for very high and extraordinary peak demands. There is no solar system installed for the production of hot water.

Cooling is provided by an air cooled chiller of a capacity of 75 kW. Rooms are served by fan coil units whereas public areas are air conditioned by air handling units.

C. Major human factors

Considerable amount of time has been spent with the manager of the hotel with whom, extensive discussions on various topics were carried out. The manager is forty years and has eight years of experience, all of which at the present hotel. From the discussions carried out it appeared that the manager was so anxious to "see" savings that he was often underestimating the difficulties of the issue. The cost for air conditioning seemed to attract the manager's major concern. However the manager appeared very reluctant to adopt measures (such as insulation) that would cost significant, according to his opinion, amounts of money. The main argument of the manager was that the owner of the hotel believed that only good housekeeping should be the staff's major concern.

The manager, was very keen to be informed of the development of new technology. Furthermore, he was very accurately informed on the cost of energy in his hotel and was able to provide accurate cost figures of all forms of energy.

The chief engineer of the hotel was also responsible with the maintenance of two other hotel owned by the same company. An engineering graduate, with seven years experience in the hotel industry, the chief engineer appeared to be well organised and quite sensitive on the energy problem. Eight people were supervised by the chief engineer directly whereas five others were supervised indirectly. The staff belonged to the company and could thus be instructed to work in any of the three hotels. The chief engineer was very conversant with most of the available energy saving technology and also very willing to learn. The staff of the hotel appeared to be not very well aware of their role in energy conservation and most of them said that this was very well taken care by the chief engineer who was visiting the hotel regularly!

D. Energy use and consumption

The energy forms used by the hotel, like almost all of the hotels on the island, are gasoil for space heating and hot water, LPG for cooking and electricity for lighting, air conditioning and appliances.

The energy bill for the hotel for 1989 was 21520 Cyprus pounds and was made of:

(a) Electricity : 17200 Cyprus pounds (80.0%)

(b) Gasoil : 3350 Cyprus pounds (15.5%)

(c) LPG : 970 Cyprus pounds (4.5%)

With respect to energy, the percentage input of each form of energy was: Electricity : 45%, Gasoil :47% and LPG: 8%

As is the case of most of the hotels on the island there were no data of energy consumption for the gasoil nor LPG. What was recorded was only the deliveries of these energy forms.

Table A.D.6 presents the monthly variation of electricity consumption and maximum demand for the years 1987-1989. Table A.D.7 presents the monthly LPG and gasoil deliveries for the years 1987-1989. Table A.D.8 presents the monthly average room occupancy for the years 1987-1989.

E. Energy conservation opportunities.

The hotel has already had an energy audit but very few measures suggested by a foreign consultant, were finally implemented. Several lamps were substituted with other more efficient ones and insulation to plant piping was added. No solar system was however installed and no modifications to the boilers so that they could operate with a less expensive fuel, was done (according to the recommendations of consultants).

The major energy saving opportunities identified were :

(a) Provide better training to the staff on ways by which they can contribute to energy conservation.

(b) Introduce labelling by which guests will be encouraged to conserve energy.

(c) Install electricity meters (for the kitchen for example) and gasoil and LPG meters.

(d) Change all non energy efficient lamps with energy efficient ones.

(e) Install power factor correction equipment (capacitors). Power factor values recorded were unacceptable (average around 78% when 85% is the minimum accepted by EAC.

(f) Insulate the envelope of the building (priority to be given to the roof).

(g) Modify electrically operated kitchen appliances to operate on LPG instead on electricity.

(h) Install a second air handling unit to the dining room instead of having only one serving both the dining room and the lounge area. Comfort will be improved and energy will be saved because of better temperature control.

Hotel E

A. The building

Hotel E is a 4 star hotel situated on the beach and having 200 rooms that can accommodate 376 guests. The building is oriented towards South and consists of 5 typical floors, a mezzanine and the basement.

In the mezzanine there are three management offices whereas in the basement there are maintenance office, stores, cold rooms and sports facilities. Each floor has 40 rooms and on the ground floor there are two large dining rooms, a bar, and

a reception area. The building envelope is made of single plastered wall made of locally manufactured bricks of 20 mm width.

Each room has an approximate area of 25 sq.m and has a veranda of an area of 3 sq.m and the roof of the building is not insulated.

B. The plant

Space heating and hot water is provided by two gasoil fired boilers rated at 800 kW each and operated on a 24 hour basis. One of the boilers is stand by while the other satisfies the entire needs of the hotel. A smaller third boiler rated at 290 kW operates during Summer time and covers the hotel's hot water needs during this period. The boilers are well maintained and their condition is very good. All insulation is kept in good condition and is of adequate thickness. There is no solar system installed on the hotel.

Space cooling is provided by two air cooled chillers each of a capacity of 280 kW.

A heat recovery system produces hot water from the air cooled chiller and satisfies the hotels hot water needs for the summer.

The hotel's swimming pool is heated in the Winter via a heat exchanger and hot water supplied from the boilers.

C. Major human factors.

Considerable amount of time has been allocated in order to interview the manager of this large hotel in an effort to evaluate his sensitivity and knowledge on the issue of energy.

The manager, in his early thirties, with 12 years of experience, is a very busy person that had never allocated enough time to properly appreciate the issue of energy.

The manager appeared quite concerned with the energy problem which he faces as a major cost. However, according to the manager's claims, lack of time was the main reason for not allocating the time required to the problem.

From the discussions and the answers to most of the questions it became evident that there were knowledge gaps related to the issue of energy. For example, the manager was not aware of the way his electricity bill was set up (charged) nor that by arranging to avoid simultaneous operation of the electrical appliances, electricity could be saved.

The manager appeared to have total confidence on the abilities of his chief engineer for whom he paid great respect. The chief engineer is a University graduate in mechanical engineering in his early thirties. A very intelligent and energy conscious person, the chief engineer supervises a team of 13 persons charged with the total maintenance of the building. The chief engineer was quite knowledgeable in his field and was very willing to learn of

new ways that would conserve energy.

The maintenance team and the other hotel staff were very sensitive on the issue of energy. However, some of them appeared to be demotivated and considered the issue as belonging to the total responsibility of the management.

D. Energy use and consumption

The energy forms used by the hotel are gasoil, (for space heating and hot water production) LPG (for cooking) and electricity (lighting, air conditioning, operation of electric appliances and sewage treatment plant).

The energy bill for the hotel for 1989 was 71400 Cyprus pounds and was allocated as follows:

(a) Electricity : 60200 Cyprus pounds (84%)

(b) LPG : 3500 Cyprus pounds (5%)

(c) Gas oil : 7700 Cyprus pounds (11%)

With respect to energy units the percentage input of the various energy forms is as follows: Electricity: 53%, LPG: 32% and Gasoil: 15%

Table A.D.9 shows the monthly electricity consumption and maximum demand for the years 1987, 1988 and 1989 and Table A.D.10 presents the monthly LPG and gas oil consumption for the years and Table A.D.11 the monthly average room occupancy for the same years.

E. Energy conservation opportunities

The most important energy conservation opportunities identified are given below.

(a) The targeting and monitoring system of the hotel should be re examined.

(b) The possibility of installing a solar hot water system should be examined.

(c) Electric dish washers, dish warmers and deep fryers should be modified so that they will utilise hot water heated by the gasoil boiler and passing through appropriate heat exchangers.

(d) The heating and cooling pumps are oversized resulting to excessive electricity consumption and inefficient operation of boilers. The possibility of having an oversised hot water pump should also be examined.

(e) Most of the hotel's lamps have been changed with energy efficient bulbs. There are however approximately 350 small 40 W spot lamps that were not changed.

(g) Insulation should be added to the roof of the hotel.

(h) Selective electric equipment could be switched off at certain times of the day without creating any disturbance to the guests.

(k) Refrigerators should be located (this is not the case) in places where they could have adequate ventilation.

Hotel F

A. The building

Hotel F is a 2 star hotel located by the seaside and having 40 rooms with 80 beds. The hotel is run by the largest hotel operator on the island.

The building, which is fully air conditioned is oriented towards south east and is composed of six typical floors and a ground floor on which there is a restaurant, the reception area, and the management's office.

The kitchen of the hotel is located at the basement (!). Because of its location the hotel's business depends heavily on its restaurant.

B The Plant

The building is fully air conditioned (heating and cooling). Both the rooms and the common areas are served through fan coils which are provided with hot/chilled water. Both heating and cooling in the rooms are provided through two 15 kW roof mounted chiller-heat pumps. Another chiller-heat pump of the same capacity serves the common areas.

The hot water needs of the hotel are supplied by a heat pump which has an input power of 6 kW and delivers 20 kW of heat to a water calorifier. A number of solar panels (18 panels each of 2 sq.m) supplement the hot water production of the heat pump.

A fire incident in the kitchen was the reason for turning the kitchen to an "all electric" (instead of LPG). Therefore the hotel became an "all electric" one.

C. Major human factors

The manager of the hotel is in his early thirties and has only five years of experience in the field. During discussions with the manager of the hotel it became evident that the energy cost was not of his major concern. The manager appeared to be much more concerned on the issues of security (they had already been through an accident) and maintaining the service standards.

Because of the quality of its meals and the attractive prices, the hotel restaurant had establish an excellent reputation. This fact combined with the unique location of the hotel is the main reason for the huge revenues (compared to its size) of the restaurant.

The manager was therefore not especially worried for managing an "all electric hotel" which certainly is the most expensive mode of operation.

The hotel does not maintain a permanent chief engineer. This is quite common in several 2 star hotels in the island. The simplicity of its structure and operations, deriving from the fact that this is an "all electric" hotel enables it to satisfy its engineering maintenance needs by occasionally calling various technicians depending on the need.

It was not possible to interview a chief engineer in this case since several persons take this role.

The staff of the hotel was not very enthusiastic and did not appear very interested on the issue of energy conservation.

D. Energy use and consumption

The energy bill of the hotel for the year 1989 was 12500 Cyprus pounds and was all paid for electricity. It is estimated that around 75% of the energy bill is attributed to the operation of the kitchen equipment. The kitchen however contributes to around the same percentage to the revenues of the hotel.

Table A.D.12 presents the monthly electricity consumption and maximum demand for the years 1987,1988 and 1989 for the hotel whereas Table A.D.13 presents the monthly room occupancy for the same years.

The variation in consumption for electricity for the same months in different years is mainly attributed to difference in the number of hours of operation of the air conditioning plant (from 8 to 24 hours per day).

E. Energy conservation opportunities

(a) Though the power factor of the hotel is around 90%, the power factor correction unit existing in the hotel could be upgraded raising the power factor level to around 99% The cost of upgrading is estimated to around 400 Cyprus

pounds and the annual savings would be of the same order (a pay back period of around one year).

(b) Significant electricity savings could be achieved if existing tungsten filament bulbs are replaced with energy efficient lamps. Savings will depend on the number of substituted lamps and the hours of operation.

(c) The addition of insulation on the roof of the hotel would yield considerable energy savings.

(d) A gasoil operated boiler connected to the existing pipe work would result to significant reduction of electricity and maximum demand. The estimated investments is of the order of 2500 Cyprus pounds and the savings around 700 Cyprus pounds (a pay back period of around 3.5 years).

(e) A targeting and monitoring system of electricity consumption should be adopted.

(f) The possibility of installing magnetic micro switches to balcony doors and windows that disable the operation of the fan coil units when the windows are opened, should be examined.

(g) The possibility of installing a so called "key fob" system that disrupts the operation of the a/c system and lighting when rooms are not occupied should be also examined.

HOTEL G

A. The building

Hotel G is a 2 star seaside hotel located at the eastern part of the island. The hotel has 42 rooms and can accommodate 80 guests.

The rooms are located in 3 typical floors (14 rooms in each floor) and the ground floor houses a dining room, the kitchen a function room, the reception area and two management offices. Each room has an area of around 17 sq.m and a small veranda which faces the beach of around 2.5 sq.m

The hotel, which was built in 1980, has also a swimming pool which is not heated during the Winter months.

The envelope of the building is made of a plastered single brick wall with locally manufactured bricks of a thickness of 20 mm. There is no insulation on the walls nor the roof of the hotel.

B. The Plant

The building is fully air conditioned. Cooling is provided by an air cooled chiller mountened on the roof and having a capacity of 25 kW. A smaller air cooled chiller of a capacity of 15 kW serves as stand by and cuts in rarely during very heavy cooling loads. All rooms are served through fan coil units whereas two air handling units serve the common areas.

Space heating is provided via two gasoil operated boilers located in the plant room. Each of the boilers has a capacity of 200 kW and one of them is almost always in a stand by mode.

A solar system consisting of 25 panels each of an area of 2 sq.m is installed on the roof of the hotel.

C. The major human factors

The manager of the hotel is in his late forties and has an experience of more than twenty years in the hotel business. He is a very and intelligent person who has been exposed to the issue of energy conservation and management in many other hotels both in Cyprus and overseas. The major philosophy of the manager, deriving as he repeatedly claimed from his wide experience, is that energy consumption should be closely monitored like any other major activity of a hotel. The second important issue, according to the manager, is to have a capable technician that would look after the maintenance of the building and the third is to actively seek the cooperation of all staff. The manager's views are quite important and certainly applicable to any hotel.

The staff has been repeatedly instructed to be sensitive on the issue of energy conservation. The technician looking after the maintenance of the hotel (he does not carry the "title" of the chief engineer), is a very competent, intelligent and progressive young man.

The technician has only one assistant and is a graduate of a four year technical high school. He has attended several technical short courses, keeps good records of the energy consumption and is very willing to learn more on energy conservation.

D. Energy use and consumption

The energy bill of the hotel for the year 1989 was 7200 Cyprus pounds and was made up of the following components :

(a) Electricity : 5160 Cyprus pounds (72%)

(b) Gas oil : 1680 Cyprus pounds (23%)

(c) LPG. : 360 Cyprus pounds (5%)

With respect to the energy input the following percentages were calculated: Electricity: 36%, Gasoil 53%, LPG:11%

Table A.D.14 presents the monthly electricity consumption and maximum demand for the years 1987,1988 and 1989 and Table A.D.15 presents the estimated monthly Gas oil and LPG consumption and Table A.D.16 presents the monthly room occupancy for the same years.

E. Energy conservation opportunities

The major energy conservation opportunities identified are listed below:

(a) The chief engineer should be trained on monitoring and targeting techniques.

(b) A boiler combustion efficiency should be performed at least before the beginning of each heating season. The possibility of having incorrect nozzles on the burner must be examined.

(c) All non energy efficient lighting fixtures should be replaced with modern energy efficient ones.

(d) The power factor should be monitored

(e) Insulation of the roof must be examined

(f) The operation of the dishwasher without sufficient load should be avoided

(g) All deteriorated room curtains should be replaced with new, heavier and certainly longer ones in order to reduce solar penetration through windows.

(h) Domestic hot water supply temperature should be reduced to 55 degrees Centigrade (now 75 degrees Centigrade) present

HOTEL H

A. The building

Hotel H is a small 2 star hotel located in one of the sea side cities of the island and having only 22 rooms that can serve 44 guests. The hotels is oriented towards South and is composed of two floors each housing 11 rooms of an area of approximately 15 sq.m and a small veranda of an area of around 2 sq.m.

The ground floor houses a reception area, a management's office and two restaurants. One of the restaurants can be modified to serve as a function room in which it can accommodate social events for a small number of people.

The hotel was built in 1982 and is made of single plastered wall of locally manufactured bricks of a width of 20 mm. There is no insulation in neither the envelope nor the roof of the hotel.

The hotel is equipped with a swimming pool which is not heated in the Winter.

Hotel H is the smallest hotel included in the sample and it represents the spectrum of the small hotels of the island.

B. The plant

The hotel is fully air conditioned and all rooms and the ground floor are both heated/cooled. The rooms are served through fan coils while the common areas are served through ducts via two air handling units.

Cooling is provided by an air cooled chiller of a capacity of 20 kW whereas heating is provided by two gasoil fired boilers installed in the basement each having a capacity of 115 kW. One of the boilers is for most of the time stand by and very rarely cuts in. There is no solar system installed on the hotel mainly because of lack of space.

C. Major human factors

The manager of the hotel is in his late twenties and is a relative of the owner of the hotel. Being a relative of the owner allows the manager to enjoy full confidence and thus have all power to take decisions.

As much as he appreciates the issue of energy management, the manager did not appear to have been closely monitoring nor understanding the issue. For the manager the energy cost appeared to be a sort of an "unavoidable cost" with which, as

he thought, there was nothing he could do.

The hotel does not have a resident chief engineer but occasionally calls in a maintenance technician who looks after the electrical installations and services the boilers. The technician is only a primary school graduate, but works as an electrician for more than twenty years. It was not possible to discuss very technical and management issues with the chief engineer as he appeared to be knowledgeable and interested only on his duties of routine maintenance.

The staff of the hotel had very small concern and was not very interested on the issue of energy conservation.

D. Energy use and consumption

The energy bill for the hotel for the year 1989 was 4620 Cyprus pounds and was made up as follows:

(a) Electricity : 3200 Cyprus pounds

(b) Gasoil : 1100 Cyprus pounds

(c) Gas oil : 320 Cyprus pounds

With respect to energy the contribution of the various sources was as follows: Electricity: 33%, LPG: 52% and Gasoil :15%.

Table A.D.17 presents the monthly electricity consumption and maximum demand for the years 1987,1988 and 1989. Table A.D.18 presents the estimated monthly LPG and gasoil consumption and Table A.D.19 the monthly room occupancy for

same years.

E. Energy conservation opportunities

(a) A monitoring and targeting program for energy consumption should be established.

(b) Changing of non energy efficient lamps to modern energy ones should take place.

(c) The building envelope, with priority given to the roof should be insulated.

(d) Free night ventilation should be attempted for the common areas.

(e) A more vigorous and systematic maintenance program should be established.

(f) Hot water supply temperature should be reduced to 55 Centigrade (now 70 degrees Centigrade).

(g) Boiler combustion efficiency should be tested

Note : Monthly energy consumption data and occupancy level for hotels D, E, F, G and H are shown in the pages following.

Month	1987 MWh	1987 kVA	1988 MWh	1988 kVA	1989 MWh	1989 kVA
Jan	20.5	59	20.1	55	22.1	61
Feb	18.5	57	18.2	56	18.2	63
Mar	18.3	50	17.3	51	23.3	64
Apr	20.8	60	21.8	62	22.8	65
May	27.5	87	27.3	83	23.3	65
Jun	35.1	95	33.1	92	36.1	112
Jul	45.2	100	45.1	102	45.1	120
Aug	38.9	95	33.3	95	46.4	115
Sep	35.6	103	35.1	101	43.8	111
Oct	27.1	93	25.1	91	27.1	95
Nov	18.8	76	16.7	78	22.7	88
Dec	23.4	55	23.8	57	21.8	60

Table A.D.6: Electricity consumption and maximum demand for Hotel D

Month	1987 LPG (kg)	1987 Gas oil (lt)	1988 LPG (kg)	1988 Gas oil (lt)	1989 LPG (kg)	1989 Gas oil (lt)
Jan	700	3900	650	4000	800	4300
Feb	750	4000	750	4200	800	4100
Mar	700	4150	650	4100	700	4250
Apr	650	3200	700	3200	750	3100
May	450	1750	600	1600	550	1850
Jun	750	1500	800	1500	850	1650
Jul	400	2200	480	2000	470	2200
Aug	600	1650	600	1550	610	1650
Sep	450	3300	450	3200	420	3400
Oct	550	2250	600	2000	650	2100
Nov	600	4150	650	4200	680	4500
Dec	700	4250	750	4000	800	4200

Table A.D.7: LPG and gasoil consumption for Hotel D

Month	1987 %	1988 %	1989 %
Jan	55	58	55
Feb	60	65	60
Mar	75	70	72
Apr	68	65	62
May	70	70	72
Jun	75	75	76
Jul	85	85	80
Aug	90	90	95
Sep	86	86	88
Oct	70	70	74
Nov	65	65	68
Dec	45	45	40

Table A.D.8: Room occupancy for Hotel D

	1987		1988		1989	
Month	MWh	kVA	MWh	kVA	MWh	kVA
Jan	76.3	155	73.9	165	78.9	180
Feb	74.3	165	71.2	170	75.1	170
Mar	80.5	150	65.6	165	80.2	170
Apr	80.6	200	81.2	210	82.1	230
May	110.3	210	110.6	230	114.9	240
Jun	155.2	270	149.3	290	159.1	300
Jul	160.3	320	165.2	330	168.9	340
Aug	174.3	360	175.2	370	178.8	380
Sep	145.3	315	149.3	320	159.8	350
Oct	120.2	310	128.9	330	138.8	350
Nov	80.2	200	78.9	240	88.9	250
Dec	65.9	150	68.6	170	68.9	180

Table A.D.9: Electricity consumption and maximum demand for Hotel E

	1987		1988		1989	
Month	LPG (kg)	Gas oil (lt)	LPG (kg)	Gas oil (lt)	LPG (kg)	Gas oil (lt)
Jan	2100	11000	2400	10950	2300	11287
Feb	2350	13550	2000	13000	2100	14267
Mar	2000	12500	1900	12000	2000	12651
Apr	2120	5000	2120	4000	2220	4498
May	2400	3600	2450	3600	2500	3654
Jun	2330	3400	2300	3400	2445	3573
Jul	2400	2300	2850	2400	2900	2485
Aug	4330	4120	2540	4300	2500	4320
Sep	3550	3550	2650	3600	2700	3560
Oct	4000	4300	2450	4110	2500	4117
Nov	7100	7150	2500	7200	2500	7243
Dec	11000	1300	2200	10900	2455	11595

Table A.D.10: LPG and gasoil consumption for Hotel E

	1987	1988	1989
Month	%	%	%
Jan	36	40	40
Feb	42	45	45
Mar	45	45	45
Apr	65	60	70
May	75	70	80
Jun	85	85	90
Jul	95	90	90
Aug	95	95	95
Sep	80	85	80
Oct	80	80	80
Nov	60	75	75
Dec	30	40	40

Table A.D.11: Room occupancy for Hotel E

	1987		1988		1989	
	MWh	kVA	MWh	kVA	MWh	kVA
Jan	9.3	33	20.1	73	19.7	67
Feb	11.6	45	17.2	61	17.4	57
Mar	13.2	48	18.9	67	25.1	90
Apr	10.8	42	17.1	47	18.2	70
May	11.2	32	17.6	57	19.2	52
Jun	13.8	55	20.9	87	22.8	72
Jul	20.8	68	31.5	94	34.5	90
Aug	25.3	70	27.5	81	33.7	88
Sep	20.5	60	29.2	79	30.2	78
Oct	12.5	50	20.3	65	19.2	72
Nov	13.3	42	19.2	78	17.3	52
Dec	16.1	68	23.2	72	21.4	95

Table A.D.12: Electricity consumption and maximum demand for Hotel F

	1987	1988	1989
	%	%	%
Jan	50	60	52
Feb	44	44	48
Mar	62	68	68
Apr	80	80	83
May	90	95	95
Jun	65	70	70
Jul	85	92	92
Aug	92	98	98
Sep	75	80	80
Oct	75	88	88
Nov	80	80	78
Dec	50	60	55

Table A.D.13: Room occupancy for Hotel F

	1987		1988		1989	
	MWh	kVA	MWh	kVA	MWh	kVA
Jan	4.1	16	8.1	18	9.1	16
Feb	5.6	22	7.3	25	6.8	27
Mar	6.1	25	8.5	28	7.7	30
Apr	5.8	21	6.3	29	6.3	29
May	6.2	19	8.6	30	8.9	31
Jun	6.5	26	10.9	31	10.2	35
Jul	10.2	34	15.5	34	15.1	36
Aug	12.1	35	13.2	32	13.8	34
Sep	10.2	30	15.2	32	14.2	33
Oct	7.1	22	11.1	29	10.6	30
Nov	6.3	21	9.2	25	9.3	26
Dec	5.3	17	8.9	19	8.1	20

Table A.D.14: Electricity consumption and maximum demand for Hotel G

	1987		1988		1989	
Month	LPG (kg)	Gas oil (lt)	LPG (kg)	Gas oil (lt)	LPG (kg)	Gas oil (lt)
Jan	180	2500	220	2000	230	2500
Feb	190	2600	200	2600	210	2800
Mar	200	2400	210	2100	200	2500
Apr	250	1100	235	1250	245	1200
May	220	850	245	850	250	900
Jun	250	900	265	850	270	900
Jul	260	850	280	950	290	850
Aug	220	1000	260	900	280	1000
Sep	260	800	260	750	290	800
Oct	210	900	220	950	240	950
Nov	230	1000	250	1000	240	1100
Dec	245	2300	250	2400	255	2500

Table A.D.15: LPG and gasoil consumption for Hotel G

	1987 %	1988 %	1989 %
Jan	48	60	50
Feb	40	45	40
Mar	55	70	65
Apr	75	80	75
May	85	95	90
Jun	85	70	75
Jul	90	90	90
Aug	95	95	95
Sep	80	80	85
Oct	75	80	75
Nov	70	75	75
Dec	50	55	45

Table A.D.16: Room occupancy for Hotel G

	1987		1988		1989	
	MWh	kVA	MWh	kVA	MWh	kVA
Jan	2.1	10	4.2	9	4.5	8
Feb	3.6	11	3.6	13	4.6	13
Mar	3.1	13	4.6	15	4.1	15
Apr	2.6	12	3.8	14	4.2	14
May	3.2	10	4.8	16	4.6	16
Jun	3.3	14	5.9	15	6.8	17
Jul	5.3	17	8.5	17	7.9	18
Aug	6.7	16	7.9	16	8.6	19
Sep	5.6	15	8.2	16	9.2	18
Oct	3.8	11	5.6	15	8.6	16
Nov	3.2	10	4.6	13	5.9	14
Dec	2.5	9	4.1	12	4.9	12

Table A.D.17: Electricity consumption and maximum demand for Hotel H

	1987		1988		1989	
Month	LPG (kg)	Gas oil (lt)	LPG (kg)	Gas oil (lt)	LPG (kg)	Gas oil (lt)
Jan	180	1200	220	1000	180	1125
Feb	190	1300	200	1300	190	1400
Mar	200	1300	210	1400	200	1300
Apr	250	600	235	1120	230	600
May	220	600	245	650	260	480
Jun	250	500	265	650	260	480
Jul	260	600	280	850	250	505
Aug	220	1000	260	750	220	950
Sep	260	800	260	750	225	800
Oct	210	900	220	950	200	900
Nov	230	1000	250	900	220	845
Dec	245	2300	250	2100	232	2400

Table A.D.18: LPG and gasoil consumption for Hotel H

	1987 %	1988 %	1989 %
Jan	44	55	50
Feb	38	45	35
Mar	55	70	65
Apr	70	80	70
May	85	90	85
Jun	90	90	90
Jul	90	75	90
Aug	95	100	100
Sep	80	80	85
Oct	70	80	90
Nov	70	80	75
Dec	50	60	60

Table A.D.19: Room occupancy for Hotel H

APPENDIX E

(Appendix to Chapter V)

Appendix E 1

Managers questionnaire

(1) Are you also the owner of this hotel?

(2) How old are you?

(3) How many years of experience do you have? How many of these in this hotel?

(4) Can you give us a draft organization chart of your hotel?

(5) Have you ever taken any energy conservation measures? If yes, when?

(6) (a) Has an energy audit ever been undertaken in your hotel? If yes, by whom? (local consultants, foreign consultants, hotel personnel)

(b) What was the professional background of the consultant?

(7) If yes, have you adopted any of the measures recommended in the audit above?

(8) What were the most important recommendations in the audit above?

(9) If you have adopted any of the recommended measures, what were the results?

(10) How do you consider the cost of energy in your hotel to be?

(a) Important issue

(b) Not important

(c) We can not do anything

(d) Other

(11) When was your energy bill higher?

(a) This year

(b) Last year

(c) Year before last

(12) What percentage on your total costs do you think energy represents?

(a) 20%

(b) 15%

(c) 10%

(d) 5%

(e) Other

(13) Where do you think is most of the energy used?

(a) Rooms

(b) Kitchen

(c) Public areas

(d) Other

(14) Where do you think is most of the energy wasted?

(a) Rooms

(b) Kitchen

(c) Public areas

(d) Other

(15) Which of the energy users below contributes most to your energy bill?

(a) A/C System (cooling/heating)

(b) Lighting

(c) Hot water production system (boiler)

(16) Would you be interested to learn more on ways to conserve energy in your hotel?

(17) Have you ever tried to convince the owner of the hotel to invest on energy conservation?

(18) If yes, have you succeeded?

(19) Do you have a personal follow up of your energy bills?

(20) If yes, what use do you make of your energy data?

(21) Can you give some approximate figures of your last energy bill for:

(a) Gasoil

(b) LPG

(c) Electricity

(d) Water

(22) (a) Do you discuss technical problems with your chief engineer?

(b) Do you hold regular meetings with your chief engineer?

(23) How do you think did the last drop in oil prices affect your energy bill?

(a) We now pay 10% less

(b) We now pay 20% less

(c) We now pay 30% less

(d) We now pay ... less

(24) What is your personal opinion on energy conservation measures?

(a) Cost too much !

(b) Affect the comfort of our customers

(c) Deserve every effort

(25) If you had decided to participate in a seminar on energy conservation, what would be your favourite topic?

(a) Energy conservation techniques

(b) New technology

(c) Learning about the functioning of the various equipment

(d) Investment appraisal methods

(26) Have you had any special training on hotel services maintenance?

(27) Would you favour a training program for your staff on energy conservation?

(28) Which of the incentives below would you be prepared to adopt in order to motivate your staff to save energy?

(a) Bonus (e.g money)

(b) Extra leave

(c) Discounts (e.g travel, free stay in hotel)

(d) Other

(29) Have you been approached by companies selling energy conserving equipment/devices?

(30) If the answer above is yes, why haven't you (in case) adopted any of the measures they had suggested?

(a) Too expensive

(b) Poor savings potential in my hotel

(c) They are hard to understand

(d) Other

(31) Do you discuss energy conservation issues with your Department Heads?

(32) What is an acceptable pay back period for an energy investment?

(33) Are there any other comments that you would like to do? If yes, please state them.

	5 STAR	4 STAR	3 STAR	W.AVERAGE
AVERAGE AGE	42	41	37	40
AVERAGE EXPERIENCE (YEARS)	13	13	12	13
OWNER ALSO (%)	0	25	22	18
SPECIAL COURSE ON E.C AND MAINTANCE (%)	40	38	44	41
YEARS IN PRESENT POST	6	8	6	7

Table A.E.1: Personal profile of hotel managers

	5 STAR	4 STAR	3 STAR	W.Average
	Percentage			
E.C measures initiated so far	100	88	100	96
Audits undertaken so far	60	62	44	54
Audit measures undertaken	100	100	100	100
Satisfied with audit measures adopted	100	100	100	100
Attempted to convince owner to invest in E.C	80	45	55	57
Succeded with attempt above	100	100	20	67
Audit was undertaken by:				
Hotel staff	0	20	25	18
Local firm	0	50	60	43
Foreign firm	67	30	0	26
Local & Foreign firm	33	0	15	14

Table A.E.2: Implementation of energy conservation measures

Managers Opinion	5 STAR	4 STAR	3 STAR	W.Average
		Percentage		
Energy is considered as :				
Very Important Issue	100	100	89	96
Not Important Issue	0	0	0	0
Energy Conservation Measures :				
Deserve Every Effort	80	76	89	82
Cost Too Much	0	0	11	5
Affect Guest's Comfort	20	12	0	9
Other	0	12	0	4
Interested For :				
In House Training	100	100	100	100
Learning about E.C. Techniques	80	100	100	95

Table A.E.3: Attitude of managers on the energy issue

OPINION	5 STAR	4 STAR	3 STAR	W. AVERAGE
			Percentage	
MOST ENERGY IS USED IN :				
ROOMS	80	50	78	68
PUBLIC AREAS	20	37	22	27
KITCHEN	0	13	0	5
OTHER	0	0	0	0
MOST ENERGY IS WASTED IN:				
ROOMS	60	75	67	68
PUBLIC AREAS	20	0	0	5
KITCHEN	20	25	33	27
OTHER	0	0	0	0

Table A.E.4 : Opinion of managers on energy use and waste

QUESTION	5 STAR	4 STAR	3 STAR	W.AVERAGE
	Percentage			
MONITOR ENERGY BILLS PERSONALLY	80	86	100	90
COULD PROVIDE FIGURES FOR ENERGY BILL OF LAST TWO MONTHS	80	87	67	77
CLAIMED TO USE DATA IN CERTAIN WAY	60	62	44	54
KNEW QUITE ACCURATELY PERCENTAGE OF ENERGY TO TOTAL COST	60	62	44	54
DISCUSS ENERGY MATTERS WITH THEIR DEPARTMENT HEADS	100	62	89	82
HOLD REGULAR MEETINGS WITH THEIR CHIEF ENGINEER	100	88	100	96
BEST TOPIC PREFFERED FOR TRAINING				
a. Energy Conservation Techniques	60	50	55	54
b. New Technology	40	37	33	36
c. Function of Equipment	0	0	0	0
d. Methods of investment appraisal	0	13	12	10
INCENTIVES TO INDUCE ENERGY CONSERVATION ATTITUTE				
a.Bonus	0	25	44	27
b.Extra leave	0	0	0	0
c.Discounts (travel, stay etc)	0	12	0	4
d.Other (employee of the month)	0	0	12	5
APPROACHED BY COMPANIES PROMOTING ENERGY CONSERVATION DEVICES	100	85	100	95
REASON FOR NOT IMPLEMENTING ENERGY CONSERVATION MEASURES WAS :				
a. Very expensive	50	100	100	89
b. Could not evaluate savings claimed	50	0	0	11

Table A.E.5 : Tabulated results of various questions

Appendix E 2

GUEST QUESTIONNAIRE

Dear Guest,

Our Hotel is participating in a survey on energy consumption for hotels. We would greatly appreciate it if you could spare a few minutes to fill this questionnaire and turn it in at the reception desk.

We thank you and wish you a very pleasant stay.

1. Country of residence for the last two years: .....

2. How many hours do you spend
   In your room between 8.00 a.m. and 6 p.m.? .....
   between 6.00 p.m. and 8 a.m.? .....
   In public spaces 8.00 a.m. and 6 p.m.? .....
   6.00 p.m. and 8 a.m.? .....
   In dinning areas 8.00 a.m. and 6 p.m.? .....
   6.00 p.m. and 8 a.m.? .....

3. Is your room temperature comfortable? Yes ..... No .....
   If no, how do you find it ? Too cold ..... Too hot ..... Other .....

4. Do you find adjusting the thermostat easy?
   Yes ..... No ..... Not tried .....

5. Do you prefer taking a bath or a shower?
   Bath ..... Shower .....

6. How often do you take a bath/shower?
   Once a day ..... Twice a day ..... Other .....

7. How do you find the temperature in the public areas of the hotel ?
   Comfortable ..... Too Low ..... Too high .....

8. How do you find the hot water temperature?
   Good ..... Too low ..... Too high .....

9. When do you usually take your bath/shower?
   Morning ..... Noon ..... Evening .....

10. What is your reaction to stickers or leaflets urging you to conserve energy?
    Obey ..... Ingnore ..... Other .....

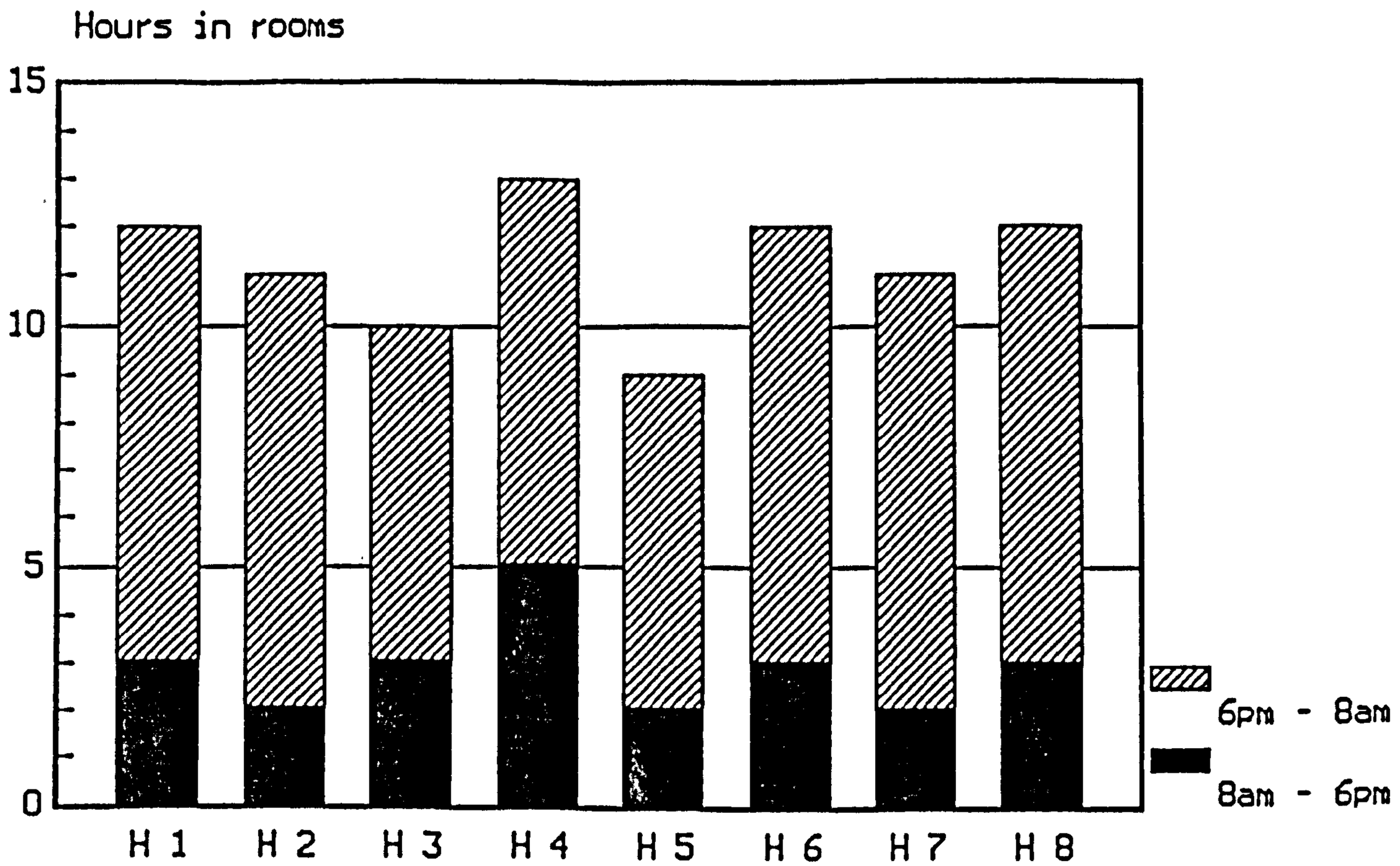


Figure A.E.1: Hours spent in rooms

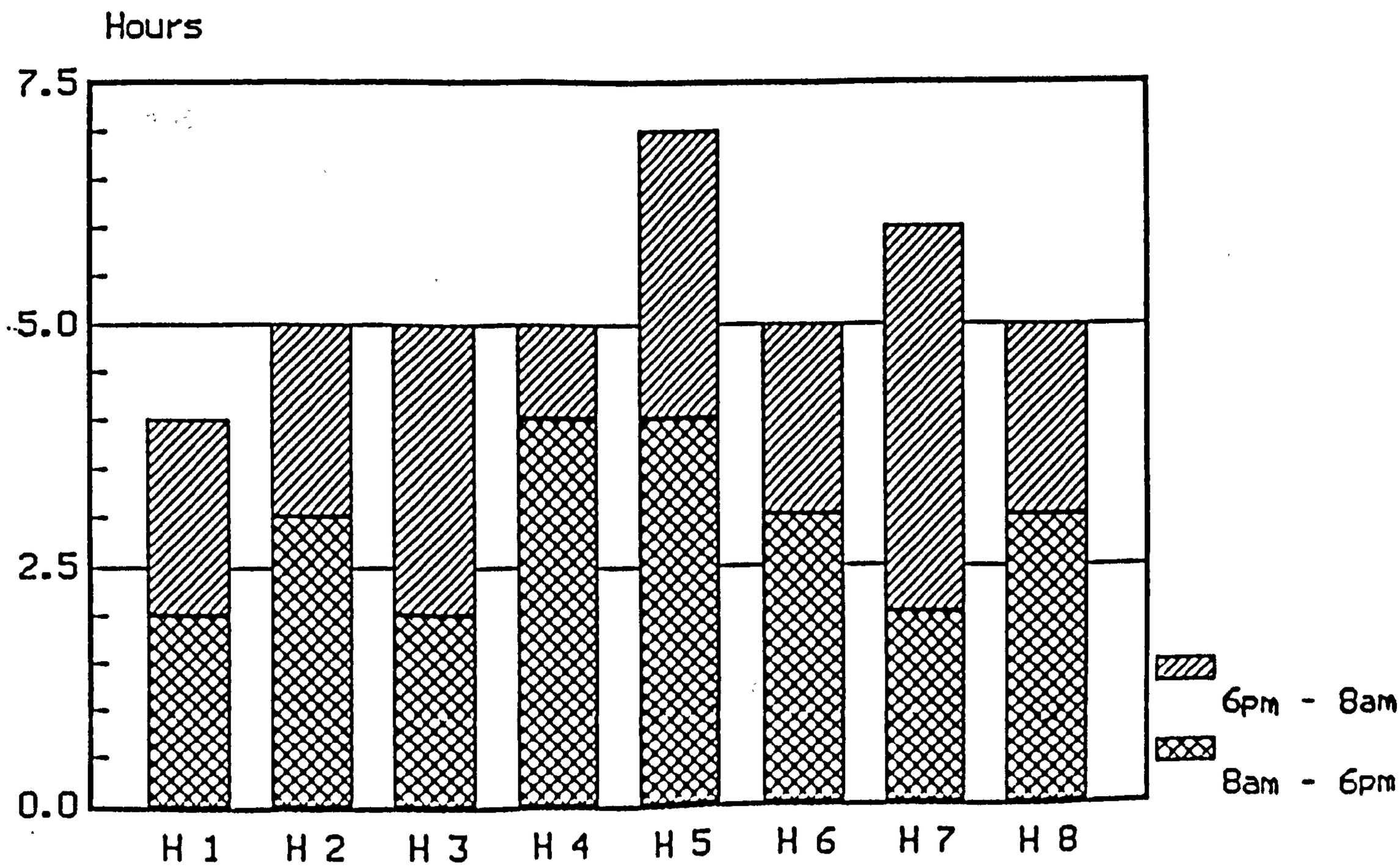


Figure A.E.2: Hours spent in dining rooms

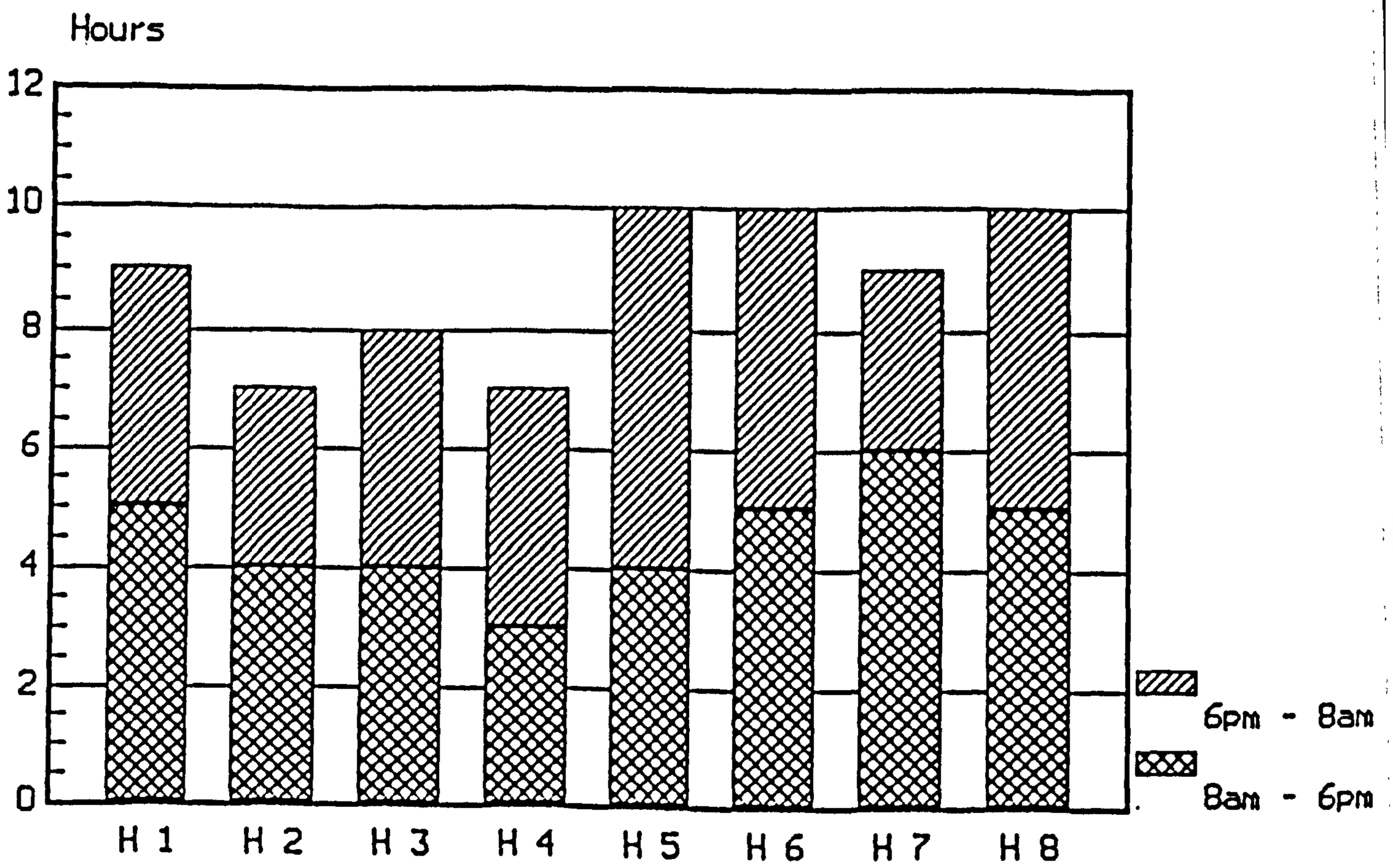


Figure A.E.3: Hours spent in public spaces

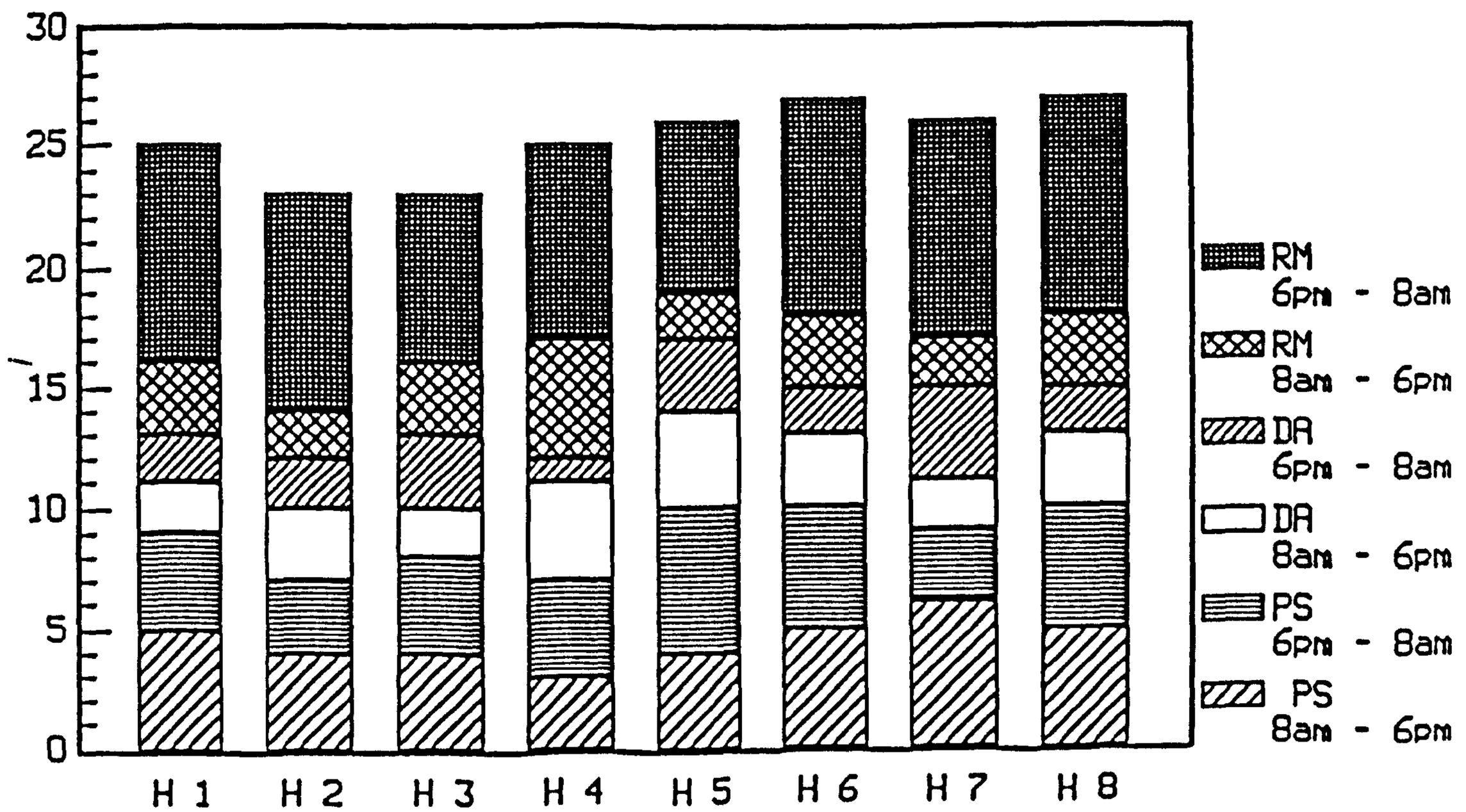


Figure A.E.4: Combined presentation of hours spent in hotel areas

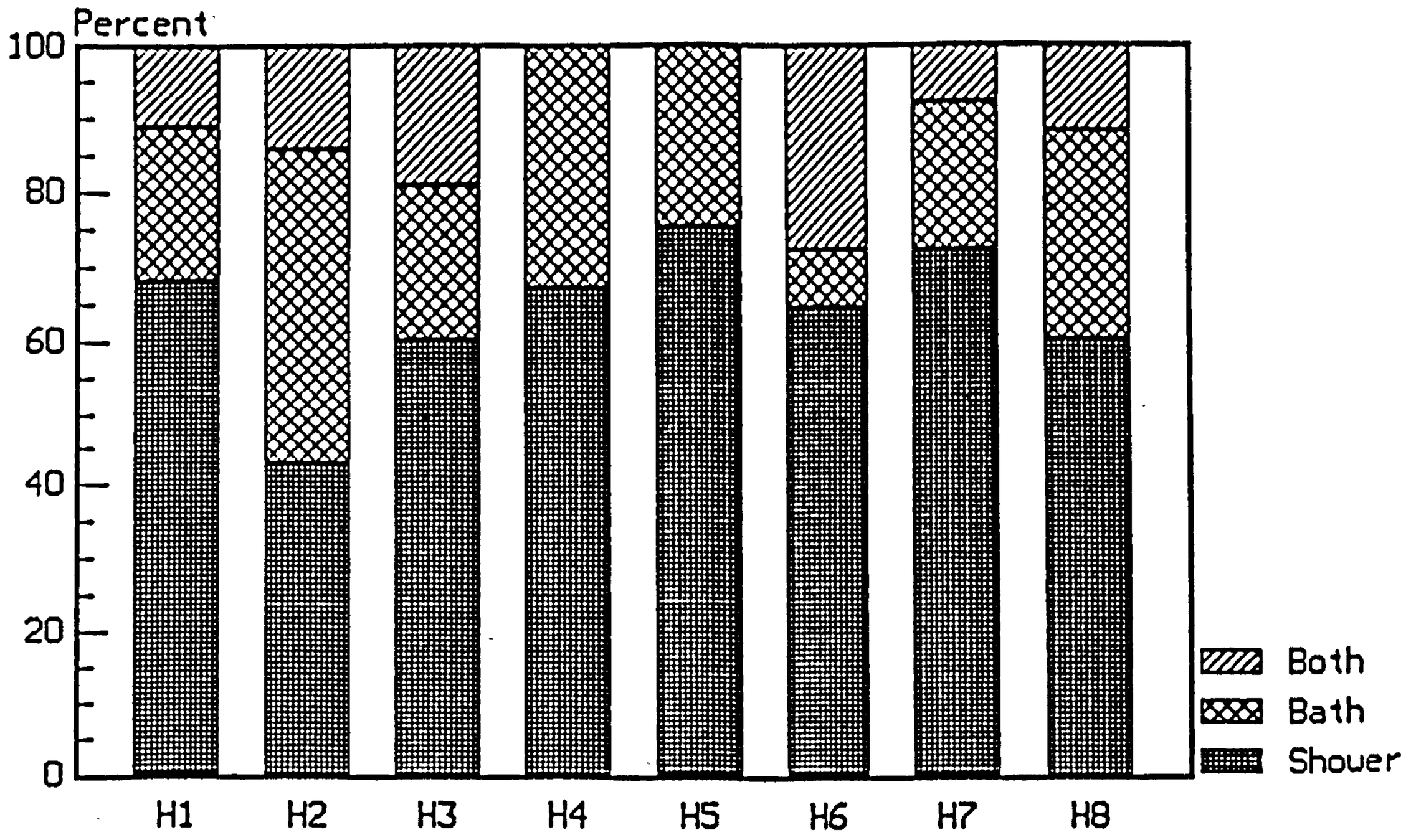


Figure A.E.5: Preference of shower - bath

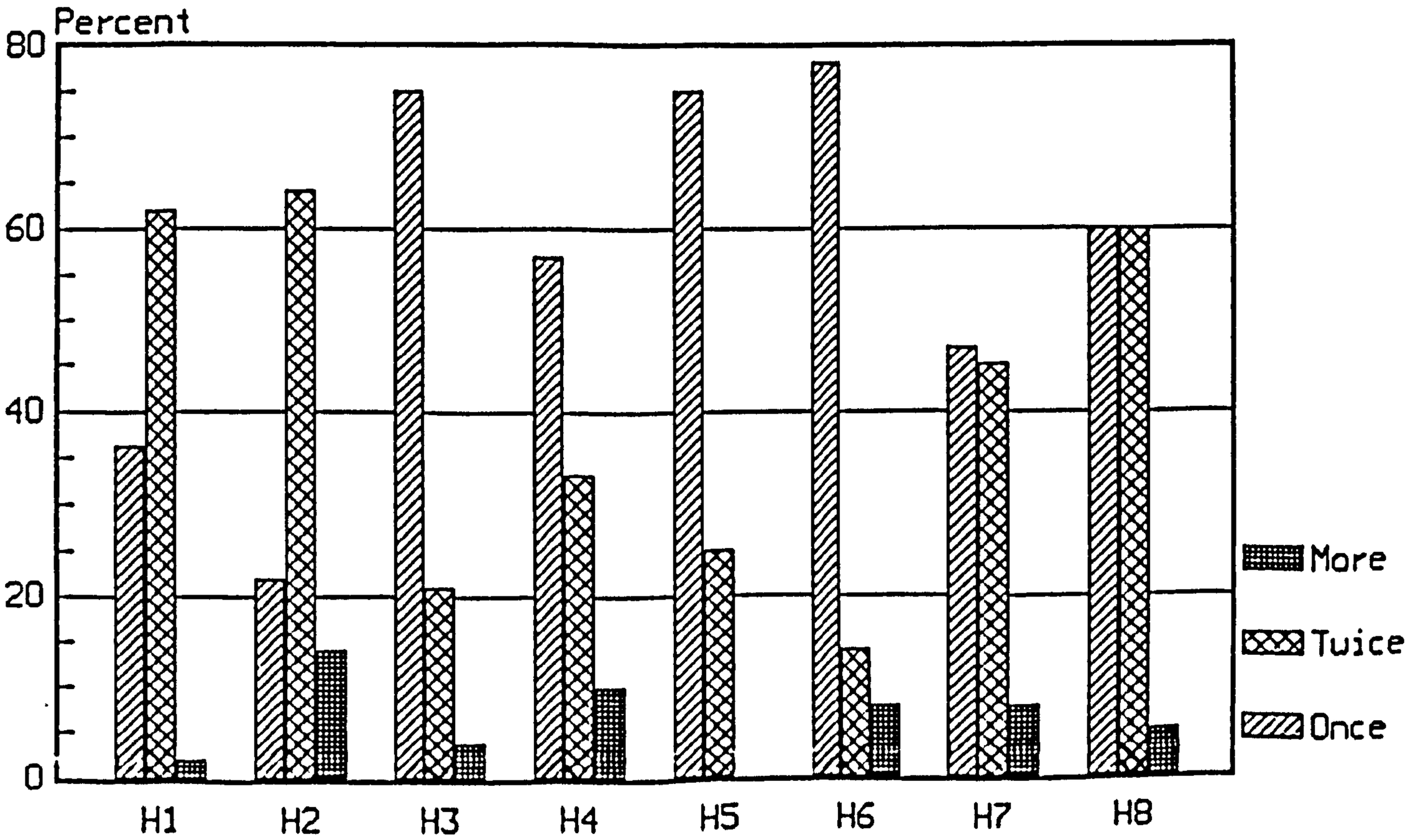


Figure A.E.6: Frequency of shower-bath taking per day

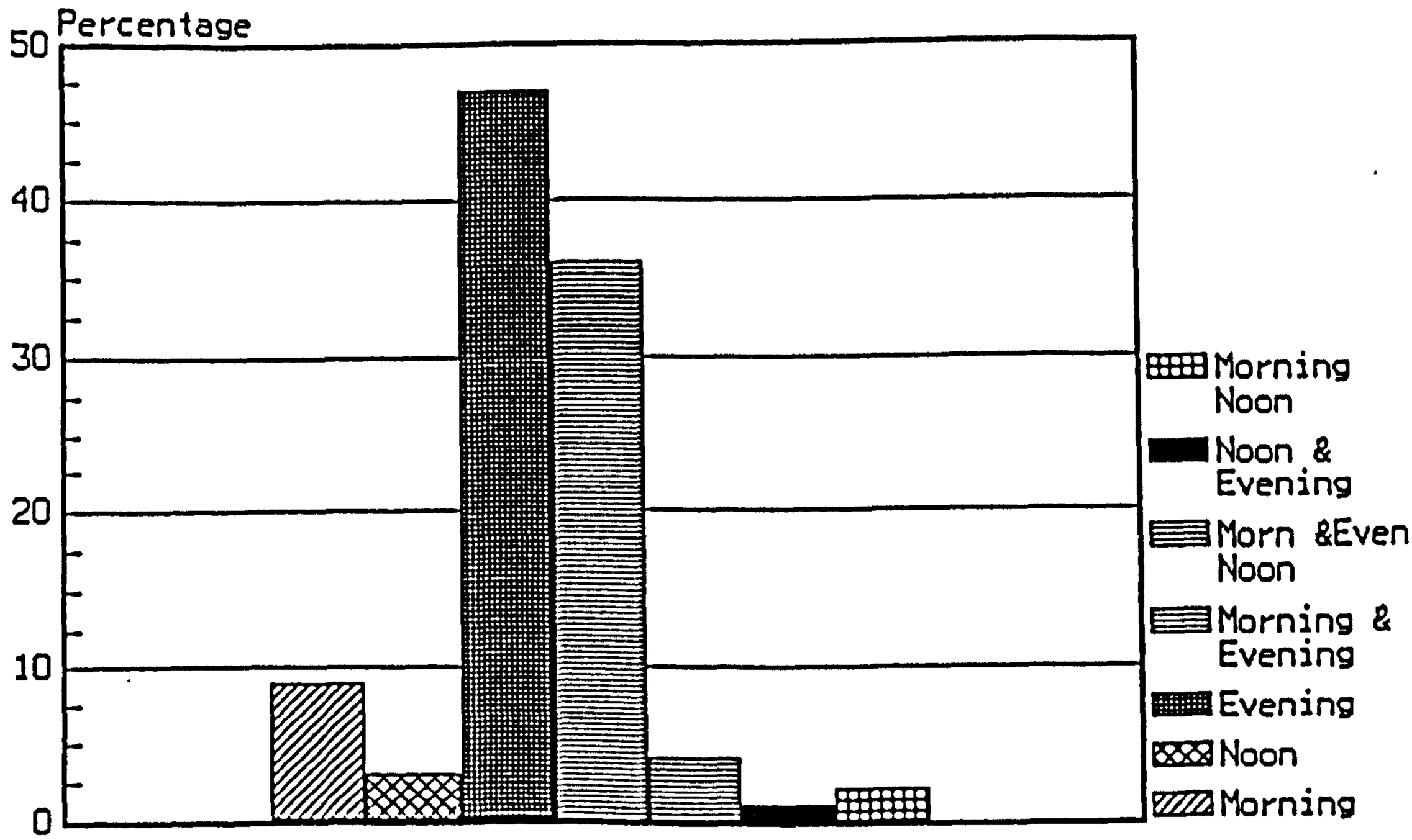


Figure A.E.7: Average percentage of guests taking shower at a certain time

	SAMPLE HOTEL							
A. Percentage of guests respondened to Questionnaire	1	2	3	4	5	6	7	8
	28	32	25	42	38	27	23	35
B. Percentage of response to Question No								
1	100	100	100	100	100	100	100	100
2	85	85	95	70	90	80	95	90
3	100	100	100	100	100	100	100	100
4	100	100	87	100	100	85	100	100
5	100	100	100	100	100	100	100	100
6	95	90	100	100	100	100	95	100
7	100	100	100	100	90	100	100	100
8	100	100	100	100	100	85	100	100
9	100	100	100	100	100	100	100	100
10	90	85	95	100	100	90	100	85

Table A.E.6: Response rate of guests to questionnaire

Question 1	Country of residence of respondents for the last two years (percentage)		
Hotel 1	Hotel 2	Hotel 3	Hotel 4
England : 68	England: 31	France : 40	England: 14
Ireland : 8	Lebanon: 24	Germany :30	Germany: 14
Holland : 8	Germany: 15	England :12	Egypt: 9
Switzerland: 6	Greece: 8	Wales : 7	Sri Lanka:8
Scotland : 6	Ireland: 8	Sweden : 7	Holland: 5
USA: 2	Scotland: 7	Denmark : 4	Japan: 5
Israel: 2	Cyprus: 7		Iraq: 5
			Uganda: 5
			Cyprus: 5
			Italy: 5
			Lebanon: 5
			Belgium: 5
			USA: 5
			China: 5
			Jordan: 5
Hotel 5	Hotel 6	Hotel 7	Hotel 8
England : 45	England: 78	England : 97	England : 55
Scotland : 35	Germany: 22	Wales: 3	Scotland: 15
Germany : 20			Germany : 15
			Lebanon : 10
			Greece : 5

Table A.E.7: Country of residence of guests

Question 2	SAMPLE HOTEL 1	2	3	4	5	6	7	8	Average all Hotels
Hours spent in ROOM between :									
8.00 am and 6 p.m	3 (0-4)	2 (1-4)	3 (0-5)	5 (3-7)	2 (0-4)	3 (0-4)	2 (2-4)	3 (3-4)	3
6.00 p.m and 8 a.m	9 (8-12)	9 (8-10)	7 (7-11)	8 (8-12)	7 (7-10)	9 (8-12)	9 (8-11)	9 (8-12)	8
Hours spent in PUBLIC SPACES between :									
8.00 am and 6 p.m	5 (0-7)	4 (2-6)	4 (1-7)	3 (0-4)	4 (3-7)	5 (0-6)	6 (0-7)	5 (2-8)	5
6.00 p.m and 8 a.m	4 (1-8)	3 (2-8)	4 (1-6)	4 (1-7)	6 (2-7)	5 (2-6)	3 (1-8)	5 (2-8)	4
Hours spent in DINING AREAS between :									
8.00 am and 6 p.m	2 (1-3)	3 (1-4)	2 (2-5)	4 (1-6)	4 (1-5)	3 (2-4)	2 (1-3)	3 (2-4)	3
6.00 p.m and 8 a.m	2 (0-6)	2 (0-4)	3 (1-5)	1 (0-6)	3 (0-4)	2 (1-5)	4 (2-7)	2 (1-6)	2

Note: First number is the average
Numbers im parenthesis is the range

Table A.E.8: Time spent by guests in hotel areas

QUESTION	SAMPLE HOTELS 1	2	3	4	5	6	7	8	Range	Weighted Average
	(Percentage)									
3 Room Temperature										
Comfort	91	100	97	76	80	100	92	88	76-100	93
Too Low	2	0	1	14	10	0	3	6	0-14	3
Too High	7	0	2	10	10	0	5	6	0-14	4
4 Adjusting Thermostat										
Easy	59	57	70	90	100	100	100	80	57-100	83
Not Easy	41	43	30	10	0	0	0	20	0-43	17
5 Preference										
Shower	68	43	60	67	75	64	72	60	43-75	62
Bath	21	43	21	33	25	8	20	28	8-43	25
Both	11	14	19	0	0	28	8	12	0-28	13
6 Frequency Shower/Bath Per day										
Once	36	22	75	57	75	78	47	60	22-78	54
Twice	62	64	21	33	25	14	45	35	14-64	38
More	2	14	4	10	0	8	8	5	0-14	8
7 Temperature Public Areas										
Comfort	98	100	96	71	100	70	100	85	70-100	90
Too Low	0	0	0	19	0	0	0	5	0-19	2
Too High	2	0	4	10	0	30	0	10	0-30	8
8 Temperature Hot Water										
Good	96	100	89	86	100	100	100	90	86-100	97
Too Low	4	0	11	0	0	0	0	5	0-11	2
Too High	0	0	0	14	0	0	0	5	0-14	1
9 Time Shower/bath										
Morning only	6	14	25	28	0	0	3	10	0-28	9
Noon only	2	0	14	5	0	7	0	0	0-14	3
Evening only	36	14	25	43	75	70	53	55	14-75	47
Morning+Even	49	58	36	24	25	16	36	35	16-58	36
Morn+Ev+Noon	2	7	0	0	0	7	6	0	0-7	4
Noon + Even	5	0	0	0	0	0	3	0	0-5	1
Morn + Noon	0	7	0	0	0	0	0	0	0-7	2
10 Reaction to Stickers										
Positive	45	100	57	3	100	100	69	80	45-100	86
Negative	55	0	43	19	0	0	31	20	0-43	14

Table A.E.9: Tabulated results of guests response to questions number 3-10

Appendix E 3

Chief Engineers Questionnaire

(1) How many years of professional experience do you have?

(2) What are your academic/professional qualifications?

(3) What was your subject of studies?

(4) What is your opinion on the issue of energy conservation?

(a) Very important

(b) Not important

(c) Other opinion

(5) How many persons do you supervise?

(6) Do you take any energy conservation measures in your hotel? If yes please state them.

(7) What equipment/measuring instruments do you use for monitoring energy consumption in your hotel?

(8) Where do you think most of the energy is consumed? Please rate with 5 the degree of consumption 4 less etc.

(a)	Rooms	5,4,3,2,1
(b)	Public areas	5,4,3,2,1
(c)	Kitchen	5,4,3,2,1
(d)	Bar/restaurant	5,4,3,2,1
(e)	Other areas	5,4,3,2,1

(9) Where do you think most of the waste takes place?

(a)	Rooms	5,4,3,2,1
(b)	Public areas	5,4,3,2,1
(c)	Kitchen	5,4,3,2,1
(d)	Bar/restaurant	5,4,3,2,1
(e)	Other areas	5,4,3,2,1

(10) Please state your opinion on the prospects for energy conservation on each of the systems/equipment below :

(a)	Air conditioning	5,4,3,2,1
(b)	Hot water system	5,4,3,2,1
(c)	Lighting	5,4,3,2,1
(d)	Laundry	5,4,3,2,1
(e)	Other (please state)	5,4,3,2,1

(11) Have you ever recommended any energy saving measures to the management of your hotel? If yes what were these measures?

(12) Were the measures recommended above (if any) accepted? If not please state the reason.

(13) Please state your opinion on the suitability of each of the technologies below for your hotel.

(a)	Building Energy Management Systems	5,4,3,2,1
(b)	Solar energy for hot water	5,4,3,2,1
(c)	Solar energy for space heating	5,4,3,2,1
(d)	Solar energy for space cooling	5,4,3,2,1
(e)	Heat recovery	5,4,3,2,1
(f)	Insulation	5,4,3,2,1
(g)	Key fob system	5,4,3,2,1
(h)	Magnetic switch for balcony doors	5,4,3,2,1
(i)	Combined Heat and Power	5,4,3,2,1

(14) Do you regularly participate in meetings with the management?

(15) Do you discuss energy matters with the management?

(16) Please give us the consumption of LPG, electricity and gasoil for last month, the same last year and the same month the year before.

(17) Please state the average power factor and average hot water temperature for last year.

(18) Have you had any specific training on energy conservation and management?

(19) Would you be interested in learning more about energy saving techniques?

(20) Do you set any targets for energy conservation?

(21) If the answer above is yes, please state on which basis you do that.

(a) Based on a percentage of last year's consumption

(b) Based on total energy consumption

(c) Base on a computer program

(d) Based on graphical presentation of consumption of previous months or years.

Hotel class	Average Number of Years	Range
3	16	3 - 17
4	18	4 - 40
5	15	7 - 33
Overall	3	3 - 40

Table A.E.10: Professional experience of chief engineers

EDUCATION	5 STAR	4 STAR	3 STAR	W. AVERAGE
Elementary	20	12	17	16
High School	40	33	66	48
College	0	0	17	7
University	40	50	0	27
Post Graduate degree	1	2	0	1

Table A.E.11: Educational background of chief engineers

Hotel class	Average Number of Staff	Range
3	2	0 - 6
4	10	4 - 20
5	17	12 - 21
Overall Average	10	0 - 21

Table A.E.12: Staff supervised by chief engineers

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Rooms	33	33	11	0	22	0	3.52
Public Areas	11	11	33	44	0	0	2.97
Kitchen	44	33	0	22	0	0	3.96
Bar/ Restaurants	22	11	22	11	33	0	2.75
Other Areas	0	0	33	11	55	0	1.76

Table A.E.13: Chief engineers' opinion on energy consumption level (3 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Rooms	50	37	0	12	0	0	4.22
Public Areas	25	25	50	0	0	0	3.75
Kitchen	25	50	25	0	0	0	4
Bar/ Restaurants	12	0	37	50	0	0	2.71
Other Areas	12	12	37	12	25	0	2.68

Table A.E.14: Chief engineers' opinion on energy consumption level (4 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
Rooms	0	40	20	20	20	0	2.9
Public Areas	0	40	20	40	0	0	3
Kitchen	60	20	20	0	0	0	4.4
Bar/ Restaurants	0	0	20	60	20	0	2
Other Areas	40	0	20	40	0	0	1.4

Table A.E.15: Chief engineers'opinion on energy consumption level (5 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Rooms	32	40	9	9	14	0	3.79
Public Areas	14	23	36	27	0	0	3.24
Kitchen	41	36	9	9	0	0	3.94
Bar/ Restaurants	13	5	27	36	9	9	2.56
Other Areas	13	4	32	18	9	23	2.19

Table A.E.16: Chief engineers' opinion on energy consumption level (all hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Rooms	11	33	0	22	22	11	3.08
Public Areas	11	22	22	11	33	0	2.64
Kitchen	33	0	33	22	0	11	3.08
Bar/ Restaurants	0	0	22	0	66	11	1.32
Other Areas	0	0	22	22	22	33	1.32

Table A.E.17: Chief engineers' opinion on energy waste level (3 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Rooms	12	12	36	12	12	12	2.52
Public Areas	37	25	25	0	12	0	3.75
Kitchen	25	12	0	25	36	0	2.59
Bar/ Restaurants	25	0	0	0	75	0	2
Other Areas	12	0	12	0	36	36	1.32

Table A.E.18: Chief engineers' opinion on energy waste level (4 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Rooms	20	20	20	0	40	0	2.8
Public Areas	0	40	20	40	0	0	3
Kitchen	60	40	0	0	0	0	4.6
Bar/ Restaurants	0	0	20	80	0	0	2.2
Other Areas	20	0	0	40	0	0	1.8

Table A.E.19: Chief engineers' opinion on energy waste level (5 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No reply	Overal Rating
	Percentage						
Rooms	13	22	18	13	22	9	2.55
Public Areas	18	27	23	14	18	0	3.13
Kitchen	36	13	14	18	13	5	3.23
Bar/ Restaurants	9	0	14	18	54	5	1.77
Other Areas	9	0	13	18	22	27	1.42

Table A.E.20: Chief engineers' opinion on energy waste level (all hotels)

	Ranking			
Consumption Centre	Overall	5 STAR	4 STAR	3 STAR
Kitchen	1	1	2	1
Public Areas	2	2	1	2
Rooms	3	3	3	1
Bar/Restaurant	4	4	4	3
Other Areas	5	5	5	3

Table A.E.21: Chief engineers' ranking of energy waste centres

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Air Conditioning	55	11	0	11	22	0	3.63
Hot Water System	44	0	0	11	44	0	2.86
Lighting	11	33	11	0	44	0	2.64
Catering Equipment	0	11	11	33	33	11	1.87
Laundry	0	0	0	11	33	55	0.55
Other	0	0	0	22	0	68	0.44

Table A.E.22: Chief engineers' opinion on prospects for energy conservation (3 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Air Conditioning	60	20	20	0	0	0	4.4
Hot Water System	20	0	20	60	0	0	2.8
Lighting	20	20	20	20	20	0	3
Catering Equipment	0	40	40	0	20	0	3
Laundry	20	20	0	40	0	20	2.6
Other	0	0	0	0	0	100	0

Table A.E.23: Chief engineers' opinion on prospects for energy conservation (4 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Air Conditioning	75	0	12	12	0	0	4.35
Hot Water System	0	25	37	25	12	0	2.73
Lighting	0	50	37	0	12	0	3.23
Catering Equipment	12	0	37	0	50	0	1.65
Laundry	0	0	0	0	25	0	0.15
Other	0	0	0	0	0	100	0

Table A.E.24: Chief engineers' opinion on prospects for energy conservation (5 star hotels)

Consumption Centre	Rating 5	4	3	2	1	No Reply	Overall Rating
	Percentage						
Air Conditioning	63	9	9	9	9	0	4.05
Hot Water System	23	9	18	27	22	0	2.81
Lighting	9	36	23	5	27	0	2.95
Catering Equipment	4	14	27	14	36	5	2.21
Laundry	5	5	0	14	23	27	0.96
Other	0	0	0	9	0	87	0.18

Table A.E.25: Chief engineers' opinion on prospects for energy conservation (all hotels)

Technology	Rating 5	4	3	2	1	No Opinion	Overall Rating
	Percentage						
Building Energy Management Systems	11	0	11	22	0	55	1.32
Solar System for Sanitary Water	33	22	0	0	0	45	2.53
Solar System for Space Heating	44	11	0	0	22	22	2.86
Solar System for Space Cooling	22	0	0	11	33	33	1.32
Heat Recovery	22	0	22	22	0	33	2.2
Insulation	67	0	0	0	0	33	3.35
Key Fob System	44	22	11	0	11	11	3.52
Magnetic Switch	55	22	0	0	0	22	3.63
Combined Heat & Power System	11	0	22	0	0	67	1.21

Table A.E.26: Chief engineers' opinion on suitability of various technologies (3 star hotels)

Technology	Rating 5	4	3	2	1	No Opinion	Overall Rating
	Percentage						
Building Energy Management Systems	64	12	0	0	12	12	3.68
Solar System for Sanitary Water	76	0	0	0	24	0	4.04
Solar System for Space Heating	64	0	0	0	24	12	3.44
Solar System for Space Cooling	52	0	0	0	24	24	2.84
Heat Recovery	52	0	0	12	12	24	2.96
Insulation	88	0	12	0	0	0	4.76
Key Fob System	88	0	0	0	12	0	4.52
Magnetic Switch	100	0	0	0	0	0	5
Combined Heat & Power System	12	0	0	0	24	64	0.84

Table A.E.27: Chief engineers' opinion on suitability of various technologies (4 star hotels)

Technology	Rating 5	4	3	2	1	No Opinion	Overall Rating
	Percentage						
Building Energy Management Systems	0	60	20	0	20	0	3.2
Solar System for Sanitary Water	20	20	20	40	0	0	3.2
Solar System for Space Heating	0	0	20	40	20	20	1.6
Solar System for Space Cooling	0	0	0	20	60	20	1
Heat Recovery	20	40	40	0	0	0	3.8
Insulation	80	0	20	0	0	0	4.6
Key Fob System	40	20	0	0	40	0	3.2
Magnetic Switch	80	0	0	20	0	0	4.4
Combined Heat & Power System	20	20	20	0	0	40	3.4

Table A.E.28: Chief engineers' opinion on suitability of various technologies (5 star hotels)

Technology	Rating 5	4	3	2	1	No Opinion	Overall Rating
	Percentage						
Building Energy Management Systems	28	18	9	9	9	27	2.66
Solar System for Sanitary Water	46	14	9	9	9	13	3.4
Solar System for Space Heating	41	5	5	9	22	18	2.8
Solar System for Space Cooling	28	0	0	9	36	27	1.8
Heat Recovery	32	9	9	13	4	33	2.53
Insulation	78	0	9	0	0	13	4.17
Key Fob System	59	14	5	0	18	4	3.84
Magnetic Switch	77	9	0	5	0	8	4.31
Combined Heat & Power System	13	5	14	5	9	54	1.46

Table A.E.29: Chief engineers' opinion on suitability of various technologies (all hotels)

APPENDIX F

(Appendix to Chapter VII)

Equation	Degrees of Freedom Regression	Residual	Total	F Value	F Probability
A	3	47	50	32	1.000
B	3	47	50	66	1.000
C	3	47	50	28	1.000
D	3	47	50	56	1.000
E	2	3	5	12	0.9623
F	2	12	14	8	0.9941
G	2	12	14	6	0.9827
H	2	21	23	15	0.9998
I	2	21	23	32	1.000
J	2	21	23	5	0.9877
K	2	21	23	7	0.9950
L	2	3	5	17	0.9779
M	2	48	50	55	1.000
N	2	3	5	3	0.7856
O	2	12	14	12	0.9984
P	2	21	23	13	0.9996
Q	2	3	5	1	0.5946

Table A.F.1: Summary of analysis of variance for the principal variables relating energy usage to operational and size factors.

Equation	Data Points	r^2	Multiple Correlation	St Error of Estimate
A	51	0.6737	0.8208	7,107
B	51	0.8085	0.8992	2,147
C	51	0.6384	0.7990	7,141
D	51	0.7802	0.8833	328,874
E	6	0.8866	0.9416	7,945
F	15	0.5782	0.7604	319,135
G	15	0.4904	0.7003	2,678
H	24	0.5938	0.7706	1,185
I	24	0.7518	0.8671	114
J	24	0.3419	0.5847	4,579
K	24	0.3991	0.6317	4,870
L	6	0.9197	0.9590	1,469
M	51	0.6972	0.8300	381,974
N	6	0.6420	0.8012	684,385
O	15	0.6695	0.8182	282,495
P	24	0.5492	0.7411	154,547
Q	6	0.4528	0.6729	38,349

Table A.F.2: Summary of important factors of the multiple regression analysis

APPENDIX G

(Appendix to Chapter IX)

Brief description of other energy consumers investigated during the initial phase of sampling across the Economy

A. Local Bank

These are the premises of a local bank in Nicosia occupying an area of approximately 1000 sq.m. The bank occupies almost 2 1/2 stories of a 5 storey building. The premises of the bank are "all electric" and its current annual consumption is around 67,000 kWh, costing around 3000 Cyprus pounds. Air conditioning absorbs around 50% of the energy and the remaining is absorbed by lighting, office equipment and lifts.

Possible energy conservation opportunities include: adding roof insulation, use of gasoil fired boiler for heating, introduction of efficient lighting fixtures, thermostat positioning, better lighting control and adoption of monitoring and targeting techniques.

The total energy consumption of the whole group of these consumers (includes all offices) is approximately 60% of the total energy consumption of the sector of hotels.

B. Hospital

This is one of the oldest hospitals on the island which has been expanded and modified many times in order to meet demands. The hospital utilises electricity, gasoil, LFO and LPG. Electricity is used for lighting, heating, cooling and the operation of various equipment. LFO and gasoil is used for hot water and steam production whereas LPG is used for

cooking. The current level of consumption are : electricity 1,600,000 kWh, gasoil 132,000 litres, LFO 580,000 litres and LPG 24,819 kg. The energy bill is of the order of 112400 Cyprus pounds.

Possible energy conservation opportunities include: substitution of electric heating appliances, power factor correction (currently 0.72 !), insulation of piping, control of water pumps, better planning in laundry works, introduction of monitoring and targeting techniques.

The total energy consumption of this group of consumers is approximately 14% of the total energy consumption of the hotel sector.

C. Canning industry

This is a fruit, juice and vegetable canning factory employing a staff of eighty. The plant has been undergoing many phases of expansion and modification. The main parts of the plant are: the reception of goods (unloading, sorting etc), the treatment (pasteurization, evaporation, sterilisation) and the packing (canning or tetrapacking). Ancillary equipments include: preheaters, cool storage rooms, refrigerators, air compressors etc. Steam is produced by two boilers operating on Light Fuel Oil (LFO). The current level of energy consumption is 540 tons of LFO and 740,000 kWh costing around 57000 Cyprus pounds.

Possible energy conservation opportunities include : boiler

insulation, condensate recycling, replacement of very old boilers with more efficient ones, boiler blow down recovery and maintenance of steam traps and adoption of monitoring and targeting techniques.

D. Dairy Industry

This is a dairy industry employing a staff of seventy producing pasteurised and UHT milk, yoghurt and cheese. The industry collects 13,200 tons of milk every year. The main production facilities include three milk vats, four milk pasteurisers, one UHT installation, water heaters, coolers, packing equipment etc. Ancillary equipment includes reception, storage and loading facilities etc. Apart from the processes considerable water and steam quantities are also used for cleaning. Ice water is used for cooling down in various steps of the procedures. Solar energy (18 sq.m of panels) is used for producing Edam cheese and for water heating. Last fuel annual fuel consumption figures amounting to around 25500 Cyprus pounds were: 338 tons LFO and 231,633 kWh of electricity.

Possible energy conservation opportunities include: warm condensate recovery, pre cooling of pasteurised milk, heat recovery from cleaning processes, boiler efficiency tests and steam trap maintenance.

E. Wine, liquor and soft drinks industry

This is an industry staffed with 120 people that bottles wine, liquor and fruit juices. The industry receives annually

30 million kg of grapes. The plant includes the main factory and a recently constructed extension. The production facilities include: the reception plant, pressing plant, fermentation tanks, bottling equipment, distillation plant, vacuum evaporators, tetrapack installation, jam producing plant, pasteurising and sterilising equipment and the cold storage. The latest energy consumption bill amounted to around 95200 Cyprus pounds included : Electricity 697,250 kWh, LPG 1500 kg and LFO 1430 tons.

Possible energy conservation opportunities include: heat recovery from warm distillation effluents, thermal insulation, replacement of steam jet air ejectors with a vacuum pump, heat recovery from evaporator effluents, replacement of old boilers with more energy efficient ones and steam trap maintenance.

The total energy consumption of the group of consumers in which sample industries C,D and E belong is approximately at the same level with that of the hotel sector .

APPENDIX H

(Appendix to Chapter X)

Time	Pattern I (August)		Pattern II (February)		Patern III (April)	
	Heat	Elec.	Heat	Elec.	Heat	Elec.
0	800	839	1268	396	832	438
1	700	828	1130	372	751	360
2	600	720	1047	318	682	288
3	500	656	810	276	543	264
4	450	632	718	274	496	274
5	380	798	720	240	480	248
6	480	739	857	240	548	252
7	750	895	1477	264	870	270
8	550	851	902	396	649	353
9	550	766	993	306	650	323
10	580	812	947	366	656	361
11	750	694	1275	420	848	408
12	780	865	1257	468	862	472
13	720	862	1083	468	776	506
14	740	926	1130	492	811	522
15	750	932	1128	492	810	463
16	700	868	1095	468	782	446
17	870	977	1183	510	847	496
18	750	728	1093	510	802	527
19	800	738	1492	480	986	526
20	900	1164	1632	510	1071	580
21	890	966	1587	462	1024	480
22	800	866	1348	444	896	461
23	780	804	1268	426	847	394

Table A.H.1: Average (3 days) real heat and electricity demand data used in the second stage simulation runs of energy demand modelling (Units in MJ).

APPENDIX I

(Self criticism and retrospective)

Self criticism and retrospective

Self criticism is not an easy and certainly not an enjoyable task. Yet, no matter how serious effort and hard work has been involved in a research project, there will always be limitations. However, the Author believes that the willingness and ability to expose and criticise limitations is one direct result of the growing and maturing effect of the research project itself.

Perhaps the most easily "identified", though not unjustified limitation of this research, is the relatively small number of hotels in which a detailed audit was performed. One could possibly argue that in order to be able draw reliable conclusions wider sampling should have been undertaken. While the possibility of having additional benefits from a larger sample of hotels is appreciated, this was not readily possible, because of either lack of historical energy data or most importantly because of reluctance of the management of candidate hotels to cooperate. Despite these difficulties we must state that the systemic nature of this research and the desire to explore and expose the roots of problems, required the adoption of a "deep " rather than a "broad" approach. Furthermore it is doubtful whether additional data obtain from a larger sample would provide quality information that would shed more light on the existing situation.

Another point that could possibly attract criticism is the set of technologies examined. One could possibly argue that this is inadequate and that more technologies ought to be

examined. The argument appears quite reasonable. However, it must be borne in mind that it was not the intention of this research to elaborate on the maximum number of technologies but rather to select those technologies that were the best candidates for examination in the sense of providing the opportunity to explore their system interactions. In addition the technologies examined provide good example components of technological energy supply mixes. Could more scenarios (more energy mixes) have been examined ? Perhaps yes. But there is always a point in which the researcher will have to draw the line and assume that the quality of the evidence he has managed to obtain is satisfactory in the sense that it enables him to draw reasonable conclusions. This "necessity and sufficiency" test is certainly not an easy task. However a decision, based on available evidence and critical judgement has to be made. A final remark concerns the researcher's capacity as a full-time government official in the energy department. The soft systems approach requires that the analyst takes an entirely "fresh" approach to the problem examined. In fact he is not, according to the methodology, seeking the solution of a specific pre known problem but rather to improve a "problem situation". As an energy officer, familiar with the energy problems of the island, the researcher, was on many occasions tempted to consider problems and solutions as they would have been considered and perhaps addressed under his official capacity. While it may not have been always possible, to avoid such temptation, consistent and systematic effort to avoid it and thus function only in the researcher's soft system analyst capacity was made.

The researcher's professional and educational background in mechanical engineering and the energy field was certainly of considerable help during this research work. However, great care was constantly required at all times in order to maintain an unbiased view in all actions originating from this background and the new capacity of addressing the problem in the management science/soft system mode.

The major difficulties expressed in these self critical thoughts have hopefully not affected the quality of the work nor limited its contribution to the investigation of a problematic energy situation in an important sector of the economy, using, perhaps for the first time in Cyprus, an entirely new approach.

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