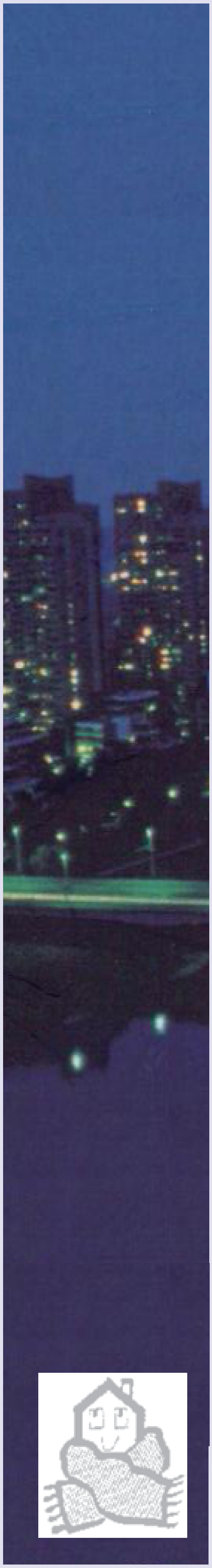
International
Energy
Agency

Technical Synthesis Report
Annexes 22 & 33

Energy Efficient Communities
& Advanced Local Energy Planning
(ALEP)



Energy Conservation in Buildings and Community Systems

Technical Synthesis Report Annexes 22 & 33

Energy Efficient Communities & Advanced Local Energy Planning (ALEP)

Edited by Richard Barton

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Preface

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster co-operation among the twenty-four IEA participating countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D).

Energy Conservation in Buildings and Community Systems

The IEA sponsors research and development in a number of areas related to energy. The mission of one of those areas, the ECBCS - Energy Conservation for Building and Community Systems Programme, is to facilitate and accelerate the introduction of energy conservation, and environmentally sustainable technologies into healthy buildings and community systems, through innovation and research in decision-making, building assemblies and systems, and commercialisation. The objectives of collaborative work within the ECBCS R&D program are directly derived from the on-going energy and environmental challenges facing IEA countries in the area of construction, energy market and research. ECBCS addresses major challenges and takes advantage of opportunities in the following areas:

- exploitation of innovation and information technology;
- impact of energy measures on indoor health and usability;
- integration of building energy measures and tools to changes in lifestyles, work environment alternatives, and business environment.

The Executive Committee

Overall control of the program is maintained by an Executive Committee, which not only monitors existing projects but also identifies new areas where collaborative effort may be beneficial. To date the following projects have been initiated by the executive committee on Energy Conservation in Buildings and Community Systems (completed projects are identified by (*)):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)

Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HEVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: Solar Sustainable Housing
Annex 39: High Performance Insulation Systems
Annex 40: Building Commissioning to Improve Energy Performance
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM)
Annex 43: Testing and Validation of Building Energy Simulation Tools
Annex 44: Integrating Environmentally Responsive Elements in Buildings
Annex 45: Energy Efficient Electric Lighting for Buildings
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser

(*) - Completed

This summary report concentrates on Annexes 22 and 33: Energy Efficient Communities & Advanced Local Energy Planning (ALEP) - A Guidebook

Annex 22: Energy Efficient Communities

Since the completion of three Annexes devoted to Community Systems in the early 1980s the potential to improve energy efficiencies, tap into new energy resources and to reduce energy demands has gained increasing interest in municipal administrations. This combined with an increasing awareness of environmental issues has resulted in major efforts in a number of countries to develop and apply Local Energy Planning (LEP). LEP has the potential to make integrated energy planning of entire community systems possible.

Methods, instruments and experiences of LEP have been developed independently within several countries and Annex 22 was conceived as a means to summarise, exchange and manage experiences between participating countries. The LEP process has two main components, the actual process of planning and design, and the transfer of LEP results to the various groups involved to implement these results.

The work was structured into **four subtasks**.

Subtasks A and B were closely related to the actual process of planning and design.

Subtasks C and D were closely related to the transfer of the results to the various groups involved in implementing the conception.

The countries participating in Annex 22 were Belgium, France, Germany, Italy, Sweden and Turkey. The Annex 22 Operating Agent was the Vereinigte Saar Elekrizitats AG, Saarbrucken

Annex 33: Advanced Local Energy Planning (ALEP) – a Guidebook

Annex 22 showed that there has been a continuous application of LEP in countries like Sweden and Germany, growing familiarity with the facets of LEP and the increasing use of specialised tools by planners accessed via their personal computers. However there was still a gap between the availability of system optimisation tools and their practical application by planners. Four countries decided to undertake case studies using the Linear Programming Optimisation Model ‘MARKAL’. The proposed aims of Annex 33, were:

- The exchange of information based on experience and results of using the model as well as the application of modern methods of process management in LEP projects, allowing for complex decision making processes;
- The development of a Guidebook on Advanced Energy Planning (ALEP) designed for readers with a background in traditional energy planning.

The countries participating in Annex 33 were Germany, Italy, Sweden and The Netherlands. The Annex 33 operating agent was the Klimaschutz und Energieagentur Baden-Wurttemberg, Germany.

Scope

This report contains a summary of the work of both Annex 22, the formal duration of which was from 1991 to 1993 and Annex 33, the formal duration of which was from 1996 to 1998. The report is mainly based upon the principal reports of Annexes 22 and 33 listed under References.

Contents

1. Introduction

Since the energy crisis in 1973 an increasing awareness in communities of their responsibility to optimise their energy supply and to minimise its environmental impact has developed. As a consequence, in a number of countries, new methods for the design of ‘energy efficient communities’ have been developed and applied, described using the expression *‘Local Energy Planning’* (LEP). Experience of using LEP has resulted in major changes in approach, methods, instruments, and objectives. However, because LEP has been based on practice rather than scientific activity these experiences have not always been disseminated to a wider audience.

Annex 22 was designed to summarise national experiences of LEP and to propose ways of managing these experiences between different countries. The task of Annex 22 was defined to:

- compare data, methods and approaches applied within the participating countries and evaluate the results with particular emphasis on transferability of information;
- develop a summary of information of practical value to individuals involved in a LEP project.

1.2 Definition of LEP

LEP has developed as an open process with many participants rather than a single well defined project. Integrated Planning Procedures, Demand Side Management, Least Cost Planning and new software have also been introduced to LEP. The objective of LEP, based on discussions arising within Annex 22, *is the development of a well-balanced and consensual solution for the supply of (low temperature heating) energy to a well-defined area.*

1.3 General Content of LEP

Existing data is used to develop logically consistent measures to achieve a given system of goals. The planner has to consider the technologies available and the principal means for improvements. LEP should address all groups affected by the proposals.

1.4 Subject of LEP

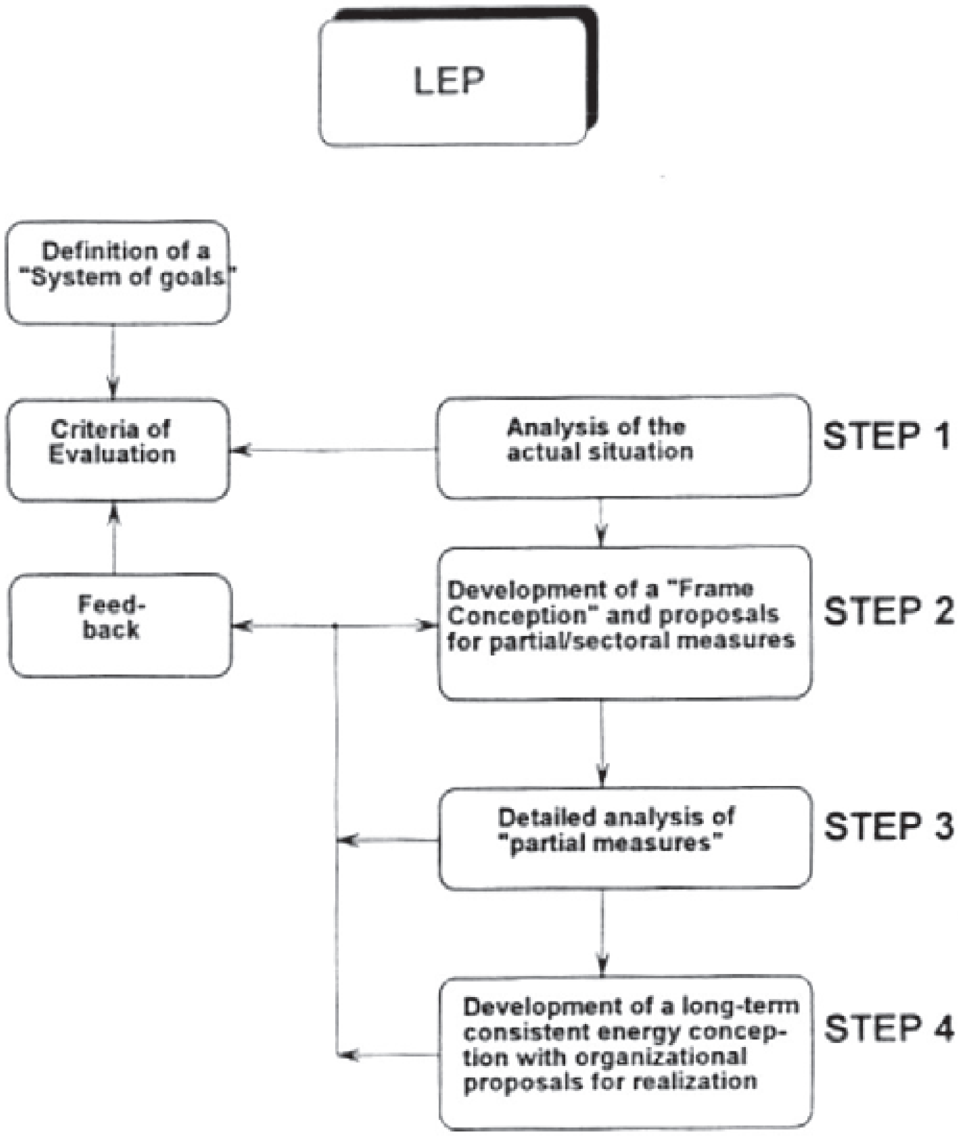
A defined administration area, for example a county or town and the low temperature heat supply of public, private and commercial sectors form the basis of LEP. The industrial sector is only considered where an enterprise can contribute to the plan, for example through the use of waste heat utilisation. High temperature heat and electricity supply, unless connected with direct heating or cogeneration are not considered.

1.5 Responsibility for LEP

The local authority is responsible for the development of LEP, which should be revised and acted upon regularly in line with changing conditions and goals. LEP has been associated more with countries with strong regional and/or local decision makers. However countries with a system of centralised governmental decision-making can utilise LEP through urban management fed back into national policy.

1.6 Schematic Approach to Develop a Local Energy Plan

Despite national differences the general approach shown in Figure 1.1 is applicable to LEP. The four steps shown have to be accompanied by procedural measures with the groups affected by the results



of LEP. The continuous control and feedback of the implementation processes by urban and utility managers can be regarded as a 'follow-up step'.
Figure 1.1 Structure of LEP working steps

2.0 Subtask A: Software Tools in Energy Planning

2.1 Introduction

One of the main objectives of Annex 22 was the collection of information on existing computer-aided instruments in LEP. Almost every part of LEP has been addressed by a large number of software tools, Figure 2.1, produced by scientific institutions, consultants, planners and utilities. A full evaluation of all these tools was beyond the scope of Annex 22 and was limited to existing software tools in each of the participating countries.

It should be borne in mind that computer software is continually changing and the software tools mentioned in Annex 22 have either undergone further development or have been superseded by new tools.

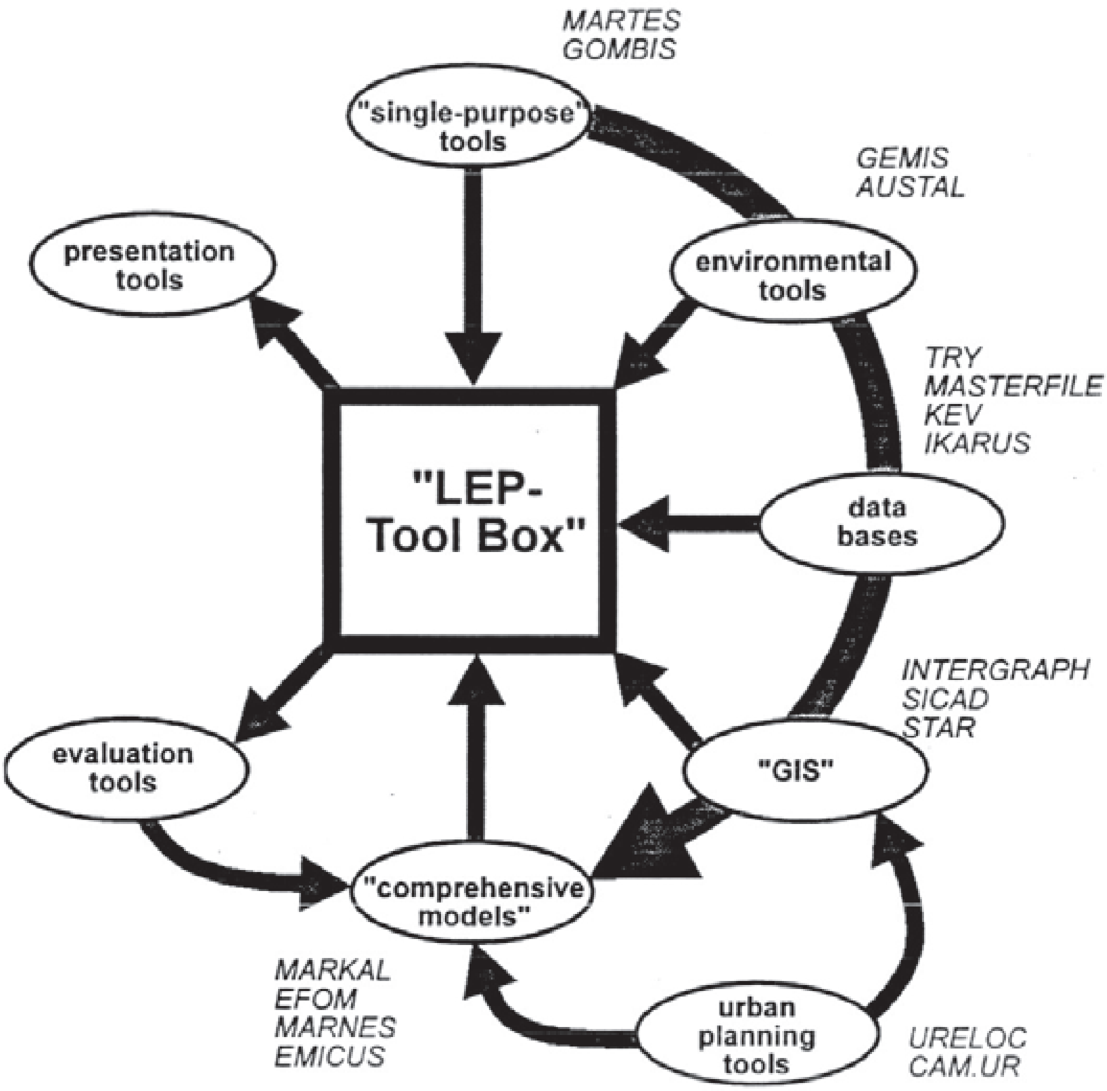


Figure 2.1 The LEP toolbox, which in principle is available to the planner. Some existing commercial or scientific software tools for different categories are indicated.

2.2 Classification of LEP software tools

LEP software in the context of Subtask A are understood as *computer-aided instruments which are used by either planners, design engineers for 'technical infrastructure' or urban decision makers within the LEP-process or during the implementation of an LEP-conception.* This excludes macro-tools used at a national level and micro-tools used, for example, to simulate a single building.

Compared to the development of databases, graphical and environmental information systems, tools directly related to LEP have only recently undergone commercial development. A transitional phase has been observed with an increasing number of planners beginning to use purpose designed software. With respect to the different existing software tools, some categories of distinction can be made. Table 2.1 shows design tools according to their scope.

Design Tool	Use within LEP
"single purpose" calculation tools	Optimisation of defined single components of the energy system (e.g., of a heat pump, solar collector array, a cogeneration plant,etc.) according to given goals
"horizontal" calculation tools	Considers and optimises the whole chain of energy transformations, or part of it, from boundary to end-use
"vertical" calculation tool	Consider an "intersection" of two or more energy supply systems (e.g., gas vs district heating optimisation, different types of cogeneration heating plants)
"integrated" calculation tools	Uses comprehensive models for the simultaneous optimisation of supply and demand side measures

Table 2.1 Energy system design tools according to their scope

2.3 Calculation Models in the Process of Local Energy Planning

Why are models of the municipal energy system needed? Models can be used to solve technical problems as well as improving the planning process. Four reasons for the use of models have been identified.

Complexity
A municipal energy system is a complex structure consisting of various technologies and sub-systems, satisfying complex objectives such as cost efficiency and low emissions.

Uncertainty
The choice of new technologies and the continuing utilisation of existing technologies are to a large extent determined by the developments in the system environment.

The learning process
Together with the model results the most important part of the planning is the learning process amongst the involved people and organisations. A model has the capability to generate both answers to questions and new questions and the success of the learning process is dependent on the awareness of the user of the necessary conditions for a learning process to get underway. Two important control points directly related to the learning process are shown in Figure 2.2

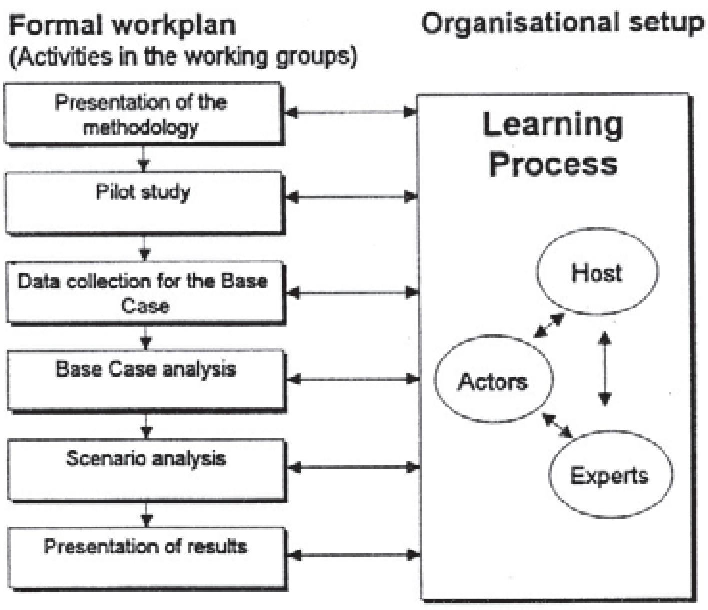


Figure 2.2 The planning process

> *Interaction between different organisations*
> A model can improve the flow of information and initiates a learning process at the organisational level. As LEP considers the entire system participant organisations will probably require a new perspective when working together. A system model, utilising the technical systems of different organisations included as subsystems provides the basis for a language at the system level.

A balance is required between the optimisation of technical solutions and the learning process within and between organisations to arrive at these solutions. If the requirement for optimising is subordinated to the learning process, ‘socially ineffective solutions’ may result because of insufficient acceptance. The most perfect technical solutions are impracticable without cooperation of the system’s interested parties.

2.4 System Engineering Models: Analysing the Technical Energy System

The technical energy system links together the different available energy sources with the energy demand. Two other factors in the system environment affect the design of an efficient technical energy system, the technology available and the restrictions given by the physical environment.

Currently practical limitations apply to the scope of the technical energy system model and transport has played a small role in the models, as shown in Table 2.2, developed so far. Only a few models consider the industrial sector. The building and commercial sector, particularly their heating systems, play a major role in the models for the technical energy system of the municipalities discussed here.

Activity	Number in inventory	Examples
Models for the Entire or Major Part of the Technical Energy System	23	MARKAL, MODEST, GEMIS, IKARUS, HEATMAP
Models for Large Scale Energy Systems	38	MARTES, GOMBIS
Energy Distribution Models	27	SWEDNET, LICHEAT, TBMENY, EASYNET, GASENOK, NIPS BETRIS, PEGASUS, BETRIS
Energy Supply and Energy Conservation in Buildings	31	ERAD, ENEM, THERMOTECT
Models for Energy Demand Calculations and Energy Conservation Assessments	42	ENORM, STATBIL, ENBIL, BLAST, TRSYS, HOVA, MARKET-MANAGER, LOADSIM, COMPASS
Models for Integrated Land Use and Energy Planning		
Models for the Calculation of Heating and Cooling Demand	9	URELOC
Transport Models	13	ESO-MAX
Combined Heating/Cooling and Transport Models	1	URELOC
Other Models	26	Most auxiliary tools

Table 2.2 Examples of models currently available within each activity

The environmental aspect is an increasingly important component of LEP. The environmental dimension is usually represented by calculations for atmospheric emissions. The analysis of emissions is generally included in the models for the entire or major part of the technical energy system. In some cases analysis of the energy supply and energy conservation in buildings is also included.
Technical solutions for the energy system include technologies for:

- Energy conversion, both large and small scale
- Distribution, e.g. district heating, electricity and gas
- Energy saving techniques at the consumer level
- The exploitation of energy carriers such as peat bogs and biomass

2.5 Future Developments

To support the decision maker and give him insights into the consequences for the energy system interesting areas for the future development of models will be:

- Environmental consequences

- Calculation of social costs
- Deregulation of the energy sector
- Cooperation between communities (or local systems) on a regional level
- Security of supply

3.0 Subtask B: Models for the Calculation of Environmental Aspects

3.1 Introduction

The objective of Sub-task B was to discuss methods currently in use within the participating countries to include environmental considerations in local energy planning. The challenge is to make dissimilar energy systems comparable with respect to their environmental impact so that decisions makers can obtain information on economic and environmental consequences of a specific option.

3.2 Environmental Impacts

Environmental evaluation has broadened in scope and consequently so has the range of energy systems under consideration. Generally these technologies have environmental emissions and burdens, the latter impacting on human health as well as biological and non-biological factors.

In principal these impacts cause external costs to the energy system. Many of the impacts are of a qualitative nature and not quantifiable at all. In general more weight is given to quantified impacts than non-quantifiable ones although the latter should not be ignored.

3.3 Valuation Methods

The principle of 'external costs equilibrium' as illustrated in Figure 3.1, is in effect a law of diminishing returns on environmental spending, by which the next increment of emission abatement may not be worth the costs to society. In LEP it is the responsibility of society to implement an overall strategy for setting up a sustainable energy system. Agreement has to found as to the environmental impacts of the different energy systems to be considered. If the consideration of environmental impacts is not a dominating issue, it will often be sufficient to confine the analysis to target approaches accompanied by cost-effectiveness analysis.

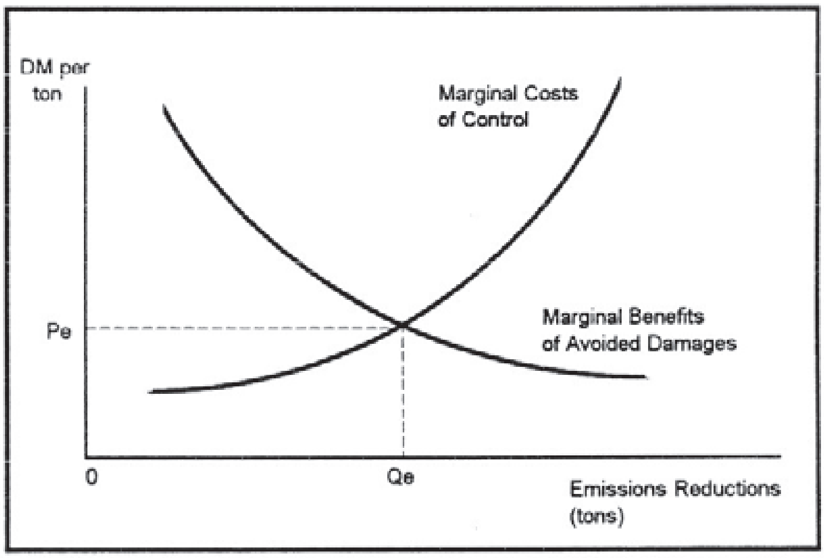


Figure 3.1 Equilibrium external costs of pollution abatement

Where a more comprehensive approach is required Life Cycle Analysis (LCA) can be useful for collecting quantifiable data and using this as the basis for an impact assessment as shown in Figure 3.2. To address the doubts that can exist for those pollutants whose pathways or impacts are not or poorly known a possible approach for the future could be the combination of LCA with use-value analysis, assigning use values or benefits to the achievement of defined goals by different energy system options using transparent algorithms of the results of the first stage of LCA as a valuation model for stage 2. However for all its scientific merits the high mathematical content of this approach, as detailed by Subtask B in the main report, is likely to affect the transparency of the LEP process.

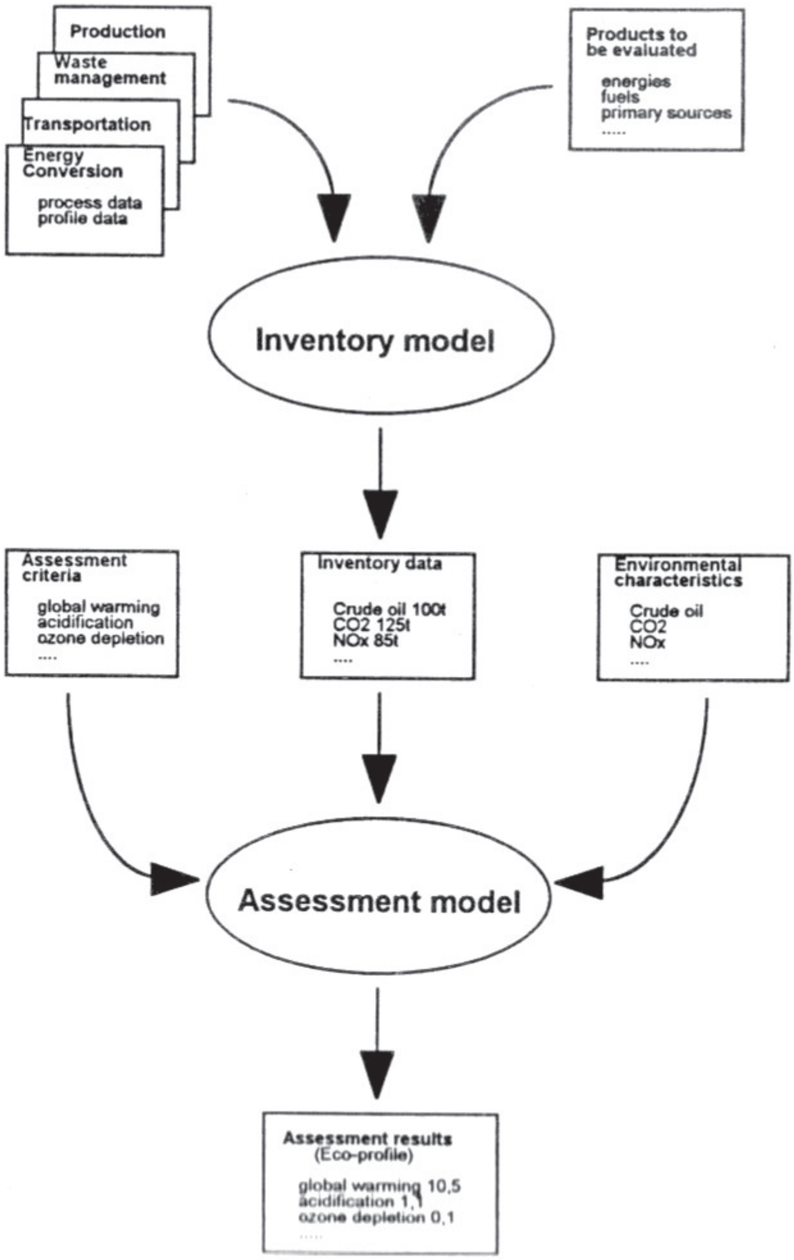


Figure 3.2 Principle of holistic environmental impact assessment.

3.4 Practical Approach to Assess environmental Impacts in LEP

Methods to compare environmental impacts of energy systems require the integration of quantitive comparisons or optimisations, for example with respect to economics, with complex environmental assessment procedures. For the practitioner of LEP the ideal approach would be one balanced between accuracy of the assessment of environmental impacts, practicability and public transparency. The following ‘rules of thumb’ may be of use:

- Consider only relevant impacts. Debate only issues that can be addressed meaningfully
- Distinguish between quantifiable emissions/burdens and non-quantifiable burdens
- Consider national targets according to actual environmental legislation
- Distinguish between global and local impacts
- Do not aggregate over several indicators or critieria expressed in different measurement units, since this would hide facts and conclusions
- Consider direct costs and external costs independently without aggregation
- Make sensitivity considerations to discuss the robustness of the interpretations
- Give assessments and interpretations of results
- Leave the decision maker with some decision power based on his own system of goals and present as neutral and transparent judgement of impacts as possible
- Involve the decision maker into the whole process continuously

Applying these rules quantifiable burdens of energy systems considered in LEP are in general atmospheric emissions, pollutants, soil emissions, temperature rise of surface water, water consumption and solid waste.

Qualitative aspects of energy systems are in general dominated by the consequences of primary energy extraction, though local effects such as demand of land area, noise or visual impact may in specific cases also have their weight in the assessment of alternatives.

3.5 Availability of Data

With limited time and money the LEP practitioner has to have to hand all the resources directly useable for the project. There are numerous sources of data available including:

Database	Source
CORBINE & CORINAIR	European Union
EDB	United Nations Environment Program UNEP and Riso National Laboratory, Denmark
IKARUS	KFA Julich, in the final stage of development
CADDET	IEA, TNO/Sittard, The Netherlands and Chalmers University, Gothenburg
MASTERFILE	Swedish database describing almost all existing
GEMIS 2.0	Swedish buildings according to newest census data Oko-Institut Darmstadt/Freiburg

Table 3.1 Prominent sources of data in Europe

3.6 Some Special Aspects

In general methods to describe environmental impacts are independent from geographic locations. Differences in results stem from different climatic conditions or from different fuel properties etc. A major dispute, however is caused by the treatment of cogeneration. This technology, which certainly allows for appreciable savings of primary energy, if compared with separated generation of heat and electricity (from thermal power plants), also has disadvantages, such as increase of local energy consumption, economic problems and increased dependency on gas or fuel oil. The assessment of the advantages of cogeneration depends on the ‘environment’ of the national energy supply structure and can be quite different in countries where electricity supply is based predominately on fossil sources, such as Italy or on nuclear and hydro energy, such as France. So while there is a necessity to optimise urban energy supply on the basis of local energy planning independently from the country, LEP results may be highly influenced by the existing national supply structure.

4.0 Subtask C: Means to Represent, Demonstrate and Advertise Planning Solutions

4.1 Introduction

The aims of Subtask C are to systematically illustrate and evaluate the information and the dissemination means in the context of LEP considering both media and institutional arrangements.

4.2 Information Media

Information media can generally be used to support the implementation of LEP in its various phases. Printed media remains the dominant means of disseminating information, taking the form of documentation on new energy technologies, examples of LEP and municipal energy plans. Alternatively computer-assisted information networks can be used for the central storage, processing and exchange of data. If used, they can play an essential role in the process of developing community energy plans.

4.3 Institutional Arrangements

The transfer of information on LEP can be achieved at all levels and through different institutional arrangements. In Sweden utilities act as commercial disseminators of information at a local level. An energy cell was created in the administration of the Belgian city of Gent to monitor the energy consumption of buildings and to advise on improving heating installations. In Germany, due to long experience with LEP, energy officers are frequently employed directly or as consultants by municipal government departments. The national organisation in France, ADEME, has created regional offices in every French Administrative region with the task of conducting nationally defined ADEME policies in cooperation with the municipal authorities.

4.4 Qualification by Seminars and Workshops

There are no specific LEP qualifications in Sweden, but higher education in the field of LEP is supplied by some Universities of Technology. Belgium offers similar training in the regions of Flanders and Walloon. In France the ADEME has the responsibility for offering specific training in the field of energy planning. Germany has, as one of a number of initiatives, encouraged the transfer of information through training and qualification provided by relevant organisations and associations.

4.5 Summary Assessment

For the assessment of the value and effectiveness of information media the following main criteria are used:

- Expected impacts on energy conservation
- Volume of the target group addressed with the aspect of information dissemination
- Anticipated multipier effect
- Relevant costs required for the realisation of the measures

The assessment is summarised in Table 4.1 below.

Measures/Institions	**Addressed Target Group**	**Multiplier Effect**	**Cost**	**Effects on Energy Conservation**	**Extent of Application in Participating Country**	
Information and Advisory Campaigns	high	high	small	small	Sweden	medium
					Belgium	small
					France	medium
					Germany	high
Specific Consulting and Qualification Measures						
Energy Conservation Programmes	small	small	medium	high	Sweden	medium
					Belgium	small
					France	medium
					Germany	high
Demonstration Projects	high	medium	high	small	Sweden	medium
					Belgium	small
					France	small
					Germany	medium
Information Systems	high	high	high	high	Sweden	medium
					Belgium	small
					France	high
					Germany	high
Energy Agencies	small	medium	small	medium	Sweden	medium
					Belgium	medium
					France	small
					Germany	high
Experience Exchange	small	medium	small	small	Sweden	medium
					Belgium	small
					France	medium
					Germany	medium
Specific Institutions at the local level						
Energy Officer, Energy Coordination Conference	small	small	small	high	Sweden	medium
					Belgium	medium
					France	medium
					Germany	high
Energy Councils	small	high	small	small	Sweden	medium
					Belgium	small
					France	medium
					Germany	high

Table 4.1 Assessment of the efficiency of dissemination activities and the extent of their application within the participating countries

It would appear, to date, that an evaluation of support and dissemination programs for energy conservation and their respective cost/benefit yields has rarely ever been made. First conclusions would indicate that a combination of measures, tailored to specific target groups is generally expected to be most effective.

A broad information campaign should be accompanied by specific 'on the spot' consulting, combined with financial programmes for measures which have proven to be economic. The advisory process should preferably be organised by a public institution or an association. Qualified and free informationof interest is normally accepted by the target group when provided using this approach. An integrated approach of combined and specifically tailored measures, adapted to the target group can be effective. Isolated measures such as some single-issue energy conservation programmes may be less effective in terms of their cost/ benefit ratio. In order to arrive efficiently at the desired energy savings and environmental improvements in support of the implementation of the LEP plan as the essential aim of LEP, a bundle of measures will be necessary. Any measures proposed in support of LEP have to be elaborated and implemented on different levels, national, regional and local, and by different actors, administrations, communities and utilities.

5.0 Subtask D: Implementation of Integrated Planning Procedures

Key to the success of LEP is the implementation of the plan through a defined municipal energy policy. However the participating countries vary in their implementation of municipal energy policy. The ability of individual municipalities to develop their own LEP within different legal and structural conditions was considered by Subtask D.

5.1 Structural Differences in Energy Supply Systems

Experience has shown that considerable variations occur between different countries in both the quality, scope and implementation of LEP. Some of these differences can be explained by regional variations in availability of energy sources. However where these are similar within different countries then structural and/or social influences have to be considered for the relative effectiveness of LEP.

The scope of and the responsibility for LEP are strongly dependent on the role municipalities play in the supply of energy. Table 5.1 also shows that a strong monopoly of the national electricity supply does not prevent the application of LEP. However it can cause a delay in the comprehensive introduction of LEP as well as influencing its scope and quality.

It would appear that LEP is less effectively realised when centralised solutions are applied. However even with a centralised energy supply structure, it might be possible to synchronize the interests of the utility and of the municipality, for example by long term cooperation contracts which allow for mutual advantages of both the municipality and the utility.

	Belgium	France	Germany	Italy	Sweden	Turkey
supply monopoly (at least >90 % of the consumption) for a national electricity supply company	y	y	n	y	n	y
concession contracts	< 30 a	?	< 20 a	?	< 15 a	n
municipal concession charge for electricity supply to be paid by supply company to municipalities	+	?	y	?	y	n
use of fossil fuels for electricity production> 50% of electric primary energy demand	n	n	y	y	n	y
obligation to take over surplus electricity from cogeneration into the public grid with fair prices	n	+**)	y	y	y	n
legal requirement to take over electricity from regenerative energy sources into public grid with fair prices	n	?	y	y	y	n
LCP-programs by utilities	n	n	y	n	y	n
legal responsibility of communities for local gas/electricity supply	n	n	y	n	y	n
widespread experiences with LEP	(+)*)	(+)*)	y	n	y	n
joint LEPs with utilities	n	n	y	n	y	n
quantified national energy plan in force	n	y	n	y	y	?

*Table 5.1 Some characteristic data on energy industry structure and LEP involvement within participating countries (y…"yes", n…"no", ?…information not provided by participant, * …special institutions within those countries only, ** <100kWel)*

5.2 Cogeneration and the System of National Electricity Supply

The issue of combined heat and power (CHP) supply deserves a special discussion since its development, or absence, is frequently the kick off to initiatives to start local energy planning projects.

The potential for CHP/cogeneration will be strongly dependent on the general energy supply conditions of a country as a whole. The goal must be to use all available sources of primary energy and to make the maximal possible use of the end energy input, in other words to optimise the energy system as a whole.

5.3 Conclusions

There are energy saving potentials in the local energy supply in all participating countries which could be exploited more effectively if there was an integrated LEP conception and concerted efforts at the local level to implement it.

The management of the municipalities should in general be the main actor in developing LEP, but independent from the legal structure of the national (electric) energy supply, it was important to involve the utility being responsible for the local supply in the process of finding an optimised use of energy. The municipality should play an active role in:

- Inclusion of all relevant groups
- Formulating a steady urban policy which is oriented to the long-term objectives of national energy policy and with clear priorities and quantified goals at the local level
- Exerting influence, if possible, to the actual boundary conditions to support those goals, such as adaptation to general urban planning and declaration of district heating priority areas
- Formulating an autonomous program of projects and other measures to minimise the energy consumption of municipal buildings and establishing a continuous energy management for them
- Establishing a long term municipal energy plan in cooperation with existing utility as a basis of an integrated energy policy which is oriented to economic and ecological goals as well
- Creating a position of institution which is responsible for the control of the implementation of this conception

The inclusion of the local (or regional) energy suppliers was considered to be crucial for such a program, since only then would sufficient technical, financial and data resources for such a program be available. To avoid possible goal conflicts, incentives should be negotiated with the utility such as long-term contracts and extension of its energy services, accompanied by defined obligations of the utility to support the development and implementation of the energy conception.

6.0 Advanced Local Energy Planning (ALEP)

Practical realisation of LEP projects has shown that a number of factors, including partial solutions for individual projects and the development of a long term strategy for the whole municipality have to optimised simultaneously to achieve a successful outcome. The process must be inclusive of a variety of different decision makers and interest groups. LEP is a long-term iterative process rather than a short-term planning task. It makes use of traditional technical planning methods and tools, but also includes ‘societal’ factors required to enable all interested parties to work together to arrive at a consensual solution.

However to gain a comprehensive view of the overall complexities of the municipal energy system and its behaviour under different assumptions and influences there is a requirement to use systems analysis which to date has not been applied in the context of LEP. The combination of the use of energy models, participative involvement of affected groups and modern methods of project management is known as Advanced Local Energy Planning (ALEP). ALEP is applicable to a municipality of medium or large size with a complex energy supply system and is an extension of the traditional LEP approach as shown in Figure 6.1.

ALEP improves upon LEP in the following ways:

- Makes use of comprehensive models of systems analysis capable of simulating and optimising the whole system, rather than only considering its components.
- Provides a long-term strategic energy plan satisfying different sustainability goals.
- Involves all affected groups and decision makers to maximise the chance of realization.
- Employs principles of modern project management and group dynamics
- The process is continuous rather than finishing at a defined point.

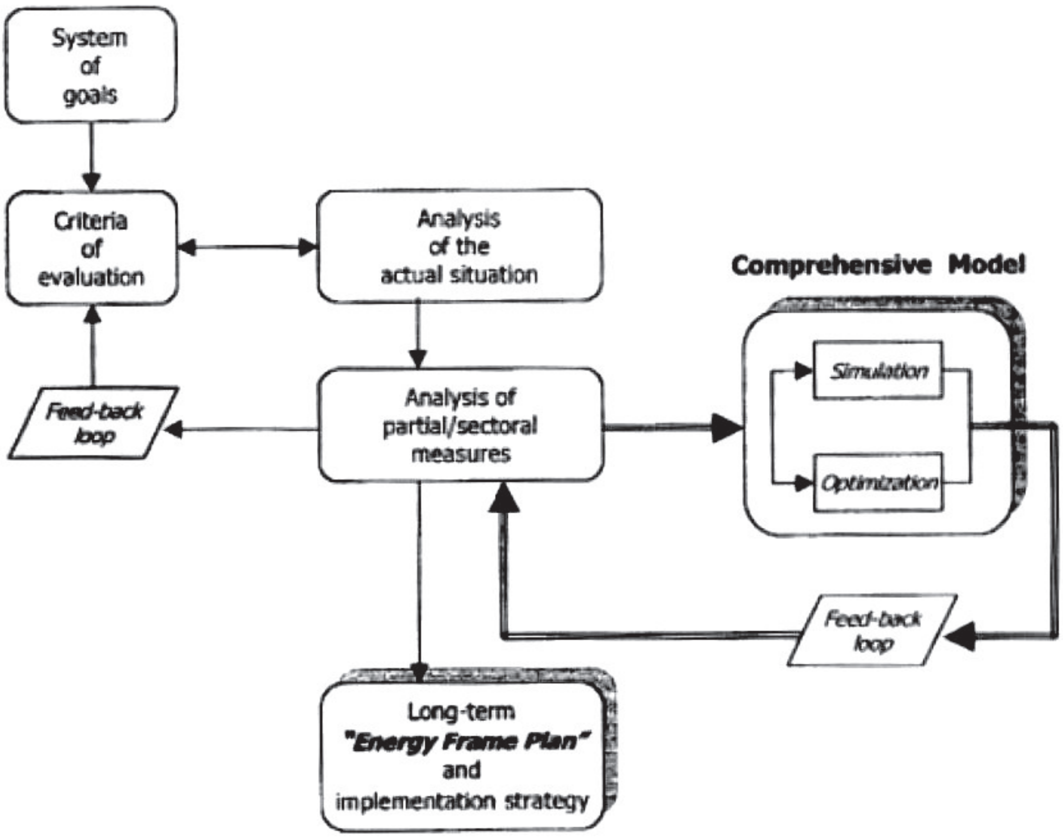


Figure 6.1 Traditional LEP and ALEP approach (double line) using support of existing software tools and a comprehensive model of the entire local energy system

7.0 Basic Principles of Advanced Local Energy Planning

The purpose of ALEP is to find a means towards an economic and ecological sustainable local energy system. This has to be achieved whilst taking into account limited financial and human resources as well as incomplete insight into the future development of economic, technical and social conditions. The planning approach to achieve these goals follows four basic principles:

> *Combining integrated long term strategic planning with detailed planning of concrete sub-system projects*
>
> Energy systems in agglomerated urban areas consist of highly interconnected subsystems like heating systems of individual buildings, stand alone district heating systems or the energy supply of production plants. Long term strategic planning for this energy system requires comprehensive analysis of the overall local or regional energy system as well as analysis and optimisation of these subsystems;
>
> The ALEP approach comprehensively analyses the whole energy system of a region exploring and analysing a range of possible strategies. A simultaneous overview incorporating existing local energy projects and integrating ongoing municipal activities is taken to provide a comprehensive and consistent long term energy plan that analyses the behaviour of the entire energy system. This will reveal the strengths and weaknesses of the present energy system and identify future needs, threats and opportunities for the future. Individual subsystems are then planned

or selected for further analysis depending on their priority and improvement potential in regard to long term strategy;

Utilisation of systems analysis methods and computerised energy system models.

Experiences with LEP have shown that a systems analysis approach to the planning process, supported by computerised energy system models, is necessary in order to describe the entire energy system adequately and find the best strategy. Models, for example MARKAL, should also be used to study the interaction between comprehensive studies and subsystem analyses. Models can also be used for analysis of specific problems in subsystems, a method already familiar and acceptable to planners;

Involving local interest groups in the planning process

A planning approach that considers only the technical aspects of energy planning and neglects social and political factors of a region often fails because it lacks consensus. The institutional organisation defines the roles of the participants directly and indirectly involved in the planning process and should be tailored to the existing decision making mechanisms within the local area. Including a comprehensive energy system model within the organisation produces impartial and reliable results for each interest group assisting in the resolution of conflicting positions.

Due to the iterative nature of ALEP, improvement of strategies is accomplished through continuous communication and discussion of partial results and new ideas between groups shown in Figure 7.1

Continuous improvement and monitoring

The principle output of ALEP is a local/regional energy plan. During implementation the actual development should be compared continuously with the planned development using suitable indicators to avoid the development diverging from that specified in the action plan. Following implementation the ALEP planning process shifts to a monitoring and evaluation phase, necessary to make adjustments to some of the goals and parts of the action plan based on earlier assumptions which no longer apply.

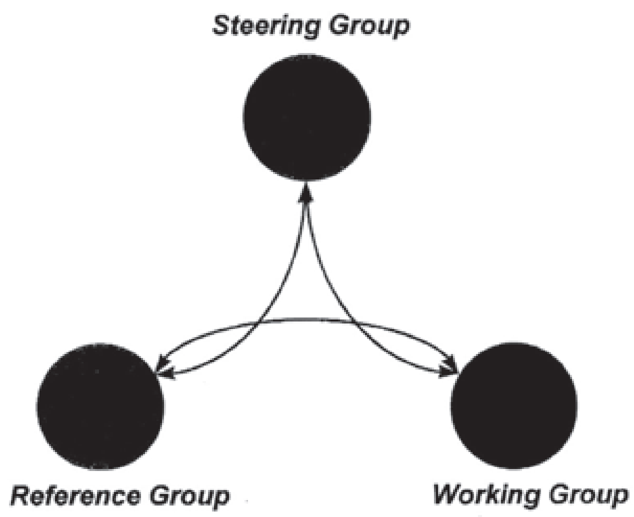


Figure 7.1 Example of an organisational set-up for an ALEP project

8.0 The Phases of the Planning Process

8.1 General Overview of the Planning Process

An ALEP project is a large-scale enterprise involving complex details and people of differing technical and non-technical backgrounds. Initially even the objectives will require further analysis and to be effective the ALEP has to be supported by carefully structured planning. The planning process can be divided into six phases as shown in Figure 8.1. Each of these, successively, goes into more detail and with further iteration improves the understanding of the energy system. The time and budget devoted to each phase depends on how the concrete planning tasks are defined and the priorities of the planning team.

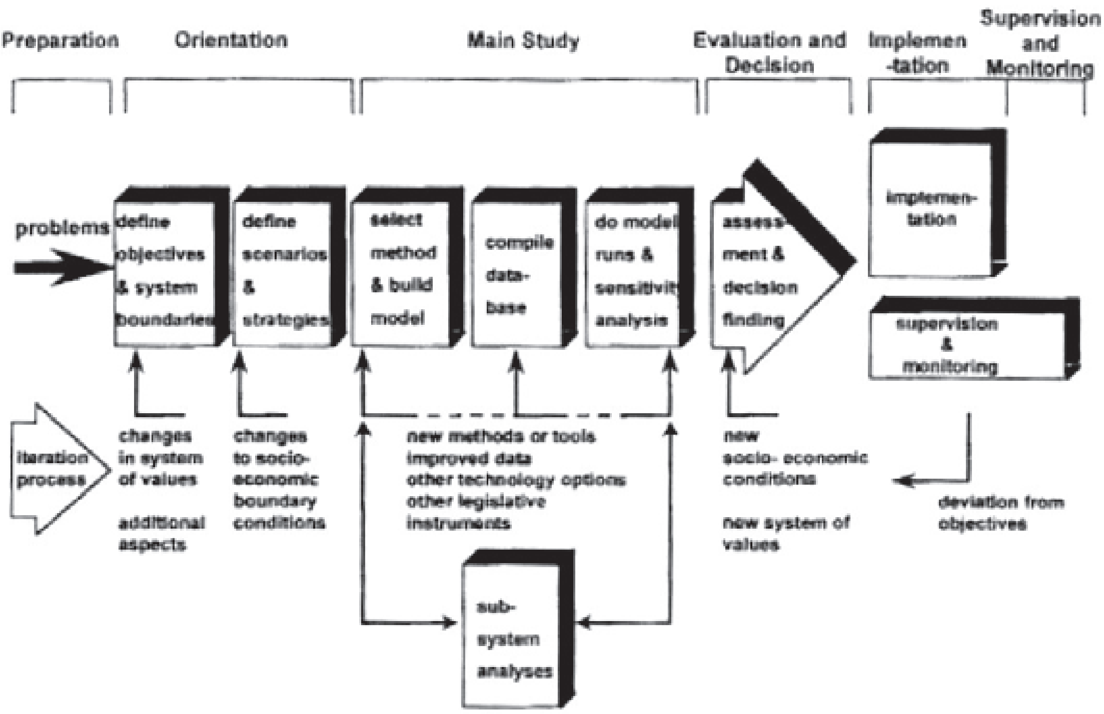


Figure 8.1 Phases and Tasks of the ALEP process

8.2 The Preparation Phase

This phase clarifies the main challenges and objectives and involves collecting basic information on the existing energy system. Local interest groups are identified and invited to participate in the project, ideally by means of a workshop. If human resources are limited then it may be necessary to include the initial preparation phase into the first part. A work plan for the next step of the project must be prepared.

8.3 Orientation Phase

This phase is devoted to the detailed description of problems, objectives, system boundaries, scenarios and measures. To avoid unnecessary work during the main study phase this stage can be used to direct and limit data collection to relevant topics of concern. Sufficient time should be allocated to achieve consensus amongst all the groups so that formal agreement can be reached.

Having established the objectives, the next step is to define the system boundaries so that it is clear which parts of the energy system can be influenced by local planners and which parts cannot. These are known as 'scenarios'. A method well suited to this task is the 'Reference Energy System' (RES) a simplified representation of the structure of the energy system.

At this point the system models and the computer software for the comprehensive study must be selected, before data collection and model building is started.

The final organisational set-up adopted according to the questions and problems of the project must be established during the orientation phase to define the role of each participant as well as the framework of communications. The reference group must bring in the specific requirements of the different interest groups and build a common system of goals and a vision for the future. The task of the steering group is to negotiate compromises between the parties at the political level.

On completion of this phase the tasks, scope and budget of the project should be well defined. The orientation phase ends with a report whose contents are subject to continual improvements during the project. The document defines the core of the project and should be accessible to all participants.

8.4 The Main Study Phase

The main study integrates a comprehensive analysis for long term strategic planning with several detailed analyses of important subsystems or questions of specific interest. The information exchange between these two planning levels produces the necessary amount of detail for the decision making process.

At the start of this phase the tasks, scope and budget of the project should be well defined and the objectives will serve as guiding principles for the development of the energy system model and the necessary data acquisition. The model will assist in the analysis of different options for competing measures and strategies. Where required iteration loops can be introduced to develop an optimal solution.

It is recommended that a small pilot study containing only the most important components is set up. This not only indicates the strengths and weaknesses of the existing system, but points to opportunities as well as potential difficulties of future development. It is preferable at this stage to take an exploitative approach using a simulation model rather than optimisation model. This is because the former approach calculates the impacts of a clearly defined strategy path, i.e. a given technology and fuel mix, whilst the latter calculates an optimal mix of technologies and energy carriers for a given cost structure and a given set of constraints. Further refinement of the model is then possible. Studies of subsystems data running in parallel to the comprehensive study should use the same base data in addition to their own specific data.

The two main components of the main study are building the structure of the model and entering the data, although these two steps are not always clearly separated in the user-interface of the models.

> *Step 1: Define the structure of the comprehensive model using the RES*
> Use the information from the preceding phases to develop the RES, a simplified representation of the structure of the energy system. The information contained in the RES is then transferred to the energy system model.
>
> *Step 2: Compilation of a model database*
> An important task within the main study is to establish a reliable database with validated data used as a common source for inputs to all models and calculations. The database management system should be set-up to allow easy storage and retrieval of data by all the participants.

Step 3: Calculation of scenarios and strategies
Initially the model is calibrated to the base year with historic data. Subsequent simulation runs investigate the development of the unaltered system. Finally the behaviour of the system is examined when new technologies or other measures, based on the proposed strategies, are introduced. The robustness of the results should be checked under different scenarios using sensitivity analysis.

Step 4: Integrating subsystem analyses
At certain points during the planning process it is necessary to find a detailed optimised solution for a specific part of the energy system by subjecting a sub system to a detailed optimisation or feasibility study. Results from detailed studies should also be fed back into the analysis to improve the comprehensive study. It is advisable to combine comprehensive models for overall optimisation and subsystem models for detailed studies in iterative steps.

Step 5: Sensitivity analysis
To validate the stability of the results from the model it is necessary to undertake sensitivity analysis. The objective is to establish that the strategies under consideration are robust and that small changes in scenario conditions do not result in big changes to the effectiveness of the strategy. The model should be improved until the results are well understood and stable.

8.5 The Evaluation and Decision Phase

The purpose of this phase is to adopt a strategy for implementing the plan. The different options elaborated during the main study are assessed and prioritised by all groups involved in the project. The result of this phase is an agreement on the strategy, an action plan and a priority list for implementation of measures thus providing the core of the local energy plan. The following information should be prepared for the assessment and decision finding process:

- RES representation of the technical energy system
- Energy balance and emission balance
- Development and market shares of energy carriers and substitution of energy carriers
- Cost and effectiveness of proposed strategies, introduction and market penetration of new technologies
- Development of cost and emissions in different sectors
- Development of specific values and indicators (energy consumption per housing area, per capita consumption, consumption per household, energy use per GDP, specific energy consumption of industry, specific costs, etc)

With the finalised strategy described in the final report, ALEP has reached its most important milestone, the Local Energy Plan.

8.6 The Implementation Phase

Continuing the ALEP process the action plan and priority list completed during the assessment and decision phase, concerning the energy sector and the emissions reduction strategy must be transformed into reality. The plan is realised through individual projects supervised to check their effectiveness. Unfavourable developments detected during the supervision phase may lead to new iterations in the planning process and even a re-evaluation of the energy plan. It is not necessary to continue the original organisational ALEP structure during this phase and the supervision of implementation can be assigned to a new group to ensure the measures are implemented in an effective manner.

8.7 The Monitoring Phase

The monitoring phase not only proves the success of the action plan, but also shows starting points for an iterative improvement of the energy system model, even initiating a new ALEP process. Ideally the system should be monitored regularly over several years to detect situations where re-orientation or a completely new ALEP process should be started. The report formats developed during the ALEP project can be used to analyse and document the performance of the system using actual measured data. When a new ALEP planning cycle starts, the database will be up to date, and only minor changes to the model and minimal data acquisition will be necessary to update the model. This reduces the cost and time for the revision of the ALEP project enormously.

8.8 Interfaces with Other Planning Activities

Energy planning is not the only activity within a region. Other activities influence the energy system and changes and vice versa. An important aspect is that urban planning can be combined with improvements in the energy system. The consideration of energy issues in urban planning, environmental planning, waste management or traffic planning can contribute to decision making in these areas. Information concerning energy balances and the operational energy cost of these projects can help identify unfavourable alternatives.

9. Steps and Tools in the Technical Analysis

9.1 Description of the Present Situation

The description of the present situation constitutes an important first step in the comprehensive analysis for subsystem studies within ALEP both the actors taking part in the planning process and later for the reader of the ALEP report.

Every ALEP must contain a description of the present situation as this is the basis for the analysis of the development of the energy system. For the majority of planners the description of the present situation is merely an overall picture of the base year for local energy planning. It consists of facts about energy production, energy use and emissions and if more advanced can include an evaluation of the present situation.

Evaluation of the present situation
The aim is to find out strengths and weaknesses in the present energy system. One useful method is the ‘trend/knowledge-analysis’, based on historical trends e.g. the development of energy demand during the past decade and present knowledge e.g. the market share of district heating in different sectors. The results from the ‘trend/knowledge analysis can be applied in ALEP.

The collection and presentation of data for the energy systems and the emissions
The data collection and processing of statistics are a central activity within the description of the present situation and are done in a traditional manner. However it is important that not many resources are invested into these elements and that suitable allowance is made for approximation in some data. Diagrams are an effective method of presenting the data to all those taking part in the planning process.

Objectives of the plan, important questions, subsystem analysis
At this stage of the planning process it may be too early to decide on the objectives of the plan. It is however advisable to check which goals exist amongst the stakeholders of the project and compare them to the present situation. This is a good basis for the development of ‘new’ objectives for the local energy planning task. It is also valuable to collect the actual strategic questions and other important questions discussed by the different actors within the local energy system. Although not all

subsystem studies can be formulated or be identified at this stage, the list as defined becomes an important part of the rich picture that the description of the present situation gives.

System boundaries
Local energy planning can be limited in practise by, for example, a city or community boundary line although other systems boundaries can also be applied.

9.2 Ways of Representing the Local Energy System

The guidebook focuses on three useful tools representing the local energy system, the Reference Energy System, the Load Curve and the Geographical Information System. These three representative tools are not alternatives, but rather complement each other. They are often required in order to analyse available information and produce the needed results for the different analysis in ALEP.

The Reference Energy System
The Reference Energy System (RES) is a scheme which models the structure of a local energy system, as shown in simplified form in Figure 9.1. The RES describes the flow of energy from sources to final use. It shows all flows of energy from the primary energy supply, large scale and small scale energy conversion, different distribution forms and the final use of energy in different sectors. Additionally the RES usually contains useful information on energy demand and even energy services. It is possible to see how energy flows and how energy conversion technologies influence the fuel-technology chains in an energy system. The roles of subsystems can be evaluated from the perspective of the entire energy system and the requirements on this system. While the RES is a graph of all relevant energy flows within the energy system, an energy balance contains the values of all energy flows. Those can be included in the graph or be presented in separate tables. In addition to the conventional energy balance and the RES, the Sankey diagram can be used to give an immediate feeling of the relative importance of the energy flows. The complete picture can be represented if the RES is complemented by more detailed Reference Energy Systems for different parts of the system. However the RES is not a geographical representation of the local energy system.

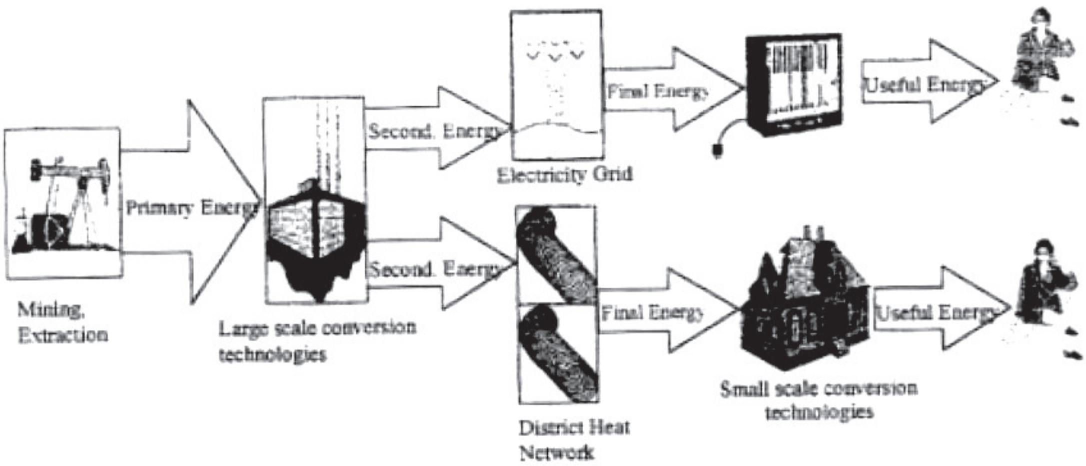


Figure 9.1 A physical representation of the Reference Energy System

The Load Curve

The load curve is an illustration of how the demand for a certain energy form in a certain application varies over time. It is typically used in order to calculate which production plants should be operating to cover the district heating load day by day.

Geographical Information System (GIS)

Geographical Information Systems, often referred to as GIS, are computer programs for presenting and handling information representing geographical locations through maps. Different layers of information can be presented together or separately. One example of a heat map is shown in Figure 9.2. It shows the location of heating plants in one layer and heat density in another layer. A base map with man made and natural geographical features constitutes the background. There are a number of interesting GIS applications, including heat maps, which are useful when working with energy planning.

Figure 9.2 A computer-based heat map

9.3 The Comprehensive Analysis

The purpose of the comprehensive analysis is to give a foundation for the choice of development for the local energy system as a whole and serves as a basis for decisions on the future local energy strategy. Comprehensive analysis can be realised by a strategic or project oriented approach each with its own contents and importance or the ALEP project. During the process of the comprehensive analysis all participating parties meet and deal with many of the central issues in the project.

Description of the present situation
The description of the present situation is the basis for the comprehensive analysis. An evaluation of the present situation should include a summary of the important questions to be treated by the ALEP study, an overview of existing studies, a definition of the 'local energy system' and its system boundaries etc.

Objectives
Based around broad discussion determining the objectives of the study, a process started in the preparation phase, is not always made before the main study is started. During the analysis the objectives must be operationalised. Only through this process can the objectives become useful for the comprehensive analysis. For those who formulate and decide on local objectives it is important to be aware of the limitations to influence the development. It is not advisable to have goals which are unrealistic or deal with issues beyond their control.

Scope of the analysis
The scope of the ALEP analysis is to a large extent determined by the objectives. When formulating and deciding on the objectives it is important to be aware of the limitations of the local decision makers influence.

The choice of approach
The choice of approach is of great important for the ALEP project. It helps to attain a good result in the most efficient manner, both in the comprehensive analysis and in the ALEP project as a whole. It also helps to drive the learning process. It is strongly recommended that before starting the comprehensive analysis that a decision is taken on the intended approach. There are two main approaches:

If the comprehensive analysis dominates the ALEP then a strategic approach should be chosen. The comprehensive energy system model has an extensive system boundary and models interdependencies between subsystems and long term developments using simplified descriptions and subsystems. Thus the comprehensive analysis will be strategic for the selection and orientation of detailed studies which can be realised in parallel. All analyses and models use a common and validated database and information flows in an iterative process between two levels. If the strategic approach is chosen a useful starting point is to run a pilot study aimed to increase the understanding of the methods and models by using a simplified RES allowing one to run through the comprehensive analysis in a short time.

In the project oriented approach the content and scope of the comprehensive study is guided by the focus of the detailed projects, but the study is designed broadly enough to describe the entire energy system. Besides the detailed projects the comprehensive energy system model contains only a small number of additional subsystems but also includes long term aspects and interdependences between subsystems. In this case the results from the ALEP project are based mainly on the detailed studies.

Although the strategic approach seems more logical and straightforward in practice it is often specific individual projects that provide the starting point for local energy planning. In this case the work proceeds from project oriented subsystem analysis to overall strategic considerations.

9.4 Structuring the Problem

Since ALEP is more than just technical analysis, there is a need for structuring of both technical and organisational aspects and there are a number of factors to be taken into account before beginning the main analysis.

The technical energy system
This takes into account energy sources (price and availability), useful energy demand in different sectors, technological progress and physical environment (e.g. constraints on the use of certain technologies, environmental regulations). Moreover the system boundaries for the local energy plan and the time horizon of the analysis (usually up to 30 years for the comprehensive study and a shorter time horizon for the detailed studies) have to be defined.

The planning process must be embedded in an organisational set-up including all interested social, political and economic interest groups. The institutional organisation should be tailored to the existing decision mechanisms within the area of investigation.

ALEP requires the understanding of problems and possible conflicting goals associated with the local energy system by different interest groups and a learning process on the various social and technical aspects of the project is quite important. Figure 9.3 shows the technical analysis loop consists of iterative considerations at different levels of detail and feedback of results. Simultaneously the learning loop improves the technical communicative and organisational knowledge of the group members and their ability to understand and support the planning process.

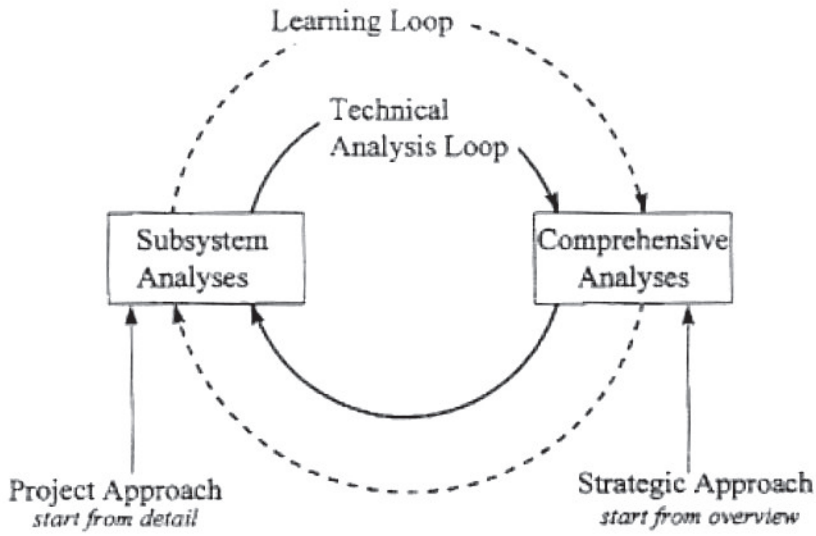


Figure 9.3 Two-fold loops of learning and technical analysis

The comprehensive analysis provides the basis for a recommendation for the long-term development of the local energy system. When all work with the comprehensive analysis has been finished, choices and decisions have to be made. This means that the comprehensive analysis must result in a recommendation for concrete decisions to be made to reach the goals. The challenge is to take the analysis further and make a choice regarding how the energy system should develop in order to meet the principle objectives.

9.5 The Interaction Between the Comprehensive and the Subsystem Studies

The interaction between the comprehensive analysis and the subsystem studies is an important part of the work in an ALEP project. The coordination between the two should be reciprocal. It is important to have an interaction of the comprehensive analysis with ongoing planning projects for subsystems and components. This is true regardless of the chosen approach for the comprehensive analysis.

9.6 Data Requirements and Data Provision

Data collection and preparation is a crucial part of planning. Databases for use by component analysis tools have already been mentioned. Data organisation, i.e. features of data input storage, selection, display and retrieval, is usually an integral part of the software. In general, the tools make use of spreadsheet, database or other standard software packages. Tools should facilitate data-set display or printout. Data may be accessed from a range of sources including municipal administrations, statistical offices, market research etc. databases continuing geographical data would be useful for facilitating visualisation of the various system elements by means of a geographical information system.

A database documentation system is needed for drawing up the single data elements, quoting the referenced material, outlining the calculation steps and assumptions made and finally presenting the data as model parameter values. It is necessary to produce information that can be discussed, put in question, improved etc. Documentation of the input data is also a prerequisite for the model results to become acceptable and will be useful to the working group in later work phases.

9.7 Analysis and Presentation of Results

In general to hedge against uncertainties of far-reaching projections or otherwise doubtful input data, different paths of future development involving more complex changes to the model database may be analysed, i.e. variations of more than one model parameter value are necessary. Hypotheses can be assembled into 'scenarios' each resulting in a model database and output information of a model run and the set of scenario results allows conclusions to be drawn on uncertain future developments.

The basis for evaluating alternative scenarios is represented by the reference scenario where no fundamental changes are assumed to take place during the time frame chosen for the comprehensive study. Each scenario results in a model database and output information of a model run and the set of scenario results allows conclusions to be drawn on uncertain future developments. Comparison of the scenarios indicates the robustness of different strategies.

As an example, Figure 9.4 shows five different scenarios analysed in the planning project of the Goteborg case study. The scenarios are defined by a number of assumptions describing the context of the energy system: increase of the electricity price, increase of the real interest rate, limited gas supply, limited expansion of CHP plants.

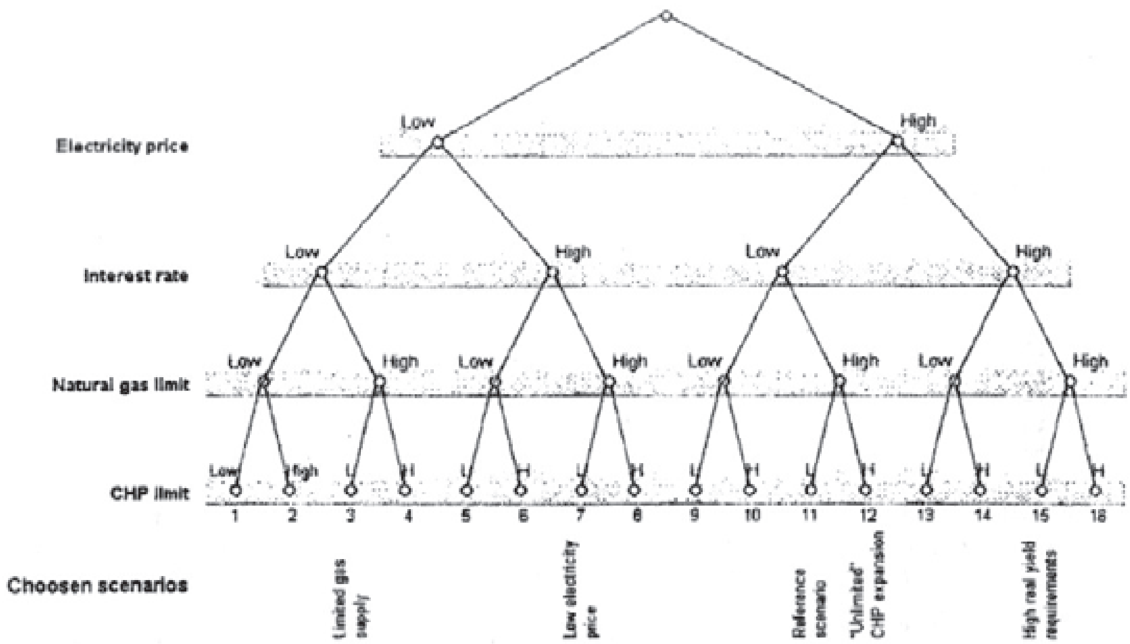


Figure 9.4 The five scenarios chosen for the Goteborg case study

Although the concept of scenario techniques has its origin in the area of comprehensive studies it is considered useful for component studies as well. For both categories, this concept facilitates a top-down approach to structuring and documenting data, performing data acquisition and communicating within the project team.

Formal and logical plausibility checks
In order to generate feasible solutions and to separate useful results, the energy models provide formal and logical plausibility checks. Formal plausibility checks trace formal input errors such as typing, unit or dimension mistakes. Logical plausibility checks eliminate logical deficits in the input elements, determined by incomplete problem definition.

Meaningful scenarios
In scenario analysis, useful results are filtered from those considered not useful. After the separation of useful results from a set of scenarios has been completed, it is essential to find a suitable format for cross-scenario presentation.

Robust recommendations and 'if then' hints
In order to derive recommendations from the scenario analysis, robust strategies are to be distinguished from 'if then' strategies. A robust strategy is defined by those elements which appear in more

or less all scenarios, whereas an ‘if then’ strategy is based upon the choice of a few conditional elements appearing in specific scenarios only.

Derivation of recommendations
From the discussion of the scenario results, recommendations can be derived for measures to be proposed by the reference group. The measures finally recommended and adopted by the reference group should first be separated into organisational and investment measures. They should then be categorised according to the time frame and characterised for possible interactions with each other. Finally priorities must be set by the reference group for the recommended measures in order to arrive at an action plan for implementation.

The documents
The presentation and publication policy for an ALEP project is not a trivial matter, since decisions for specific energy strategies often involve a number of sensitive issues affecting various aspects of society. Release of information and presentation of results should therefore be planned deliberately. The project management group should normally be given the responsibility of disseminating the information. The reference and steering groups should monitor the dissemination activities.

It is advisable to decide from the outset which information should be released, and at which phase of the project, to those expecting information. The project management group should normally be given the responsibility of disseminating the information. The Reference Group and Steering Group should monitor the dissemination activities.

10.0 Case Studies

10.1 Introduction

The ALEP guidebook is based on the experiences of the participants using the comprehensive energy model MARKAL throughout individual projects.

10.2 Goteborg

Local energy planning is an ongoing process in Goteborg starting two decades ago. Since 1987 it has been characterised as advanced local energy planning. The ‘Energy Plan 2000’ published in 1995 is a typical example of ALEP. The objective of the ‘Energy Plan 2000’ is to provide a broad direction for Goteborg’s energy policy. The initiative for the plan came from the Environment Policy Steering Group and prepared by the Goteborg Planning Commission. The Energy Group, comprising municipal, utility and national members, developed the plan. The Environmental Policy Steering Group were kept well informed about developments and relevant members of a Reference Panel were invited to hearings when particular issues were discussed.

As part of the project the district heating production was analysed using both MARKAL and MARTES, see Figure 10.1. The results from the two models were not exactly the same, e.g. regarding the suggested size of a future CHP plant. This can partly be explained by the different degree of detail in the used load curve with the simplified load curve of MARKAL being the basis of determining the size of the CHP plant, since the load level during spring and autumn was constant. However the load level during the winter was too short to make CHP production at that power level economic. The load curve of MARTES does not affect the size of a CHP plant in the same way.

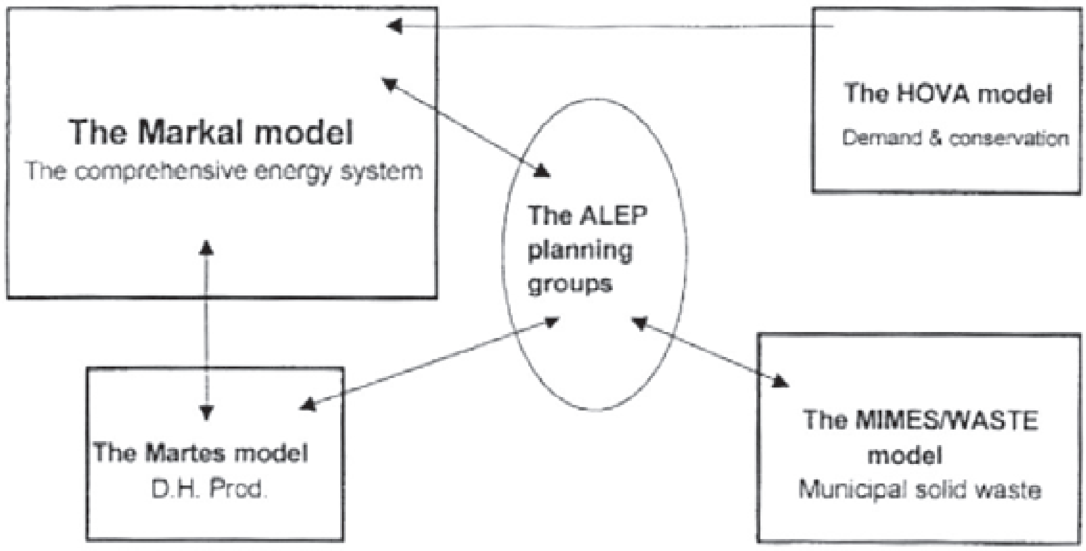


Figure 10.1 Models used in the ALEP planning process in Goteborg

10.3 Mannheim

The main purpose of the Mannheim case study is to analyse and possibly verify the existing local energy plan, developed during the 80s by MVV Energie AG, for the city of Mannheim with a comprehensive computer model MARKAL.

The MVV heat atlas was designed as a marketing instrument. Typical data of every building in Mannheim is located in the buildings register. This file is updated periodically from a database maintained by the city of Mannheim. The accountancy system of MVV contains important data for every customer (e.g. energy consumption). The combination of selected data from both systems through the street address constitutes the database of the heat atlas. Consumption data maintained in the accountancy system is loaded into the heat atlas during night-time to keep the records up to date. The heat atlas could then be used to aggregate consumption data, floor space etc. for specific building types within regions as input data for the energy model.

The outcome of the work has shown that the comprehensive model was able to reveal and quantify sources of future uncertainties, which have to be analysed in more detail using other tools. It has also demonstrated the value of a combined strategic and operational approach.

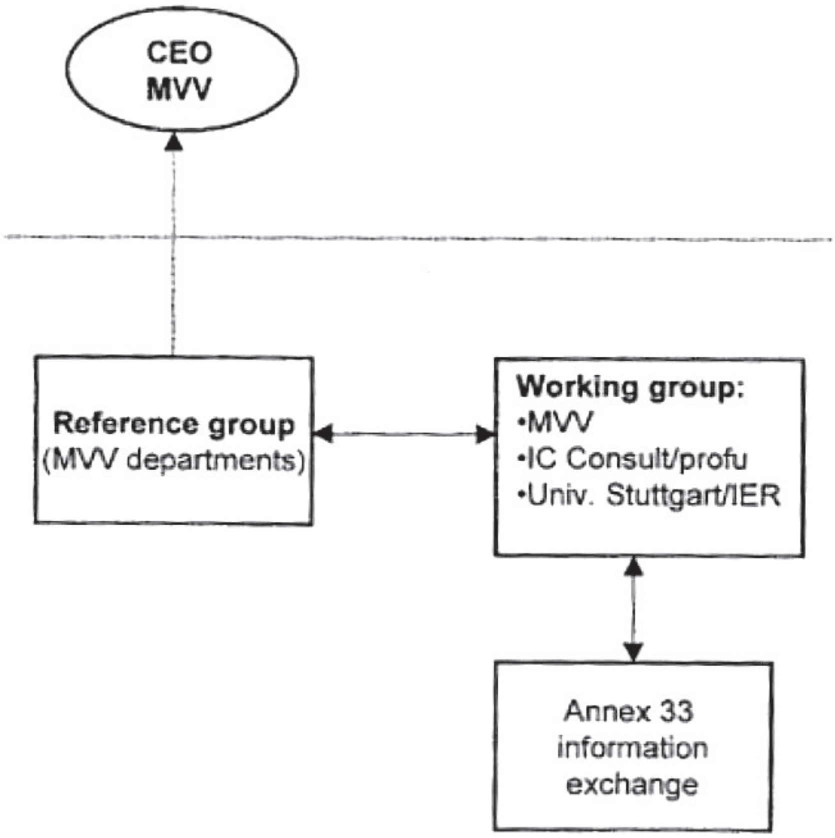


Figure 10.2 Structure and relationship between groups involved with the Mannheim Case Study

11. Conclusions

For a long time many practitioners of LEP worked in isolation with little knowledge of what others are doing.

Annex 22 reviewed the different methods, instruments developed in the field of LEP by interested IEA countries, and can be considered as a supplement to almost all other annexes of the IEA programme which are devoted to single buildings or their subsystems rather than to community systems. A major outcome of Annex 22 was the formalisation of LEP into a process accessible to a wider audience.

Although LEP is capable of modelling a complex local energy system, further improvements to user friendliness were required. These have been made in Annex 33 by the exchange of information based on experience and the results of using modelling. The work of Annex 33 has also identified areas where improvements to the comprehensive model MARKAL, used in the Annex 33 case studies, can be made and these are being addressed by further international cooperation with IEA-ETSAP.

The Guidebook on Advanced Local Energy Planning describing the principles and sequence of steps in an ALEP project can be used by those with a background in traditional energy planning to understand the potential benefits of comprehensive systems analysis tools for strategic planning.

12. References

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Appendix 1 Participating Organisations

Belgium

Studiecentrum voor Economisch en. Sociaal Onderzoek, University of Antwerp
Studiecentrum STEM

France

RE-Sources

Germany

Federal Ministry for Education and Research (BMBF), Bonn/Berlin
Research Center Julich (FZJ)
MVV – Energie AG, Mannheim
IC Consult GmbH
Vereinigte Saar-Elektrizitats AG (VSE)
Ped GmbH
B & S.U. GmbH

Italy

Basilicata Regional Authority
INFM – National Institute for Physics of Matter
IMAAA – CNR Institute of Advanced Methodologies for Environment Analysis – National Research Council
LAME – Energy Department, Politecnico di Torino

Sweden

Swedish Council for Buildings Research
Goteborg Energi AB
Energy Systems Technology Division, Chalmers University of Technology
Profu AB

The Netherlands

NOVEM b.v.

Turkey

Ankara Greater City Municipality
Belko Ankara Coal and Supply materials Distribution Company

Appendix 2 MARKAL

MARKAL is a generic model tailored by the input data to represent the evolution over a period of usually 40 to 50 years of a specific energy system at the national, regional, state or province, or community level. As a comprehensive model for energy-environmental planning it allows the user to get a holistic view of the system, by integrating data coming from different sources. In particular, energy, soci-economic and environmental constraints can be combined and taken into account simultaneously to determine the optimal future configuration of the anthropogenic activities' system which achieves the desired targets.

The basic components in a MARKAL model are specific types of energy or emission control technology. Each is represented quantitatively by a set of performance and cost characteristics. A menu of both existing and future technologies is input to the model. Both the supply and demand sides are integrated, so that one side automatically responds to changes in the other. The model selects that combination of technologies that minimizes total energy system cost.

Unlike some "bottom-up" technical-economic models, MARKAL does not require, or permit, an a priori ranking of greenhouse gas abatement measures as an input to the model. The model chooses the preferred technologies and provides the ranking as a result. Indeed, the choice of abatement measures often depends upon the degree of future abatement that is required.

Typically, a series of model runs is made examining a range of alternative futures. The model requires input projections of, for example, energy service demands, room space to be heated or vehicle-miles to be travelled and projected resource costs. Then, a reference case is defined in which, for example, no measures are required to reduce carbon dioxide emissions. A series of runs is then made with successive reductions in emissions: emissions stabilized at present levels, for example, then reduced by 10 percent, 20 percent, etc., by some future date before being stabilized.

In each case, the model will find the least expensive combination of technologies to meet that requirement, up to the limits of feasibility, but with each further restriction the total energy system cost will increase. Thus, the total future cost of emission reductions is calculated according to how severe such restrictions may become. These can be plotted as continuous abatement cost curves. In addition, the marginal cost of emission reduction in each time period is determined.

The International Energy Agency (IEA) Energy Conservation in Buildings and Community Systems Programme (ECBCS)

The International Energy Agency (IEA) was established as an autonomous body within the Organisation for Economic Co-operation and Development (OECD) in 1974, with the purpose of strengthening co-operation in the vital area of energy policy. As one element of this programme, member countries take part in various energy research, development and demonstration activities. The Energy Conservation in Buildings and Community Systems Programme has sponsored various research annexes associated with energy prediction, monitoring and energy efficiency measures in both new and existing buildings. The results have provided much valuable information about the state of the art of building analysis and have led to further IEA sponsored research.