On Sustainability in Local Energy Planning

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Doctoral Thesis

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To My Parents

Abstract

Energy is among the main driving forces needed for sustainable development. Provision of energy services, from the supply side to transmission/distribution and use, must include management, and good management requires tools. Energy planning is a tool for managing the community energy system through assessing and balancing supply and demand.

This thesis explains an approach to energy planning which increases the capacity for managing and developing the community energy system in a more sustainable manner. Explaining the logic of planological integration in planning theory, the author describes how this logic can be applied to existing energy planning methods. These methods could be modified in such a way that fulfillment of sustainability objectives can be integrated into the planning process.

Energy planning has been and is still used for managing the Swedish energy system at both national and local level. Since 1977, Swedish municipalities have been legally required to have a document called "Energy Plan" decided upon by the local government. Over 30 years of municipal energy planning and its effectiveness in promoting the local energy system is studied in this thesis. The main objective is to investigate to what extent existing energy planning methods can address energy-related sustainability objectives. A pilot project is carried out to examine whether proxy variables can be used to measure and monitor sustainability dimensions of local energy systems.

It is observed that existing energy planning praxis is less suitable in addressing sustainability objectives. The main reason for the shortcomings of existing energy planning methods is that they typically have a narrow focus on local energy systems such as input-output (supply-demand) systems, which makes them inefficient as regards the transition toward sustainable energy systems. Other reasons identified include weaknesses in the relevant legal planning framework (the Municipal Energy Planning Act), problems caused by the deregulation of electricity markets, and a lack of financial resources for energy

planning. Results from the pilot project indicate that properly defined energy indicators (such as energy use per capita, transport energy intensity, solid waste to energy) can be useful in monitoring the sustainability of local energy systems. It is observed that such energy indicators can also be useful in developing local energy systems through knowledge exchange and learning processes.

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Nomenclature

ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie (*The French Environment and Energy Management Agency*)
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon dioxide
CSD	Commission on Sustainable Development
EEA	European Environment Agency
EFOM	Energy Flow Optimization Model
EISD	Energy Indicators for Sustainable Development
ENPEP	Energy and Power Evaluation Program
EU	European Union
Eurostat	Statistical Office of the European Communities
GDP	Gross Domestic Products
GHG	Greenhouse Gas
GWP	Global Warming Potentials
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KLIMP	Klimatinvesteringsprogram (*Climate Investment Program*)
KWh	Kilo Watt hour
LEAP	Long-range Energy Alternatives Planning
MARKAL	Market Allocation Model
MCDA	Multiple Criteria Decision Aid
MESAP	Modular Energy System Analysis and Planning
MESSAGE	Model for Energy Supply Systems And their General Environmental impact
MURE	Mesures d'Utilisation Rationelle de l'Energie (*Rational Measures for Energy Use*)

MWh	Mega Watt hour
N_2O	Nitrous Oxide
NGO	None Governmental Organizations
NUTEK	Närings- och Teknikutvecklingsverket (*Swedish Agency for Economic and Regional Growth*)
ODYSSEE	Online Database for Yearly Assessment on Energy Efficiency
OECD	Organisation for Economic Co-operation and Development
PASTILLE	Promoting Action for Sustainability Through Indicators at the Local Level in Europe
PEPESEC	Partnership Energy Planning as a tool for realising European Sustainable Energy Communities
PRIME	Preference Ratio in Multiattribute Evaluation
RETscreen	Renewable-energy and Energy-efficient Technologies
RRV	Riksrevisionsverket (*The Swedish National Audit Office*)
RUE	Rational Use of Energy
SEA	Strategic Environmental Assessment
SEP	Sustainable Energy Planning
SFS	Svensk författningssamling (*Swedish Code of Statutes*)
SOU	Statens offentliga utredningar (*Government Official Reports*)
SYSAV	Sydskånes avfallsaktiebolag (*South Scania Waste Company*)
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNDPCSD	Department of Policy Co-ordination and Sustainable Development, UN Division for Sustainable Development
WECD	World Commission on Environment and Development

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1. Energy planning – a tool for sustainable development

1-1. Introduction

Living in a sustainable manner is an ever increasing and important desire of many countries, governments, communities and individuals. The term 'sustainability' is associated more and more with our social activities, people's behavior, institutional values and environmental issues. The concept of sustainability has now entered into a broad range of different fields of human life, which causes different interpretations of the term among different people. The concept is broad enough to allow various approaches in defining what it means; however, attempting to be sustainable can generally play a positive role in improving the quality of human life over time. It is a continuous improvement which covers almost all dimensions of human life with interrelationship among themselves and their surrounding environment. This procedure of continuous improvement is famous as 'Sustainable Development', a procedure in which various dimensions of life should have a harmonized progress. These dimensions in turn have various elements which are often organized into three main categories: environmental, economic and social.

Among all these elements, energy is chosen in this study as one of the key elements, which has strong relationships with all the three main dimensions of sustainable development. Human well-being and improvement of social welfare greatly depend upon affordable access to energy services. Almost all the goods and services that are necessary for communities' development are linked to the provision of sufficient energy supply. Energy is also among the important driving forces that can affect the environment both by extraction of energy from natural resources and by energy use. The negative

environmental impacts of energy use and particularly global warming are now leading many countries to prepare for transition towards more sustainable energy systems.

The setting of international energy-related strategies, e.g., by the European Council in March 2007, which has a target of 20% reduction of greenhouse gas emissions by the year 2020, is among the examples that show the importance of long-term energy strategies at the highest levels of decision-making systems. The willingness to set similar strategies at the lower levels of communities can also be seen through other programs, e.g., 3-NITY[1] and Wise-Plans[2] and PEPECEC[3] which aim to integrate local/regional energy strategies with sustainable development goals. The strong relationship of energy with the environmental, social and economic aspects of sustainable development means that community energy systems are becoming more complex and complicated to run. The importance of energy for achieving sustainable development goals has been a major driving force towards new approaches to community energy planning (Ferreira, 2007). Conventional energy planning methods are generally focused on energy supply, distribution and use, mostly from technical and economic points of views. To address the sustainability challenges, taking integrated approaches to energy planning that comprise energy-related aspects, environmental, economic and social, seems to be necessary.

This study aims to provide a deeper insight into energy planning and how it can be used as a tool for implementing sustainable development. This will be done through establishing and explaining the relationship between Planning Theory and the principles of sustainable development.

1-2. Objectives

Energy planning is known as a means to manage community energy systems. It has been (and still is) applied in many countries as a tool for setting up future energy policies ranging from national to local levels. This thesis focuses

[1] For more information see: http://www.ieeprojects.net/treenity.html
[2] For more information see: http://www.wiseplans.eu/
[3] For more information see: http://www.pepesec.eu/

on local (municipal) energy planning in a Swedish context. Previous studies on municipal energy planning in Sweden have shown that the importance of energy planning as a tool for community energy management has diminished over time (Swedish Energy Agency, 2006; D. Rad, 2008; Ivner, 2009). It has been observed that many Swedish municipalities in recent years have not updated their energy plans; instead, local authorities are more in favor of working on climate plans, environmental analyses and in general they are more concerned about sustainability issues.

The overall objective of the thesis is to investigate how sustainability can be fully implemented in local energy planning. It explores weaknesses inherent in conventional energy planning methods and suggests how these methods can be improved. Furthermore, the thesis attempts to develop a practical methodology by way of which the sustainability of local energy systems can be measured and monitored.

1-3. Theoretical framework

In order to get a better understanding of the relationship between energy planning and sustainability aspects, it is necessary to create first a logical framework based on two theoretical pillars:

- Planning Theory
- Well-defined principles of Sustainable Development

In this thesis, the author attempts an approach to energy planning which is based on a network of links between the community energy system with both planning theory and the principles of sustainable development. This network describes the research approach to community energy planning. On one hand it explains the logical structure of energy planning, and on the other hand it illustrates the environmental, social, economic and institutional principles of sustainable development that should be integrated into the planning process (Figure 1).

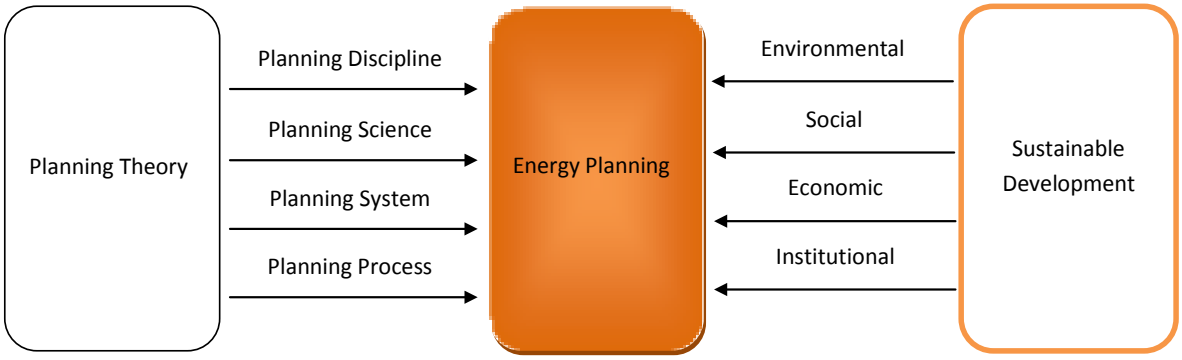


Figure 1: A schematic drawing of the theoretical framework

1-4. Research methodology

This thesis is in two main stages. The first stage is to clarify the research approach which is based on the relationship between planning theory and the principle of sustainable development. This clarification helps to reach a better understanding of the concept of the term 'sustainability', its various dimensions and how these dimensions should be addressed through the planning procedure. The core discussion is extended to energy planning to identify the characteristics that a sustainable energy plan should consist of. Furthermore, as a background, factual information about municipal energy planning in Sweden is given, both in terms of its evolution over time and of its current status.

In the next stage, a practical methodology for measuring and monitoring the sustainability of a local energy system is developed. This methodology is based on identification of a set of energy indicators which are applied to three municipalities with rather different energy systems.

1-5. Research boundaries and limitations

Energy planning deals with a wide range of various aspects, e.g., environmental, economic, social and institutional; hence, doing any related

research requires systematic thinking and a multidisciplinary approach to the field. To avoid confusion, the boundaries of the research area should be clarified specifically. This thesis is focused on local (municipal) energy planning in Sweden. The word 'municipality' in this thesis refers to the whole geographical territory and the administrative entity, which is governed by a mayor and a council. The timeframe for municipal energy planning is from the time that it was made law by the Swedish parliament in 1977 up to 2010.

Two major limitations that affect this thesis should be mentioned. Firstly, Sweden has 290 municipalities, but the existing official reports on Swedish municipal energy planning do not represent all municipalities since more than 25% of them are not working with energy planning. This will consequently affect the generalization of the results on the status of local energy planning. Moreover, most of the available official reports and other related publications on local energy planning are from recent years (less than ten years) and therefore the general analysis of the evolution of local energy planning throughout the research timeframe will be limited to the few available resources.

Secondly, the municipal energy-use data are available from various organizations and entities, e.g., the National Statistical Center, local energy companies and the municipalities themselves. Since different actors, depending on their needs and interests, may collect data according to different methods and categorizations, it is important that careful attention is paid to the selection of the most reliable data sources. In this thesis, the National Statistical Center "Statistics Sweden" is used as the main data source while other sources have been occasionally used in the event of data gaps or abnormalities.

1-6. Outline

The thesis consists of 7 chapters:

Chapter 1 provides an introduction to energy planning and its relationship with sustainable development. It also explains the objectives of this thesis, its theoretical framework, how the research methodology is designed and what limitations exist.

Chapter 2 describes the theoretical approach taken in this thesis by describing linkages between planning theory and principles of sustainable development.

Chapter 3 provides a deeper understanding of the concept of 'sustainability' by discussing its various definitions and interpretations. Thereafter, the relationship between energy and the sustainability dimensions is discussed.

Chapter 4 presents an overview of energy planning procedures and various methods of their application. The role of energy planning in promoting the sustainability of the community energy system is also discussed in this chapter.

Chapter 5 starts with a background to the overall status of local (municipal) energy planning in Sweden and how it has evolved over time. The effectiveness of energy planning in developing the local energy system, the existing challenges and how they could be resolved are discussed in this chapter.

Chapter 6 presents a pilot project exemplifying how local energy indicators can be applied. A methodology is presented for measuring and monitoring energy-use trends and how they should be linked to the sustainability objectives is described in this chapter.

Chapter 7 contains the main conclusions of the thesis.

2. Theoretical framework

This chapter explains how the theoretical framework of the thesis is formed by describing linkages between planning theory and principles of sustainable development. These linkages are used to structure the research approach to community energy planning. They are also used as the platform for further discussions and analysis.

2-1. The planning concept

To arrange their daily activities, shopping, weekend activities, where to travel in their holidays, etc., people normally think about how to do it, at what time, where, at what cost and many other related issues to identify the most appropriate way of doing it. Planning can sometimes be very simple and routine, such as going to work every day, but it can also be a very complex procedure, for instance, how to land humans on the moon and bring them safely back. Simple or complex, all plans follow similar procedures that consist of taking a series of steps to achieve one or more goal(s) in the future. Planning techniques have evolved over time and have become the subject of many studies and researches that have developed various planning methods and models.

Ozbekhan (1970) explains the evolution of planning as humans' attempt to develop tools to overcome problems. He points at many difficulties driven by the fact that humanity has crossed over many boundaries e.g. information, communication and mobility, which provides a living environment with

characteristics that are found in large, integrated, inter- and intra-active, complex, dynamic systems. The overall behavior of these systems (and their subsystems, e.g., natural environment, society and institutions) is quite difficult to understand; therefore, Ozbekhan refers to planning as a problem-solving approach and a tool with which to deal with such difficulties. This tool should help us to overcome various problems that are structured both in terms of priorities, of the needs they create and of the solution they appear to suggest. According to Ozbekhan, *"it is impossible to grapple with one problem without grappling simultaneously with all the others, and this fact alone has grave implications for the future because solutions require decision"*; and therefore he defines planning as *"a future-directed decision continuum"* which consists of various functional relations that tie these decisions into a complex network of action flows and control mechanisms (Ozbekhan, 1969, p. 135).

Several definitions of such planning have been introduced by various people differently and for different purposes, but with a common conceptual framework that could be said to constitute principles of planning (science). Ozbekhan described planning as a human social activity and defined it as a process whose function is to reduce entropy and increase organization within the environment.

Ackoff (1970) defines planning as the design of a desired future and of effective ways of bringing it about. He believes that planning should be a continuous process and hence no plan is ever final; it is always subject to revision. Ackoff divides the planning process into parts which a plan should contain:

1- **Ends**: specification of objectives and goals
2- **Means**: selection of policies, programs, procedures, and practices by which objectives and goals are to be pursued.
3- **Resources**: determination of the types and amounts of resources required how they are to be generated or acquired, and how they are to be allocated to activities.
4- **Implementation**: design of decision-making procedures and a way of organizing them so that the plan can be carried out.

5- **Control**: design of a procedure for anticipating or detecting errors in, or failures of, the plan and for preventing or correcting them on a continuing basis.

Sagasti (1973) defines planning as *"anticipatory decision making. It is a process whereby a system selects outcomes and courses of action in a series of interrelated choice situations which have not yet occurred, but which are envisioned to occur in the future"*. He explains the act of planning as a process related to events which have not occurred yet and that are possible to influence by taking action at present. Sagasti points at three fundamental aspects of planning which are important to understand in the planning process; first, its close relationship with the decision-making procedure, second, its orientation toward the future and third, the interrelation between the different anticipated choice situations and the decisions made at each of them.

Friedmann and Hudson (1974) suggest the provision of a broad definition of planning. They define planning as "*an activity centrally concerned with the linkage between knowledge and organized action*". They look upon planning as a professional activity and as a social process which is located precisely at the interface between knowledge and action. Friedmann (1987) defines planning as "*an attempt to link scientific and technical knowledge to actions in the public domain*". He is aware of the limitation of this definition, which is its usefulness for specific actors in the public domain. Hence, to avoid creating conflict between bureaucratic state planners and other planners in other fields, e.g., economic, public administration, organization development, etc., Friedmann suggests a further definition as "*an attempt to link scientific and technical knowledge to process of societal guidance and social transformation*".

2-2. Planning theory

Attempts to build a conceptual framework for Planning Theory have been made since the early 1960s. Various approaches have been taken to form a general theory of planning through linking planning processes within different (but related) fields, e.g., environmental, socio-economic, urban planning, with various disciplines of social sciences, philosophy, politics, economics, public administration, etc.

These approaches, in one way or another, were adopted to overcome a widespread skepticism about the possibilities of building a general planning theory. A detailed discussion of each of these approaches is beyond the framework of this research[4]; instead, investigation of the general debate on planning theory and various approaches taken to the subject are considered to form the theoretical structure of research.

To explain what is meant by the term 'Planning Theory' is rather complicated, since the term 'planning' is utilized within many different fields. Various definitions of what planning theory implies are based on different interpretations made by different people, planners or planning theorists. One of the most well-known approaches to planning theory is the systems approach taken by Faludi in 1973.

He forms his systematic approach by explaining the general interactions between the planning processes, as a part of a social guidance system, and its surrounding environment. Faludi points at modification of actions resulting from the planning process which is aimed at the specific set of environmental variables (Figure 2). Based on this view, Faludi defines planning theory as a theory "*explaining what planning processes performed by societal guidance institutions have in common; including their systematic variations"* (p. 69). This definition should be general enough to cover all the specific areas of planning application (Faludi, 1973; Friedmann, 1987). According to Faludi, a specific theory of planning should explain how the activities of a particular planning system relate to a general theory of planning.

[4] Through this research, many other related works and literatures on planning theory written by, e.g. ,Taylor N. (1979), Salet W.G.M (1981), Healey P., McDougall G. and Thomas M.J. (1982), Lauria M. (2010), and Stiffel B. (2000), have been studied but not judged to be of central importance for this specific thesis.

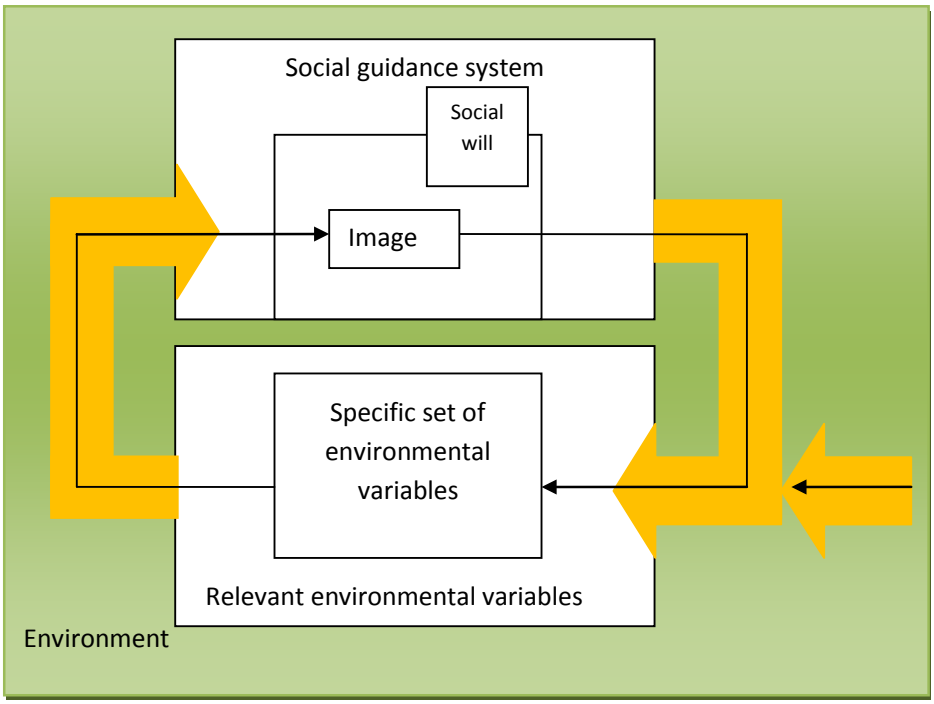


Figure 2: The conceptual framework for planning theory

(Source: Faludi, 1973)

Faludi's definition for planning theory is among the well-known attempts to create a conceptual framework for planning theory. Campbell and Fainstein (1996) express the view that definition of planning theory is a slippery subject whose explanation is often frustratingly tautological. They point at four reasons to explain why it is not easy to define planning theory:

- Overlapping with theory in all the social science disciplines
- Unclear boundary between planners and other professionals such as real estate developers, architects, city council members (planners do not just plan and non-planners also plan)
- Different interpretation of planning by those who define it according to its object (land-use, natural environment) and those who define it by its method (the process of decision-making)
- Different planning methodologies

Although planning as a process can be done in many different fields and through various methods, identification of a general theoretical framework should not be confusing, since any planning activity is about achieving desired goal(s) in the future, through some steps and within a specific period of time. The debate on how planning theory ought to be, on the other hand, can help create a better understanding of the concept and its different dimensions which are applied in different disciplines. There follows a collection of discourses on planning theory and various approaches taken to the subject which are fundamental to the theoretical framework of this research.

Hudson (1979) was among those planners who made attempts to develop new perspectives within the theory. He identified a five-part classification of planning traditions as Synoptic, Incremental, Transactive, Advocatory and Radical (SITAR) planning:

- Synoptic planning, also known as the 'Rational Comprehensive Approach', looks at problems from a system point of view and uses conceptual or mathematical models, with heavy dependence on numbers and quantitative analysis. Hudson believes that synoptic planning, compared to other planning traditions, is more robust in the scope of problems it addresses and the diversity of operating conditions that it can tolerate. However, Lindblom (1959) states that (synoptic) planning based upon models and simulations is unrealistic. Boyne et al. (2004), in their empirical test of this tradition in public agencies, were faced with large technical problems. They stated that the data required for synoptic planning are hard to obtain and even harder to interpret.

- Incremental Planning is based on the accomplishment of public policy through decentralized bargaining processes in a free market and a democratic political economy (Lindblom, 1959). According to Lindblom, incremental planning's greatest strength is that instead of attempting to be rational and comprehensive it describes decision-making as it actually occurs. In this tradition, policy is continually

being made and re-made; thereby it avoids errors that come with radical changes in policy and stays within a predictive capability.

- Transactive planning approach is rather different in its methodology compared to other traditions. Its method is more focused on the whole experience of people's lives, the existing challenges and the policy issues that need to be addressed. It goes through a face to face contact with the community inhabitants that are affected by the decisions. This planning tradition does not need very much of field surveys and data analysis, instead it focuses more on inter-personal dialogues followed by a process of mutual learning (Hudson, 1979). Transactive planning is actually operated through decentralized planning institutions which help people to take more control over the social processes that govern their welfare (ibid).

- Advocacy planning aims to develop plural plans rather than a unit plan (Davidoff, 1965). It is a pluralistic form of local politics around competing plans that are produced by different interest groups (Faludi, 1973). Hudson (1979) describes the advocatory method as a planning procedure which is based on legal adversary procedures to defend the interests of weak (or poor) community groups against the strong and established power of businesses and government. Advocacy planning encourages citizen partnership in the planning process, which consequently moves the formulation of future policies from smaller interest groups out to larger social clusters.

- Radical planning is a tradition of planning that is more action-oriented and has its roots in civil society rather than the state (Friedmann, 1987). It is often in opposition to the state (and sometimes to corporate interests), and allies itself with social movements to defend the right to housing, socially and ecologically sustainable development, feminist concerns and others (Friedmann, 1987, 2008).

Hudson believes that these traditions (above) are sufficient to map various challenges that planners address. He compares the taxonomy of these traditions to a Sitar[5] that can render a reasonable solo performance in good hands (of planners), while more complete possibilities can be provided by using each theory in conjunction with the others. Hudson continues that planners should have the ability to mix different approaches to be able to respond with sensitivity to the diversity of problems and complex situations. John Friedmann presented more detailed typologies of planning theory in his book *Planning in the Public Domain* (1987). He identifies four traditions of planning thought as planning as policy domain, social learning, social reform and social mobilization (Table 1)[6].

Table 1: The four traditions of planning theory

Social reform: includes the disciplines of sociology, institutional economics, and pragmatism. It recognizes the state as the vehicle of social action. Planning is a scientific endeavor to make state action more effective. The economy can be adjusted to serve representative needs through business-cycle analysis, input/output analysis, economic policy models, and others.

Policy analysis: includes the disciplines of systems analysis, welfare and social choice, and policy science. It concentrates on decision making as a means of identifying the best possible courses of social action. Planning is a decision process which emphasizes stages that begin with the identification of goals that will structure the decision and ends with program analysis, which evaluates the correctness of the decision. This is the rational model participated in by technical planners who view themselves as social engineers serving the existing power base.

Social learning: includes the field of organization development. It is an effort to minimize the contradictions between what we know and how we act. Planning attempts through social experimentation to change social behavior. This is accomplished by doing: knowledge is validated practice, and theory is enriched from lessons learned from experience. Planners and client actors are involved in

[5] An Indian instrument (a type of lute)

[6] These summaries of Friedmann's planning theory traditions are adapted from Burchell (1988).

nonhierarchical exchanges of information to further learning.

Social mobilization: includes neo-Marxism, the Frankfurt School (of critical theory), and a category Friedmann calls utopians, social anarchists, and radicals. It is a view of the primacy of action from below. Planning is a political activity which attempts to change the status quo of oppression and alienation under capitalism. Social mobilization emphasizes the politics of disengagement and confrontation. The planner's role is one of community organization, advocacy presentation and interpretation of data, and representation within and cooptation of the decision-making process.

Friedmann (1987) believes that the major object of planning theory is to solve the "*meta-theoretical problem of how to make technical knowledge in planning effective in informing public actions*" (p. 36). He extends his approach to the terrain of planning theory and concludes:

> *"a comprehensive exploration of the terrain of planning theory must cull from all the relevant disciplines those elements that are central to an understanding of planning in the public domain. The theory of planning is an eclectic field, bounded by political philosophy; epistemology; macro-sociology; neo-classical and institutional economics; public administration; organisation development; political sociology; anarchist, Marxist, and utopian literature" (Friedmann, 1987, pages 39-40).*

Friedmann's approach presents a more sophisticated understanding of planning theory which is actually too complex to be bounded. According to Allmendinger (2002), Friedmann's approach has "*sidestepped the substantive–procedural distinction by focusing more on the antecedents of planning theory*". He continues that Friedmann is pluralizing the theory by adding to it rather than addressing why it was happening. Friedmann's use of a timescale for 'theory as progress' to locate different traditions of planning theory and their relationship to each other is also criticized by Allmendinger, since he believes that the complex relationship between theories, society, time and space denies an easy analysis. He avoids a linear approach to theoretical development and putting a 'timeline' upon the different traditions, and states:

> *"There is no simple linear development of theory but a more complex situation. Planning theories exist side by side with varying degrees of overlap… Further the interpretation of such theories cannot be assumed to be uniform across space" (Allmendinger, 2009, p.230).*

Archibugi (2008) has another viewpoint on Friedmann's approach; he believes Friedmann's definition has expanded the scope of planning theory too much. He argues that this definition is developed over a very broad area of vast boundaries that "*could be at the root of the regretted loss of identity of planning theory itself*". Archibugi considers that planning theory should be exactly the opposite:

> *"It should start with a rigidly restrained field of analysis (planning, in its different applications) and bring to it an enormity of points of view; those points of view have remained until now very separate, to such an extent as to make each one incapable of providing a truly integrated and comprehensive vision of planning" (Archibugi, 2008, p.9).*

The vastness of the planning theory field seems a little dangerous to Archibugi, since the multidisciplinarity of the approaches to planning theory can mislead the development of planning theory itself. The substantive aspects of planning can cover the different areas of housing, transportation, economic development, health services, etc., which are hard to delimit. Alexander (1992) states that "*the planning theory explores the planning process and examines its components: What are they? How do they interrelate? How are they affected by the context of planning efforts? How do they determine planning outcomes?"* All these affect the question of how planning should be done; and therefore he believes:

> *"The core of planning theory is the planning process: how should and do people plan?" (Alexander, 1992, p.9)*

Following the vast current trends of the debate on planning theory, Archibugi states that it is time now to create a logical framework which could implement the desired advancement towards a greater integration of the different planning approaches, a framework through which it may be possible to establish stable links between procedural and epistemological planning and to get a "*unitary methodological scheme*". Archibugi argues that looking at planning as a trans-disciplinary activity which applies within various disciplines, e.g., physical (urban planning), economic (planning), social (planning), development (country or regional planning) and operational (management planning), is responsible for malfunctioning and crisis. He continues that planning should be emancipated from the conditions of other disciplines by taking a unified approach to a new discipline of 'planning science' (in the singular form), or *Planology*. The logic of planology is summarized in the following lines:

- "to elaborate and strengthen the unitary procedure scheme in the preparation of plans, with the relative indication of the phenomena (variables) to be quantified in the various phases of preparation of a typical integrated plan;
- to strengthen and define schemes of the systemic inter-relationship between the various levels of planning and thus of the various plans;
- to design institutional procedures (and relative institutions) for plan bargaining at all levels; as well as to design consultation systems of the opinions and preferences of the participants interested in the plan;
- to design (and manage) suitable information systems that correspond to the preselected variables and to the accounting systems instituted, (according to the previous points);
- to design monitoring and evaluation systems of the operational capacity of the plans, and of a periodical review and updating of the same" (Archibugi, 2008, p. 41)

Although all of these areas are covered with an 'integrated' character, taken from different fields of various disciplines, they all have one common characteristic which allows them to belong to the new discipline of planning science and Archibugi calls it "*plano-centric*". In other words, they are aimed

at the preparation and implementation of plans[7], a common procedural framework with distinctive functions that is called the planning process. Archibugi defines the subject of the planning process based on two main categories of *selection* (or choice of plan) and *implementation* of a plan (Figure 3).

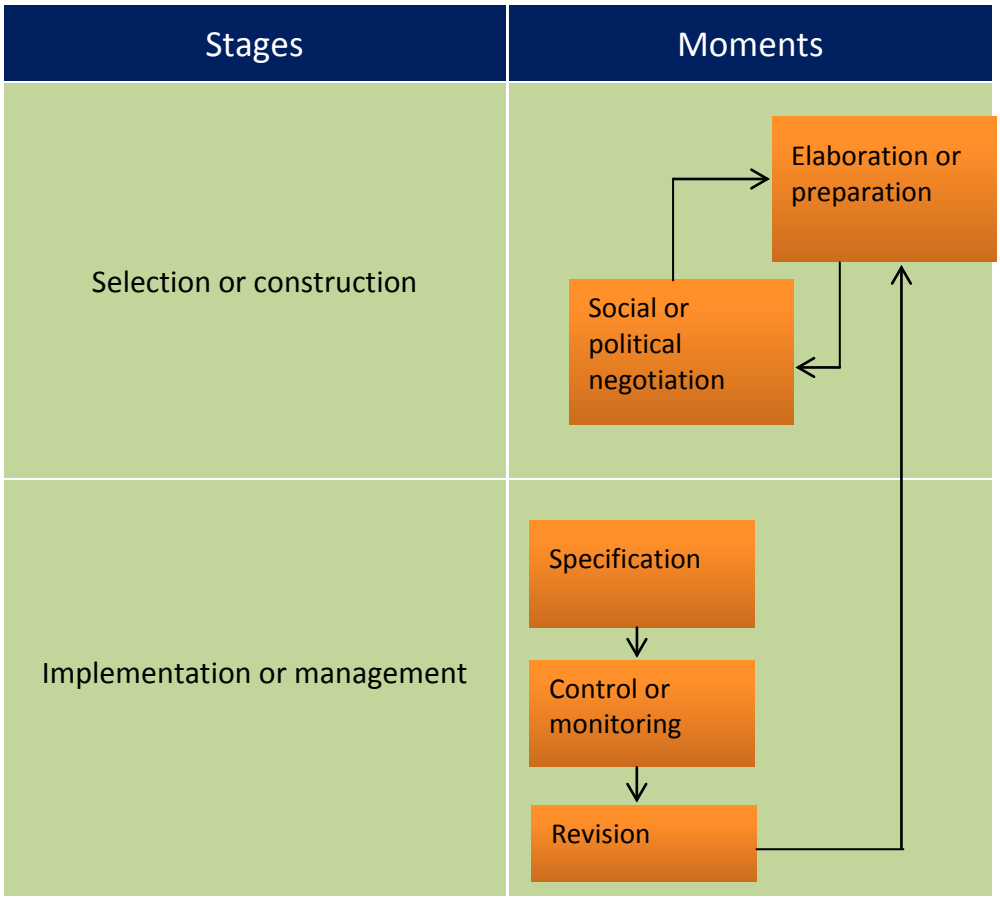


Figure 3: The planning process model

(Source: Archibugi, 2008)

[7] The plano-centric characteristic of the above-mentioned areas is used as the fundamental element for building the framework of this research. It is discussed in the next step how the principles of sustainable development should be integrated into the planning process, and ultimately into community energy planning.

Dividing the planning process into 'selection phase' and 'implementation phase' is described by Archibugi as a simplified and useful working system that can be applied "*at every stage or level of planning (since there is almost always a superior and inferior level at any stage which can sensibly reshape the process as a whole)*". He uses this working system to model his planning system with two subsystems: planning selection and planning implementation. The planning selection subsystem is important because of its strategic nature, what is aimed at (in the plan) and how it should be achieved. For this subsystem, Archibugi identifies three basic dimensions of the selective (strategic or decisional) model with their articulated taxonomy (Figure 4).

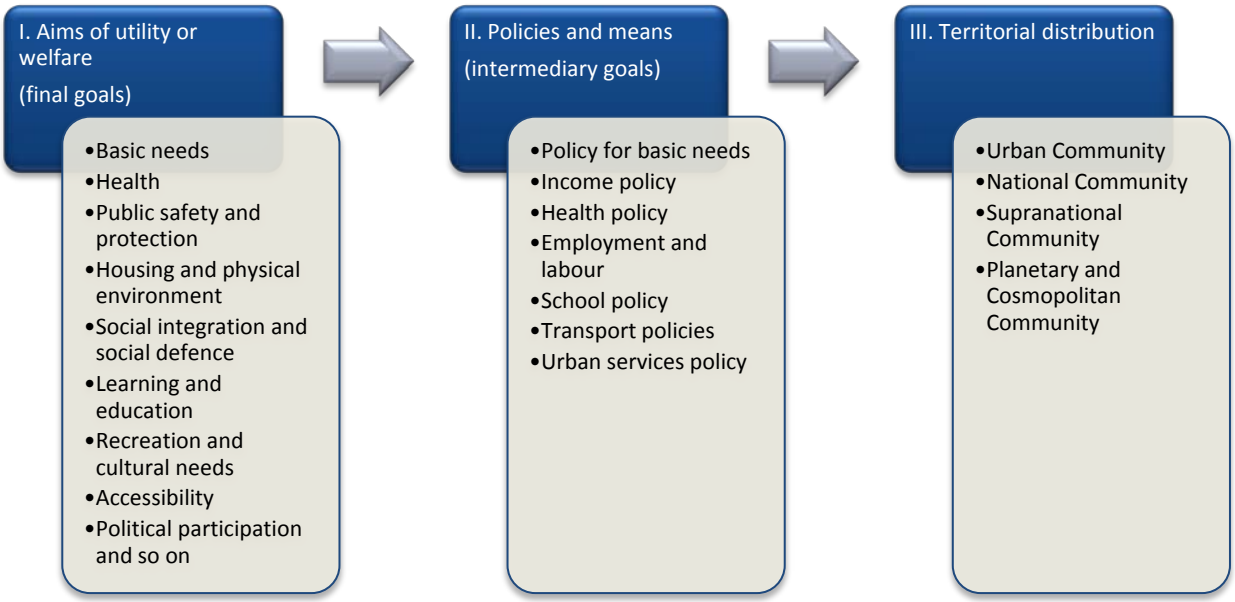


Figure 4: The planning selection system model

(Source: Archibugi, 2008)

The planning implementation subsystem is also divided by Archibugi into three dimensions, as an operational model in which the plan's effectiveness is

controlled and evaluated while its political and procedural features are considered (Figure 5).

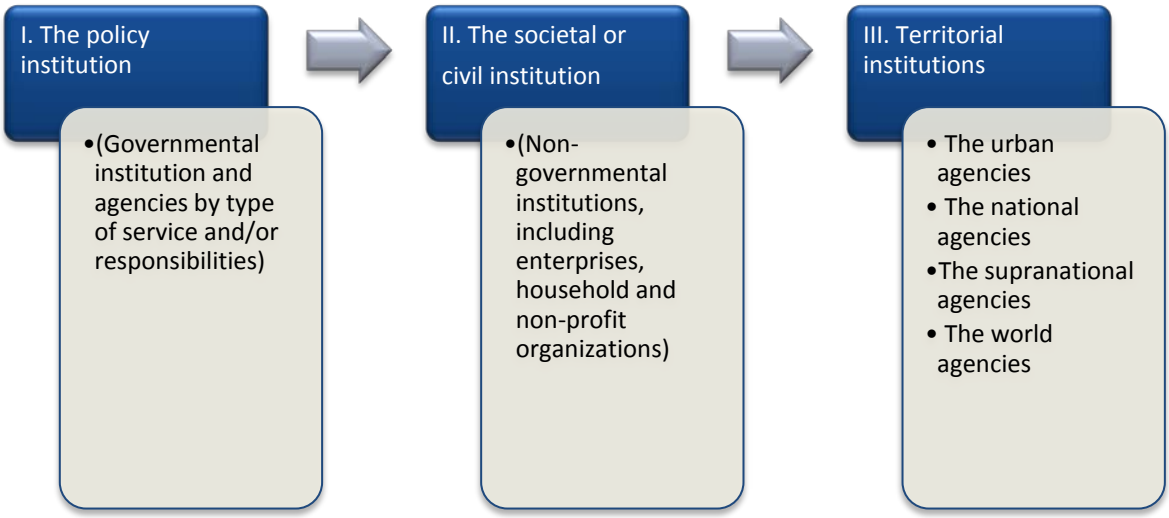


Figure 5: The implementation planning model

(Source: Archibugi, 2008)

"The subject of planning in the field of public planning is the institution, and the implementation problem includes not only how to do something, but also who will do what. Any modeling of the implementation system must take this into account. A successful plan will require a degree of effective co-ordination between the various planning operators, i.e., between the various institutions" (Archibugi, 2008, p. 68).

Archibugi uses these planning models as a basis to take his approach to the new planning discipline, which he calls 'planological integration'. He refers to planological integration as the key element of the new approach for restructuring planning theory and summarizes the topics of the integration as:

1. The integration between systems of economic accounting and systems of social accounting

2. The integration between planning systems (and related accounting) and technological forecasting
3. The integration between socio-economic planning and physical (or environmental or spatial or land use) planning
4. The integration between socio-economic-physical planning and institutional public planning
5. The integration between institutional public planning and collective bargaining with private and independent planning and projecting

These topics cover the important areas (disciplines) of societal and environmental systems that are in direct relation with the development of human lifestyle. In the following sections, the way that the integration approach should be applied in the field of energy planning is discussed.

2-3. Sustainable development - the principles

Although not exactly in the way the term is used today, the concept of 'sustainable development' is commonly ascribed to Paul R. Ehrlich[8] and Edward Goldsmith[9], who were concerned about the future of mankind on the earth. The publication of *Our Common Future*, a report of the World Commission on Environment and Development (WECD) in 1987, brought the phrase 'sustainable development' to worldwide recognition. The report, which is also known as 'The Brundtland[10] Report', has also helped create an

[8] Born in 1932, Ehrlich is an American biologist, educator and Nobel Prize winner (1990), who studied the problem of rapid population growth and food production. In his book *The Population Bomb* (1968), he warned of the mass starvation of humans in the 1970s and 1980s due to overpopulation. As a solution, he suggested immediate action to limit population growth. (S*ource: Encyclopedia Britannica Online*, *retrieved on 2010-07-22 from: http://www.britannica.com/EBchecked/topic/180897/Paul-R-Ehrlich)*

[9] Edward René David Goldsmith (1928-2009) was an environmentalist, writer and philosopher. He co-authored *Blueprint for Survival* with Robert Prescott-Allen (1972) and discussed the magnitude of environmental problems, which could cause "*the breakdown of society and the irreversible disruption of the life-support systems on this planet*" (*Source: The Ecologist, 1972 http://www.theecologist.info/key27.html*)

[10] The former Norwegian Prime Minister, Gro Harlem Brundtland, is a politician, diplomat, physician, and an international leader in sustainable development and public health. She has served as the Director General of the World Health Organization. She now serves as a Special Envoy on Climate Change for the United Nations Secretary-General Ban Ki-moon.

internationally widely known vision about how sustainable environmental and socio-economic development could take place. The report defines sustainable development as "*a development that meets the needs of the present without compromising the ability of future generations to meet their own needs*", which contains two key concepts:

1. The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
2. The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs (WECD, p. 43)

This definition covers a broad field of human activities and the surrounding natural environment with regard to their interrelations and qualities. The report identifies the requirements for sustainable development as:

- a political system that secures effective citizen participation in decision-making,
- an economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis,
- a social system that provides for solutions for the tensions arising from disharmonious development,
- a production system that respects the obligation to preserve the ecological base for development,
- a technological system that can search continuously for new solutions,
- an international system that fosters sustainable patterns of trade and finance, and
- an administrative system that is flexible and has the capacity for self-correction (WECD, p. 89)

The definition of sustainable development, in such a multidisciplinary context, brought a demanding task of revision and/or reconstruction of the existing regulations and policies within the above-mentioned systems. It was a bold call for recalibration of the institutional mechanisms to guarantee the promotion of economic development, social wellbeing and protection of the

natural environment (Sneddon et al., 2006). The definition has also established a significant base of international development thinking and practice since, first, it was "*the most widely accepted starting point for scholars and practitioners concerned with environment and development dilemmas; and second, it signaled the emergence of the environment as a critically important facet of international governance*" (ibid. p. 255).

On the other hand, this definition addressed a broad range of future activities and goals, which were widely criticized. Sneddon argues that steps toward implementation of sustainable development with such broad goals "*would be thwarted*" since, first, the overall procedure of economic growth in developing countries is in fundamental contradiction with ecological conservation; and second, the power relations among the actors and institutions from local to global levels are not considered. Criticisms of the definition were rooted not only in the conflictive nature of the subject, but also in its implementation, approaches and interpretations from various social, environmental, political and institutional perspectives. It is not the intention of this research to go into deep post-Brundtland debate upon the subject, but rather to clarify the necessary theoretical framework. The main purpose of this section is to identify those principles of sustainable development that have strong linkages with the energy planning procedure.

Many efforts have been made to provide a general framework of guidelines and principles of sustainable development. Thus, many approaches have been taken, based on the interests and visions of governmental organizations, academics, etc., concerned with the implementation of sustainable development.

Some of the various approaches taken to the subject are mentioned in the following.

Although the approaches taken to identification of a set of principles for sustainable development may seem rather different, one can observe areas (or subjects) which all the approaches have in common. These subjects, in one way or another, generally deal with human life, its surrounding environment, and the related issues which can affect human lifestyle, e.g., welfare, governance and justice. Through investigating the existing literature it can be observed that extensive discussions and interpretations of the concept of

'sustainable development' have generally been around the environmental, economic and social aspects. Harris (2000) sees these three aspects as follows:

- **Economic**: An economically sustainable system must be able to produce goods and services on a continuing basis, to maintain manageable levels of government and external debt, and to avoid extreme sectoral imbalances which damage agricultural or industrial production

- **Environmental**: An environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions[11], and depleting non-renewable resources only to the extent that investment is made in adequate substitutes. This includes maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources

- **Social**: A socially sustainable system must achieve distributional equity, adequate provision of social services including health and education, gender equity, and political accountability and participation (p. 5)

According to Harris, these principles "*have resonance at a commonsense level*", in which they can raise the issue of balancing the multidimensional (and conflictive) objectives and judging success or failure. Yet Harris does not clearly address how this issue of balancing should be done. If sustainable development is about improving the quality of life, balancing its multidimensional aspects requires systematic institutional supports. In 1995, the UNDPCSD (Department of Policy Co-ordination and Sustainable Development, UN Division for Sustainable Development) formally introduced the institutional dimension as the fourth dimension of sustainable development. According to the United Nation's Commission on Sustainable Development:

> "*Appropriate legal and policy instruments are required as an institutional framework to encourage and implement sustainable development. The*

[11] The environment's capacity (e.g. air and water) to absorb and assimilate wastes

> *integration of social, economic, and environmental factors is a particular important feature of such instruments. Implementation of sound sustainable development strategies and international treaties by countries should contribute to improved socioeconomic and environmental conditions, and help reduce potential sources of conflict between countries*" (Article 159, p. 44)

Thereby, it is rational to add the institutional dimension as the fourth principle of sustainable development into Harris's tripartite scheme. In Figure 6, the institutional dimension is placed in the middle of the sustainability triangle to emphasize its important role in (balanced) implementation of sustainable development.

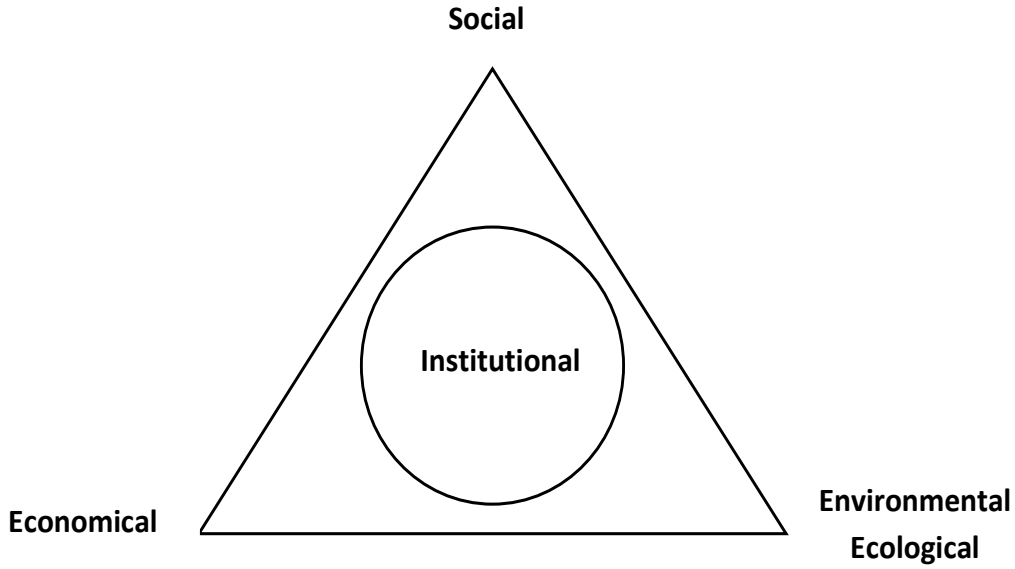


Figure 6: Schematic of the principles of sustainable development

The four principles identified here play an important role in forming the theoretical framework of this research which is based on an integrated approach to energy planning. In the next chapter, the relationship between

energy and sustainable development and what sustainable energy planning means, is elaborated.

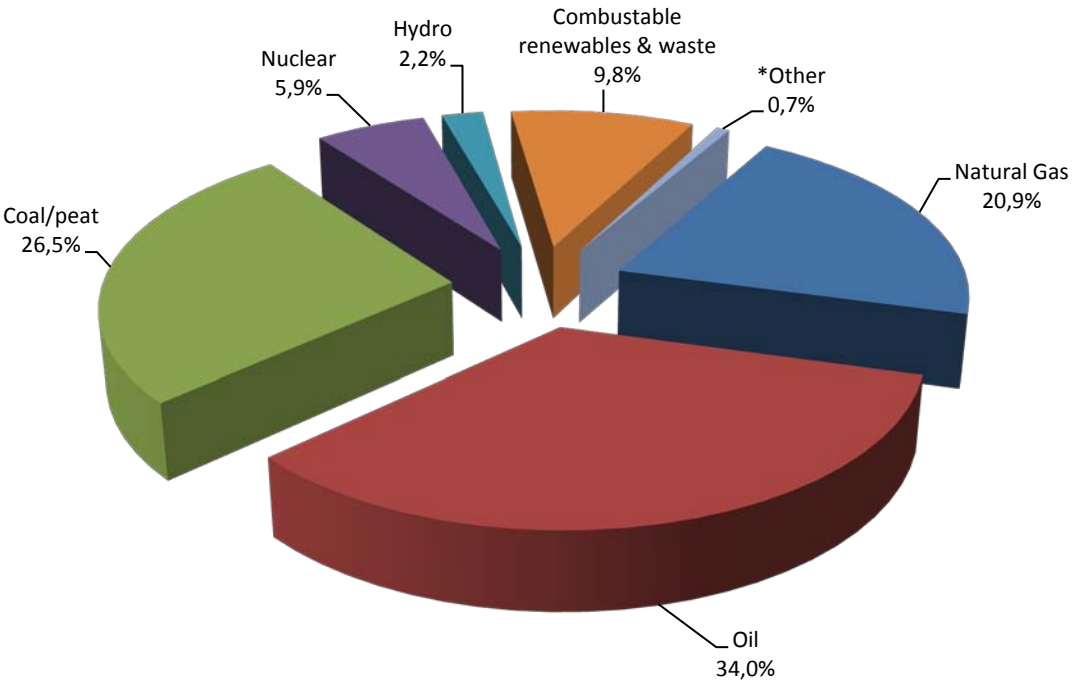
3. How is energy related to sustainable development?

3-1. Introduction

Right from the beginning in the 1980s, when the term 'sustainable development' came into global consideration, energy was seen as an important aspect. The key role of energy in future development is emphasized by the authors of *Our Common Future* (1987), who devoted a full chapter to the subject, explaining its relationship with environmental, economic, social and institutional aspects, as well as the dilemmas associated with its contribution to a sustainable future. They describe it as a necessary element for 'providing essential services' for human life - heat for warmth, cooking, and manufacturing, or power for transport and mechanical work, the future development of which "*crucially depends on its long-term availability in increasing quantities from sources that are dependable, safe, and environmentally sound*" (chapter 7, p. 168). Adequate and affordable energy supplies have been playing an important role in economic development and the transition towards modern industrial and service-oriented societies. They are a key element for improving social and economic well-being, and are vital to most industrial and commercial wealth generation; and in general, they are necessary for improving human welfare and living standards.

The primary energy sources that are used for providing these services are mainly non-renewable (oil, natural gas, coal, peat). Utilization of renewable

energy sources (wind, solar, geothermal, hydro power, wood, tidal, etc.) has also been developed over the last decades; however, their share in total primary energy supply is still low. According to the International Energy Agency, the total share of renewable energy sources was about 12.7% in 2007 (Figure 7).



**Other includes geothermal, solar, wind, heat, etc.*

Figure 7: World's total primary energy supply by fuel

(Source: IEA, 2007)

The balance of non-renewable and renewable energy sources does not show a sustainable energy path. All available energy sources have their own technological, economic, health and environmental advantages, which can affect future development strategy. On the other hand, energy use patterns are not efficient enough to guarantee a sound sustainable development. Regarding the multidimensional role that energy plays in the implementation of the development process, it is necessary for the authorities to make the right decision in order to:

- Provide sufficient and secure energy supplies for future energy needs
- Adopt measures for more efficient use of energy
- Deliver public services
- Protect the natural environment

During the 1990s, these energy-related challenges entered into the political agenda more seriously and grew to be among the important issues for decision-making systems. The most common way of managing energy-related issues then was the application of conventional energy planning methods. These methods were generally focused on planning for the community's energy supply, energy transportation/distribution and energy use, while the new sustainability paradigm was dealing with energy in a more complex context that conventional planning methods could not address. To meet the complexity of the relationship between energy and the various dimensions of sustainable development, many attempts have been made (and are still ongoing) to develop energy planning methodologies in a more sustainable manner. These new methods, which are known as 'sustainable energy planning', generally aim to include more sustainability aspects in the planning process. Prior to discussing how sustainability can be achieved in energy planning, first let us present an overview of what sustainability means, what energy planning is and how they can be merged.

3-2. What is sustainability?

Sustainability is not a new concept. It can be seen as a desire for stability and permanence of civilizations in the ancient historical records of various cultures around the world (D. Rad, 2008). The term in the present context appeared during the 1970s, particularly after publication of *A Blueprint for survival*[12] and *Limits to growth*[13] prompted discussion of the development of

[12] By Edward Goldsmith, Robert Allen and others, published in January 1972, http://www.edwardgoldsmith.org/

[13] By the Club of Rome (1972), http://www.clubofrome.org

human lifestyle. Since the United Nations Conference on the Human Environment (Stockholm, 1972), which emphasized the need for a common outlook and principles of enhancing the human environment, the sustainability concept has evolved and became a buzz word for both environmentalists and industrialists, but with little agreement on the definition (Khator, 2006). After the Brundtland Report, it became a significant issue among various academic disciplines. Although the Brundtland Commission did not invent the notion of sustainability, it was the most widely cited source of 'sustainability' definitions (Molnar et al., 2001). Following the Brundtland Report, hundreds of research programs started, articles were published and several definitions of sustainability were introduced and applied to almost all human activities. Its vast conceptual framework allowed different people to define it in their own way depending on their interests. They applied the term to their profession and business and to almost all activities related to human life. The meaning of sustainability is strongly dependent on the context in which it is applied and may be defined based on its use in a social, economic, or ecological perspective (Brown et al., 1987). Green activists have used it mostly through its environmental dimension, while businesses have adopted the sustainability terminology in such a way that they can benefit from it as tools for (economic) profit maximization (e.g., efficiency of energy/material use); and the environmental benefits were seen as a side effect, not the targeted goal (Molnar et al., 2001). The different semantics of the sustainability concept has led to conflictive debates on economic (growth), environmental (degradation/protection) and social (poverty/well-being) dimensions of human lifestyle development (Lele, 1991).The debate between environmentalists and economists on the concept of sustainability is about the key question of whether natural capital (strong sustainability) can be substituted by man-made capital (weak sustainability)[14] (Neumayer, 2007). In order to get a deeper insight into what sustainability means, various visions and definitions from the existing literature are presented in the next section.

[14] This study is not intended to go deeply into the debate between weak and strong sustainability. These can be simply explained: weak sustainability implies the possibility of substitution of the manufactured capital of equal value by natural capital, while this substitution cannot be made according to strong sustainability.

3-3. Concepts and definitions

Starting with dictionaries, the word *Sustain* means 'to keep in existence (maintain), to supply with necessities or nourishment (provide for), to support from below; keep from falling or sinking (prop), to support the spirits, vitality, or resolution of (encourage), to experience or suffer' (The American Heritage Dictionary, Fourth edition 2009). The Merriam-Webster dictionary defines *Sustainability* as 1) capable of being sustained, 2) a- of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged, b- for or relating to a lifestyle involving the use of sustainable methods'[15]. Although, sustainability is just one word, there are hundreds of different interpretations of it. Most of the definitions originate from the relationship between humans and the resources they use (Voinov, 1994). According to Pearce (1999), sustainability reestablishes a close relationship between the omnipresent human drive to improve our quality of life with the limitations imposed on us by our global context. Pearce believes continuous, sustainability requires unique solutions for improving human welfare that do not come at the cost of degrading the environment or impinging on the well-being of other people. Yet there is no precise agreement on the sustainability definition and people use it in ways that suit their particular applications (Voinov, 1994).

Some definitions[16]:

> "*Sustainability is a vision of the future that provides us with a road map and helps to focus our attention on a set of values and ethical, moral principles by which to guide our actions, as individuals, and in relation to the institutional structures with which*

[15]Merriam-Webster Online Dictionary, Retrieved on 2010-07-21 from: http://www.merriam-webster.com/dictionary/sustainability

[16] Over 245 definitions of the term 'sustainability' can be found here: http://maven.gtri.gatech.edu/sfi/resources/pdf/definitions.pdf (2008-08-25), and www.utoronto.ca/envstudy/sustainabletoronto/resources/SustainableTorontoDefinitionsPaper-FinalDraft.doc *(2008-09-28)*

> *we have contact – governmental and non-governmental, work-related, and other.*" (Viederman, 1995, p.2)
>
> "*In general terms, the idea of sustainability is the persistence of certain necessary and desired characteristics of people, their communities and organizations, and the surrounding ecosystem over a very long period of time (indefinitely). Achieving progress toward sustainability thus implies maintaining* and preferably improving, both human and ecosystem wellbeing, not one at the expense of the other. The idea expresses the interdependence between people and the surrounding world" (Hardi and Zadn, 1997, p. 8)
>
> "*Sustainability refers to the ability of a society, ecosystem, or any such on-going system to continue functioning into the indefinite future without being forced into decline through the exhaustion or overloading of key resources on which that system depends.*" (Gilman, 1992, p. 1)
>
> "*The sustainability of ecosystems, future durability and socio-economic stability is undeniably necessary for promoting the quality of human lifestyle; however, it has been argued that the concept of sustainability is too indistinct to be applicable in the real world. Yet of course one has to consider that sustainability is a complex and challenging concept, which is not open to simple technical solutions.*" (Ulrich Steger et al., 2005, p.24).

Some believe that environmental sustainability is in contrast with economic sustainability (economic growth). For instance, Williams (1998) believes development at the global level has become unsustainable, largely due to patterns of overconsumption in the advanced industrial countries. He continues: "*sustainability cannot be managed within a capitalist world*

economy… due to the values, interests, and power behind the capitalist international division of labour" (p. 4).

Mitcham (1995) describes the concept of sustainability as "*one of those ideals which like love or patriotism, points towards something necessary and even noble, but can also readily become a cliché and be misused by ideologues*"… "*It is not exactly clear, however, to what extent sustainability has to mean continued growth. The concept entails some studied or creative ambiguity, which is precisely what makes it useful for bridging the gap between no-growth environmentalists and pro-growth developmentalists*"(pp. 1, 7).

Martens[17] (2006), in his explanation of the sustainability concept, refers to Richard Feynman's[18] statement: …"*Whoever says that he understands quantum theory, in all probability does not*", and continues: "*Whoever says he knows what "sustainability" is, in all probability does not. In a certain sense, a sustainable world is a fiction*" (p. 5).

"*You can't see sustainability as a premium product; you need to make it something in day to day business*" said Shaun McCarthy, Chairman of Sustainable London 2012[19].

The term sustainability has become very attractive because of its resistance against a single, accepted interpretation (Neumayer, 2007). Thus, the concept is applicable to a broad range of different aspects, from natural to social sciences, which makes it rather appropriate for the positive evolution of human lifestyle in a viable living environment. The important thing is how and in what directions the capacities for community development should be improved towards these viable conditions. This study does not aim to discuss these improvements and, as mentioned earlier, it attempts to provide a broader view of the concept of sustainability which can assist in finding more appropriate ways for transition towards sustainable energy systems. However, this transition would be a difficult task due to the ambiguity of the concept of

[17] For more information see: http://www.icis.unimaas.nl/personal/pim.html

[18] One of the greatest physicists of the last century (1918-1988), for more information see: http://www.britannica.com/eb/article-9034161/Richard-P-Feynman

[19] For more information see: http://www.cslondon.org/

sustainability. Attempting to find a comprehensive definition of sustainability seems to be in vain, since there are too many aspects arising from the particular applications and implementations of the term (Voinov, 1994). Instead, it might be more helpful if we try to develop the conditions which help to achieve sustainability. McKenzie (2004) refers to many attempts to define sustainability as conditions that can be measured with a series of indicators. These conditions can be developed through the establishment of rational connections between different sustainability dimensions.

3-4. Sustainability dimensions in relationship with energy

The general concept of sustainability deals with the relationship between human activities and the living environment. These activities, with the aim of developing human well-being, affect the natural environment. Sustainability is actually a balancing act between the social, environmental and economic dimensions of human needs. These balanced dimensions are constantly changing as a consequence of growing human population and their needs. Therefore, since the dimensions of sustainability are not independent of one another, the constant balancing act of sustainability makes it a dynamic concept rather than a static state (Pearce, 1999). The dynamic characteristic of sustainability requires decision-makers to be flexible in their approaches regarding changes in human needs and desires, the environment or technological advances (ibid). Hence, an important new dimension which we should consider adding to sustainability is the institutional dimension. Managing the necessary policies in an ever-changing living environment requires sufficient institutional arrangements towards a dynamic balance of sustainable development. From a sustainability point of view, every society can be described as comprising economic, social, environmental and institutional dimensions (Spangenberg, 2005). For any society to be sustainable, each of these dimensions has to maintain its potential to survive and develop, while remaining balanced with the other dimensions. A schematic model of the relationship between energy and the four dimensions of sustainability is shown in Figure 8.

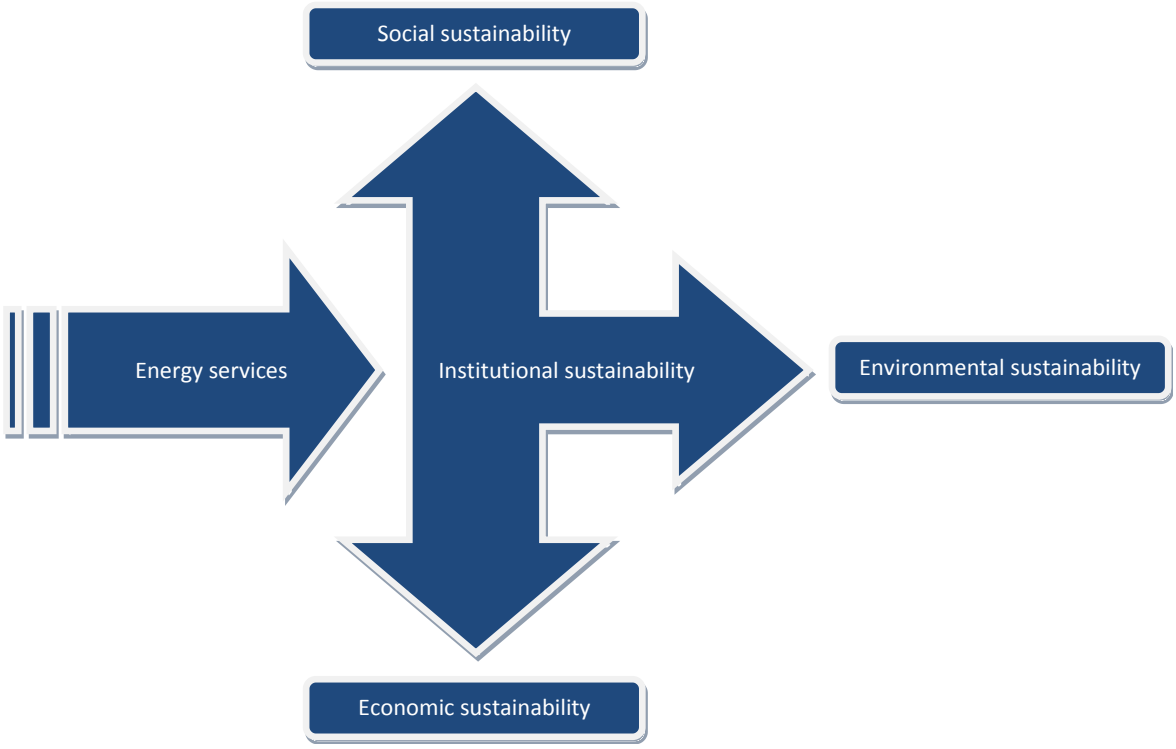


Figure 8: The model of energy and sustainability dimensions

3-4-1. Energy and the environmental dimension

The natural environment is the context that every human being depends on for his existence. The ecological systems of the earth provide us with both the necessary resources of life (food, energy, raw materials, etc.) and the natural recycling system to absorb the residual material. The ecological dimension of sustainability focuses on natural biological processes, and the ecosystem's health and functionality, as well as continuous productivity with minimum environmental impacts (D. Rad, 2008). The sustainability of the earth's natural environment is vital for the human being. The natural environment is the physical context within which we live, and sustainability requires that we recognize the limits of this environment (Pearce, 1999). There are two important issues regarding environmental sustainability. The first is that the available natural resources of the earth are limited. Some, such as trees and

wildlife, can be regenerated in a shorter time than others such as minerals, soil and fossil fuels. Environmental sustainability depends on protecting resources and conserving biological diversity (Pearce, 1999). Therefore, achieving environmental sustainability requires a rational use of our natural resources. The second key environmental issue is the protection of the ecosystem by minimizing the negative impacts of our activities on it. The natural ecosystem may recover from some small impacts; however, the larger ones can harm the ecosystem's health. Environmental pollution, natural resource degradation and loss of biodiversity affect the ecosystem's health by increasing ecological vulnerability.

There are large amounts of scientific literature explaining the relationship between energy, the environment and sustainable development. While energy is essential for a sustainable development process, it can affect the natural environment from two major perspectives; first, improper exploitation of energy resources, e.g., over-harvesting of wood for energy production and environmental pollution from oil rigs, and second, inefficient energy-use, which emits harmful components into the environment. The negative impact of energy-use on the environment has become an increasingly important issue among nations over the last decades. Several international conferences and seminars have been held to address and resolve this challenge. For instance, at the 14th session of the United Nations Commission on Sustainable Development (CSD) in 2006, the CSD focused on the area of energy with respect to industrial development, atmosphere/air pollution and climate change. Another example is the European Commission energy policy in 2007, which proposed an integrated energy and climate change package to cut emissions for the 21st century. This should be implemented through increasing the share of renewable energy resources and saving total primary energy consumption by 2020.

It is clear today that the existing energy supply/use patterns are not functioning in an appropriate environmentally friendly or, in other words, sustainable manner (D. Rad, 2008). The global, national and local commitments on reducing energy-related environmental degradations such as global warming, deforestation, pollution of the air, land, water, etc., show the important role of energy in sustainable development.

3-4-2. Energy and economic dimension

Economics, as a social science, is important for a sustainable community since it deals with a broad range of human activities such as production, distribution and use of commodities and services (Pearce, 1999). These activities depend on both finite and renewable natural resources. The World Commission on Environment and Development states that every generation should use natural resources in such a way that future generations may be able to meet their needs. From an economic point of view, some believe that this approach may not be the ultimate method for a sustainable development. Solow (1993) defines sustainable development "*as an obligation to conduct ourselves so that we leave to the future the option or the capacity to be as well off as we are*" (p. 181). Solow believes that since resources are fungible in a certain sense, goods and services can be substituted for one another. Moreover, Solow says we do not know about the technology that will be available to future generations and what resources they will require. Therefore, he believes we do not owe anything in particular to future generations. He defines sustainability as the sharing of well-being between present people and future people; in other words, it is about distributional equity. Another perspective on economic sustainability is the discussion about the limitation of the natural capital which prevents an efficient substitution of goods and services. Daly (1992) believes that fungibility and substitutability are not a true picture of the real world, since the productivity of man-made capital can be affected by the decreasing supply of natural capital. In other words, although one resource can substitute for another, the substitution process cannot be perfect, since both are raw materials undergoing transformation into a product and both play the same qualitative role in production. In addition to the environmental aspects, the social aspects could also be addressed from an economically sustainable point of view. An economically meaningful definition of sustainability should focus on sustaining well-being or utility (Weitzman, 2003). Sustainability as an overall guideline for economic development should be based on generalized well-being and equivalent utilities (ibid).

The role of energy in the development process from an economic point of view contains a broad area from supply to use of energy in communities. The strong relationship between energy and economic activities influences almost

all parts of society from macro to micro levels including infrastructures, transportation, markets, manufacturing, social welfare, etc. (D. Rad, 2008). The concept of economic growth, in most cases, usually refers to the supply side of the communities that concerns the production of commodities and services. The ratio of total energy use per unit of Gross Domestic Products (GDP), which is defined as Energy Intensity, is often considered as a proper evaluating tool for the energy efficiency of a nation's economy. In order to gain a better understanding of the real nature of the relationship between the economy and energy use, it is important to assess the most energy-intensive side of the economy which is the production sector. Energy is a key element for the industrial sector and manufacturing processes. Therefore, the rate of energy consumed for production (which is commonly referred to as the energy per GDP ratio) can be considered as an appropriate index for the economic growth rate of a country. The energy per GDP ratio is among the economic indicators commonly used in comparison studies and assessing countries' economic development trends. A high ratio of energy intensity indicates a high price of converting energy into GDP and vice versa. Dincer (1997) argues that the energy per GDP ratio can differ among countries, depending on different circumstances such as climate, diversity of their natural resources and even monetary valuations of GDP; hence, it cannot be considered as a reliable economic index but is useful as a preliminary indicator of energy demand. The use of the energy per GDP ratio for a country could be more practical in comparing the economic development growth situation and providing a picture of energy demand over time (ibid). Hwang et al. (2008) argue that the relationship between energy consumption and economic growth differs among countries and depends on the corresponding income levels[20]. They indicated that: (a) in low income countries, there is no causal relationship between energy consumption and economic growth; (b) in middle income countries, economic growth leads energy consumption positively; (c) in high income countries, economic growth leads energy consumption negatively. Although the rate of energy use per GDP is expected to decline over time due to the adoption of more efficient technologies, even with a tendency towards more efficient energy

[20] Hwang et al. used the panel data of energy consumption and GDP for 82 countries from 1972 to 2002 based on income levels defined by the World Bank.

use, the ratio of energy per GDP may continue to increase within the context of a possible rebound effect[21] (Ockwell, 2008). The desire for continuous economic growth by governments worldwide and the strong linkage between the use of energy and economic activities is seen by Ockwell to indicate the importance of energy as a fundamental factor in development.

3-4-3. Energy and the social dimension

There are many components and principles needed for a society to function and be sustainable. Meeting the basic needs of all groups in the society is one of the most fundamental aspects of equity (Baines et al., 2005). A socially sustainable community must have the ability to maintain and build on its own resources and have the resiliency to prevent and/or address problems in the future (Gates et al., 2005). Resources that are required to build a sustainable society are mainly from individual or human capital and social capital. Individual capitals such as health, education, skills, values and leadership can contribute to their own well-being (and to the well-being of society as a whole), while social capital includes services, networks, relationships and norms that facilitate cooperation towards improving the quality of life (ibid). According to Goodland (2002), the creation and maintenance of social capital, as needed for social sustainability, is not yet adequately recognized. He believes social, sometimes called moral, capital requires maintenance and replenishment by shared values, equal rights and cultural interactions which are essential for social sustainability.

McKenzie (2004) takes a rather different approach to social sustainability in which it is regarded as an independent field from environmental and economic concerns. His defines social sustainability as a phenomenon which "*occurs when the formal and informal processes, systems, structures and relationships actively support the capacity of current and future generations to create healthy and livable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life*"

[21] The rebound effect refers to the idea that increases in energy efficiency might result in increases in energy consumption.

(p. 20). McKenzie's approach has a broader vision on social sustainability that does not go very much into details. He looks at social sustainability as "*a positive condition within communities, and a process within communities that can achieve that condition*" (p. 25). McKenzie explains that these conditions may be achieved through the following 'aspirational and visionary' principles:

- **Equity**: the community provides equitable opportunities and outcomes for all its members, particularly the poorest and most vulnerable. While equity is listed as a separate principle, it is such a fundamental component that it cannot really be separated from the other principles. Equity is a filter through which all other principles are viewed.
- **Diversity**: the community promotes and encourages diversity.
- **Interconnectedness**: the community provides processes, systems and structures that promote connectedness within and outside the community at the formal, informal and institutional level.
- **Quality of life**: the community ensures that basic needs are met and fosters a good quality of life for all members at the individual, group and community level.
- **Democracy and governance**: the community provides democratic processes and open and accountable governance structures (p. 18)

In addition to these principles, Gates et al. (2005) have added two more points:

- **Security** - individuals and communities have economic security and have confidence that they live in safe, supportive and healthy environments. People need to feel safe and secure in order to contribute fully to their own well-being or engage fully in community life.
- **Adaptability** – resiliency for both individuals and communities and the ability to respond appropriately and creatively to change. Adaptability is a process of building upon what already exists, and learning from and building upon experiences from both within and outside the community (p. 6).

Energy clearly plays a significant role in achieving social sustainability through the above-mentioned conditions. These conditions differ among countries (developed and developing), but the basic needs of societies and people's daily life greatly depend on energy services. Spending just a few days without electricity and fuel for transportation, heating, cooling and cooking can lead to serious chaos. Quality of life, poverty and health are among the major social subjects related to energy use (D. Rad, 2008). Access to basic energy services at affordable rates is still one of the main social problems of some developing countries. Around 2 billion people have no access to modern energy services and most of them are still meeting their essential energy needs for cooking and heating from natural resources such as wood and crops (Johansson, 2002).

Social equity and health are two principal themes that are considered under the social dimension of sustainable development. The rate of fairness and inclusiveness in distributing energy resources and accessing affordable energy services underlie the social equity (Vera, 2007). Energy supports social health from several points of view, e.g., food provision and controlling indoor temperature at a comfortable level. Moreover, almost all medical centers and health care services depend on energy for their activities.

3-4-4. Energy and the institutional dimension

The central role of institutions as a tool for implementation of sustainable development is emphasized in almost every chapter of Agenda 21 by assigning clear tasks to institutions, e.g., organizations of the UN, intergovernmental as well as national, regional and local governments (Pfahl, 2005). Although no clear definition of institutions can be found in Agenda 21 or in the UN's manual on institutional indicators[22], it can be seen in both documents that institutions are recognized as political or social organizations with legal personality and staff that are involved in policy-making or implementation (ibid.). North (1990) defines institutions as "*commonly devised constraints that shape human interactions. In consequence they structure*

[22] Published by the United Nations' Commission for Sustainable Development in 1996

incentives in human exchange, whether political, social, or economic. Institutional change shapes the way societies evolve through time and hence is the key to understanding historical change". The role of institutions in promoting sustainable development is described by Brinkerhoff and Goldsmith (1992) as entities that can assist the decision-making process, serve a range of implicit and explicit goals of the sustainability paradigm, and/or they can facilitate the implementation of the political decisions. Accordingly, institutional sustainability can be identified from political, social and economic perspectives. The political science approach to institutional sustainability focuses on the politically relevant aspects of the role of organizations, decision-making processes and orientations, as well as their impacts and consequences (Spangenberg et al., 2002). This approach, in fact, assists global development in a sustainable manner. Based on this, institutions can be defined as having structured rules for political decision-making and implementation, which have to take aspects of sustainable development into consideration (ibid).

The social perspective of institutional sustainability deals with the impacts and effects of institutions on social relationships and how they can change the behavior of actors. From a sociological point of view, institutions on the one hand are influenced by actors and their activities, and on the other hand they also considerably influence actors by shaping their interests and behavior (March and Olsen, 1984). There is a mutual relationship between institutions and actors in such a way that social values can shape institutional structures and as a response, institutional values appear as a measure for rational evaluation of actors. Consequently, institutions act as an entity between actors and structures, creating new value orientations or reference points, which influence actors and their behavior (Spangenberg et al., 2002). From an economic point of view, institutional sustainability can be defined as "*the ability of an organization to produce outputs of sufficient value so that it acquires enough inputs to continue production at a steady or growing rate*" (Brinkerhoff and Goldsmith, 1992). This definition underlines the dynamic character of institutional sustainability as an ongoing input-output process (ibid). Stable institutions play an important role in the cost-benefit assessment of actors since they can contribute to lower transaction costs by creating security (Spangenberg et al., 2002). Moreover, institutional

reliability reduces uncertainty in the decision-making process, which consequently enables actors to take faster and cheaper decisions.

The institutional setting is a critical component of sustainable development in which development policies are conceived, funded, implemented and managed (Brinkerhoff and Goldsmith, 1990). A continuous adaptation of institutional capacity into performance, together with constant adjustment to changes in environment and circumstance, is required to guarantee effective sustainability (Brown, 1998). This can be applied in all fields and areas that institutions are responsible for, and among them energy.

The energy crisis of the 1970s was a major driving force for expanding energy-oriented institutional capacities particularly within the public sector. Governmental organizations (bodies, entities) from national level (ministries) to local level (municipalities) have developed (increased) their capacities both in decision-making and in administration of energy-related issues. During the 1980s, governmental institutions became more experienced in managing energy-related activities, e. g., adoption of energy policies, energy planning at national, regional and local levels, energy management within the industrial, buildings (commercial/residential) and transportation sectors. Following the deregulation of electricity markets in 1990s, the state monopoly in the energy sector has broken down and the private sector has gained the possibility to develop its institutional potential in a competitive energy market. One can say that the institutional power of governments (both in decision-making and administration) has gradually diminished since the deregulation of electricity markets. However, it can be seen from another angle in which institutional entities have become more important in providing the appropriate basis for public private participation.
In addition to enhancing public private participation, institutions play an important role as a hub in governance[23] and balancing the activities of various sustainability dimensions. Focusing on the sustainability of the community

[23] According to the UN, "*Governance* is viewed as the exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences".

energy system, good institutional structure can play a key role in facilitation of:

- Adaptation and implementation of energy plans and policies at international, national regional and local levels
- Harmonization and synchronization of future energy strategies at various levels
- Coordination of an effective relationship among actors and stakeholders
- Assessing the quality of energy policies and plan implementation
- Monitoring and evaluation of goal achievements

4. What is sustainable energy planning?

4-1. Energy planning procedure - an overview

The ever increasing energy demand, with a wide range of technological, political and environmental limitations, has been a major driving force for developing planning methods to overcome energy challenges. Planning of future energy strategies has been and is still often considered by decision-makers at local, regional and national levels. The definition of energy planning varies among planners since they may apply it in different conditions. A general definition of energy planning is presented by Kahen (1995) as "*a matter of assessing the supply and demand for energy and attempting to balance them now and in the future*" (p. 4). The procedure of energy planning consists of setting energy-related goals and policies, gathering and evaluating information, developing alternatives for future actions and policies and proposing the best energy plan. Plan evaluation is another important step in planning procedure, which starts after selecting a plan. Thörnqvist (1975) classifies energy planning process into seven basic steps (Table 2).

Table 2: Energy planning process

Steps	Basic functions
Introduction	Presentation Background Aim of research
Frames of planning	Laws and regulations Local prerequisites Time limits
Survey of actual status	Energy demand Production resources Distribution networks Organizational resources External interested parties
Previous energy plan follow-up	Results Analysis
Energy goals of the community	General Service level Energy conservation Flexibility and adaptability
Plan alternatives	Forecasting alternatives Main program selection Emergency program selection
Guidelines for realization	Action proposals Control function

(Source: Thörnqvist, 1975)

Energy plans can structure procedures for provision, transmission and distribution of energy at national, regional and local levels within a defined time range. Although the implementation of energy planning procedure is different depending on the economic, political, social and environmental characteristics of the communities, it is often conducted using integrated approaches that consider both the provision of energy supplies for meeting the energy needs, and reducing energy consumption by increasing efficient

energy use. The implementation of the energy planning process differs from developed to developing countries and from energy importing countries to energy producing countries. Energy planning in democratic and liberalized countries is more decentralized and more market-oriented compared to countries with state-controlled markets using central planning systems.

In spite of these differences, energy plans can be seen as a tool for decision-makers to facilitate setting future energy strategies. Van Beeck (2003) defines a planning process as the process of making choices between alternatives. She considers energy planning as the decision-making process of selecting the preferred local energy infrastructure to invest in (p. 22). Although utilization of energy planning as a tool for the decision-making process can be different depending on the circumstances, in general, the ultimate goal of energy planning is to balance the community's energy supply and demand now and in the future. The energy planning procedure can be done through different methodologies and models. Cormio et al. (2003) classify energy planning methods depending on the planning level (local, regional or national) and required time scale (short, medium or long-term) in three categories:

1- *Planning by model*, including econometric model and optimization model, generally based on mathematical and statistical methods, such as the market allocation model (MARKAL)[24] and or the energy flow optimization model (EFOM).[25]
2- *Planning by analogy,* which is the process of making a new plan based on the structure of an existing successful plan. This method simulates the quantitative data and checks the outputs with the other methods.
3- *Planning by inquiry*, which is a method based on the statistical evaluated and optimized answers of selected experts (Delphi method).

[24] The MARKAL model "is a large scale, technology oriented activity analysis model, which integrates the supply and end-use sectors of an economy, with emphasis on the description of energy related sub-sectors" (EIA, 2006).

[25] EFOM is an engineering oriented bottom-up model of a national energy system, which is a network of energy flows to meet the demand for energy services.

Van Beeck (2003) classifies energy models by the model characteristics which can support local energy planning (Table 2). Throughout the last decades, various energy models were developed as decision support tools for energy planning with the aim of providing energy forecasts. Assessment of the impact of energy use on the natural environment was another important aim of these energy models. The main energy models (often computerized) with some of their characteristics are presented in Table 3.

Table 3: Classification of energy models by characteristics

Classification	Description
Perspective on the Future	Forecasting, exploring, backcasting
Specific Purpose	Energy demand, energy supply, impacts, appraisal, integrated approach, modular build-up
The Model Structure: Internal Assumptions & External Assumptions	Degree of endogenization, description of non-energy sectors, description end-uses, description supply technologies
The Analytical Approach	Top-Down or Bottom-Up
The Underlying Methodology	Econometric, Macro-Economic, Economic Equilibrium, Optimization, Simulation, Spreadsheet/Toolbox, Backcasting, Multi-Criteria
The Mathematical Approach	Linear programming, mixed-integer programming, dynamic programming
Geographical Coverage	Global, Regional, National, Local, or Project
Sectoral Coverage	Energy sectors or overall economy
The Time Horizon	Short, Medium, Long Term
Data Requirements	Qualitative, quantitative, monetary, aggregated, disaggregated

(Source: Van Beeck, 2003)

Although energy models were developed to assist policy makers in the framing of appropriate policy directions, their effectiveness in achieving the planned goals is still open to debate. For instance, Laitner et al. (2003) argue that such models provide biased estimates that tend to reinforce the current situation, inadequately inform policy-makers about new market potential, and restrict the development of innovative policies.

Table 4: The main energy models

Energy Model	Specific purpose
MARKAL	Energy supply with constraints. The objective includes target-oriented integrated energy analysis and planning through a least cost approach
ENERPLAN	Energy supply, energy demand, matching demand and supply
MESSAGE-III	Energy demand and supply, environmental impacts. Modular package. The objective includes generation expansion planning, end-use analysis, environmental policy analysis, investment policy
LEAP	Demand, supply, environmental impacts. Integrated approach. The objective includes energy policy analysis, environmental policy analysis, biomass- and land-use assessment, pre-investment project analysis, integrated energy planning, full (all) fuel cycle analysis. Applicable to industrialized as well as developing countries
EFOM-ENV	Energy supply, subject to technical, environmental and political constraints. Detailed description of (renewable) technologies possible. Appraisal through cost-effectiveness analysis. The objective includes energy and environment policy analysis and planning in particular regarding emission reduction
MARKAL-MACRO	Demand, supply, environmental impacts. Integrated approach for economy-energy-environmental analysis and planning. The objective is to maximize utility (discounted sum of consumption) from a neo-classical macro-economic perspective

Energy Model	Specific purpose
MESAP	Modular package. Demand, supply, environmental through different modules: ENIS = database; PLANET/ MADE = demand which can be coupled to supply module; INCA = comparative economic assessment of single technologies; WASP = generation expansion based on least-cost analysis; MESSAGE = integrated energy systems analysis
ENPEP	Energy demand, supply, matching demand and supply, environmental impacts. Detailed analysis for electricity based on least cost optimization. Integrated approach. Allows for energy policy analysis, energy tariff development, investment analysis, generation expansion planning and environmental policy analysis
MICRO-MELOIE	Energy demand, supply, environment. Integrated approach. The objective includes an analysis of macro-economic energy and environment linkages
RETscreen	Energy supply. Specially designed for renewable energy technologies

(Source: Van Beeck, 2003)

4-2. Community energy planning

Different energy planning methods are used by different countries depending on several factors, e.g., political, technical, economic and geographical circumstances. Most of the developing countries enjoy a national energy planning system while lower levels of community energy planning (regional and local) are more popular in industrialized countries. This depends on two major elements; first, the political structure and second, the level of development. Energy planning in democratic countries is generally under the responsibility of local (municipalities) or regional governments (Van Beek, 2003). In developing countries, it is the central government that is the main decision-maker and local governments and or regional authorities (counties or provinces) have insufficient power to make decisions. The country's level of development, particularly technological development, also plays an important

role in selection of energy planning methodology. The energy infrastructure in developing countries is usually based on old and/or cheap technologies with low efficiency and higher energy losses. In these countries, the energy infrastructure is normally controlled by the central government or by state-run companies. They also lack appropriate detailed information (or statistical) systems needed for the planning process, which leads them to focus only on large-scale national energy planning (Van Beeck, 2003).

Community energy planning may cover different time horizons of short, medium or long terms. Klein et al. (1984) refer to planning time horizons of 4 years or less for short term, between 5 and 9 years for the medium term and 10 years or more for long range. However, there is generally no standard planning time horizon and it depends on the purpose of planning, since different economic, social, and environmental processes take effect at different time scales (Van Beek, 2003).

4-3. Sustainable energy planning

The energy crisis of the 1970s has increased the need for application of energy planning as a tool for better management of community energy systems. Adding the term 'sustainable development' into the political agenda in 1980s has increasingly engaged environmental, economic and social issues in decision-making and has also influenced planning processes. These changes, together with technological developments, have added to the complexity of community energy systems, which it was rather hard to address using the existing conventional energy planning methods. New approaches to existing energy planning methods have been taken to be able to deal with the new circumstances (or in order to adapt them for the new sustainability paradigm) by, e.g., increasing the share of renewable energy resources in energy supply systems, focusing on more efficient energy production i.e. co-generation and CHP utilization, etc. (D. Rad, 2008). Several mathematical models such as the *Multiple Criteria Decision Aid* (MCDA), and *Preference Ratio in Multiattribute Evaluation* (PRIME) have been developed to assist decision-makers in a complex energy system.

These comprehensive optimization models can provide a complete picture of all energy flows and energy conversions within a well-defined energy system. Wene (1988) emphasizes the need for a comprehensive model of the community energy system from a "rational" planning point of view. However, he argues that "*a model can be a technical success but still fail to make any impact on the planning process*" (p.213). Wene points at technical issues (substantive) and the procedural aspects of planning which may give rise to conflicts in the actual process of planning. He believes that, although comprehensive mathematical models are useful for solving technical (substantive) problems in an energy system, they fail to cope with the procedural aspects of planning for energy systems since they do not belong to a unique system. The community energy system consists of many subsystems, e.g., electricity, district heating, fuels, etc., with different managements and organizations, which makes it difficult for a comprehensive energy model to fit (ibid). Regarding "*the complexity of energy policy and energy strategy issues no model can give answers to all the questions. Rather, it will require several models with different objectives and specifications in order to effectively support the development of energy policies and energy planning*", says Rath-Nagel (1981). Yet no mathematical model is presented with the capability of integrating technical issues with organizational aspects of the planning process. Biswas (1990) argues that models are only applicable for what can be modeled (i.e. the quantifiable aspects), implying that qualitative aspects such as people's behavior cannot be taken into account. Van Beeck (2003) states that many social and environmental aspects of energy systems, albeit well known, are not incorporated in models since they cannot be quantified in a satisfactory manner. Van Beeck continues that capturing every aspect of reality in a model is impossible: "*At best, models provide a (highly) simplified representation of parts of reality*" (p. 23).

Although, the models may assist in making proper decisions, they cannot determine what decision is 'good' or 'best' and in fact the model users (decision-makers) ultimately determine what the 'best' option is (ibid). Biswas and Van Beeck argue that context-related issues are neglected in decision support models in general and energy models in particular. They believe most models focus mainly on economic and technical aspects and are not designed to include the interests of actors other than investors. In reality, the key actors in decision-making are the different parties involved in the

decision process, who have their own objectives and interests, and normally decisions involve some compromise (Thörnqvist, 1975; Arrow et al., 1996; Van Groenendaal, 1998). Therefore, focusing only on the (financial) interests of investors can easily lead to the exclusion of the other actors' interests, or, at the other extreme, rejection of the model itself. Although comprehensive planning models are good in assisting decision-makers in a better understanding of the technical aspects of energy systems, they are not enough to make the final decision. In reality, energy strategies are set within a network of public authorities, energy companies and the other related stakeholders (D. Rad, 2008). Each member of this network as a subsystem of the community energy system has its well-established organization, management and adequate experience of how to run the subsystem and how to act in relation to or against influences from the other subsystems (Wene, 1988). Decisions on future energy strategies are normally taken through these organizations, which Beer (1975) has called 'esoteric boxes'. Beer describes the esoteric boxes as a strongly robust subsystem which is in equilibrium with the surrounding environment and the other subsystems. The actual management of the community energy system occurs through the network of esoteric boxes (Wene, 1988). The community energy system can be influenced by political decisions but only through the workings of one or more of the esoteric boxes (ibid). The appropriate relationships and functioning of the network of esoteric boxes are among important factors for stability of the energy system. Other factors which can influence the stability of an energy system are energy markets, useful energy demand, energy technology and the natural environment. Hence, the community energy system should be considered as an open system which consists of three main components (D. Rad, 2008):

- Technical systems
- Energy management
- System relations (both internally and with its environment)

The stability (and/or sustainability) of the community energy system greatly relies on managing the relationships between the above-mentioned components. This management needs tools and energy planning is the most appropriate tool for this purpose. In this context, energy planning should be seen as more than just a mathematical modeling tool. Orchestrating the

political, institutional and social objectives within the planning process needs the use of human intellectual capacity. In other words, it is the duty of the planner or the planning committee to benefit from all available instruments, policies, social, institutional and political networks to select the most acceptable scenario for the energy plan. This will increase the legitimacy of the plan among the stakeholders and will lead to a more harmonized plan implementation. In this approach the planning group should identify the environmental, social, economic and institutional objectives, integrate them into the planning process and finalize the best possible option by assessing various scenarios. This is called Sustainable Energy Planning. Figure 9 presents the community energy planning diagram. The diagram indicates the role of the planning process in relation to the three (different in nature but related) components of the community energy system. It should be mentioned here that the energy management in this diagram should not be considered as a unique subsystem, since it actually consists of the network of other sub-systems (or esoteric boxes).

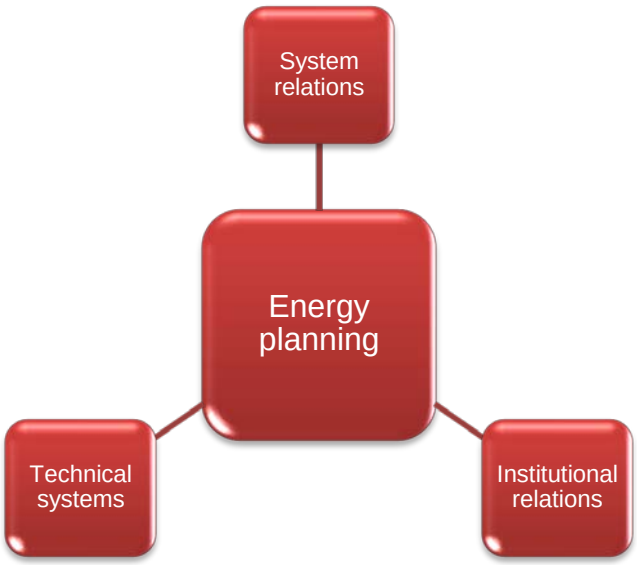


Figure 9: Community energy planning diagram

4-4. Characteristics of sustainable energy planning

The sustainability objectives that should be considered and integrated into the energy planning process are explained in the previous sections. These also explain why existing energy planning methods are unable to address those objectives that form the characteristics of sustainable energy planning. These characteristics can be outlined better through a brief overview of the weaknesses of existing energy planning methods.

Conventional energy planning methods generally focus on the communities' energy supply and use, ending with a set of policies to meet future energy needs. These methods can hardly integrate all energy-related aspects into the energy planning process. Existing planning methods may be able to address some economic or environmental aspects, but they lack the capacity to cover all energy-related issues simultaneously.

Conventional energy planning methods are also sensitive to upcoming changes in their surrounding environment. In other words, they could easily be influenced by, e.g., energy market fluctuations, the political system and new technologies. Economic conditions can have a great influence on decisions taken at local level concerning energy investments (Olerup, 2000). For instance, the increasing energy prices in 1973 changed almost all the calculations in the then quite recently published energy plan of the city of Malmö. The most important reason for such planning failures is the plan's inflexibility against changes. Seeking frequent feedback and regularly following up plans are important parts of the planning process which can help to reduce vulnerability to unexpected changes. Moreover, existing energy planning methods are limited by their short time perspective which is normally around 10 years. Thörnqvist (1980) argues that an energy plan should naturally have a long-term planning horizon since community energy infrastructures, such as district heating systems, natural gas pipelines and energy distribution facilities can technically be in service for up to 30 years (p. 21). Although technological advancements and/or changes in the energy use patterns of the community may possibly not be seen and discussed in a long-

term perspective, the planning system should be open enough to deal with such changes (ibid).

Another weakness of the conventional energy planning methods is their neglect of the appropriate relationship between the community energy system and the other systems or subsystems. Community energy systems are open and dynamic systems that can always be influenced by external factors and unexpected technological, economic and social changes. Public participation in the planning process, which is advocated in contemporary democratic societies, is not considered seriously in conventional energy planning methods. According to Webler and Tuler (2006), a good (planning) process should consider readily and openly share information among all stakeholders and people, and should propose the best scenario in which all participants' interests are satisfied. Although public participation promotes the legitimacy of the planning process, it is not always successful in improving the policy delivery (Rydin and Pennington, 2000). Healey (1992) argues that this dilemma appears through the increasingly diversified opinions of citizens with different levels of knowledge. Hence, the communication between planners and the others will be affected (and in a way limited) by the dominant narrow and scientific rationalized planned goals. Dialogs between (planning) experts and ordinary citizens and involving them from the early stages of the planning process can help to get their support for the proposed policies (Ivner et al., 2010). In addition to the importance of public participation in implementation of energy plans, the other energy-related stakeholders, e. g., energy companies, waste management companies, industries and related businesses should also be involved in the planning process. The mechanisms for engagement of energy-related stakeholders were not adequately considered in existing energy planning methods since these methods were structured at a time when governments were the major decision-makers and had the monopoly in the energy planning process, energy companies, energy transmission/distribution networks, etc. This shortage was exposed in energy planning particularly after the electricity market deregulation in the 1990s and local governments had no effective solution to cope with this shortage (D. Rad, 2008).

The above-mentioned shortages of conventional energy planning methods actually form the topics that should be addressed through the sustainable

energy planning procedure. Transition to sustainable (community) energy systems requires a robust planning method with a set of characteristics that can be mapped as shown in Figure 10.

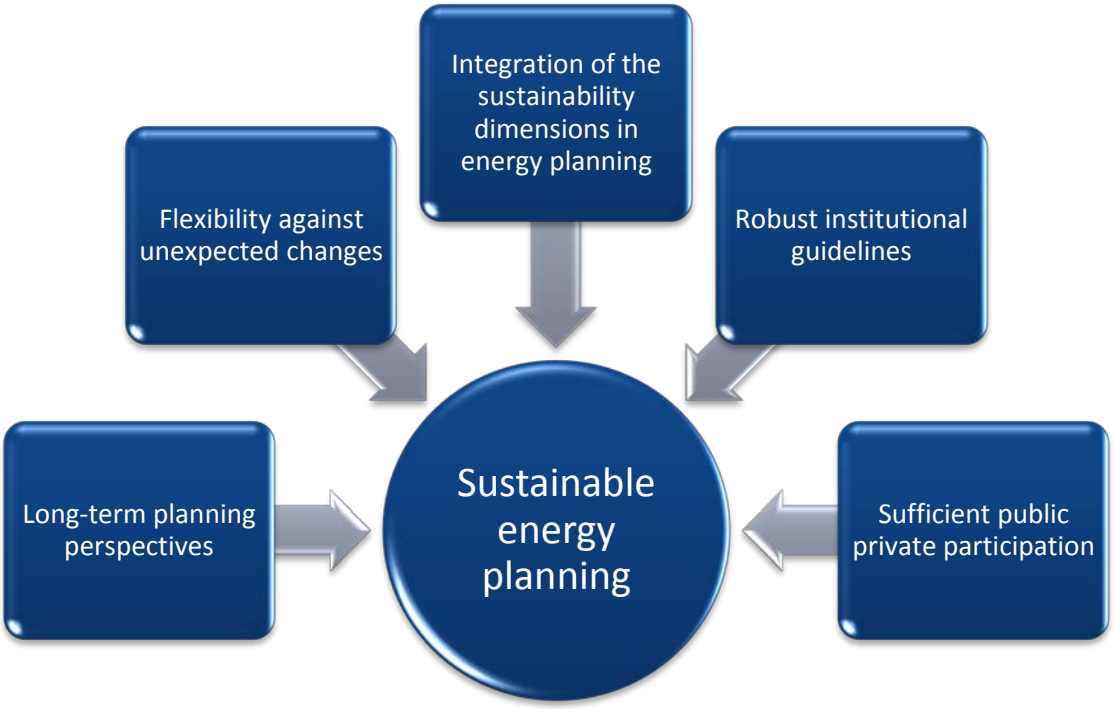


Figure 10: Characteristics of sustainable energy planning

5. Energy Planning in Sweden

In this chapter we narrow down the focus of our discussion about energy planning and sustainable development to a local perspective. Local (municipal) energy planning in Sweden is selected as our case study. Sweden is selected because of more than 30 years of the country's experience in municipal energy planning. By presenting the background to the Swedish energy system, this chapter aims to investigate how sustainability aspects are considered in local energy planning.

5-1. The Swedish energy system - an overview

The Swedish energy system has undergone a major transformation throughout the last decades. In 1970, around 80% of the total energy supply was from imported fossil fuels. This figure changed by reducing the fossil fuel imports to 30% today, which indicates significant changes in the structure of the Swedish energy system (Swedish Energy Agency, 2009). The country's energy supply increased by 36.5% from 457 TWh in 1970 to 612 TWh in 2008 (Figure 11).

Today in Sweden, the industrial sector, with a 25% share of the total energy demand, is the largest energy consumer. The residential and transportation sectors, with shares of 23 and 17% respectively, are in the next positions (Figure 12). Electricity production in Sweden is basically fossil-free. Around

half of the electricity production comes from hydropower (47%) and the rest is provided by nuclear power (42%), combined heat and power (5%), industrial back pressure power (4%) and wind power (1%). The total share of renewable energy resources has increased from 33.3% in 1990 up to 44.1% in 2008 (Swedish Energy Agency, 2009).

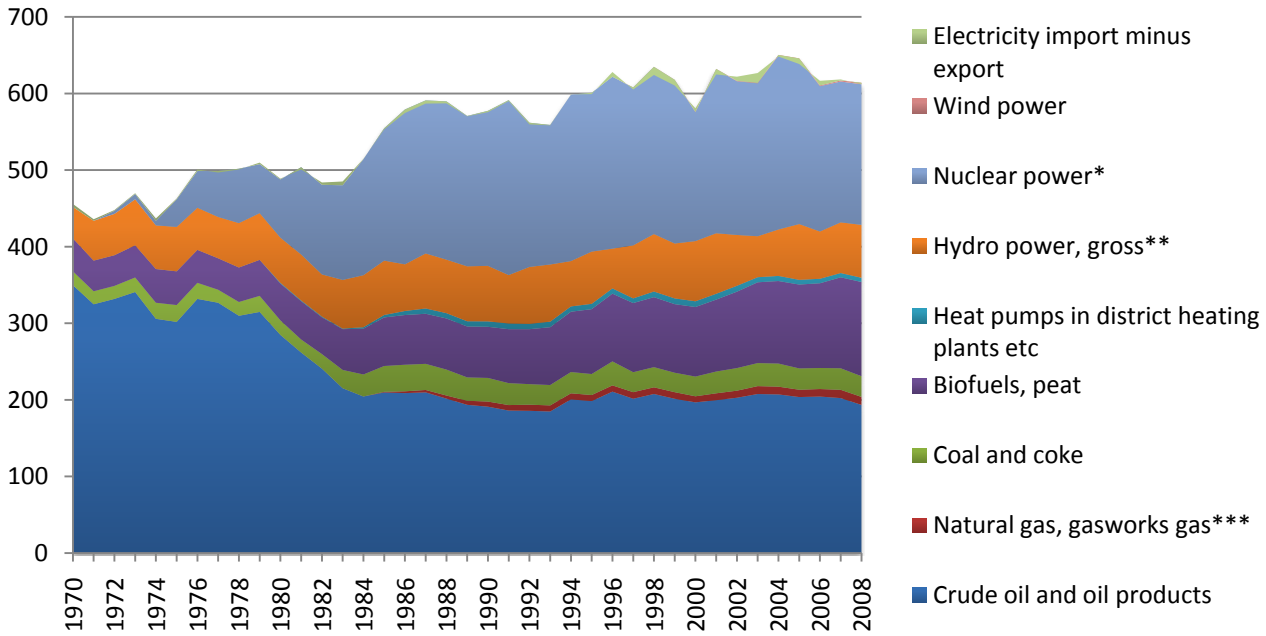


Figure 11: Total energy supply in Sweden 1970-2008 (TWh)

(Source: Statistics Sweden and Swedish Energy Agency, 2009)

**In accordance with the UN/ECE method for calculating contribution from nuclear power*
***Includes wind power up to and including 1996*
****Gas works gas covers all types of gas produced in public utility or private plants, whose main purpose is the manufacture, transport and distribution of gas. It consists of gas produced by carbonization (including gas produced by coke ovens and transferred to gas works), by total gasification (with or without enrichment with oil products), by cracking of natural gas, and by reforming and simple mixing of gases and/or air. This heading also includes substitute natural gas, which is a high calorific value gas manufactured by chemical conversion of a hydrocarbon fossil fuel.*

Over the last decades, energy use patterns in Sweden have gradually changed through shifting from the dominant fossil fuels to other energy sources. One important driver of this change was the development of district heating systems, which has led to a significant reduction in the use of fossil fuel based furnaces for space heating. Sweden enjoys an extensive district heating sector.

District heating accounts for about 40% of the Swedish heating market (Swedish Ministry of Enterprise, Energy and Communications, 2009). Use of district heating increased by approximately 280% from 14.6 TWh in 1970 to 55 TWh in 2008 (Swedish Energy Agency). More than 77% of district heating is used for space heating in buildings (residential and commercial). Compared to 1970, the fuel mix of district heating has changed dramatically. Today, oil accounts for only 2.7% of the energy input for district heating and more than 71% of the energy needed is supplied by biofuels.

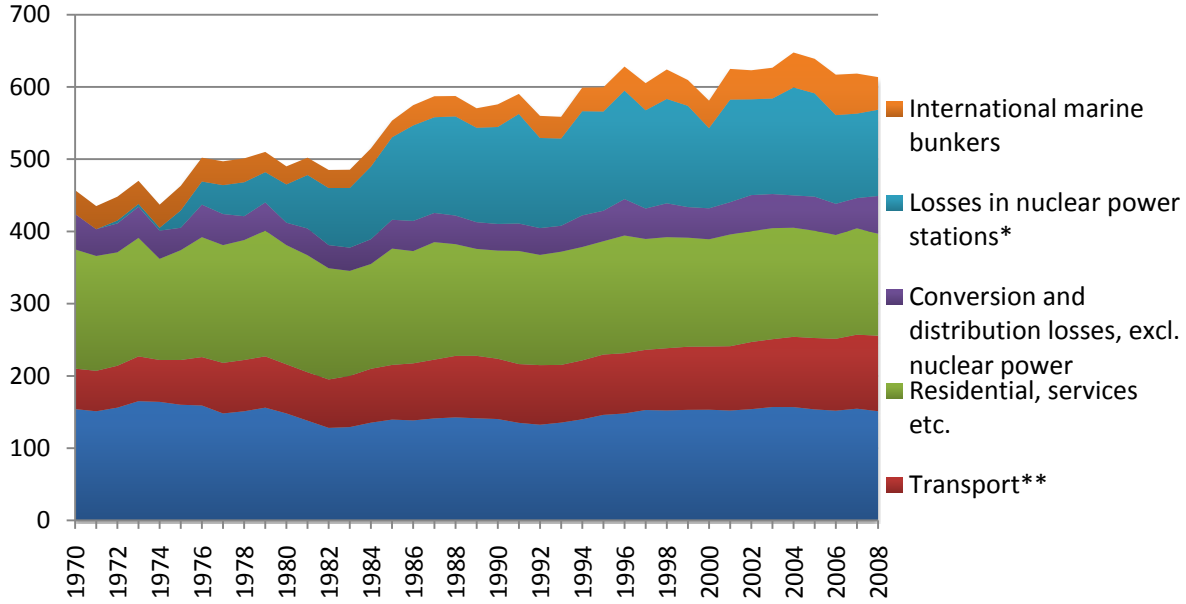


Figure 12: Total energy use in Sweden 1970-2008 (TWh)

(Source: Statistics Sweden and Swedish Energy Agency, 2009)

** In accordance with the UN/ECE method for calculating nuclear power's contribution*
*** Includes international aviation*

In Sweden, the engagement of energy and politics is an old tradition dating back to the 19th century when Swedish politicians together with the industries began to investigate possible ways of reducing their dependency on imported coal (Kaijser, 2001, p.62). The Swedish government's influence on energy-related issues can be also traced in the early 20th century, with the adoption of laws, e.g., the Electricity Act in 1902[26] or the Water Act in 1918[27]; however, energy was not really considered as a political issue until the oil price crises of the 1970s (D. Rad, 2008). Before that, it was assumed that the whole structure of Swedish economic well-being could be sustained based on the supply of cheap electricity and profligate use of imported oil (Vedung, 2001).

The first comprehensive Swedish energy policy was introduced in 1975, when the country's parliament decided to start a national energy conservation program. The policy's main aim was to reduce the accelerating increase of energy supply by limiting its average growth rate to 2% per year until 1985 (Vedung, 2001). Moreover, further limitations were to be made between 1985 and 1990 in order to reach zero growth in energy demand by 1990 (ibid). The 1975 decision led to greater reliance by the Swedish energy system on nuclear energy. One important reason for the development of nuclear energy was to reduce the dependency on imported oil. Implementation of this policy was successful and as a result the country's nuclear electricity production capacity increased from 4 TWh in 1972 to 202 TWh in 1990 (Figure 13).

In 1997, the Swedish Parliament approved a new energy policy towards creating a sustainable energy system. The major goals of the new policy were the development of an ecologically and economically sustainable energy supply mainly through renewable energy resources, and improving energy efficiency (Swedish Parliament, 1996/97:84).

[26] The 1902 Electricity Act concerned obtaining permission for constructing high-voltage lines

[27] This Act concerned the development of water resources for power generation

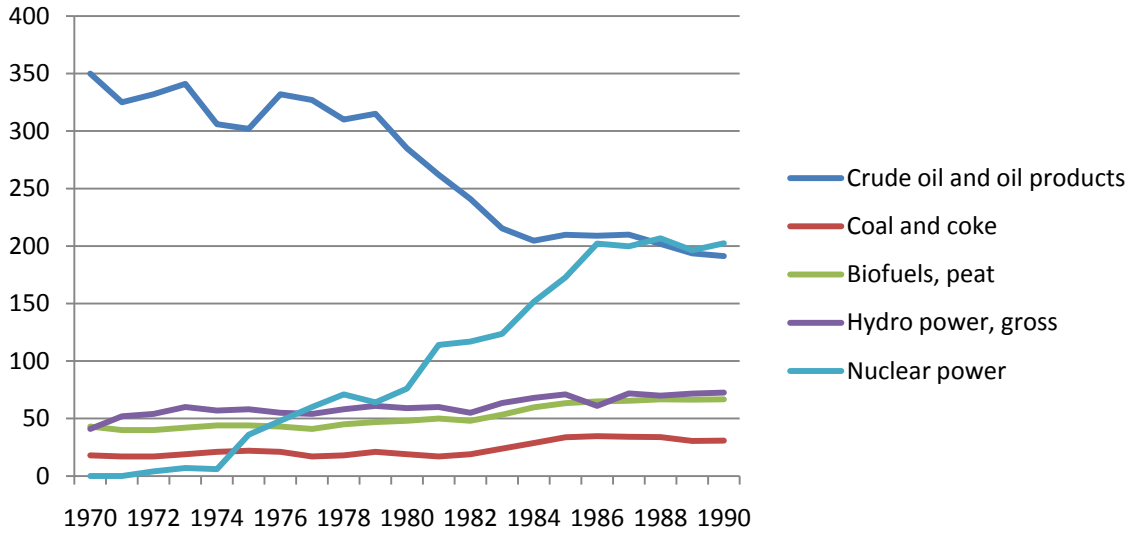


Figure 13: Energy supply trend in Sweden 1970-1990 (TWh)

(Source: Swedish Energy Agency)

Today, the Swedish energy policy is to create a sustainable energy system with a long term vision for the country to obtain all the energy supply from renewable energy sources (Swedish Ministry of Enterprise, Energy and Communications, 2009).

In Sweden, local authorities have an important role in pursuing the country's policy towards a sustainable energy system. An important tool that local authorities use to develop the local energy systems in Sweden is municipal energy planning. The background to Swedish municipal energy planning and its effectiveness in the development of local energy systems is presented and discussed in the next section.

5-2. Local (municipal) energy planning in Sweden

5-2-1. Background

In Sweden, the municipalities traditionally have their own self-governing local authority with certain responsibilities (Swedish Association of Local

Authorities and Regions)[28]. They are responsible for providing a wide range of public services, such as health and environmental protection, water and sewerage, physical planning and building issues, social services, waste management, etc. Energy is among the fundamental factors to provide these services. Sweden's municipalities are key operators in managing the local energy system. They can act as public operators, real-estate owners, employers and/or owners of an energy company. They can also influence the strategic development of the energy system by benefiting from an energy plan (Swedish Energy Agency, 2006).

Involvement of Swedish municipalities in energy issues goes back more than 150 years to when the municipal gas-work companies were established during the 1860s, particularly for the purpose of street lighting (Thörnqvist, 1984). Gasworks were the first very important technological systems that municipalities were involved in (Kaijser, 1986). Along with the development of electricity generators in the late 1880s, most of the municipalities became interested in producing their own electricity. Increasing electricity consumption, particularly after the Second World War, made it clear that hydro power alone would not be able to meet the growing demand. During the 1950s, Combined Heat and Power plants (CHP) appealed to several municipalities as an interesting alternative for electricity generation and district heating (Thörnqvist, 1984). A municipal district heating system could provide many advantages, e.g., cheaper primary fuels, improved energy efficiency, better air quality in cities, less urban fuel for transport, reduced labor needs for fuel, etc. With their local energy company and district heating network, municipalities could have a significant influence on the energy system. In 1970 a new approach to municipal engagement in energy supply emerged by assigning a key role to the predominantly urban heat supply. In a Governmental Inquiry, it was suggested that all municipalities should be liable for the heat supply in urban areas and they should develop a municipal heat plan (SOU 1970:13). However, it was observed in 1972 that the municipal heat plans were not enough for developing the local energy systems; moreover, the Swedish municipalities would need adequate legal rights to promote their energy systems (Thörnqvist, 1984). This was actually

[28] More information is available on: http://www.skl.se

the time for the Swedish government to decide upon providing the municipalities with more legal rights to undertake extensive energy planning.

5-2-2. Legal perspective

According to Swedish law, municipalities are legally required to provide an 'energy plan' (Municipal Energy Planning Act, Swedish parliament, SFS 1977:439). Based on the Act, local authorities are required to promote the efficient use of energy and work for a reliable and adequate energy supply. Moreover, every municipality must have an up-to-date plan for the supply, distribution and use of energy. The Act also emphasizes collaboration of the local authorities with other municipalities and/or other energy related stakeholders, such as energy companies, in order to resolve the important issues in energy efficiency and energy supply. According to the Act, the Municipal Council is responsible for deciding upon the energy plan's approval. The Act has contributed to the decentralization of responsibility to the local authorities in line with the country's policy on general development toward decentralization (Ivner, 2009).

The Act has been amended several times since 1977. These revisions and complementary legislation were added to the Act based on new circumstances in the country's energy policy over time (Olerup, 2000). Following the 1979 oil crisis, the first amendment was added to the Act in 1981, and required the municipalities to plan for reducing their oil consumption. In 1985, it was decided that energy should be integrated into the municipal master development plan (Stenlund, 2006). According to this amendment, energy plans should not focus only on collective energy systems, which are under the control of municipal energy companies, but individual energy systems should also be considered in the plan (Olerup, 2000). Another amendment was made to the Act in 1991 when the Swedish Parliament decided the municipal energy plans should be supplemented by an environmental impact study (Swedish National Energy Administration, 1998). The latest amendment was made to the Act in 2004 in line with the implementation of the EU directive on Strategic Environmental Assessment, SEA (2001/42/EC). According to this amendment, an environmental impact assessment should be included in municipal energy planning (SFS 2004:602).

5-3. Facts and figures in local energy planning

Sweden has 290 municipalities. The latest information about municipal energy planning was released officially by the Swedish Energy Agency in 2006. The figures presented in the report were the result of a national questionnaire-based survey, to which 236 municipalities responded. According to the report, 73% of the Swedish municipalities have an energy plan. This means only 172 out of 236 municipalities have an energy plan and if we assume that the remaining 54 municipalities (which did not complete the questionnaire) had no energy plan, then the real figure would be 59% (Figure 14). To avoid further confusion, the data reported by the Swedish Energy Agency is used in this thesis.

One may wonder why, after more than 30 years of legislation through the Local Energy Planning Act by the Swedish parliament, more than half of all municipalities are still pay no attention to it. (This issue is discussed in the following sections.)

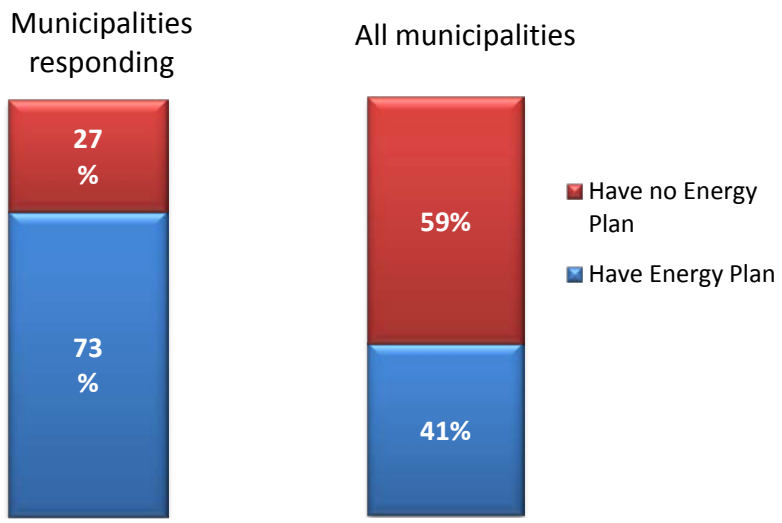


Figure 14: The status of municipal energy planning in Sweden (2006)

The publication date of local energy plans shows that many of the Swedish municipalities have energy plans that are at least 5 years old (Swedish Energy

Agency, ER 2006:40) (Figure 15). This figure was significantly lower in the 2002's survey, when 35% had an energy plan that was 5 years old or more.

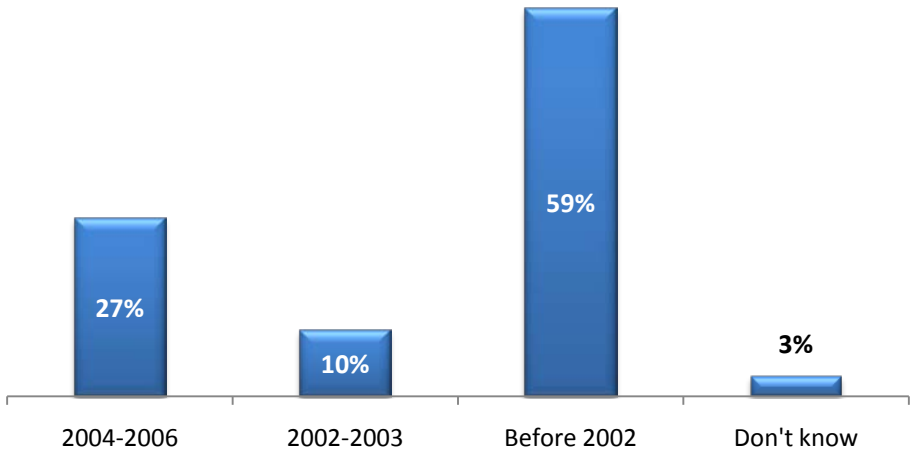


Figure 15: Age of the energy plans

(Source: Swedish Energy Agency, 2006)

Since 21 July 2004, municipalities are required to include an environmental impact assessment in their energy plans (SFS 2004:602). However, only 46% of the existing energy plans are environmentally assessed (Figure 16). The main reason that most energy plans were not environmentally assessed was that they were adopted before the Act came into force. Other reasons given were, inter alia:

- that the person(s) responsible for energy planning is/are unaware of the law
- that the energy plan is part of another document, e.g., the energy and climate strategy
- lack of environmental related information, material and data

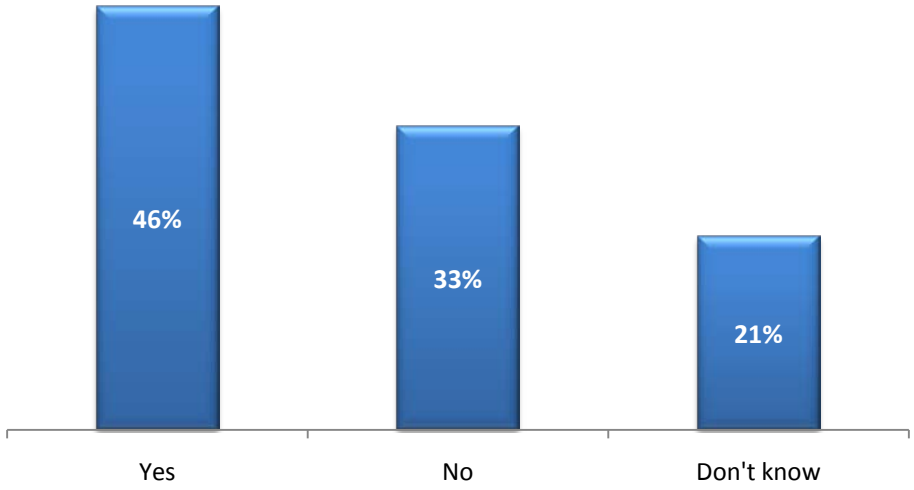


Figure 16: Environmental impact assessment in municipal energy planning

(Source: Swedish Energy Agency, 2006)

In many municipalities energy plans have some relationship with their climate strategies. Some municipalities have both in the same document and others have separate documents (Figure 17).

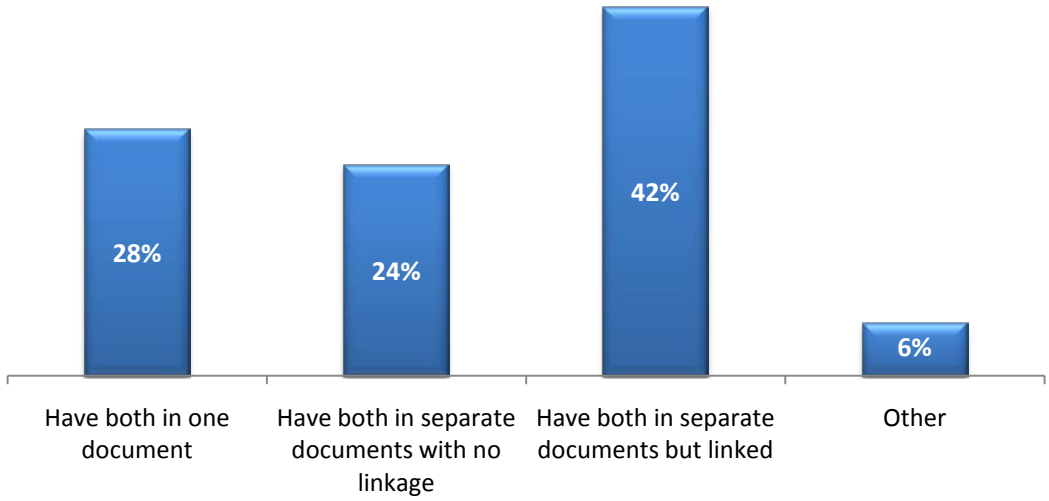


Figure 17: Municipalities with energy plan and climate strategy

(Source: Swedish Energy Agency, 2006)

The report points at the similarities between the energy plans and climate plans, as they deal mainly with the same areas and may take the same approaches. They are also to be developed through a similar process in which the same actors within and outside the municipal organization are involved. According to the Swedish Energy Agency, the energy plan itself can be the municipality's climate strategy and it is difficult to see any reason for a municipality to have two separate documents. The main reason for many municipalities to develop a climate plan (or strategy) was to seek governmental grants from the Climate Investment Program of KLIMP[29].

5-4. The role of the Swedish Energy Agency

In 1997, the Swedish parliament set out an energy policy program with the objective of creating an ecologically sustainable and economically viable energy system for the country. To implement this policy, the Swedish Energy Agency (*Energimyndigheten*) was formed in 1998 as the central administrative authority for working towards transforming the Swedish energy system. The Swedish Energy Agency is a governmental agency which operates in various sectors of society to create conditions for efficient and sustainable energy use and a cost-effective Swedish energy supply[30].

It is stated in the official website that the Agency's mission is[31] "*to promote the development of Sweden's energy system so that it will become ecologically and economically sustainable. This means that energy must be available at competitive*

[29] The Swedish Government's support to Climate Investment Programs (KLIMP) is a tool for reaching the Swedish climate objective as formulated in the Swedish climate strategy in 2002. KLIMP has enabled municipalities and other local actors to receive grants for long-term investments that reduce greenhouse gas emissions. For more information see: http://www.naturvardsverket.se/sv/Lagar-och-andra-styrmedel/Ekonomiska-styrmedel/Investeringsprogram/Klimatinvesteringsprogram-Klimp/

[30] Retrieved from the website of the Swedish Energy Agency on 2010-08-06

[31] Retrieved on 2010-11-08 from: http://www.energimyndigheten.se/en/About-us/Mission/

prices and that energy generation must make the least possible impact on people and the environment; in simple words, a smarter use of energy". The Agency's strategic objectives are as follows:

1. The Agency works to ensure that energy matters are automatically taken into account in relevant social sectors

2. The Agency supports the achievement of the national climate targets

3. The Agency promotes an energy system that is economical on resources and energy efficient, and that uses an increasing proportion of renewable energy sources

4. The Agency works to ensure that there is a safe and reliable energy supply

5. The Agency works for efficient energy markets in which customers have a strong position

6. The Agency is a modern and efficient public authority in all respects

7. The Agency is an attractive employer whose employees are given good development opportunities in a sound working environment

Except for the two last items, the Agency's strategic objectives reveal its important role in implementation of the national policies in the country's decentralized energy system. The role of the Agency in local energy planning is mainly as an advisor and informer about the national energy policies and guidelines on matters relating to the application of the Municipal Energy Planning Act (SFS 1997:883). The Agency refers to municipalities as important actors in developing the local energy system by having a holistic approach to energy planning. It is stated in the official website that "*The Agency operates, finances and participates in a variety of activities based on the local or regional level. These include development programs such as 'Sustainable Municipality' and support for information and education, and assistance in various forms to the local energy and climate advice and regional energy agencies.*

The Agency also supports the county administrative boards in their work with the regional energy and climate strategies"[32].

Although the Agency has an energy planning office, it does not actively work with municipal energy planning. Instead, it is more focused on another municipal program called Sustainable Municipalities (*Uthållig kommun*). The program was launched by the Swedish Energy Agency in 2003 as a 5-year pilot project with five municipalities. In June 2008, the second phase of the program started, based on the results of the pilot project, which were declared positive. All the 60 participating municipalities are required to produce an energy strategy. The requirement does not refer to the Municipal Energy Planning Act (Ivner, 2009). According to the Swedish Energy Agency, the local strategies should only include activities within the power of the local authorities. Therefore, municipalities should:

1. Implement measures for energy efficiency and energy conservation in their operations, properties, etc., that are profitable,
2. Clarify, prioritize and resolve energy issues within the municipality's responsibilities and activities in accordance with an energy and climate strategy,
3. Encourage citizens and businesses to implement profitable energy efficiency measures and energy conservation. These effects are achieved mainly by the municipality's established energy and climate consultancy and business development.

These guidelines are very similar to those in the Municipal Energy Planning Act. All of them are actually about development of a local energy system. It is interesting to see that local authorities are not obliged to do energy planning (which actually has a legal basis) while in the new program they are obliged to have an energy strategy.

The Swedish Energy Agency is doing the same job which was criticized in one of its own earlier reports. In a report on municipal energy planning published by the agency in 2006, the Agency refers to the similarities between

[32] Retrieved on 2010-11-08 from: http://www.energimyndigheten.se/sv/Om-oss/Var-verksamhet/Effektiv-energianvandning/

energy plans and climate plans in their areas of approach, methods and the actors involved in the process; thereafter, the Agency questions the reason why a municipality should have two separate documents while the energy plan can itself be the municipality's climate plan (ER 2006:40, p. 31). Ivner (2009) has discussed this issue from the legitimacy point of view. She states: "*when the Energy Authority chooses not to promote municipalities' work with their energy strategies within the existing legal framework for energy planning, this may undermine the legitimacy for energy planning as a whole*" (p. 73).

In general, it can be seen that the Swedish Energy Agency is not working sufficiently with municipal energy planning. Although the Agency has a defined set of strategies on local energy system development, its role in relation to municipal energy planning is not clear.

5-5. The importance of Swedish local energy planning

Municipal energy planning in Sweden has had an important legal position since 1977; however, its effectiveness in developing the local energy system has been a subject for debate over the last three decades. In the first decade, a general evaluation of the effectiveness of local energy planning might still not have been feasible since the municipalities were new to energy planning and were still practicing the process. Ten years after the law (the Energy Planning Act) came into force, only half of the municipalities actually had an energy plan (Diczfalusy, 1987). The Act has been recognized as a weak instrument without sanctions (RRV, 1990). It also lacked strict requirements on what an energy plan should comprise (ibid).

In the second decade, municipalities became more experienced in energy planning and this can be observed through comparing the more mature comprehensive energy plans with the old versions of the 1980s (D. Rad, 2008). Municipalities have applied more advanced methods of goal-setting in their energy planning. Most of the goals fulfilled were those that local authorities could influence directly such as district heating expansion plans and energy efficiency measures in public buildings (Ivner, 2009). Two important events of the second decade that affected the municipal energy

planning were firstly, deregulation of the electricity market in the mid-1990s and secondly, the growing trend on local climate policy development. Deregulation of the electricity market during the 1990s resulted in a weakening of the dominant power of municipalities in controlling some parts of the community energy system which were functioning under the supervision of local government, e.g., energy companies, electricity grids and district heating networks (D. Rad, 2008; Ivner, 2009). Another important feature of this period was the growing attention to environmental objectives, particularly climate change. Municipalities became more interested in working with climate plans since, firstly this was a new and positive theme in the political agenda that hardly could be criticized and, secondly, in contrast to energy planning, climate plans could receive various financial supports from national and international funds.

The third decade of municipal energy planning shows no significant improvements compared to the previous decades. According to the Swedish Energy Agency, energy planning has a lower priority on the agenda since municipalities are unsure about their rights and obligations in regard to energy planning (Report No.P12662-1, 2002). Instead, environmental issues that are mostly driven by the industrial and transportation sectors were considered by municipalities as higher priority issues. It could be observed that the importance of municipal energy planning as a tool for managing the community energy system diminished among the local authorities. At the national level, the state authorities' attempts to improve the willingness to work with local energy plans were also not effective. During the 1990s and early 2000s, several initiatives were made to encourage local energy planning, e.g., providing energy planning seminars and courses for municipal staff as well as publication of energy planning handbooks by the Swedish Agency for Economic and Regional Growth (NUTEK) and the Swedish Energy Agency; however, the Swedish municipalities' response was low (Ivner, 2009). Although municipal energy planning has a legal basis, its requirements on the local authorities' obligations are vague and consequently increase uncertainty about how the energy planning process should be performed (Olerup, 2000; Ivner, 2009). Moreover, there is no officially appointed national agency to approve or control municipal energy plans (Stenlund, 2006). This is actually a weakness of the law, since there is no sanction to apply if a plan is not made (Olerup, 2000). It means that there is no penalty for municipalities that do

not comply with the law. The state authorities have no supervision on whether the local energy plans are in line with national energy policies. There is also no mechanism to check whether the municipalities are either updating their energy plans or following up the planned goals. Insufficient resources are allocated by the national administration to thoroughly follow up on achievements at the local level (Olerup, 2000). According to a survey by the Swedish Energy Agency in 2006, barely half of the municipalities have conducted an annual follow-up of their energy plans (Figure 18).

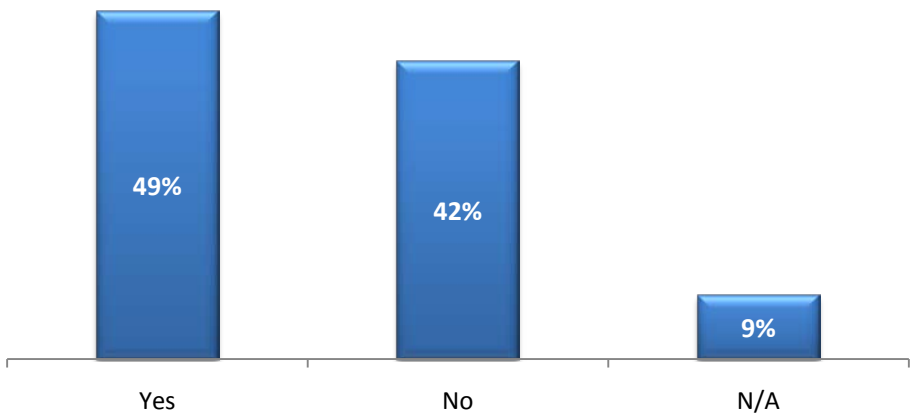


Figure 18: Annual follow up of energy plans in Swedish municipalities

(Source: Swedish Energy Agency, 2006)

To design and include a control function is an important part of the planning process. Regular following up of the plan is necessary to keep moving toward the planned goals. Control functions in municipal energy planning are very important since they deal with energy-related issues within the ever changing and dynamic systems that are called societies. Energy planning without considering control functions is a waste of time and money. This matter is even more important when talking about sustainability and sustainable energy systems. Regular monitoring of energy trends and evaluation of their effectiveness in developing the energy system are very important in order to understand and assess the ongoing situation.

An overview of more than three decades of municipal energy planning in Sweden shows ups and downs in its effectiveness and significance over time. It had a rather good start in terms of practicing systematic work on local energy systems by the local authorities. Energy planning also helped the municipalities to achieve important goals, e.g., reducing oil consumption and increasing the share of renewable energy, which were in line with the national energy strategies. However, the importance of municipal energy planning as a tool for developing local energy systems has diminished over the last decade (D. Rad, 2008). According to Stenlund (2006), the effectiveness of energy planning in terms of goal achievement was also low. She refers to the narrow scopes of energy plans, which were often limited to technical approaches to supply and efficiency measures for the service sector. Although the addition of objectives for energy and environmental policies, i.e., Agenda 21 in the mid-1990s, has widened the scope of energy planning, the planning procedure has not been much considered as an important tool by the local authorities so far.

Several other factors influenced the local energy system more than municipal energy planning, e.g., the deregulation of the electricity markets, large investment programs, Agenda 21 and environmental objectives (D. Rad, 2008; Ivner, 2009; Palm, 2004; Olerup, 2000). The deregulation of the electricity markets in the mid-1990s led to a reduction of the dominant power of the municipalities in managing and controlling local energy systems. Some municipalities sold all or part of their share in local energy companies and therefore decision-making on the company's future investment plans and strategies has been mostly transferred to the free market. This has consequently steered some parts of the power balance from local government to local energy companies and related businesses.

Municipal energy planning was also influenced by Agenda 21 and its environmental objectives. Climate change and air pollution were among the important environmental objectives which were prioritized by municipalities. Although these objectives have strong links with energy use, climate strategies have developed mostly as a separate task from energy planning (Figure 17). Two main reasons can be identified for municipalities focusing more on their environmental objectives, and particularly on climate change. Firstly, the municipalities could apply for and receive financial support from the state

authorities, whereas there was no such financial support for local energy planning. The costs for energy planning were not covered by the state authorities since it was assumed that the municipalities could themselves gain from the application of efficiency measures (Olerup, 2000). Although working on climate strategies was not statutory like energy planning, nearly half of all municipalities had a climate plan. In a survey by the Swedish Energy Agency in 2006 the municipalities were asked why they work on climate objectives, and a large number replied: "*to be able to apply for the governmental grant for the climate program (project KLIMP)*" (Figure 19).

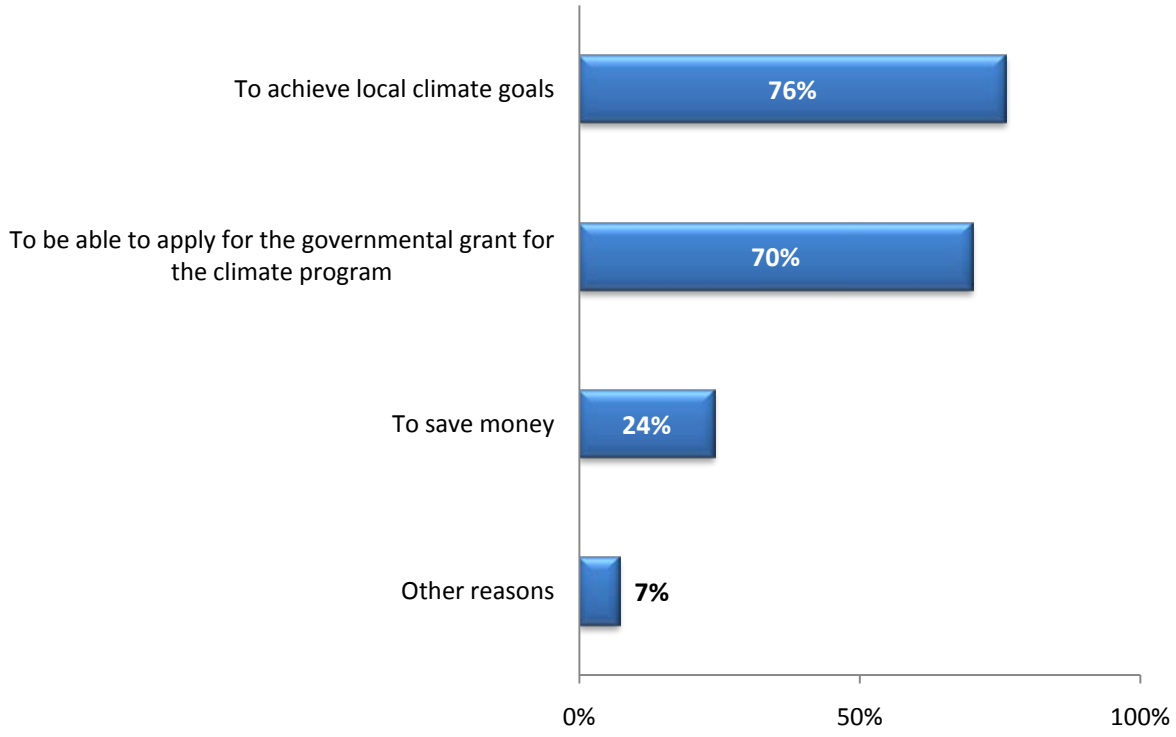


Figure 19: Why has the municipality adopted a climate strategy?

(Source: Swedish Energy Agency, 2006)

Secondly, conventional energy planning methods were unable to address the sustainability objectives of Agenda 21, and particularly those linked to energy use. The municipalities were trained to work with the kind of planning that

focuses mostly on energy supply and use from a technical and economic point of view (Figure 20). Therefore, the challenges that were introduced by the new sustainability paradigm of Agenda 21 were difficult to address through the existing energy planning methods at that time.

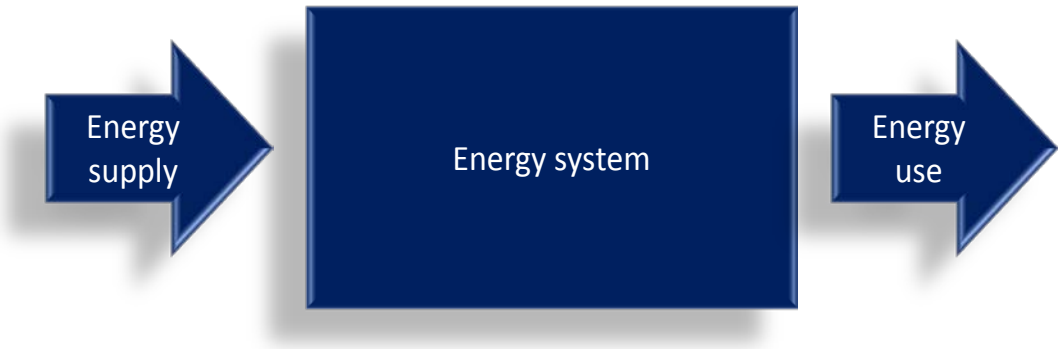


Figure 20: Community energy system (input-output) in conventional energy planning methods

5-6. Discussion

The Swedish energy authorities have the ambition of moving towards an economically and ecologically sustainable energy system[33]. Bearing in mind the complexity of community energy systems, transition in line with this high ambition requires adaptation of systematic long-term strategies. Municipal energy planning, with its legal position in Sweden, has existed as a tool in the

[33] Reference to the Swedish Energy Agency which is the government agency for national energy policy issues: "Our mission is to promote the development of Sweden's energy system so that it will become ecologically and economically sustainable. This means that energy must be available at competitive prices and that energy generation must make the least possible impact on people and the environment", retrieved on 2010-11-15 from: http://www.energimyndigheten.se/en/About-us/Mission/

hands of decision-makers since 1977; however, as explained in section 5-4, the importance and effectiveness of municipal energy planning in Sweden has diminished during the last decade. The main factors that influence municipal energy planning can be summarized as:

1. the weaknesses of the law (the Municipal Energy Planning Act)
2. deregulation of the electricity market
3. lack of financial resources to support municipal energy planning
4. Agenda 21 and its sustainability objectives were difficult to address using existing energy planning methods

The question is how much energy planning can still be helpful to overcome the above-mentioned challenges? Ivner (2009) has practically implemented the process of energy planning to examine its effectiveness in developing a municipal energy system. In her PhD thesis, Ivner has applied the four different decision-making tools of a citizen's panel, scenario techniques, and quantitative and qualitative environmental assessments during the planning process and she has concluded that "*energy planning has potential for being an effective tool for strategic energy work at the local level*". If the authorities' intention is to move towards sustainable energy systems, they should consider and promote all the sustainability objectives related to energy simultaneously. They also should build and evaluate various scenarios to be able to make the best possible decision. Olerup (2000) refers to the strength of planning in its capacity to generate alternatives in which the effects of technological, economic and ecological objectives are considered and assessed. Above all, planning can maximize the use of human intellectual capacity in decision-making and selection of the best possible option. By elucidating a wide scope of the way from problem identification ahead to goal achievement, planning can help humans (decision-makers) to gain a better and deeper insight into the facts needed to make the right decision.

The author believes that energy planning has sufficient potential to be used by the Swedish municipalities as a helpful tool for transition towards sustainable energy systems. However, in order to benefit from its full potential, it is necessary to reconsider and resolve the factors encountered in municipal energy planning. A range of related actions are needed to prepare a suitable basis for the application of municipal energy planning in a new

sustainable context. First of all, the existing legislation, without clear requirements, instructions and supports, is not adequate; hence, the well-known weaknesses of the law (the Municipal Energy Planning Act), e.g., the ambiguity of its requirements and lack of State sanctions and supports, need to be considered and revised. The Act does not go further than as a legal basis. It does not consist of by-laws and/or guidelines for how the municipalities should work with their energy planning.

The next step is to upgrade existing energy planning methods with new methods that allow energy planners to identify, integrate and assess the environmental, social, economic and institutional objectives into the planning process. Providing the municipalities with knowledge, guidelines and tools can be completed using financial support. One may argue that there are already several nationwide sustainability projects, such as 'Sustainable Municipality' (*Uthållig kommun*)[34], 'Sustainable Cities'[35] (*Hållbara Städer*) and KLIMP[36] (*Klimatinvesteringsprogram*), that enjoy governmental financial support; however, they could all be developed and implemented through the existing legally based framework of municipal energy planning. The issue of climate change, as the major common objective of these projects, has a strong relationship with energy use in the buildings (commercial/residential), industrial and transportation sectors, which can be addressed through the energy planning process. The focus on climate and environmental issues is very positive but what about the other sustainability objectives? One major advantage of sustainable energy planning is its capacity to deal with all sustainability objectives because energy is related to all of them (section 3-4). Implementation of parallel projects by various entities but with the common goal of sustainability may result in wasting of resources. We do not want to re-invent the wheel.

[34] With a total budget of SEK 54 million for the period 2008-2011

[35] The total level of support for the period 2009-2010 was SEK 340 million. For more information see: http://hallbarastader.gov.se

[36] Since 2003, the Environmental Protection Agency has granted a total of SEK 1.8 billion in grants for 126 climate investment and 23 independent measures in municipalities, county councils and companies across Sweden. For more information see: http://www.naturvardsverket.se/sv/Lagar-och-andra-styrmedel/Ekonomiska-styrmedel/Investeringsprogram/Klimatinvesteringsprogram-Klimp/

6. Is it sustainable?

One important part of the planning procedure that is neglected in many of the Swedish municipalities is following up the energy plans. According to the Swedish Energy Agency in 2006, only 42% of the municipalities conducted annual follow-ups of their energy plans. Observation of a plan's implementation and evaluation of its progress plays an important role in keeping on track towards the planned goals. Control functions are important tools to adjust and update the plan in adapting to upcoming changes. This importance is more noticeable in regard to the complexity of sustainability objectives that should be addressed in municipal energy planning. This chapter explains the pilot project which was carried out by the author to develop a method for monitoring energy-use trends and to examine the usefulness of energy indicators for municipal energy planning.

6-1. Monitoring the sustainability of an energy system

Regular monitoring and assessment of the plan's implementation is one of the basic principles of the planning process. Archibugi (2008) refers to plan evaluation as "*the other side of the coin to every work of planning*" (p. 7). Municipal energy planning likewise should consist of proper control functions to monitor local energy-use trends. The pace of progress in the sustainability of a local energy system can also be illustrated through monitoring energy-use trends in the various sectors of buildings (commercial/residential), industry and transportation. The question of how local energy-use trends can practically be measured and monitored was the main incentive for carrying out the pilot project on the application of energy

indicators. The author and his research group were also interested in examining whether energy indicators can be used to monitor and evaluate the sustainability of local energy systems.

6-2. Why energy indicators?

The application of indicators for implementing sustainable development is suggested in chapter 40 of Agenda 21. In this chapter, articles 40.5 and 40.6 emphasize the collection and use of multi-sectoral information in decision-making processes at local, provincial, national and international levels, as well as developing the concept of indicators for sustainable development. Sustainability indicators are proxy variables that can help to understand, track and evaluate the development progress. They can be used to monitor the status and trends of the planet's ecosystem, natural resources, pollution and socio-economic variables. They can also assist planners and decision-makers in setting sustainable development policy goals.

Regarding the important role of energy in the implementation of sustainable development, it is important to develop methods for measuring and monitoring community energy trends. Energy indicators can provide a clearer picture of the energy system that can assist decision-makers and planners to evaluate the planned goals. They can be used to address the existing challenges and reach the appropriate solutions more accurately. Energy indicators are not purely data and basic statistics. They provide us with a deeper understanding of important relations that cannot be observed through basic statistics. Energy indicators express the effectiveness of long-term policy implementation and their consequences and trade-offs (IAEA, 2005). Deciding upon future energy policies for the various sectors of transportation, households, industry, etc., can be done in a more realistic manner based on the picture of an energy system that energy indicators can provide.

6-3. Previous works

After the oil shocks of the 1970s, many works were started to reduce oil dependency by increasing the efficiency of community energy systems by

analyzing energy-use trends and planning for long term solutions at national, regional and local levels. In parallel with developing comprehensive energy planning methods, several methods of collecting data for analytical purposes were also developed. Planning community energy systems and formulating future energy policies principally involve setting objectives that rely on large volumes of data. Regular monitoring and evaluation of the impact of energy policies and measures requires up-to-date data. Most analytical methods focus on collecting disaggregated data which helps to gain a better understanding of energy-use trends in different sectors and levels. The OECD countries and the European Union (EU) have been applying and are still using disaggregated methods to analyze household energy use, CO_2 trends and energy efficiency in the industrial and transportation sectors (Vera, 2005). The development and use of aggregated energy indicators with the ultimate goal of promoting directed and effective energy, environmental and economic policies and measures at the EU level has been done by leading organizations such as the International Energy Agency (IEA), European Environment Agency (EEA) and the Statistical Office of the European Communities (Eurostat) (ibid).

Monitoring of energy trends and evaluation of energy policy impacts relies on accurate and up-to-date data, and working with data needs tools. One well-known monitoring tool has been developed at the EU level through the ODYSSEE-MURE project[37]. ODYSSEE-MURE aims to evaluate trends in energy efficiency and discuss the pattern and impact of policy measures in the new EU member countries. The ODYSSEE database on Energy Efficiency Indicators and the MURE database of Rational Use of Energy (RUE) measures (both currently co-ordinated in a joint project by ADEME[38]) have been developed as EU-wide monitoring tools for analyzing policy issues arising in the context of efficient use of energy (Intelligent Energy Europe, 2007). ODYSSEE comprises a comprehensive indicator database to monitor energy efficiency progress by sector and CO_2 emissions reduction for the EU-27 plus Norway and Croatia. The purpose of the ODYSSEE project is to monitor the energy efficiency of final consumers within the sectors of

[37] ODYSSEE stands for "Online Database for Yearly Assessment on Energy Efficiency" and MURE stands for "Mesures d'Utilisation Rationelle de l'Energie"

[38] The French Environment and Energy Management Agency

transportation, households, industry and services[39]. MURE is a policy evaluation tool which is based on an information platform on energy efficiency policies in Europe. MURE provides a comprehensive database of RUE measures covering all end-use sectors; a quantitative database describing the energy system of each country for a base year on a sectoral bottom-up level; a simulation tool to construct and run RUE scenarios in order to calculate potential costs and impacts associated with the implementation of RUE policies and measures[40].

Another example is the PASTILLE[41] project, which was carried out from March 2000 to September 2002 in selected cities in four European countries (England, France, Austria and Switzerland). PASTILLE aimed to define a range of local sustainability indicators and examine their impact and effectiveness in public policy decision-making development within each partner city.

There are a few other scientific literatures on the subject of energy indicators or monitoring. Among them are: a PhD thesis written by Mineur (2007) discussing the effectiveness and influence of sustainability indicators in local governance; the usefulness of energy indicators for sustainable development at national level, by Vera et al. (2005, 2007); and the application of energy indicators for analyzing trends in Baltic States, by Streimikiene et al. (2007).

Although these projects have been carried out in the field of energy indicators, monitoring energy trends and sustainable development, they have all taken a different approach to what is aimed at in this thesis. Some, such as ODYSSEE-MURE, have focused on monitoring energy efficiency trends at

[39] For more information see: www.odyssee-indicators.org

[40] For more information see: www.mure2.com

[41] PASTILLE (Promoting Action for Sustainability through Indicators at the Local Level in Europe) research project is being undertaken by a consortium drawn from four European countries - Austria, France, Switzerland and the UK. PASTILLE was founded by the European Commission under its 5th Framework Research Program. Each country team is a partnership between a municipality and one or more research competences. The Pastille website provides a summary of action research projects into local sustainability indicators, including literature review and annotated bibliography on sustainability indicators. For more information see:

http://www.esprid.org/details.asp?resid=275

national and international levels, while the work of this thesis is narrowed down to the local level. Those that have been conducted at local level, for instance the Covenant of Mayors[42] and the PASTILLE project, dealt with general sustainability indicators, both environmental and social, whereas the focus of this thesis is energy indicators that link energy-use trends to sustainability dimensions.

One of the most comprehensive works on energy indicators was carried out in 2001 by the International Atomic Energy Agency (IAEA) with contributions from the United Nations Department of Economic and Social Affairs (UNDESA), the International Energy Agency (IEA) and other international and national organizations, and was presented at the 9th session of the Commission on Sustainable Development (CSD-9). The final set of energy indicators, under the name 'Energy Indicators for Sustainable Development' (EISD), was designed to observe and measure current energy related trends at the national level. Although the IAEA's group of energy indicators is defined to apply at the national level, their categorization and the way that they are linked to sustainability objectives is in line with the author's purpose in the application of local energy indicators. Therefore, this thesis draws on the IAEA's guidelines in measuring and monitoring energy-use trends to examine whether they can be adjusted to be applied at municipal level.

6-4. Method of research

This research project was based on two main phases. The first phase consisted of structuring the framework of research and identifying the appropriate local energy indicators. The selected energy indicators should be capable of linking energy-related issues to communities' environmental, economic and social aspects. In this study, the term 'community' refers to the local (municipal) level. The three municipalities of Lund and Kristianstad in Sweden and Stavanger in Norway, each with a different energy system, were chosen in order to identify the most common set of energy indicators. One important feature of this research was to involve municipal personnel in the whole

[42] For more info see: http://www.eumayors.eu/home_en.htm

period of the project's implementation, from project design to identification of indicators and finalizing the project report. The scientific approach of the IAEA's methodology and categorization was chosen as the basis for the project design.

The indicator selection in this study was based mainly on the needs and interests of the municipalities, as well as on the availability of data. Collecting the corresponding data was also the task of the first phase. This is an important and time-consuming stage, but it is important because it plays a key role in indicator validation. Indicator validation was the purpose of the second phase. The validation process consists of analyzing the historical trends and justifying whether energy indicators can demonstrate a reasonable picture of energy trends in the local energy system. The study was planned to be implemented in 6 months.

6-5. Case study

This section provides some information about the partner municipalities to provide a general picture of their similarities and differences in, for example, their social structure, geography, energy system, etc. A comparison of the fuels and energy carriers used in these municipalities is presented in Table 5.

Table 5: Total energy use in selected municipalities in 2006 (MWh)

	Lund	Kristianstad	Stavanger
Coke			200
Petrol (Gasoline, kerosene)	481 714	443 610	352 300
Diesel (Diesel, gas and light fuel oil, special distillate)	183 213	381 663	517 000
Fuel oil (Heavy fuel oil, waste oil)	75 436	322 076	45 900
Natural Gas	89 290		157 500
Wood Fuels	18 626		89 500
District Heating	784 000	296 807	
Total Fuel	1 637 264	1 755 335	1 162 400
Electricity	855 394	908 313	1 685 900
Total Energy	2 492 658	2 663 648	2 848 300

6-5-1. Lund

Lund municipality, with a total area of 442.9 km^2 and 109,147 inhabitants (Statistics Sweden, 2010) is located in the south-west of Skåne (*Scania*) County, Sweden. Lund is among the oldest cities in Sweden and is believed to have been founded around 990[43]. Lund University (founded in 1666) is one of the largest Scandinavian international centers for research and education and has approximately 48,000 students. The climate is relatively mild compared to other locations on similar latitude, mainly because of the Gulf Stream. The average temperature in summer is between 14°C and 22°C, while in winter time it is between -1°C and 3°C. Because of its latitude, daylight lasts around 17 hours in midsummer and 7 hours in midwinter. Approximately 170 days of the year have light to moderate rainfall. Light snowfall occurs normally between December and March. The main industries of the city include Alfa Laval (heat exchanger and separator), Tetra Pak (food packing), Gambro (medical and pharmaceutical), and high-tech companies such as Sony Ericsson and Ericsson Mobile Platforms. The energy use per fuel and energy carrier for the year 2006 was 2,492,658 MWh (Figure 21).

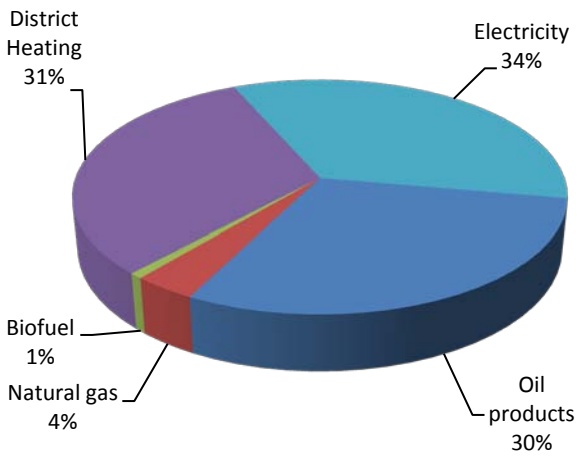


Figure 21: Energy use per fuel and energy carrier in 2006 in Lund (MWh)
(Source: Statistics Sweden, 2010)

[43] *Touchdowns in the history of Lund*, retrieved on 2010-02-18 from www.lund.se

Lund's district heating system covers around 90% of the buildings in the city. The fuel mix of the district heating system is illustrated in Figure 22.

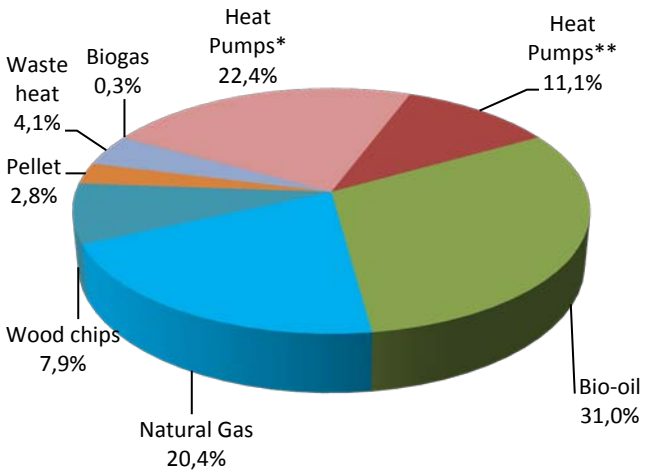


Figure 22: Fuel mix in Lund's district heating system

(Source: Lund Energy AB, 2009)

* Geothermal, heat from waste water, heat from the cooling production, heat from the aquifer
**Electricity

6-5-2. Kristianstad

The municipality of Kristianstad, with 1828.5 km^2 and 78,788 inhabitants (Statistics Sweden, 2010), is located in the south-east of Skåne (*Scania*) County, in Sweden. Kristianstad is 2.41 meters below mean sea level; therefore, a part of the city has to be protected from flooding by a system of levees and water pumps. Agriculture and foodstuffs with their related businesses are the core of the city's industry and commerce. In 1999, the Kristianstad municipality declared that it would be a fossil fuel municipality. A climate strategy including measures for transport and agriculture was adopted by the municipality in 2005. Kristianstad enjoys a bio-fuel powered

combined heating and power plant (CHP), named *Allöverket*, with a capacity of 60 MW*th* plus 15MW*el* (C4 Energy AB, 2009). Total production of the Allöverket CHP plant in 2008 was 300 GWh*th* and 70 GWh*el*. Waste from forestry, which is taken from within a radius of 100 km, together with biogas from landfill and from the *Karpalund* biogas production plant provided 99% of the fuel needed by the Allöverket CHP plant in 2009 (Figure 23). The Karpalund plant produces 44 GWh of biogas every year, which corresponds to about 4.4 million liters of gasoline; and at present 24 buses and 250 lighter vehicles are fuelled in Kristianstad with this renewable fuel (SWENTEC[44], 2010).

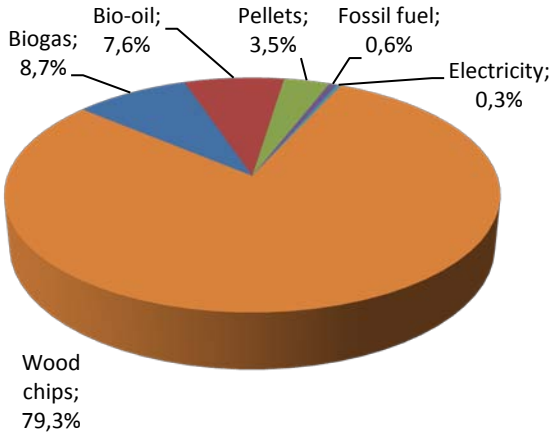


Figure 23: Fuel mix in Kristianstad's CHP plant

(Source: C4 Energy AB, 2009)

The city's total energy supply in 2007, for all sectors of the energy system (transport, residential/commercial, industry), is illustrated in Figure 24.

[44] Swedish Environmental Technology Council, retrieved in 2010-11-25 from: http://www.swentec.se/en/Start/find_cleantech/Plantscontainer/Karpalund-biogas-plant-in-Kristianstad/

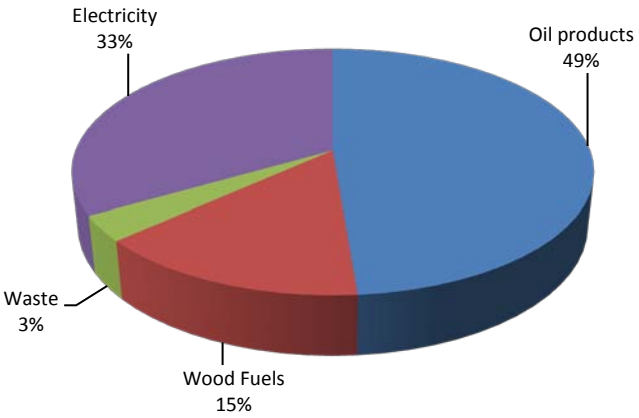


Figure 24: Energy supply in Kristianstad

(Source: C4 Energy AB, 2009)

6-5-3. Stavanger

The municipality of Stavanger is located in Rogaland County, on the south west coast of Norway. The city is located on a peninsula with an area of 77.98 km^2 and total population of 121,610 (SSB, 2010). Stavanger has fulfilled an urban role since the Stavanger bishopric was established in the 1120s. Shipping and shipbuilding with fish-canning industries were among the most important industries for long periods of time, until 1969 when oil was discovered in the North Sea. Today, Stavanger is referred to as the petroleum capital of Norway. The city is significantly influenced by foreign oil companies and related businesses. The University of Stavanger, with around 8,300 students, was established in 2005 and has strong links with the oil industry and related R&D. Stavanger enjoys a maritime and rather windy climate with an average precipitation of 1200 mm/year.

The energy supply resources of Stavanger's stationary energy system are rather different from the two previous cities and are mostly based on hydro power. Electricity provides more than 95% of the city's stationary energy needs, particularly in households. In 2007, electricity use, at 1915 GWh out of the total (stationary + mobile) 3129 GWh, comprised more than 61% of Stavanger's energy use (Figure 25). A waste-fueled CHP plant called Forus,

with a capacity of 86 GWh, converts 38,000 tons of waste to energy annually. This small CHP plant supplies the city's district heating system.

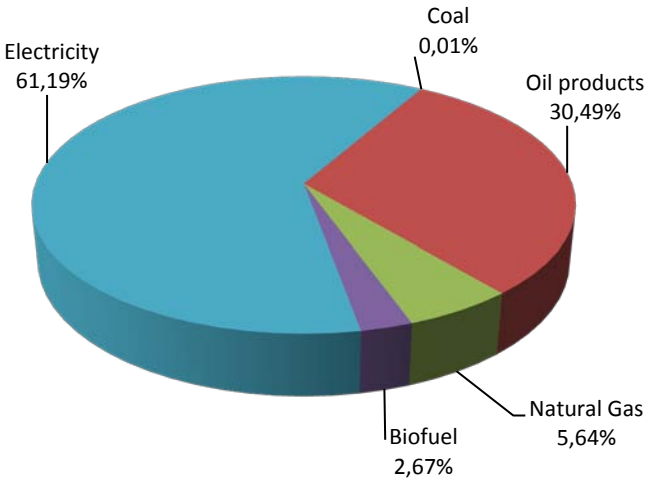


Figure 25: Energy use in Stavanger

(Source: Lyse Energy AS, 2007)

6-6. Identification of local energy indicators

In this study, the IAEA's categorization of energy indicators for sustainable development is used to identify the most appropriate local energy indicators. This categorization divides energy indicators into the three environmental, economic and social groups. Each energy indicator has its own methodology sheet with a comprehensive description of the type of data needed, their relevancy to sustainable development, their units, and the methodology for data gathering and calculations. Several planning meetings were arranged with municipal staff in order to identify what energy indicators could usefully be applied at the local level. Since the duration of the research project was limited to 6 months, it was decided to concentrate on the indicators for which data were available. For this purpose, a questionnaire was sent to the municipalities and they were asked to select indicators based on data availability. The result was three short lists with very similar types of indicators. The final combination of these short lists is presented in Appendix 1. It can be observed from this short list that environmental indicators were

the most common ones among the municipalities. To get better results, it was decided to focus on those energy indicators for which date were available and which were used in common between all three municipalities.

6-7. Data gathering and categorization

After selection of the energy indicators, the participating municipalities were asked to collect and send the data corresponding to each indicator. An adequate and reliable database is fundamental to using energy indicators. Most energy-related analyses depend upon examining past trends, whether they are energy intensity, economic activities, markets or consumption (Gold & Elliott, 2010). The data sheets received from the municipalities were quite different. Most of the energy use data were different since they had been collected by different organizations using different methods

One important problem that appeared at this stage was the time gaps between most of the data sheets. Complete time series are essential for analyzing energy trends. The existence of time gaps could be observed in all the partner municipalities. To complete the energy-use database, the statistical archives of other resources such as local energy companies, the National Statistical Center, environmental organizations and NGOs were also used. Although more energy-related data were found, they could not fill all the data gaps; meanwhile, they also had different units driven by different methods of data collection. Data collection from all these sources resulted in the creation of a large database consisting of more than 75 Excel sheets. This database contained a variety of energy-related information, e.g., on energy use by type of energy source in households, transportation and industry, emissions from the local energy system, municipal waste production and incineration, etc.

6-8. Data analysis

Different municipalities may use different data categorizations and units depending on their needs and interests; therefore, data filtering should be done prior to analyzing the energy trends. Table 6 illustrates an example of differences in categorization among the partner municipalities. In this study

the filtering procedure is done by unifying the energy units and re-categorizing energy related data.

Table 6: Categorization for emissions driven from energy use in different sectors

Lund and Kristianstad	Stavanger
Transportation	
Cars	Light vehicles, petrol
Light trucks	Heavy vehicles, petrol
Heavy-duty trucks and buses	Light vehicles, diesel
Mopeds and motorcycles	Heavy vehicles, diesel
Domestic commercial vessels	Motorcycles, mopeds
Domestic air traffic	Domestic air traffic
Other transport	Domestic Ships and boats
	International sea traffic
	International air traffic
	Others
Industrial	
Energy use via the electricity and heating plants	Stationary combustion: Oil and gas extraction
Fugitive emissions from fuel handling	Stationary combustion: Mining and manufacturing
Boiler	Stationary combustion: Other industries
Refineries	Process emissions: Oil and gas extraction
Industrial Processes	Process emissions: Mining and manufacturing
Mineral industry	Process emissions: Landfill gas
Chemical Industry	Process emissions: Other
Metal industries	
Households	
Space heating (no electricity or district heating)	Stationary combustion: Private households

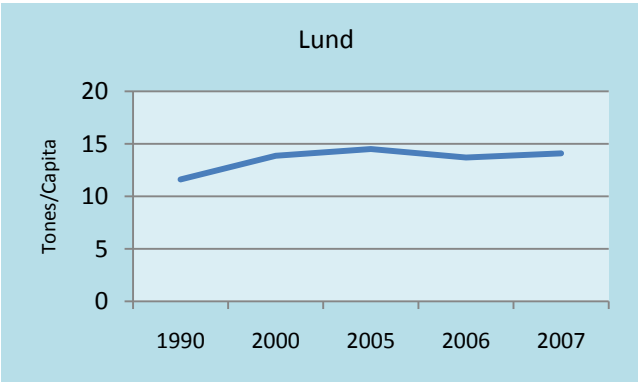
6-9. Indicator validation

The methodology used for indicator validation was subjected to analytical assessment of historical trends and justification of their capacity to demonstrate the facts within the local energy system. In other words, the usefulness of energy indicators was examined by comparing the trends shown by the indicators with the existing historical information from the energy system. This assessment of the selected indicators was done together with the

municipal staff. Availability of data was a major limitation in performing the assessment, since the data gaps within the time series could not be manipulated. Those energy indicators that adequately met the requirements on data availability and an acceptable time series were selected for validation analysis as follows:

6-9-1. per capita emission (ENV1)

This indicator measures the total per capita emissions of the three main greenhouse gases (GHG), including carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) from energy use. The measurement unit is annual GHG emission in tonnes per capita.
Emissions of CH_4 and N_2O are converted to CO_2 equivalents using the 100-year global warming potentials (GWPs) provided in the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report (1995). Kristianstad's significant GHG reduction is because of the development of a district heating system powered by the Allöverket CHP plant and fueling the city buses with biogas produced by the Karpalund waste-to-energy plant. The increase of GHG emissions in Stavanger has mainly been driven by the transportation sector.



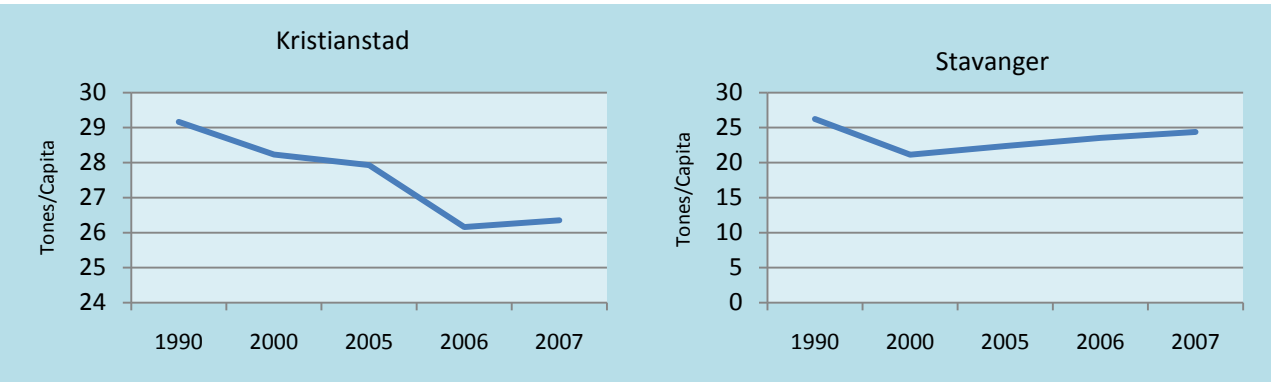


Figure 26: ENV1, per capita emission

6-9-2. Energy use per capita (ECO1)

A per capita basis for measuring energy use gives the pattern of aggregated energy intensity within a society. The term 'energy use' refers to total final fuel consumption and final electricity use per capita. The unit used in this study is MWh per capita. The reason for two anomalies in Lund (2005) and Kristianstad (2004) was unclear. The corresponding data for this indicator in Stavanger was not available for the years before 2005.

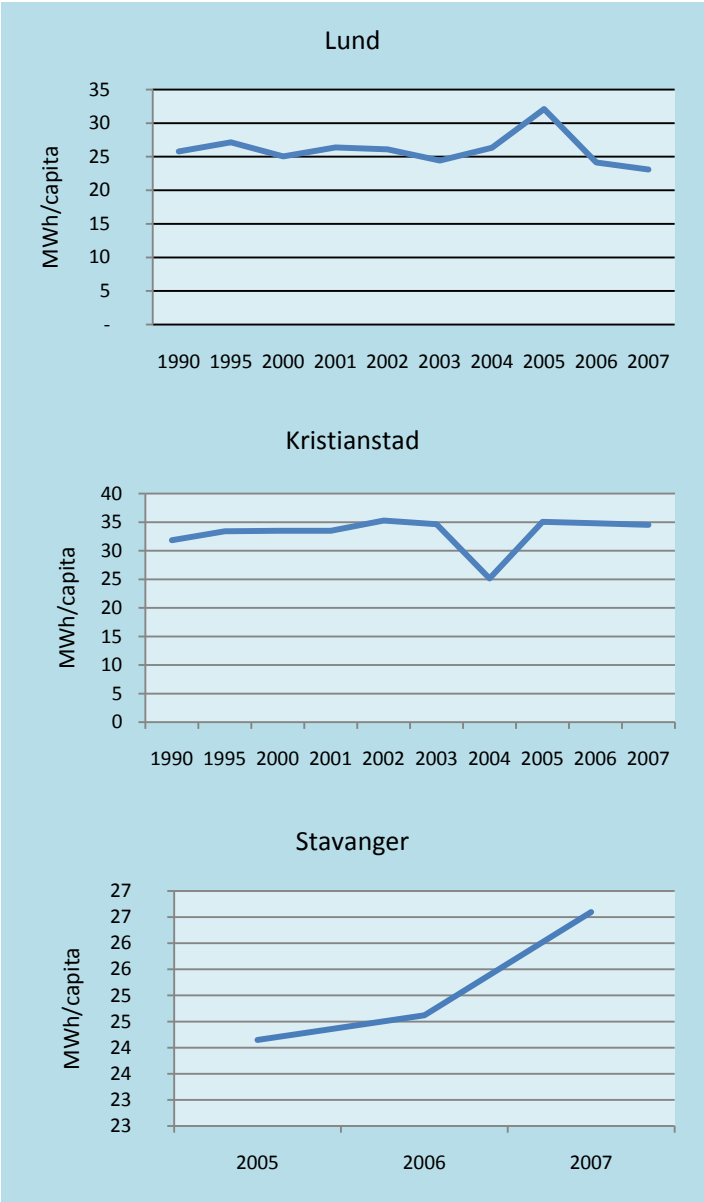


Figure 27: ECO1, energy use per capita

6-9-3. Household energy intensity (ECO9)

This indicator is for monitoring the total energy use (fuel, district heating and electricity) in the household sector. The unit is KWh per capita. Data for Stavanger before 2005 were not available; however, the municipality is in the process of developing a method for data collection on energy use in the household sector. The increase of household energy intensity in Lund in 2005 was because of the cold winter that year, which caused an extensive isolation program to be run for buildings in subsequent years. The reason for the anomaly in Kristianstad is not clear.

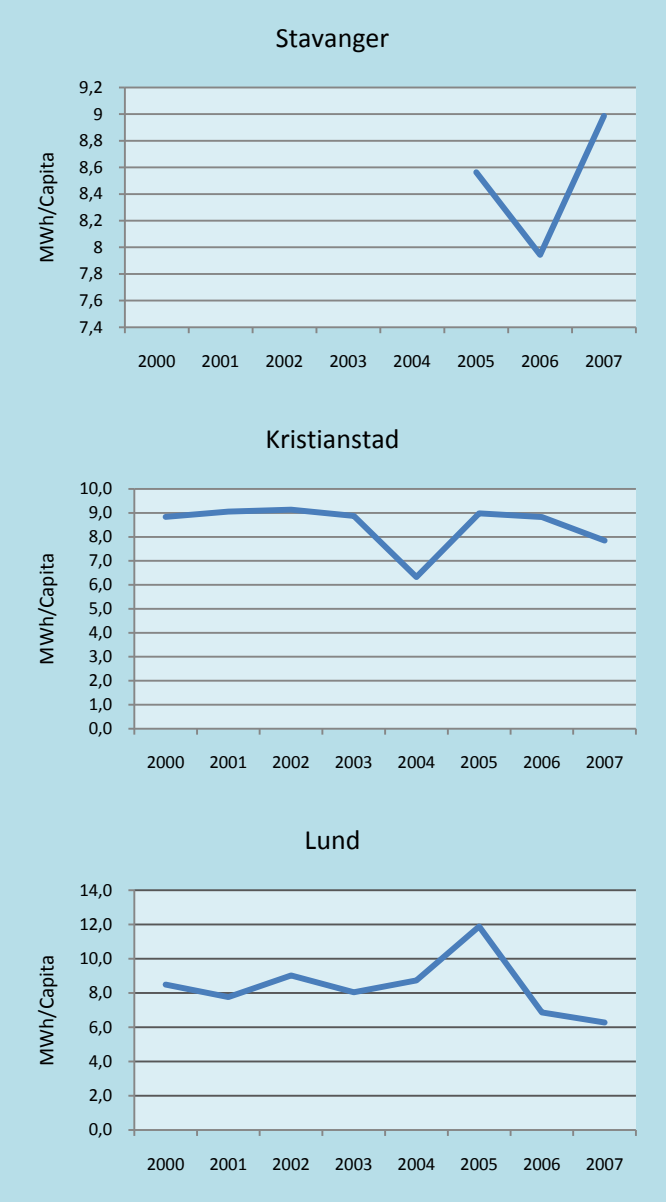


Figure 28: ECO9, household energy intensity

6-9-4. Transport energy intensity (ECO10)

This indicator is used to monitor energy use in the transportation sector for both goods and people. Transport, as a major consumer of fossil fuels, is an important source of air pollution within the community energy system. The unit used in this study is MWh per capita. All three municipalities show an increase in their energy use in the transportation sector. Local authorities believe that this is mainly because of the increasing numbers of passenger cars. Data for Stavanger were not available for the years before 2004.

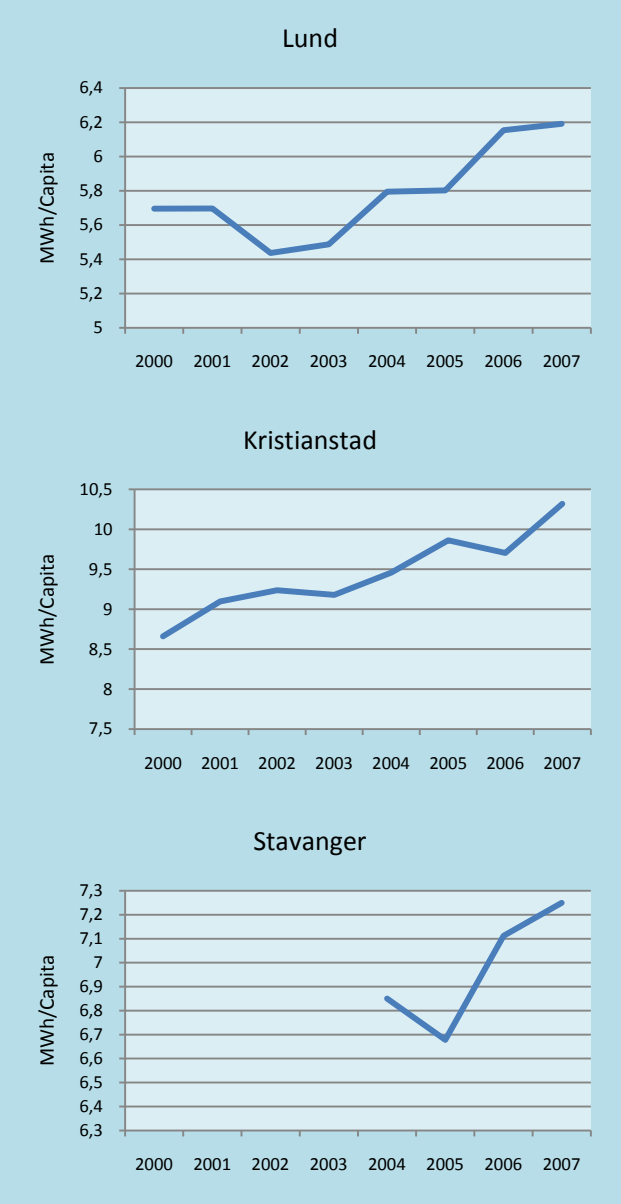


Figure 29: ECO10, transport energy intensity

6-9-5. Solid waste to energy (ENV7)

The main purpose of this indicator is to provide information on the ratio of solid waste used to generate energy through incineration and the landfill process. The unit is percentage. The rise in the percentage of energy produced from waste in Lund is because of increasing the capacity of the SYSAV waste-to-energy plant in the neighboring city of Malmö. The reduction in Stavanger is due to the limited capacity of the Forus waste-to-energy plant to respond to an increase in the total waste production.

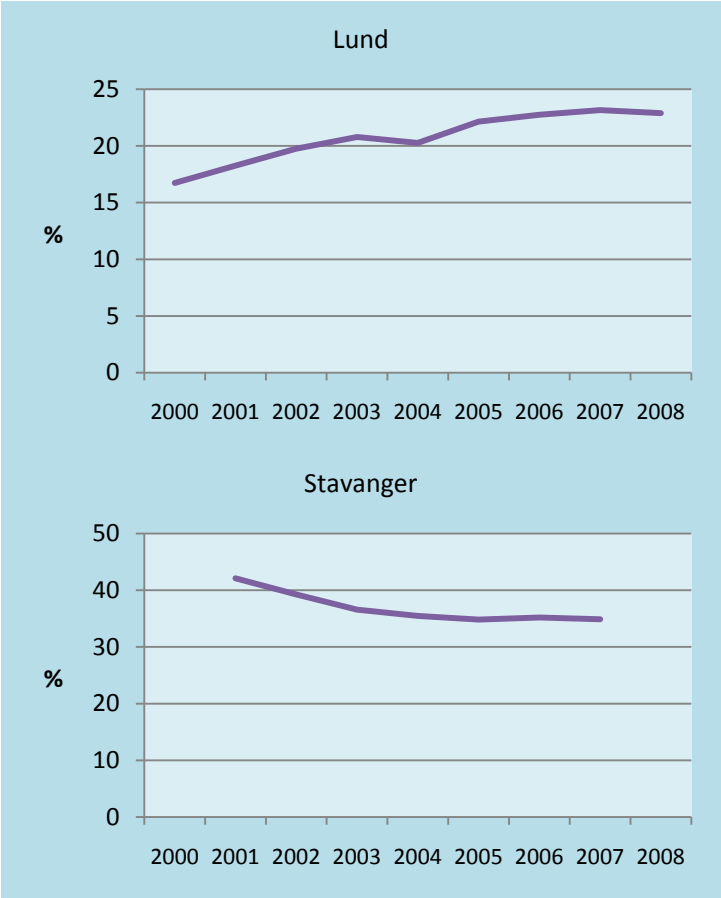


Figure 30: ENV7, solid waste to energy

Data from Kristianstad had too many anomalies to be used in this study. The reason was that most of the corresponding data collected by the local waste-to-energy and biogas plant (Karpalund) were not available.

6-10. Results

It was observed that the energy indicators identified in this study can be useful for monitoring some of the environmental and economic dimensions of sustainable development; however, there is still a lot to do to achieve fruitful results. Social energy indicators can hardly be applied due to a lack of data. This lack of data is identified as the most important challenge throughout this study. Time gaps and data accuracy were also identified as important limitations to making an adequate comparative analysis. The need to collect energy-related information at the local level is still great. One suggestion is for the municipalities to collect more detailed energy-use data on a regular basis (annually). This should be done not only by the municipalities themselves but jointly with the local energy companies and other related entities. Most of the existing data from the participating municipalities and the related entities were collected by different methods, using different units and categorizations, and this restricts the application of energy indicators in comparative studies. Regarding the differences in the cities' geography, socio-economic structures, etc., energy indicators for comparison studies should be used with care; however, it was observed that energy indicators can be useful in developing local energy systems through a knowledge exchange and learning process.

7. Conclusion

The aim of this thesis was to investigate whether energy planning can still be considered as a proper tool for managing local energy systems. The thesis discussed why existing energy planning methods should be developed in such a way that they can address the sustainability objectives within community energy systems. The author's argument was based on investigating over 30 years of ups and downs in municipal energy planning in Sweden. We explained why the importance and effectiveness of municipal energy planning in the development of local energy systems has diminished over time.

The most important reason identified for the deterioration of local energy planning in Sweden is the weakness of conventional energy planning methods in addressing the complex dimensions of sustainable development. It seems that taking a new approach to existing energy planning methods can help to resolve the problem. This approach should be in line with the latest evolution of planning theory known as 'planological integration'. Planological integration could be considered as the key element for restructuring conventional energy planning methods. It is also discussed why this approach should focus on integrating sustainability objectives into the energy planning process. The approach that is called *sustainable energy planning* can be considered as an important tool for implementation of sustainable development from national to local levels.

Another important reason is that the law (the Municipal Energy Planning Act) is no more than a legal basis for energy planning. The weaknesses of the law in providing clear requirements, guidelines and supports for municipalities should be considered and revised.

Other reasons for the reduced importance and effectiveness of municipal energy planning in Sweden can be summarized as:

- the deregulation of electricity markets in mid 1990s
- the lack of governmental financial support
- the focus on climate strategies

There is no doubt that climate strategies and environmental protection policies should be supported and developed; however, the other objectives of sustainable development should not be neglected. A successful transition toward sustainable energy systems requires strategies that address all sustainability objectives simultaneously. Since energy has strong relationships with sustainability objectives, energy planning can be considered as an effective tool for this transition.

The adoption of appropriate energy strategies is heavily dependent on a correct understanding of the existing challenges and opportunities within the community energy system. A clear picture of the community energy system can give decision-makers a better insight into how sustainable the energy system is and which challenges need to be addressed. To realize this, a method for measuring and monitoring community energy-use trends and their links to sustainability objectives is developed and examined. The preliminary results show the usefulness of energy indicators in assisting decision-makers and energy planners in their work with community energy systems. The methodology of local energy indicators for sustainable development at local level needs further improvement.

This thesis demonstrates that energy planning has sufficient capacity for addressing the sustainability objectives of community energy systems. An effective planning process comprises the plan implementation, evaluation and following up of the planned goals. As Lindroth (2003) says, "*the planning process is more important than the final product (*the plan*) itself*". The model for sustainable energy planning presented in this thesis should be developed, examined and practiced by the major stakeholders of the community. Moreover, the successful application of sustainable energy planning requires trained planners with a broad cross-disciplinary knowledge and vision, who

are good communicators and are familiar with the social, environmental, economic and political sciences and above all with planning science.

Future work

There are many things in the framework of sustainable energy planning that should be explored, developed and practiced. The sustainability objectives discussed in this thesis are mostly seen from the national (or international) perspective, while local sustainable energy policies are to be seen within other and more specific frames of limitation. Therefore, municipal energy planning should be developed based on local sustainability characteristics. How these sustainability characteristics should be identified and integrated into the energy plan is the subject of an action research by academia and local/regional authorities. Work on developing energy indicators for sustainable development should also be carried out within this research. Given that municipal energy systems are not isolated from neighboring municipalities, developing a regional framework for sustainable energy planning and energy indicators seems to be a more interesting, practical and valuable way forward to invest in.

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Appendix 1- List of energy indicators

(Orange color means that data is available)

I. Environmental indicators

Theme	Sub-theme		Energy indicator	Components	Lund	Kristianstad	Stavanger
Atmosphere	Climate Change	ENV1	GHG emissions from energy production and use per capita	GHG emissions from energy production and use			
				Population			
	Air Quality	ENV2	Ambient concentrations of air pollutants in urban areas	Concentrations of pollutants in air			
		ENV3	Air pollutant emissions from energy systems	Air pollutant emissions			
Water	Water Quality	ENV4	Contaminant discharges in liquid effluents from energy systems including oil discharges	Contaminant discharges in liquid effluents			
Land	Soil Quality	ENV5	Soil area where acidification exceeds critical load	Affected soil area			
				Critical load			
	Forest	ENV6	Rate of deforestation attributed to energy use	Forest area at two different times			
				Biomass utilization			
	Solid Waste Generation and Management	ENV7	Ratio of solid waste generation to units of energy produced	Amount of solid waste			
				Energy produced			
		ENV8	Ratio of solid waste properly disposed of to total generated solid waste	Amount of solid waste properly disposed of			
				Total amount of solid waste			
		ENV9	Ratio of solid radioactive waste to units of energy produced	Amount of radioactive waste (cumulative for a selected period of time)			
				Energy produced			

II. Economic indicators

Theme	Sub-theme		Energy indicator	Components	Lund	Kristianstad	Stavanger
Use and Production Patterns	Overall Use	ECO1	Energy use per capita	Energy use (total primary energy supply, total final consumption and electricity use)			
				Population			
	Overall Production	ECO2	Energy production by the local energy company	Energy production(Electricity, district heating/cooling) in MWh			
	Supply Efficiency	ECO3	Efficiency of energy conversion and distribution	Losses in transformation systems including losses in electricity generation, transmission and distribution			
	Production	ECO4	Reserves-to-production ratio	Proven recoverable reserves			
				Total energy production			
		ECO5	Resources-to-production ratio	Total estimated resources			
				Total energy production			
	End Use	ECO6	Industrial energy intensities	Energy use in industrial sector and by manufacturing branch			
				Corresponding value added			
		ECO7	Agricultural energy intensities	Energy use in agricultural sector			
				Corresponding value added			
		ECO8	Service/commercial energy intensities	Energy use in service/ commercial sector			
				Corresponding value added			
		ECO9	Household energy intensities	Energy use in households			
				Number of households, floor area, persons per household, appliance ownership			
		ECO10	Transport energy intensities	Energy use in passenger travel and freight sectors			
				Passenger-km travel			

Theme	Sub-theme		Energy indicator	Components	Lund	Kristianstad	Stavanger
				and tone/km freight			
	Diversification (Fuel Mix)	ECO11	Fuel shares in energy and electricity	Primary energy supply and final consumption, electricity generation and generating capacity by fuel type			
				Total primary energy supply, total final consumption, total electricity generation and total generating capacity			
		ECO12	Non-carbon energy share in energy and electricity	Primary supply, electricity generation and generating capacity by non-carbon energy			
				Total primary energy supply, total electricity generation and total generating capacity			
		ECO13	Renewable energy share in energy and electricity	Primary energy supply, final consumption and electricity generation and generating capacity by renewable energy			
				Total primary energy supply, total final consumption, total electricity generation and total generating capacity			
	Prices	ECO14	End-use energy prices by fuel and by sector	Energy prices (with and without tax/subsidy)			
Security	Imports	ECO15	Net energy import dependency	Energy imports			
				Total primary energy supply			
	Strategic Fuel Stocks	ECO16	Stocks of critical fuels per corresponding fuel consumption	Stocks of critical fuel e.g. oil, gas etc.			
				Critical fuel consumption			

III. Social indicators

Theme	Sub-theme		Energy indicator	Components	Lund	Kristianstad	Stavanger
Equity	Accessibility	SOC1	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	Households (or population) without electricity or commercial energy, or heavily dependent on noncommercial energy			
				Total number of households or population			
	Affordability	SOC2	Share of household income spent on fuel and electricity	Household income spent on fuel and electricity			
				Household income (total and poorest 20% of population)			
	Disparities	SOC3	Household energy use for each income group and corresponding fuel mix	Energy use per household for each income group (quintiles)			
				Household income for each income group (quintiles)			
				Corresponding fuel mix for each income group (quintiles)			
Health	Safety	SOC4	Accident fatalities per energy produced by fuel chain	Annual fatalities by fuel chain			
				Annual energy produced			

"Failing to plan is planning to fail"

Benjamin Franklin