Inventory of building practice, barriers and solutions for market introduction of alternative energy systems

Hansen, Klaus

Publication date:
2007

Document Version
Publisher's PDF, also known as Version of record

INVENTORY OF BUILDING PRACTICE, BARRIERS AND SOLUTIONS FOR MARKET INTRODUCTION OF ALTERNATIVE ENERGY SYSTEMS (STATUS 3/2007)

September 07

SENTRO

Sustainable Energy systems in New buildings – market inTROduction of feasibility studies under the Directive on the Energy Performance of Buildings

Report no.: SENTRO/ 3 / 2007/WP3
EC-contract: EIE/06/102/SI2.445679
www.sentro.eu

Intelligent Energy Europe

Author:
Klaus Hansen, SBi, Denmark

Contributing authors:
Suzanne Joosen and Jasper Vis, Ecofys, Utrecht, The Netherla nds;
Paul Masselink, SenterNovem, The Netherlands;
Marjana Sijanec Zavrl, BCEI ZRMK, Ljubljana, Slovenia;
Egidijus Norvaisa, LEI, Lithuania;
Michal Siembab, Ecofys, Poland;
Hubert Despretz, Ademe, France,
Åsa Wahlström, SP, Sweden;

Edited by:
Klaus Hansen, SBi, Hoersholm, Denmark, e-mail: klh@sbi.dk

Aknowledgements:
SENTRO project partners would like to thank all the actors involved in the introduction of alternative energy systems in the building process, in the respective countries, who participated in the WP3 inventory interviews.

Date:
September 07

Report no:
SENTRO/ 3 / 2007/WP3

EC contract:
EIE/06/102/SI2.445679

Project co-ordinator
Ecofys Netherlands BV
Utrecht, The Netherlands

Suzanne Joosen
S.Joosen@ecofys.nl

Supported by:

Intelligent Energy Europe

Project description

The buildings sector accounts for 40% of the EU's energy requirements. An estimated potential of one-fifth of the present energy consumption could be saved by 2010. To translate this potential into reduced energy consumption, the Energy Performance of Buildings Directive (EPBD) 2002/91/EC is set to promote the improvement of energy performance of buildings. An important aspect (art. 5) of the EPBD is that all member states are obliged to ensure that the feasibility of alternative energy systems is considered within national building codes for new buildings over 1000 m^2.

At the moment barriers such as higher cost, lack of knowledge and confidence, are hindering alternative energy systems. For article 5 to have a substantial impact, feasibility studies on alternative energy need to become commonplace.

The SENTRO project aims to develop and promote an "optimal" approach in order to effectively incorporate the feasibility studies of alternative energy systems (art. 5 EPBD) in the common building practice.

The project starts by making an inventory on how European member states comply with the requirements of conducting a feasibility study for alternative energy systems for new buildings. The inventory also encompasses which policy they pursue to actively introduce this requirement. Subsequently, in the seven SENTRO countries (Denmark, France, Lithuania, Poland, Slovenia, Sweden and the Netherlands), an inventory is also made of the building practices as possible barriers of the implementation of alternative energy systems. After this inventory phase, tools are developed to ensure that assessment of alternative energy systems will become an integral part in the common planning process of new buildings. These tools, such as universal checklists for requirements, handbooks and flowcharts, cover technical, financial as well as organizational aspects. Core of the project is the test of these tools in a field trial in the participating countries. Towards the end of the project the experience is disseminated through courses and conferences to policy makers and key actors in the building process.

Expected results (deliverables) from the SENTRO-project are:

- Up-to-date information concerning the status of the feasibility study part of the EPBD in all EU-25 MS
- Insight in the barriers which are hindering the use of alternative systems and insight in possible solutions to overcome these barriers
- Supporting methods and checklist for imbedding feasibility studies in the common building practice
- Lessons learned from the field trial of these tools and the evaluation of this element of the EPBD

Project partners

Ecofys Netherlands	
SenterNovem Netherlands	
Building and Civil Engineering Institute ZRMK, Slovenia	
Danish Building Research Institute (SBi) Denmark	
Lithuania Energy Institute, Lithuania	
Ecofys Polska SP. Z.o.o., Poland	
Agence de l'environnement et de la maitrise de l'energie (Ademe), France	
SP Technical Research Institute of Sweden, Sweden	

Executive Summary

Art. 5 of Directive on Energy Performance of Buildings (EPBD) (2002/91/EC) prescribes that obligatory feasibility studies of alternative energy systems shall be made for all new buildings with a total useful floor area over 1000 m^2. The feasibility studies shall include technical, environmental and economic aspects. In SENTRO also organisational aspects are included.

This inventory report gives an overview of the findings concerning possible barriers and solutions for the implementation of alternative energy systems (AES) in seven European countries: Denmark, France, Lithuania, Poland, Slovenia, Sweden and the Netherlands. The focus is on the building process, and on technical, financial and organisational conditions for successful implementation of alternative energy systems in new buildings. A limited number of key actors in all the participating countries in SENTRO have been interviewed to fill in the questionnaire to get a snapshot of the current building practice and the main barriers of AES in the seven researched countries.

In general, the building process exists of 6 stages, which are schematically presented in figure A, which also includes the findings regarding the needed actions in the building process for implementation of feasibility studies on implementation of alternative energy systems in buildings.

The most important stages in the building process regarding the choice of energy system were registered to be the planning stage, the proposal stage and the project stage. Also the programming stage is crucial, because it is of high importance, that the awareness of alternative energy systems is raised and that the feasibility study is asked for in the building programme. The results of the feasibility study have to be available when the final choice of energy systems is made.

During the planning stage decisions are made concerning the energy infrastructure of the building area, such as district heating and provision with natural gas. This can be of high importance, because municipal heat plans may limit the possibilities for introduction of other energy systems. It is of importance to state that district heating often can involve extensive use of alternative energy systems such as the use of waste heat, biomass (incl. waste incineration), heat pumps and geothermal energy, but also conventional CHP.

In all participating countries, the actors which first of all influence the choice of energy systems are: clients, developers and investors, and architects and engineers. Beside, the municipalities are of high importance in countries, where heat plans are made, normally based on the presence of infrastructure for district heating and gas supply.

Concerning the registered driving forces, barriers and solutions, the main findings are presented in Table A. The findings are related to a number of aspects of

importance for the feasibility studies, and the solutions which will be further elaboration in SENTRO are mentioned.

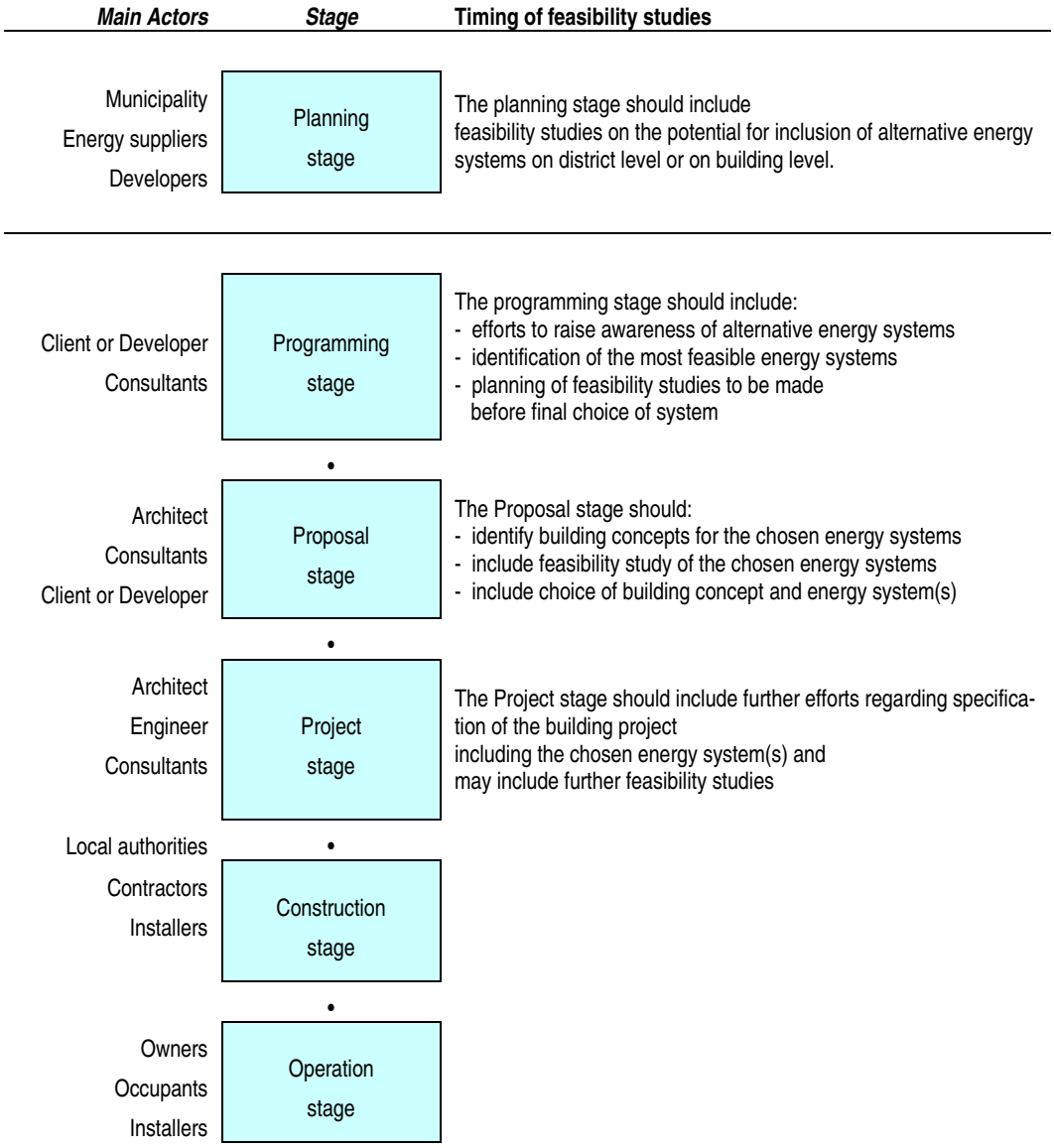


Figure A. Schematic flow chart of the stages in the building process for a new building, and the needed activities related to the right timing of the feasibility studies of alternative energy systems. See also Figure 1.

The new energy performance regulations are of high importance for the introduction of alternative energy systems, because the effect of energy efficiency and use of renewable energy systems are taken into consideration in the energy calculations. The strengthened requirements for reduction of the energy consumption implies also that use of alternative energy systems may prove more feasible than further development of the traditional reduction means like further insulation.

Also the requirements regarding feasibility studies on the inclusion of AES has been pointed out as an important driving force driver in a number of MS', where this requirement has been implemented. This is underlined by the fact that lack of required feasibility studies is pointed out as an important barrier in countries, where feasibility studies are not yet required.

To strengthen the impact of the requirement on feasibility studies, it was also pointed out that a common protocol for the feasibility studies are needed, supplemented with the needed tools and data for the technical, environmental and economic feasibility studies. This can be seen in parallel to the existing combination of energy performance regulations and the national tools for the energy calculations.

Higher investment costs were mentioned as one of the most important barriers. Like most other energy reduction measures, AES includes higher investment costs, but also because introduction of new solutions includes higher costs until these solutions are further developed and fully introduced at the market. Not surprisingly, financial support was registered as the most important general measure to further market introduction of alternative energy systems. The economic support could be direct or indirect using tax incentives, e.g. use of a CO_2 tax.

Feasible methods, tools and data for economic feasibility studies were asked for as one of the most important measures regarding feasibility studies. These studies should be based on LCC (life cycle costing) or payback calculations, and also consider the barrier of uncertain long term economy. Supplementary, most interviewed actors in the Netherlands meant that solving the split incentives imbalance would be sufficient to solve the barrier of high investment costs.

Lack of confidence including higher risks was mentioned as very important. This is connected to the fact that also lack of building examples was mentioned as important; the building sector want good documentation for introduction of new solutions. This barrier is linked to the previous one because the lack of confidence is often the result of a lack of knowledge. But it is also important that appeal of AES has been pointed out as an important driving force in some countries. Therefore well documented demonstration projects and good practice examples were mentioned as important general measures by most participating MS.

General environmental consciousness has been mentioned as a very important driving force, e.g. defined in an environmental policy for the company. It is therefore of high importance that the energy requirements and the required environmental feasibility studies reflects and measure the environmental performance of the considered AES.

Actors in all the participating MS pointed out that inertia to change are an important barrier. A barrier of conservatism, which normally are explained by the fact that the time and resources for design and construction are rather limited, that the organisation includes short-term relationships between a considerable number of actors, and that the construction outputs are rather complex. This explains also, why the possibility of introduction of AES often are considered to be introduced too late in the building process, unless the client or his consultants due to a general environmental consciousness asks for that already in the programming stage or the proposal stage of the process.

Additional time and costs for feasibility studies are asked for, and also for inclusion of design alternatives in the proposal stage of the design process. Including all actors from an early moment on in the building process is mentioned as well. This will make sure that all can share their knowledge of their specialities and decisions can be made based upon all available input.

From the inventory phase of the SENTRO-project, it becomes clear that at least two points deserve particular attention. These are the starting points for the development of an optimal approach to embed the feasibility study aspect of the EPBD in the common building practice:

1. Timing of feasibility study of AES early in the building process is crucial
2. The approach has to tackle a combination of barriers to gain the confidence of decision makers in AES conclusively

It is usually a combination of barriers, which is responsible for hindering the use of AES. Core of the barriers is the estimation of risk on the part of the decision makers towards often unfamiliar, possible unreliable and expensive AES. To generate a level playing field of AES, it is important that during the proposal phase good objective insight in the technical and economic opportunities for the various AES, including their environmental benefits is available.

Table A. Overview on the links between the registered primary drivers, barriers and proposals for solutions referring to regulatory, economic, technical, environmental, organisational, and communicative aspects. Also the areas in focus for SENTRO are mentioned.

Aspects	Driving forces	Barriers	Solutions	SENTRO
Regulatory	**Energy performance regulations (EPR)** (D1)		**Stronger inclusion of AES in EPR** (M2)	
	Feasibility studies (FS) required (D2)	Lack of legislation on FS (B10)	**Legislation on obligatory FS** (M9)	
		Lack of tools and data for FS (B11)	**Protocol for feasibility studies (FS)** (M10)	**X**
Economic	Reduced life cycle costs (D5)	**Higher investment costs** (B4) No certainty in pay-off (B6) Uncertain long term economy (B5)	**Financial support** (M1) Solution for the split-incentive (M8)	
			Tools for economic FS (M13) **Additional costs for FS** (M14a)	**X**
Technical	Appeal of AES technologies (D4)	**Lack of confidence** (B2) Lack of building examples (B3)	**Data for design and energy calculations** (M4)	
			Tools for technical FS (M11) **Demonstration projects** (M6)	**X**
Environmental	**General environmental consciousness** (D3)		Tools for environmental FS (M12)	**X**
Organisational		Inertia to change (B7)	AES introduced too late (B9) **Additional time for FS** (M14b)	**X**
Communicative		**Lack of knowledge** (B1)	Education and training (M13)	X

Contents

1 Introduction

This inventory is one of the elements of a European project within the Intelligent Energy – Europe (IEE) programme. The project is called, Sustainable Energy systems in New buildings-market introduction of feasibility studies under the Directive on Energy Performance of Buildings (SENTRO). The main aim of the overall project is to develop and promote an "optimal" approach in order to effectively incorporate the feasibility studies of alternative systems in new large buildings in the common building process. One of the first steps in the project is to identify possible barriers for the implementation of alternative energy systems. Furthermore, an investigation is made to identify the instruments needed to overcome these barriers. The focus is on technical, financial and organisational conditions for successful implementation of alternative energy systems in new buildings. A limited number of key actors in the seven in SENTRO participating countries are approached to fill in the questionnaire to get a snapshot of the current building practice and the main barriers of AES in the seven researched countries. The results of the inventory are used as background information for the development of a checklist and additional tools to imbed feasibility studies in the common building process in the next phase of the project.

Art. 5 EPBD on feasibility studies

For new buildings with a total useful floor area over 1000 m^2 Member States shall ensure that the technical, environmental and economic feasibility of alternative systems such as decentralized energy supply systems based on renewable energy, CHP, district or block heating or cooling, if available, heat pumps, under certain conditions, is considered and is taken into account before construction starts.

Framework of the inventory

The information was gathered through interviews based on a written questionnaire, which included two parts:

Part A to be answered by the SENTRO partner and verified by the interviewed actors including questions on:

1. Relevant alternative energy systems (chapter 2)
2. District heating and heat plans (chapter 2)
3. Relevant stages and actors in the building process (chapter 3)

Part B to be answered by a limited number of relevant actors in the building sector including questions on:

4. Driving forces for introduction of alternative energy systems (chapter 4)
5. Barriers for introduction of alternative energy systems (chapter 5)

6. Solutions for tackling the barriers (chapter 6)

2 Alternative Energy Systems (AES)

The main questions to be answered were:

- Which alternative energy systems are first of all in focus for further introduction on the market, and which energy systems do already have a substantial market share?
- Which energy sources is district heating based on?
- To which extend is (municipal) heat plans used to regulate the energy systems to be used, and which energy systems are in focus for these plans?

2.1 Conclusions

The following energy systems are first of all of interest for further market introduction in the participating countries:

- solar thermal and PVsystems
- biomass systems
- CHP in buildings
- heat pumps

Beside a number of countries also have an interest in further introduction of: district heating incl. substantial use of renewable energy, district or block cooling and geothermal energy.

The existing market share for the energy systems of interest differs from country to country, which might imply, that experience can be transferred between the participating countries. All the mentioned systems except district or block cooling do have a certain market share in at least one or more countries. Besides district heating, which is well established in a number of MS, also solar thermal systems, biomass systems and heat pumps do have a certain market share in more than one country, while solar electrical systems, CHP in buildings and geothermal energy systems only have a good market position in one of the participating MS.

Because alternative energy systems for heating also are being introduced at supply level for district heating in a number of countries, this has to be taken into consideration in the feasibility studies for the potential introduction of other alternative energy systems at building level.

2.2 National reports

The table below gives an overview of the received answers.

Table 1 Alternative energy systems which first of all are in focus for further introduction on the market are. XX means that the energy system already has a certain market share.

	Alternative energy systems	NL	SLO	DK	LT	PL	F	S
	Decentralised energy supply systems (in buildings) based on renewable energy (RES)							
E1	Solar thermal systems (hot water and / or heating)	X	X X	X X	X	X X	X	X
E2	Solar electricity systems (photovoltaics, PV)	X	X	X X		X	X	X
E3	Biomass energy systems (hot water and / or heating)	X	X X	X	X X	X X		
E4	Wind energy systems	X						
	CHP and district or block heating or cooling							
E5	CHP (micro) in buildings	XX	X	X	X	X	(X)	X
E6	District or block heating incl./excl. CHP primarily based on the use of fossil fuels					XX		
E7	District or block heating incl./excl. CHP incl. substantial use of renewable energy	X	X			X X	X	
E8	District or block cooling	X		X		X	X	X
E9	Other: …							
	Heat pumps, under certain conditions							
E10	Geothermal energy systems (heat pump for heating and/or cooling)	XX	X		X	X	X	
E11	Heat pumps (other than geothermal)	X	X	X X	X	XX	X	
E12	Combination of E10 and E11							X

The Netherlands

Natural gas is the main energy source in the Netherlands. Therefore the majority of the energy systems in buildings are based on natural gas. As a consequence there is also a strong lobby on the energy market to use natural gas.

An alternative energy system which is rather common in specific buildings (hospitals, industrial) is CHP (in buildings). Natural gas is the most common energy source in the Netherlands and gas-fired CHP is a very commonly used system in Dutch power plants (also as source for district heating). A pilot project for micro-CHP in residential buildings has just been set up, which is not considered of interest for large new buildings (>1000 m^2).

In large cities many utility buildings are connected to district heating. This is one of the main alternative energy systems in place. As early as 1930 the first systems were set up in mainly Amsterdam and Rotterdam to use all available waste heating from surrounding industry and power plants. Rotterdam is now increasing the amount of waste heat from industry, while Amsterdam increases the use of heat from waste incineration. Still however new gas-fired CHP with relatively low efficiency is used as a source for smaller district heating schemes. In much of these areas the decision on systems is influenced by the local authorities. Sometimes municipalities force building investors to connect to these systems in order to make the investments for the district heating systems feasible. On the other hand, in large cities building owners of large office buildings often are able to make their own choice where renewable energy systems based upon heat pumps and cold storage aquifers are preferred. Since the Netherlands has subsoil that is very suitable for heat and cold storage, heat pumps with Cop's up to 5.5 are a very usable alternative energy system. These systems are now widely used for larger office buildings but are in need for further market introduction in smaller office buildings.

Bio-energy as source for heating is rarely used, except for heating based on waste incineration. Currently, some changes in the market are observed. Investors of many district heating networks are discussing ways to use renewable energy as feedstock for their networks (nowadays approximately 10% of renewable energy in the Netherlands). Small district heating networks are built using both heat pumps and CHP plants, also in The Hague a large part of the network will be fed with deep geothermal energy.

Considering the current situation the following systems are in need for further market introduction:

- heat pumps
- heat pups in combination with heat and cold storage for buildings (>1000 m^2, <10000 m^2)
- biomass as source for individual or collective (CHP, district heating) systems,
- solar thermal and PV systems

Finally, it is important that besides the market introduction of alternative energy system attention has to be paid to energy savings as well.

Slovenia

Regarding the current market situation in Slovenia the district or block heating systems should be first of all in focus for further market introduction. The second alternative energy systems which need further introduction on the market are biomass systems. Then follow the solar systems, geothermal energy systems and heat pumps. Most of these systems are already available on the market, in our opinion they only need a better promotion to the public.

The most frequently used energy source in residential sector is oil (32%), natural gas holds 6%, while 26% of buildings are heated by wooden biomass, approximately 9 % of residential buildings are covered by district heating (SURS 2002, census).

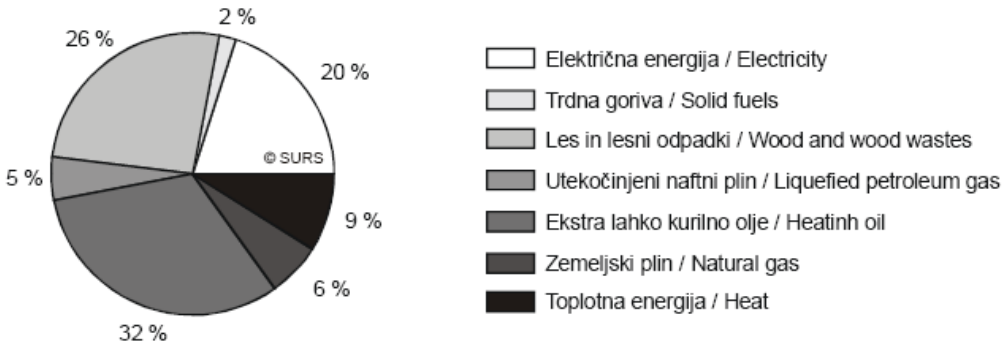


Figure 1. Final energy consumption in households by the energy source, Slovenia 2002 (Source: SURS, census 2002).

In 2005 the energy source for district heating in Slovenia were solid fossil / coil (56.7%), natural gas (38.7%), liquid fossil (2.7%) and wood biomass (2.0%) (Energy balance of Rep. of Slovenia, 2005).

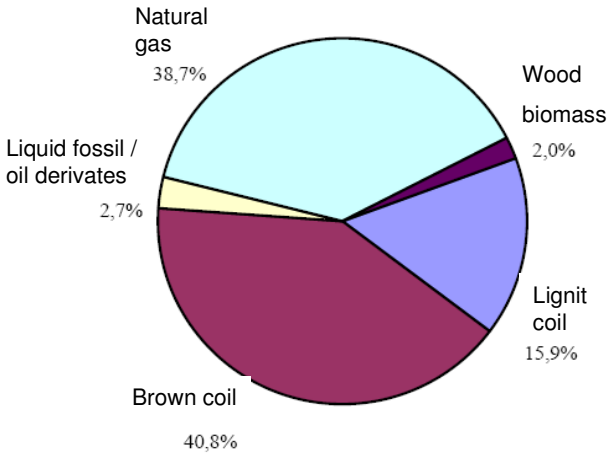


Figure 2. Energy source used for district heating in Slovenia in 2005, (Source: Energetska bilanca Republike Slovenija, MG, 2005).

Eight biomass district heating systems were introduced in the last years in some smaller cities, six of them financed in frame of GEF project “Slovenia - Removing barriers for the increased use of biomass as energy source” (2002-2006).

The energy supply for the particular building area:

- may be defined in the local energy plan (acc.to Art.17 of Energy Act),
- may be defined according to the regulation from Art.36 of Energy Act, i.e.

– the minister responsible for energy in consensus with the minister responsible for environment can prescribe a type of heating in specific areas of local communities and in particular industrial areas (environmental, energy, technological reasons)

• may be defined in the regulation at the local level (…municipal decree), i.e. prescribed obligatory energy source or obligatory connection to the specific energy network.

Connection to existing d.h. networks is obligatory in the above defined areas. The priority areas for d.h. and natural gas network are defined in energy plans, in order to enable maintenance of good efficiency characteristics of d.h. systems.

Denmark

In Denmark, heating of buildings and provision of hot water are primarily based on the use of district heating incl. use of other alternative energy systems (app. 60%), oil (app. 20%) and natural gas (app. 15%). Secondarily also electricity, solid fuel incl. biomass and heat pumps are used to some extend, while solar energy systems only are used to a minor extend, and CHP in buildings and district or block cooling only are used to a very limited degree.

In Denmark further market introduction of alternative energy systems should therefore first of all focus on solar systems and heat pumps, but also on CHP in buildings and district or block cooling, which still need to be used in an additional number of buildings to demonstrate their functional, economic and environmental performance.

In Denmark district heating is to a very high extend based on the use of CHP, only a minor part of the production facilities do only produce heat. The facilities include centralised, decentralised and private facilities, and the heat production is primarily based on the use of natural gas, biomass and coal, but also by the use of waste heat from industries and non-biodegradable waste. First of all due to further use of CHP and biomass, the CO2 emission for district heating has gone down from 87 kg/GJ in 1980 to 34 kg/GJ in 2005. Further reductions are expected, both because of a stronger integrations of the major energy systems, and because the district heating facilities are expected to include solar energy, geothermal energy, heat pumps, and further use of biomass and low temperature district heating.

This development raises three questions: one regards the use of alternative energy systems in buildings versus the use for district heating, two regards the integration of energy systems at building level with public energy systems, and three regards how to include the environmental gains in various public systems in the measure for the energy performance of buildings.

Heat plans cover 75-80% of Denmark. The plans focus on district heating and natural gas supply. Dispensation can normally only be given for one family houses build as low energy buildings class 1 or 2.

In areas without public supply of district heating or natural gas, there is are restrictions regarding choice of energy system, but due to the 2.5 factor on electricity, that will be rather uncommon.

Lithuania

District heating (DH) covers 46% of total heat supply market in Lithuania [1]. In the cities DH networks are supplying 75% of total heat [2]. Natural gas is the main fuel used for heat generation in Lithuanian and its share in the DH sector was 82% in 2006. The share of heat generated from biomass was about 14% in 2006. Geothermal energy makes 1.6% (one pilot unit in Klaipeda city, capacity 14MW) [1]. Biomass and waste heat from industry are expected to have growing market share for DH in the future.

Total amount of heat supplied to the DH networks was 9.4 TWh (2005). The amount of heat produced in CHP plants was 5.2 TWh (55%), however even 90% of this amount was generated and supplied to DH networks in the two biggest cities of Lithuania [3]. According to Lithuanian National Energy Strategy the share of heat produced in CHP plants and supplied to DH network should reach 75% in 2020. Solar systems for heat generation and heat pumps are not used for large buildings (> 1000 m2) at all and have very small share in family houses and countryside tourism buildings sector. Biomass (mainly wood and wood waste) is used widely in Lithuania. However for the public buildings this technology is more typical in rural areas (schools, recreation centres).

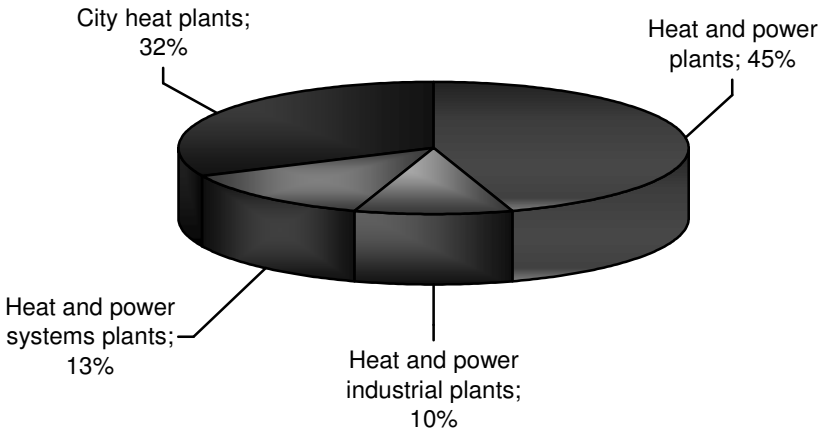
District heating systems incl. /excl. CHP primarily based on the use of fossil fuels and in some extent on renewables is going to maintain its positions and continue to be dominant heating technology in cities. In addition biomass systems and heat pumps could be as alternative for DH and natural gas based heating and they share in the market should increase. Possibilities to use the solar energy are very limited.

According the Law on Heat [4], approved in 2003, all municipalities shall manage the heat sector and should prepare the long-term heat supply plans. The focus in heat plans is on the use of district heating and natural gas. The ecologically clean heat energy sources (electric, geothermal, etc.) could be used in the whole territory of municipality. The requirements of heat plans is not obligatory for one family houses. In areas without public supply of district heating or natural gas, there are no restrictions regarding choice of energy system.

Poland

Fossil fuels are still the most important source of energy in Poland. More than 94% of electric energy is produced from coal; 2% from natural gas and about 4% from renewable energy sources. Heat energy is produced from fossil fuels also but more energy is taken from natural gas. Lot of municipalities exploits district heating systems to provide the municipalities with energy. Main energy sources in centralised energy networks are still fossil fuels. But lots of customers use waste heat from industry. Percentage production of heat is presented on the picture below.

Heat supply in Polish district heating systems.



Only about 30% of citizens use district heating. Rest of them uses individual heating systems which are mostly based on fossil fuels like coal, brown coal and natural gas. Fossil fuels prices are increasing, that's why growing number of energy users prefer biomass to produce heat. Price of wood biomass in Poland is competitive to price of coal per GJ but lots of boilers are prepared to use these two types of fuel. Clients do not need to pay additional costs for thermo-modernisation of boilers. Growing number of fossil fuels used for that purpose makes wood a product which can be difficult to get on free market.

We can observe a significant increasing of renewable energy production in individual houses. Especially solar thermal heaters and heat pumps are attractive energy sources for individual clients. Short term of payback time and good efficiency makes the alternative energy very popular. CHP becomes also popular in bigger district heating power plants to improve energy efficiency and decrease environmental impact.

France

The alternative energy systems, which first of all should be in focus for further market introduction regarding the current market situation in France, are:

- Solar systems, both thermal and photovoltaic

- District or block heating (and cooling) including a substantial use of renewable energy

- Heat pumps of all types and principally ground or geothermal based.

District heating in France is still mostly based on conventional energy sources (fossil fuels). Heat plans are decided and laid down by municipalities on a voluntary basis. Quite few have such plans to date. Heat plans are generally intended to focus on "local" energy sources.

Sweden

For the Swedish market the use of energy systems varies widely between different building categories. For multi-dwelling buildings and commercial buildings is district heating dominating. Outside the district heating net buildings have had oil burners or electrical heaters but the conversion to heat pumps and also biomass systems is progressing.

The energy systems that are in most need for market introduction in Sweden are solar systems, both thermal and electrical, CHP at building level, district or block cooling systems and heat pumps that combines exhaust air heat pumps (EAHP) and geothermal heat pumps. CHP in buildings are not directly used in Sweden since Sweden are more focused on large scale CHP with distribution of heat by district heating since district heating nets are well developed. Solar systems in Sweden are beginning to become more common for usage in multi-dwelling buildings. Since the solar systems are not efficient during the heating season they are not able to cover more than 20 % of the heating demand and about half of the annual heating of hot water. The production of district cooling is not that common but it's beginning to be built since the need for cooling, of especially offices, is increasing. Therefore, the cooling needs today mostly is covered by local cooling systems with electrical compressors. The usage of EAHP is very common, especially in new single-family houses but also in multifamily houses with low heating demands. For older buildings or buildings with higher heating demands, or combined heating and cooling demands, the conversion to geothermal heat pumps is more common. The combination of the above heat pumps is not often used but might increase.

The fuel for the district heating consists of different combinations depending on the local supply. (Biomass 36 %, waste 11 %, waste heat from industry 12 %, heat pumps 12 %, fossil fuels 14 %, natural gas 6 % and other sources 8 %). The sources that expect to increase are heat pumps (especially on sewage) and also the use of biomass and waste. District heating covers 47 % (45.6 TWh) for heating of buildings. In Sweden there are no general heat plans that regulate the selection of energy systems. For the municipal buildings the first choice is nearly always district heating, when available. For the private sector the developers are free to choose any energy system. However the selection is almost always between district heating and heat pumps and in some cases also biomass systems. The supplier of district heating is also interested in extending their district heating net to be an option for new project or for conversion for other systems in older buildings.

3 Building process and actors

The main questions to be answered were:

- At which stages of the building process is the choice of energy systems considered and decided upon?
- Which actors are normally involved in the various stages of the building process, which actors do first of all influence the choice of energy systems, and which other actors do first of all provide guidelines, tools and data for these stages?

3.1 Building process

In this report the building process has been divided up in 6 stages:

- Planning stage
- Programming stage
- Proposal stage
- Project stage
- Construction stage
- Operation stage

The process and the terminology differ from country to country, so the following description does not necessarily fit the practice in all the participating countries.

The *planning stage* includes urban planning, local plans and heat plans. In general these plans include plans for energy infrastructure incl. heat plans and number, use, location and size of buildings to be build at the area. The main actor will normally be the municipality, but others such as energy suppliers and developers may also be involved.

The *programming stage* defines the owners' and occupants' needs and requirements in the building programme or building brief. This will normally be done by the client or the developer assisted by consultants.

In the *proposal stage* (schematic design stage / pre-design phase), both a motivated outline proposal and a final project proposal is made. The project proposal is the basis on which the client makes its decisions on the aesthetic, functional, technical and financial solution of the project in question, principles of operation and maintenance as well as financing.

In this stage alternative concepts for the building incl. energy systems could be considered and decided upon. The project proposal is a revision of the approved outline proposal to such an extent that all decisions pivotal to the project have been made. The main actors will normally be the architect and consultants. Subsequently, the client or developer, who decides which alternative to be used in the project.

In the *project stage* (design development stage), the preliminary project (regulatory project) is a revision of the approved project proposal for consideration by the authorities including final decisions concerning energy related topics (insulation, energy systems, connection to district heating etc.). Together with the preliminary project, the main project describes the project in unique terms to allow it to form a basis for final approval by the authorities and for tendering, contracting and construction. Main actors will normally be the architect and engineering consultants. The process is interactive also the client or developer does have a decisive role. In addition, the contractors and others may be involved.

The final approval of the project is given by the local authorities, who are responsible for the building permit.

In the *construction stage*, the building is constructed incl. energy systems and needed connections to existing energy supply systems, so that a use permit can be given. Main actors will normally be the contractors and installers.

In the *operation stage*, the building is in use. When the building is rented, the owner not coincides with the user of the building and its energy systems. This can lead to an imbalance: the investor of alternative energy systems does not benefit from the lower energy costs (split incentive). Besides the behaviour of the occupants of the building, good maintenance and tuning of installation by installers determines the actual energy consumption.

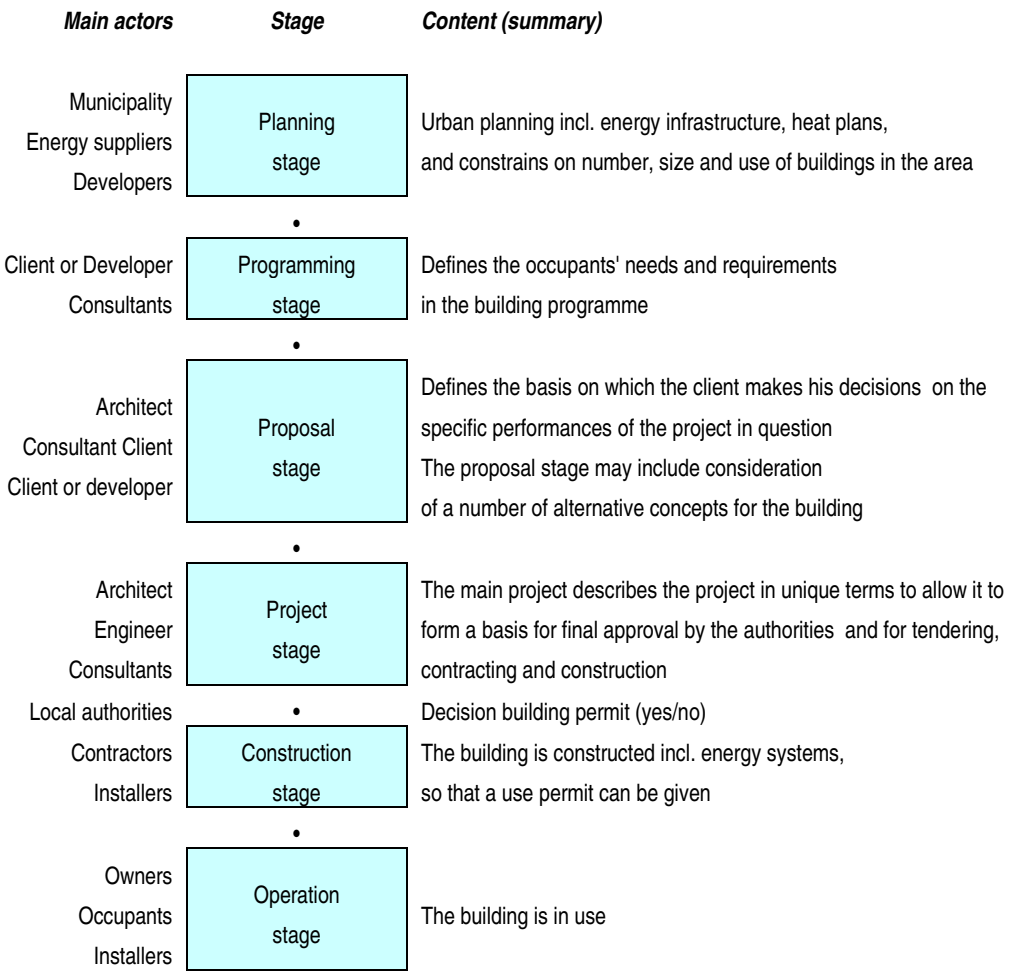


Figure 1. Schematic flow chart of the design stages of a new building. For France a more detailed figure is shown, see Figure 2.

3.2 Conclusions

The most important stages in the building process regarding the choice of energy system is registered to be:

- planning stage
- proposal stage
- project stage

The programming stage must also be considered important so that the building programme (brief) includes an option for introduction of relevant alternative energy systems integrated and optimized into the design concept and process of the building.

During the planning stage decisions are made concerning the energy infrastructure of the building area, such as district heating and provision with natural gas.

This can be of high importance, because municipal heat plans may limit the possibilities for introduction of other energy systems. It is also of importance to state that district heating often can involve extensive use of alternative energy systems such as the use of waste heat, biomass (incl. waste incineration), heat pumps and geothermal energy, but also conventional CHP.

The proposal stage, which includes the possibility of evaluation of different concepts for the building, is in most countries pointed out as decisive for the choice of energy systems included in the building. At this point in the decision for energy systems should be a level playing field in the comparison between different energy concepts taking into account the environmental boundaries of the local system. The final choice of the energy systems in many building projects is often postponed to the project stage in which the building permit is asked for, and in which the feasibility study on inclusion of alternative energy systems are delivered. A well balanced optimisation of energy demand and production is not possible anymore in this stage of the process.

From the previous inventory in the SENTRO-project (WP2) it appears that in most EU member states (17) the feasibility study is obligatory at the building permit. However, the precise requirements are usually not elaborated yet. For a proper functioning of the feasibility study element of the EPBD it is essential that this becomes clear at short term. Because only then actors can be made aware that they have to take into account a serious consideration of AES in the early stage of the building design.

In conclusion, it is of high importance, that the feasibility study is asked for in the first stages of the building process (planning and programming stage). In addition, the results of the feasibility study have to be available in the process stage, when the definitive choice of energy systems is made.

Considering the actors involvement in the process, the actors which first of all influence the choice of energy systems are registered to be:

- clients, developers and investors
- architects
- engineers
- local authorities, municipalities

Clients, developers and investors do normally take the final decisions on choice of energy systems, and the decisions are normally based on design concepts and evaluations made by the involved architects and engineers.

3.3 National reports

The Netherlands

The energy performance ambitions stated at the very start of a project are the guidelines in deciding on the energy system in a project. It depends on the most influential actor in this stage if the energy performance ambitions will be equal to the minimum requirements or higher.

If the municipalities are the owner of the land on which the building is planned, than they can set ambition targets that developers have to meet in order to start building. In this case, the municipality is the most influential actor in the planning stage and they will either indirectly or directly make a choice for an energy system.

Since developers/investors are in general a rather conservative group, the ambitions for the build-in will equal the minimal requirements if they own the land. Apart from the very first stage, developers are throughout the building process the most influential actors.

Architects (urban designers) are involved in the early stages of the project, up until the project stage. Engineers are involved in the proposal, the project and the construction stages. Energy utility companies get into the project during the project stage, followed by the energy equipment companies, both right until the final stage. Contractors and installers are being involved in both the project and construction stages.

As energy consulting companies are very often involved in feasibility studies and in advising parties on alternative energy systems, they are involved right from the start until the construction stage.

Tendering of the energy systems starts in the pre-design (programming/proposal) phase. Sometimes the result of a feasibility study can be that multiple systems are suitable, in which case the market is requested to make an offer for what they believe to be the most suitable system for the particular area through a tendering procedure.

Once the energy performance ambition has been stated, energy concepts can be chosen. Therefore the energy systems are in general firstly considered during the programming stage, and decided upon in either the proposal or project stage. This goes for internal (individual), external (collective), and supplementary energy systems. Both internal and supplementary systems can be re-viewed in the operation stage.

Slovenia

Actors which are most important and involved in building process (program stage, proposal stage, project stage) are developers/clients, architects and engineers. A municipality has strong influence on choice of planning stage and less on the other stages.

For successful implementation of alternative energy systems the investors/developers, architects and engineers are expected to co-operate closely dur-

ing all phases of design, but mostly at early stages. Recently there have been some such good cases recognized. Usually, the suppliers and contractors are consulted already in the design process, not only in the construction phase. This practice is more frequent when architectural competition is required, i.e. for big projects. To overcome the problems of traditional conservative design process, above all the awareness of the core design group is important. Though the limited investment resources can easily hinder the implementation of more expensive alternative systems, even in case of lower life cycle costs (investor – user dilemma).

Denmark

The municipalities have a leading role during the planning stage, where local plans are developed and decided upon. But because local plans very often are strongly related to plans for new buildings, the client or developer and their consultants also are involved and maybe also contact to relevant energy equipment companies.

Most municipalities, clients and developers do not have an interest in alternative energy systems. But a number of them have, and it will now be decided, that the municipalities can decide to include requirements on low energy buildings in their local plans, and maybe also requirements on Swan labelled one family houses.

For most locations in Denmark, heat plans are decided upon including the use of district heating or natural gas. So if the client or developer wants to use other energy systems, this has to be accepted by the municipality and may also include the involved energy utility company.

The client or the developer has the leading role during the programming stage involving also the consulting architects and engineers, and it will normally be so that if alternative energy systems should be considered, this should be decided in included in the building programme, the brief. Since the new energy regulations has been decide upon, it is normally necessary to involve the engineers from the beginning of the building process to meet the requirements.

If alternative energy systems are taken into consideration, the proposal stage may include a comparison between alternative energy systems linked to different concepts for the building in question, These concepts are developed and evaluated by the consulting architects and engineers and will to some degree include technical, economical and energy evaluations similar to the feasibility studies in focus for SENTRO. It will normally be the outcome of this stage that the concept for the building is decided including decisions regarding the choice of the primary energy system. The final decision is taken by the client or the developer.

During the project stage, minor adjustments of the energy system may be included. This will seldom be the case during the construction case, unless the tendering includes alternative solutions. The building permit is given during the project stage.

As mentioned above, energy equipment companies or associations may also be involved, which also could be the case for energy utility companies, if the energy system in the building interacts with the energy supply system.

Lithuania

In the planning stage the key role belongs to the municipality, during the planning process of urban territory it is planed which energy systems could be there. Usually special municipal heat plan specifies which external heat supply systems are obligatory. At this stage centralized energy supply companies (DH, natural gas, electricity companies) are active participants. The public opinion and recommendations of research and development institutions are also taken into account.

At building programming stage the most important are the needs of clients and investors if they have possibility to choose energy system, according to the local heat plan. Clients along with architects and engineers considering possible energy systems for the building (it could be external or internal energy systems).

The estimation of energy demands and the potential ways to satisfy them mostly depends from architects and engineers. They formulate and propose to the client concrete options of energy systems. At the proposal stage concepts for the energy systems which satisfy needs of client is finally considered and decided. At this stage the energy equipment companies are also involved.

At the last stages of building designing it could be decided about installation of different supplementary internal energy systems, for example solar collectors on the roof, etc. At design development and tune up stage (project stage) are involved investors (clients), architects as well as other actors of building process.

At the construction stage the maximum number of actors is involved, but the essential decisions were made at the past stages and the energy systems changes are not considered.

Poland

The biggest responsibility for energy solutions during the building process lies on investor's. They are supported by engineers' offices which are responsible for a construct project. Architects and engineers propose electric and heating solutions to Investors according to the rules and obligatory prepared by local authorities and governmental rules.

Heat solutions are chosen on the beginning of building process. Before a project stage they must be clear for all actors and accepted by investor. Any feasibility studies or energy studies need to be prepared during programming or proposal stage to give an opportunity to discussion between all parties. Final decision lies on investor's side but it should be based on feasible assumptions.

France

In the French system, the building permit demand takes place in the preliminary design stage. Decisions regarding energy are mostly taken at this stage, whereas they have been envisaged at the schematic design stage and will be confirmed and finalised at the detailed project stage.

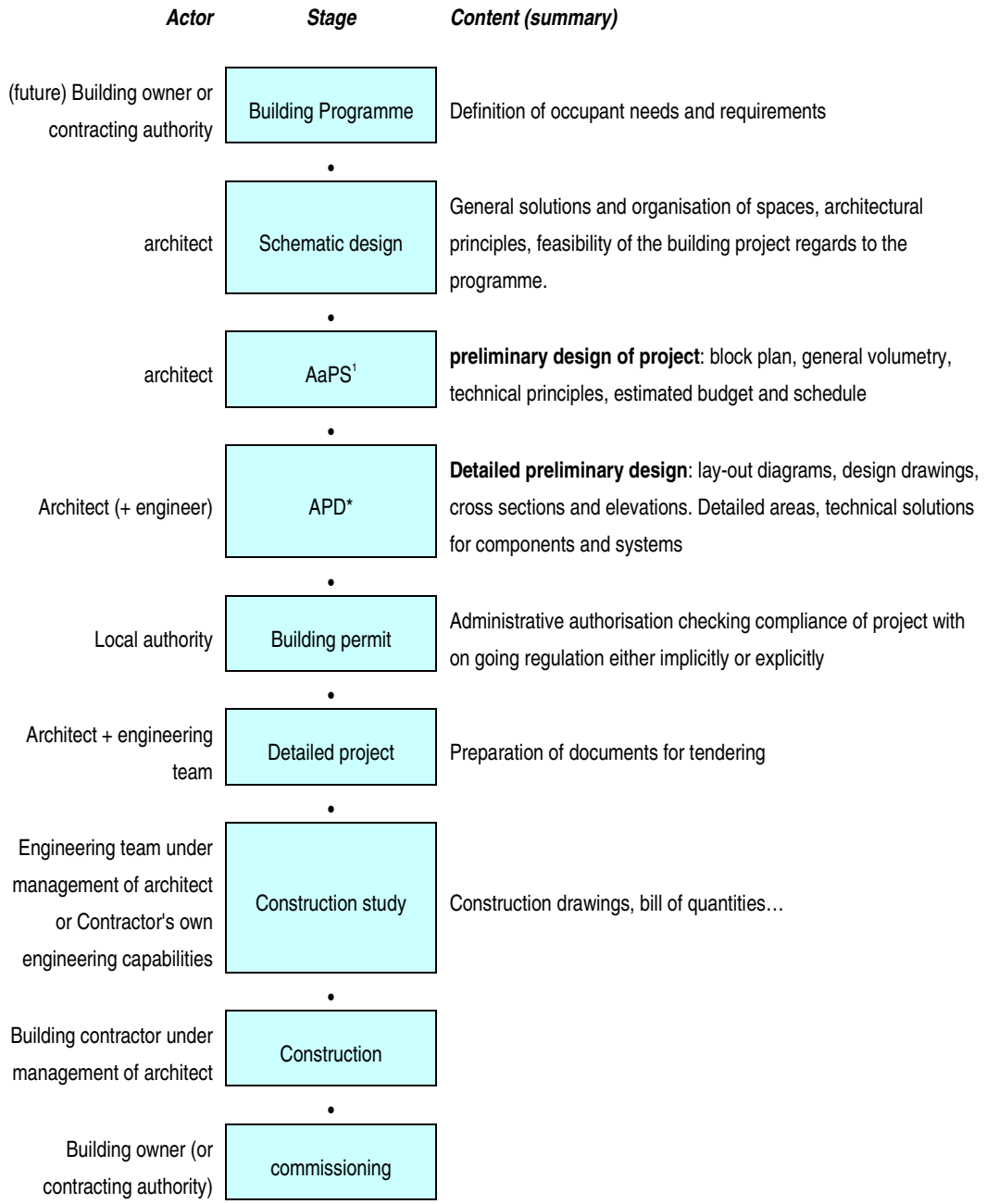


Figure 2. Schematic flow chart of the design stages of a new building for France.

Sweden

When municipalities are involved in the building process the selection is made in the first stages of the project, i.e. in the planning stage. Since the municipalities develop and invest in their own buildings they choose which energy system that should be used for heating of the building. If the clients, developers or investors are not municipalities they will influence the selection a bit later in the process, i.e. in the programme stage. If the selection of energy system for the building has not

[1] APS and APD may be merged into one step only. It is the case with residential buildings..

been made before the proposal stage the architects and engineers will have a possibility to influence the energy system to be chosen. In some cases the clients do not have sufficient competence for determine the energy system and than it's extra vital to have the input from engineers.

The selection of external energy supply system versus internal energy system is normally considered in the planning stage and decided upon in the programme stage. Which external energy system that should be used is normally considered and decided in the programme stage. For the selection of different internal energy system the question is taken under consideration in the programme stage and decided upon in the proposal stage. The same is valid for the choice of different supplementary internal energy systems.

The focus for part B will be for municipalities, architects and engineers and all type of buildings will be included.

4 Driving forces

The main questions to be answered were:

- Which driving forces are of high importance for market introduction of alternative energy systems in buildings?
- Which actors act as driving force for market introduction of alternative energy systems in buildings?

4.1 Conclusions

In common, the strongest driving forces were registered to be:

- the new energy performance regulations
- a general environmental consciousness

Beside, also the new national requirements for feasibility studies and reduced life cycle costs are mentioned as strong driving forces.

The new energy performance regulations are now of high importance for the introduction of alternative energy systems, because the effect of energy efficiency and use of renewable energy systems are taken into consideration in the energy calculations. The strengthened requirements for reduction of the energy consumption implies also that use of alternative energy systems may prove more feasible than further development of the traditional reduction means like further insulation. This is further stimulated by the requirement for feasibility studies for alternative energy systems, which also has been mentioned as an important driver in a number of MS', where this requirement has been implemented.

Environmentally, general environmental consciousness has been mentioned as a very important driving force, e.g. defined in an environmental policy for the company. It is therefore of high importance that the energy requirements and the required environmental feasibility studies reflects and measure the environmental performance of the considered alternative energy systems.

Economically, reduced life cycle costs have been mentioned as important. But as mentioned later on barriers, life cycle costs are not always considered that important during the design process for buildings.

Technically, appeal of alternative energy systems has been pointed out as an important driving force in some countries. But as mentioned later, lack of confidence has been mentioned as a rather important barrier.

In common, the most important actors acting as driving force for the market introduction of alternative energy systems in buildings were registered to be:

- municipalities
- clients, developers and investors
- architects
- engineers
- energy equipment companies
- research and development institutions

The importance of these actors differs between the MS, and in a few countries also energy utility companies and installers are in pointed out as very important actors.

Compared with the registration of the actors having the strongest influence on the choice of energy systems, see figure 1, shows that these to a high degree are the same as the actors among whom the most important actors acting as driving force can be found.

4.2 National reports

The Netherlands

Almost all actors mention new national energy performance regulation, or specifically a more stringent regulation than the current one, as a important driving force: if one cannot meet the energy performance requirements with applying 'common', traditional systems, than one is forced to apply alternative energy systems. Municipalities are then seen as the main actors that could act as driving forces for alternative energy systems. Either through ambitions energy performance demands or through speeding up certain regulation procedures for alternative energy systems.

General environmental consciousness with clients (occupants) is also mentioned by many: if clients get more demanding concerning the energy systems in their future buildings as a result of their heightened consciousness, then developers will be inclined to meet their demands.

Another very important driving force that is not in place would be lifting the imbalance which exists in the Netherlands in investments and the resulting gains: developers have to invest more in their building, but the occupants will get the lower energy bills. Increasing the use of the Life Cycle Costs (LCC) approach if one way of tackling this imbalance.

Developers/investors are perceived as theoretically major driving forces, but in reality rather the opposite, as this group is generally conservative. The same goes for installers and consultant as well. This large body of the main stream in the market is an important barrier for the introduction of alternative energy systems. If they would look at their business in a different way, i.e. including economic gains from optimizing the building process and valuing the opportunity to distinguish themselves in the market (client orientated, modest energy bill for users of the building) , then it would make sense to invest in alternative energy systems. But as the majority in the market does not have such an image of their business, all they want is to construct a building for a low price and sell it for a high price. In the Netherlands this type of market approach is possible in the domestic market which is a supply side market rather then a demand side market. In the large commercial building market the situation is the other way around where decisions are made by the client and not by the supplier.

Finally, it is suggested that the introduction of new actors, such research institutes, in the start phase of the building process could help the stimulation of alternative energy systems

Slovenia

According to the answers we gathered from the inventory questionnaires the highest impact of potential driving forces for market introduction of relevant alternative energy systems on building level has new national energy performance regulations for buildings according to EPBD. EPBD regulation as a driving force is followed by a more detailed regulation on new national requirements for feasibility studies of alternative energy systems and higher energy prices for fossil energy sources and state incentives. Other drivers are also lower life cycle costs, increased interest for alternative energy sources / systems as a part building owners image and environmental consciousness.

Engineers as consultants make crucial decisions in the design process, so their recommendation to the design team is an important driving force.

To stimulate the implementation of heat pumps electro utility company should offer better prices.

Denmark

Almost all the interviewed actors meant that the following driving forces for further use of alternative energy systems was the most essential ones:

- The new energy performance regulations for buildings inclusive the definition of two low energy classes
- General environmental consciousness including appeal of alternative energy technologies among a number of the involved actors

But also the potential for reduced life cycle costs was mentioned.

The new energy performance regulations include so much stronger demands, that the inclusion of alternative energy systems now is a much more interesting option for meeting the demands than before, especially for office buildings and low energy buildings.

Regarding the role of the various actor groups as driving forces, the answers differed more, because the number of driving actors still is limited and differs between different areas of the building sector.

Most actors pointed at the architects and the municipalities as the most active actors. It has been said that especially a number of young architects do have a high interest in inclusion of alternative energy systems and on the evaluation of these, especially if they have a strong influence on the design and choice of concept for buildings. A number of municipalities have included demands on low energy buildings, when they had the possibility to do so. Finally also clients, developers, engineers and energy equipment companies were mentioned by almost all as important driving forces.

The energy utility companies also contributes to the introduction of alternative energy systems, but has at least until now also sometimes acted against this, if their interests was challenged.

Lithuania

District heating in Lithuania is widely used and promoted, so it is not analysed in the following chapters.

According to the opinion of interviewed actors first of all the alternative energy systems should be legally promoted, the financial risk related to the installation of these systems should be reduced. Therefore one of the major driving forces should be requirement to do feasibility studies on alternative energy systems for the new buildings. Generally the feasibility studies are not done at the moment, while the choice of alternative systems depends on clients and architects own initiative. General environmental consciousness is at the low level in Lithuania at the moment and energy system selection mostly determined by the cost. Sometimes, when client will be the occupant of building, he might choose more expensive alternative energy system (this is more common for small individual houses). In Lithuania, the „appeal of energy technologies“ is associative with systems which is well known, their installation is simple and don’t require high time and cost consumption.

At the moment, as driving force for the market introduction of alternative energy systems in buildings in Lithuania really acts clients, architects and to the greatest extent - the energy equipment companies, who has direct interest. From the alternatives mentioned in the EPBD directive municipalities most of all promotes the district heating option. In the process of promotion of other systems the influence of municipalities is negligible. Energy utility companies (DH and natural gas) not interested in the development of alternative energy systems (possible direct competitors).

Poland

The most important actor to implement obligation of renewable energy sources during building process is Ministry of Construction. Still we didn't have implemented EPBD. Without legal act and obligatory standards and codes decision depends only on investor.

Architects and engineers are a perfect support for investors during preparation phase. Proposed solutions are usually implemented during construction phase. Energy utility companies and independent energy consultants are responsible for knowledge transfer and information about new solutions.

But without EPBD implementation our country would not achieve a final success. Only complex actions can give a significant result.

France

The following potential driving forces should have a significant impact for market introduction of relevant new alternative energy systems on building level:

- new national energy performance regulations for buildings according to EPBD
- general environmental consciousness, e.g. defined in a environmental policy for the company
- simplification of administrative burden
- development of third party financing including studies

Sweden

The actors there were interviewed had a bit varying opinions regarding the potential driving and there influence on the market introduction of new alternative energy systems. For the driving force "National requirements for feasibility studies" the architects and the engineers agreed that it will have some impact. All of the actors believe that the general environmental is the most important potential driving force. Here the engineers thinks that it will have high impact for all of the specified energy systems, the architects for all except the district cooling and municipalities for the district cooling and combined heat pumps. The new national energy performance regulations as well as increased focus on LCC is also agreed to have a large impact for the market introduction of alternative energy systems. The municipalities believe that new national energy performance regulations and reduced life cycle costs will have a high impact which will work in favour for combined heat pumps.

The actors that act as driving forces for the introduction of alternative energy systems vary between the municipalities, architects and the engineers. The architects and the engineers both assume that the contractors and also installers have least impact. Otherwise most of the actors are assumed to have some impact for all of the energy systems. One thing that is interesting is that the engineers assume that the architects will act as driving forces in minor extend while the architects them self think that they will have impact for all energy systems and to a high extend for solar systems. The engineers also think that the municipalities have a large influence for introduction of district cooling while the architects believe that research institute will have a large impact for solar systems and micro CHP at building level. The municipalities think that the energy utility company acts as driving force to a high extend for district cooling systems and energy equipment companies for combined heat pumps. The municipalities also believe that research and development institutes have a high impact for introduction of solar systems.

The general energy awareness will be the most important driving force. Basically it has to come from either of, or both of owners and occupants. They have to realise that energy savings costs money. Municipalities already today have the largest impact on the extent of the district heating and cooling since they often own these plants.

5 Barriers

The main question to be answered was:

- Which barriers do first of all slow down the market introduction of alternative energy systems in buildings?

5.1 Conclusions

In common, the most important barriers were registered to be:

- higher investment costs
- lack of knowledge
- lack of confidence

But also a number of other important barriers were mentioned as important barriers by a number of actors: Lack of building examples, uncertainty regarding long term economy, no certainty in pay-off, inertia to change, lack of legislation on feasibility studies, lack of tools and data for feasibility studies, and finally that options for alternative energy systems are introduced too late in the design process.

Economically, higher investment costs were mentioned as one of the most important barriers. But also uncertainty regarding long term economy and no certainty in pay-off was mentioned as important by a number of actors. It appears that decisions regarding new buildings to a high extend focus on the construction costs not on the costs for operation, and also that not all developers, building owners or investors do profit from reduced costs for operation.

Lack of knowledge was mentioned as one of the most important barriers. More communication and learning are needed for all the involved actors. It is obvious that an unknown technology will not be applied. Often, the technology may be known, but it is associated with wrong or incomplete information. If the involved actors are not convinced of the benefits, they will not adopt the system.

Technically, lack of confidence was mentioned as very important. Connected to the fact that also lack of building examples and demonstration projects was mentioned as important, may demonstrate that the building sector want good documentation for introduction of new solutions. This barrier is linked to the previous one because the lack of confidence is often the result of a lack of knowledge.

Regulatory, the fact that feasibility studies on alternative energy systems is not yet required in a number of MS, was mentioned as an important barrier together with the lack of the needed tools and data for the technical, environmental and economic feasibility studies.

Organisationally, it was mentioned as important, that the possibility of introduction of alternative energy systems often was introduced to late in the building process. This is maybe connected to the fact that actors in all the participating MS pointed out that inertia to change are an important barrier. A barrier of conservatism, which normally are explained by the fact that the time and resources for design and construction are rather limited, that the organisation includes short-term relationships between a considerable number of actors, and that the construction outputs are rather complex.

Environmentally, no barriers was mentioned, which related to the fact, that environmental consciousness was mentioned as one of the strongest driving forces implies that environmental feasibility studies first of all are meant for strengthening the environmental arguments for introduction of alternative energy systems.

5.2 National reports

The Netherlands

The main barriers, as mentioned by all parties, are the perception of the high investments and the uncertainty in pay-off. This is primarily caused by the construction in the Netherlands where the party developing the building is not the occupant of that building. In other words: the party making the higher initial investments for alternative energy systems will not be the one who profits from the lower energy bill.

As an organisational barrier the rather conservative attitude in the Dutch construction world is mentioned. Also a lot of actors feel that they are not included in the building process in a stage where they could have an influence on the choice of energy system.

Although it was not one of the main outcomes of the inventory, it is known from experiences in practice that lack of knowledge with installers is one of the main barriers for the market introduction of alternative energy systems.

Slovenia

Based on the opinion of various market actors, the CHP (micro) at building level should be the first in focus for further market introduction regarding the current market situation. The second alternative energy systems which need further introduction are biomass systems. Then follow solar systems, district or block heating and heat pumps. Most of these systems are already available on the market, but they only need a better promotion to the public.

Higher investment cost is most frequent barriers for introduction of alternative energy systems, especially for biomass systems and solar systems and heat pumps.

An important organisational barrier is traditional conservative design process that prevents the penetration of innovation; i.e. engineers are working on projects according to the same scheme that is adapted to old energy systems, tight deadlines are leaving no time for adjustments to alternative technologies.

Not enough cooperation among different actors involved in planning of new building is a frequent reason for failure of integration of alternative energy systems at the design stage.

The actors' opinion is that in case of biomass systems the uncertainty of biomass market is very high, the prices increased in last two years for 50-80%. CHP at building level need more information on actual installations, i.e. even if there are examples, they are not sufficiently presented in the public. The investment in CHP systems is high, so the designers' opinion is that incentives for investments are needed. District heating: higher investment cost – in comparison with other fuels. The engineers are concerned about uncertainty regarding long term economy of alternative energy systems, especially for CHP (tariffs, energy prices).

Denmark

Almost all the interviewed actors meant that the following barriers for further use of alternative energy systems were the most essential ones:

- Higher investment costs as the most important
- Lack of knowledge including lack of confidence
- Lack of demonstration projects

But also lack of data and tools for feasibility studies and conservative building practice was mentioned by almost all.

Higher investment costs are very essential for most clients, developers and investors, both because focus normally is on the upfront money not on the life cycle costs, and because the decision maker not always get the benefits of lower operation costs. If the payback time is considered, very often a very short payback time is required.

Lack of knowledge including lack of confidence, especially among the consultants, is linked to the fact, that the time and costs for the design of buildings are very limited, so that well known solutions very often are in focus. Very often, only a limited number of the employed energy experts do have the knowledge needed for including alternative energy systems. The building sector is rather conservative compared with a number of other sectors.

Lack of demonstration projects, especially well documented projects, plays a major role both for clients and developers and for the consultants. Even if a client wants to demonstrate his interest for energy savings, he does not want to use solutions, that has not proved to be well functioning. Buildings are expected to have a very long service life.

Feasibility studies regarding alternative energy systems are not yet required at building level in Denmark, but are expected to include at energy supply level, especially regarding heat plans. Never the less, better data and tools for feasibility studies of alternative energy systems including other energy saving measures are expected to be of high importance for further developments in the area; needed because the Danish energy requirements for buildings are planned to be revised in 2010 and 2015.

Lithuania

Below are presented key barriers for all alternative energy systems (except DH). At the moment the architect (or other actor) is not legally liable to analyse different energy supply alternatives and formulates the solutions to use one or another energy system according to his own criterion and motives. The other important barriers are higher investments for the non traditional energy systems, high inertia to changes and conservative building practice, the installation of alternative systems is related to lack of confidence and higher risks. All of interviewed actors have mentioned the lack of knowledge as important barrier for at least one of the systems. There is no any support for alternative energy systems from the government side at the moment: there are no financial exemptions and compensations, the loans on easy terms are not provided, etc. Therefore the investors are seeking to minimize additional time and investment cost by choosing well known and budget traditional energy supply systems.

The main barrier for solar energy systems is climate conditions in Lithuania (it is north-eastern country). Also it is lacking of scientific research results in this field; there are no comprehensive estimations about the real effectiveness of solar systems in local conditions.

The barriers for biomass systems in large building are related to the particularity of technology (additional space for fuel storage, additional cost for fuel feeding automation, higher maintenance cost, insufficient fuel supply infrastructure and volumes).

Micro cogeneration as technology is considered as very attractive in Lithuania. But in this case the essential barrier is problems related to procurement of additional electricity and heat to networks. Also the fees and technical requirements for connection into networks are too high. The legislation is favourable for DH and electricity distribution companies, which do not allow the competitors to enter the market (due to overcapacities in the electricity and heat infrastructure).

The technology of heat pump is known and to some extent is used in small individual family buildings. But because of support from government absence this is quite expensive alternative. The operation of these systems in large buildings in many cases should be problematic because of technical difficulties (no relevant environment, not enough space in surroundings, etc.). Under certain conditions (no DH or gas network, suitable environment) this alternative could be competitive on the market. The attractiveness of this technology is reducing the concern about the future electricity prices (it is related to scheduled closure of Ignalina nuclear power plant in 2009 and expected electricity price jump). But on the other hand, natural gas prices likely will increase also.

Other barriers mentioned in the questionnaire are not significant at the moment.

Poland

Main barrier for introduction of alternative energy systems are lack of law obligatory. Without EPBD implementation main actors will not use alternative systems because:

- Lack of knowledge about alternative sources;

- High price of alternative systems;
- Low price of conventional energy and longer payback time of investment;
- Lack of knowledge about savings caused higher energy efficiency.

Usually investors are not final users of buildings. Developers are not interested in bigger investment cost and low exploitation cost. Exploitation cost is customer problem. If energy performance preparation is obligatory for developers, final clients would have a chance to choose a better investors offer. Competition on building market is always good for developers' clients.

Lack of regulations and EPBD implementation is not good for Polish economics. Our energy demand in buildings makes our economics very uncompetitive among other European countries. Frequent changes in The Ministry of Construction Board are main barriers in implementation process. Different philosophy of next crew inside ministry interrupts a legislation process.

France

Different actors see different barriers.

Dissemination of knowledge is necessary towards local authorities and building managers whereas more central organisations don't need it (or don't ask for it)

Problem of risks is considered highly by building managers and other investors/contracting authorities whereas it is dismissed by construction companies and professionals.

Some "shining" examples are missing but not in all sectors or for all alternative energies. The most important identified lack lays in micro cogeneration in buildings.

All concerned parties agree on the question of higher investment costs for alternative energy solutions as a barrier.

The inertial building practices are more intensively resented on the building manager and local authorities' side.

All people involved directly in the day-to-day activity of designing and constructing buildings seem to detect a difficulty in scheduling correctly the design process and fear inconsistency with the feasibility study on energy optimisation.

Absence of direct obligation on feasibility studies is an obvious barrier for all. People in charge of large renovations, in general, rely on an energy audit which include some feasibility analysis, particularly as far as renewable are concerned.

Tools exist but are not widely known

It is difficult at the programming stage, to evaluate additional investment costs and potential savings, which makes it hard to convince decision makers.

In a global context of reduction of public budgets and expenses (as for local authorities), it is extremely difficult to argue on energy efficiency solutions, when nothing is compulsory.

Lack of transparency in tariffs or maintenance costs plus uncertainties on energy prices evolution

Building owners or building managers are specialist neither in building construction nor in energy. In a building project there are already so many administrative burdens that they definitely do not wish any additional one

Feasibility studies should be introduced as early as possible and preferably at the programming stage to be able to incorporate choices which may have an impact on the architectural design.

There is a need to provide building managers with a detailed framework and standard calculation tools and data to facilitate both the execution of the study AND its interpretation.

Other technical barriers:

- there are a number of bad examples with heat pumps or thermal solar systems
- micro cogeneration is so little disseminated that few consultants are able to introduce it as an option

Other financial barriers:

In Public organisations budget for investments is separated from budget for operating costs, with different people in charge. Those in charge of design and construction lack the proper motivation to rack their brain on the energy performance

Also there is a lack of (financial) guarantee on efficiency and results of alternative energy solutions

Rather low costs of conventional energies (nat. gas, electricity) limit strongly the cost effectiveness of solar alternatives

Other organisational barriers:

- Building owners or building managers consider it not being their "business" to produce and sell electricity and check the return on investment.
- In privately owned multifamily dwellings, the French Law on joint ownership is a serious hindrance to taking decisions (specific to large renovations).

Sweden

Most of the barriers have been found to have some impact and to slow down the market introduction. The barriers that have been found to have high impact are mostly related to CHP at building levels. Here the architects believe the barriers for CHP are, lack of knowledge, lack of building examples, higher investment costs, uncertainty regarding long term economy, inertia to change and to late introduction in the design process have a high impact. The engineers also see high impact regarding CHP due to lack of confidence and higher investments costs. The other barrier with high impact that the engineers assumes is the higher in-

vestment costs for solar systems. The municipalities has the opinion that lack of knowledge, lack of confidence, lack of building examples, higher investment costs, uncertainty regarding long term economy (B1-B5), burden some administration, and lack of tools (B8 and B11) has a high impact as barrier for introduction of CHP. For solar systems the municipalities have found the following barriers to have a high impact; burdensome administration, lack of tools, (B8 and B11) together with other technical barrier such as there is no need in the summer for extra heat production since the district heating uses waste burning, and other financial barrier as there is no subsidy if its within the district heating area. For the district cooling the municipalities also think that uncertainty on long term economy and on pay off will have a high impact and also that one will become tied up with one supplier of energy source (no competition).

The architects and the municipalities have identified more barriers with higher impact than the engineers. For solar systems the architects have located main barriers in lack of building practice, higher investment costs, long term economy and inertia to change. Regarding district cooling systems there are main barriers on the higher investment costs, long term economy and for combined heat pumps also due to uncertainties in long term economy according to the architects.

The barrier that seems to have only minor impact is burdensome administration. This is valid for all energy systems according to the architects and for the district cooling and combined heat pumps according to the engineers. The engineers also states that there is only minor impact for all energy systems except CHP regarding lack of confidence and lack of building example in practice.

According to the engineers the overall barrier is the focus on short pay-off times and that one often lock on the energy savings investments from a strictly economical point of view. This in combination with to low energy prices in Sweden not taking the earths increasing carbon dioxide levels into consideration. Soon we have to realize that reducing carbon dioxide level must be allowed to cost money. In Sweden there is small potential for CHP in buildings due to the restricted usage of natural gas. In Sweden there is instead a large focus for CHP in large scale with bio mass and waste as fuel.

6 Solutions

The main questions to be answered were:

- Which measures can tackle the general barriers that slow down the market introduction of alternative energy systems in buildings?
- Which measures can facilitate the introduction of technical, environmental and economic feasibility studies of alternative energy systems for buildings?

6.1 Conclusions

Conclusions is presented separately for general measures and for measures for fesibility studies.

On general measures

In common, the most important general measures were registered to be:

- Financial support and tax incentives incl. CO_2 taxes

Beside three other general measures was regarded important by actors in most of the participating member states:

- Stronger inclusion of alternative energy systems in the energy performance regulations
- Demonstration projects and good practice examples
- Specific information and data needed for building design and energy calculations

Beside also guidelines, tools, education and training was mentioned by number of countries.

Economically, for all participating member states financial support was registered as the most important general measure to further market introduction of alternative energy systems. The economic support could be direct or indirect using tax incentives, e.g. use of a CO_2 tax. In the Netherlands, most actors meant that solving the split incentives imbalance would be sufficient, a solution which recently also has been discussed in Denmark.

Stronger inclusion of alternative energy systems in the energy performance regulation has also been mentioned as an important measure, e.g. by introduction of a CO_2 indicator. This measure needs further considerations of the regulations, the calculation methods and the energy factors to be fully justified.

Technically and communicatively, further well documented demonstration projects and good practice examples was mentioned as important by most participating member states. Introduction of new energy systems in buildings may involve efforts in the upstart phase, which not necessarily are economically and technically profitable. Later, when the systems has demonstrated to be viable, specific information and data needed for building design and energy calculations is needed, as mentioned by many actors, and supplemented by guidelines, tools, education and training.

On measures for feasibility studies

In common, the most important measures for feasibility studies were registered to be:

- Legislation on obligatory use of feasibility studies
- Methods, tools and data for economic feasibility studies

Beside also a number of other general measures were regarded important by actors in most of the participating member states:

- Protocol for feasibility studies
- Methods, tools and data for technical feasibility studies
- Additional time and costs for feasibility studies

Finally methods, tools and data for environmental feasibility studies were asked for by four member states.

Legislation on obligatory use of feasibility studies is what the actors first of all asks for, and preferably also a common protocol for the feasibility studies. This can be seen in parallel with the combination of energy performance regulations and a mandatory tool for the energy calculations.

Feasible methods, tools and data for economic feasibility studies are asked for based on LCC (Life Cycle Costing) or payback calculations. Tools for life cycle costing has for long been established in Denmark, but are only used to a limited degree due to the focus on the investment costs and short payback times, not on long term costs for operation.

Feasible methods, tools and data for technical feasibility studies are also asked for, but the focus points are not fully clarified.

Environmentally, methods, tools and data for feasibility studies are not asked for to the same degree as for economic and technical feasibility studies. The reason could be that the energy calculations do include a measure for the energy efficiency of alternative energy systems and thereby reflect the environmental impact, especially if the energy performance requirements also would include a CO_2 indicator, as mentioned regarding general measures. At least in France, another reason could be that information on environmental tools and data is already known and acknowledged by all type of actors.

Organisationally, additional time and costs for feasibility studies are asked for. As mentioned under barriers, it is a challenge to introduce new solutions in buildings.

Communicatively, the data needed for the feasibility studies has to be defined and provided by the energy equipment companies or others.

6.2 National reports

The tables bellow gives an overview of the received answers.

*Table 2. **General measures**: The registered indications of the potential measures that could tackle the general barriers that slow down the market introduction of relevant new alternative energy systems on building level: XX for high relevance, X for relevance and nothing for minor relevance. Focus is only on the energy systems, which needs further introduction on the market, see table 1.*

	Country / Potential measures	NL	SLO	DK	LT	PL	F	S
M1	Financial support and tax incentives incl. CO_2 taxes	XX	XX	XX	XX	XX	XX	XX
M2	Stronger inclusion of alternative energy systems in the energy performance regulation, e.g. by introduction of a CO_2 indicator	X	X	X		X	XX	XX
M3	Guidelines, tools, education and training		X	X		X	X	X
M4	Specific info and data needed for building design and energy calculations		X	XX	X	XX	X	X
M5	Certification of the equipment for the energy systems							X
M6	Demonstration projects and good practice examples		X	XX	X	X	XX	X
M7	Solution for the split-incentive balance	XX						
M8	Inclusion of all actors from the beginning of the process	X						

Table 3. ***Measures regarding feasibility studies****: The registered potential measures that could facilitate the introduction of technical, environmental and economic feasibility studies of alternative energy systems for buildings: XX for very relevant, X for relevant and nothing for minor relevance. Focus is only on the energy systems, which needs further introduction on the market, see table 1.*

	Potential measures for feasibility studies / Country	NL	SLO	DK	LT	PL	F	S
M9	Legislation on obligatory use of feasibility studies		XX	X	XX	X	XX	XX
M10	Protocol for feasibility studies	XX	X		X		X	XX
M11	Feasible methods and tools for technical feasibility studies		X	XX	X	X	X	X
	Information and data needed for technical feasibility studies	X		XX			X	X
M12	Feasible methods and tools for environmental feasibility studies incl. well defined indicators, e.g. for CO_2		X	XX	X			X
	Information and data needed for environmental feasibility studies	X		XX				X
M13	Feasible methods and tools for economic feasibility studies, e.g. for LCC (life cycle costing) or pay back	XX	X	XX	X	X	X	X
	Information and data needed for economic feasibility studies	X	X	X		X	X	X
M14	Additional time and costs for feasibility studies		X	X		X	XX	XX

The Netherlands

General measures

By far the most popular general solution mentioned is financial support. But most actors relate this to the already mentioned lifting of the split incentives imbalance. So they do not seek direct financial support as such, but investing money to solve this imbalance problem.

Consistent legislation and obligations are also looked upon a straightforward solution: if the Government imposes a certain (high) energy efficiency of a building, then there will be no way around alternative energy solutions for anybody. A very important aspect to this solution is consistency: energy policy should have a longer time frame than four years – i.e. the term of a Dutch cabinet.

Including all actors from an early moment on in the building process is mentioned as well. This will make sure that all can share their knowledge of their specialities

and decisions can be made based upon all available input. Such an approach will reduce the risk of finding out in a very late stage that something could have been done more efficiently or cheaper.

Measures regarding feasibility studies

A consistent protocol is seen as a solution regarding feasibility studies. Also a good overview of information and data that is required for a feasibility study will help introduction.

Adopting a LCC-approach is a natural solution: in a proper adaptation to this approach one simply cannot ignore feasibility studies for alternative energy systems. One actor suggested incorporating an LCC-approach into designer tools: if an architect/engineer can see immediately how much impact a certain decision has on energy performance, than this will make them more aware of the (sustainable) options that they have.

In conclusion the introduction of alternative energy systems in the Netherlands will improve swiftly if the so-called split-incentive imbalance is solved. This can be supported by clear, consistent, and strict regulation concerning energy performance in buildings.

Slovenia

General measures

The most relevant measures for tackling the general barriers that slow down the market introduction of relevant new alternative energy systems at building level are financial support and tax incentives incl. CO2 taxes and stronger inclusion of alternative energy systems in the energy performance regulation, e.g. by introduction of a CO2 indicator, demonstration projects and good practice examples.

Measures regarding feasibility studies

For the implementation of feasibility studies in design process the legislation on obligatory feasibility studies is considered as a very relevant measure; just like also the protocol for feasibility studies, feasible methods and guidelines / tools for feasibility studies.

Denmark

General measures

The needed general measures should first of all meet the challenges raised by the identified main barriers: Higher investment costs, lack of knowledge and confidence and lack of demonstration projects.

Most all the interviewed actors meant that the following measures were of highest importance for further use of alternative energy systems:

- Financial support or CO2 based tax incentives

- Education, training and specific information and data needed for building design and energy calculations, maybe including stronger inclusion of alternative energy systems in the building regulations

- Well documented demonstration projects

But also certification of equipment for the energy systems was mentioned.

Financial support is needed, because, because it often will be so that the benefits from more sustainable energy systems first will accumulate over a number of years, while the first costs has to be paid, when the building is build. Many options for alternative energy systems can only be cost-effective, if there is a large market to justify the adequate investments in product development, marketing and demonstration projects. Beside the benefits will often be social or societal, whilst costs are the responsibility of the individual clients, consultants and contractors involved. A client underlined that the political will to support the development of sustainable energy systems for buildings is very essential.

Education and training are needed for the consultants, and specific information and data needed for building design and energy calculations from the energy equipment companies and others. It is important that this information to a very high degree are focused on whole systems and building concepts, not only on the included construction products. Beside it should also be considered, whether some of the alternative energy systems should be stronger included in the energy regulations, e.g. by including considerations on their impact on the CO2 emissions.

Well documented demonstration projects including data on their operation and performance in practice are of high importance for the clients and consultants confidence in building concepts including alternative energy systems.

It should be noted, that these measure needs differs between the different energy systems due to their characteristics and market penetration until now. In Denmark, Financial support is first of all needed for solar electrical systems, while demonstration projects are needed for CHP in buildings in buildings.

Measures regarding feasibility studies

Feasibility studies for alternative energy systems are not yet required in Denmark. But as mentioned for barriers, the inventory pointed out, that feasibility studies regarding alternative energy systems of alternative energy systems including other energy saving measures are expected to be of high importance for further introduction of these energy systems and for further developments in this area.

The inventory pointed out that the needs included both the technical, economic and environmental aspects, and that further data especially are needed for technical and environmental evaluations.

Tools for life cycle costing has for long been established in Denmark, but are only used to a limited degree due to the focus on the investment costs and short payback times, not on long term costs for operation.

Lithuania

General measures

It is missing the practical activity on implementation of measures that could tackle the existing barriers on the market introduction of relevant new alternative energy systems in Lithuania. Current legislation is beneficial for centralized energy supply companies; the support is available only to energy from RES supplied to networks. Only solar systems for electricity generation (from systems at building level described in the directive) are supported in Lithuania by setting the feed-in tariff. However the support level is not sufficient and there are no such projects implemented so far. The systematic educative activity on alternative energy systems is not executed.

Financial support for alternative energy systems should be one of the major solutions, which was mentioned by all interviewees. Tax incentives also could be meaningful measure which could help introduce on market low emission technologies in larger scale.

Demonstration projects, specific information and data needed for building design and energy calculations also were mentioned as important measures.

Measures regarding feasibility studies

Legislation on obligatory use of feasibility studies definitely could be the most effective measure, which is missing at the moment. There are no officially licensed methods or tools designed for feasibility studies. Technical and economical data about different energy systems is provided by energy equipment supplier or seller. Life cycle costs are not taken into account when different energy systems are evaluated and considered. At the moment CO2 emissions are not taken into account in a planning phase of the new building; no data about possible CO2 emissions from different heat supply sources in the buildings.

Poland

General measures

The biggest barriers are connected with lack of knowledge on investors' side and high price of investment cost. Without knowledge of renewable solutions investors will not use them. But even if they will be well known high investment cost makes them not attractive.

Subsidy solutions are not attractive for investors. One important factor for investors to resignation with renewable energy sources are low subsidies. If we combine them with low energy prices we will get a long payback time. It is the most important barrier.

Especially expensive solutions like CHP, heat pumps or PV are not attractive for investors. Also problems with national energy suppliers make those solutions not attractive. Fast building process cannot wait for years for connection condition and permits.

Measures regarding feasibility studies

Without EPBD implementation we cannot count for feasibility studies preparations during building process. Investors and developers do not have enough know how

about energy efficiency and usually they did not want to increase an investment costs. More seminars or scholarships focused on developers or housing owners companies could create a good atmosphere around that subject.

France

General measures

Some potential measures that could tackle the general barriers that slow down the market introduction of relevant new alternative energy systems on building level, are listed:

- Financial support and tax incentives incl. CO2 taxes
- Stronger inclusion of alternative energy systems in the energy performance regulation, e.g. by introduction of a CO2 indicator
- Specific info and data needed for building design and energy calculations
- Certification of the equipment for the energy systems
- Demonstration projects and good practice examples

Compulsory solutions based on renewable (like in Spain) would avoid complex studies without enough strength to make the decision happen.

When a building manager/owner or the contracting authority has no particular background or relationship with electricity supply, he should not bother with it. Like when a mobile phone provider takes in charge all technical aspects and investments when installing an antenna on a building, it should be up to the electricity utility to manage the whole project, simply paying a rent to the building owner.

Measures regarding feasibility studies

Some measures are listed that could facilitate the introduction of technical, environmental and economic feasibility studies of alternative energy systems for buildings:

Legislation on obligatory use of feasibility studies

- Protocol for feasibility studies + methods and tools for technical feasibility studies
- Information and data needed for above mentioned technical feasibility studies
- Feasible methods and tools for economic feasibility studies, e.g. for LCC (life cycle costing) or pay back + Information and data needed for economic feasibility studies
- Additional time and costs for feasibility studies

Contracting authorities (technical department in towns or large patrimony owner) are strongly requiring additional regulation when they are motivated on the subject of energy performance and/or sustainable development,

Yet large differences between actors show that, although tools already exist in the French market, there still exist people who have never heard of them, even though they are involved on the subject and motivated on the objectives!!! Conclusion from that is the need is not on development but on information and training!

It is stunning to observe that the information on environmental tools and data is known and acknowledged by all type of actors.

Not surprisingly, most, if not all, actors are demanding on economic data (interest rates, life duration,…) so that all studies can be made using a "standard" set of economic information and thus make the economic criteria reliable and really comparable.

All those in charge of buildings (construction and/or renovation) feel that not enough means and time are allotted to energy options in building design budget and schedules.

Sweden

General measures

All of the potential measures (M1-M6) have been found either by the municipalities, architects and the engineers to have some relevance to tackle the general barriers. The municipalities believe that stronger inclusion and guidelines (M2 and M3) for solar systems and guidelines and demonstration projects (M3 and M6) for CHP in buildings could have a high relevance for tackle the general barriers. Financial supports (M1) are relevant in order to tackle barriers for all specified alternative energy systems. The certification of equipment (M5) the municipalities think will have a minor relevance. Another financial barrier could also be long term energy price contracts for the district or block cooling.

The architects believe that the financial support (M1) and stronger inclusion of alternative energy systems (M2) have a high relevance to tackle the general barriers for all of the specified alternative energy systems. The architects also think that the certifications of equipment (M5) and demonstration projects (M6) have a high relevance for all energy systems except the district of block cooling. The other two measures, i.e. guidelines (M3) and info and data (M4), the architects only believe to be relevant for tackle the barriers for introduction of alternative energy systems.

The engineers has the opinion that the stronger inclusion (M2) will have a high relevance for all energy systems except for district or block cooling were it is only relevant. The other measure that is believed to have a high impact is the financial support (M1) for CHP at building level while for the other energy systems it will only be relevant. The engineers also think that guidelines (M1) and demonstration projects (M6) will have relevance for all the energy systems but not any high impact. The other two measures, i.e. specific info (M4) and certification (M5) the en-

gineers does not believe that they will have any relevance on tackling the general barriers.

In Sweden there are a couple of existing measures that could tackle some of the general barriers. CO2-exhaust rights for large scale plants is one first try where the plants have maximum allowed annual exhaust levels. In Sweden there are new building code regulations set by the National Board of Housing, Building and Planning regarding maximum allowed annual energy usage for buildings (kWh/m2 and year). Subsidy for municipalities of investment and installation costs with 30 % for solar thermal systems and 70 % for solar electrical systems is available in Sweden. Some municipalities have set own goals for reducing the energy usage. One example of goals is to lower the annual energy usage for heating to 100 kWh/m2 before 2010 and before 2015 there should be no oil usage within the municipality. The Swedish government has established goals that the energy use in dwellings and premises should be reduced with 20 % until 2020 and with 50 % until 2050 compared to the energy use in 1995. In 2020 no fossil fuels should be used in the building sector and the use of renewable energy sources should be increased.

Measures that are missing or has to be sharpened might be the following. The carbon dioxide focus should be increased with maximum allowed exhaust levels down to each building. This will also put focus on the energy supply and how the energy is produced and wider the perspective to not only focus on the energy usage for buildings. The overall most import issue is however to increase general “crisis awareness” regarding the exhaust of greenhouse gases.

Measures regarding feasibility studies

Regarding measures that could facilitate the introduction of feasibility studies of alternative energy systems for buildings the architects claims that all of the measures (M9-M14) will be relevant for all of the specified energy systems. However none of the measures was found to be very relevant.

The engineers believe that all of the measures (M9-M14) will be either very relevant or relevant for the introduction of feasibility studies. Additional time and costs (M14) the engineers found to be very relevant for all of the specified energy systems. Also for combined heat pumps the legislation (M9) and protocol for feasibility studies (M10) was by the engineers claimed to be very relevant.

The municipalities that all of the measures will be relevant expect for legislation, protocol and methods (M9-M11) for CHP and legislation for solar systems that will have minor relevance. High impact could the legislation, protocol and methods (M9-M11) have for CHP in buildings.

In Sweden the engineers is not familiar with any general methods or tools to be used for feasibility studies. Methods developed for these studies could be used by engineers in the design stage of the building process. The municipalities can not specify any national tool. However there is a practical developed tool available for fast overview evaluation if solar thermal will be economical for different buildings. There is also an existing research tool, the Eco-factor method, which could be used to evaluate the indoor climate and outdoor environmental impact for different energy solutions. The methods and tools should be used in the pre-design phase.

7 Discussion and conclusions

The chapter summarizes and analyzes the findings of the inventory on building practice, barriers and solutions related to market introduction of alternative energy systems.

The discussion and conclusions are based on the fragmentary conclusions included in the previous chapters.. The section on driving forces, barriers and solutions do focus on the connections between the main findings using a number of aspects like regulation, economy and organisation as starting point.

7.1 Alternative Energy Systems (AES)

Solar, biomass, CHP in buildings and heat pump systems are of interest for further market introduction in most participating countries. In addition, the results of the inventory show that in a number of countries the further market introduction of district heating incl. substantial use of renewable energy, district or block cooling and geothermal energy are considered to be relevant.

It is also stated that the market introduction of the various energy systems varies from country to country, and that the characteristics concerning economical, technical, environmental and organisational feasibility are different for the different energy systems. It is therefore needed to take these differences in consideration in the feasibility studies.

Finally, it is of importance to state, that alternative energy systems for heating also are being introduced at supply level for district heating in a number of countries. In these countries it is therefore of importance, to include scenarios for this development, when feasibility studies compare district heating with introduction of alternative energy systems at building level.

7.2 Building process and actors

Building process

The most important stages in the building process regarding the choice of energy system were registered to be the planning stage, the proposal stage and the project stage. Also the programming stage is crucial, because it is of high importance, that the awareness of alternative energy systems I raised and that the feasibility study is asked for in the building programme. The results of the feasibility study have to be available when the final choice of energy systems is made.

During the planning stage decisions are made concerning the energy infrastructure of the building area, such as district heating and provision with natural gas. This can be of high importance, because municipal heat plans may limit the possibilities for introduction of other energy systems. It is of importance to state that

district heating often will involve extensive use of alternative energy systems such as CHP, biomass (incl. waste incineration) and geothermal energy.

Feasibility studies

For the introduction of alternative energy systems and for the timing of the feasibility study, it is therefore of high importance to state that:

- The planning stage should include feasibility studies on the potential for inclusion of alternative energy systems on district level or on building level.

- The programming stage should include:
  - efforts to raise awareness of alternative energy systems
  - identification of the most feasible energy systems, e.g. use of checklist
  - planning of feasibility studies to be made before final choice of system

- The Proposal stage should:
  - identify building concepts for inclusion of the chosen energy systems
  - include feasibility study of the alternative building concepts including alternative energy systems, e.g. use of handbook and tools
  - include choice of building concept and energy system(s)

- The Project stage should include further efforts regarding specification of the building project including the chosen energy system(s) and may include further feasibility studies.

As it appears in most researched countries the feasibility study requirement is included in the building permit procedure, normally included in the project stage of the building process. This means that the actual requirement is late in the building process, as the decision upon energy systems is usually made during the planning, programming and proposal stages. This means that for properly functioning of the feasibility study aspect of art 5 of the EPBD attention has to be paid to the content and the enforcement of the specific requirements.

Actors involved in the process

In all participating countries, the actors which first of all influence the choice of energy systems are: clients, developers and investors, and architects, engineers and other consultants. Beside, the municipalities have a high importance in countries, where heat plans are made, normally based on the presence of infrastructure for district heating or gas supply.

Feasibility studies

For the introduction of alternative energy systems and for the use of feasibility studies, it is of high importance:

- That the decision makers (clients, developers and investors) are aware of the alternative energy systems, and that the feasibility studies answers their major concerns and interests.

- That the involved architects, engineers and other consultants include professional knowledge regarding the inclusion of alternative energy systems in buildings

According to the inventory, the concerns and interests of the clients, developers and investors include driving forces and barriers regarding economic, technical, environmental and organisational aspects, which will be further commented upon in the following section.

7.3 Driving forces, barriers and solutions

In this section the mentioned solutions are linked to the main drivers and main barriers, using the following aspects as starting point:

- Regulatory aspects
- Economic aspects
- Technical aspects
- Environmental aspects
- Organisational aspects
- Communicative aspects

This is done rather simplistic to get an overview of the main arguments for the proposed solutions regarding general measures and measures for the feasibility studies.

On regulatory aspects

Concerning regulatory aspects, focus is on two important driving forces:

- the energy performance regulations for buildings
- the requirements regarding feasibility studies

Table 4. Overview on the links between main drivers and main barriers and measures referring to a number of aspects: regulatory, economic, technical, environmental, organisational, and communicative.

Aspects	Driving forces	Barriers	General measures	Measures for feasibility studies
Regulatory	**Energy performance regulations (EPR)** (D1) Feasibility studies (FS) required (D2)	Lack of legislation on FS (B10) Lack of tools and data for FS (B11)	**Stronger inclusion of AES in EPR** (M2)	**Legislation on obligatory FS** (M9) **Protocol for feasibility studies (FS)** (M10)
Economic	Reduced life cycle costs (D5)	**Higher investment costs** (B4) No certainty in pay-off (B6) Uncertain long term economy (B5)	**Financial support** (M1) (solution for the split-incentive (M8))	**Tools for economic FS** (M13) **Additional costs for FS** (M14a)
Technical	Appeal of AES technologies (D4)	**Lack of confidence** (B2) Lack of building examples (B3)	**Data for design and calculations** (M4) **Demonstration projects** (M6)	**Tools for technical FS** (M11)
Environmental	**General environmental consciousness** (D3)			Tools for environmental FS (M12)
Organisational		Inertia to change (B7) AES introduced too late (B9)		**Additional time for FS** (M14b)
Communicative		**Lack of knowledge** (B1)	Education and training (M13)	

Beside, a long lasting political will is of high importance, as stated in the national reports from the Netherlands and also in the conclusions from other studies, such as the Build-On-RES project.

The new energy performance regulations are now of high importance, both because the effect of energy efficiency and use of renewable energy systems are taken into consideration in the energy calculations, and because strengthened requirements for reduction of the energy consumption implies that new reduction means may prove more feasible than the traditional reduction means like further insulation.

Stronger inclusion of alternative energy systems in the energy performance regulation has been mentioned as an important measure, e.g. by introduction of a CO_2 indicator. This measure needs further considerations of the regulations, the calculation methods and the energy factors to be fully justified.

Finally current legislation is in some countries beneficial for centralized energy supply systems, which can be a barrier for introduction of alternative energy systems in buildings.

Feasibility studies

The requirements regarding feasibility studies on the inclusion of alternative energy systems has been pointed out as an important driving force, underlined by the fact that lack of required feasibility studies is pointed out ass an important barrier in countries, where feasibility studies is not yet required.

To strengthen the impact of the requirement on feasibility studies, it was also pointed out that a common protocol for the feasibility studies are needed, supplemented with the needed tools and data for the technical, environmental and economic feasibility studies. This can be seen in parallel to the existing combination of energy performance regulations and the national tools for the energy calculations.

On economic aspects

Concerning economic aspects, focus is primarily on one important barrier:

- Higher investment costs

Beside focus is also on the deriving force of reduced life cycle costs and the barriers of no certainty of pay-off and of uncertain long term economy.

Higher investment costs were mentioned as one of the most important barriers. Like most other energy reduction means alternative energy systems includes higher investment costs, but also because introduction of new solutions includes higher costs until these solutions are further developed and fully introduced at the market.

It appears that decisions regarding new buildings to a high extend focus on the construction costs not on the costs for operation, and also that not all developers, building owners or investors do profit from reduced costs for operation. But it is also so that a limited number of clients are willing to pay more for alternative en-

ergy systems due to their environmental consciousness, which for a number of actors is an essential driving force.

Not surprisingly, financial support was registered as the most important general measure to further market introduction of alternative energy systems. The economic support could be direct or indirect using tax incentives, e.g. use of a CO2 tax.

Reduced life cycle costs have been mentioned as important. But as mentioned above, life cycle costs are not always considered that important during the design process for buildings.

Feasibility studies

Feasible methods, tools and data for economic feasibility studies were asked for as one of the most important measures regarding feasibility studies. These studies should be based on LCC (life cycle costing) or payback calculations, and also consider the barrier of uncertain long term economy. Supplementary, most interviewed actors in the Netherlands meant that solving the split incentives imbalance would be sufficient to solve the barrier of high investment costs. Finally additional costs for feasibility studies were asked for.

The economic feasibility study should focus on:

- investment costs as well as life cycle costs (or payback times) for each of the interested parties
- identification and inclusion of national arrangements regarding financial support

On Technical aspects

Concerning technical aspects, focus is primarily on two important barriers:

- Lack of confidence
- Lack of building examples

Beside, presumably lack of confidence is to a high degree related to lack of knowledge mentioned below.

Lack of confidence including higher risks was mentioned as very important. Connected to the fact that also lack of building examples and demonstration projects was mentioned as important, may demonstrate that the building sector want good documentation for introduction of new solutions. This barrier is linked to the previous one because the lack of confidence is often the result of a lack of knowledge. But it is also important that appeal of alternative energy systems has been pointed out as an important driving force in some countries.

Well documented demonstration projects and good practice examples was mentioned as important general measures by most participating MS. Introduction of new energy systems in buildings may involve efforts in the upstart phase, which not necessarily are economically and technically profitable.

Later, when the systems has demonstrated to be viable, specific information and data needed for building design and energy calculations is needed, as mentioned by many actors, and supplemented by guidelines, tools, education and training.

Feasibility studies

Feasible methods, tools and data for technical feasibility studies are asked for from the energy equipment suppliers or others, but the focus points are not fully clarified.

The technical feasibility study should focus on:

- the reliability of the energy systems; e.g. by including information and data on existing building examples incl. data on operation and maintenance

On Environmental aspects

Concerning environmental aspects, focus is primarily on one important driving force:

- General environmental consciousness

Beside, the environmental consciousness is for some alternative energy systems combined with an appeal of new energy technologies.

General environmental consciousness has been mentioned as a very important driving force, e.g. defined in an environmental policy for the company. It is therefore of high importance that the energy requirements and the required environmental feasibility studies reflects and measure the environmental performance of the considered alternative energy systems.

Environmentally, no barriers was mentioned, which related to the fact, that environmental consciousness was mentioned as one of the strongest driving forces implies that environmental feasibility studies first of all are meant for strengthening the environmental arguments for introduction of alternative energy systems.

Feasibility studies

Environmentally, methods, tools and data for feasibility studies are not asked for to the same degree as for economic and technical feasibility studies. The reason could be that the energy calculations do include a measure for the energy efficiency of alternative energy systems and thereby reflect the environmental impact, especially if the energy performance requirements also would include a CO2. At least in France, another reason could be that information on environmental tools and data is already known and acknowledged by all type of actors.

The environmental feasibility study should focus on:

- a life cycle orientated environmental assessment of the energy systems, taking into account all substantial contributions from needed complementary products and infrastructure input

Focus should be on energy related issues like the CO_2 emission; but other issues of national interest, or in focus for the client, could also be included.

On organisational aspects

Concerning organisational aspects, focus is primarily on two barriers:

- Inertia to change
- alternative energy systems are introduced too late in the design process

Actors in all the participating MS pointed out that inertia to change are an important barrier. A barrier of conservatism, which normally are explained by the fact that the time and resources for design and construction are rather limited, that the organisation includes short-term relationships between a considerable number of actors, and that the construction outputs are rather complex. This explains also, why the possibility of introduction of alternative energy systems often are considered to be introduced too late in the building process, unless the client or his consultants due to a general environmental consciousness asks for that already in the programming stage or the proposal stage of the process.

Feasibility studies

Additional time and costs for feasibility studies are asked for, and also for inclusion of design alternatives in the proposal stage of the design process. Including all actors from an early moment on in the building process is mentioned as well. This will make sure that all can share their knowledge of their specialities and decisions can be made based upon all available input.

The organisational feasibility study should focus on:

- the extend to which the needed time and expertise can be allocated to all relevant stages in the building process

One of the characteristics for the building process is as mentioned above the considerable number of actors included in the process. The manufacturers and providers of energy systems constitute only a minor part of the involved actors.

7.4 Some general comments on market introduction

Introduction of alternative energy systems in buildings is a very demanding task, because it often will be so that the benefits from more sustainable energy systems first will accumulate over many years, while the first costs has to be paid, when the building is built. Many options for alternative energy systems can only be cost-effective, if there is a large market to justify the adequate investments in product development, marketing and demonstration projects. Beside the benefits will often be social or societal, whilst costs are the responsibility of the individual clients, consultants and contractors involved.

Usually a combination of technical, organizational and financial constraints are hindering the use of AES, so there is a need for a combination of incentives which are addressed to overcome them all.

Market introduction of alternative energy systems in buildings consist of a combination of requirements including:

- raise awareness of the systems among al the relevant actors in the building sector
- educate professionals in all relevant stages of the building process
- develop standardised measures to determine the feasibility of the systems regarding economic, technical, environmental and organisational aspects
- carry out demonstration projects and design competitions
- improve the efficiency of the systems and the building concepts in which, they are included as an ongoing effort

Therefore a stepwise market introduction must be expected as described by the Product Life Cycle model, which normally include four stages: Introduction, Growth, Maturity and Decline, see figure 3.

SENTRO focus primarily on feasibility studies of alternative energy systems in the introduction stage, in which further developments may still be needed concerning some of the requirements mentioned above.

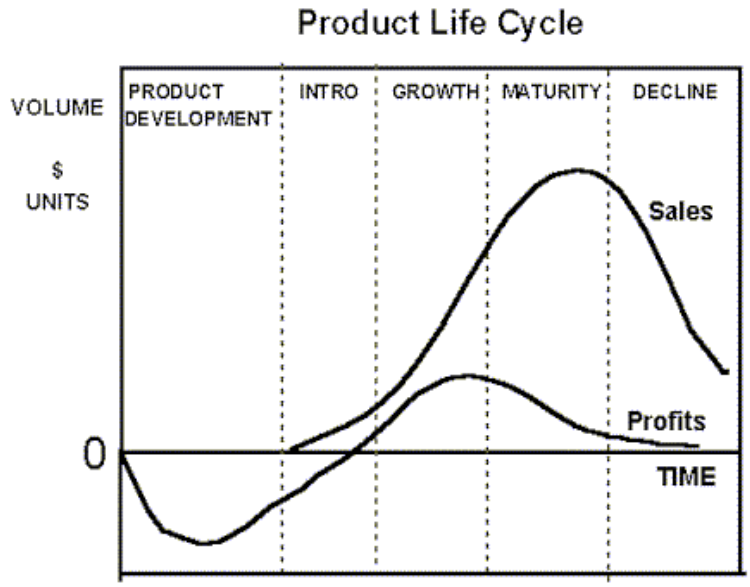


Figure 3. General figure for a products life cycle. SENTRO focus on the introduction stage for alternative energy systems integrated in buildings.

7.5 Recommendations on feasibility studies

Based on the previous sections, the recommendations for the introduction of feasiblity studies of alternative energy systems in buildings can be shortly summarised as follows.

On building process and actors

For the introduction of alternative energy systems and for the timing of the feasibility study, it is stated that:

- The Planning stage should include feasibility studies on the potential for inclusion of alternative energy systems on district level or on building level.

- The Programming stage should include:
  - efforts to raise awareness of alternative energy systems
  - identification of the most feasible energy systems, e.g. use of checklist
  - planning of feasibility studies to be made before final choice of system

- The Proposal stage should:
  - identify building concepts for inclusion of the chosen energy systems
  - include feasibility study of the alternative building concepts including alternative energy systems, e.g. use of handbook and tools
  - include choice of building concept and energy system(s)

- The Project stage should include further efforts regarding specification of the building project including the chosen energy system(s) and may include further feasibility studies.

See Figure 4.

For the actors involved, the introduction of alternative energy systems and the use of feasibility studies should include:

- That the decision makers (clients, developers and investors) are aware of the alternative energy systems, and that the feasibility studies answers their major concerns and interests.

- That the involved architects, engineers and other consultants include professional knowledge regarding the inclusion of alternative energy systems in buildings.

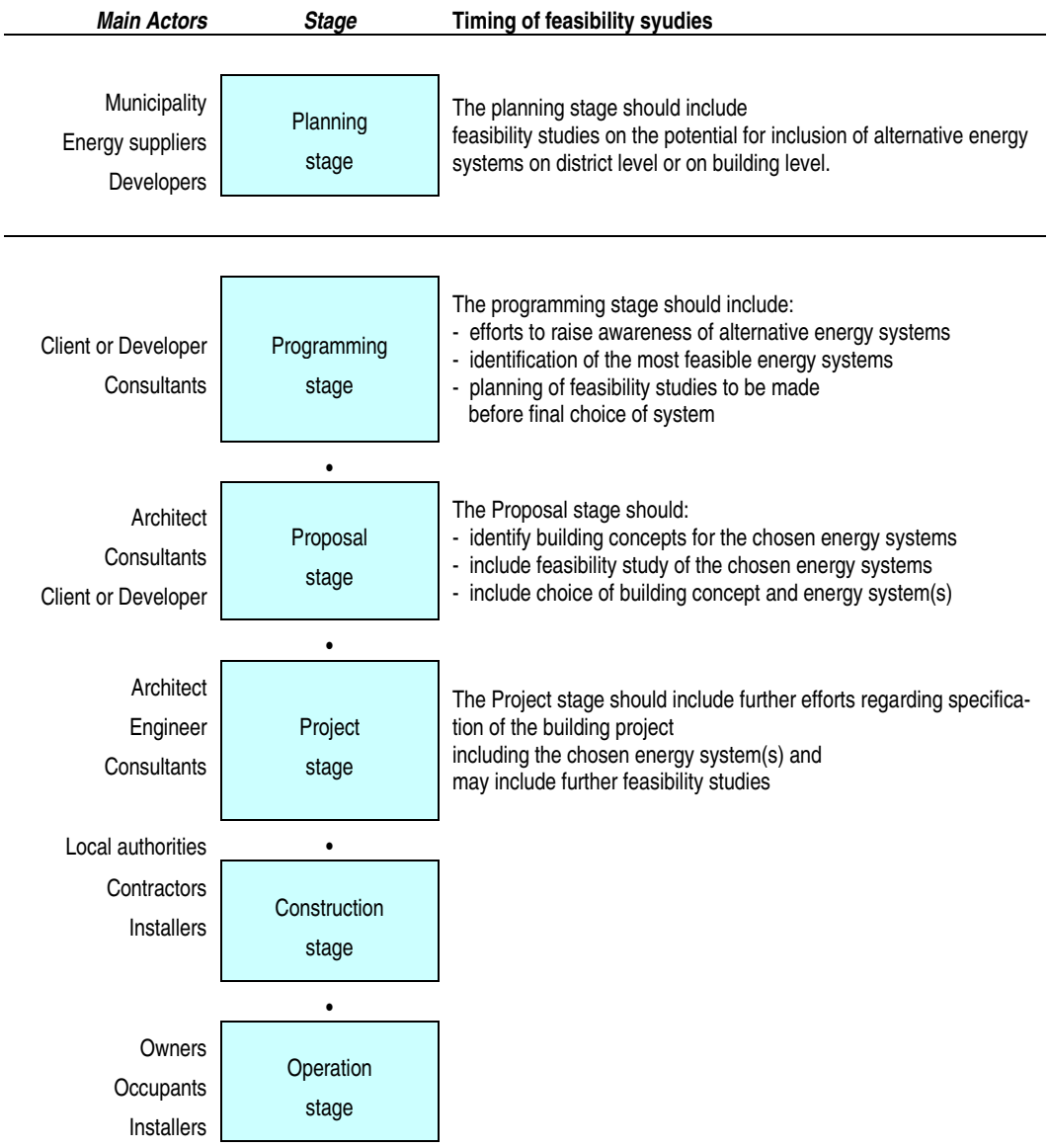


Figure 4. Schematic flow chart of the stages in the building process for a new building, and the needed activities related to the right timing of the feasibility studies of alternative energy systems. See also Figure 1.

On the feasibility studies

The feasibility studies should include economic, technical, environmental as well as organisational aspects.

The economic feasibility study should focus on:

- investment costs as well as life cycle costs (or payback times) for each of the interested parties
- identification and inclusion of national arrangements regarding financial support

The technical feasibility study should focus on:

- the reliability of the energy systems; e.g. by including information and data on existing building examples incl. data on operation and maintenance

The environmental feasibility study should focus on:

- a life cycle orientated environmental assessment of the energy systems, taking into account all substantial contributions from needed complementary products and infrastructure input

The organisational feasibility study should focus on:

- the extend to which the needed time and expertise can be allocated to all relevant stages in the building process

8 ANNEX 1: Supplementary tables

Table 5. Renewable energy systems for heating can be introduced both at building level and at supply level for district heating, which is shown here: XX for large contribution, X for minor contribution and nothing for any contribution.

		DK		LT		PL		S	
	Energy sources (and systems)	Now used for district heating	Expected to be used more for district heating	Now used for district heating	Expected to be used more for district heating	Now used for district heating	Expected to be used more for district heating	Now used for district heating	Expected to be used more for district heating
S1	Natural gas	**X X**		**X X**			X	**X**	
S2	Other fossil fuels	**X X**		**X**		**X X**		**X**	
S3	Solar energy		X						
S4	Biomass and Wastes	**X X**	X	**X**	X		X	**X X**	
S5	Geothermal energy		X	**X**	X		X		
S6	Waste heat (from industry)	**X**		**X**	X	**X**		**X**	
S7	Other energy source: …							**X**	
S8	CHP (system)	**X X**		**X**	XX		X		
S9	Heat pump (system)		X				X	**X**	
S10	Other: Low temperature district heating		X						

Table 6. The stages of the building process in which the choice of energy system(s) are considered (X) and decided upon (XX).

Country / Process	Planning stage	Programming stage	Proposal stage	Project stage	Construction stage	Operation stage
NL		X	**X-XX**	**X-XX**		(X-XX)
SLO	X *	X	**X-XX**	X-XX		(X)
DK	**X-XX** *	X	**X-XX**	X-XX		
LT	**X-XX** *	X	**X-XX**	X-XX		
PL		X	**X-XX**	XX		
F		X	X	**X-XX**	X	(XX)
S	X	**X-XX**	**XX**			

*) Heat plans

Table 7. The stages of the building process in which the choice of energy system(s) are considered (X) and decided upon (XX).

Country / Process	Planning stage	Programming stage	Proposal stage	Project stage	Construction stage	Operation stage
NL		X	**X-XX**	**X-XX**		(X-XX)
SLO	X *	X	**X-XX**	X-XX		(X)
DK	**X-XX** *	X	**X-XX**	X-XX		
LT	**X-XX** *	X	**X-XX**	X-XX		
PL		X	**X-XX**	XX		
F		X	X	**X-XX**	X	(XX)
S	X	**X-XX**	**XX**			

*) Heat plans

Table 8. The actors who first of all influence the choice of energy systems: XX: high influence, X: involved. Heat plans are not considered.

	Actors **Country**	NL	SLO	DK	LT	PO	F	S
A1	Municipalities	X						X
A2	Clients, developers and investors	XX	X	XX	XX	X	X	XX
A3	Architects	X	XX	XX	XX	X	XX	XX
A4	Engineers	X[2]	X	XX	XX	XX	X	XX
A5	Energy utility companies	X						
A6	Energy equipment companies		X		X			X
A7	Contractors	X						
A8	Installers	X						
A9	Occupants							
A10	Research and development inst.							X

[2] incl. energy consulting companies

Table 9. The registered potential driving forces for market introduction of relevant new alternative energy systems on building level: XX for high impact, X for some impact and nothing for minor impact. Focus is only on the energy systems, which needs further introduction on the market, see Table 1.

	Country / Potential driving forces	NL	SLO	DK	LT	PL	F	S
D1	New national energy performance regulations for buildings according to EPBD	XX	X	XX		XX	X	XX
D2	New national requirements for feasibility studies on alternative energy systems according to EPBD		XX		(XX)	XX	X	X
D3	General environmental consciousness, e.g. defined in a environmental policy for the company	XX	X	XX		X	XX	XX
D4	Appeal of alternative energy technologies			XX		X	X	
D5	Reduced life cycle costs (LCC)	(XX)		X	X	XX	X	XX
D6	User demands							X
D7	Higher energy prices for heat and electricity		X			X		
D8	Financial incentives		X			X		
D9	Municipal demands	(XX)		X	X	X		

( ): expected driving forces

Table 10. The registered indications on the extend to which the actors mentioned below acts as driving force for the market introduction of alternative energy systems in buildings: XX for high extend, X for some extend and nothing for minor extend. Focus is only on the energy systems, which needs further introduction on the market, see table 1.

	Potential driving forces / Country	NL	SLO	DK	LT	PL	F	S
A1	Municipalities	X		XX	X	X	X	XX
A2	Clients, developers and investors	X		X	X	XX		X
A3	Architects			XX	XX		X	X
A4	Engineers			X	X	X	XX	X
A5	Energy utility companies					XX		X
A6	Energy equipment companies			X	XX	X	XX	X
A7	Contractors					X		
A8	Installers					XX		
A9	Occupants							X
A10	Research and development inst.	X				X	X	XX

Table 11. The registered potential barriers that slow down the market introduction of relevant new alternative energy systems on building level: XX for high impact, X for impact and nothing for minor impact. Focus is only on the energy systems, which needs further introduction on the market, see table 1.

	Country / Potential barriers	NL	SLO	DK	LT	PL	F	S
B1	Lack of knowledge, unfamiliarity with (a) techniques, and/or finding right (b) expertise and/or (c) financing		XX	XX	X	XX	XX	X
B2	Lack of confidence, higher risks		X	XX	X	XX	XX	X
B3	Lack of building examples in practice, few demonstration projects		X	XX		X	X	X
B4	Higher investment costs	XX	XX	XX	X	X	XX	XX
B5	Uncertainty regarding long term economy, e.g. tariffs, energy prices and maintenance costs		X			X	X	XX
B6	No certainty in pay-off (desegregation between ownership versus person benefiting from energy savings)	XX					XX	X
B7	Inertia to change, conservative building practice	X	X	X	X	X	X	X
B8	Burdensome administration or complex regularly structures		X			X	X	X
B9	Options for alternative energy systems are introduced too late in the design process	X		X			XX	X
B10	Lack of legislation and/or no direct obligation on technical, environmental and economic feasibility studies of alternative energy systems (Art. 5 not implemented)		X		X	X	XX	X
B11	Lack of tools and data for technical, environmental and economic feasibility studies of alternative energy systems			XX			XX	X
B12	Other technical barriers: …					X		X
B13	Other financial barriers: …					X		X
B14	Other organisational barriers		X[3]			X		X

[3] traditional engineer practice incl. limited time