PROMOTING UPTAKE OF ALTERNATIVE ENERGY SYSTEMS IN BUILDINGS

Results, Impact and Recommendations of the European SENTRO project

April 2009

SENTRO

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Auteur(s):
Suzanne Joosen, Ecofys Nederland;
Onno Kleefkens, SenterNovem, Nederland;
Fieke Geurts, Ecofys Nederland;
Marjana Sijanec Zavrl, BCEI ZRMK, Slovenië;
Klaus Hansen, SBI, Denemarken;
Egidijus Norvaisa, LEI, Litouwen;
Natalia Makowska, Ecofys, Polen;
Hubert Despretz, Ademe, Frankrijk;
Svein Ruud, SP, Zweden.

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Projectcoördinator
Ecofys Netherlands BV
Utrecht

Suzanne Joosen
S.Joosen@ecofys.nl

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Executive Summary

In the European Union, the buildings sector accounts for about 40% of the total energy use. It is the sector offering the largest single potential for energy efficiency improvement and the reduction of CO₂ emissions.

An estimated 15% of energy consumption in buildings could be saved by 2020\(^1\). [COM 2008, 780 final]. To translate this potential into reality, policies are needed that raise awareness and encourage more efficient building design and the use of more efficient technologies. In Europe, the Energy Performance of Buildings Directive (EPBD), is set to promote improvements in energy performance of buildings, with requirements that are expected to become more stringent over time.

One of the components (Art.5) of the Directive on the Energy Performance of Buildings (EPBD) (2002/91/EC) prescribes obligatory consideration of the feasibility of Alternative Energy Systems (AES) for all new buildings with a total useful floor area over 1000m\(^2\). The article has been included in order to promote energy savings that can be achieved by energy efficient supply systems and renewable energy systems, as opportunities for these systems are generally not explored to their full potential. Measures that reduce the energy demand (e.g. insulation) of a building are largely covered by other articles in the EPBD.

Feasibility studies in Article 5 of the EPBD (2002/91/EG)

[.] For new buildings with a total useful floor area over 1000m\(^2\), member states shall ensure that the technical, environmental and economic feasibility of alternative energy 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,

are considered and is taken into account before construction starts.

\(^1\) The potential for cost-effective energy savings is about 30% of the whole sector’s expected energy consumption by 2020, which would lead to significant economic, social and environmental benefits. The savings stimulated by the main current EU measures are estimated to result in about 15% total energy savings [COM 2008, 780 final].
In November 2006 the European SENTRO project (Sustainable Energy systems in New buildings – market inTROduction of feasibility studies under the Directive on the Energy Performance of Buildings) is started. The main aim of the SENTRO-project is to develop and promote an approach to effectively incorporate the feasibility studies for alternative energy systems in the common building practice.

The developed approach to incorporate the consideration of Alternative Energy Systems (AES) in the building process

The approach considers what activities are needed from the various key actors to guarantee a proper performance of the consideration of various AES during the building process.

First of all, awareness for the opportunities of AES has to be raised in an early stage of the building project. As support shining examples of successful implementation and answers to frequently asked questions can be used.

The next step is to filter out unrealistic AES options. For this purpose a checklist can be used. The aim is to identify at least two interesting AES options considering the local conditions and building characteristics.

A more detailed feasibility study will then be performed for these AES of interest. The handbook serves as protocol how to carry out a feasibility study: what technical, financial, environmental and organizational aspects have to be taken into account, which tools can be used and which sensitivity analysis provide more insight.

The approach, including supporting tools as the checklist and the handbook is visualized by Figure 1. The main target groups are: 1) decision makers on the investment of the energy system (in particular local authorities and real estate developers) and 2) consultants who perform the feasibility study.

The focus of the approach is on the development of individual utility buildings (such as municipal buildings, apartment blocks, and offices). Nevertheless, it has to be stressed that besides new buildings the developed approach and the supporting tools are as well applicable for refurbishment projects in which the energy supply system has to be reconsidered. The development of a complete new building area is often more complex and demands more research. In this case the planning stage should include an exploratory study on the potential for inclusion of AES on district level or on building level.
Figure 1 Activities to incorporate the feasibility study in the building process, including supporting tools.

<table>
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<tr>
<th>Building process</th>
<th>Activities feasibility study AES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning*</td>
<td>Agreement on starting points</td>
</tr>
<tr>
<td></td>
<td>Raise awareness of AES</td>
</tr>
<tr>
<td></td>
<td>Gain insight in the potential of AES on district level or on building level</td>
</tr>
<tr>
<td></td>
<td>Request for feasibility study</td>
</tr>
<tr>
<td>Program</td>
<td>Formulate energy requirements</td>
</tr>
<tr>
<td></td>
<td>Filter out unrealistic options</td>
</tr>
<tr>
<td></td>
<td>Towards 2 or more energy concepts</td>
</tr>
<tr>
<td></td>
<td>Identify building concepts for the chosen energy systems</td>
</tr>
<tr>
<td></td>
<td>Detailed feasibility study</td>
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<tr>
<td></td>
<td>Choice of building concept and energy system(s)</td>
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<td></td>
<td>Specifications energy concept(s)</td>
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<td>Project</td>
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<td>Construction</td>
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</tr>
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**SENTRO Awareness**
- Shining examples
- FAQ

**SENTRO Handbook**
- Specifications request feasibility study

**SENTRO Checklist**

**SENTRO Handbook** – how to perform the feasibility study and references to existing software tools

**Calculation methods** – different national and international software tools

**Building permit**

*In case of an individual building, the activities of the planning phase are applicable during the programming phase.*

Space to find suitable solutions to realize a high quality building
Transposition of the feasibility study requirement and recommendations to improve functioning of this element of the EPBD

The national status and ways of transposition of the feasibility study requirement vary largely within the European Union. In general, three situations can be distinguished:

1) *Frontrunner countries in the field of energy performance.* Usually, these countries have implicitly transposed art 5, based on existing legislation, such as energy performance requirements in building standards and/or predefine of a district heating system under certain circumstances. From the evaluation it appears that the legislation is functioning. Nevertheless, adjustments are recommended to optimize the impact, for instance by:

- Take surrounding aspects\(^2\) into account in the energy performance calculation.
- Anticipate on the possible future role of district heating.
- Planning of energy infrastructure should include feasibility studies on the potential for inclusion of alternative energy systems at district level or at building level.

In addition, strengthening of the compliance system is recommended. (Denmark, Sweden and the Netherlands)

2) *Countries which have lately directly transposed Art. 5* into their legislation by for instance a definition of the protocol for feasibility studies, have to focus on raising awareness, reliable supporting tools and a proper compliance system (eg. France and Slovenia).

3) For *Countries with no or little legislation in place* the focus for the coming period should be on awareness and on dissemination of the learning experiences from other countries with comparable building practice and energy infrastructure (eg. Lithuania and Poland).

Impact and conclusions

The project contributed in several ways to the promotion of the uptake of alternative energy systems in buildings. First of all, the investigation of at least two promising energy systems is adopted as requirement in official Slovenian legislation. Secondly, the developed approach is partly structural embedded in the method for consideration of heat supply options by the energy agency in the Netherlands. Thirdly, several municipalities indicated they are going to use/test

\(^2\) Think of surrounding aspects such as: geothermal conditions, opportunities to use waste heat, infrastructure and specific environmental legislation.
the checklist and the handbook in their daily practice. Finally, awareness about the feasibility study requirement is created at national and local authorities’ level (eg. Lithuania). In France, the developed feasibility study course will be included in the more general training concerning energy performance requirements.

The testing of the approach is carried out by field trials concerning the development of 27 building projects in 6 European countries. The field trials were usually performed in an early stage of the process (usually planning – programming – proposal stage).

In almost all cases this has led to serious consideration of various types of AES. Several times it already contributed towards the final decision for AES. It is estimated that the SENTRO-project directly resulted in 520 ton CO₂ emission reduction per year. However, in most countries the realization of a building requires a number of years. As a result within the project timeframe only one or two stages could be covered and the decision upon the energy concept is often not yet taken.

Most participants evaluated the checklist as useful decision support tool, especially for communication and structural attention for several type of AES in the project design teams which includes key actors with various backgrounds.

The general recommendations to improve the functioning of the feasibility study requirement of the EPBD (Art. 5) are presented in the blue text boxes on the next pages.

Finally, Art.5 of the EPBD offers opportunities to broadening the scope of the consideration of AES and to generate a fair level playing field for various options for a sustainable energy supply in buildings.

### Crucial success factors

From the experiences during the project, in particular in the field trials, the following factors are observed to be essential for a successful implementation of alternative energy systems:

- **Team work!** Commitment of all key actors involved for the energy concept throughout the various phases of the building process.
- **People in the building team with sufficient skills and knowledge.**
- **Awareness and feasibility study for AES on time.** Most successful if started in programming phase and elaborated during proposal phase.
- **At least two alternatives** of promising energy concepts have to be identified. In this way a better level playing field is created for alternative energy concepts versus conventional energy concepts.
During the SENTRO-project the following **preconditions** towards optimal functioning of the feasibility study requirements of Art.5, are observed:

- **Increase awareness** of the obligation of Art.5 and its national transpositions.
- **Structural embedding** of the consideration of the energy concept (building shell & AES) into the activities of key actors in the building process.
- **Guarantee of the quality** of a feasibility study

Currently, it is often not clear yet how the quality of the feasibility study is guaranteed, and who is responsible for the control.

- **Proper compliance systems** (Art.5 EPDB).

Without a proper compliance system in place, the feasibility study requirement (Art.5 EPDB) holds the risk that calculations/reports are made, but there will not be much impact in practice.

- Coherent requirements, supported by simplified clarifications and tools. Indication of which **software is reliable and starting points** for the detailed feasibility calculation.
- Extend the feasibility requirement to buildings with a total useful floor area over 1000 m\(^2\) as it is common that new housing areas exist with large number of small houses.

**Next steps**

Within the project only one or two stages of the building process could be covered. It would be interesting to test and extend the approach for the complete building process: from planning to exploitation. Until now, the checklist and handbook are more or less ‘living tools’. It is recommended that they are further tested in practice and updated after a certain period.

In addition, the approach can be further tuned for several involved key actors. In the end the approach should be embedded in the instruments key actors use in their daily decision and investment making.
Possible solutions for:

**Improved quality guarantee**

- The SENTRO handbook can be regarded as first step towards a quality protocol for performance of feasibility studies.
- Arrange clear responsibility for the quality of a building, including energy performance from beginning to realization. For instance, by use of a partnering organizational scheme. Involve energy experts and/or installers in an early stage.
- Improve conditions for proper (holistic) and reliable investment cost evaluation.
- Increase awareness of the sensitivity of the outcomes for energy prices and environmental issues (especially emission factor of used electricity).
- Gain insight in reliable performance data of alternative energy systems.
- Standardize technical regulations and outcomes. For instance at least the following topics could be requested as outcomes of a feasibility study per alternative energy system: 1) total final energy use, 2) primary energy use, including corresponding CO₂ emissions 3) kind of renewable energy used 4) percentage of renewable energy used. A next step could be to make it mandatory to present these outcomes on energy certificates.
- Insight on national, regional and preferably also on local level in the potential of alternative energy systems (as mentioned in Art.5 of the EPBD) should be available. This means maps indicating geothermal conditions, available waste heat sources, energy-infrastructure etc. This type of information should become available during the planning phase of a building project.

**Improved compliancy**

- Issue the building permit not until detailed specification of building and systems have been defined (for example as in Germany and Switzerland). In addition, it is essential that alternative energy systems are requested by design terms or at least valued within design terms.
- Set obligations to implement cost-effective alternative energy systems selected by national studies (for example as in Spain and Portugal).
- Control if the consideration of the feasibility of alternative energy systems has properly taken place by random checks. These random checks have to cover the calculations as well as the building practice.
- Introduce penalties for ignoring or not fulfilling the legislation.
- Assure sufficient capacity, resources, and skills at local authorities for their enforcement tasks.
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## Project partners

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1 Background, impact and next steps

1.1 Energy consumption in the buildings and climate policy

Implementation of renewable energy and energy savings are in general regarded as essential to keep the effects of climate change within its acceptable limits and to guarantee the certainty of the energy supply.

The final energy consumption in residential and non-residential buildings in the 27 European member states is 451 Mtoe in 2005. This is 39% of the total final energy consumption in Europe Union. The corresponding direct CO$_2$-eq. emissions are 668 Mton (PRIMES, 2008).

The sector has significant untapped potential for cost-effective energy savings which, if realized, would mean that in 2020 the EU will consume 11% less final energy.

To meet the EU Kyoto target the European Commission has developed several directives concerning acceleration of energy production based on renewable sources, energy saving measures and energy efficiency improvements. One way the EC aims to reach the CO$_2$ emission reduction potential in residential and non-residential buildings is by the obligations in the Energy Performance of Building Directive (EPBD) (2002/91/EC).

As of 4th January 2006, all EU-countries are obliged through the EPBD to create within legal and administrative framework of their building codes, minimum energy performance requirements, energy certification, calculation procedures, feasibility studies requirements, inspection of boilers and air conditioning systems.

Till now, the focus has been on the calculation and certification methods for the energy use of new and existing buildings. Less attention has been given to the requirements for feasibility studies of alternative systems for new large buildings (part of article 5 of the EPBD).

Feasibility studies in Article 5 of the EPBD (2002/91/EG)

[..] 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 energy 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,

are considered and is taken into account before construction starts.
Measures which reduce the energy demand (e.g. insulation) of a building are for a large extent stimulated by other articles in the EPBD. The mentioned part of Art.5 focuses on the promotion of energy savings which can be achieved by energy efficient supply systems and renewable energy systems.

Speeding up the implementation of AES does not happen automatically due to various bottlenecks, such as: possibly higher investments compared to fossil based systems, lack of expertise and willingness. Art. 5 of the EPBD offers an unique framework to contribute towards diminishing the just mentioned bottlenecks as through feasibility studies more actors will become aware of alternative solutions for their energy systems.

These were the underlying reasons to start a European project called “Sustainable Energy systems in New buildings-market inTROduction of feasibility studies under the Directive on Energy Performance of Buildings” (SENTRO). This project that runs from 1 November 2006 till March 2009 aims to contribute to promote the uptake of alternative energy systems in buildings.

1.2 Alternative Energy Systems in the building sector: State-of play

In general, there is no structural consideration of alternative energy systems during the building process. There are three types of important possibly exceptions to this rule:

1) A few countries (e.g. Spain and Portugal) have performed a national feasibility study for the average national building stock, this resulted that cost effective alternative energy systems (such as solar thermal systems and photovoltaic systems) are obliged to implement under standard conditions (reverse proof mechanism).

2) A number of countries value alternative energy systems within their energy performance building standards. Nevertheless, structural consideration of various AES only takes place when the standard is set sufficient strict.

3) Several countries (Scandinavia, Poland, Lithuania) have obligations to connect to district heating systems. When the energy performance of the system has a high yield, it can be regarded as a proper energy supply. However, this legislation can also hamper as well the use of other alternative energy systems with an improved performance as the realization of low energy buildings.

The findings of the SENTRO-project demonstrate clearly that currently, the potential for AES is not fully explored. In addition, it is known that this potential is considerable: only by heat pumps and solar thermal systems savings up to 10% of the final energy demand in buildings in 2020 can be reached [EHPA, (2008); ESTIF, (2007)].
1.3 Impact

In the beginning
When the project started there was little awareness of the feasibility study requirement of the EPBD. Especially, all kind of key actors involved in the building process were ignorant of this specific requirement of the EPBD.

From our inventory in March 2007, it appeared that most countries completed the process of transposition of the feasibility study requirement on the legal level. The requirement of Art.5 of the EPBD) is transposed in various ways into the national legislation of 27 EU-MS [Sijanec Zavrl, M. et al. (2007)]. Two main approaches were identified:

1) Direct transposition of Art.5 into the national legislation, usually combined with subsidiary legislation. This subsidiary legislation is based in either a definition of the protocol for feasibility studies or a list of obliged selected alternative energy systems.
2) Implicit transposition, Art.5 is integrated in either (already existing) EPBD calculation procedure and tools or legislation concerning heat supply and/or planning predefined the use of AES corresponding to the scope of Art.5.

However, to a much lesser extent operational regulations were in place. Technical guidelines and supporting tools were in many countries still under development or not yet started. The latter instruments take much more time to become fully in place [status March 2007, Sijanec Zavrl, M. et al. (2007); Joosen, S. et al. (2008)].

Current status and related project achievements
Still most local policy makers and key actors involved in the building process are unfamiliar with the feasibility study requirement. The SENTRO-project contributed to call attention for this specific element of the EPBD by:

- Presentations for policy makers and market stakeholders [E. Norvaiša and R. Gatautis, 2008; Sijanec Zavrl, M. et al., 2008; Joosen, S et al (2008); for a complete overview see project website www.sentro.eu]
- Technical session during the CA-EPBD meeting the 20th of May in Lyon
  [Minutes technical session CA-EPBD meeting May 2008 in Lyon]
- National courses and training sessions
  [The Minutes of these sessions can be found on the project website]

In addition, within the project an approach, including a checklist and a handbook, are developed to effectively incorporate feasibility studies in the common building process. Subsequently, this approach is tested in the building practice of 6 countries. In almost all cases it led to a serious consideration of the various types of alternative energy systems. In a number of cases it already resulted in a decision towards use of an alternative energy
system. A number of key actors (3 municipalities in the Netherlands, inclusion in Ademe trainings’ course) indicated that they are going to test/use the tools in their daily decision making.

In Slovenia the core of the approach, namely investigation of at least 2 interesting energy systems is adopted in their official legislation.

In the Netherlands, the checklist served as basis for structural consideration of heat supply options for redevelopment areas or new building areas.

### 1.4 Next steps

The challenge for the coming period will be to assure further commitment for and adoption of the developed approach, including the checklist and the handbook.

In the current project only one or two stages of the building process could be covered. It would be interesting to test and extend the approach for the complete building process: from planning to exploitation. Until now, the checklist and handbook are more or less ‘living tools’. It is recommended that they are further tested in practice and updated after a certain period.

In addition, the approach can be further tuned for specific involved key actors, such as real estate project developers and local authorities. In the end the approach should be embedded in the instruments key actors use in their daily decision and investment making.
2 The SENTRO-project

2.1 Activities

The SENTRO project aimed at developing and promoting 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 started with 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 has also been made of specific building practices as possible barriers for the implementation of Alternative Energy Systems (AES).

Based on the findings of these inventories an approach is developed and tested to effectively incorporate feasibility studies of alternative energy systems in the common building process. The approach considers what activities are needed from the various key actors to guarantee a proper performance of the consideration of various AES during the building process. To support this approach within the SENTRO-project 4 tools are developed:

1) Checklist: to filter out unrealistic options
2) Handbook: how to perform a feasibility study
3) Documentation for raising awareness:
   a. Shining examples
   b. Frequently Asked Questions
4) Overview of existing tools

Core of the project has been the testing of the approach in a field trial in the participating countries.

Besides, the field trial also an evaluation of the current functioning of national legislation regarding the feasibility study requirement of Art.5 of the EPBD is carried out.

Towards the end of the project, the experiences have been disseminated through courses and conferences to policy makers and key actors in the building process.
2.2 Developed Approach

The approach considers what activities are needed from the various key actors to guarantee a proper performance of the consideration of various AES during the building process.

At district level, the planning stage should include feasibility studies of the potential for inclusion of AES at district level or at building level, so that considerations and limitations regarding the use of alternative energy systems at building level are well thought out. Municipal energy plans can have a considerable influence on the possibilities for incorporation of AES at building level, and some AES’s are maybe better integrated in a district heating system than in the individual buildings.

At building level, awareness for the opportunities of AES has first of all to be raised during the program and proposal phase of the building project.

As support shining examples of successful implementation and answers to frequently asked questions can be used. The next step is to filter out unrealistic AES options. For this purpose the checklist can be used. The aim is to identify at least two interesting AES options considering the local conditions and building characteristics.

A more detailed feasibility study will then be performed for these AES of interest. The handbook serves as protocol how to carry out a feasibility study: e.g. what technical, financial, environmental and organizational aspects have to be taken into account, which tools can be used and which sensitivity analysis provide more insight.

The results of these more detailed feasibility studies must be available when the final decision is made on the building’s energy system.

An impression of the checklist is presented in Figure 2.

The approach, including supporting tools as the checklist and the handbook is visualized by Figure 3.

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3 There is a universal English version available (Wahlström, Å. et al (2007)). This universal format can serve as guidance for the preparation of national handbooks. This is necessary, because great variation in national circumstances with respect to as well legislation in place as building practice. For the 7 SENTRO-country these national handbooks are available.
### Decentralised energy supply

<table>
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<tr>
<th>Technical parameters</th>
<th>Solar thermal systems (hot water and/or heating)</th>
<th>Low effort demand to realise success = 3 points</th>
<th>Medium effort demand to realise success = 2 points</th>
<th>High effort demand to realise success = 1 point</th>
<th>SCO RE to fill in, SUBSc ore (%)</th>
<th>Weigh ting Total Score (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>premises with restaurant, sports activities, hotel or hairdresser, Residential buildings</td>
<td>premises with kitchen facilities, ordinary showers, partly residential</td>
<td>day offices</td>
<td>3</td>
<td>89%</td>
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<tr>
<td></td>
<td>space heating demand</td>
<td>demand during summer season</td>
<td>demand during autumn and spring</td>
<td>demand during mid-winter</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>suitable roof</td>
<td>roof with large open area towards south with possibility to place the collector in 30 to 45 degree angel, no shading from surrounding, possibilities to integrate the collector into the roof or other building envelope parts</td>
<td>roof towards west or east, possibilities to install the collector on the roof, partly shaded</td>
<td>no suitable roof, in shadow</td>
<td>2</td>
<td>50%</td>
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<td>Financial parameters</td>
<td>system price</td>
<td>lifecyclecost (LCC) price of kWh equal to reference system (i.e. electricity, oil or gas)</td>
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<td>availability of subsidy schemes</td>
<td>subsidies of 30% or more</td>
<td>subsidies over 15%</td>
<td>no subsidy</td>
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<td>possible to get</td>
<td>difficult and expensive to get</td>
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<td></td>
<td>system maintenance</td>
<td>minimum need of maintenance</td>
<td>need maintenance every third year</td>
<td>need maintenance several times each</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>reliable system supply</td>
<td>runs for 10 years without change of spare equipment</td>
<td>runs for 5 years without change of spare equipment</td>
<td>high probability to fail</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>knowledgeable installer</td>
<td>easy to find certified installers</td>
<td>possible to find installers with good qualifications</td>
<td>difficult to find installers</td>
<td>1</td>
<td>83%</td>
</tr>
<tr>
<td>Environmental par.</td>
<td>Effect on global warming</td>
<td>high impact = 3 points</td>
<td>medium impact = 2 points</td>
<td>low impact = 1 point</td>
<td>2</td>
<td>67%</td>
</tr>
</tbody>
</table>

Figure 2 Part of the checklist, showing evaluation of solar thermal systems by rules of thumb in a 1-3 point system.
Figure 3 Activities to incorporate the feasibility study in the building process, including supporting tools.

<table>
<thead>
<tr>
<th>Building process</th>
<th>Activities feasibility study AES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning*</td>
<td>- Agreement on starting points</td>
</tr>
<tr>
<td></td>
<td>- Raise awareness of AES</td>
</tr>
<tr>
<td></td>
<td>- Gain insight in the potential of AES on district level or on building level</td>
</tr>
<tr>
<td></td>
<td>- Request for feasibility study</td>
</tr>
<tr>
<td>Program</td>
<td>- Formulate energy requirements</td>
</tr>
<tr>
<td></td>
<td>- Filter out unrealistic options</td>
</tr>
<tr>
<td></td>
<td>- Towards 2 or more energy concepts</td>
</tr>
<tr>
<td></td>
<td>- Identify building concepts for the chosen energy systems</td>
</tr>
<tr>
<td></td>
<td>- Detailed feasibility study</td>
</tr>
<tr>
<td></td>
<td>- Choice of building concept and energy system(s)</td>
</tr>
<tr>
<td></td>
<td>- Specifications energy concept(s)</td>
</tr>
<tr>
<td></td>
<td>- Qualification builder, installer</td>
</tr>
<tr>
<td></td>
<td>- Compliance selected energy concept</td>
</tr>
<tr>
<td>Project</td>
<td>- Monitoring performance energy concept</td>
</tr>
<tr>
<td>Construction</td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td></td>
</tr>
</tbody>
</table>

- **SENTRO Awareness**
  - Shining examples
  - FAQ

- **SENTRO Handbook**
  - Specifications request feasibility study

- **SENTRO Checklist**

- **SENTRO Handbook** – how to perform the feasibility study and references to existing software tools

- **Calculation methods** – different national and international software tools

- **Building permit**

*In case of an individual building, the activities of the planning phase are applicable during the programming phase.

Space to find suitable solutions to realize a high quality building
2.3 Results

Field trials

There are large differences in:

1) The national status of the transposition of the feasibility study part of Art.5 and
2) The existing building practice and energy infrastructure in the countries.

This means that the actual activities in the field trial to test the developed approach, including its supporting tools, had to be tuned to fit these differences in the national context.

The focus of the tests was on the approach and the checklist, because the handbook was still in preparation. Based on the experiences in the field trial the approach (including the checklist and handbook) were interactively improved and tuned to the national context.

The testing of the approach is carried out by field trials concerning the development of 27 building projects in 6 European countries. The field trials were usually performed in an early stage of the process (usually planning – programming – proposal stage). A detailed overview of all the field trials is presented in the annex of the report Towards an optimal consideration of alternative energy systems (Art.5 EPBD) in the common building process - Results of the field trial and evaluation [Joosen, S. et al (2009).

The field trials concentrated on the early stages of the building process. In almost all cases this lead to serious structural consideration of various types of AES. In a number of cases it already contributed towards the final decision upon a promising AES. The estimated CO₂ emission reduction is around 520 ton CO₂ per year.

However, in most countries the realization of a building requires several years. As a result within the project only one or two stages could be covered. This means that the final decisions are usually not taken within the project timeframe. A very rough indicative projection of the possible knock on from the SENTRO-project is that by serious use of the approach this will result in a typical CO₂ emission of 25% to 60% per building.

The field trial consisted of a various mix of building types. There were three field trials dealing with an complete area development. As a consequence the number of buildings involved is above 27 considerably. In 30% of the field trials (8) it concerned municipal buildings. An overview is shown in Figure 4.
The building owners in the field trials are equally divided amongst public and private owners, as is illustrated by Figure 5.

Finally, Table 1 presents a selection of the most promising alternative energy systems which were identified during the field trials.
Table 1 Selection of identified most promising alternative energy systems during the field trials

<table>
<thead>
<tr>
<th>Promising alternative energy systems identified in the SENTRO field trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass boiler</td>
</tr>
<tr>
<td>Biomass boiler (using municipal waste wood) in combination</td>
</tr>
<tr>
<td>with a photovoltaic (PV) system</td>
</tr>
<tr>
<td>District cooling using sea water cooling (SWC)</td>
</tr>
<tr>
<td>Geothermal heat pump</td>
</tr>
<tr>
<td>Geothermal heat pump, solar wall and PV</td>
</tr>
<tr>
<td>Geothermal heat pump and district heating</td>
</tr>
<tr>
<td>Ground based heat pump combined with heat and cold storage</td>
</tr>
<tr>
<td>Ground based heat pump combined with heat and cold storage</td>
</tr>
<tr>
<td>and possibly a solar thermal system</td>
</tr>
<tr>
<td>Ground based heat pump combined with heat and cold storage</td>
</tr>
<tr>
<td>(and Concrete Core Activation).</td>
</tr>
<tr>
<td>Low exergy technologies for heating and cooling with</td>
</tr>
<tr>
<td>controlled ventilation, geothermal heat pumps, Central</td>
</tr>
<tr>
<td>solar large heating system for DHW and PV power plant</td>
</tr>
<tr>
<td>Exhaust air heat pumps</td>
</tr>
<tr>
<td>Exhaust air heat pumps or central boiler plant on gas or</td>
</tr>
<tr>
<td>biomass</td>
</tr>
<tr>
<td>Solar thermal collectors for DHW and PV power plant</td>
</tr>
<tr>
<td>Solar thermal collectors and Cooling based on ground water</td>
</tr>
<tr>
<td>cooling (GWC)</td>
</tr>
<tr>
<td>PV systems</td>
</tr>
<tr>
<td>District heating and combine it with a solar thermal heating</td>
</tr>
<tr>
<td>Low temperature district heating, which might be combined</td>
</tr>
<tr>
<td>with solar collectors, and maybe also geothermal heat pumps</td>
</tr>
<tr>
<td>Use of waste heat</td>
</tr>
<tr>
<td>CHP at building level</td>
</tr>
</tbody>
</table>

Lessons learned from testing the approach – field trials

In general, it can be concluded from the experiences during the field trial regarding the SENTRO approach for the structural consideration of AES, that:

- Intervening early in the building process is crucial.
- Most successful, if started in programming phase and elaborated during proposal phase. For the first filtering out unrealistic options, some basic data have to be available (for instance basic estimation of heat, cooling, electricity demand).
- Team work is important.
- Objective comparison is not easy, actors only rely on their own experience.
- Accessibility of expertise of new techniques has to be improved.
- Restrictions regarding obligatory connection to district heating or natural gas district may restrict the use of AES at building level.

Specific conclusions regarding the checklist are:
- Useful decision support tool, especially for non-energy experts.
- Useful for communication in the project and/or design team, which includes key actors with various backgrounds. In particular, structural attention for all type of AES is achieved.

Evaluation
Next to the field trials the functioning of the feasibility study obligation (Art.5 EPBD) was evaluated. The aim is to see if already from this evaluation of the early experience of the EPBD transposition conclusions can be drawn regarding the functioning of this requirement. Furthermore, lessons learned will be communicated to the policy makers so that they can be included in tuning of the existing legislation and/or tuning of the technical regulations and/or supporting tools.

The main research questions for the evaluation were:
1. Are indeed more alternative energy systems realized in new large buildings than before the introduction of the EPBD?
2. Does the transposed national legislation (including its operational regulation) function properly?
3. What adjustments are needed to improve the impact of the policy instruments? Where in the process is strengthening required?

In 7 countries around 70 interviews with different key actors in the building process are held. Main key actors involved were: architects, building companies, national and local authorities, consultants, branch organizations of installers and renewable energy system suppliers. A detailed overview is presented in the annex of the report Towards an optimal consideration of alternative energy systems (Art.5 EPBD) in the common building process - Results of the field trial and evaluation [Joosen, S. et al (2009).

For Lithuania and Poland country specific questionnaires were made because in these countries there was no feasibility study requirement of alternative energy systems in place. Instead of the functioning of the feasibility study requirement their main research question was about how the situation regarding serious consideration of AES can be improved.
**General findings concerning the functioning Art.5 of the EPBD**

The lessons learned of the evaluation depend on the national status and way of transposition. Three situations have been distinguished.

For **countries with implicit transposition** for proper functioning of Art.5 fine-tuning towards tailor made solutions is needed. Usually implicit transposition concerns existing legislation, such as energy performance requirements in building standards and/or predefine of district heating system under certain circumstances. From the evaluation it appears that the legislation is functioning. Nevertheless, adjustments are recommended to optimize the impact, for instance by:

1) Take surrounding aspects\(^4\) into account in the energy performance calculation.
2) Anticipate on the possible future role of district heating.
3) Planning of energy infrastructure should include feasibility studies on the potential for inclusion of alternative energy systems at district level or at building level.

In addition, strengthening of the compliance system is recommended.

**Countries which have lately directly transposed Art.5** into their legislation have to focus on raising awareness, reliable supporting tools and a proper compliance system.

For **countries with no or little legislation in place** the focus for the coming period should be on awareness and on dissemination of the learning experiences from other countries with comparable building practice and energy infrastructure.

### 2.4 Case studies (one on each page)

One characteristic case study per participating country is described in this paragraph.

---

\(^4\) Think of surrounding aspects such as: geothermal conditions, opportunities to use waste heat, infrastructure and specific environmental legislation.
Apartment building in Slovenia

**Description of the pilot project**

Apartment building condominium nearby Ljubljana in a green environment by two rivers. Around 138 flats are designed in two wings with a common cellar, garages, wellness and swimming pool for residents (around 18,000 m²). The aim of the investor is to improve the contemporary building practice in flats design, to offer better living comfort, lower operational costs, based on energy efficiency and use of RES and LCC thinking.

Investor: Objekta, d.o.o., Ljubljana

Anticipated interventions and results:

- SENTRO tools were tested early in design process, well before the final design for building permit was agreed
- SENTRO testing gave recommendations to the design team on the proper steps in design process for optimized RES based energy concept of the building. The investor ordered the complete feasibility study and accepted the geothermal probes based heating and cooling.
- Based on the design finished in late 2008, the construction is planned in mid 2009.

**Outcome and realized impact**

The technical part, based on SENTRO recommendations, covered definition of 4 basic cases of AES, used later in feasibility study.

Based on the experiences collected in SENTRO tools, results of feasibility study and also based on the national RES using buildings mostly from non-residential sector, the case (1a) was selected, with 40 geothermal probes. This result in 181 ton CO₂ emission reduction per year compared to the reference situation.

Several meetings with GI ZRMK were done also after the testing of SENTRO tools for FS of AES; mostly for assistance in detailed planning aiming at RES and RUE. The architects and SENTRO national team try to further promote the integrated and RES oriented design approach, assisted by feasibility study, in media.
Office building in Denmark

Description of the pilot project

Building category and type: Office building. Size 1,200 m², 1 storey
Client and owner: Egernsund Tegl, Responsible for the sale of bricks, tiles etc. from 7 Danish brick works.
Consultants: ARKITEMA (architect Lars Kvist), Bascon (ingeniør Poul Kusk)
Energy performance requirements: Low energy building class 1, eventual class 2, as defined in the Danish energy regulations for buildings.
Other relevant requirements: High quality of indoor climate
Existing/expected energy supply net: Gas net, which is not utilized.
Local context: Open area, large building site.
Decisions regarding design concept: Focus on the use of masonry and on high technical quality, good indoor climate and low energy consumption incl. demonstration of an alternative energy concept and energy systems.

Outcome

The proposed energy concept to study in detail includes:
- A solar wall,
- Geothermal heat pump
- PV’s.
This concept is considered as an alternative to traditional solutions.
Apartment building in France

Description of the pilot project

Collective dwellings (22 apartments) in Paris for the Régie Immobilière de la Ville de Paris Social Housing Developer.

The baseline solution is a collective central heating system with low temperature gas boilers.

Outcome

All possible AES are considered as required under the French Law with the two sections of the feasibility study (1) advantages and drawbacks of solutions, impossible ones, 2) tables of comparative indicators.

<table>
<thead>
<tr>
<th>To be considered</th>
<th>Explanations</th>
</tr>
</thead>
</table>
| Solar thermal systems| Yes
Large terrace roof available for solar collectors
Could reduce HDW needs that represent half of this building energy demand |
| Photovoltaics        | Yes
Not integrated in walls because of narrow streets and other nearby shadings. – But potential for PV on the roof |
| Biomass              | No
No supply logistic in the area
Little room available for boiler and storage |
| Wind system          | No
No wind |
| District Heating     | Yes
CPCU urban network in the near vicinity |
| Geothermal heat pump | No
Building in dense urban area. No opportunity for ground heat resource |
| Other heat pump      | Yes
Air to water refrigerating and heating unit on the roof |
| Condensing boiler    | Yes
Well insulated building with low temperature radiators,
temperature of feedback heating system consistent with condensation of exhaust fumes |
| CHP                  | Yes
There are cogeneration units commercially available in that range of power |
New building area in Sweden

Description of the pilot project

The building project called Tollare, near Stockholm, Sweden will consist of about 700 dwellings with a total area of approximately 90000 m². 2/3 is apartment blocks and the rest is small houses and terrace houses.
The commissioner of the project is the company NCC. The apartments will be sold as co-operative flats.
The energy need for the buildings (space heating and domestic hot water) is estimated to 125 kWh/m².year without heat recovery and 100 kWh/m².year with heat recovery. In the beginning of 2008 the building process was for the first stage was in the proposal phase. If the project get building permit in October 2008 as estimated the construction of the first phase will start in 2009 and be finished in 2010/2011.

Outcome

The alternatives that were investigated were:
- Exhaust air heat pumps (separated in each house) serving one part of the building project area (ca 55000 m²) and a common heat pump station for geothermal/sea heat pump energy serving the rest of the building project area (ca 35000 m²).
- Common heat station for a biomass boiler (pellets) serving one part of the building project area (ca 55000 m²) and a common heat pump station for geothermal/sea heat pump energy serving the rest of the building project area (ca 35000 m²).
- Common heat station for a biomass boiler (pellets) serving the whole building project area.
- Common heat station for an oil boiler serving the whole building project area.
- Exhaust air heat pumps (separated in each house) serving the whole building project area.
- District heating serving the whole building project area.

For each one of the alternatives the investment costs, the energy costs and the operational costs have been specified. A LCC (life cycle cost) calculation has been made of these costs. The time period for this calculation is assumed to 15 years and the cost of capital is assumed to be 5%. The calculation leads to the suggestion from the energy consultant that the alternative with air heat pumps in each houses in the whole project area is the most profitable to choose.

Early 2009 the project was still in the planning and programming stage. They have also reconsidered their first alternatives, and now want to build passive houses or some type of low energy house. The reason for the change is that they have come further in their environmental thinking, and want to give the company an environmental profile. The preliminary plan is that the passive houses is built with heat recovery devices to recover the heat from the exhaust air and district heating or heat pumps to heat the tap water that will be used. This means that a decision is to be expected later in 2009.
School building in the Netherlands

Description of the pilot project

The municipality Breda, the Netherlands, is developing a multifunctional building with a gross floor area of 4316 m² in a residential area. The building encloses: two schools: Laurentius and Dr. Visser, a day care-centre: Kobergroep, and a sport facility. The picture on the right shows the area where the new schools will be build.

In 2007 the building process was in the pre-design phase, it is planned that the building will be finished in 2010. The municipality of Breda is also the owner of the building. The users of the schools and day care centre will pay for the energy costs; other third parties will rent the sport accommodation in the evening (rent includes energy costs).

Outcome and realized impact

The AES that best suit the situation in Breda are heat and cold storage with a heat pump, a wood boiler and a solar thermal system. The results of using the checklist are presented in the picture below.

"chances for succes" System

<table>
<thead>
<tr>
<th>Heat pump with storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat pump with ground heat exchange</td>
</tr>
<tr>
<td>Solar boiler</td>
</tr>
<tr>
<td>Wood boiler</td>
</tr>
<tr>
<td>PV</td>
</tr>
<tr>
<td>Urban turbines</td>
</tr>
<tr>
<td>Biomass combined heat and power</td>
</tr>
<tr>
<td>Geothermal energy</td>
</tr>
<tr>
<td>MicroCHP</td>
</tr>
<tr>
<td>District heating</td>
</tr>
<tr>
<td>District cooling</td>
</tr>
</tbody>
</table>

Conclusion: the outcome was that three alternative energy systems are promising, i.e. technical, economic and environmental feasible. Nevertheless, it has to be internally arranged who is responsible for the additional investments of these alternative systems. The field trial contributed to a detailed investigation how the sustainability of own municipality buildings can be financed. The findings are directly used in the decision upon sustainable energy concepts of two other municipal schools.
Alimentary shopping centre in Lithuania

Description of the pilot project

Alimentary shopping centre, 2600m². The shopping centre is planned to be constructed in Vilnius district, Buivydiskes village. The site for the building is indicated in the picture. The final user of building will be company VP-Market. There are no specific energy requirements or ambitions for this building.

Outcome

According to the results the best suitable energy systems for this project are geothermal heat pumps and district heating. However district heating infrastructure is in the distance from the building site. Solar systems also could be technically possible, but the customer rejected it as unrealistic option for this project (mainly because of economical and organizational reasons). The client wanted to add the gas boiler in the list of systems for further evaluation. The client made decision that the economical study of possible installation of heat pumps will be made by the JSC Vilpra. The highest priority for the client in this particular case is the investment cost of the energy system. The reduction of final energy (heat) price is not so important. The investment cost for the connection to the gas network is lower. These circumstances are not favorable for the AES and could prevent the realization of AES in this project.
3 Dissemination

3.1 Reports

Inventories transposition and building practice

The SENTRO-project started with two inventories on:

1) How all European member states comply with the requirements of conducting a feasibility study of alternative energy systems for new buildings?
2) The building practices as possible barriers of the implementation of alternative energy systems for seven SENTRO countries (Denmark, France, Lithuania, Poland, Slovenia, Sweden, the Netherlands).

The results are presented in two reports, respectively titled:

- Inventory of implementation of feasibility studies from EPBD art. 5 - EU27 (status 3/2007)
- Inventory of building practice, barriers and solutions for market introduction of alternative energy systems (status 3/2007)

Primary target groups for these reports are: international and national policy makers, energy agencies and other implementing agents in the field of alternative energy systems in buildings.

Both reports can be downloaded from the project website www.sentro.eu

Field trial and evaluation

The details of the backgrounds, used methods, results and conclusions of the field trial and evaluation are described in a report, titled An optimal consideration of alternative energy systems (art. 5 EPBD) in the common building process - Results of the field trial and evaluation.

All results of the individual fields and the selected shining examples are described in a condensed format.

Primary target groups for this report are the key actors who decide upon the realization of sustainable energy systems in new large buildings (in particular: local authorities, real estate project developers, consultants and engineering installers).
For policy makers an executive summary of the main findings is available.
The report, all field trials and the executive summary for policy makers are published via the project website [www.sentro.eu](http://www.sentro.eu).

### 3.2 The developed approach, including the checklist and the handbook

The English version of the checklist and the handbook are published at the project website [www.sentro.eu](http://www.sentro.eu).

They served as foundation of the national versions. It has to be notified that as consequence of the differences in as well the national context as the way of transposition of the feasibility study requirement these national versions differ in most cases considerably from the English universal version. Also these national versions of the checklist and the handbook are published at the project website [www.sentro.eu](http://www.sentro.eu).

The checklist can be used as decision support tool in a early stage of the process in the project team. The handbook is targeted at decision makers and consultants. In the introduction is indicated which chapters are of importance for the different target groups.

### 3.3 Training sessions and presentations

In total 3 presentations\(^5\) were held and 5 training sessions were organised. The presentations were approximately attended by 32 participants (among others national policy makers). By the workshops 95 market actors were reached (local authorities, architects, real estate project developers).

In Table 2 an overview is presented of the activities in the several countries.

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\(^5\) Not included are 6 general presentations at international conferences about interim and final results of the SENTRO project.
Table 2 Training sessions and presentations in framework of the SENTRO-project.

<table>
<thead>
<tr>
<th>Type of event</th>
<th>Date</th>
<th>Country</th>
<th>Type of participants</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop</td>
<td>13 January 2008</td>
<td>France</td>
<td>Local authorities, energy consultants, architects and ESCO</td>
<td>23</td>
</tr>
<tr>
<td>Presentation &amp; discussion</td>
<td>11 December 2008</td>
<td>Lithuania</td>
<td>National policy makers, housing agency, energy agency, university, alternative heating association</td>
<td>13</td>
</tr>
<tr>
<td>Round table session EIE EAST-GSR project</td>
<td>11 April 2008, Kielce</td>
<td>Poland</td>
<td>Technical institutes, Universities, technologies suppliers, energy agencies</td>
<td>34</td>
</tr>
<tr>
<td>Presentation at Regional Centre for Innovation and Technology Transfer</td>
<td>16 April 2009</td>
<td>Poland</td>
<td>Enterprises and consultancies</td>
<td>9</td>
</tr>
<tr>
<td>Workshop</td>
<td>27 November 2008</td>
<td>Slovenia</td>
<td>Designers, municipalities, housing associations, technologies suppliers, real estate developers, energy advisors, bank representative</td>
<td>32</td>
</tr>
<tr>
<td>Round table session EIE EAST-GSR project</td>
<td>16-17 May, 2008, Ljubljana</td>
<td>Slovenia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td>25 November 2008</td>
<td>The Netherlands</td>
<td>Local authorities, consultants, energy agency</td>
<td>6</td>
</tr>
<tr>
<td>Presentation &amp; discussion</td>
<td>2 February 2009</td>
<td>The Netherlands</td>
<td>National policy makers</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>127</td>
</tr>
</tbody>
</table>
Most participants of the discussions and workshops have a positive impression of the developed approach, and the supporting tools (checklist and handbook). In particular the fact that the checklist is relative simple to use and it gives an impression of the main decision criteria for various alternative energy systems. Furthermore, the participants indicate and this is subscribed by the project consortium that at this stage it is highly recommended that the instruments shall be used combined with the expertise of reliable energy specialists during building project meetings.

The checklist and handbook should be regarded as living supporting instruments. This means that it is necessary to look for ways how it can be guaranteed that the instruments are regular updated.

The presentations and the minutes of the workshop are published at the project website www.sentro.eu.

3.4 Advisory Committee

The advisory committee of the SENTRO-project consists of representatives of the European Heat Pump Association (EHPA), BSRIA and Cogen Europe. The 26th of November 2008 a WebEx meeting was arranged to get their feedback on the project deliverables. In general, this response was positive. A number of issues were added and the remarks were included in the executive summary for policy makers. The minutes of the WebEx meeting are published on the SENTRO-project website.
4 Conclusions

General findings concerning the functioning Art.5 of the EPBD, experiences evaluation and field trials

It can be concluded that as far as the feasibility study obligation according to Art.5 of the EPBD is transposed into the national legislation, this legislation is functioning. Nevertheless, improvements are needed to achieve more impact in practice. This means that adjustments, tuning of legislation and/or support mechanisms are highly recommended.

With regard to the implementation of AES in buildings in general (the goal of Art.5) progress is observed [Sijanec Zavrl, M. et al. (2007); Hansen, K. et al. (2007)]. International legislation, as Art.5 of the EPBD, combined with other driving forces such as: 1) existing national energy polices, 2) market for low energy buildings and green image 3) favorable economy for several AES 4) currently strongly fluctuating energy prices, contribute to this successful implementation.

Furthermore, Art.5 of the EPBD offers opportunities to broadening the scope of the consideration of AES and to generate a fair level playing field for various options for a sustainable energy supply in buildings. The potential for AES is considerable: only by heat pumps and solar thermal systems savings up to 10% of the final energy demand in buildings in 2020 can be reached [EHPA, (2008); ESTIF, (2007)].

The main conclusions of the project are explained in the blue text boxes below.

Crucial success factors

From the experiences during the project, in particular in the field trials, the following factors are observed to be essential for a successful implementation of alternative energy systems:

- **Team work!** Commitment of all key actors involved for the energy concept throughout the various phases of the building process.
- People in the building team with **sufficient skills and knowledge**.
- **Awareness and feasibility study for AES on time.** Most successful if started in programming phase and elaborated during proposal phase.
- **At least two alternatives** of promising energy concepts have to be identified. In this way a better level playing field is created for alternative energy concepts versus conventional energy concepts.
During the SENTRO-project the following *preconditions* towards optimal functioning of the feasibility study requirements of Art.5, are observed:

- Increase **awareness** of the obligation of Art.5 and its national transpositions.
- **Structural embedding** of the consideration of the energy concept (building shell & AES) into the activities of key actors in the building process
- **Guarantee of the quality** of a feasibility study

Currently, it is often not clear yet how the quality of the feasibility study is guaranteed, and who is responsible for the control.

- **Proper compliance systems** (Art.5 EPDB).

Without a proper compliance system in place, the feasibility study requirement (Art.5 EPDB) holds the risk that calculations and reports are made, but there will not be much impact in practice.

- Coherent requirements, supported by simplified clarifications and tools. Indication of which **software is reliable and starting points** for the detailed feasibility calculation.
- Extend the feasibility requirement to buildings with a total useful floor area over 1000 m² as it is common that new housing areas exist with large number of small houses.
Possible solutions for:

Improved quality guarantee

- The SENTRO handbook can be regarded as first step towards a quality protocol for performance of feasibility studies.
- Arrange clear responsibility for the quality of a building, including energy performance from beginning to realization. For instance, by use of a partnering organizational scheme. Involve energy experts and/or installers in an early stage.
- Improve conditions for proper (holistic) and reliable investment cost evaluation.
- Increase awareness of the sensitivity of the outcomes for energy prices and environmental issues (especially emission factor of used electricity).
- Gain insight in reliable performance data of alternative energy systems.
- Standardize technical regulations and outcomes. For instance at least the following topics could be requested as outcomes of a feasibility study per alternative energy system: 1) total final energy use, 2) primary energy use, including corresponding CO₂ emissions 3) kind of renewable energy used 4) percentage of renewable energy used. A next step could be to make it mandatory to present these outcomes on energy certificates.
- Insight on national, regional and preferably also on local level in the potential of alternative energy systems (as mentioned in Art.5 of the EPBD) should be available. This means maps indicating geothermal conditions, available waste heat sources, energy-infrastructure etc. This type of information should be available during the planning phase of a building project.

Improved compliancy

- Issue the building permit not until detailed specification of building and systems have been defined (for example as in Germany and Switzerland). In addition, it is essential that alternative energy systems are requested by design terms or at least valued within design terms.
- Set obligations to implement cost-effective alternative energy systems selected by national studies (for example as in Spain and Portugal).
- Control if the consideration of the feasibility of alternative energy systems has properly taken place by random checks. These random checks have to cover the calculations as well as the building practice.
- Introduce penalties for ignoring or not fulfilling the legislation.
- Assure sufficient capacity, resources, and skills at local authorities for their enforcement tasks.
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