Towards an optimal approach to effectively incorporate feasibility studies of alternative energy systems (art. 5 EPBD) in the common building process

Suzanne Joosen, Ecofys Netherlands B.V., the Netherlands
Åsa Wahlström, SP Technical Research Institute of Sweden, Sweden
Marjana Sijanec Zavrl, Building and Civil Engineering Institute ZRMK, Slovenia

Abstract
The Energy Performance of Buildings Directive (EPBD) has imposed obligatory feasibility studies of alternative energy systems (AES) for large new buildings. Most countries have transposed the requirements into their national legislation. However, operational legislation, technical guidelines and support tools are usually not yet in place. Within EIE SENTRO project (http://www.sentro.eu/) an approach is being developed to effectively incorporate the introduction of feasibility studies of AES in the common building process. The approach consists of a checklist to filter out most promising AES at an early stage and a handbook with a protocol to carry out feasibility studies. Technical, economic, environmental and organizational aspects are covered by the approach to assure that a complete package of barriers is dealt with. The paper describes the approach, including the tools. Furthermore, the first two experiences with testing the approach in practice on school building design are reported. These first results show that the checklist is a helpful tool in filtering out the most interesting AES. In addition, the proposed approach turned out to be very useful for communication within a project/design team, which consists of key actors with all different kind of backgrounds. For the foundation of these conclusions more results are needed. It is aimed at 35 cases in total divided over 7 EU-countries. It is expected that the final results of the field trial will be published in the autumn of 2008 on the project website (www.sentro.eu).

Introduction
CO_2 emission potential
In general implementation of renewable energy and energy savings are regarded as essential to keep the effects of climate change within acceptable limits and to guarantee the certainty of the energy supply.

Energy efficiency measures in new and existing buildings could considerably reduce CO_2 emissions with net economic benefit. By 2030 about 8% of the worldwide emission reduction potential (30% of the potential in the building sector) can be avoided with net economic benefit. The reason that this potential is still available is related to multiple barriers. These barriers include financing, poverty, higher cost of reliable information, and lack of an appropriate portfolio of policies and programs (IPPC, 2007).

EPBD – feasibility study requirement
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.

As of 4th January 2006, the EPBD enforces all EU-countries to create within legal and administrative framework of the their building codes, minimum energy performance requirements, energy certification, calculation procedures, feasibility studies requirements, inspection of boilers and air conditioning systems. It is estimated that through these requirements a cost-effective savings potential is realizable by 2010 of around 22% within the building sector. If this potential is realized, around 20% of the EU Kyoto commitment can be met (Buildingsplatform, 2006). This is about 35-45 Mtonne CO_2 emission reduction in the EU-15 member states by 2010 (ECCP, 2003).

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 paid to the requirements for feasibility studies of alternative energy systems (AES) for new large buildings (part of article 5 of the EPBD).

This part of article 5 of the EPBD states:
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.

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 article 5 focuses on the promotion of energy savings which can be achieved by energy efficient supply systems and renewable energy systems. Usually a combination of barriers hinders the use of AES. For example: higher investment costs, lack of knowledge and additional required permits. Core of the barriers is the estimation of risk on the part of the decision makers towards often unfamiliar AES.

Article 5 of the EPBD offers a unique framework to contribute towards diminishing the above-mentioned bottlenecks, since through performing feasibility studies more actors will become aware of alternative solutions for their energy systems.

SENTRO-project
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). In this project, which is scheduled to run from 1 November 2006 till March 2009, it is expected to gain insight into solutions to overcome barriers in the realization of AES in new buildings. The main aim is 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 started by making an inventory on how European member states comply with the requirements of conducting a feasibility study of alternative energy systems for new buildings. The inventory also encompasses which policies they pursue to actively introduce this requirement. The results are presented in the next section. Subsequently, in the seven SENTRO countries (Denmark, France, Lithuania, Poland, Slovenia, Sweden and the Netherlands), another inventory is made of the building practices as possible barriers of the implementation of alternative energy systems. Several main conclusions are given in the next section.

Based on the outcomes of the inventory phase, an approach is being developed to ensure that assessment of alternative energy systems will become an integral part in the common planning process of new buildings. The outline of the approach is discussed in a separate section. To support the approach two tools are made. It concerns a universal checklist and a handbook, which cover technical, financial, organizational as well as environmental aspects. Some explanation of these tools is reported.

Core of the project is the test of these tools in a field trial in the participating countries. As the field trial is carried out in the period November 2007 till July 2008, only preliminary results are discussed in this paper. Till now 8 test cases have been carried out.
Towards the end of the project the experience is disseminated through workshops 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-27 MS (Sijanec Zavrl, M. (2007)).

- Insight in the barriers which are hindering the use of alternative systems and insight in possible solutions to overcome these barriers (Hansen, K. (2007)).
- 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.

Status March 2007 - Feasibility study requirement EPBD

An overview of EPBD art. 5 transposition status in EU-27 countries and Norway (status 3/2007) is presented in Table 1.

The results show that in March 2007 most countries completed the process of transposition on the legal level. However, to a much lesser extent operational regulations are in place. Technical guidelines and supporting tools are in many countries still under development or not yet started.

Two main approaches to EPBD art. 5 transposition are identified:

1) Direct approach - i.e. transposition of art.5 at a legal level and subsidiary legislation based on either
   a) A definition of the protocol for feasibility studies (e.g.: Slovenia, Finland, France) or
   b) A list of selected alternative energy systems (e.g.: Spain, Portugal).
2) Implicit transposition – i.e. based on already existing regulation or through an EPBD calculation methodology, i.e.:
   a) Art. 5 is integrated in EPBD calculation procedure and tools (e.g.: The Netherlands, Bulgaria, Luxemburg)
   b) Other legislation concerning heat supply and/or planning predefine the use of renewable energy systems corresponding to the scope of art.5 (e.g.: Denmark, Lithuania).

Furthermore, most researched countries (17) have the feasibility study requirement included in the building permit procedure. However, the decision upon energy systems is usually made before the building permit is considered. This implies that for article 5 to function properly, attention has to be paid to the content and enforcement of the specific requirements.

It is possible that the current status is somewhat different from the presented status in Table 1. However, it is expected the two overall conclusions are still valid: (1) almost all countries have taken care of national transposition of feasibility study requirements, (2) technical guidelines and supporting tool are still needed in a number of countries. Inquiry about the status of the seven participating SENTRO-project countries teaches us that (status March 2008):

- For Lithuania, Poland, The Netherlands and Sweden the status is as presented in Table 1.
- For France art. 5 is transposed into national legislation. Support measures are also available.
- For Slovenia the technical regulation has been drafted and has passed the public consultation procedure. The process for promulgation is expected to be completed in April 2008. The regulation defined obligatory elements of feasibility study in order to enable evaluation of the energy, environmental, financial and other (technical, technological and spatial) aspects of an AES. At least two AES have to be analyzed; the evaluation must be based on a set of predefined energy, CO_2 and financial (including LCC) indicators. The existing VEM tool covers environmental and financial aspect for selected AES. Various energy simulation tools can cover technical (energy) aspects. By the end of 2008 also the official Slovenian tool for EPBD energy calculation will be ready. The enforcement framework is developing, though more demonstration projects would facilitate the increased implementation of AES.

Table 1 Status of art. 5 transposition in EU-27 and Norway, (March 2007)

GENERAL APPROACH A) Detailed regulation planned for feasibility studies from Art. 5 / B) Feasibility study integrated in regulation about EPBD calculation methodology and min.requirements / C) Feasibility studies integrated in other existing regulation / D) technology list prepared	**SUMMARY Art. 5 implementation level** (country status: March 2007)	**Art. 5 implemented at legal level**			**Art. 5 technical regulation** and/or other adequate support for implementation of alternative systems (i.e. technology list) ready			**Support measures for enforcement of Art.5 regulation** (tools, checklists, information, promotion...)		
		Not yet / action just started	**Draft law ready**	**Law adopted / finished**	**Not yet / action just started**	**Draft ready**	**Adopted / finished**	**Only some technology promoted, not systematically**	**Promotion programmes, incentives available**	**Tools available, good promotion, advisory programmes, demonstration projects**
B	**Austria**		[orange]			[orange]				[green]
A	**Belgium**		[orange]		[red]			[red]		
B	**Bulgaria**		[orange]		[red]			[red]		
decision in progress	**Cyprus**	[red]			[red]			[red]		
B	**Czech Republic**		[orange]			[orange]			[orange]	
C	**Denmark**			[green]			[green]	[red]		
decision in progress	**Estonia**	[red]			[red]			[red]		
A	**Finland**	[red]			[red]					
A	**France**		[orange]				[green]	[red]		
B	**Germany**		[orange]			[orange]		[red]	[orange]	
decision in progress	**Greece**	[red]			[red]			[red]		
B	**Hungary**			[green]			[green]			[green]
A	**Ireland**			[green]			[green]		[orange]	[green]
B	**Italy**			[green]			[green]		[orange]	
decision in progress	**Latvia**		[orange]		[red]			[red]		
C	**Lithuania**			[green]	[red]			[red]		
B	**Luxembourg**		[orange]				[green]	[red]		
B	**Malta**			[green]	[red]			[red]		
B	**The Netherlands**			[green]			[green]		[orange]	
decision in progress	**Poland**		[orange]			[orange]			[orange]	
D	**Portugal**			[green]			[green]	[red]		
B	**Romania**	[red]			[red]			[red]		
A	**Slovakia**			[green]		[orange]			[orange]	
A	**Slovenia**			[green]	[red]				[orange]	
D	**Spain**			[green]			[green]	[red]		
B	**Sweden**			[green]	[red]			[red]		
B	**United Kingdom**			[green]	[red]			[red]		
C, no detailed information	**Norway**			[green]			[green]			[green]

The inventories carried out within the SENTRO-project make 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) Early timing of a feasibility study of AES 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.

To generate a level playing field of AES, it is important that good objective insight in the technical and economic opportunities for the various AES – including their environmental benefits – becomes available before the final design of the building.

Outline of an optimal approach to integrate the feasibility study of AES into the building process

Based on the inventories, it has become clear how the feasibility study of AES ideally should be integrated in the building process. The approach is illustrated by two figures (1 and 2).

Figure 1 shows the building stages, the involved main actors and the related actions to consider the feasibility of AES before constructions starts. Of course the building process differs in the various EU-countries. However, in general it is possible to distinguish six different stages as defined in the figure.

During the planning and programming phase awareness of the AES has to be created first of all. This can be done by putting the topic on the agenda of project meetings. As a support to raise awareness, descriptions of the basics of AES as well as good national practice examples in the handbook can be used. Also answers to frequently expressed objections towards AES are listed.

Depending on how the feasibility requirement of article 5 of the EPBD is transposed there are several paths to proceed.

1) When there is a direct obligation, the key actors have to fulfill the legislation.
2) When the transposition is implicit, key actors have to be made aware that AES are valued in the energy performance calculations.
3) When there is no obligation (yet) the next step is to achieve commitment that the feasibility of AES has to be studied.

In all cases, it is recommended that key players ask for a feasibility study at an early stage of the process.

The proposed approach of a possible implementation of AES feasibility studies consists of a checklist for a brief pre-feasibility study and of a method for a more detailed feasibility study of the interesting AES. The feasibility study starts with filtering out unrealistic AES options. The checklist (detailed description in next paragraph) can be used for this selection. The aim is to identify at least two interesting AES options at the beginning of the proposal stage.

Thereafter, a more detailed feasibility will be performed for these interesting AES. The results have to be available when the final decision is made (often at project stage) on the building's energy system. To support the evaluation of AES, a handbook is being developed. Besides technical aspects, a protocol for financial, organizational and environmental issues is included. All the collected and calculated insights have to contribute towards an optimal consideration of AES in the decision making of the final energy system.

As the approach is being developed to support impact of art 5 of the EPBD, the focus is on AES. It has to be stressed that an optimal energy concept can never be achieved without taking into account building related energy measures such as insulation, ventilation and use of day light. The importance of integral energy design is included in the handbook.

Three situations can be distinguished in realizing AES in buildings: 1) new individual building 2) new housing area 3) renovation of existing building(s). As the focus is article 5 of the EPBD is on new buildings, the approach is concentrated on the first two situations. The third situation is beyond our scope, unless the building is totally stripped. In this case it can be regarded as a new building.

The approach is more or less the same for the first two situations. In this paper the approach, including the tools, is explained for a new individual building. The development of a new housing area differs from a new single building with respect to more opportunities for collective energy systems and more freedom in the choice of energy infrastructure. As a consequence, in this case the study of the feasibility of AES is more complex and has to take place at the very beginning of the building process. For instance, decisions about the energy infrastructure usually are made at the planning stage.

Figure 2 is added to stress the importance of taking energy concepts into account right from the beginning of the building process. The space to find suitable solutions to realize an optimal energy concept in the building is funnel-shaped (marked blue). This illustrates that when for example AES is only considered from the project stage there are fewer opportunities to realize a good AES concept compared to a consideration on AES which was initiated in the planning stage. Of course the available solution space to realize a high quality building, including its energy concept, is also closely related to the required cost. Little solution space indicates higher cost and much solution space indicates lower costs. (Prins, 2006; WBCSD, 2007)

Main actors	***Building stage***	***Content***	***Action related to the feasibility study***
Municipality Energy suppliers Developers	Planning stage	Urban planning incl. energy infrastructure, heat plans, and constrains on number, size and use of buildings in the area.	The planning stage should include feasibility studies on the potential for inclusion of alternative energy systems on district level or on building level... This means also start to identify most feasible options by using the checklist.
	↓		
Client or Developer Consultants	Programming stage	Defines the occupants' needs and requirements in the building program.	Start of the feasibility study. 1. Identification of the most feasible energy systems. Use **checklist** to find at least two options of alternative energy systems. 2. Make efforts to arise awareness of alternative energy systems. (good practice examples and answers to frequently asked questions are included in the **handbook**) 3. Planning of the coming stages in the feasibility study.
	↓		
Client or developer Architect, Consultants	Proposal stage	Defines the basis on which the client makes his decisions on the specific performances of the project in question. The proposal stage may include consideration of a number of alternative energy concepts for the building	1. Optimization of the energy demand and production. Identify building concepts for inclusion of chosen energy systems. 2. Evaluation of at least two energy systems based on **handbook** and by using suitable simulation tools. 3. Include choice of building concepts and energy systems.
	↓		
Client or developer Architect, Engineers and Consultants	Project stage	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	Decision of the energy system. 1. Complete the feasibility study and hand in along with the building permit application. 2. Decide on needs for further feasibility studies.
Local authorities	•	Decision building permit (yes/no)	
Contractors Installers	Construction stage	The building is constructed incl. energy systems, so that a use permit can be given	
	•		
Owners Occupants Installers	Operation stage	The building is in use	

Figure 1 Building stages and actions towards an optimal consideration of the technical, economic, environmental feasibility of AES before construction starts

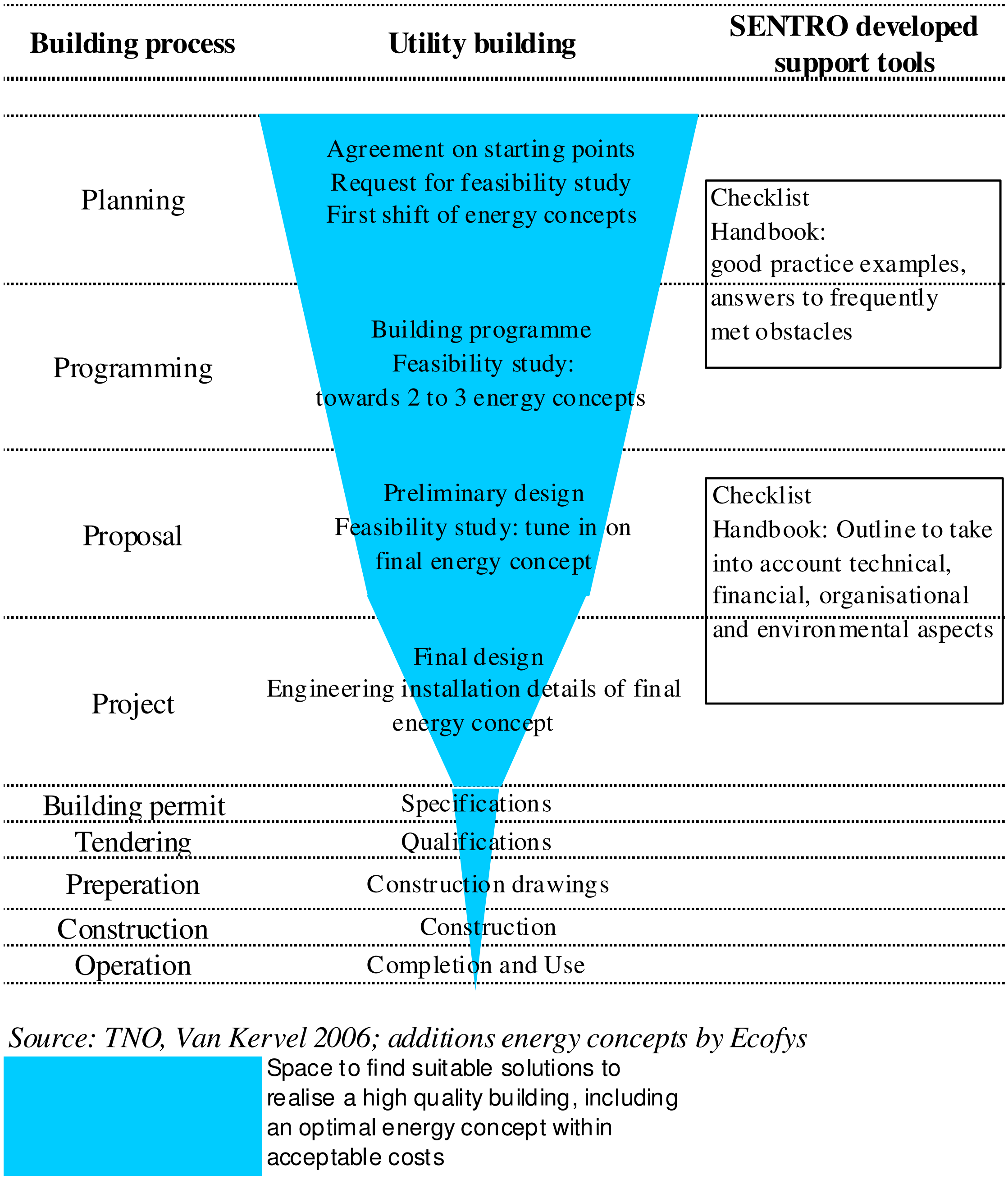

Figure 2 Solution space to realise a high quality building, including optimal energy concept and the developed support tools taking AES into consideration

Developed support tools Checklist and Handbook

Checklist, explained by first experiences of testing it in field trials in Slovenia and in The Netherlands

The objective of the SENTRO pre-evaluation checklist (Wahlström, 2007), intended to be used early in the building process, is to make a fast identification of promising AES for further investigations. By using the checklist it should be possible to choose a few alternative energy systems for further investigations together with the conventional system. It is recommended that at least two promising energy systems are chosen for further investigations.

The checklist is explained by two test cases. In the first case, carried out in Slovenia, the originally universal developed checklist is tested. In the second case, carried out in the Netherlands, it turned out that the originally checklist needed some improvements.

AES checklist field trial in rebuilding of schools complex in Kamnik

The municipality of Kamnik, Slovenia, is planning a rebuilding of a school area, with two old existing elementary schools. The municipality is highly interested in sustainable solution, since it has the role of both investor and owner and it is also paying the operational and maintenance costs. As part of the planning stage a call for architectural competition for 9.616 m^2 of new and/or partly rebuilt school area was prepared. As the terms for evaluation of architectural solutions should consider also the economy of the proposed design in a whole life-cycle and environmental acceptability of the renovated schools the checklist was used to pre-select the AES with considerable prospects for realization. The results are presented in Figures 3 and 4. They indicate the micro CHP and the heat pumps using geothermal energy the most promising systems and therefore worth of utmost consideration in further elaboration in design proposals.

For each alternative energy system four evaluation parameters are considered. Each evaluation parameter is weighted with weighting parameters, which are set on the first page in the Excel spread sheet tool (Figure 3), default weighting value is 0.3 for technical, 0.2 for financial, 0.1 for organizational and 0.4 for environmental aspect, as the most important one. Once the weighting parameter is set, the same weighting will be used for all alternative energy systems. If the weighting parameters are set to 0.25 for all parameters it means that they all are equally important. The evaluation parameters are in their turn weighted between numbers of aspects that are relevant to consider in order to tackle the barriers for each specific alternative energy solution. Each aspect is evaluated with scores from 1 to 3; 1 means that it needs a high effort to realize success while 3 means that it only need a low effort.

SENTRO
WP4- CHECK LIST FOR FEASIBILITY STUDIES

		Score Technical parameters	Score Financial parameters	Score Organisational parameters	Score Environmental parameters	Probability for sucess in comparison of efforts
	Weighting to fill in, (0 - 1)	0,3	0,2	0,1	0,4	
	Decentralised energy supply					
A1	Solar thermal systems (hot water and/or heating)	56%	50%	83%	67%	62%
A2	Solar electricity systems (photovoltaics, PV)	100%	60%	75%	67%	76%
A3	Biomass energy systems (hot water and/or heating)	67%	78%	40%	50%	60%
	CHP and District or block heating or cooling					
A4	CHP (micro) at building level	89%	78%	50%	100%	87%
A5/A6	District or block heating	50%	44%	33%	33%	41%
A7	District or block cooling	33%	33%	33%	33%	33%
	Heat pumps					
A10	Geothermal energy systems (heat pumps for heating and/or cooling)	72%	67%	67%	100%	82%
A11	Heat pumps other than geothermal	0%	33%	75%	100%	0%

Figure 3 A summary page of the checklist with predefined weighting of technical, financial, organisational and environmental parameters (Walström, 2007); results refer to a pre-selection of AES in case of a checklist field trial in Kamnik schools, Slovenia.

A3	Biomass energy systems (hot water and/or heating)	Low effort demand to realise sucess = 3 points	Medium effort demand to realise sucess = 2 points	High effort demand to realise sucess = 1 point	SCORE to fill in, 1 to 3	SUBScore (%)
Technical parameters	sufficient space for fuel storage	available room for storage that are protected towards moisture	possible ta arrange for a two week storage that are protected towards moisture	no space for storage	1	
	accessibility of fuel storage	easy to access with a truck that can load fuel directly in the automatic feeder	need for manual move from truck to storage or from storage to the automatic feeder	difficult to access, need several manual loadings	3	
	efficiency (availability of technology on the market, with an good design)	yearly mean efficiencies over 75%	yearly mean efficiencies over 65%	yearly mean efficiencies less than 65%	3	
	fuel logistic system	fuel supply system available and well functionally	fuel supply system available	no fuel supply system in the neighbourhood	1	67%

Figure 4 Fragment of a checklist showing evaluation of biomass technical parameters by rules of thumb in a 1 to 3 points system (results for Kamnik field trial), (Walström, 2007).

The scores are based on rules of thumb. It may be necessary to change some of the parameters in order to adapt to local conditions. It is meant that the design team should only need to use one or two hours of discussion by filling the checklist in and thus get a relatively good overview of AES for further investigation in a detailed feasibility study (Figure 3). Therefore the design team should only set the scores based on previous experiences and no background investigations or calculations should be needed. In the worst case this may lead to constant abandoning of some systems, which the design team has a previous bad experience with. On the other hand, it is only compulsory to do the feasibility study, and not to actually use the suggested alternative energy system. In order to get real actions it might be more successful to concentrate on systems that the design team feels comfortable with.

Each evaluation parameter is followed by a number of aspects that should be assessed with scores from 1 to 3. For technical aspects the lowest score should describe the most difficult to realize the aspect. If it is impossible to realize a technical aspect the whole alternative system solution fails and further assessments should be done for other systems. In the same way technical aspects that will not cause any problem in implementation are not considered. The following example illustrates the criteria for evaluation of one of financial aspects, i.e. availability of subsidy schemes for PV systems: low effort demand to realize AES successfully, evaluated with 3 points, is chosen when subsidy of over 60% of investment is available; medium effort demand and corresponding 2 points are chosen if subsidy of over 30% is easy to get; while high effort demand to realize PV system and corresponding 1 point are selected when minor or no subsidy is available.

In the summary sheet (Figure 3) the scores for different aspects are presented, so that the design team can choose one or two AES that have high scores (preferably above 75%) and thereby promising qualities. Note that some of the systems are independent of each other and may therefore need separate assessments. For example, it is possible to use a solar thermal system together with district cooling.

AES checklist field trial in multifunctional building in Breda

The municipality Breda, the Netherlands, is developing a multifunctional building with a gross floor area of 4316 m^2 in a residential area. The building encloses: two schools: Laurentius and Dr. Visser, a day care-centre: Kobergroep, and a sport facility. 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).

Within the field trial three meetings are arranged. The aim is to have a serious consideration of AES at the beginning of the building process, ultimately towards decisions upon AES. During the first meeting as much as possible information is collected to make a first shift towards performable energy systems. At that point some problems were encountered by using the original checklist. First of all, several options appear to be not realistic under local circumstances. This means it is not useful to enter all the data in the checklist for these options. Secondly, some questions on financial data (LCC costs etc) are hard to answer: In addition, people that are able to answer these questions do not need a checklist to decide which AES are most feasible. Finally, the choice between the three categories can be made easier if we give examples as well as “numbers”. Based on these findings it was decided to adapt the checklist towards the Dutch national contact. It is expected that some of the changes are adopted by other countries as well, especially the fast filtering of unrealistic options.

The structure of the checklist is explained in figure 5. It is a two step process. In the first step unrealistic options are filtered by questioning the main features of the project and its' surroundings per AES. Only yes, no or unknown are possible answers. The second step is to select the two to three most promising options. This is done by valuing the key factors that influence the opportunity for successful realization per AES. Score runs from 3 to 1, respectively positive and negative influence. Beside the fact that financial valuation based on LCC is not considered, the content of this second filtering is strongly based on the originally checklist.

In the second meeting the checklist developed within the SENTRO project is tested and evaluated. The selection of AES is further tuned towards three favorable options. During the field trial in Breda it turned out that a heat pump in combination with heat and cold storage, solar thermal systems and wood fired boiler are the most interesting AES options. The requirements for a detailed feasibility study of these favorable AES, including solution paths for possible financial and organizational obstacles will be discussed during the third meeting. Furthermore in the last meeting appointments for the upcoming period will be made. The selection scheme, including the results for the multifunctional building in Breda, is presented in Figure 5.

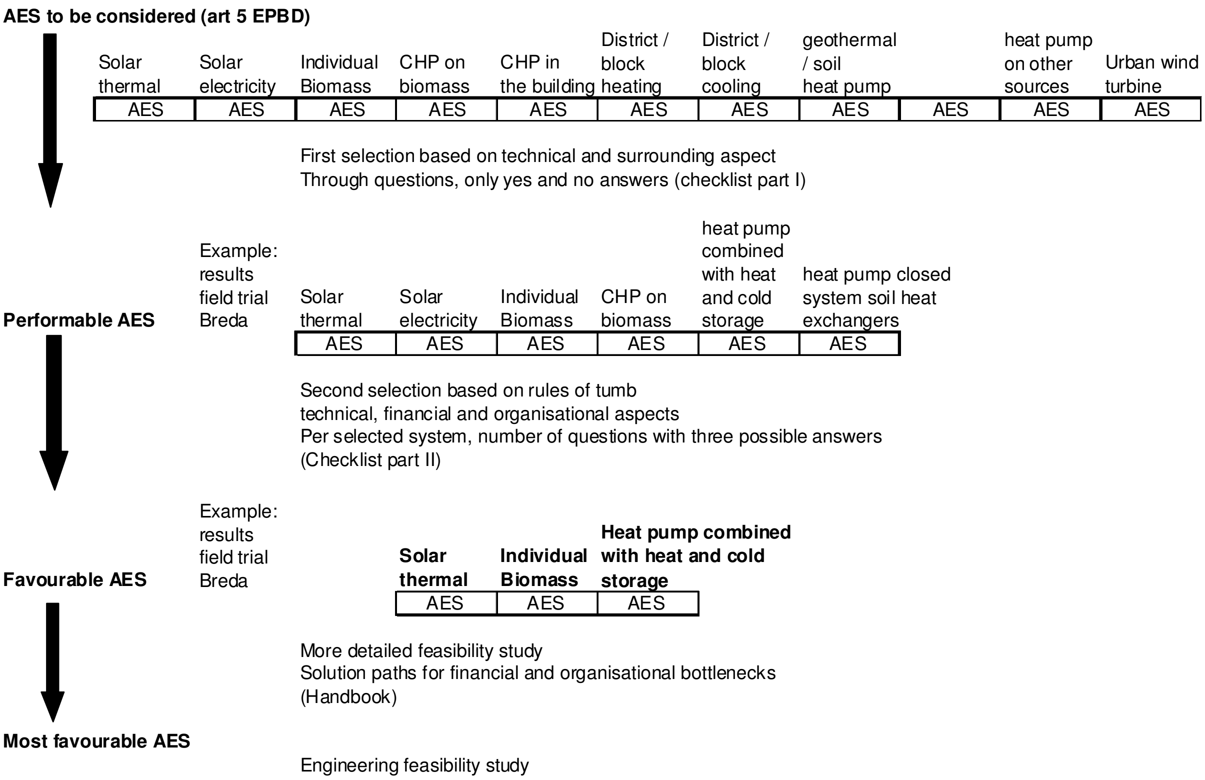

Figure 5. AES selection scheme in multifunctional building in Breda, The Netherlands.

The field trial demonstrated the score of 75% in case of geothermal heat pumps (closed and open systems), 72% for wood biomass boiler, 58% for solar thermal systems (hot water and/or heating), 49% for PV system and 42% for biomass combined heat production (CHP). Other AES like geothermal energy systems district or block heating and/or cooling and micro CHP at building level were found to have negligible potential for success.

Handbook

Since the article 5 of EPBD requires an evaluation of a technical, environmental and economic feasibility of AES, the main feasibility study has been developed from these aspects. Besides these aspects also organizational aspects need to be considered and so in the suggested method the feasibility study is divided into four parts: technical, economical, organizational and environmental. First a technical evaluation is performed to see if it is possible to technically install the energy system. Here the right size of the alternative energy system is decided for and thereby space, construction and installation requirements. The energy system's performance parameters are used in order to calculate the expected yearly energy use in the building's operation phase. The results from the technical evaluation are used in order to make an economical and environmental evaluation. In the economical evaluation different scenarios of the development of energy prices and interests are calculated. The environmental evaluation is made for different mixes of electricity sources and for different scenarios of future energy sources, for example in a district heating system. The feasibility study also consists of an organizational evaluation of experts' knowledge both during the performance of the feasibility study (design team) as well as in the operation of alternative energy systems (employees or users). All the results from the economical, organizational and environmental evaluation are thereafter summarized in one common score.

This means the background of the checklist is thoroughly explained in the handbook. Also included are good practice examples of feasibility studies for AES per country, how to respond to frequently put forward objections against the use of AES and an overview of relevant tools for feasibility studies.

Conclusions so far

Most EU-countries have transposed the feasibility study requirement of the EPBD into their national legislation. However to a much lesser extent countries have operational regulation, technical guidelines and support tool in place.

To effectively incorporate feasibility studies of AES into the common building process early timing is crucial. The first experiences in the field trial show that the checklist for the implementation of feasibility studies is helpful for identifying the most promising AES. Furthermore, the proposed approach turns out to be very useful in communication with a project/design team, which includes key actors with all kind of different backgrounds.
For the foundation of these conclusions of course more results are needed. For instance, the preliminary case for a new housing area in the Netherlands shows that this situation is more complex because of the opportunities for collective AES systems.
It is aimed at 35 cases in total divided over 7 EU-countries. It is expected that the final results of the field trial will be published in the autumn of 2008 on the project website (www.sentro.eu).

Acknowledgements

The authors would like to thank the experts of the SENTRO project team who provided national country information and other contribution to this research: Klaus Hansen and Kirsten Engelund Thomsen (BRI, Denmark), Norvaisa Egidijus (LEI, Lithuania), Natalia Makowska (Ecofys Poland), Hubert Despretz (Ademe, France), Fieke Geurts, Jasper Vis (Ecofys Netherlands), Onno Kleefkens (SenterNovem, The Netherlands). EIE SENTRO project is supported by EC in the frame of Intelligent Energy Europe programme (EIE/06/102/SI2.445679) and by respective national ministries.

References

Buildingsplatform, 2006, Information on website http://www.buildingsplatform.eu/cms

ECCP, 2003, Second ECCP Progress Report Can we meet our Kyoto targets?

IPCC, 2007, Fourth assessment report "Climate Change", Building chapter

Joosen, S., Hansen, K. and Sijanec Zavrl, M. (2007), "Feasibility studies for alternative energy systems in large new buildings: state of the art, possible barriers and how to overcome them?", in Attali, S. and Kenya Tillerson, K. (Eds.), eceee 2007 Summer Study, Saving energy – just do it!, 4 – 9 June, 2007, La Colle sur Loup, France, Conference proceedings, ABA Intercopy, ISBN 978-91-633-0899-4, pp. 903-909

Hansen, K. (2007), " Inventory of building practice, barriers and solutions for market introduction of alternative energy systems (status 3/2007), SENTRO 2/2007/WP3, September, 2007", available at: http://www.sentro.eu/

Prins, M. et al, "sturen op warden bij Projectalliantiecontracten, de toepassing van incentives op kwalitieit, Technical University Delft, faculty real estate and housing, June 2006

Sijanec Zavrl, M. (2007), "Inventory of implementation of feasibility studies from EPBD art. 5 in EU-27 (status 3/2007), SENTRO 1/2007/WP2, September, 2007", available at: http://www.sentro.eu/

Wahlström, Å. (2007), "Handbook for performing feasibility studies of alternative energy systems, SENTRO 3/2007/WP4, December, 2007", will published at: http://www.sentro.eu/

WBCSD, 2007 Energy Efficiency in Buildings, business realities & opportunities, summary report