

CONSIDERING ALTERNATIVE ENERGY SYSTEMS IN FACILITY MANAGEMENT PROCESS

Marjana Sijanec Zavrl
Building and Civil Engineering Institute ZRMK, Slovenia
marjana.sijanec@gi-zrmk.si

Suzanne Joosen
Ecofys, Netherlands
s.joosen@ecofys.nl

Åsa Wahlström
SP Technical Research Institute of Sweden, Sweden
asa.wahlstrom@sp.se

ABSTRACT

EU Directive on Energy Performance of Buildings (EPBD) imposed obligatory feasibility studies of alternative energy systems (AES) for large buildings. Within EIE SENTRO project (<http://www.sentro.eu/>) an approach is developed to incorporate the introduction of feasibility studies and use of AES in the process of design of new buildings as well as renovation. The approach consists of a checklist to filter out most interesting AES at an early stage and of a handbook for a pre-design stage with a protocol to carry out feasibility studies. Technical, economic, environmental and organizational aspects are covered by the approach to assure that it is dealt with a complete package of barriers. The paper describes the background and tools. The application of the checklist for identification of appropriate AES is demonstrated on two case studies of building renovation planning. The benefits of the implementation of AES are shown by the Dutch residential buildings refurbishment case study.

KEYWORDS: alternative energy systems, feasibility studies

INTRODUCTION

Since January 4, 2006, all EU-countries are legally bound through the article 5 of Energy Performance of Buildings Directive (2002/91/EC) (EPBD) to include the requirements for feasibility studies of alternative energy systems (AES) within their national legislation. From an inventory carried out in March 2007 as part of the EIE SENTRO project (<http://www.sentro.eu/>) it appears that the associated feasibility studies will be implemented in very divergent ways in EU countries.

In order to support the EPBD transposition process, SENTRO project developed a protocol and tools for the implementation of feasibility studies of AES. The aim of the tools is to facilitate the AES evaluation process at an early design stage and to encourage the actual implementation of AES. Technical, economic, environmental and organizational aspects are covered by the approach to assure that it is dealt with a complete package of pros and cons for the particular AES in a specific building context.

Although the EU requirement itself covers new buildings with a total useful floor area over 1000 m², its implementation in the national regulation may extend the requirement also to renovation of existing buildings. Moreover, the checklist and handbook developed for facilitating the implementation of AES can be used to support the sustainable decision making in facility management process. AES like decentralized energy supply with solar thermal systems or photovoltaics, biomass energy systems, CHP at the building level, district

or block heating and cooling, heat pumps, including geothermal energy systems, may, when technically feasible, significantly improve the economical and environmental performance of a facility.

The paper describes the status of protocols for investigation of AES feasibility in EU countries' legislation as well as in their building practice. Further on, a new approach for incorporation of feasibility studies of AES in design of new buildings and renovation is presented. The approach consists of a checklist to filter out most interesting AES at an early stage. The use of the checklist is illustrated by two case studies from the Netherlands and Slovenia, where the recommended AES are pointed out by ranking. To demonstrate the importance of aftercare and monitoring on the actual impacts of the implementation another case study on the Dutch residential buildings refurbishment is added.

STATUS IN EU-27

The inventory in EU-27 and Norway carried out in March 2007 as part of the EIE SENTRO project (Sijanec Zavrl, 2007) showed that the transposition of requirements for obligatory feasibility studies of AES (article 5 of EPBD) was completed on the legal level in 50% of countries, while only 35% of countries declared to have the secondary regulation ready for use. The most common barrier preventing the reliable comparison of AES with conventional solutions is the lack of professional tools for investigation of technical, economic, and environmental and organizational feasibility.

The analysis showed that the sooner in the building design process the feasibility study is done, the better the chances are for proving the feasibility of alternative energy systems. A building permit represents a milestone in the building design process. The investigation of envisaged solutions about positioning of feasibility study in the process of building design before the application for building permit showed, that 17 countries linked or planned to link the feasibility study to a building design needed for acquisition of the building permit. 4 countries do not connect feasibility studies with the building permit. In 7 of EU-27 and Norway countries the relation between a feasibility study and a building permit has not been defined yet.

The article 5 of EPBD, however, does not bring a clear definition of either a feasibility study or alternative energy systems and it also does not imply any requirements about actual implementation of an alternative energy system. A feasibility study can be standardized in order to reduce the administrative burden for a designer, to bring clear and understandable results for the client, and to facilitate the control of compliance with regulation. The inventory evaluated to what degree the content of feasibility studies of alternative energy systems is standardized on the national level. 20 countries have clearly indicated that they do not plan to standardize the content of a feasibility study. The other 8 countries intend to do so or they already have the tools that implicitly standardize the structure and content of the study. In spite of clearly indicated lack of tools for feasibility studies the progress protocols development and software support seems slow for the time being. In Ireland a comprehensive tool PASSES is in preparation, in Slovenia a VEM tool for feasibility studies of biomass systems vs. district heating systems, heat pumps and other common energy systems has been developed, in other countries, like the Netherlands and Austria detailed separate tools are available, covering different AES technologies and targets (technical, environmental, economical), respectively (Joosen et. al, 2007).

Moreover, the investigation of design processes in EU countries showed a clear need for a pre-evaluation checklist enabling the selection of AES for a detailed feasibility study in more detailed stages of design.

The final decision about actual implementation of AES in a building is left to investors and designers. Several general bottlenecks for implementation of AES are already known, like higher investment costs, lack of technical knowledge and confidence in new applications, insufficient knowledge about environmentally orientated subsidies and financing opportunities, lack of interest for life-cycle thinking, and lack of tools providing clear decision-making criteria.

The aim of SENTRO project was to develop an “optimal” approach in order to effectively incorporate the feasibility studies of alternative energy systems (art. 5 EPBD) in the common building practice and thus to support optimisation of the facility management process.

METHOD

Outline of feasibility study

The proposed method 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 for the chosen AES. The aim of the checklist is to select at least two promising alternative energy systems for further investigations. This is done early in the building process (in the planning stage). Thereafter, a more detailed feasibility study will be performed for at least two chosen AES. A detailed feasibility is performed in the program stage of the building process.

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 organisational aspects need to be considered and so in the suggested method the feasibility study is divided into four parts: technical, economical, organisational 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 organisational 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, organisational and environmental evaluation are thereafter summarized in one common score.

Checklist for brief feasibility study

The objective of the SENTRO pre-evaluation checklist (Wahlström, 2007), intended for use 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 one alternative energy

system for further investigations together with the conventional system or another alternative energy system. It is recommended that at least two promising energy systems are chosen for further investigations.

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 1), default weighting value is 0.3 for technical, 0.2 for financial, 0.1 for organisational 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 realise 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 success 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 1. 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.

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 2). 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 realise 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 realise 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 1) 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.

A3	Biomass energy systems (hot water and/or heating)	Low effort demand to realise success = 3 points	Medium effort demand to realise success = 2 points	High effort demand to realise success = 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 to arrange for a two week storage that are protected towards moisture	no space for storage	1	67%
	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	

Figure 2. 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).

CASE STUDIES

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 m² 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). Municipality of Breda is active in the field of sustainable building and participates in the field trial of the SENTRO project.

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. In the second meeting the checklist developed within the SENTRO project is tested and evaluated. The selection of AES is further tuned towards three favourable 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 favourable AES, including solution paths for possible financial and organisational 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 3.

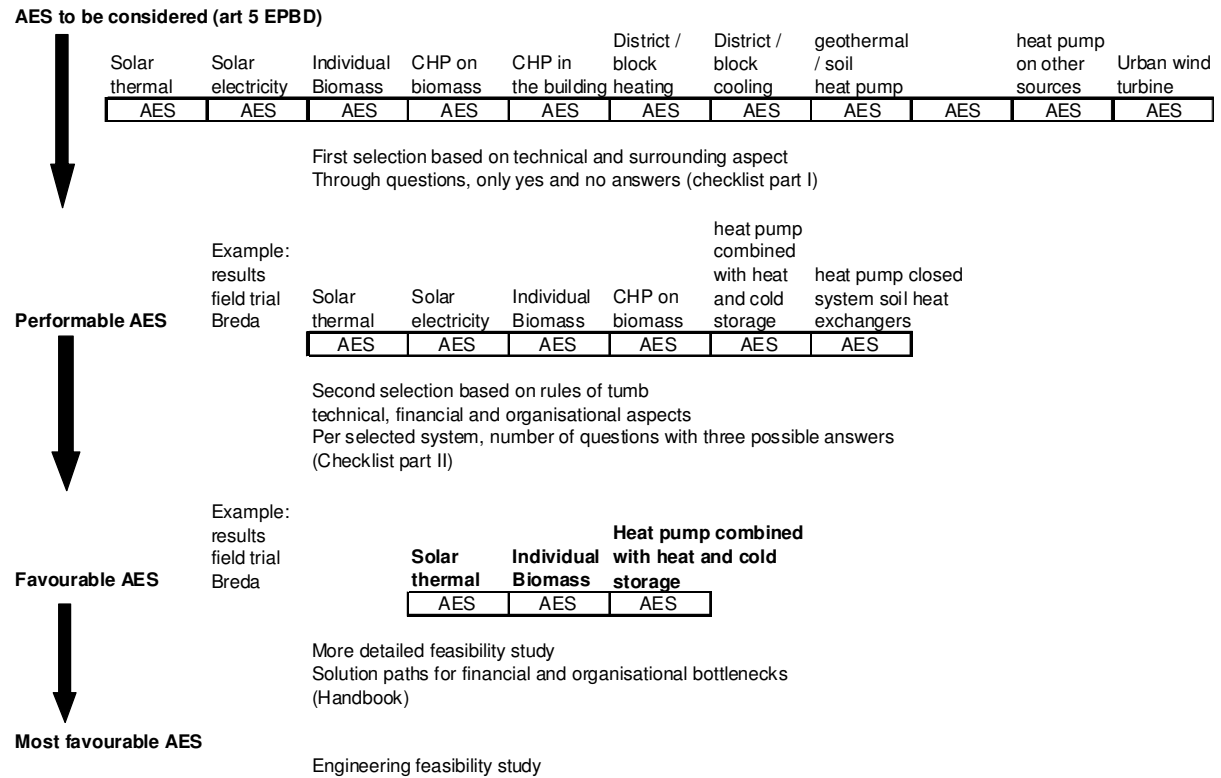


Figure 3. AES selection scheme in multifunctional building in Breda, The Netherlands.

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.

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 is in a role of 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 m² 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 realisation. The results are presented in Figures 1 and 2. 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.

AES in renovation of Prinsenflats in Rijswijk

The next case study illustrates the implementation and monitoring phase of AES project. Although the design tools indicate expected savings in energy use, costs and emissions, the reality may be different due to hidden technical problems. The case study shows the importance of monitoring of relative innovative AES to reach proper functioning and the calculated energy savings.

The housing-association Vidomes has an ambition to significantly reduce the annual energy-use of the Prinsenflats in Rijswijk through renovation. AES were considered in 5 high-rise buildings containing 506 apartments in total. A feasibility study showed annual savings of 55% within a payback time of 15 years. A European approach called SynPack was carried out. This approach aims at comparison of various packages of measures, which reinforce each other. Measures refer to maintenance, energy savings and/or use of renewable energy. The following five synergy measures were concerned at the renovation of the Prinsenflats: 1 - simultaneous improvement of the district area and renovation of the residential buildings, 2 - simultaneous improvement of the appearance and the energy efficiency of the residential buildings, 3 - replacement of individual open gas heaters by a collective heat pump boiler for hot water with ventilation air as a source, 4 - improved insulation, to make a lower supply temperature possible (as a consequence - improved use of condensing heat from exhausting air of the collective space heating boiler), 5 - tuned insulation measures and the existing construction possibilities.

The impact of the last three measures on the energy savings in practice has been closely monitored in one high-rise dwelling, called Johan-Friso, during one year (van de Bree, 2004). It turned out that the energy saving measures in the first year after the renovation led to a reduction of 51% of the primary energy consumption. Insulation measures are responsible for the majority of this reduction. The non-transparent parts have been upgraded to an average heat resistance of 3.0 m²K/W. Transparent parts were provided with so-called highly efficient insulating glass (with a U-value of 1.2 W/m²K). The ventilation has been secured by installing new registers in the window frames. The existing construction and the possibilities it offers were taken into consideration in designing the insulation, so that the insulation was optimised in a simple way.

Table 1. Impact of renovation of Prinsenflats with AES (van de Bree, 2004)

Impact	Energy consumption				Emission		Financial (index 2004)	
	Natural gas (m ³ /a)	Electricity (kWh/a)	Primary energy (GJ/a)	%	CO ₂ (ton/a)	%	Cost (Euro/a)	%
Before renovation	1.168.443	345.773	44.263	100	2.271	100	569.166	100
After renovation	511.112	407.850	21.730	49	1.142	50	292.722	51

The operating time and as a consequence the contribution of the heat-pump concept to the domestic hot water supply appeared to be below expectations. Besides a number of technical but solvable defects (in the first half year) the main reason was the supply-temperature of domestic hot water, which has been set at 65°C to prevent Legionella disease. This means that the heat-pump can only make a modest contribution (from 12°C to a maximum of 45°C), and auxiliary gas-fuelled boilers supply the rest. In spite of these problems 20-30% of the primary energy is saved compared to a less innovative concept, which offers an equal level of comfort. It appears that maintenance and control of functioning of an innovative system is essential to guarantee that the calculated energy savings are met or at least are as optimal as possible. A comparison of the annual energy-use as well as annual energy costs of the Prinsenflats before and after the renovation is presented in Table 1, based on an extrapolation of the monitored Johan-Friso building results.

CONCLUSION

The communication within a design team based on reliable facts is very important in the building process to achieve the set goals in time with a high quality building as a result. The proposed method for the implementation of feasibility studies of AES has been recognized based on a field trial in 7 EU countries as a very helpful tool for long-term planning of sustainable building and thus a promising support tool in facility management.

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