

# Feasibility studies for alternative energy systems in large new buildings: state of the art, possible barriers and how to overcome them?

Suzanne Joosen  
Ecofys the Netherlands BV  
The Netherlands  
S.Joosen@ecofys.nl

Klaus Hansen  
Danish Building Research Institute (SBI)  
Denmark  
klh@sbi.dk

Dr. Marjana Sijanec Zavrl  
Building and Civil Engineering Institute ZRMK (BCEI ZMRK)  
Slovenia  
marjana.sijanec@gi-zrmk.si

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## Abstract

Since 4<sup>th</sup> January 2006, all EU-countries are legally bound through the Energy Performance of Buildings Directive (EPBD) to include within their national legislation the requirement within article 5 for feasibility studies of alternative energy systems (AES). This covers new buildings with a total useful floor area over 1 000 m<sup>2</sup>.

It appears that the associated feasibility studies will be implemented in very divergent ways in EU countries. For example: In the Netherlands AES are integrated in the building calculation method. Strict energy performance standards have to guarantee that AES are taken into consideration during the design phase of a building. In Denmark, the obligation in article 5 is first of all handled in the regulations for the heat planning, but it is not emphasized in the building regulation. In Slovenia the environmental aspect of article 5 is implemented through the energy performance calculation method in a draft building regulation, while a complete, also technical and economic, aspect of feasibility studies will be prescribed in detail with separate specific regulations.

Usually a combination of barriers is responsible for hindering the use of AES. Barriers can be classified in three main groups: technical, financial and organisational. Core of the barriers is the estimation of risk on the part of the decision makers towards often unfamiliar, possible unreliable and expensive AES. For the market introduction of AES, it is important that during an early stage of the building process good insight in the technical and economic opportunities for AES becomes available. In

addition, good demonstration projects are essential to gain the confidence of stakeholders.

The requirement of feasibility studies brings along specific barriers, such as lack of clear objective procedures. Currently, only a few countries have initiatives in place to overcome these barriers. Exchange of knowledge and experiences on this topic is therefore strongly recommended.

## Introduction

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 service sector is about 432 Mtoe in the 25-EU member states (EC, 2006). Buildings in the households and the service sector absorb 39 % of the final consumption in the EU-15 countries. An overview of the energy consumption in buildings compared to other sectors is presented in figure 1 (Ademe, 2005).

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<sub>2</sub> 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 4<sup>th</sup> January 2006, all EU-countries are obliged through the EPBD to create within legal and administrative framework of the their building codes, minimum energy performance requirements, energy certification, calculation procedures,

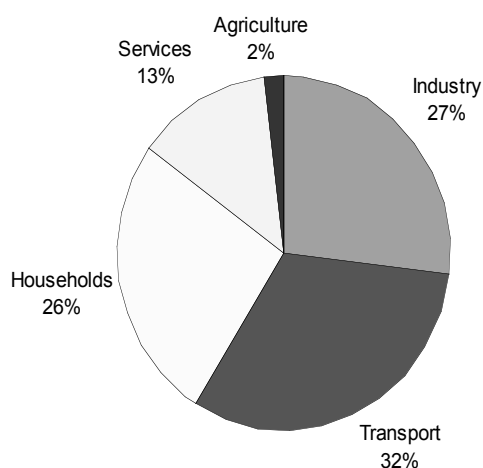


Figure 1 Final energy consumption by sector in EU15 member states in 2003 (Ademe, 2005)

feasibility studies requirements, inspection of boilers and air conditioning systems.

It is estimated that through these requirements a cost-effective savings potential is realisable by 2010 of around 22 % within the building sector. If this potential is realised, around 20 % of the EU Kyoto commitment can be met (Buildingsplatform, 2006). This is about 35-45 Mtonne CO<sub>2</sub> 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 given to the requirements for feasibility studies of alternative systems 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 1 000 m<sup>2</sup> Member States shall ensure that the technical, environmental and economic feasibility of alternative systems such as:*

- decentralised 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.

Several general bottlenecks for implementation of AES are already known: higher costs, lack of knowledge and confidence in new applications. Article 5 of the EPBD offers a unique framework to contribute towards diminishing the above-mentioned bottlenecks as through feasibility studies more actors will become aware of alternative solutions for their energy systems. Usually more than one bottleneck has to be dealt with. For instance, through studies environmental benefits and costs of alternative systems can be made clear. The gained knowl-

edge can lead to diminished confidence due to higher cost of a certain alternative energy system compared to a fossil based system. The next step can be to look for the specific opportunities of financing of the alternative energy system (e.g. financial support by banks or authorities, which are environmentally orientated).

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 methods for overcoming barriers in the realisation of AES in new buildings.

The project is started with making an inventory on how the seven European countries participating in the project (Denmark, France, Poland, Lithuania, Slovenia, Sweden and the Netherlands) are complying with the requirements of conducting a feasibility study for AES for new buildings and which policy they pursue to actively introduce this requirement. It is aimed to cover all 25-27 EU countries by the end of May 2007. In addition, an inventory is also made of the practices as possible barriers of the implementation of AES. This second inventory only includes the above mentioned seven countries.

This paper focuses on the first results of this inventory phase. Currently, only information of the seven countries participating in the project is available. As the final draft reports are planned to be finished end May 2007, the presentation at ECEEE-summer conference will include the latest information.

Based on the outcomes of the inventory phase, needed methods and checklist tools will be identified and developed to ensure that assessment of AES will become an integral part in the common planning process of new buildings. These tools will include technical, organisational as well as financial aspects. Possible and probable tools (indicative options) include: flow-charts for decision makers on how to handle AES in various situations; list of ideas for local authorities or real estate project developers on how to react to frequently raised objections from various market players; and list of favourable financing schemes including contact persons (at banks, funding organisations etc.). One of the issues which have to be taken into account is how an adequate consideration of environmental benefits of AES can be assured (e.g. CO<sub>2</sub> indicator).

A core element of the SENTRO-project is a field trial in which the developed methods/tools will be tested in The Netherlands, Denmark, Sweden, France, Lithuania, Poland and Slovenia. Finally, experiences are disseminated through courses and conferences towards the different target groups (e.g. national and international policy makers and key actors in the national building process).

Expected results of the project are:

- Insight into how to overcome barriers in the realisation of AES in new buildings in the participating countries;
- Several best practices examples of how to imbed feasibility studies of sustainable energy systems in the common planning process of new buildings;
- First recommendations for international, national and local policy makers based on the lessons learned from the evaluation of the early period of the EPBD.

**Table 1. Status of legal implementation of part of article 5 of the EPBD, concerning feasibility studies for alternative energy systems (AES) in buildings with a useful floor area over 1 000 m<sup>2</sup> in 8 EU-countries (January 2007)**

Country	Planned legislation or legislation in place to comply with the feasibility study part of the EPBD
Denmark	Municipalities are obliged to make heat plans (focus on district heating) based on feasibility studies. In certain areas there is an obligation for buildings to connect to a natural gas supply or district heating system. Low energy buildings are dispensed from this obligation.
France	The feasibility study part of the EPBD and its principles are planned in art. 27 of Energy Policy law (15/07/2007). A decree (draft status) is planned to be issued halfway 2007 and an application order is planned before the end of 2007. The law states that builders are liable to produce before the construction, a feasibility study.
Lithuania	There is no direct reference in present legal acts to do technical, environmental and economic feasibility studies of alternative systems before building construction starts. Designers and constructors should take alternative systems into consideration if they want to fulfil the requirement that new building should have at least C energy performance class.
Portugal	Based on a national study concerning all the systems that are listed in EPBD article 5, some systems (e.g. solar water heaters in residential sector) became mandatory, some systems must always be implemented under certain conditions, but designers have the possibility to carry out a study to show that they are not economically justified and other systems are not required and no studies have to be made by designers for their designs (Maldonado, 2006).
Poland	Polish parliament and government prepare one act, one decree and revision of three decrees to implement 2002/91/EC Directive. Obligations from art. 5 EPBD will be implemented in the Polish law as a revision of Decree of Ministry of Infrastructure from 3rd of July 2003 about scope and form of a building design. Due to elections the exact planning of the implementation process is still unclear.
Slovenia	Since 17 November 2006 the amended Energy Act includes the following provision: feasibility study has to be submitted as a part of design documentation when the request for building permit is submitted to the local administrative unit. The methodology for preparation of feasibility study shall be prescribed by the minister responsible for the environment (and buildings). Technical regulation is not in place yet, but it is expected before the end of 2007. A voluntary tool (Orodje VEM) for feasibility studies of biomass systems vs. d.h., heat pumps and other common energy systems was developed in framework of GEF project.
Sweden	The feasibility study part of the EPBD is included in the Swedish EPBD law which is valid from the 1 of October 2006. The National Board of Housing, Building and planning is responsible for the implementations. In their current suggested draft regulation the feasibility study part is not mentioned. A new draft of regulations is expected in February.
The Netherlands	Current building calculation methods already include AES. As it is planned that the building standard for non-residential buildings is becoming more stringent in the nearby future, it is expected that this will have positive effect on the implementation rate of AES. This is already the case for residential buildings. However, the level of the energy performance coefficient is based on cost-effective measures on average. This means that possibilities for collective systems and certain individual systems (such as heat pumps in combination with aquifers) are not taken into standard consideration. Therefore it is recognized by the governmental that additional support is necessary. So, additionally a voluntary method will be introduced and marketed through a website of the energy agency (SenterNovem).

The real value added of the project strategy is to influence national policies in an early stage with respect to implementation of AES. On the longer term it is aimed that for instance a developed checklist is adopted in the future revision of the EPBD legislation in several Member States.

### State of the art (in 8 EU countries)

In December 2006 and January 2007 buildings experts of several EU countries gathered information about the status of the legal implementation of the feasibility study part of article 5 of the EPBD (see acknowledgements). In table 1 an overview of the results of this inventory is shown. A thorough investigation of the legal implementation of the feasibility studies for alternative energy in new large buildings in all 27 EU countries is scheduled for the period February to May 2007. The outcomes will be downloadable from a website ([www.sentro.eu](http://www.sentro.eu)) and presented during the ECEEE summer conference 2007.

It appears that the feasibility studies from article 5 of the EPBD will be implemented in very divergent ways in EU countries. This is not surprising, as the ways to comply with European legislation depends for a large extent on national building practices and building legislation.

In Denmark the requirement is fulfilled by legislation which was already in place before the EPBD was coming into force. Most countries researched have legislation planned to comply with the EPBD requirements for feasibility studies of AES. In these countries it is often not yet completely clear how the requirements will be carried out in practice.

In Lithuania and the Netherlands the requirement of a feasibility study is integrated in the calculation method to determine the energy performance of a building. In order to fulfil strict energy performance standards, which are necessary to obtain a building permit, AES have to be taken into consideration. Several countries have or will developed specific methods regarding feasibility studies for AES. For example, in Slovenia

the environmental aspect of article 5 is implemented through the energy performance calculation method in a draft building regulation, while a complete, also technical and economic, aspect of feasibility studies will be prescribed in detail with specific regulation.

Portugal has chosen a pragmatic approach (Maldonado, 2006). A national study is carried out for all the systems that are listed in EPBD article 5. For typical market conditions, economics were evaluated and compared to a benchmark of 8 to 12 year pay back time. Based on the results of this study:

- Solar water heaters are mandatory in residential buildings, except when the roof is significantly shaded by external obstacles. As support booklets have been produced with the results of the study and advice on good design practices. Also manufacturers are required to provide a 6-year warranty and a regular maintenance service.
- In non-residential buildings, following systems, such as solar water heaters, if local biomass is available, biomass-based systems, geothermal energy in selected regions, autonomous systems based on renewable sources in remote locations, cogeneration systems for buildings over 10 000 m<sup>2</sup> and heated swimming pools and connection to existing local district heating and cooling systems, have to be installed, except if designers are able to show that they would have a payback period of more than 8 years.

In Ireland a national study on AES to meet the requirements of the EPBD has been carried out. The study will result in a software tool which will be freely available and can be downloaded from the internet. The tool will be designed for application at both the initial design stage and at the more detailed design stage. It is intended that use of the tool will be evidence that the feasibility of AES has been assessed for a development (SEI, 2006). Sustainable Energy Ireland (SEI) announced that this software tool will be available in 2007.

Finally, in the EPBD it specifies that AES needs "to be considered", but there is no obligation to implement AES. This means that member states have a choice in their national policy to comply with the feasibility study part of the EPBD: 1) to implement merely to achieve nominal compliance or 2) to implement proactively in a way that facilitates the tackling of barriers within the market. Currently, it is observed that already some countries -for example, Ireland, Portugal and Slovenia- have initiatives to actively use Article 5 to promote and realise AES in practice. In the Netherlands we see a mixture of both attitudes. The possibility of AES can be taken into consideration during the determination of the energy performance of a building. In practice this has led to the market introduction of for instance heat pumps with heat and cold storage in large new buildings of over 10 000 m<sup>2</sup>. However, the strict energy performance standard does not have effect for all buildings and all AES. This is recognized by the Dutch government and research is therefore being pursued with a view to promoting uptake on a voluntary basis with more building types and AES.

## Barriers

AES still are not automatically taken into consideration during the design phase of a building. What are the underlying reasons for this situation? The constraints of the realisation of AES, and especially renewable energy systems are studied in several EU-projects (within IEE, ALTENER programme, such as Build-On RES and OPTRES). Next to the outcomes of these studies, building experts in 7 EU countries are asked about their opinion on the main barriers of implementation of alternative energy study in their country. The results of this short investigation are shown in table 2.

In the period February 2007 to May 2007 the constraints and possible solutions are to be studied in 7 European countries (Denmark, France, Lithuania, Poland, Slovenia, Sweden and The Netherlands). The results will be described in a report, which will become available from a website ([www.sentro.eu](http://www.sentro.eu)) and will be presented during the ECEEE summer conference 2007.

Barriers can be classified in three main groups: 1) technical, 2) financial and 3) organisational. Furthermore a distinction is made between constraints in general and constraints on carrying out feasibility studies themselves.

For decision makers, it is first of all important to have insight in which energy systems are technically applicable with respect to the specific local conditions, such as geographic circumstances and availability of waste heat. Therefore it is necessary that there are sufficient specialised engineers and installers who have knowledge and skills concerning AES.

A second barrier can be that several AES have higher investment cost than systems based on fossil fuels. A number of countries have financial schemes in place to overcome this barrier. Unfortunately, often decision makers are not always fully aware of the possible ways to finance alternative energy projects. Next to investment cost, operational cost and especially energy savings have to be considered during the decision making process. In particular in the case of split incentive – the investor is not the owner of the system, and thus not benefiting from lower energy costs- it has to be looked after how the investor can earn his investments back.

Organisational constraints are the third category. For instance, long lasting permit procedures for certain AES. In countries in which the heating demand of a large share of the building stock is already based on collective heating systems, such as district heating and cogeneration, this often restrict the possibility for the realisation of other AES. Also the yield of district heating and/or cogeneration systems depends on a large extent on the number of buildings connected. In some countries this leads to a situation in which building developers are not free in their choice for an energy system.

In Slovenia, there are exceptions foreseen, where feasibility studies are not required due to other provisions related to the choice of energy system or energy source. Thus feasibility studies are not obligatory: for the buildings with energy supply already defined in the local energy concept, for the buildings, where the prescribed type of heating is prescribed by the minister responsible for energy in consensus with the minister responsible for environment (i.e. in specific areas of local communities and in particular industrial areas due to environmental, energy, technological reasons and for the buildings where

**Table 2. Main constraints to implementation of alternative energy systems (AES) (January 2007)**

<b>Constraint category</b>	<b>Constraints in general</b>	<b>Sources, countries*</b>
Financial	Higher cost	Build-On-RES, France, Lithuania, Poland, Sweden
(also organisational)	No certainty in pay-off (desegregation between ownership versus person benefiting from energy savings) in case of social apartment blocks, comparable low income of habitants	Build-On-RES, Slovenia, Sweden
(also organisational)	Unfamiliarity with ways of financing	Build-On-RES
	Uncertainties of economic conditions on longer term, e.g. feed-in tariffs electricity, prices biomass	Build-On-RES, Slovenia
Technical	Lack of knowledge/ lack of skills Unfamiliarity with techniques	Build-On-RES, France, Lithuania, Slovenia, Sweden and the Netherlands
	Only few examples in practice, few demonstration projects	Lithuania, Slovenia
Organisational	Burdensome administration or complex regulatory structures	Build-On-RES
(more specific cultural)	Conservative working methods/lack of will (investors, project developers, architects, engineers, installers, contractors)	France, Slovenia, Sweden
	Options for AES come too late in the picture of the design phase of a building	Denmark, Sweden, the Netherlands
	Lack of accessibility to knowledge/ lack of confidence,/ lack of skills	Build-On-RES, France, Lithuania, Slovenia, Sweden and the Netherlands
<b>Constraint category</b>	<b>Constraints especially regarding feasibility studies of alternative energy systems</b>	<b>Sources</b>
Financial	Additional time and cost of feasibility studies	France, Slovenia, Sweden
Organisational	Lack of political support, and/or not clear when legislation comes into force, and/or no direct obligation	Build-On-RES, Lithuania, Poland
	Lack of obligatory protocol for feasibility studies and related regulation	Slovenia
	Obligation/pressure to connect to existing district heating systems	Denmark, Lithuania, Poland
Organisational/Technical	Lack of comprehensive/integral tool to carry out feasibility studies	Slovenia

\*It is indicated if the specific constraint is reported by the expert in one of the seven countries studied. However, this does not mean that the barrier does not occur in the other countries as well.

the regulation at the local level (i.e. municipal decree) already prescribed obligatory energy source or obligatory connection to the specific energy network.

Most constraints are closely related to each other. For example, due to the conservative working method in the building sector the technical and economic opportunities for AES are often not taken into consideration in the beginning of the building process. As it appears from good practice examples, it is necessary for a optimal low energy building design to look at the complete picture of building physic energy measures (such as insulation) and energy efficient installations. This is also true from an economic perspective: the installed capacity of the system has to fit the low energy demand (i.e. oversized installed capacity brings along higher costs). This means that the overall low energy concept (buildings shell, HVAC installations) has to be an integral part of the building design phase.

It can be concluded that it is a combination of barriers (types) which are responsible for hindering the use of alternative energy technologies in the built environment. Obviously, the influence of barriers varies per technology applied and per

country. For instance, long lasting permit procedure for heat pumps based on ground /surface water and CHP based on biomass are important constraints in the Netherlands (OPTRES, 2006). In other countries, such as Denmark, this constraint is of minor importance.

At the heart of the barriers is the issue of risk, perceived or real, on the part of the decision makers towards what are often regarded as unfamiliar and possible unreliable and expensive AES. So for the market introduction of AES it is important that there are mechanisms and incentives in place which are addressed at overcoming all barrier types: technical, financial as well as organisational.

**Possible solutions to overcome barriers**

The next step, after identifying the barriers of implementation of AES, is to see how these barriers can be overcome. There are some studies available which already look into possible solutions paths to tackle the barriers (Build-On-RES, 2004); (OPTRES, 2006). Often these studies concentrate on one specific

**Table 3. Several possible solutions to overcome barriers of implementing alternative energy systems (AES) (January 2007)**

<b>Constraint category</b>	<b>Solutions in general</b>	<b>Main barrier to tackle*</b>
Financial	Financial support, tax incentives	Higher cost
Technical/Organisational	Guidelines, tools, education and training	Lack of knowledge /confidence/ skills Conservative working method/ lack of will
Organisational	Energy performance regulation But avoid mandatory application of specific techniques	Options for AES come too late in the picture of the building process
Technical/Financial/ Organisational	Demonstration projects, good practice examples	Lack of knowledge/confidence
<b>Constraint category</b>	<b>Solutions/tools especially regarding feasibility studies of alternative energy systems</b>	<b>Main barrier to tackle*</b>
Financial/Technical/ Organisational	One national study to see which systems can be made mandatory, and which systems are mandatory under certain economic and surrounding conditions (Portugal approach)	Time/cost feasibility study, Lack of protocol Lack of knowledge / confidence / skills
Financial/Technical	EPBD-hub, calculation software tool giving insight at various levels of possibilities of various AES (under development in the Netherlands)	Time/cost feasibility study Lack of knowledge /confidence / skills
Financial/Technical	Orodje VEM, calculation software tool for technical, environmental and economic evaluation of AES (shall be upgraded in Slovenia)	Time/cost feasibility study Lack of knowledge /confidence / skills
Financial/Technical	PASSES, calculation software tool (under development in Ireland)	Time/cost feasibility study Lack of knowledge /confidence / skills

\*In this column it is indicated to which main constraint the solution is addressed. Often a solution influences more barriers at the same time. For example financial support will also diminish the risk of the project and the lack of confidence.

alternative energy system (for example heat pumps in Groundhit project (Novak, 2006). Possible solutions and which main barrier they are addressed to overcome are presented in table 3. In addition, the first results are presented which calculation tools are already available or being developed regarding feasibility studies of AES in various European countries.

The findings show that there are solutions for all three groups of barriers. Some solutions paths address two or more barriers at the same time. For instance, to gain the confidence of key actors in the market good demonstration project of the implementation of AES are of great importance. It was one of the key factors for the success of the building code in the Netherlands. Each time the standard for the energy performance level was set higher, demonstration projects showed, before the introduction of the new standard, that it was possible to meet the standard with no or small additional cost and with measures which were technical properly functioning in practice. In this way commitment of most stakeholders was created (Ecofys, 2006). Experiences in Denmark are the same: a precondition for a cultural change in the building sector towards new solutions is that a number of well respected actors changed their attitude first ("market leaders" or "early adopters"). This also means that introduction of new solutions in the building practice very often takes time.

As it appears many countries are in the beginning phase of complying with the feasibility study requirement of the EPBD. In a few countries (e.g. Portugal, Ireland, Slovenia and the Netherlands) there initiatives to develop tools which support the legislation concerning the feasibility study part of the EPBD. The tools have in common that they all address more barriers types at the same time. Because it can be expected that the legislation will go into force the coming years, it is strongly recommended to take care of a good information transfer of knowledge and experience gained during this starting period between all EU member states.

### Conclusions so far

Till now the focus of the EPBD concentrates on the calculation and certification methods for the energy use of new and existing buildings. Less attention has been given to the requirements for a feasibility study of alternative systems (AES) for new large buildings. Most of the countries studied are planning to have legislation regarding this aspect of the EPBD in place before the end of 2007.

It appears that feasibility studies of AES will be implemented in very divergent ways in EU countries. A rough distinction can be made between countries in which where separate feasibility studies are needed at the request for a building permit (Slovenia, France) and countries in which the requirements of feasi-

bility studies are incorporated in other procedures. An example of the latter approach is an indirect obligation by requiring a strict energy performance standard as precondition to obtain a building permit in the Netherlands and Lithuania. In addition, some countries (Denmark, Lithuania, Portugal and Slovenia) have obligations that under certain conditions alternative systems, such as district heating, have to be implemented.

However, the elaboration of how the feasibility study requirements will exactly be carried out in practice is usually still unclear.

At the moment, the technical and economic opportunities for AES are generally not taken into account as standard practice during the building design. Barriers can be categorised in three groups: technical, financial, and organisational. It can be concluded that it is often a combination of barriers (types) which are responsible for hindering the use of AES in buildings. For the market introduction of AES, it is essential that there are incentives in place which are addressed to overcome all these barrier types.

Already possible solutions to overcome these barriers are observed. Some solutions - such as good practice examples, education and training - address to more than two barriers at the same time.

The requirement of feasibility studies brings along specific barriers, such as lack of protocol (clear objective procedures etc.). Currently, it looks that there are not many tools and solutions in place to overcome these specific barriers. Because many countries are still in the beginning phase of complying with the feasibility study requirement of the EPBD, information transfer between EU member states is strongly recommended. This will also include information of methods to overcome barriers to the realisation of AES in practice, through best practice examples of how to embed feasibility studies of AES in the common planning process of new buildings.

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