

Energy+ pumps – Technology procurement for very energy efficient circulation pumps, first results of the current IEE-project

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Abstract

About 2 % of the overall electricity consumption of the EU is caused by circulators in single or double family homes and flats. A new technology of pumps with electronically commutated (EC) motor pumps is available now; it is one possible way to achieve a reduction in circulator annual electricity use by 60 % or more.

The project’s objective is a market transformation towards this new very energy-efficient pump technologies – Energy+ pumps – for circulators in heating systems, both stand alone and integrated in boilers. Only few manufacturers have so far introduced the new pump technology to the market for single or double family homes and flats.

To bring more products to the market from all major manufacturers, the project will adapt and apply the technology procurement methodology as it was very successfully tested in the European Energy+ project on energy-efficient cold appliances [5] [6].

Large buyers will be aggregated, to activate the pump and boiler manufacturers. Sales and training materials and a sizing spreadsheet software for installation contractors will be developed and applied. A competition both for energy-efficient products and marketing campaigns will be organised and the information on the Energy+ pumps will be disseminated widely through website, newsletter, media, and fairs.

This paper gives a short overview of this project and presents the results of the first project phases: a European wide market

study on circulators and heating systems, and the first Energy+ lists for circulators, buyers and supporters.

Introduction

In the EU-27, the electricity consumption by circulators for heating purposes in households amounted to about 50 TWh per year. This is caused by over 100 Million circulators, most of them with a power input below 250 W. But private households often do not even know that they have a circulator in their heating system, much less do they know that the circulator is responsible for 5 to 10 % of their electricity bill. As long as their rooms get warm, they don’t care about this and trust their installer that he or she installed a good system. The consumer does not know the electricity costs he or she has to spend for running the circulator and if he/she knew, he/she also might not care because the absolute amount of money of about, say, 60 Euros per year is not so high that the consumer would try to spend much effort to minimise this.

For society, however, the energy used by circulators in all types of buildings is equal to about 2 % of the overall electricity consumption and causes CO₂ emissions of more than 30 million tons per year, so efforts to minimise this would be worthwhile both for economic and for climate change mitigation reasons.

POTENTIALS

A typical circulator used in European heating systems has a power input of 80 to 100 W. Several studies show that this is far oversized (e.g. [1], [2], [3]). Installation contractors tend to install a big pump so as to receive no complaints from their customers; the contractors do not have to pay the electricity

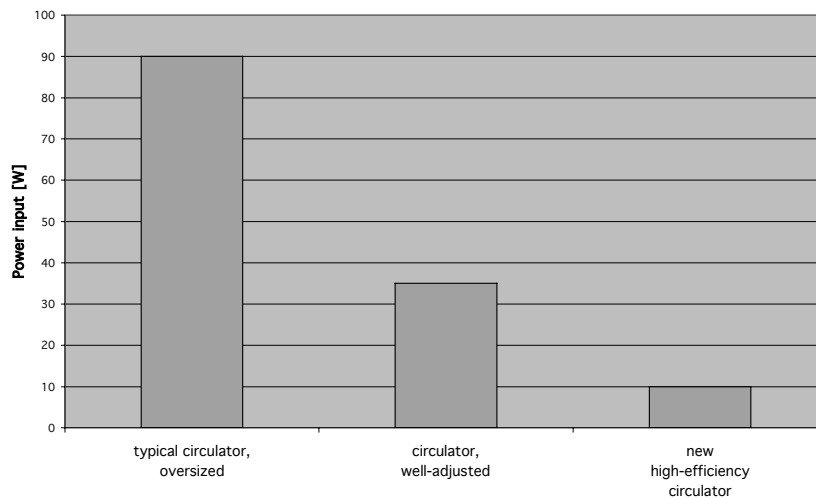


Figure 1. Comparison of the input power of different circulators. Source: [2]

bill. Normally, a smaller pump would be sufficient in a heating system. An additional issue is the hydraulic balance: A correct hydraulic balance secures the same heat supply to all radiators. If the heat supply is uneven, a stronger pump will be necessary to compensate this. So, if the hydraulic balance were correct in a heating system, which is not the case under normal circumstances, even a smaller pump could be installed. For the above mentioned example, a conventional technology circulator with 35 W will be sufficient [2].

For a number of years, a new technology of pumps with electronically commutated (EC) motor pumps has been available. By this high-efficiency circulator, a reduction in circulator annual electricity use by 60 % or more is achievable. In our example, the new technology would only need 10 W of power input for a well-adjusted heating system with hydraulic balance performed [2]. Figure 1 shows a comparison of the possible savings compared to a typical situation.

This new high-efficiency circulator, that was first developed by the Swiss manufacturer Biral in 2000 and brought to the market soon afterwards (see Fig. 2), would save about 1 % of current EU electricity consumption, that is 30 TWh/year, and reduce CO₂ emissions by at least 20 million tons per year. For the first few years, this new pump was not very successful on the market. It was caught in a vicious cycle of high initial prices and low production numbers. Therefore, Biral remained for a number of years the only manufacturer to have introduced the new pump technology to the market for single or double family homes and flats. Only in the autumn of 2005, the two European pump market leaders, Grundfos and Wilo, entered the market with a similar pump. With an end-consumer price of about 300 Euros, the price is still high but much more affordable now.

The Energy+ Pumps project

Though the conditions for the introduction of the new technology in the market are given now, there exist a lot of barriers. Current market barriers include a high initial price (300 Euros) due to low production numbers, low customer interest caused by the fact that not the final customer but installation contractors or even boiler manufacturers are usually choosing

the pump, and vendors selling to the final customer on product price only.

This is a notable difference to the market for medium-sized circulators (200 to 400 Watts of input power, for office and other larger buildings), for which major manufacturers (Grundfos, Wilo, Biral, Smedegaard; KSB) all have a range of EC motor pumps on the market. The reason is that this is a market of institutional buyers that specify the pumps themselves and are used to economic calculations, hence easier to convince than the single homeowner.

The Energy+ Pumps project is, therefore, mainly targeting the market for the small-scale circulators, to foster the market entry and uptake of these.

The short-term objective of the project is, therefore, to bring even more products to the market (our target is that at the end of the project the lists should hold at least 10 pumps for space heating and sanitary hot water by at least 3 manufacturers, and at least 10 condensing or low energy boilers with the new pump built in), to support their rapid break-through in the market and thereby to reduce their prices through mass production. According to one manufacturer, an annual production volume of 30,000 to 40,000 pumps would be needed to start mass production and bring down prices.

We expect that the project will contribute to bringing small-scale Energy+ circulators to the market for single or double homes and flats from all major manufacturers, and to reducing the price premium over conventional electronically controlled circulators for that market to less than 50 % or 60 Euros. A conservative estimate is that the buyers aggregated by the project might purchase 10,000 Energy+ pumps during the project; this would save 2.5 million kWh per year. If at the end of the project, a market share of 5 % has been achieved, it will mean annual savings of 100 GWh/year from the products sold in that year alone.

This will be achieved through the methods of technology procurement that have been successfully tested in the European Energy+ project for energy-efficient refrigerators and freezers, co-funded by the SAVE programme (cf. [5] and [6]).

The project's approach is, therefore, to bring together institutional buyers such as housing companies, intermediate buyers

such as boiler manufacturers, installation contractors and their associations, and pump manufacturers to build mutual trust:

- confidence for the pump manufacturers in the existence of a market demand large enough to start mass production,
- confidence for installers and boiler manufacturers that it will be feasible and easy to convince final buyers of the benefits of the new pumps,
- and buyer awareness of the benefits of the new technology and confidence that a supply at appropriate prices will be feasible.

The methodology of technology procurement therefore implies an active co-operation with the following target groups.

- On the demand side of circulators: particularly large institutional buyers to sign procurement declarations, but potentially all building owners as purchasers of the new kind of pumps, or boilers that have these pumps built in;
- On the supply side of circulators: pump and boiler manufacturers, as well as installation contractors and their associations;
- For support of the dissemination of information: further national, regional, and local energy agencies than those already in the consortium, environmental and consumer NGOs, energy companies, associations of building owners and market participants, and other organisations interested in the subject.

Potential large institutional buyers have been approached and invited to sign a procurement declaration. This either concerns an indicative number of pumps, e.g., for replacement, or of boilers that have the new pumps integrated. Final customers buying such pumps in larger quantities could be big housing companies. Apart from bigger multifamily buildings where the bigger pumps are needed, they may also have blocks of smaller multifamily or even row houses, or they may have heating systems by apartment (with wall-mounted boilers). In the bigger multifamily houses, such small pumps could be used in sanitary hot water circulation systems. Although the small circulators are at the focus of this project, the procurement declarations also include medium-sized circulators (up to 300 Watts of input power) used in bigger apartment blocks, office, and other larger buildings, in order to achieve synergies.

The pump manufacturers have been invited to develop and launch to the market pumps fulfilling the criteria developed by the project, and to present them to the Energy+ team for inclusion in lists of qualifying products. They are also expected to actively market their products once they are on the market.

Boiler manufacturers have been contacted, too. They are in an intermediate position as buyers of the pumps, but manufacturers of products that are sold to the final customers. Hence, they must see a potential market for boilers with the efficient pumps integrated, in order to become buyers for the pumps. The project will build their trust in such an initial market.

Finally, further energy agencies, environmental and consumer NGOs, energy companies, associations, and other organisations interested in the subject have been invited to support the project with publicity. Governments and energy compa-

nies might also support the market uptake of the new pumps with financial incentive programmes. This will indirectly target the whole market of all building owners in order to achieve a wider market break-through for the new energy-efficient circulators.

To further support this process and increase sales volumes, installation contractors must be integrated in the project. They too must be convinced that there is a market for the new pumps and that it is worth the effort to actively sell them to their customers. For this purpose, they must receive easy-to-use materials to convince their customers and be trained about selling the efficient pumps based on life-cycle costs. The project will develop and disseminate such materials as well as a software tool for proper sizing of circulators, and a training seminar. In order to achieve synergies, this will cover both the small and medium-sized circulators.

The project will actively co-operate with professional training agencies, institutes and organisations, associations of installation contractors, and pump and boiler manufacturers to organise the training seminars.

None of the primary market agents (buyers, manufacturers, installers) are Members of the Consortium. The reason is that the Co-ordinators of a technology procurement at European and national level must be independent from those directly involved in the target market.

All of these market agents have been actively involved in the project from the beginning. Their interest in the project and its objectives has been stimulated during the first work package with direct information and interviews. They have then been invited to sign procurement declarations, support declarations, or to file products to the lists. The participants and products will be featured on the website and the other publicity organised by the project. As has been described above, the different target groups – manufacturers, supporters, associations of installers – will also be actively involved in the dissemination of project results.

The project will also enable a field-test of the appropriateness of the method for classification of circulators proposed by the European manufacturer organisation Europump. The consortium will also actively seek to co-operate with Member State governments and energy suppliers about potential financial incentive programmes and awareness campaigns. E.g., the new pumps could be targets for energy efficiency programmes in the framework of the Italian White Certificate system, or the obligations for Flemish grid companies, or the Energy Efficiency Commitment in the UK.

Furthermore, in the context of the EU Directive on the overall energy performance of buildings, reducing the electricity consumption for the circulator will make it easier to achieve the primary energy performance targets for new and refurbished buildings.

The ultimate long-term objective is to transform the market so that the new technology will become the standard technology, at prices close to those of today's pumps. This seems feasible, since the new technology enables smaller pumps and hence requires less material, and the extra costs of the electronic controls are constantly decreasing.

Table 1. Typical water-based heating systems with important market shares in the examined EU Member States

Typical water-based heating system	Annual hours of use	Countries where the heating system is applied
Condensing or low-temperature gas boilers, wall-mounted , with modulating burner , for use in systems with thermostats, small circulator integrated	2,500 to 5,000	Austria, Germany, France, Italy
Conventional gas boilers, wall-mounted , with on-off control , for use in systems with room thermostats, small circulator integrated	1,900 to 2,500	Austria, Belgium, Spain, France, Greece, Italy
Floor-standing oil or gas boilers (1- or 2-family houses), with control by outdoor temperature , small circulator stand-alone	5,000 to 8,760	Austria, Belgium, Czech Republic, Germany, Spain, Finland, France, Greece, Italy
Floor-standing oil or gas boilers (1- or 2-family houses), with on-off control , small circulator stand-alone	2,500	Austria, Belgium, Czech Republic, Spain, France, Greece
District heating substations (standardised, 1- or 2-family houses), with small circulator integrated	8,760	Austria, Finland
District heating substations or collective heating system, medium-sized circulator stand-alone	4,500 to 8,760	Austria, Belgium, Czech Republic, Germany, Spain, Finland, France, Italy
Heat pumps (standardised, 1- or 2-family houses), collector and heat distributor pump integrated	3,000 (collector), 8,760 (distribution)	Austria, Spain, Finland, France, Greece

Table 2. Typical water-based heating systems: annual average circulator energy consumption (kWh/year)

Type of system	AT	BE	CZ	DE	ES	FI	FR	GR	IT
gas, wall-mounted, modulating	300		325	290			50		
gas, wall-mounted, on-off	250	163	210		220		300 – 450	135	125
oil, or gas, floor-standing, continuous circulator operation	450	570	490	540	450	440	50 – 100	368	500
oil, or gas, floor-standing, on-off	250	163	200		220		300 – 450	240	
District heating substations, standardised	1000		300 – 1,200			440			
District heating substations/collective heating, individual	300	1,800	600 – 1,540			880 - 1,300	75 – 125**		17,000
Heat pumps	300		650			1,790*	100	300	

* includes both collector circuit and heat distribution circulator

** average consumption per household

Results of the European wide market study on circulators and heating systems

The project partners carried out interviews with different stakeholders. On the supply side, all major European pump, boiler, district heating substation and heat pump manufacturers were interviewed. As the project design puts emphasis on the demand side, housing companies and other institutional buyers were approached. And to get a complete picture of the market, wholesale companies, installers, end-users and their associations were involved as well. In total, more than 140 interviews were made.

The heating market structure revealed itself as very diverse over Europe. The typical water-based heating systems that are used in the different countries are summarized in the following table.

The following tables summarize the annual average circulator energy consumption for the different heating systems, the stock and sales of circulators and the potential energy savings in heating system circulators.

TARGET GROUPS FOR POLICY, INCENTIVES AND INSTRUMENTS

A further result of the market study was that our assumptions on the market structure (Fig. 2), the functioning of the market (cf., e.g., table 6, showing the decision-makers in circulator or boiler purchases), and the market barriers for the important actors were generally confirmed. The project design and the elements of the co-operative procurement process proposed for the project were, therefore, confirmed with only minor adjustments as well. But the interviews also provided ideas about further complementary actions that could be implemented, e.g., by organisations joining the project as supporters.

Within the Energy+ pumps project design, the procurement aspect is crucial. Therefore, the end-users, private end-users like homeowners and tenants, as well as institutional buyers like rented housing companies, building developers, and district heating companies, are a very important group in achieving the objective that high efficiency pumps will become the standard in future.

Table 3. Typical water-based heating systems: stock of circulators (millions)

Type of system	AT	BE	CZ	DE	ES	FI	FR	GR	IT
gas, wall-mounted, modulating	0.2			4.6			0.17		0.12 - 0.24
gas, wall-mounted, on-off	0.45	1.0			7.3		6.3	0.6	8.4
oil, or gas, floor-standing, continuous circulator operation	0.8	0.34	1.4	8.6	3.1		3.3	0.6	2.6
oil, or gas, floor-standing, on-off	0.5	3.07	2.1		3.1		3.3	2.5	
District heating substations, standardised	0.33								
District heating substations/collective heating, individual	0.25	0.05			0.1				0.05
Heat pumps	0.45				1.5		0.19	0.3	

Table 4. Potential energy savings in heating system circulators (TWh/year)

Type of system	AT	BE	CZ	DE	ES	FI	FR	GR	IT
Small, stand-alone	0.39	0.35	0.45	3.3	0.4	0.35	1.4	0.12	0.7
Small, integrated in wall-mounted boiler	0.1	0.15	0.15	1.0	>0.9		1.6		0.7
Medium-sized (residential only)	0.31	0.06	0.25		0.2	0.05		0.11	0.4
Total	0.8	0.56	0,85	4.3	1.8	0.4	3	0,23	1.8

Table 5. Sales of circulators (1,000s/year)

Type of system	AT	BE	CZ	DE	ES	FI	FR	GR	IT
Small, stand-alone or replacement	110	130	95	650	110	40	380	235	312
Small, integrated in wall-mounted boiler	46 + 20?	120	70	350	480		610	42.5	800
Small, integrated in DH substations						2.6		1	
Small, integrated in heat pump	4				150	2	3.5		
Medium-sized	4 + 38 non-res.	3?			40	4.5		13.3	

The market study revealed a lack of information on the end-users' side. Often end-users even did not know the new efficient pumps. To overcome this, information about these pumps and the benefits for end-users needs to be spread. Financial incentives for purchase, given for a couple of years, would be important as well to create a demand. Although there usually exists a net financial benefit over the lifetime of the efficient circulator, the initial costs are high and may prevent end-users from buying it. For institutional buyers, the recognition as a good landlord or landlady, who cares for his/her tenants, might be an additional incentive.

Instruments to address end-users include information campaigns and advice. The Energy+ lists of high efficiency pumps and heat generators will certainly be useful for that purpose. The Europump voluntary circulator label and the building certificates are also considered important instruments, as the latter gives strong arguments to contractors to convince the end-users. For institutional buyers, guidelines and training for plan-

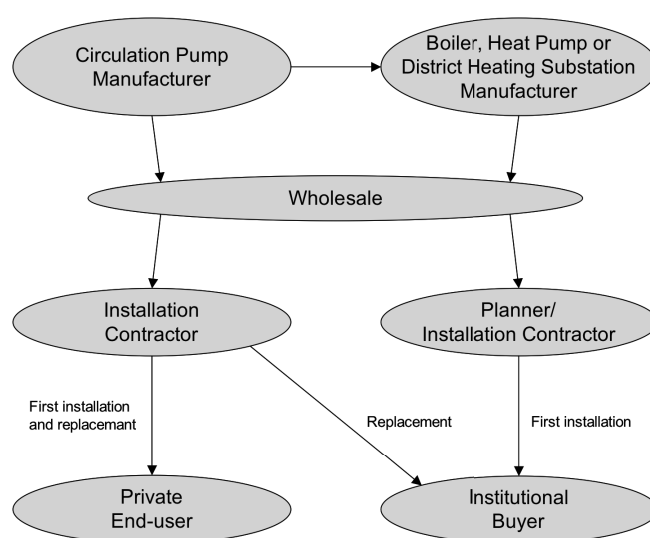


Figure 2. Product flow of circulation pumps

Table 6. Typical water-based heating systems: usually, who makes the decision?

Type of system	First installation	Circulator replacement
gas, wall-mounted, modulating	Boiler manufacturer + planner (MFH) or contractor (SFH)	Installation contractor
gas, wall-mounted, on-off	Boiler manufacturer + planner (MFH) or contractor (SFH)	Installation contractor
oil, or gas, floor-standing, continuous circulator operation	Planner (for development company) or contractor (SFH)	Installation contractor
oil, or gas, floor-standing, on-off	Planner (for development company) or contractor (SFH)	Installation contractor
District heating substations, standardised	Manufacturer + planner	Installation contractor
District heating substations/collective heating, individual	Planner (specifications), contractor (choice of brand)	Installation contractor
Heat pumps	Manufacturer + planner or contractor (SFH)	Installation contractor

SFH = single family house, MFH = multi-family house

ners, but also voluntary agreements and co-operative procurement actions are very important.

One of the most important links within the product flow are the installation contractors and planners. They need demand from informed customers. Information about the benefits and costs of Energy+ circulators will help them to convince their customers. A related issue is that there should be no additional time effort linked with selecting, selling and installing the new efficient technology and that they can trust in its quality. For this to achieve, the circulator label, the building certificate and the Energy+ lists are very helpful. But even more, the installation contractors need professional training and easy-to-use planning and selling tools. Publicity on pilot projects to prove the quality and energy cost savings of the new technology can add to these instruments. A further incentive for installation contractors to sell the high efficiency circulators may also be a quantity discount from manufacturers.

The wholesale companies are considered to be more or less neutral towards the new technology. But they can very easily distribute information materials from manufacturers and independent information. Moreover, they can achieve a quantity discount from manufacturers as an incentive to stock Energy+ circulators and heating units, and to market them to installation contractors.

The pump and boiler manufacturers must see that there is a demand from the end-users for the high efficient pump. Besides private end-users and institutional buyers, boiler manufacturers can act as kind of institutional buyers for pump manufacturers. They could conclude a voluntary agreement to integrate the high efficiency circulators into their boilers. Manufacturers also can achieve a high recognition as provider of high-quality, high efficiency products. The circulator label, the Energy+ lists and the Energy+ award will reinforce this effect. Particularly the Energy+ awards for the most energy-efficient circulators and the heating units with the lowest circulator energy consumption will provide such recognition.

And last but not least, energy companies with obligations to save energy can support high efficiency circulators if they get the allowance to include these pumps in measures to fulfil the obligation.

CRITERIA FOR PRODUCTS

Circulators

During the market study, criteria for qualifying circulators and boilers have been developed.

The focus of the project is clearly on small heating circuit pumps as used in apartments, single family houses and small flats. However, medium-sized circulators for use in multi-family houses and smaller non-residential buildings are also included.

Other areas of application for small pumps, such as hot water circulation pumps, solar collector circuit, or heat pump source circuit pumps will at least in the beginning not be presented in the Energy+ product lists. They may, however, be treated in training and information materials.

To define the energy efficiency of stand-alone circulators, the project applies the load profile and classification of the Europump Labelling Scheme [4].

- The minimum energy efficiency required is equivalent to Europump Label Class A for heating circuit pumps.
- The upper size limit is given by: $P1 \text{ (max.)} = 300 \text{ W}$ ($P1^1 = \text{electric power consumption}$).

Heating units

To establish an overall efficiency rating of heating units seems to be a very complicated task, not to be accomplished in the framework of the Energy+ Pumps project.

Therefore it was decided to include units (gas boilers, oil boilers, premanufactured district heating substations) with a high thermal energy efficiency and to treat the circulator efficiency of these heating units by the declaration properties of the built-in or attached pumps.

The minimum energy efficiency required, therefore, concerns requirements for the thermal energy efficiency as well as the circulator energy efficiency.

- Gas and oil boilers have to be condensing boilers.

1. $P1 \text{ (max.)}$ as declared in data sheets is hardly different from $P1$ in the operation point of maximum hydraulic power and can therefore be taken as the significant value for setting the size limit.

Table 7. Categories of circulators on the Energy+ Pumps lists

Range from – to (m ³ /h)	associated heating system type*
0 1.85	flat, apartment, single family house
1.86 2.35	large single family house, up to 6 flats/ apartments
2.36 more	more than 6 flats/ apartments or equivalent commercial building

* very well insulated buildings need a 50% lower flow rate

- Heat pumps and district heating substations are not yet included; these will follow, when a minimum thermal efficiency can be defined.
- Regarding the circulator energy efficiency, the manufacturer of the heating unit has to declare that the unit has a circulator built in or packaged that would qualify for Europump Label Class A if run and controlled like a stand-alone circulator.
- To avoid a forced circulation inside the unit, the maximum allowed internal hydraulic resistance of a unit at nominal flow rate must be limited to 50 mbar.

THE FIRST ENERGY+ LISTS FOR CIRCULATORS, BUYERS AND SUPPORTERS

A core element of the Energy+ project are Energy+ lists of qualifying pumps and heat generators, of institutional buyers and of supporting organisations. The first lists were presented at the ISH trade fair in Frankfurt, the world's leading trade fair for bathroom, building, energy, airconditioning, on March 6, 2007.

To provide an easy overview for the users of the lists (installers, planners, some end-users), subcategories of circulators are made to split the lists by pump size. The size measure for splitting should be the flow rate, as the flow rate is the first dimensioning measure to set for a pump, and it is well-known to users. The head results from the circuit properties and pump settings. At starting to view a list, the fundamental dimensioning procedures will be explained.

Flow rate categories will be defined as follows; the values given meaning the flow rate at the operating point of max. hyd. power.

The units lists are also split into subcategories for different applications, such as flats, single family houses, and multi-family houses.

At ISH, the project team could present a list of 19 highly efficient pumps of five manufacturers (Askoll, Biral, Grundfos, Smedegaard, Wilo) covering all three categories. This represents almost the whole market choice. Moreover lists with 12 supporters and 6 institutional buyers could be presented, which can be regarded as a promising starting point.

Conclusions

In order to reduce the energy consumption in the EU, many energy end-use efficiency technologies and potentials have to be used. The Energy+ Pumps project is targeting one of the easiest, most cost-effective technologies available for this target – the new generation of highly efficient EC motor pumps. The market study done as the first step of the project has confirmed

the existing energy saving potentials assessed for this technology by recent studies.

A further result of the market study was that our assumptions on the market structure, the functioning of the market, and the market barriers for the important actors were generally confirmed. The project design and the elements of the cooperative procurement process proposed for the project were, therefore, confirmed with only minor adjustments as well. The work programme was adapted accordingly.

The pump manufacturers played an active role in the project and supported it quite well. But also the feedback of supporters and institutional buyers is very promising for the next steps of the project as the launch of the Energy+ award, training of installation contractors and further dissemination.

References

- [1] Bidstrup N. Promotion of Energy Efficiency in Circulation Pumps, especially in domestic Heating Systems. EU SAVE II Project, 2001, can be downloaded at: www.eci.ox.ac.uk/lowercf/eusave_circulation.html
- [2] Nipkow J. Klein-Umwälzpumpe mit hohem Wirkungsgrad. Bundesamt für Energiewirtschaft, 1994
- [3] Wolff D., Jagnow K. OPTIMUS –Optimal Energie nutzen, Technische Optimierung und Energieeinsparung. Deutsche Bundesstiftung Umwelt 2005
- [4] Europump Industry commitment to improve the energy performance of Stand-Alone Circulators, 2005
- [5] STEM energy+ Aggregated purchase of energy efficient refrigerator-freezers at European level. EU SAVE project 2001
- [6] SenterNovem 2E+ Procurement on very efficient white goods. EU SAVE project 2005