EuP Lot 11 Preparatory Studies

Circulators in buildings

21 June 2006

Inception Report to European Commission

Title	EuP Lot 11 Preparatory Studies Circulators in buildings (Steps 1-3)
Customer	European Commission
Customer reference	TREN/D1/40-2005/LoT11/S07.56639
File reference	N:\FES\Projects\International\ED02287 EuP Motors\Working files\Circulators
Report number	ED02287
Report status	Issue 1.1

AEA Technology plc
Future Energy Solutions
Harwell
Didcot
Oxfordshire
OX11 OQJ
Telephone +44 (0) 870 190 6034

AEA Technology is the trading name of AEA Technology plc
AEA Technology is certificated to BS EN ISO9001:(1994)

	Name	Signature	Date
Author	Charles Gaisford		
Reviewed by			
Approved by			

Introduction

The purpose of this introduction is to provide a short summary of the context of this inception report

The EuP Directive and the Preparatory Studies

The Energy Using Product (EuP) Directive allows the European Commission to implement (unspecified) measures to reduce the eco-impact of energy using products within the EC. Products that do comply with these measures may have the CE mark attached, those which do not could ultimately be prohibited from being traded within the EC.

This Directive goes beyond just energy efficiency considerations, as it also considers whole life cycle costs, including production and disposal costs. It can therefore be thought of as "energy efficiency, but not at any price."

A previous EC-funded project, undertaken by VhK, has designed a MEEUP methodology that gives eco-weightings for all key environmental factors, (energy, waste, water, emissions to air, emissions to water). This preparatory study is essentially about collecting the data for inputting to this model, and comprises economic, material and energy use data. The model just requires the input of this information in a structured way, and uses an internal database to convert material quantities from product Bill of Materials (such as grammes of types of plastic, metal and other materials) in to standard ecofactors.

The Inception Reports

These Inception reports all follow the prescribed sequence of headings in the MEEUP methodology. At this early stage the focus is on collecting the data for steps 1-3, which will give the evidence base for making the important decisions regarding the precise types of product to be considered. In particular we have focussed on collecting and analysing market sales statistics for the different varieties of product, and so at this stage have not completed collection of data on all eco inputs, especially those that are not related to energy considerations. This is largely because of the importance of energy consumption in life cycle eco impact, and because such data is more readily available.

In summary, the methodology is to start by considering all types of sub-product within each of the four categories within this Lot. So for pumps the first level of split is into reciprocating and centrifugal pumps, which are then broken down even further into sub categories. By looking at market data, the sub categories that are significant can then be identified.

The EuP gives indicative annual minimum sales within the EC of 200,000 units pa as the threshold for products to be within the scope of the Directive. Our interpretation of the wording of the Directive is that the flexibility allows us to include high eco-impact products that fall just below this threshold, and similarly exclude low eco-impact products that are just above this threshold. We will not though understand the eco-impact of different sub-products until we have started the analysis, and so there will be some iteration before we are able to make a final decision on the products to be included in our work.

The next step of the work is to select the precise specifications of products to be used to create the "basecase reference model". This is one that can be considered representative of a whole class of products, and should represent the "typical" case that we expect will be sold in three years time. This projection is necessary so that any implementing measures relate to product available at the anticipated time of introduction. For the products in Lot 11, we suggest that a “small” and ”large” model are necessary such that the manufacturing and other issues associated with all products within the product class are represented. In order to facilitate discussion, we have wherever possible made suggestions as to what the specification of these models should be.

The next step is to then re-run the eco-analysis with the improved products that we expect will be available at the same time, from which the EC can understand the eco gains that can be made from measures to improve their share of the market.

At a later stage we will re-run the methodology in order to undertake a sensitivity analysis of any key inputs that might change during the lifetimes of the products.

In many places we invite stakeholder comment or suggestions, and so this report will be considerably revised, with a final report on Steps 1-3 being published at a later date.

Data accuracy

We are aware that in many cases the available data on sales and other factors is poor, and so in these cases we have made suggestions or “best guesses”, backed up with what evidence is available. Accordingly, we particularly invite external expert views on these suggestions.

However, the spirit of the preparatory reports is that we should not spend excessive time debating the detail of all numbers or statistics, rather we should focus on the factors that are significant.

Next Steps

We invite all stakeholders to make comment on the reports, , and to attend the open meeting on 29 June at DG TREN, Brussels (sign up to be included as a stakeholder at www.ecomotors.org for further details).

More about the studies

The study is about technical and market issues only. if you wish to discuss any points relating to possible implementing measures or other policy matters.

A general point is that the study group and the European Commission are aware of the larger energy savings achievable through improving the design and control of the system to which the products in this Lot are driving. However, the scope of this particular programme of work is clearly restricted to the product only.

Existing efficiency classification schemes for motors and circulators mean that we expect work in these areas to proceed more quickly than those for fans and pumps where there is currently no agreed method of efficiency classification.

At this stage in the work we are trying to analyse the products separately, eg splitting an extract unit into the motor and fan/casing. While it is possible that at a later stage implementing measures may apply to combined units, for this stage in the study it is thought better to keep the two components separate.

Stakeholders are encouraged to read key background documents to this study, downloadable from the web-site www.ecomotors.org. Of particular interest is the MEEUP background methodology and the EuP Directive itself.

Table of Contents

1 PRODUCT DEFINITION, STANDARDS AND LEGISLATION 7

1.1 Product definition (classification, definition of primary and secondary functional parameters) 7

1.1.1 Product Classification 7

1.1.2 Definition of Primary Functional Parameters 9

1.1.3 Secondary Functional Parameters 10

1.2 Inputs on relevant harmonized standards for performance testing/energy use/health and safety 10

1.2.1 Harmonised standards - Performance testing 10

1.2.2 Harmonised standards - Energy use 11

1.2.3 Harmonised standards – Health and Safety 11

1.3 Existing relevant environmental legislation inside and outside EU, existing self regulation. 12

1.3.1 Existing relevant environmental legislation inside and outside EU 12

2 ECONOMICS AND MARKET 15

2.1 Macro data on EU trade, production and apparent consumption. 15

2.1 Micro market data on prices, sales, installed products, established for reference years in the past (1990), present (most recent) and future (2010 – 2020, stock model calculations). 18

2.2 Market trends in product features and key parameters (eg energy use, product weight) of best products. 18

2.2 Consumer expenditure: Rates, tariffs, prices, multiplier product costs/consumer prices. 18

3 CONSUMER ANALYSIS AND LOCAL INFRASTRUCTURE 19

3.1 Part load characteristics of pumps (and circulators) 19

3.2 System characteristics 19

3.3 Affects of the heating system operation on circulator efficiency 20

3.4 Affects of system configuration on circulator energy consumption 20

3.5 Environmental affects on circulator energy consumption 21

3.6 Scope for consumer influence on circulator energy consumption 21

3.7 Affects of fuel mix on energy consumption by circulators 21

3.8 Temperature/timer settings 21

3.9 Dosage of aux. inputs during use 21

3.10 Economical Product Life (=in practice) 22

3.11 End-of-Life actual behaviour (present fractions to recycling, re-use, disposal, etc) 22

3.12 Best Practice in Sustainable product use 22

3.12.1 Circulator Maintenance 22

3.13 Local infrastructure (energy, water, telecom, physical distribution, etc) 22

4 FUTURE WORK – NEXT STEPS IN THE ECOIMPACT METHODOLOGY 23

APPENDIX 1 METHOD OF CLASSIFYING CIRCULATOR PERFORMANCE, EUROPUMP CLASSIFICATION SCHEME 26

APPENDIX 2 28

1 Product definition, Standards and Legislation

1.1 Product definition (classification, definition of primary and secondary functional parameters)

1.1.1 Product Classification

This study concerns *'Circulators in buildings'*:

A brief description of a circulator is: 'an inline pump used to re-circulate heating or cooling media within a closed circuit'.

The types of application that are considered to be in the 'Circulators in buildings' category include:

- Heating circulators in household and small commercial central heating systems including
    - Central heating systems
    - Hot water systems
    - Under floor or wall heating systems
    - Thermal solar heating systems
    - Heat pump systems
- Heating circulators in large commercial central heating systems or district heating systems.
- Circulators in air conditioning and cooling applications

Given the scope of application types, the size range - from around 25 watts through to several kW, and the types of circulator design that could be included, the study definition is wide ranging.

In order to rationalise the selection of circulators included in the study the following points are considered:

Boundaries between 'pump' and 'circulator' definitions

Given that circulators are in fact a type of pump and that pumps are also being considered as part of the study within Lot 11, it is important to consider the boundaries of definitions and application; i.e. what constitutes a 'circulator' and what constitutes a 'pump'?

Circulators used in large commercial central heating systems or district heating systems tend to be 'glanded' circulators (or pumps) whilst the majority of circulators used in domestic or light commercial applications tend to be 'glandless' or wet running. It is therefore proposed that this important constructional feature should be one of the criteria in distinguishing the boundaries between the product types.

Heating vs. cooling applications

The majority of circulators are rated for operation in both cooling and heating applications, e.g. -10^{o}C to +110^{o}C. The control regime and hence average running hours for circulators in cooling applications is likely to be significantly different to that for circulators in heating applications. The market for circulators in cooling applications is principally in commercial installations whereas the market for circulators in heating applications covers both domestic and commercial installations and is significantly larger.

It is therefore proposed that circulators designed exclusively for cooling applications are excluded. For products suited to both applications we have been unable to differentiate between these applications in the sales figures, and so stakeholder views on this point would be welcome.

Sizing issues
There are several existing documents that have been consulted to understand the power range of interest:

- Power ratings for the majority of circulators supplied range from 25W through 1.1kW, the average being 150W[1]. The SAVE study defined three groups of circulators; '*Small*' (<250W), '*Large*' (>250W) and '*E-controlled*' (variable speed).
- The test standard BS EN1151-1:2006 defines circulators rated 200W and less as being generally for domestic use whilst those larger than 200W are generally for commercial use.
- In Germany there is the 'Blue Angel' labelling scheme which identifies domestic central heating circulators as 'self controlled circulators' with a maximum size of 250W.
- Most circulators are designed for single phase connection; circulators larger than 2.5kW are more likely to require connection to a 3 phase supply.

Note that all power ratings are for the electrical input.

Existing classification schemes
The European Association of Pump Manufacturers (EUROPUMP) launched a classification scheme for comprised circulators in January 2005[2]. Circulators included in the scheme are only those used in residential and commercial heating systems within the European Union.
In addition the circulators must also comply with the following:

a) be stand alone circulators with integrated pumps and motors
b) be wet running (I.e. the rotor operates in the pumped fluid)
c) be centrifugal pumping; only circulators with this type of pumping are comprised
d) have a P1<2500W (for each pump head on twin pumps)

Europump claim that circulators represented by this classification scheme represent both the largest market and the largest energy consumption by circulators within Europe.

The international product classification scheme as used by EU customs and Eurostat, called PRODCOM (Products of the European Community) has the following definition 29.12.24.17 'Glandless impeller pumps for heating systems and warm water supply'. There is no breakdown by capacity, power consumption or similar measure.

Standalone vs. integrated products
The Europump classification scheme is limited to stand alone circulators.

[1] Source: Europump
[2] Industry Commitment. To improve the energy performance of Stand Alone Circulators through the setting up of a classification scheme in relation to energy labelling, Europump, January 2005 (www.europump.org)

The SAVE II study[3] considered both stand alone and circulators integrated within heating boilers; it indicated stand alone circulators to be in the region of some 20% – 30% of total boiler stock. There is an increasing proportion in the numbers of circulators being incorporated in boilers as this both simplifies and reduces the cost of installation of a heating system.

It is therefore proposed that both stand alone and integrated circulators be included in the study.

Taking all of the above factors into consideration, and by reference to Europump sales and the SAVE II study statistics (see section 2.1), it is suggested that circulating pumps relevant to this study should meet the following criteria:

	Criteria	Comments
1	Be rated 2500W and below (for each pump head on twin pumps)	Larger units will be considered under the 'pumps' study
2	Be of centrifugal type	The market for positive displacement circulators is understood to be small
3	Be wet running (glandless)	
4	Be an integrated unit (pump and motor)	
5	Be for heating applications	The market for circulators in cooling applications that meet criteria 1) through 4) is believed to be considerably smaller than that for heating applications. Further data is required.

Selection of specific circulators for analysis
The SAVE II study indicated that in most EU countries over 90% of circulators supplied are in the size range <90W of which those having a power input 'P1' of 60W – 65W are the most typical. [4]

While Europump have indicated an average circulator power of 150W, we believe that the average is actually lower than this, and so would welcome further discussion on this point.

1.1.2 Definition of Primary Functional Parameters

The primary functional parameters are: Rated flow ("Q", m^3/hour) and the pressure or head ("H",m).

The functional unit is the reference value for any pump considered, and is independent of type. It also helps to set the boundaries for comparison of different products. For the pumps in this study, this may be assessed by considering "the rate of water pumped at the specified head (pressure), (m^3/h, m)". [5]

---

3 EU SAVE II Project – Promotion of energy efficiency in circulation pumps, especially in domestic heating systems, May 2001

4 An example is the Grunfos UP 25-40, whose nominal duty is a flow rate of 1.67m3/hr at a head of 2.95m. It is noted that Grundfos have since replaced this model with a more efficient unit, the UPS 25-40.

5 There is no formal naming and classification system, some manufacturers classify their products by inlet diameter and maximum operating head (against a closed valve), and some by inlet diameter and the full range of operating head. With regard to energy performance ratings they are also classified by power

1.1.3 Secondary Functional Parameters

Other technical factors influencing selection include;

- Pump volume.
- Pump weight.
- Position and size of fixing holes.
- Bearing arrangements.
- Noise.
- Expected lifetime of the pump.
- Seal arrangements.
- Net Positive Suction Head
- Minimum clearances required.
- Efficiency.
- Material type
- Motor type
- Control type

1.2 Inputs on relevant harmonized standards for performance testing/energy use/health and safety

1.2.1 Harmonised standards - Performance testing

The most common standard for performance testing of circulators is:
EN 1151-1:2006 '*Pumps – Rotodynamic pumps – Circulation pumps having a rated power not exceeding 200W for heating installations and domestic hot water installations*. *Part 1: Non automatic circulation pumps, requirements, testing, marking'.*

- This test is regarded as a type test, as it should be applied to several samples of the same type of pump.
- The standard does not provide any guidance as to how efficiency should be determined.
- The standard does not specify any ratings or tolerances for the procedures or equipment used to measure the head and flow.
- The standard specifies the hydraulic characteristic of a circulation pump to be described in the form of a H(Q) performance curve. The permissible tolerance on the operating head at the point where the product of the head and flow is at a maximum is large (+/-10%).

To determine pump efficiency, the ratio of power actually gained by the fluid to the shaft power supplied must be calculated. The operating head value is included in the calculation; consequently any inaccuracy in the operating head will be reflected in the final efficiency value.

---

consumption. The majority of circulators are of the centrifugal type, their hydraulic power consumption will vary with impeller (shaft) speed, and hence operating speed is an important parameter. Power consumption will also depend on where the circulator characteristics intersect with the system characteristics, and the density of the fluid.

This error will be carried through to calculations of energy consumption: for small circulators with typical input powers under 100W and operating heads under 5 metres the wide head tolerance may not impact the absolute energy consumption figures significantly, however as circulator sizes increase so their corresponding power consumption increases and the absolute error in energy consumption becomes large.

One explanation given for the wide head tolerance is that it is difficult to manufacture small circulators to tight tolerances; manufacturing tolerances in the pump element result in a spread in pump performance, whilst in the motor element the losses due to bearings and friction and a wide stator to rotor gap – to allow fluid passage – are relatively high.
It will be more difficult to justify this argument with increasing circulator size as relative manufacturing tolerances improve.

The study group is unaware of any standards relating to circulators larger than 200W.

Europump specify EN1151-1 as the test standard for all circulators in their labelling scheme (including circulators up to 2500W). *When calculating efficiency (and energy consumption) of the larger circulators consideration must be given to the wide tolerance in the standard*.

1.2.2 Harmonised standards - Energy use

In studies such as the '*EU SAVE II Project – Promotion of energy efficiency in circulation pumps, especially in domestic heating systems'*, circulators were identified as being responsible for significant amounts of energy consumption. Europump has responded to this by launching a voluntary classification and energy labelling scheme for circulators in January 2005.

The scheme defines a test methodology which in turn uses a load profile developed for the German 'Blue Angel' energy labelling scheme for circulators, the methodology is described in Appendix 1.

More information is needed to complete this section.

1.2.3 Harmonised standards – Health and Safety

The most relevant documents are:

EN 1151-2:2006 '*Pumps – Rotodynamic pumps – Circulation pumps having a rated power not exceeding 200W for heating installations and domestic hot water installations*. *Part 2: Noise test code (vibro acoustics) for measuring structure – and fluid borne noise'.*

EN ISO 12100-2:2003, Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles (ISO 12100-2:2003)

EN 60 335-1: Safety of household and similar electrical appliances: General requirements.

EN 60 335-2-51: 1997 Particular requirements for stationary circulator pumps for heating and service water installations.

1.3 Existing relevant environmental legislation inside and outside EU, existing self regulation.

1.3.1 Existing relevant environmental legislation inside and outside EU

The Europump classification and voluntary labelling scheme currently applies to comprised circulators up to 2500W in heating applications. This is a voluntary scheme and relies on self policing by participating members. (See 'Ecopump - Circulators Labelling Commitment', www.europump.org).

In Germany legislation requires the installation of speed controlled circulators in heating systems larger than 50kW.

One requirement of the EC Energy Performance of buildings Directive is that air conditioning systems with a capacity of greater than 12kW must be inspected regularly. This will have implications for some circulator systems.

General EC safety and environmental legislation applicable to circulators includes the following:

EU Legislation	Reason	Reference
Waste Electrical and Electronic Directive (WEEE)	The aim of the WEEE Directive is to establish producer responsibility to prevent the generation of electrical and electronic waste and to promote reuse, recycling and other forms of recovery. The directive states that equipment, "which is dependent on electric current or electromagnetic fields in order to work properly, and equipment for the generation, transfer and measurement of such currents and fields" are applicable. Circulators will fall within this legislation.	http://ec.europa.eu/environment/waste/pdf/faq_weee.pdf http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00240038.pdf#search='WEEE%20directive'

EU Legislation	Reason	Reference
Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)	Restrictions on the use of hazardous substances in the manufacture of electronic equipment are being imposed from 1 July 2006, through the RoHS Directive. The type of electronic equipment is defined as in the WEEE Directive. The substances excluded are lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). Lead-based solder that may be found in circulators is effected by this directive.	http://ec.europa.eu/environment/waste/pdf/faq_weee.pdf
Low Voltage Directive (LVD)	For the purposes of this Directive "electrical equipment" means any equipment designed for use with a voltage rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current. Circulators will fall within this Directive.	http://ec.europa.eu/enterprise/electr_equipment/lv/direct/73-23.htm
General Product Safety Directive (GPSD)	The Directive applies to products intended for or likely to be used by consumers. It obliges producers to place only "safe" products on the market.	http://ec.europa.eu/consumers/cons_safe/prod_safe/gpsd/currentGPSD_en.htm

EU Legislation	Reason	Reference
Machinery Directive	An assembly of linked parts or components, at least one of which moves, with the appropriate actuators, control and power circuits, etc., joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material, - An assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole, - Interchangeable equipment modifying the function of a machine, which is placed on the market for the purpose of being assembled with a machine or a series of different machines or with a tractor by the operator himself in so far as this equipment is not a spare part or a tool.	http://ec.europa.eu/enterprise/mechan_equipment/machinery/direct/dir98-37.htm#art1
Electromagnetic Compatibility (EMC) Directive 89/336/EEC as amended by 91/31/EEC and 93/68/EEC.	Since January 1 1996, most electrical and electronic products to be sold in the EC must be constructed so that they do not cause excessive electromagnetic interference and are not unduly affected by electromagnetic interference.	http://ec.europa.eu/enterprise/electr_equipment/emc/directiv/text2004_108.htm

2 Economics and Market

2.1 Macro data on EU trade, production and apparent consumption.

The primary data source for this is Eurostats. This is selected so that all policies at an EC level (both EuP and other initiatives) are from the same data source, and it remains the most complete data set for our work.

However, in order to gain better resolution of data, Europump has recently started to collect its own data, using a variety of public and private sources. The data supplied is subject to continuing revision, changing as new data becomes available, but is believed by Europump to be the best available. Note that this is based on 1998 data, reflecting the time it takes for quality and comprehensive data to become available.

In addition, the 2001 SAVE II study has provided a useful source of data.

There are discrepancies between these primary sources of data, and so we would welcome any comments from Europump or other stakeholders relating to these differences, especially the accuracy of the publicly available statistical data.

Age of data: It can take several years for information to be collected and presented in the database.

Missing countries: Only some countries have reported, with new member states in particular not having filed returns for these early years.

Definitions and categories:

- Abrupt changes can result from the re-definition of product categories.
- Categories may be interpreted differently by different countries, reflecting their individual methods of collecting data.
- Financial values in particular can be greatly distorted by the inclusion of auxiliary components or spares.

Europump data
Europump data (April 2005) shows EU production (and consumption) of heating circulators at 14 million units (Table 2.2).

SAVE II Study
The SAVE II study concluded the 1995 EU market for circulators (<250W) was in the region 8 to 8.5 million units whilst stock levels were 87 million units. These figures are believed to be larger now due to both growth in the market and expansion of the EU.

Eurostats

DECLARANT / PRCCODE 29122417 Glandless impeller pumps for heating systems and warm water supply	PRODUCTION, 1998, UNITS	IMPORTS, 1998, UNITS	EXPORTS, 1998, UNITS	NET ANNUAL CONSUMPTION, 1998
France	5,274,054	580,902	4,607,107	1,247,849
Netherlands		410,072	12,698	397,374
Germany	905,063	2,634,527	1,484,211	2,055,379
Italy	178,587	1,950,736	267,085	1,862,238
United Kingdom	-	281,640	940,779	659,139
Ireland		62,323	176,200	113,877
Denmark	2,717,683	51,575	2,540,621	228,637
Greece	-	193,532	11,883	181,649
Portugal	-	17,586	-	17,586
Spain	1,709	379,867	30,558	351,018
Belgium	-	225,574	1,174	224,400
Luxemburg	-	-	-	-
Iceland	-	-	-	-
Norway	-	-	-	-
Sweden	75,552	205,108	10,148	270,512
Finland	-	9,859	4,473	5,386
Austria	-	220,887	6,782	214,105
Estonia				
Latvia				
Lituania				
Poland				
Czech Republic				
Slovakia				
Hungary				
Romania				
Bulgaria				
Slovenia				
Croatia				
TOTAL	9,152,648	7,224,188	10,093,719	**6,283,117**

Table 2.1 Eurostats data on EC circulator production (1998)

Data was not available for all member states, for states where the data has been included the total consumption of circulators was calculated as 6.3 million units in 1998.

The Eurostat data does not specify the size range of circulators covered, the SAVE study considered circulators principally <250W, whilst Europump data includes all circulators <2500W. It has not been possible to analyse the overlap between these different data sources, however it is safe to conclude that the majority of circulator sales will be in the size range <250W.

It has not been possible to determine what proportion, if any, of circulator sales within the Eurostat data are attributable to applications other than heating systems.

Segment	Number	Average Input kW (Annual running hours)	Total linked GWh
Heating Circulators	14,000,000	0.15 (3,000)	6,300

Table 2.2 Europump data on annual sales and linked energy consumption (Heating circulators), published April 2005

	Production	Delta France	Delta Belgium	Delta NL	Delta Italy	Delta GB	Delta DK	Selta South	Selta Sca	Delta Austria	Germany	Market	Considered
Heating circulators	10 000 000	-4 000 000	350 000	600 000	1 700 000	-350 000	-1 500 000	620 000	250 000	250 000	2 700 000	10 620 000	14 000 000

Table 2.3 Europump data on net production of circulators by member state

We are aware that the Eurostats and Europump data does not include any information on New Member States (NMS), and so would welcome any information about this. In the event of the absence of any other data we suggest an analysis of building stock for NMS, and then assume a similar distribution of circulators as per the methodology used in the SAVE II study.[6]

2.1 Micro market data on prices, sales, installed products, established for reference years in the past (1990), present (most recent) and future (2010 – 2020, stock model calculations).

We so far have no data on prices except for catalogue data, which represents maximum sales prices. Some manufacturers offer a wide range of circulator products, before seeking further information we need to agree on the most common products to consider in seeking indicative prices.

The SAVE II study concluded that a demand side analysis of the market would be more plausible than one developed using supply side data from public sources.
The study team will therefore be seeking further information from suppliers in order to build a reliable model of the circulator market in the EU.

Table 3:11 in APPENDIX 2 is an extract from the SAVE II study and indicates the stock and sales of circulators in 1995.

2.2 Market trends in product features and key parameters (eg energy use, product weight) of best products.

Several positive trends are noted[7].

- The uptake of variable speed controlled units is increasing.
- Circulators with higher efficiency motors (permanent magnet motors) are becoming more widespread.
- The latest generation of circulator products have been developed to attain the 'A' rating in the labelling scheme; most examples combine better hydraulic design (tighter manufacturing tolerances), permanent magnet motors and variable speed control.
- There is an increased proportion in the numbers of circulators being incorporated in boilers as this both simplifies and reduces the cost of installation of a heating system.
- In Denmark it is understood that variable speed circulators have become the norm.

2.2 Consumer expenditure: Rates, tariffs, prices, multiplier product costs/consumer prices.

This data is important primarily so that we can calculate the purchase, installation and running costs of improved products. It will ultimately allow us to understand how far it is possible to reduce the eco-impact of products without incurring excessive costs to the consumer.

[6] Some work on this type of analysis has been undertaken, but lack of data means that so far this has only been done for Czech Rep. Estonia, Hungary, Latvia, Lithuania, Slovakia & Slovenia.

[7] From ongoing conversations with manufacturers. We would welcome quantitive data to support these trends.

3 Consumer Analysis and Local Infrastructure

3.1 Part load characteristics of pumps (and circulators)[8]

Pumps are defined by the basic Pump characteristics below (figure 3.1). They show the relationship between head, power and efficiency against flow. For pumps with a steep efficiency curve running at a duty (head and/or flow) below their rated duty is likely to lead to a significant reduction in pump efficiency. The Best Efficiency Point (BEP) of a pump is ideally at the rated duty point. The peak power consumption will not necessarily be at the BEP.

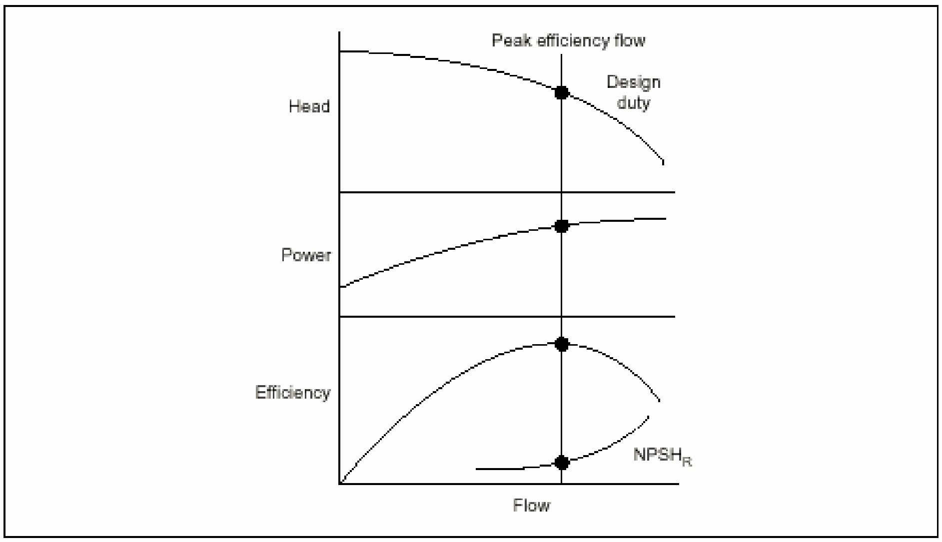


Figure 3.1 Centrifugal pump characteristics

Running at reduced flow, or indeed above rated flow, will move the pump away from its BEP (and in larger pumps will also accelerate pump wear and ultimately lead to operational problems and failure). It is therefore important to ensure that a pump operates as near to it's BEP as possible.

One method of ensuring a pump operates as near to it's BEP is through the adjustment of it's operating speed. Reducing the speed of a pump will have the affect of moving the Head / Flow characteristic towards the intersection of the X and Y axis whilst increasing the speed will have the affect of moving the characteristic in the opposite direction. The change in hydraulic power absorbed will vary in a cube law relationship with the change in speed.

3.2 System characteristics

In a pumped fluid system the resistance to flow changes approximately with the square of the change in velocity of the fluid; for a given duty flow rate, a change in pipe diameter will affect the velocity and hence resistance, in addition any obstruction or source of turbulence such as valves, bends and Tees will increase the system resistance.

Valves, such as thermostatic radiator valves (TRV's) are used to regulate the amount of flow through a convector such as a radiator; by reducing the flow the system pressure will

8 Extract from SAVE Study on improving the efficiency of pumps, Appendix C.

increase and move the pump's duty point back to the left resulting in a flow rate reduction; the pump also moves away from it's BEP resulting in a drop in efficiency.

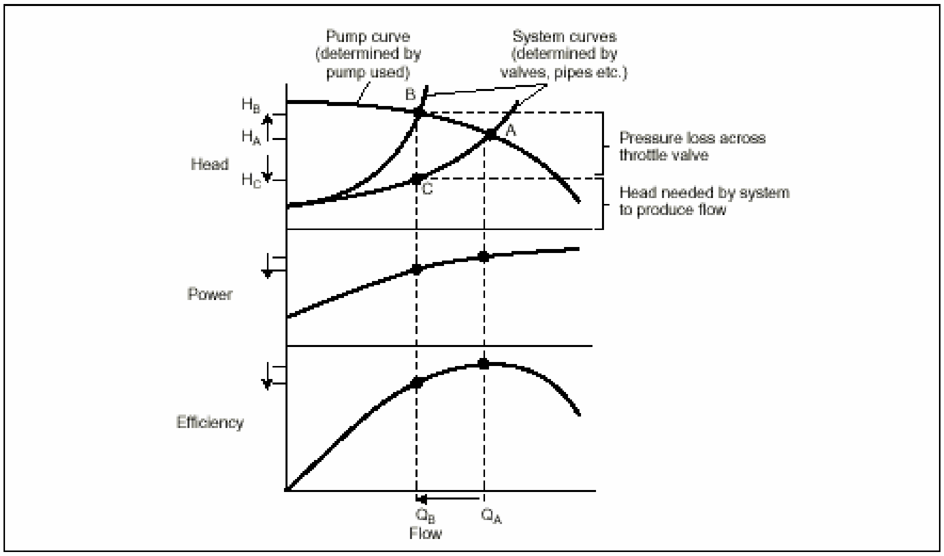


Figure 3.2 Affects of increased system resistance through valve throttling

3.3 Affects of the heating system operation on circulator efficiency

- The pump should be sized such that the typical system duty requirements (head and flow) closely match the pump performance at BEP. In order to aid this requirement the majority of circulators are supplied with multiple speed settings, (three typically) and this is set at commissioning time in order to achieve the optimum flow rate in the system.

- These pumps are ideally suited to older heating systems where there is little heat and consequently flow variation e.g. no thermostatic radiator valves, (TRV's).

- More modern heating systems have a variable heat demand according to the number of radiators (or similar convector devices) that are operating; these may be either preset or adjustable through the use of TRV's. Consequently circulators are subject to large flow rate fluctuations, with a corresponding affect on efficiency.

- The latest generation of circulators incorporating variable speed control are designed for use in heating systems with variable demand and achieve the best match between circulator speed and flow rate demands of the system.

- A minimum flow rate is required in order to ensure safe operation of the heat exchanger in the boiler.

3.4 Affects of system configuration on circulator energy consumption

Several factors affect actual energy usage by circulators, these include:

- **Boiler controls** – timer settings, room thermostat set points, whether or not a system has TRV's fitted and their set points.
- **Circulator controls** – whether stand alone circulators have no controls (continuously on), run timers or are boiler controlled (on/off). All circulator types

may have no speed selection, multiple speed selection, or be variable speed controlled.

- **Type of heating system** – these may be single independent systems, collective or district heating systems.
- **Number of circulators in the heating system** – independent systems may have one or more circulators whilst dwellings supplied by a district heating system may or may not have a circulator installed locally.
- **Size of circulator and actual power absorbed** – on multiple speed circulators, the speed at which it is set.
- **Function** – running hours influenced by whether the system is used for heating, hot water, or both.

3.5 Environmental affects on circulator energy consumption

Regional and climatic factors will affect circulator running hours; circulators in the colder regions of the EU will have longer running hours than those in warmer regions. Exceptionally cold periods and longer than normal winters will increase typical running hours.

3.6 Scope for consumer influence on circulator energy consumption

Stand alone circulators that are not controlled by the boiler are likely to be left running continuously; the user could switch them off when not in the heating season, however this will not be possible in systems which are also coupled to hot water supplies.
If the circulator is variable speed controlled then energy consumption will be affected by the heat demand, which the user can influence.

3.7 Affects of fuel mix on energy consumption by circulators

Losses in a circulator are translated into heat; in the case of glandless circulators in a heating system this heat loss is transferred to the heating medium (pumped liquid) and hence the carbon impact due to circulator efficiency is related to the boiler fuel type and the fuel mix associated with electricity production. We would particularly welcome stakeholder views on this important consideration, as the net eco savings from improved circulators is not as large as would appear from simple energy consumption considerations.

3.8 Temperature/timer settings

Circulator running hours are affected by both the heat demand (temperature settings) on a heating system and the duration for which the circulator is running which is in turn influenced by the type of control, E.g. boiler controlled.

Overall duty patterns are given by the German Blue Angel scheme.

3.9 Dosage of aux. inputs during use

Glandless circulators are designed to be maintenance free during their life. There are no direct auxiliary inputs required.

However, we would welcome view on circulator failure, and the net eco-cost of replacement.

3.10 Economical Product Life (=in practice)

The SAVE study indicated the life expectancy of circulators to be influenced by whether they are stand alone or incorporated in a boiler. Overall it is estimated at approximately 13 years.

3.11 End-of-Life actual behaviour (present fractions to recycling, re-use, disposal, etc)

Prior consultation by EC with stakeholders led to the agreement on nominal end of life behaviour fractions used in the MEEUP ecomodel[9] for materials in all products across the EC. As a default we will use these already agreed fractions – we may deviate from these if there is very good reason, otherwise it is preferable to accept these in order to enable comparisons with other products to be made on a common basis.

The replacement, repair, disposal or recycling of circulators is managed by the installer. In cases of replacement this is likely to be in a like for like manner.

There does not appear to be any significant re-use or second hand market for circulators.

3.12 Best Practice in Sustainable product use

Following the earlier discussion on circulator and system matching, it is apparent that the correct selection and configuration of circulators is at least as important as the selection of circulator by highest BEP.

It is also important to install suitable controls that will ensure circulators are run for the least number of hours possible.

Circulators with multiple speed settings go some way to ensuring a good match between circulator and system whilst variable speed circulators attempt to achieve the best match possible.

3.12.1 Circulator Maintenance

Glandless circulators are designed to be maintenance free during their life time.

3.13 Local infrastructure (energy, water, telecom, physical distribution, etc)

The controls and method by which the circulator is controlled (E.g. controlled by the boiler) is the most important factor in the 'local infrastructure'.

[9] http://europa.eu.int/comm/energy/demand/legislation/doc/2005_11_28_finalreport1_en.pdf

4 Future work – next steps in the Ecoimpact methodology

This section gives a short overview of the next steps in this work. This is presented for two reasons:

- To give greater clarity on the methodology of the remainder of the work.
- To encourage stakeholders to think about the features that define "state of the art" circulators and production facilities.
- Revise and complete the report for steps 1-3.

Definition of Basecase (Step 4)

- *Selection of average EU representative model or construction of average EU model characteristics from several important product-subcategories in the product group.*

- *Definition of STANDARD BASECASE, ie the environmental impact, functionality and Life Cycle Costs for a reference year measured according to harmonised test standards (that would also be used for compliance testing.)*

- *Definition of REAL-LIFE BASECASE, ie the (estimated) environmental impact, functionality and Life Cycle Costs in real life for a reference year with actual consumer behaviour and ambient conditions.*

What this means in summary is that we need to construct a standard eco-impact basecase (or basecases) for the different types of pumps that we have agreed to consider in this study. This is done by entering the BOMs and life cycle information for these basecase pumps into the MEEUP eco-impact methodology spreadsheet. This model then gives a detailed list of the lifecycle eco- impact of each product in terms of all significant environmental emissions. Note that the formulae used to calculate material and energy use into these emissions has already been agreed during an extensive stakeholder consultation during the development of this model, and so we are encouraged not to re-visit these unless there is a compelling case to do so.

Environmental Analysis

In summary, the following additional data is required to perform the environmental analysis:

Production Phase

- Bill of Materials (BOMs), including packaging
- Manufacturing processes
- Proportion of scrap raw materials produced
- Volume and weight of the packaged product

Distribution Phase

- Volume and weight of the packaged product.

In Use Phase

- Product lifetime
- Lifetime energy Consumption according to both test standards and the real-life situation.
- Decline in efficiency over time
- Repairs (parts, cost and eco-impact of personnel involved, eco-impact of affected production processes)
- Any product specific direct emissions

End of life phase

- Proportions close-loop recycled, re-used, sent to landfill

Technical Analysis Best Available Technology (BAT) (Step 5)

- *State of the art in applied research of the product (prototype level)*
- *State of the art at component level (prototype, test and field trial level)*
- *State of the art of best existing production technology globally (extra-EU)*

This is really an information gathering exercise for the next steps, the object being to make sure that we have a common understanding as to the very best technologies available.

Improvement Potential

- *Identification of design options:*
- *Their monetary costs (extra production cost*multiplier = end-use price increase) and – if any – benefits (lower operating expense)*
- *Their environmental benefits and – if any – adverse environmental trade-offs.*
- *Ranking of options according to Life Cycle Costs/Payback Period and identification of point of LLCC, with its environmental improvement potential.*
- *Assessment of (cluster of) options with the highest absolute environmental saving potential: the so-called Best Available Technology BAT, with its environmental improvement potential.*

With reference to the basecase model(s), we will calculate the eco-impact and lifecycle cost difference of the improved design options.

Policy, Impact and Sensitivity Analysis

- *Policy and scenario analyses: Assessment of what is “significant”, “appropriate”, etc. and what policy measures are appropriate, what would be the gain over “business as usual” etc.*
- *Impact analysis industry and consumers: investment level, appropriate timing (in line with platform change)*

- *Sensitivity analysis; test of the robustness of the "significant environmental aspects", varying base assumptions.*

While this project is explicitly not about defining policies, it will look at the impact of any changes in behaviour that might result from any EC legislation or voluntary actions. To ensure that any such EC actions are reasonable, we will also investigate the wider impacts on consumers and producers, and undertake a sensitivity analysis concerning the significant environmental impacts used in our assumptions.

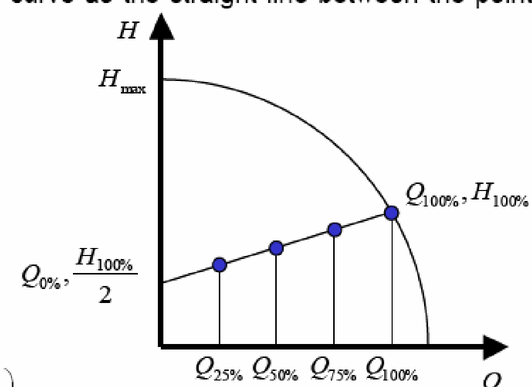
APPENDIX 1 Method of classifying circulator performance, Europump classification scheme

Annex II

COMMON AND STANDARD CLASSIFICATION OF COMPRISED CIRCULATORS AS AGREED IN THE SELF-COMMITMENT

To obtain an overview of the method described for the classification of comprised circulators, the classification method is described hereunder[1]:

1. Measure the pump on maximum setting
2. Find the point where $Q \cdot H$ is maximum according to EN 1151-1 and define the flow and head at this point as $Q_{100\%}$ and $H_{100\%}$ [2].
3. Calculate the hydraulic power P_{hyd} at this point.
4. Calculate the reference power as $P_{ref} = 2.21 \cdot P_{hyd} + 55 \cdot \left(1 - e^{-0.39 \cdot P_{hyd}}\right)$
5. Define the reference control curve as the straight line between the points $(Q_{100\%}, H_{100\%})$ and $\left(Q_{0\%}, \frac{H_{100\%}}{2}\right)$



6. Select a setting of the pump (free choice) ensuring that the pump on the selected curve reaches $Q \cdot H$ = max point according to EN 1151
7. Measure P_1 and H at the flows $Q_{100\%}, 0.75 \cdot Q_{100\%}, 0.5 \cdot Q_{100\%}, 0.25 \cdot Q_{100\%}$ [3] [4].

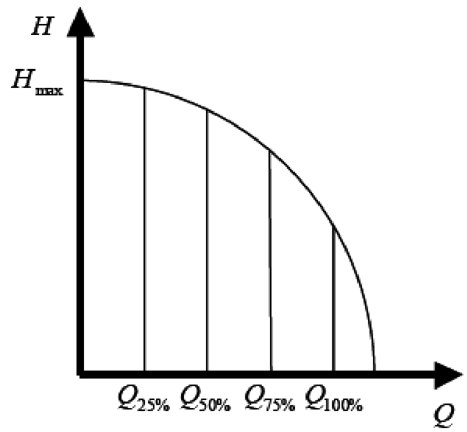
[1] For twin pumps the measurements and calculations are performed in a single pump operation if this is a selectable mode of operation. The selection of motor head for single pump operation is optional.
[2] It is allowed to use interpolated values, but it must be possible to measure values between ±5% of the interpolated values.
[3] Interpolated values are permitted but is must be possible to measure values between 0% and - 5% of interpolated values respecting the settling time of the pump.
[4] Flows are measured from 100% to 25%. Average values of the calculated EEIs based on measurements of decreasing and increasing flows i.e. 100% to 25% and from 25% to 100% respectively, are permitted.

8. Calculate at these flows $P_L = \frac{H_{ref}}{H_{meas}} \cdot P_{1,meas} \quad , if \quad H_{meas} \le H_{ref}$, where $P_L = P_{1,meas} \quad , if \quad H_{meas} > H_{ref}$

H_{ref} is the head on the reference control curve at the different flows

9. Using P_L and this load profile

Flow [%]	Time [%]
100	6
75	15
50	35
25	44



10. Calculate the weighted average power $P_{L,avg}$ as

$$P_{L,\,avg} = 0.06 \cdot P_{L,\,100\%} + 0.15 \cdot P_{L,\,75\%} + 0.35 \cdot P_{L,\,50\%} + 0.44 \cdot P_{L,\,25\%}$$

11. Calculate the Energy Efficiency Index as: $EEI = \frac{P_{L,avg}}{P_{ref}}$

APPENDIX 2

Extract from SAVE II Study: Estimated stock and sales of circulators (1995)

Chapter 2.2.1 Market

Table 3:11 Estimated stock and sales, EU 1995

Country	Housing stock		Circulator pump stock			Circulator pump market				
	No. of households	Households with CH	small (<250 W)	large (>250 W)[g]	total stock circulators	Boilers in New built homes	Boilers in Reno-vations[h]	Boiler Replace-ment	Circulator repairs	Total market
	(*1,000)	(*1,000)	(*1,000)	(*1,000)	(*1,000)	(*1,000)	(*1,000)	(*1,000)	(*1,000)	(*1,000)
AU	3,228	2,647	2,022	7	2,029	47	9	102	51	209
B	4,128	3,509	3,100	5	3,105	32	6	155	78	272
DK	2,400	2,186	1,009	13	1,022	16	3	51	26	96
DE	37,600	30,531	22,173	93	22,266	352	70	1,115	557	2,096
FIN	2,250	2,090	1,116	11	1,127	28	6	56	28	118
F	23,700	19,387	15,099	48	15,147	233	47	758	379	1,419
IRL	1,220	878	856	0	857	30	6	43	21	101
I	20,533	16,447	11,439	56	11,495	138	28	576	288	1,030
NL	6,760	5,949	5,219	8	5,227	80	16	262	131	489
P	3,320	332	332	0	332	9	2	17	8	36
ES	12,900	3,741	3,277	5	3,282	80	16	164	82	342
SV	4,100	4,100	2,314	20	2,334	12	2	117	58	189
UK	57,500	21,152	18,678	27	18,705	150	30	937	468	1,586
LUX	145	123	109	0	109	3	1	5	3	11
EL	3,203	320	320	0	320	8	2	16	8	34
Total	149,400	113,392	87,064	293	87,356	1,217	243	4,374	2,187	8,027