Work on Preparatory studies for implementing measures of the Ecodesign Directive 2009/125/EC

ENER LotENER Lot 29 – Pumps for Private and Public Swimming Pools, Ponds, Fountains, and Aquariums (and clean water pumps larger than those regulated under ENER Lot 11) – Task 3: Consumer Behaviour and Local Infrastructure

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Task 3: Consumer Behaviour and Local Infrastructure

Consumer behaviour has a significant direct effect on the use of pumps for clean water pumps, during the use phase of the product. It also has some influence on the End-of-Life phase, depending on the type of product. To some extent, product-design can influence a consumer's behaviour thus regulating the environmental impacts and the energy efficiency associated with the product use.

The aim of this task is to investigate the influence of providing product information to the end-users of pumps for private and public swimming pools, ponds, fountains, and aquariums (and clean water pumps larger than those regulated under ENER Lot 11), and on the influence they can have on the environmental performance of the equipment.

The areas covered in this task are divided into following three main sections:

- Section 3.1: Real life efficiency
- Section 3.2: End-of-life behaviour
- Section 3.3: Local infrastructure

Other areas investigated include eco-practices in sustainable product use; and whether it could be useful to consider labelling or provision of other eco-information (e.g. ecological profile of the product). Barriers to the provision of such information and ecodesign measures, due to social, cultural, and infrastructural factors are also investigated. Further, analysing real life use conditions of products in comparison with standard test conditions provides a more accurate picture of the real energy use.

3.1 Real life efficiency

The aim of this subtask is to understand how the real life efficiency of pumps in the ENER Lot 29 differ from those tested in standard conditions and to quantify user defined parameters. Identification of actual user behaviour (average EU) includes:

- Real life efficiency, such as load efficiency (real load vs. nominal capacity), timer settings; dosage, quality and consumption of auxiliary inputs; frequency and characteristic of use; power management enabling-rate and other user settings
- Best practice in sustainable product use
- Repair and maintenance practice (frequency, spare parts, transportation and other impact parameters)

3.1.1 Pump applications

A. Large water pumps

Pumps of this size represent a major capital investment, and so are far more likely to be carefully sized and specified, as is the motor that run them. The running costs are also so large that impellers may be changed to match the pump duty to the actual demand.

Depending on the exact specification of pump agreed, large multi-stage pumps with removable sections may be included. These will see the number of stages increased as for example water levels fall, avoiding running at very low loads.

These represent major investment, and so if they wear are likely to be re-furbished during their lifetime. Condition monitoring that detects a fall off in performance is also more likely with these larger pumps. As pumps will keep working even when in poor condition, this deterioration may not be appreciated until they fail catastrophically, by which time their efficiency may be as much as 20% below the as new performance.

Where a VSD is used in variable flow applications, the pump efficiency will be maintained at a good level at speeds much less than the design point.

B. Swimming pool pumps

Swimming pool pumps can be used to pump water through filters, heaters, and chemical dosing systems. The number of changes of water required per day is the subject of regional regulations, which vary considerably. Harmonisation of these standards would seem to offer the biggest opportunity for saving, but it is beyond the scope of this study. However, in parallel with this study it would be good if the EC was to start discussions with a view to harmonisation.

There are many online tools available for calculating the required pump size as a function of size, number swimmers etc. The theoretical turnover period for the pool water can be calculated from considerations of pump flow rate and volume, and will vary from 5 minutes for a leisure water bubble pool to 6 hours for a private pool. In practice, 7 volume changes are needed to ensure that 99% of water actually passes through the filter.

This variation in duties will dominate energy consumption, and hence it is important that more attention is given to creating regulations based on real requirements.

Pool skimming is also important for removing the bulk of the contamination that is found in the top 15cm of the pool, as it reduces the load on the pump filters. Filters should be backwashed at least once a week, or when the pressure drop exceeds 3psi.

The range of duties, and the flow required, is indicated in Figure 3-1.

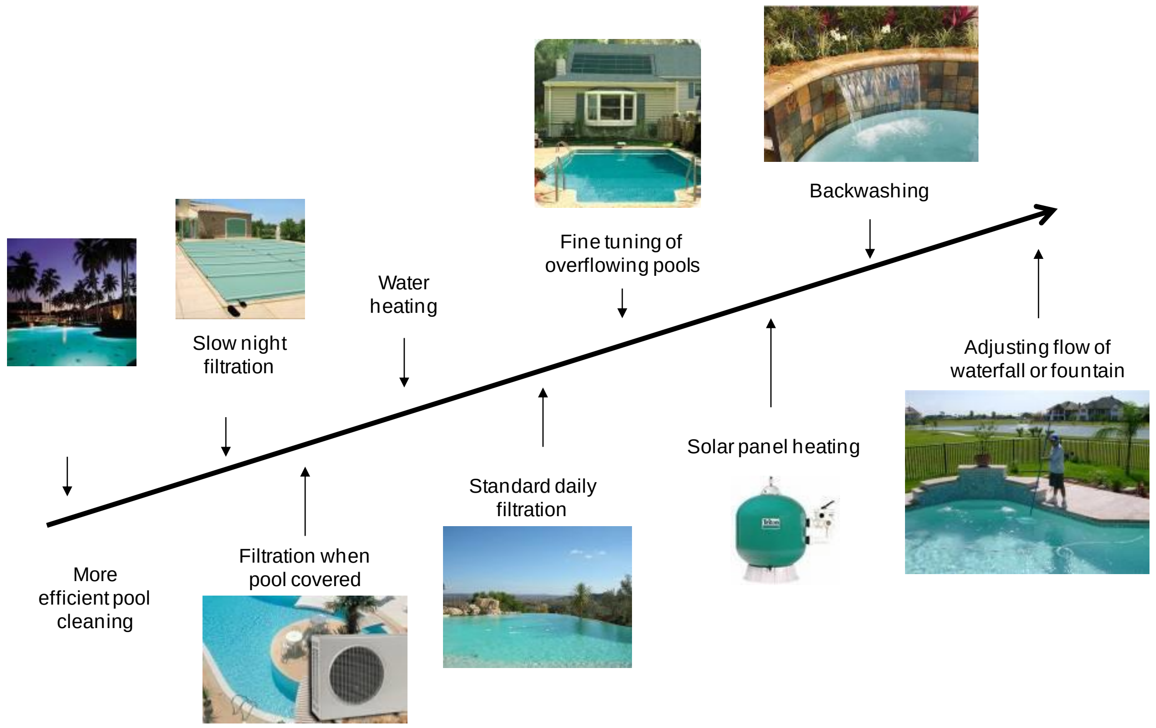


Figure 3-1: Inteliair diagram indicating the variation of duties a pump may be expected to supply – Many domestic pumps will only perform filtration, heating and backwashing

A 0.75hp (0.6kW) pump is generally adequate for standard residential pools, although 1hp (0.75kW) is the most common size in the US.

The economic product life is provisionally estimated to be similar to that shown for the smaller pumps in the EU regulations, i.e. about 10 years.

C. Fountain, pond and aquarium pumps

Pond circulators, aquarium pumps and aquarium powerheads will work on continuous (24/7) duty in order to protect the stock.

Fountains will work for limited hours according to resident requirements, but likely to be limited to warmer/dryer seasons and for hours when they are present.

The load factor for each will be constant in operation, but a nominal load factor for each type will need agreeing.

System Aspects

Because few consumers have the understanding to precisely match the performance to the duty, it is assumed that most pumps work sub-optimally. There are several factors that will lead to poor performance in real life:

- Filters - blocked. As conventional filters block up, the pressure drop increases, putting additional load on the pump.
- Filters – pressurised type. These more compact types are increasing in popularity, but have a higher pressure drop than conventional types.

- Excess flow. Many consumers and retailers are unsure about specifying a pond or aquaria pump, and so will opt for a design which is considerably higher than needed in order "to be on the safe side".

3.1.2 Frequency of use

The range of pumps considered in scope has a wide range of operating hours. Table 3-1 shows the annual number of operating hours of the ENER Lot 29 pumps. Domestic products have lower operating hours per year than commercial and industrial ones, and some specific products such as spa pumps and counter-current pumps have a low number of operating hours per year. In these, the low operating hours mean that non-energy considerations become more important, for example materials and reliability. The implication of this is that improvements in energy efficiency can only be made as far as they do not adversely affect these other parameters. A challenge for possible MEPS regulation will be to allow high reliability / low efficiency pumps to be used in low duty applications. Similarly, there is a need to avoid users selecting these less efficient pumps in higher duty applications

Table 3-1: Annual operating hours of the ENER Lot 29 pumps

Pump type (and sub-categories)		Annual operating hours[1]
Swimming Pool pumps (integrated motor+pump)	Domestic with built in strainer up to 2.2 kW	1,500
	Domestic/commercial with built in strainer over 2.2 kW	3,375
Fountain, pond, aquarium, spa and counter-current pumps	Fountain and pond pumps to 1 kW	6,000
	Aquarium pumps (domestic/small aquarium - non-commercial) to 120 W	8,720
	Aquarium power head to 120W	8,720
	Spa pumps for domestic & commercial spa's	350
	Counter-Current Pumps	20
End suction water pumps (over 150kW-P2)	ES CloseCoupled from 150 kW to 1 MW	3,600
	ES CloseCoupled Inline from 150 kW to 1 MW	3,600
	ES Own Bearing from 150 kW to 1 MW	3,000
Submersible bore-hole pumps	8" Submersible bore-hole pumps	2,565
	10" Submersible bore-hole pumps	2,725
	12" Submersible bore-hole pumps	3,114
	Submersible bore-hole pumps larger than 12"	3,352
Vertical multi-stage pumps	Vertical multi-stage pump (25 to 40 bar and/or 100 to 180 m3/hr)	2,700
	Vertical multi-stage pump (>40 bar and/or >180 m3/hr)	3,450

3.1.3 Product related eco-information

This section primarily relates to clean water pumps larger than those analysed in ENER Lot 11 preparatory study.

- **Repair and maintenance practices**

[1] The information on the annual operating hours of the ENER Lot 29 pumps are provided by Europump.

Larger pumps will require some basic consumables and replacement parts, including lubricant (grease) for bearings, replacement seals, new bearings and new wear rings. Coatings may also be applied to both reduce friction (and hence hydraulic losses) and reduce corrosion, which can be used both from new and for in service refurbishment. For the smaller pumps in this study, it will not be economic to change these parts, and so they will instead be replaced with new pumps. The effect of the wear of pump and the wear trends are presented in Figure 3-2 and Figure 3-3.

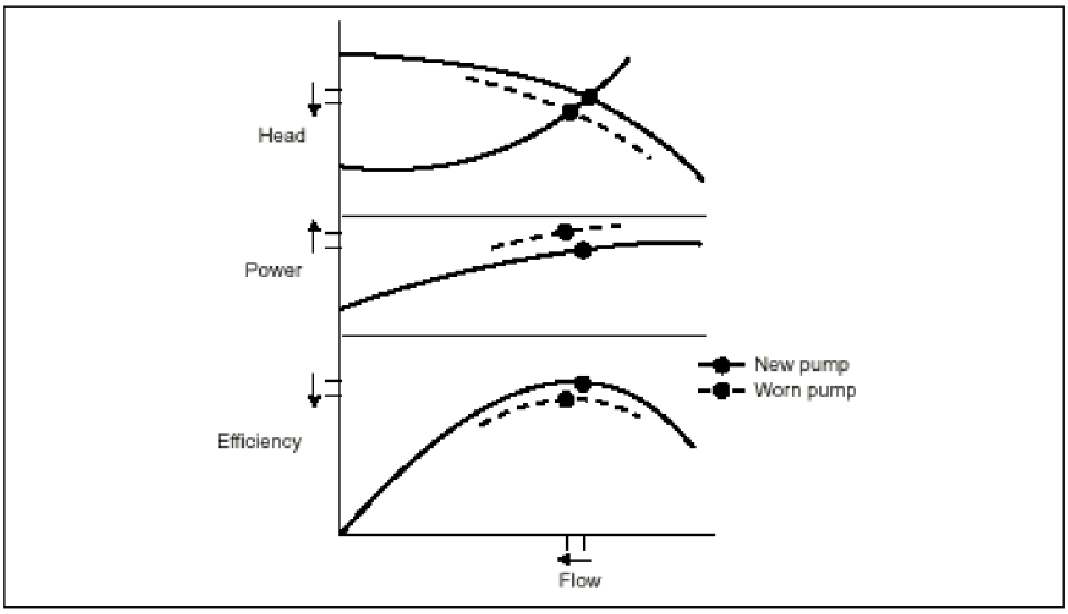


Figure 3-2: Effect of wear on pump characteristics

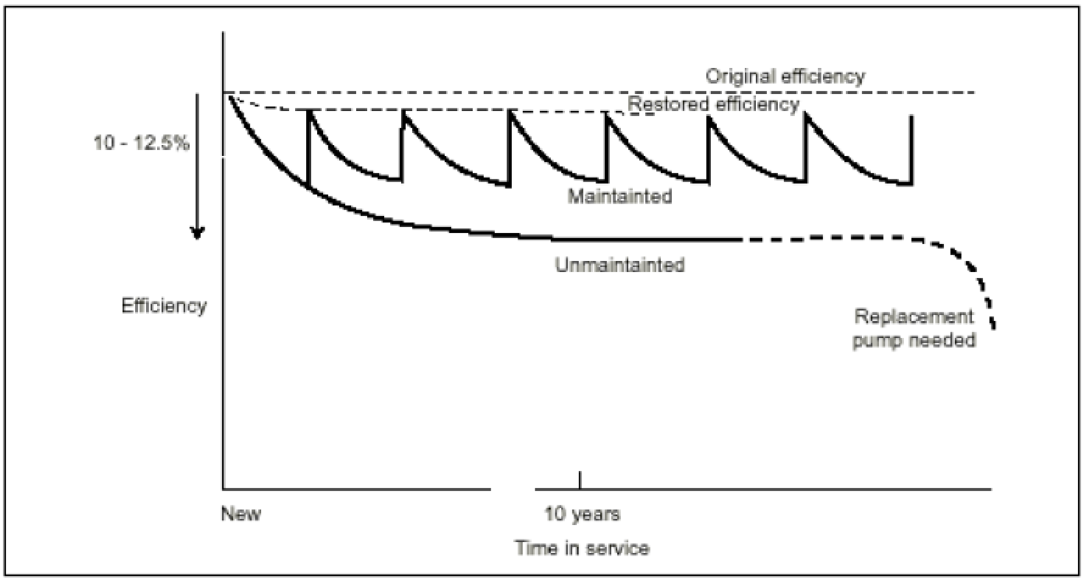


Figure 3-3: Average wear trends for maintained and unmaintained pumps

Large pumping stations are visited for maintenance on a risk-based approach, with the following factors taken into consideration: historic frequency of breakdown, impact if there is a breakdown (properties impacted, type of wastewater) and Supervision Control And Data Acquisition

(SCADA) equipment to transmit information when there is a problem. Maintenance activity includes condition inspections, security checks, electrical tests and jetting.

- **Correct Selection of Pump**

A critical issue in determining efficiency and lifetime is the correct selection of pump. While specifiers are often at fault for not having an accurate idea of the real duty requirements, the limited number of models in a manufacturers' range may mean that the "nearest" pump is actually a long way from the actual duty point. Supplying pumps with a variety of impeller sizes does help, but at the cost of reduced efficiency. Ideally, a manufacturer would have a very large range of pumps to cater for a range of duties, but the costs make this prohibitive, and so this is a source of energy loss. Theoretically, specifiers could often do better by "shopping around", but because they usually order all pumps for a new installation from a single supplier, this does not happen. With regards to smaller domestic products such as aquarium and garden pumps the selection process is based on the calculation of the correct turnover of water inside the aquarium tank or inside the pond basin (pump must recirculate the entire volume of water from 3 to 5 times every hour).

It is considered that because pumps are made wholly or almost entirely of easily recyclable metals, and that they are handled by professionals who are aware of their value, they will all be recycled. The market for second hand pumps is only very small.

Given that mainly industry or commerce, rather than consumers use these products, it is hard to identify how social or cultural factors will impact patterns of use.

However, although beyond the scope of this report, measures to reduce water consumption would reduce the operating duties of many of the pumps covered by this study, and ultimately reduce the number of pumps needed, with a consequent reduction of eco-impact. It is becoming increasingly common that industrial premises are looking to reduce water consumption to minimise effluent charges. In domestic pumps such as aquarium and pond pumps, water conservation methods are unlikely to have an impact on their usage.

It is clear that the correct selection of pump is at least as important as the selection of pump by Best Efficiency Point (BEP). The following text explains how manufacturers design a range of pumps to suit all duties within a range, and the compromises that this means in terms of being able to select a pump for a particular duty.

When selecting a pump, a manufacturer will use "tombstone" curves, which show their ranges of pumps to cover a range of duties, (Figure 3-4). Typically, the duty you want will be roughly 20% below the maximum flow shown on the tombstone, which corresponds to the BEP of the selected pump (each tombstone is built up from individual pumps). However, for economic reasons they have to restrict the number of pumps that they offer. This means that even a manufacturer of particularly efficient pumps may lose out, when quoting efficiencies in competition with less efficient pumps whose BEP just happens to be nearer the requested performance. The worked example (Figure 3-5) following makes this clearer.

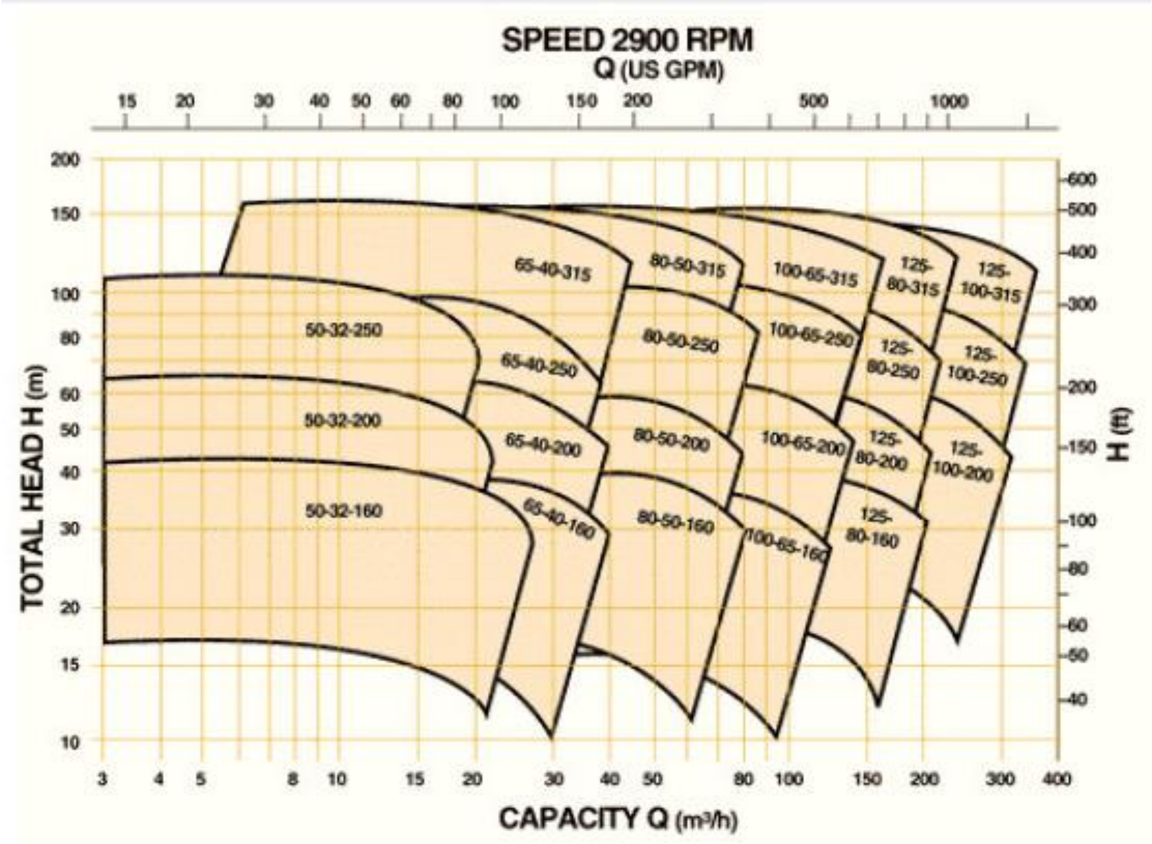
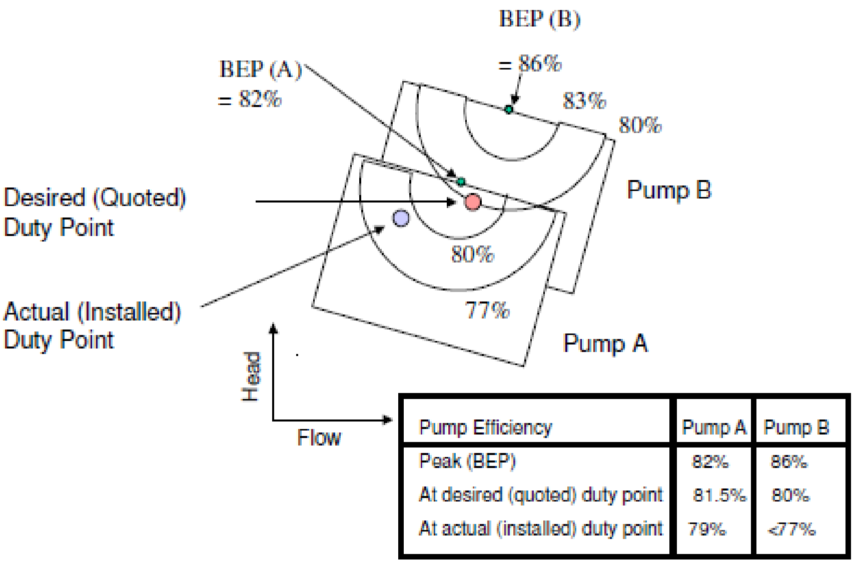


Figure 3-4: "Tombstone" curves for the selection of pumps by duty



Pump Efficiency	Pump A	Pump B
Peak (BEP)	82%	86%
At desired (quoted) duty point	81.5%	80%
At actual (installed) duty point	79%	<77%

Figure 3-5: Worked example showing the importance of correct selection of a pump

A user requests quotes for a pump at a particular desired duty. Manufacturers A and B offer the pumps shown, which are the best that they can offer from the ranges that they have.

There are two important points:

While pump B has a higher BEP, at the desired duty, pump A actually has a higher efficiency than pump B. Over-specifying the duty means that at the actual installed duty, the efficiency of the pump will be considerably less than quoted. (In this particular case, it would be better to use a reduced diameter impeller, or perhaps a quite different pump to either of those quoted).

System Energy Savings

This report concerns solely the energy savings that can be achieved by using a more efficient pump – but in terms of the overall savings that can be found in a pumping system these savings represent only a small proportion of the total system loss.

Considering the entire pump system ("electricity to water"), it is found that on average, most significant energy savings come from attention to the way in which the SYSTEM is designed and controlled. Improving the approach to pump system design would include measures such as optimal pump selection and pipework sizing, minimising velocities and reducing friction losses, optimising operating pressures, and ensuring adequate controls will realise significant energy savings within the whole pumping system. The SAVE study[2] identified energy savings associated with these measures as follows:

- Selecting better sized pump: 4%
- Better installation / maintenance: 3%
- Better System Design: 10%
- Better System Control: 20%

In particular, the use of Variable Speed Drives to adjust the flow to match the actual system requirements can make energy savings in some systems. The most efficient control method depends on the specific application needs.

Part load characteristics of pumps

Pumps are always defined by the basic Pump characteristics as shown in

Figure 3-6 shows the relationship between head, power and efficiency against flow. It is important to see just how "peaky" the efficiency might be; showing that running at a duty (head and/or flow) below 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. As shown in Figure 3-7, the peak power consumption will not necessarily be at the BEP.

[2] SAVE Study on Improving the Efficiency of Pumps', AEAT for the European Commission, February 2001

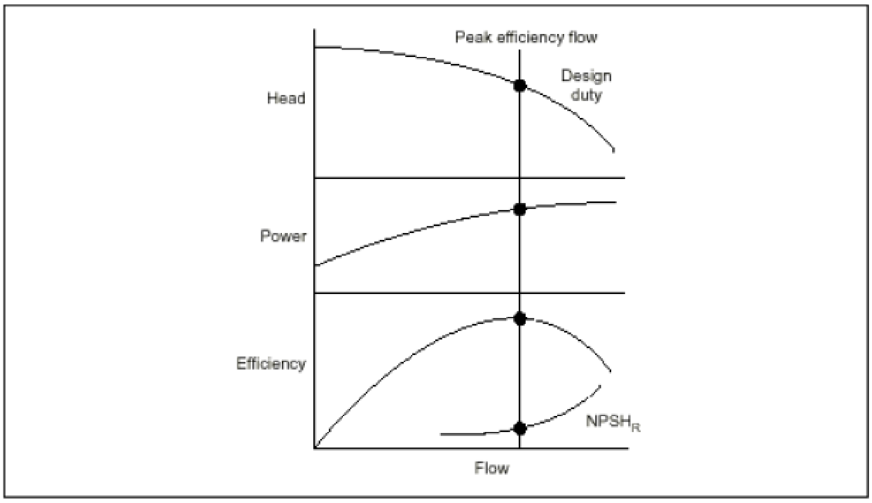


Figure 3-6: Centrifugal pump characteristics

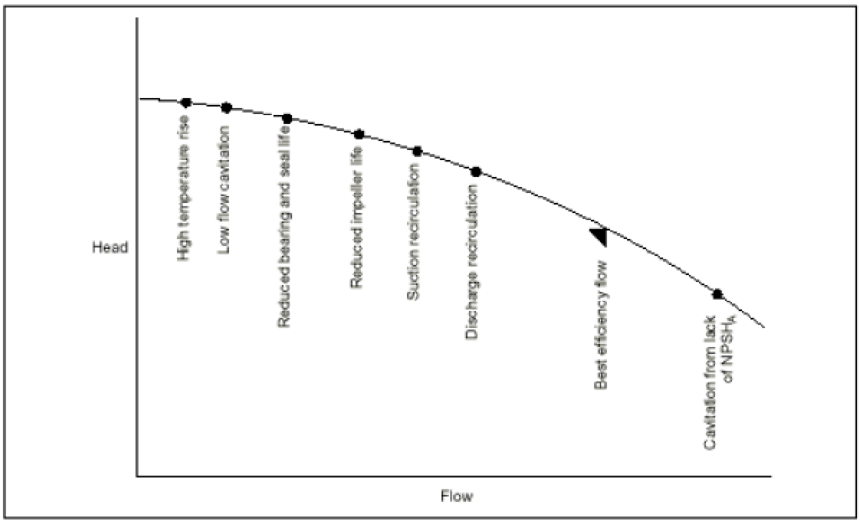


Figure 3-7: Onset of adverse effects when operating a pump away from its peak efficiency flow

The importance of selecting a pump to operate as closely as possible to its BEP cannot be overemphasised. Not only should this save on energy costs, it will have several other benefits:

- The pump should run smoothly with minimum internal disturbing forces, thereby saving on maintenance costs due to premature failure of components such as bearings, wear rings, bushes, couplings and seals.
- The risk of damage to pump components due to cavitation should be reduced.
- Vibration should be minimised, benefiting other equipment.
- Noise should be minimised, improving the environment.
- Pressure pulsations should also be minimised, reducing the risk of problems in the pumping system as a whole.

Figure 3-8 indicates some of the problems that can result from operating away from BEP. Some of these problems may not be serious in small pumps, but they increase in severity as pump power increases, and should therefore be discussed with the pump supplier.

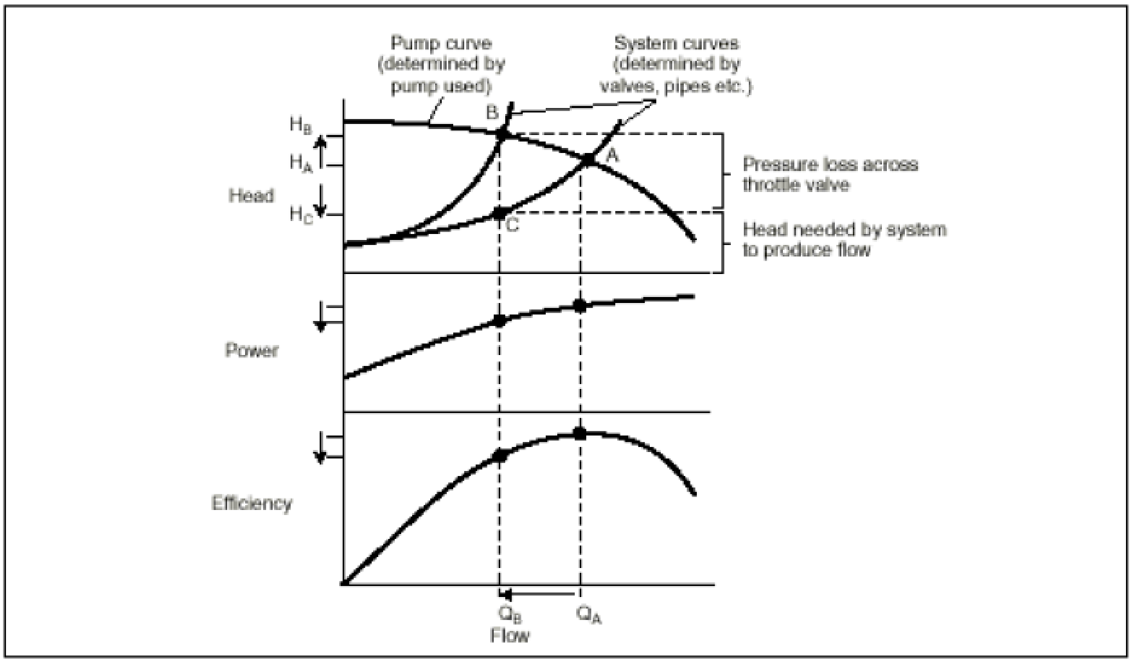


Figure 3-8: Illustration of the effect on the efficiency of throttling a pump

Taking account of both the wear, and the fact that operation is away from the BEP, stakeholders agreed with the study team's suggestion that the average pump of the types included in this study is operating 10-20% (15% average) below the catalogue efficiency.

3.2 End-of-life behaviour

A. Large water pumps

These pumps are likely to be returned to factory for refurbishment when their performance deteriorates too far. Pump manufacturer often provide a comprehensive range of spares for these pumps. Routine maintenance will be performed in the field.

When these pumps reach the end of their life, as they are all metal they will be sent for scrap. There is little market for second hand pumps.

B. Swimming pool pumps

Given the cost of these pumps, at failure they are more likely to be replaced than repaired. Spare motors are for example readily advertised. The second hard market is only small, as consumers are unlikely to upgrade unless their pump fails.

C. Fountain, pond and aquarium pumps

Given the low value of these, they are likely to be disposed of when they fail, not repaired. The motor contains valuable metal, but the plastic pump and case is unlikely to be recycled.

3.2.1 Economical Product Life (in practice)

The lifetime of a water pump will rarely be dictated by obsolescence. The pump will usually be replaced when it fails, due to a broken component or an unacceptable drop in output. The estimated technical life and actual time to disposal for pumps in this study is analysed in Task 2 of this preparatory study. The product life in practice is usually equal or shorter than its maximum technical life. In some cases, pumps may be replaced due to an upgrade of the overall system (e.g. aquarium powerheads and pumps), or refurbishing works (e.g. spa pumps and swimming pool pumps), etc. The difference between technical life and economic life is usually small in large pumps with high purchase prices (e.g. end suction pumps, submersible borehole pumps, etc.). In these cases, the high investment cost prevents from replacing the pump before the end of its technical life.

3.2.2 Present fractions to recycling, re-use and disposal

The BOMs for the pumps in the study show the proportion of non-metallic components by weight. Pumps are heavy items, and have both a positive scrap value and an avoided disposal cost, and so it is to a company's advantage to send old pumps for scrap. In practice, it is the norm for pumps to be sent for scrap. To a good approximation, it can be assumed that all of the metallic and none of the non-metallic components are recycled from large pumps. For small and medium-size pumps, segregation of different metal fractions is often not done, leading to the loss of valuable copper and aluminium in iron metal recycling. Table 3-2 shows the weight of pumps split by metallic and non-metallic components:

Table 3-2: Proportion of non-metallic components in the pumps considered in the study

Pump type	Percentage of non-metallic components (%)	Source
Swimming Pool pumps	11-31	Europump
Fountain & pond pumps	47-60	Estimate
Aquarium pumps	50-69	Estimate
Spa pumps	27	Europump
Counter-current pumps	23	Europump
End Suction pumps (ESCC, ESCCI & ESOB) (Size > ENER Lot11)	0	Europump
Submersible bore-hole pumps (8", 10" & 12")	1	Europump
Vertical Multistage pumps (Size > ENER Lot11)	0-1	Europump

Re-use in the context of this study refers to parts that can be removed from a product and re-used in a new product. There are in practical terms no such parts on pumps. (Motors on pump sets could well be re-used. This is frequently practiced for large pumps but is less common for the smaller pumps in the study. It should be noted that 100% separation of the main metal fractions from the pump is difficult and is not actually achieved during scrap treatment leading to, for example, lower iron recycling quality due to its remaining copper content.

The smaller domestic pumps in the study are typically disposed of in the municipal waste collection and not via separate WEEE collection.

Unlike products that are used by domestic consumers where most goods end up as landfill, the professional market that is responsible for disposing of old pumps is used to sending metal products for scrap. The 8% landfill figure set in the EcoReport (the simplified life cycle assessment tool that will be used to assess environmental impacts and life cycle costs in tasks 5 and 7) is therefore thought to be too high. However, as the EcoReport model carried out in the screening in Task 1 showed that materials are not responsible for much of the total environmental impact; this does not represent a significant error, and so is not investigated any further.

3.2.3 Estimated second hand use, fraction of total and estimated second product life (in practice)

There is some use of second hand pumps, but is not a significant factor in the market. There is no developed second hand pump market as there is with some other consumer or industrial equipment, it is rather the result of the occasional factory closure or where a pump is incorporated into a larger item of plant that is sold. Therefore, in terms of this study, this second hand life is included in the total lifetime of the product referred to Task 2, and so this lack of definitive data does not affect the analysis.

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

The aim of this subtask is to identify and describe barriers and opportunities relating to local infra-structural factors. It deals with the differences between theory and practice, which is very important for the success of green-design. The benefit of technology only persists if the product is properly used. So there are a variety of very good ideas which are not used, because either, end users do not accept or do not care about them.

The end user is a central player concerning the environmental impacts of energy using products. One essential factor is barriers that hinder users from behaving in more environmentally sound ways. It is not only the question of how many and what kind of products are being purchased by end users, but also how these products are being used and for how long they are used are crucial for their overall environmental impacts.

3.3.1 Local infrastructure factors

- **A. Large water pumps**

These pumps will draw a high electrical power, and so may need an appropriate MV electrical connection. In some cases, an engine drive will be used, for example on emergency pumps.

When money is short, the decision may be taken to refurbish rather than replacing pumps, hence delaying the impact of any regulations.

- **B. Swimming pool pumps**

There are not thought to be any significant infrastructure constraints on the adoption of improved products, but this will be tested.

- **C. Fountain, pond and aquarium pumps**

With the exception of dry pond pumps that require a dry space for fitting, there are no local infrastructure requirements for these types.

3.3.2 Barriers to ecodesign

In practice, many barriers to ecodesign may come from the supply chain rules. For example, investment-related questions may be directly involved: often the more energy-efficient the product is the more expensive is purchase price. Buyers and product distributors are not in charge of the system operation afterwards and thus do not pay the final electricity bill. Following are some other barriers:

- **Preference for stabilised technologies:** technology changes often generate a temporary increase in breakdown rates due to a necessary learning period.
- **Fear of complexity:** as an example, components of complex systems with many connections to the other components and replacing one of these components may necessitate global adaptations of the whole system.
- **Lack of knowledge:** E.g., relevant information is not available to pumps for in the study.
- Other **non-technical barriers** (lack of internal incentives, e.g. reduction of budget for subsequent years).

In this study, the analysis will be made first for the pump alone, and then for the systems which will have been selected (see Task 4).

3.4 Conclusions

Task 3 has considered consumer behaviour and local infrastructure issues associated with the pumps covered by this study. Large clean water pumps represent major capital investment and therefore tend to be carefully sized and specified to provide highly efficient operation. In variable flow, systems provided with variable speed drives, which allow the supply to match the demand whilst maintaining a high level of efficiency.

Conversely, smaller pumps, such as those found in swimming pools and gardens, tend to be sized through well-accepted rules of thumb rather than after a detailed calculation of the site-specific system losses. The energy savings to be made in these pumps arise from better selection, improved installation and maintenance, better system design and better controls. Of these, better controls, offer the biggest scope for improvement.

There is a significant amount of metal in the large clean water pumps, which may be recovered as scrap at the end of their lives. There is little market for second hand pumps of this kind. Swimming pool pumps are likely to be repaired at failure rather than replaced and there is an established market for spare motors. There is only a small second hand market. Fountain, pond and aquarium pumps are likely to be disposed, if they fail, rather than repaired, as they are low value items. The motors contain metals, which are likely to be recycled. Again, there is not a significant second hand market.

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