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

ENER Lot 28 – Pumps for Private and Public Wastewater and for Fluids with High Solids Content – Task 3 – Consumer Behaviour and Local Infrastructure Working Document

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Task 3: Consumer Behaviour and Local Infrastructure

Consumer behaviour has a significant direct effect on the use of pumps for wastewater and fluids with high solid content, during the use phase of the product and the End-of-Life phase. To some extent, product-design can be used to influence a consumer's behaviour to improve 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 wastewater and solids handling pumps, and on the influence, they can have on the environmental performance of the equipment. The main aspects covered in this task include: real life efficiency, end of life behaviour, and 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 reflect on how the real life efficiency of pumps for wastewater and fluids with high solid content, 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), 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)

While energy efficiency is important, there is a vital trade off with ability to pass solids and resist clogging or ragging. “Rag” is a term used to describe the fibrous solid matter found in wastewater. The ability to resist wear is also crucial so that efficiency is maintained over a pump's lifetime.

By way of comparison, the typical BEP efficiency of a 30 kW wastewater pump is c.30 - 73 %, compared to the typical efficiency of an equivalent duty clean water pump of 65 – 80 %. Users traditionally accept this efficiency penalty in order that the pumps do not regularly block and fail.

3.1.1 Impeller Design for centrifugal pumps

Impellers for clean water pumps have fine clearances to minimise backflow and to maximise hydraulic efficiency. These are typically known as closed impellers, see Figure 3-1. The impellers in centrifugal wastewater treatment pumps are designed to allow solids to pass through the pumps without clogging it up, and so have a very different appearance. They are also considerably less efficient.

Figure 3-1: Example of a closed impeller used for clean water applications

The downtime due to clogging can be significant and costly. Figure 3-2 shows an example of material that can get clogged in a sewage pump.

Figure 3-2: Typical material removed from a conventional 300mm discharge sewage pump

Through careful selection of the impeller, it is possible to achieve the best efficiency with an acceptable (if any) likelihood of blockage from ragging.

Three common impeller types are used in wastewater treatment: *open* which have large spaces between vanes; *vortex* which creates a vortex within the pump bowl which prevents the solids from coming into contact with the impeller; and *grinder impellers which break up the solids which allows them to pass through the pump with greater ease.*.

Open impellers come in a range of types including a screw centrifugal impeller (Figure 3-3)which guide solids through the pump without damaging them. Some designs offer free passage for solids up to 300 mm. This can be of great benefit in some areas of wastewater treatment where a wider passage allows a smooth transfer of activated sludge, but there is an efficiency penalty for this.

Figure 3-3: Passage of a rag through a screw centrifugal impeller (Courtesy of Hidrostal)

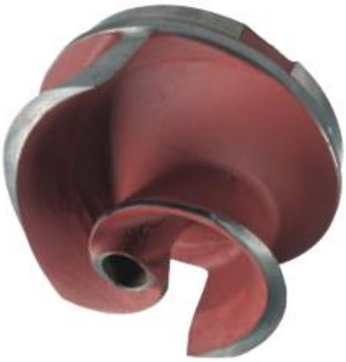

Figure 3-4: Example of an open impeller

In medium sized pumps, open single and two channel impellers are common, with the wear disc adjustable to compensate for wear and hence maintain efficiency over pump lifetime. Some larger pumps have closed channels (two sides to the impeller).

In smaller sized pumps besides mostly open single and 2-channel impellers, vortex impellers are very common as they do not make contact with the solids within the pumped liquid and therefore are much less prone to being clogged up by rags. Despite their relatively low efficiencies, their use can be appropriate for applications with low duty and low annual operating hours. Due to their good non-clogging behaviour, they are well suited to remote applications where cal-outs would be expensive. Figure 3-5 shows the operation of a vortex impeller, with the impeller generating a vortex that pulls through the water and any solids without the solids passing through the impeller.

Certain pumps, particularly when used with smaller pipe diameters have the ability to chop the big solid particles into smaller ones. Figure 3-6 shows one such cutting/grinding pump.

Figure 3-5: Vortex impeller

Figure 3-6: Example of cutter type impeller

The following table is indicative of the relative efficiencies of the different impeller options available for the same basic pump.

Table 1: Maximum efficiency of different types of wastewater impeller (source Europump)

Impeller	Max Efficiency
Open	87%
Vortex	63%
Grinder	42%

3.1.2 Pump applications

The pumps within the definition of scope of ENER Lot 28 study are largely designed for use in specific applications. This means that it will be clear to any user what type is appropriate for a particular application. For some applications, there may be alternative technology options. This is of relevance to the ecodesign process, as it means there is a risk that regulation could inadvertently lead to users selecting a less good pump that has less demanding regulations applied to it. Conversely, risk averse users may not be aware of the more efficiency alternatives to the types they have used in the past, and so the ecodesign process has a very important role to play in overcoming this critical barrier.

The first step in understanding the use of pumps in scope of ENER Lot 28 is to establish a descriptor of the user requirements of the systems in which they are applied. This section gives an overview of these applications.

The applications considered are:

- Wastewater pumping stations
- Wastewater treatment plants

Pumping stations

Pumping stations are found throughout the wastewater collection network. The collection network starts in the catchment area and brings together the collected wastewater in to progressively larger pumping stations until they are pumped to the wastewater treatment works for processing. Most wastewater pumping stations are used to lift the wastewater into a sewer network where it moves by gravity to the next pumping station in the line. This minimise the pumping power required as most of the work is done by gravity. The size of the collection network is dependent on a number of factors including population density and topography, and can be several kilometres in length.

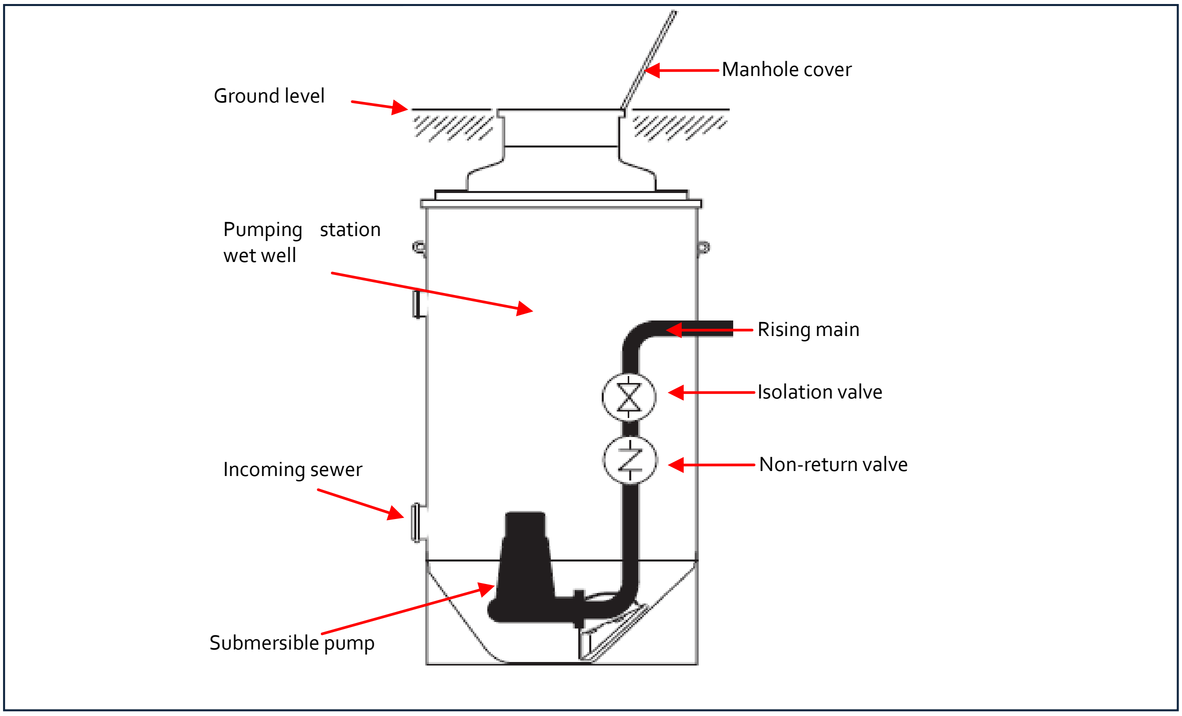

Figure 3-7: Typical submersible pumping station arrangement

Wastewater collection networks can come in two configurations, separate and combined. In a combined system, rainwater collected from road, building drainage is combined with the wastewater, and it is all sent to the wastewater treatment works together. In a separate system, only wastewater is sent to the treatment works and rainwater is discharged directly to the local watercourse.

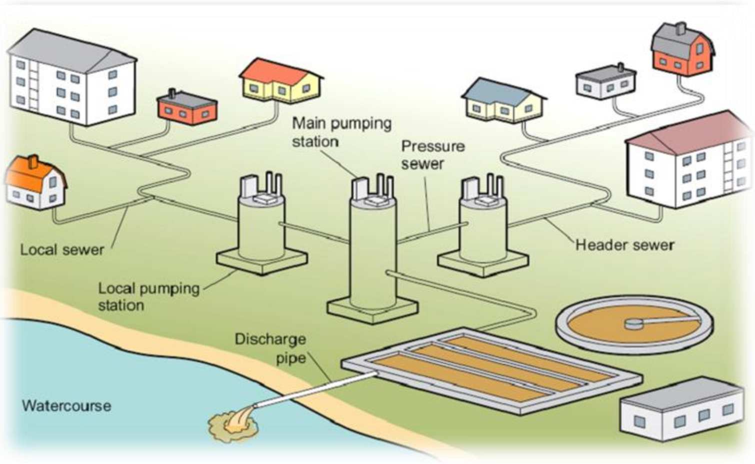

Figure 3-8: Diagram of pumping station network from source to WWT plant

A typical small or medium sized wastewater pumping station consists of two parallel submersible pumps in a wet well. The pumps are operated in a duty / standby or duty / assist configuration. The duty pump is called to run when the water level in the wet well reaches a pre-defined level, and stops when the level approaches a defined stop level, taking into account the minimum submergence needed, given e.g. by NPSHa, motor cooling or prevention of air sucking vortices. The size of pumping station is dependent of the catchment they serve, which can range from a few houses to a large industrial estate. Typical pumps used vary in size from 4 – 200 l/s with a head of 3 – 50 m, and have a rated power of between 3 – 150 kW. The wet wells are sized to ensure that the pumps do not start more than, depending on motor size and design, 6 to 20 times per hour so as to avoid premature motor failure.

The pumps required in a combined collection network are larger than those in a separate system and are subject to much larger variations in flows. A benefit of using a combined system is that the rainwater dilutes the wastewater which, results in principle in less risk of blockages, however combined systems are prone to overloading the pumping stations with accumulated trash from the sewer systems during storm events. As a consequence of this, pumping stations in combined systems are sometimes equipped with a third pump which is scheduled to operate during periods of high rainfall. These larger pumping stations are sometimes fitted with dry well pumps instead of submersible for easier access for repairs and maintenance purposes.

It can sometimes be useful to fit terminal pumping stations, (the final pumping stations before the treatment works) with variable speed drives. This will help to ensure that wastewater reaches the treatment works in a steady stream rather than in batches. This is primarily done to ensure the wastewater treatment process is not overloaded, rather than for reasons of energy efficiency.

- **Wastewater treatment plants**
  - **Preliminary Treatment**

During the preliminary treatment stage, the wastewater is screened to take out the large solids and often there is a grit removal process. Inlet screens are sometimes located higher than the incoming sewer and pumps are required to lift the wastewater to them. Although centrifugal pumps may be used for this purpose, Archimedean screw pumps are often employed due to their excellent solids handling capability and their ability to pump variable flows. In the grit removal process, vortex pumps are often used due to the abrasive nature of grit. Figure 3-9 shows typical material collected by a primary screen, which may have been pumped a long way along the sewerage network and needs keeping out of the WWT station.

Figure 3-9: Refuse collected on wastewater treatment inlet screens[1]

- **Primary Settlement Treatment (PST)**

Heavy solids are removed in the primary settlement stage with settlement tanks where the sludge is drawn off the bottom of the tank and pumped to a sludge-holding tank. Progressing cavity pumps or centrifugal pumps are used due to the solids content of the liquid. Pump selection can depend on the height of the sludge holding tank, the distance to be pumped and the viscosity of the sludge. Sludge is drawn off and pumped away in batches.

- **Biological (secondary) Treatment**

The two most common biological treatment stages are biological filtration and activated sludge. Biological filtration involves passing the wastewater through a bed of inert media where microorganisms breakdown the dissolved organic matter. The resultant effluent is settled in a settlement tank and humus is drawn off the bottom of the tank. This humus has a low sludge content and so it suitable for pumping with centrifugal pumps. The humus is typically drawn off in batches and pumped by dry well pumps. During periods of low wastewater flow into the treatment works, some of the effluent from the settlement tank can be pumped back to the filter media to stop it from drying out.

In the activated sludge process, the wastewater is mixed with aerobic bacteria and oxygen in a tank. The resulting effluent is passed to a final settlement tank where activated sludge is drawn off the bottom. Unlike primary sludge and humus, activated sludge is drawn off continuously and is returned to the activated sludge plant. Any surplus activated sludge is pumped to the sludge holding tanks. This activity is particularly well suited to the use of variable speed drives as the return rate of the activated sludge can be matched to the mixed liquor suspended solids contents

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[1] Thames Water

of the process tank. This reduces the energy use of the process compared to the fixed speed operation.

- **Additional Pumping stations**

Depending on the topography of the site it is possible for the wastewater to pass between the various treatment stages via gravity, however in many sites inter-stage pumping stations are required. These pumping stations generally resemble the pumping stations found in the collection network and a typically fitted with submersible or dry well centrifugal pumps.

The volume of product that can safely pass through a pump is a key criterion in pump design and selection. Larger clearances necessarily mean lower efficiencies, and so this factor will need taking account of in the data collection phase.

3.1.3 Frequency of use

The range of pumps considered in scope has an exceptionally wide range of operating hours. Of particular interest are those used just occasionally to transport wastewater from domestic or small commercial buildings. 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.

By comparison, pumps at the WWT works will have much longer operating hours, and so here, efficiency considerations become much more important.

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 2 shows the annual number of operating hours of the ENER Lot 28 pumps.

Table 2: Annual operating hours of the ENER Lot 28 pumps

Pump Type		Annual operating hours	Source
Centrifugal submersible pump			
	Radial sewage pumps 1 to 10kW	1 000	Europump
	Radial sewage pumps >10 to 25kW	1 500	Europump
	Radial sewage pumps >25 to 160kW	2 000	Europump
	Mixed flow & axial pumps	5 000	Europump
Centrifugal submersible pump – once a day operation			
	Shredding, grinding pumps	30	Europump
	Radial sewage pumps 1 to 10kW	30	Europump

Pump Type		Annual operating hours	Source
	Where volute is part of a tank	30	Europump
Centrifugal submersible domestic drainage pump < 40 mm passage		30	Europump
Submersible dewatering pumps		2 000	Europump
Centrifugal dry well pump			
	Radial sewage pumps 1 to 10kW	1 000	Europump
	Radial sewage pumps >10 to 25kW	1 500	Europump
	Radial sewage pumps >25 to 160kW	2 000	Europump
	Mixed flow & axial pumps	250	Europump
Slurry Pumps			
	Light duty	2600	Europump
	Heavy duty	2000	Europump

3.1.4 Product related eco-information

Real life efficiency

Once the pumping station wet well has filled to a set limit, the pump is activated and keeps working until the well has fallen to a lower limit. The total operating hours of a pumping station depends greatly on the flow of water into the wet well. Pumps are generally sized to pump at a flow rate of twice (to 4 times) the average inflow rate, although, due to static head changes, the actual flow rate will vary depending on the level of the water in the well. The routine fitting of standby pumps also halves the average operating time of each pump. On this basis, the maximum duty of any pump is 25% or 42 hours per week, but on average will be much lower.

For isolated premises with their own pumping station, the duty may be extremely small, just a few hours per week. In these applications, extremely reliable but less efficient vortex pumps are popular, with the efficiency trade-off being accepted in order to minimise the risk of blockages.

Reducing pump speed decreases the head drastically ($H \sim n^2$) and so the opportunities for speed reduction in water lifting applications is limited. It also reduces the flow rate, which can cause issues in wastewater pumping, as a minimum flow velocity is required to ensure that the solid particles do not settle out of the water. Reduced pumping speeds also encourages ragging. Variable Speed controls are sometimes used within wastewater treatment works to provide a steady inflow to the process, but minimum speeds are rigorously enforced to maintain flow velocities. In addition, VSDs can be used in reverse in "de-clogging" cycles to attempt to spin off any materials attached to the pump impeller.

Repair and maintenance practices

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 also reduce corrosion, which can be used both from new and for in service refurbishment. For smaller pumps in sewage pumping stations, it has to be weighed if repair or replacement is economical. For small pumps as e.g. in building and commercial applications, it will not be economic to change these parts, they will instead be replaced by new pumps.

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 Supervisory 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.

Pumps that offer increased wear resistance, less ragging, easier passage of materials and easier to change parts are understandably popular. Wastewater pumps with the ability to pass solids and fibrous materials do have a lower efficiency than conventional pumps, however they are less susceptible to wear. This results in less degradation in performance over time.

Statistically, a wastewater pump in a small pumping station will be replaced 5-6 times over a system's 60-year life, and so the pumping station layout and design will be a key constraint on the type of pump needed. In larger pumping stations pumps are replaced typically 2 to 3 times over a system's design life. Mechanical and hydraulic connections will be a key constraint, with changes in local sewer condition or loading imposing another constraint in terms of flow speeds.

For new pumping stations, for ease of construction, developers will prefer a drop-in pre-fabricated unit.

Figure 3-10: Example of a prefabricated pumping station

Remoteness of pumping stations will dictate more rugged designs with back-up systems and telemetry and monitoring.

Pump run time monitoring is sometimes used to monitor the increase in pump operating time as pump efficiency and flow deteriorate due to wear, offering an economical solution to assessing pump performance.

- **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.

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 affect use patterns, however the content of wastewater is affected by cultural factors and this in turn has an effect on pump selection. For example, the type of food cooked will affect the amount of fats, oils and grease in the wastewater. In addition, educational and social factors may affect whether non-organic waste items are flushed down the toilet.

However, although beyond the scope of this report, measures to reduce water consumption would reduce the operating duties of pumps, 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 properties, grey water use is reducing the effluent generated.

It is clear that the correct selection of pump is at least as important as the selection of pump by highest 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 the ranges of pumps to cover a range of duties, (Figure 3-11: "Tombstone" curves for the selection of pumps by duty). 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 following figure makes this clearer.

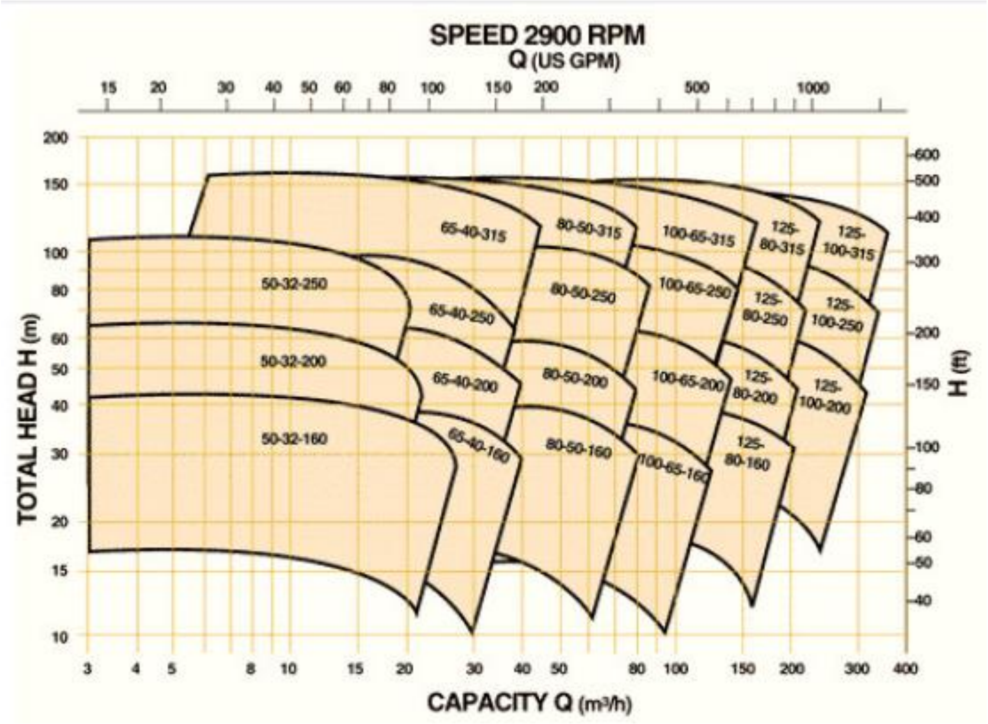
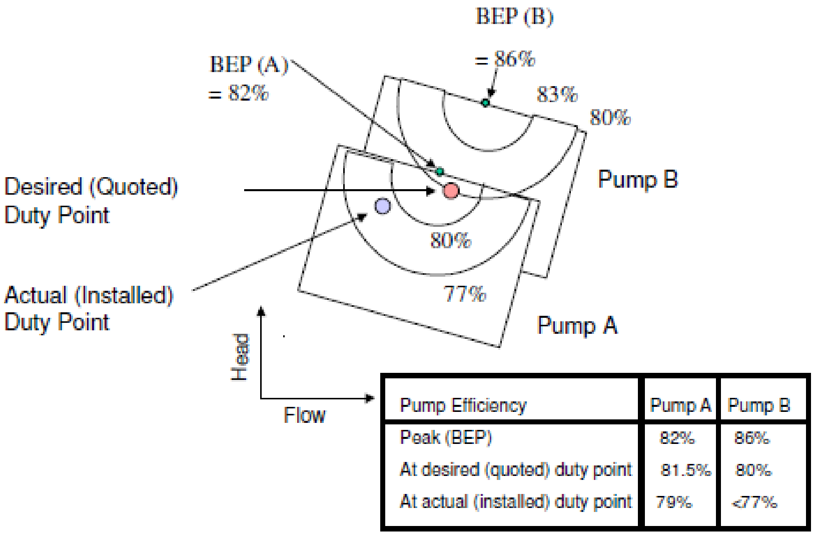


Figure 3-11: “Tombstone” curves for the selection of pumps by duty

A user requests quotes for a pump at a particular desired duty (Figure 3-12). 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 for.



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 3-12: Worked example showing the importance of correct selection of a pump

▶ System Energy Savings

This report concerns solely the energy savings that can be achieved by using a more efficient pump and extended product – 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 pumping 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 complete pumping system. 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.

… "In particular, the use of Variable Speed Drives (VSD) to adjust the flow to match the actual system requirements can lead to energy savings of over 50% in some systems, and so is something to be encouraged.

Wastewater pumping applications in general tend to be batch operations, i.e. emptying a wet well once it fills to a certain level. It is therefore not expected to have significant benefit from fitting VSDs to these pumps, but they can be used very effectively in non-batch pumping operations.

Part load characteristics of pumps

Pumps are always defined by their basic characteristics as shown in Figure 3-13: Centrifugal pump characteristics. They show 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. The peak power consumption will not necessarily be at the BEP.

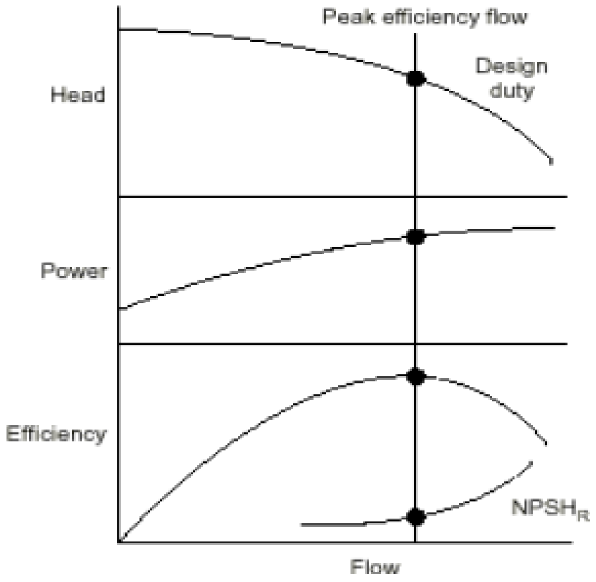


Figure 3-13: Centrifugal pump characteristics

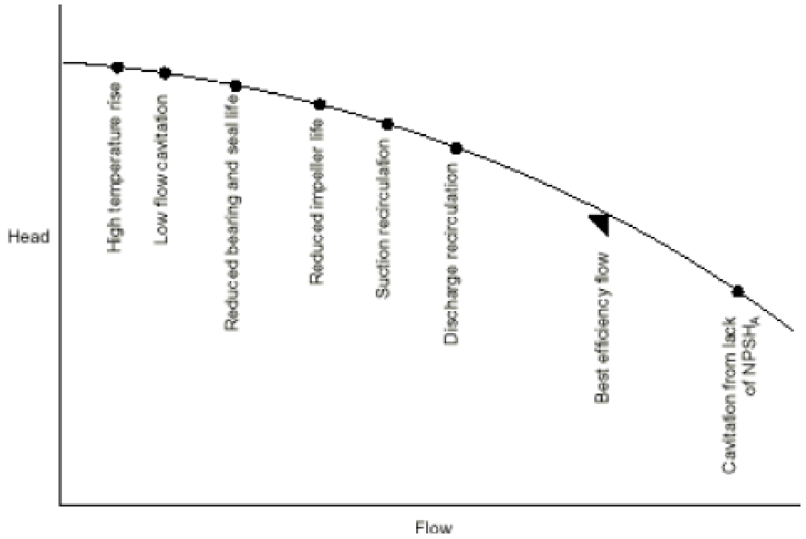


Figure 3-14: Onset of adverse effects when operating a pump away from its peak efficiency flow

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 would be reduced
- Vibration would be minimised, benefiting other equipment
- Noise would be minimised, improving the environment
- Pressure pulsations would also be minimised, reducing the risk of problems in the pumping system as a whole.

Figure 3-15: Illustration of the effect on power and efficiency of indicates some of the problems, which 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.

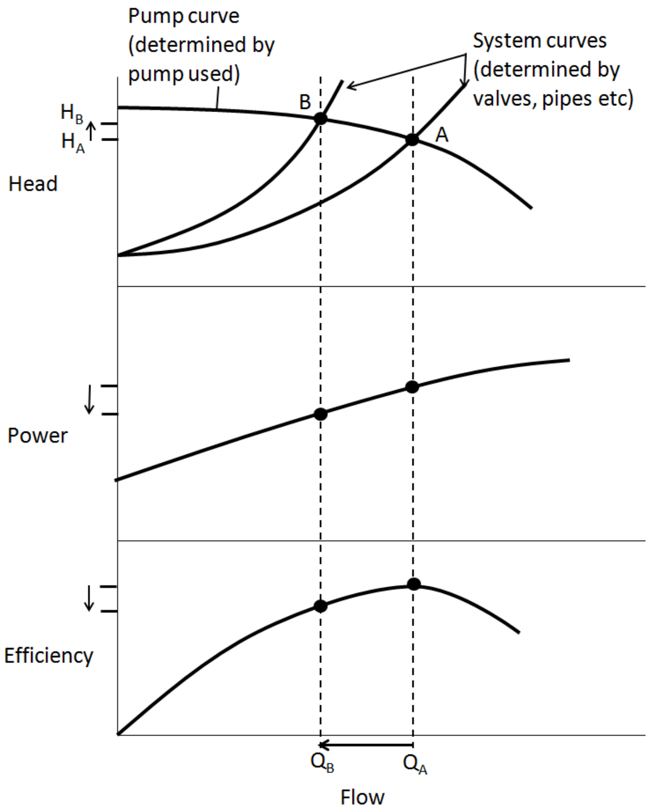


Figure 3-15: Illustration of the effect on power and efficiency of operating away from the BEP of a pump

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 BEP efficiency.

3.2 End of life behaviour

The high metal content of pumps means that they are likely to be sold for scrap at the end of their lives. However, wastewater pumps may need cleaning to remove pathogens prior to being moved to the scrap yard.

3.2.1 Present fractions to re-use, recycling and disposal

The Bill of Materials (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 is assumed that all of the metallic components are recycled. It should be noted, that in real life situations 100% separation of the main metal fractions from the pump is difficult and is often not achieved during scrap treatment, often leading to lower iron recycling quality due to the remaining copper content. The following table shows the weight of pumps split by metallic and non-metallic components:

Table 3: Proportion of materials in the pumps considered in the study

Pump Type		Materials					Total weight
		Steel (%)	Other ferrous-metals (%)	Non-ferrous metals [Al, Cu] (%)	Plastics [PP, PS, ABS, Others] (%)	Others (%)	
Centrifugal submersible pump							
	Radial sewage pumps 1 to 10kW	20	68	10	1	1	80 kg
	Radial sewage pumps >10 to 25kW	20	68	10	1	1	200 kg
	Radial sewage pumps >25 to 160kW	25	58	15	1	1	1 000 kg
	Mixed flow & axial pumps	25	58	15	1	1	400 kg
Centrifugal submersible pump – once a day operation							
	Shredding, grinding pumps	20	68	10	1	1	50 kg
	Radial sewage pumps 1 to 10kW	20	68	10	1	1	45 kg
	Where volute is part of a tank	15	40	10	34	1	40 kg
Centrifugal submersible domestic drainage pump < 40 mm passage		48	0	28	23	1	8 kg
Submersible dewatering pumps		34	14	44	1	7	50 kg
Centrifugal dry well pump							
	Radial sewage pumps 1 to 10kW	5	90	0	1	4	80 kg
	Radial sewage pumps >10 to 25kW	5	90	0	1	4	125 kg
	Radial sewage pumps >25 to 160kW	5	90	0	1	4	550 kg
	Mixed flow & axial pumps	10	85	1	0	4	1 500 kg
Slurry Pumps							
	Light duty	22	70			8%	600 kg
	Heavy duty	19	81				700 kg

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 in pumps. Motors on pump sets could however well be re-used.

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 (same value as that used for pumps in ENER Lot 11 study) 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 results of the environmental impact analysis in Task 5 showed that materials are not responsible for much of the total eco-impact, this does not represent a significant error, and so is not investigated any further.

3.2.2 Estimated re-use 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, rather it is as 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, and so this lack of definitive data does not affect the analysis.

3.3 Local infrastructure

The end user is a central player concerning the environmental impacts of energy–related 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.

- **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. Following are some of the barriers:

- **Preference for stabilised technologies:** technology changes often generate a temporary increase in breakdown rates due to a necessary learning period.
- **Fear of complexity:** e.g. 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 users of pumps for wastewater and fluids with high solid content, etc.

- Other "non technical barriers" (lack of internal incentives e.g. reduced budget next year).

3.4 Conclusions

Task 3 has addressed consumer behaviour and local infrastructure issues associated with ENER Lot 28 pumps. The pumps in this study are specifically designed to pump solids and resist clogging. This in turn has an effect on their real life efficiency. Users have traditionally accepted this efficiency penalty in order to ensure a more reliable operation of these pumps. The biggest factor in the real life efficiency of a pump is the impeller type used. There are a number of impeller options open to users when pumping solids and the most efficient impellers may not be the most appropriate choice when looking for reliable operation. These pumps do require regular maintenance to ensure continued efficient operation over their entire lifetime.

There are certain applications where there is a range of pump types available. For example in wastewater treatment, submersible pumps or dry well pumps could be used for the same application, although they would require different pumping station arrangements. Progressing cavity pumps are typically used for thicker sludge pumping applications, however there are sludges with lower percentage dry solids contents where submersible or dry well pumps could also be used.

The high metal content of the pumps means that they will often be sold for scrap at the end of their working life. 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; rather it is as the result of the occasional factory closure or where a pump is incorporated into a larger item of plant that is sold.

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