AEA

The Energy Using Products Directive

Lot 11 Final Stakeholder Meeting

WATER PUMPS (IN COMMERCIAL BUILDINGS, DRINKING WATER PUMPING, FOOD INDUSTRY, AGRICULTURE).

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Brussels 24 Oct 2007

Pumps included in the study

Chapter 1 - Summary

ISO9906 (currently under revision) is the accepted international test standard for measuring the performance of pumps, which allows various specified tolerances to be used. However, there is no agreement on what tolerance should be used for performance schemes. The assumption of zero measurement uncertainty used by manufacturers during in-house product tests is unsatisfactory.

While pumps are actually excluded from RoHS and WEEE legislation, manufacturers do in any case comply with these directives.

The earlier SAVE scheme to select pumps by efficiency is described, but this was not intended to be the basis of a pump labelling MEPS scheme. It is therefore not appropriate for this study.

China is also proposing a method that take account of performance at both peak and low and high flows. It is recommended there is an attempt to harmonise:

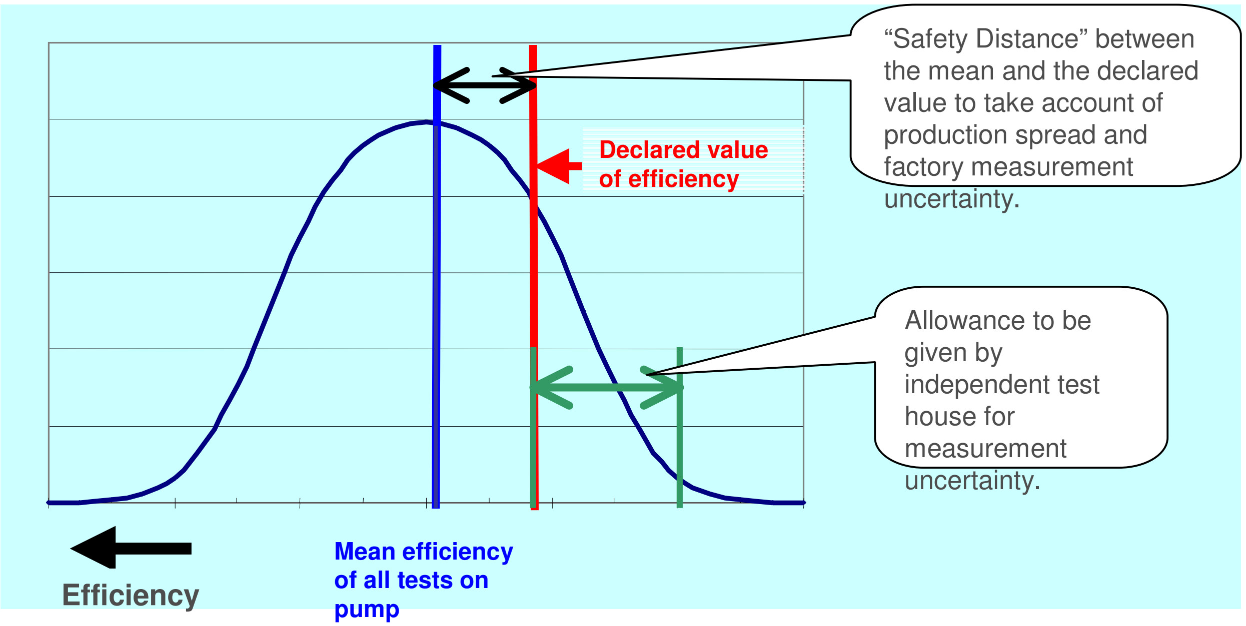
The flows at which low and high flow are assessed.

The values of the reduced efficiency allowed at the low and high flow points.

A key part of the methodology is the value of the *correction factor* for specific speed. It is also recommended that it is attempted to harmonise this factor.

It should be noted that this study considers the pump only; it excludes the motor, coupling, baseplate and any other ancillary items.

Testing and verification



It is important that the actual efficiencies of products placed on the market comply with any claimed energy performance class. Manufacturers currently use a statistical approach such that all of their pumps (except for a small statistical proportion) will exceed the declared efficiency value, (figure 1.21). They will test typically to ISO 9906:1999 Grade 2, which allows for a -5% tolerance on quoted efficiency. (Acceptance) testing is generally done at the manufacturer's own test facility, and may be witnessed by a representative of the purchaser.

Although ISO 9906 does also publish the measurement uncertainties for different measurement techniques, manufacturers will not normally make any specific allowance during acceptance testing for the uncertainties inherent in their test methods, since these uncertainties will usually be less than the permitted tolerance.

Manufacturers will take a statistical risk in how they position the declared and mean production values of efficiency. Those who control production to give a tighter spread may chose either to produce pumps with a lower mean efficiency and reap any cost savings, or quote a higher efficiency.

It is often the case that only a small percentage of each pump size included in this report will actually be tested by the manufacturer, either for customers or for quality control purposes.

Chapter 2 - Summary

This section has reviewed several sources of data in order to come to a conclusion on pump sales, stock and lifetime. In each case the market has been split into "large" and "small", as it is important that technical and economic differences are not lost when considering the cost effectiveness of different design options.

By making assumptions on the price to the user of basecase pumps, a total annual EU sales value of 1,500 M euros has been calculated.

Purchase, installation and maintenance costs of the different types of pumps have also been estimated for each type and size of basecase design.

Even for the commodity type (mass produced) pumps that are the subject of this study, most are manufactured within the EU.

There are several developments in pump technology that will lead to a reduction in energy consumption:

Greater sales of pumps with pressed stainless steel or plastic impellers that lead to reduced friction.

Variable speed control incorporated in integrated packages to give large energy savings in for examples many building services applications.

Pumps available with built-in condition monitoring, although sales so far are poor.

Some larger pumps will have friction reducing coatings on the cast iron volute.

Stock, energy use

Pump Style	Basecase type	Sales adj to EU-25	Pump Life (years)	Stock (Nos)	Operating hours pa
End Suction Own Bearings (	Small	200000	11	2200000	2250
	Large	50000	11	550000	2250
End Suction Close Coupled	Small	200000	11	2200000	2250
	Large	50000	11	550000	2250
End Suction Close Coupled	Small	80000	11	880000	4000
	Large	20000	11	220000	4000
Submersible Multistage	Small	560000	11	6160000	1000
	Large	140000	11	1540000	1000
Vertical Multistage	Small	200000	11	2200000	1500
	Large	50000	11	550000	1500
			Total	17,050,000	

Type of pump	Basecase size	Total annual energy consumption of stock (P2) (GWh pa)	Related motor efficiency (%)	Primary energy consumption of stock (P1) (GWhpa) by type, size	Total Primary energy consumption of stock (P1) (GWh pa)
End Suction Own Bearings (ESOB)	Small	18,988	84.2	22,551	42,466
	Large	17,923	90.0	19,915	
End Suction Close Coupled (ESCC)	Small	16,040	84.2	19,050	38,978
	Large	17,936	90.0	19,928	
End Suction Close Coupled Inline (ESCCi)	Small	9,597	84.2	11,398	24,433
	Large	11,732	90.0	13,035	
Submersible Multistage	Small	13,189	82.6	15,967	24,739
	Large	7,632	87.0	8,773	
Vertical Multistage	Small	2,983	76.2	3,915	6,002
	Large	1,691	81.0	2,087	
		117,711		**Total**	**136,620**

Chapter 3 - Summary

The energy savings from the optimum sizing of a pump can be equal to or larger than those from picking a higher efficiency pump. This is because the efficiency of a standard centrifugal pump will fall off much more rapidly than for a comparably sized motor. Wear of the pump will also be accelerated if operated away from the rated point, leading to a reduction in lifetime operating efficiency and also reduced lifetime.

Design of the system and controls can yield energy savings that will usually exceed that from the selection of a more efficient pump. The use of variable speed or intelligent controls for saving energy is outside the scope of this study, but is to be encouraged.

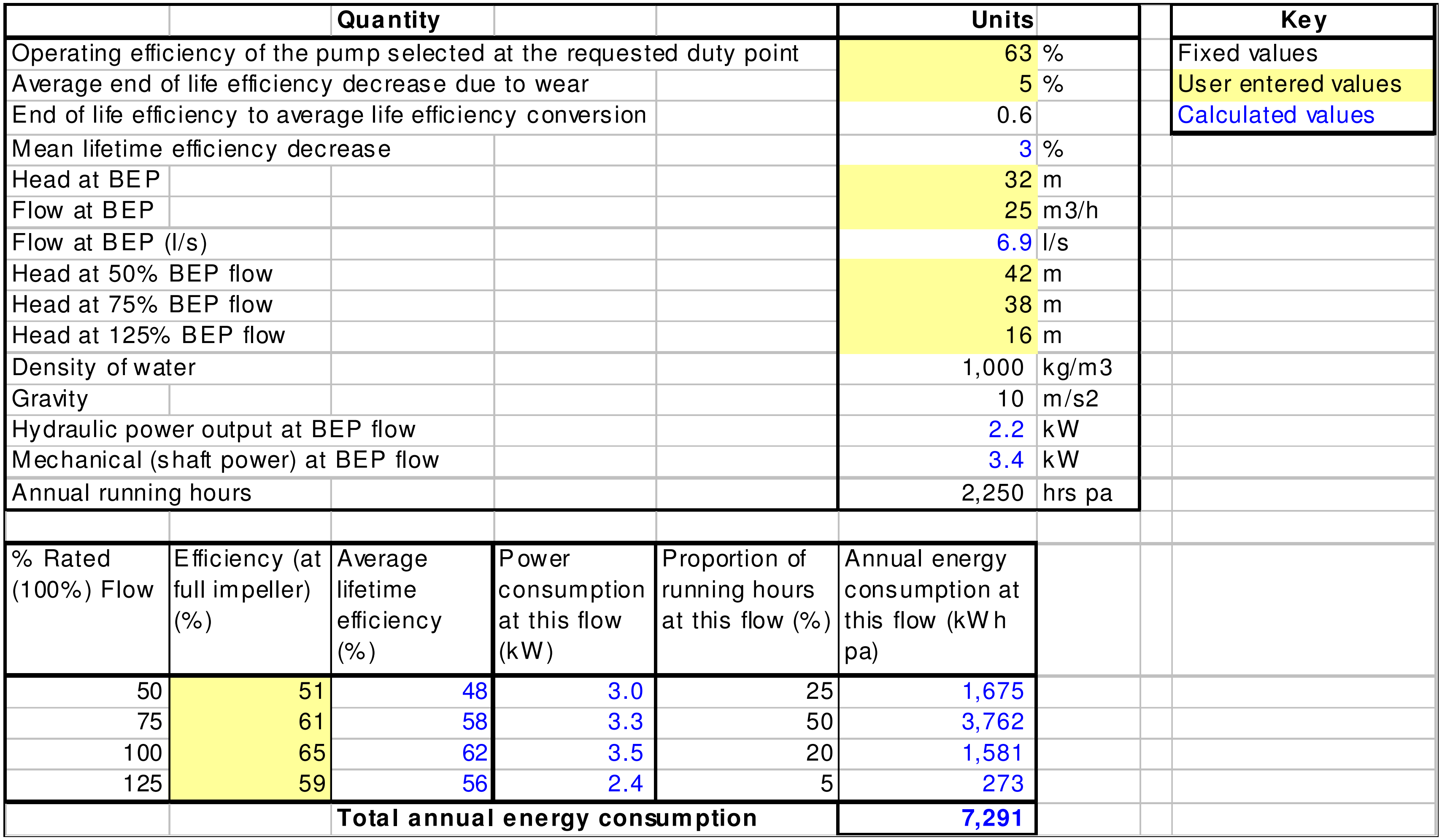
Chapter 4 - Summary

This section presents the technical inputs (materials and energy performance) needed as inputs to the MEEUP model.

Because in real life pumps are likely to work for all or part of their time at flows away from the rated flow point, it is important that the energy analysis takes account of this. An additional worksheet has therefore been added to the MEEUP model that derives a single energy use figure based on operation under typical flow profiles. It is this figure that is then entered into the proper MEEUP model as a single total energy consumption figure. Note that all the calculations in this chapter are in terms of mechanical power, and so in order to calculate the environmental impact (due to electrical energy) in the following section, use of a Class Eff2 motor is assumed.

Because of the big differences in design of the small and large basecase models, the analysis is run for both types separately, with the total impacts of each type of pump by adding the two basecase EIAs together.

Calculation of annual energy use - ESCC



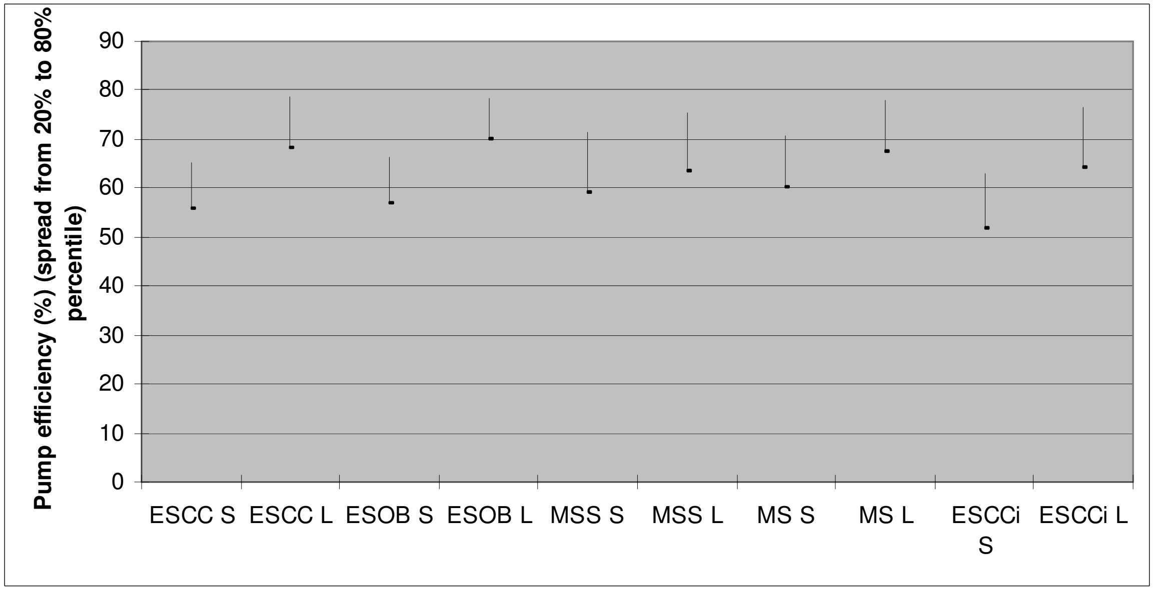
Quantity		Units
Operating efficiency of the pump selected at the requested duty point	63	%
Average end of life efficiency decrease due to wear	5	%
End of life efficiency to average life efficiency conversion	0.6	
Mean lifetime efficiency decrease	3	%
Head at BEP	32	m
Flow at BEP	25	m3/h
Flow at BEP (l/s)	6.9	l/s
Head at 50% BEP flow	42	m
Head at 75% BEP flow	38	m
Head at 125% BEP flow	16	m
Density of water	1,000	kg/m3
Gravity	10	m/s2
Hydraulic power output at BEP flow	2.2	kW
Mechanical (shaft power) at BEP flow	3.4	kW
Annual running hours	2,250	hrs pa

Key
Fixed values
User entered values
Calculated values

% Rated (100%) Flow	Efficiency (at full impeller) (%)	Average lifetime efficiency (%)	Power consumption at this flow (kW)	Proportion of running hours at this flow (%)	Annual energy consumption at this flow (kWh pa)
50	51	48	3.0	25	1,675
75	61	58	3.3	50	3,762
100	65	62	3.5	20	1,581
125	59	56	2.4	5	273
		Total annual energy consumption			**7,291**

Assumed basecase and actual average efficiencies

Type of pump	Basecase size	Assumed basecase efficiency (%)	Actual Statistical mean efficiency (%)	Deviation of assumed from actual efficiency (% points)
End Suction Own Bearings (ESOB)	Small	65	61.9	3.1
	Large	72	75.2	-3.2
End Suction Close Coupled (ESCC)	Small	65	61.2	3.8
	Large	73	74.7	-1.7
End Suction Close Coupled Inline (ESCCi)	Small	62	58.4	3.6
	Large	70	71.1	-1.1
Submersible Multistage	Small	63	66.2	-3.2
	Large	73.4	70.3	3.1
Vertical Multistage	Small	60	52.6	7.4
	Large	65	66	-1
			Average	**1.08**

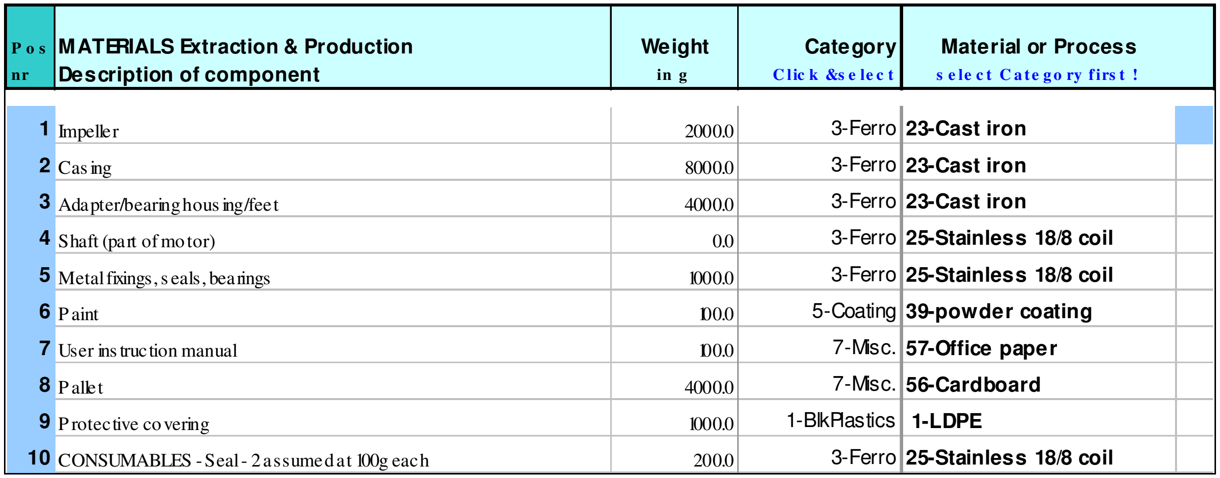


Chapter 5 - Summary

This analysis has shown that the eco impacts from the Production, Distribution and End-of-life phases are very small or insignificant compared to the USE phases. This justifies the focus on energy efficiency as the primary means for improving the eco performance of pumps.

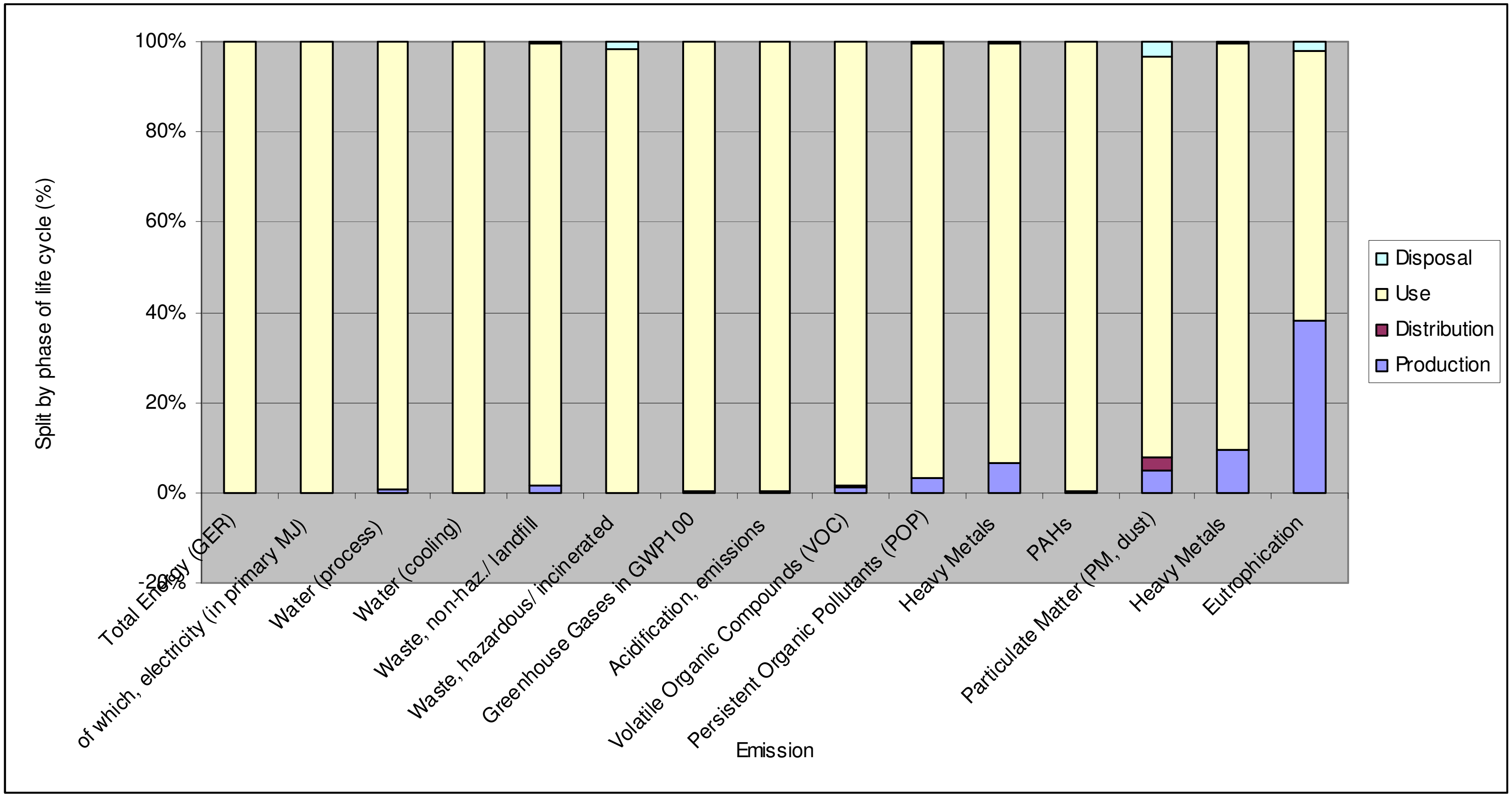
Reductions in the weight of the products is something that manufacturers would wish to do anyway, but will not have a significant impact on the overall eco impact of the products.

Bill of Materials – ESCC pump



Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Impeller	2000.0	3-Ferro	**23-Cast iron**
2	Casing	8000.0	3-Ferro	**23-Cast iron**
3	Adapter/bearing housing/feet	4000.0	3-Ferro	**23-Cast iron**
4	Shaft (part of motor)	0.0	3-Ferro	**25-Stainless 18/8 coil**
5	Metal fixings, seals, bearings	1000.0	3-Ferro	**25-Stainless 18/8 coil**
6	Paint	100.0	5-Coating	**39-powder coating**
7	User instruction manual	100.0	7-Misc.	**57-Office paper**
8	Pallet	4000.0	7-Misc.	**56-Cardboard**
9	Protective covering	1000.0	1-BlkPlastics	**1-LDPE**
10	CONSUMABLES - Seal - 2 assumed at 100g each	200.0	3-Ferro	**25-Stainless 18/8 coil**

Eco-impact by lifecycle phase – ESOB (small)



Chapter 6 - Summary

This section has discussed the many ways in which efficiency of centrifugal pumps can be increased. Each of the design options has an economic cost, and in some cases may impact adversely on pump lifetime. The detailed decisions on what options are most appropriate for a particular pump will vary from design to design, and so in the LCC analysis in chapter 7 a generic relationship between efficiency and production cost is derived.

Beyond improvements to the actual design of the pump itself, the use of electronic speed controls frees the designer from the specific speed constraints of standard fixed speed induction motors. This enables the efficiency of some pump sizes to be improved by being designed to operate at a more favourable speed and hence specific speed.

The use of speed controls and intelligent controls, although beyond the scope of this study, offer the potential to save even more energy, often actually larger than that from the use of just improving the pump itself, (section 7.6).

(See appendix 1 also)

Summary – Chapter 7

This section has presented the analysis of the cost and energy savings from improving pump efficiency through removing the worst n% of pumps from the market. This is based on a statistically accurate analysis of the efficiencies of pumps sold on the market today, but the costs of different types of pumps and typical duty patterns are best estimates only.

Life Cycle Costing analysis has shown that removing the worst 50-60% of pumps from the market will still give the consumer a reduced life cycle cost.

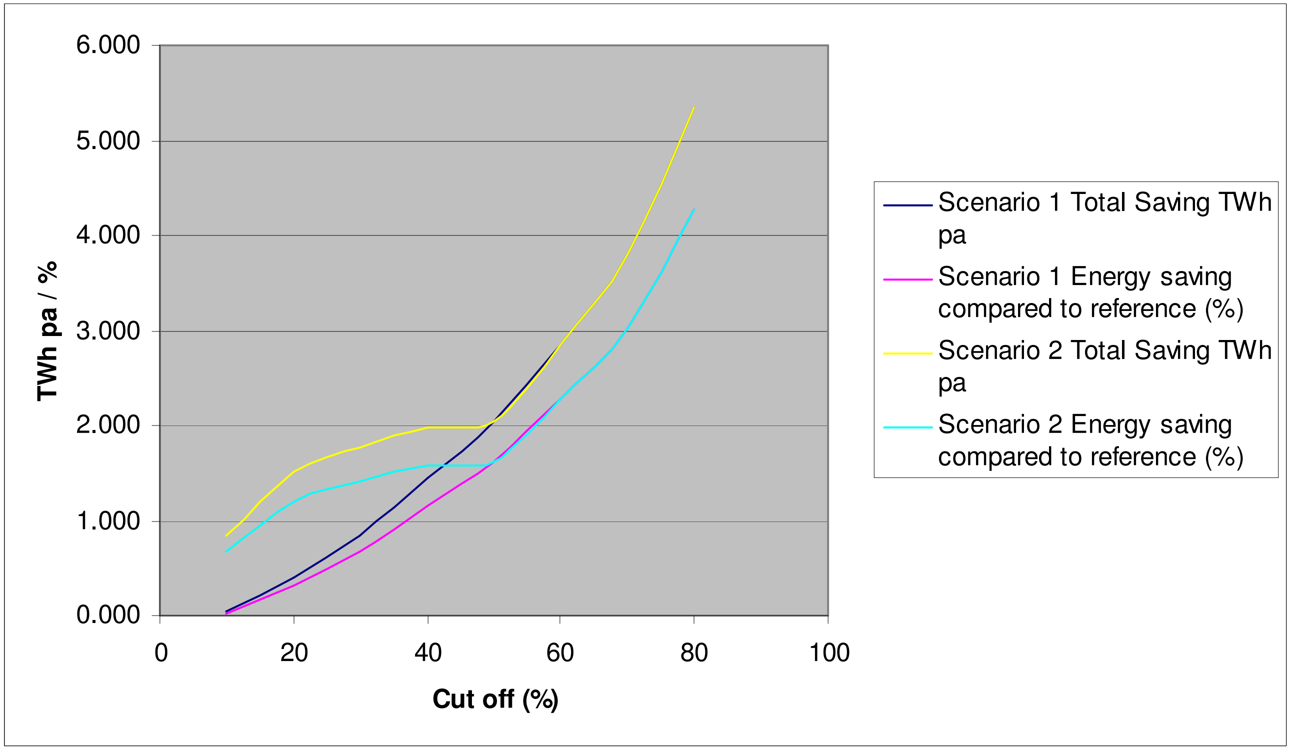
End suction types of pumps account for 73% of the estimated energy savings, (assuming that the same percentage of worst performing pumps is removed from each category).

This method is based on data provided by the detailed analysis of over 2,500 pumps by Technical University Darmstadt, (Annex 3). While the approach taken is technically acceptable for commodity type pumps of the type considered in this study, it is not so suitable for the analysis of more highly engineered types of pumps.

For many products, legislation to remove the worst performing products will lead to a “bunching” of products just over the minimum threshold. This has been used as the first scenario. However, because many of the worst performing pumps are actually very old designs, if they were to be re-designed, they would probably achieve at least the basecase (mean) efficiency. The energy savings from this more optimistic scenario 2 have also been estimated.

Energy savings of 2.34TWh pa (electrical) (2%) can be achieved by removing the worst 40% of pumps from the market, and 6.3 TWh pa (electrical) can be achieved ifall pumps below the 80% cutoff were raised to the 80% cutoff level. (These figures are indicative of the size of the potential, and should not be taken as a proposed policy option).

Energy savings vs. Cut-off %



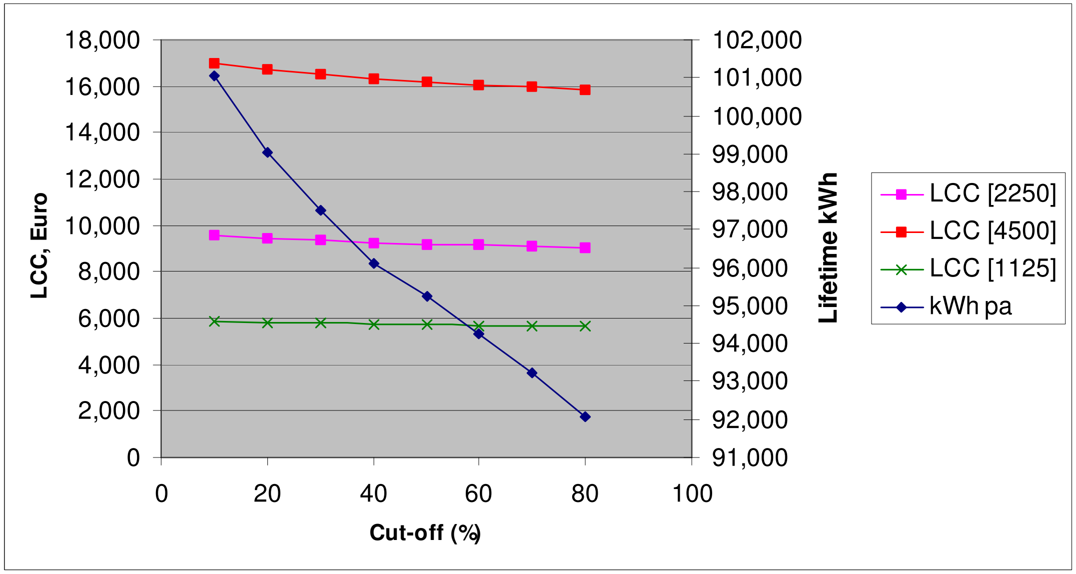
Appendix 3

(Written by Technical University Darmstadt)

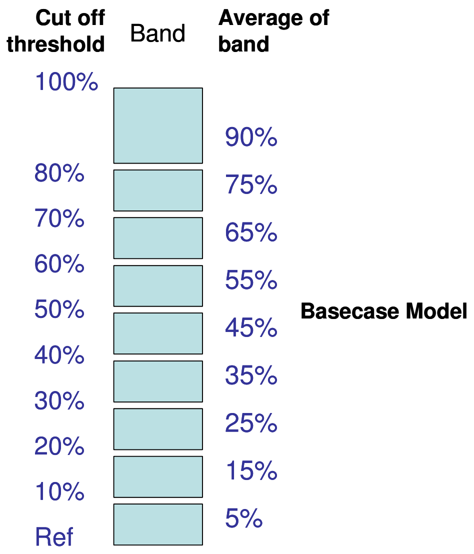
Life Cycle Cost analysis

ESCC_small **Mean (2250) hours pa**

Relative efficiency (from TUD analysis)	Efficiency difference relative to basecase	Relative energy performance (italics - derived)	Annual energy consumption (kWh pa) from MEEUP	Cut-off (%)	Relative cost (Additional % relative to basecase)	Calculated actual cost (Euros)	Lifetime electricity consumption (P1, kWh)	Lifecycle cost (Purchase, Acquisition, Main & Electricity) (Euros)
126.54	-3.32000	68.32000	7,049	80	10	990	92,088	9,058
127.75	-2.11000	67.11000	7,137	70	5	945	93,241	9,098
128.8	-1.06000	66.06000	7,214	60	2	918	94,241	9,145
129.86	**0.00000**	**65.00000**	**7291**	**50**	**0**	**900**	**95,251**	**9,201**
130.77	0.91000	64.09000	7,357	40	**0**	900	96,117	9,265
132.23	2.37000	62.63000	7,464	30	**0**	900	97,508	9,367
133.82	3.96000	61.04000	7,580	20	-1	891	99,023	9,469
135.93	6.07000	58.93000	7,734	10	-5	855	101,032	9,581
Reference			7,769					



Scenario analysis - methodology



Scenario 1 (third (bottom) tables in 7.4.1)

This assumes that the worst pumps are replace by those just over the minimum acceptable threshold. This is a very pessimistic scenario, as it is thought that in practice most manufacturers would take the opportunity to replace them with at least those of the mean (50% cutoff) efficiency.

Eg The 10% cut off is calculated by assuming that the worst 10% of pumps are improved to the 10% cut off line. Ie the energy consumption of these falls from the average of the bottom band to that of the cut off line.

The 20% cut-off is calculated by assuming that the worst 10% improve to the 20% cut off, and the 10-20% band of pumps improve to the 20% cut off. This is repeated to the 80% cut off line.

Scenario 2

This is calculated in a similar way, but assumes that pumps up to the 40% cutoff will be replaced with those mid-way through the 50-60% band. Above this the scenario is the same as scenario 1.

Both of these scenarios are summarised in figures 7.5.4 – 7.5.7.

In the absence of any other data, and in line with the general findings from the SAVE 2 Pump efficiency study, the business as usual (BAU) case assumes no changes in pump efficiency without external intervention.

Calculated energy savings vs. cut-off %

Cut off (%)	ESCC S	ESCC L	ESOB S	ESOB L	MSS S	MSS L	MS S	MS L	ESCCi S	ESCCi L	Total Saving TWh pa	Energy saving compared to reference (%)
80	0.730	0.751	0.976	0.917	0.879	0.483	0.193	0.107	0.540	0.700	**6.275**	**5.33**
70	0.557	0.543	0.685	0.515	0.664	0.365	0.116	0.082	0.395	0.452	**4.376**	**3.72**
60	0.427	0.399	0.530	0.370	0.521	0.286	0.078	0.059	0.284	0.324	**3.278**	**2.78**
50	0.316	0.310	0.398	0.284	0.341	0.187	0.044	0.026	0.201	0.230	**2.340**	**1.99**
40	0.238	0.213	0.288	0.195	0.232	0.127	0.035	0.023	0.148	0.169	**1.670**	**1.42**
30	0.141	0.122	0.182	0.115	0.112	0.061	0.022	0.008	0.099	0.114	**0.977**	**0.83**
20	0.065	0.051	0.079	0.055	0.052	0.029	0.017	0.005	0.053	0.061	**0.468**	**0.40**
10	0.005	0.005	0.006	0.004	0.007	0.004	0.001	0.001	0.003	0.004	**0.040**	**0.03**
Total energy use (2006)	**19,050**	**19,928**	**22,551**	**19,915**	**15,967**	**8,773**	**3,915**	**2,087**	**11,398**	**13,035**	**136,619**	

Cut off (%)	ESCC S	ESCC L	ESOB S	ESOB L	MSS S	MSS L	MS S	MS L	ESCCi S	ESCCi L	Total Saving TWh pa	Energy saving compared to reference (%)
80	0.730	0.751	0.976	0.917	0.879	0.483	0.193	0.107	0.540	0.700	**6.275**	**5.33**
70	0.557	0.543	0.685	0.515	0.664	0.365	0.116	0.082	0.395	0.452	**4.376**	**3.72**
60	0.427	0.399	0.530	0.370	0.521	0.286	0.078	0.059	0.284	0.324	**3.278**	**2.78**
50	0.316	0.310	0.398	0.284	0.341	0.187	0.044	0.026	0.201	0.230	**2.340**	**1.99**
40	0.307	0.299	0.386	0.195	0.329	0.181	0.043	0.026	0.196	0.224	**2.187**	**1.86**
30	0.276	0.265	0.346	0.115	0.287	0.158	0.040	0.023	0.177	0.202	**1.890**	**1.61**
20	0.236	0.219	0.295	0.055	0.250	0.137	0.039	0.024	0.157	0.179	**1.591**	**1.35**
10	0.130	0.120	0.163	0.004	0.136	0.075	0.023	0.013	0.088	0.101	**0.853**	**0.72**
Total energy use (2006)	**19,050**	**19,928**	**22,551**	**19,915**	**15,967**	**8,773**	**3,915**	**2,087**	**11,398**	**13,035**	**136,619**	

Costs to Manufacturers and Users

Cut off (%)	Development costs of new pumps (Meuros)
10	43.2
20	120.9
50	550.8
80	1,382.4

Cut off (%)	**ESCC S**	**ESCC L**	**ESOB S**	**ESOB L**	**MSS S**	**MSS L**	**MS S**	**MS L**	**ESCCi S**	**ESCCi L**	**Total cost pa (Euros)**
80	12,420	11,385	6,072	3,450	35,162	9,660	13,800	3,450	4,968	4,554	**104,921,400**
70	6,120	5,610	2,992	1,700	17,326	4,760	6,800	1,700	2,448	2,244	**51,700,400**
60	2,880	2,640	1,408	800	8,154	2,240	3,200	800	1,152	1,056	**24,329,600**
50	1,080	990	528	300	3,058	840	1,200	300	432	396	**9,123,600**
40	1,080	990	528	300	3,058	840	1,200	300	432	396	**9,123,600**
30	1,080	990	528	300	3,058	840	1,200	300	432	396	**9,123,600**
20	720	660	352	200	2,038	560	800	200	288	264	**6,082,400**
10	0	0	0	0	0	0	0	0	0	0	**0**

EUP Lot 11 Pump report

End of chapter 7