Lot 11 Water Pumps (in commercial buildings, drinking water pumping, food industry, agriculture).

Lot 11 Pumps: Working Draft 2007
Chapter 4

Report to European Commission

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STATUS

This is a working draft only designed to facilitate development of the methodology with providers of data. Accordingly, there are several points that are unresolved within this version. Feedback from other stakeholders is therefore not formally requested on this version, as it is only “work in progress”, but any comments would be welcome.

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4 Technical Analysis Existing Products

This chapter contains all the inputs for the MEEUP model for each of the pump types in this study. This comprises the production phase (materials), distribution (distance to point of use from wholesaler) and the In use phase (energy and maintenance costs).

The economic data used in the MEEUP model, which includes costs of all stages of the life cycle, are shown in chapter 3.

Because in real life pumps may work for all or part of their time at flows different to the rated flow point, it is important that the energy analysis takes account of this. We have therefore included an additional worksheet in the MEEUP model that comes up with a single energy use figure that is then entered into the proper MEEUP model as a single total energy consumption figure. The importance of this step is that any design options must take account of typical operating profiles, with the efficiency at reduced flow often being more significant than that at design flow in terms of total energy consumption. In fact, it is thought likely that any design options should be specify MEPS at a range of flows.

The model uses this information to calculate the environmental impact of each of phase of product life in terms of environmental emissions and energy consumption. Because the pump itself does not actually use energy, the model assumes electrical energy is used, with the conversion being through a typical (Eff 2) induction motor.

Derivation of the Average Basecase model

As discussed earlier, the two real life basecases (small and large) selected for each style of pump are not suitable for calculating the EIA of groups of products. It is therefore necessary to introduce an additional virtual (or Energy Weighted Averagel) basecase, which is a virtual construct created especially to allow the MEEUP model to be used for calculating these total impacts.

Figure 1 Calculating energy/stock data: the "top down" and "bottom up" methods – ensuring the different approaches are consistent (see text)

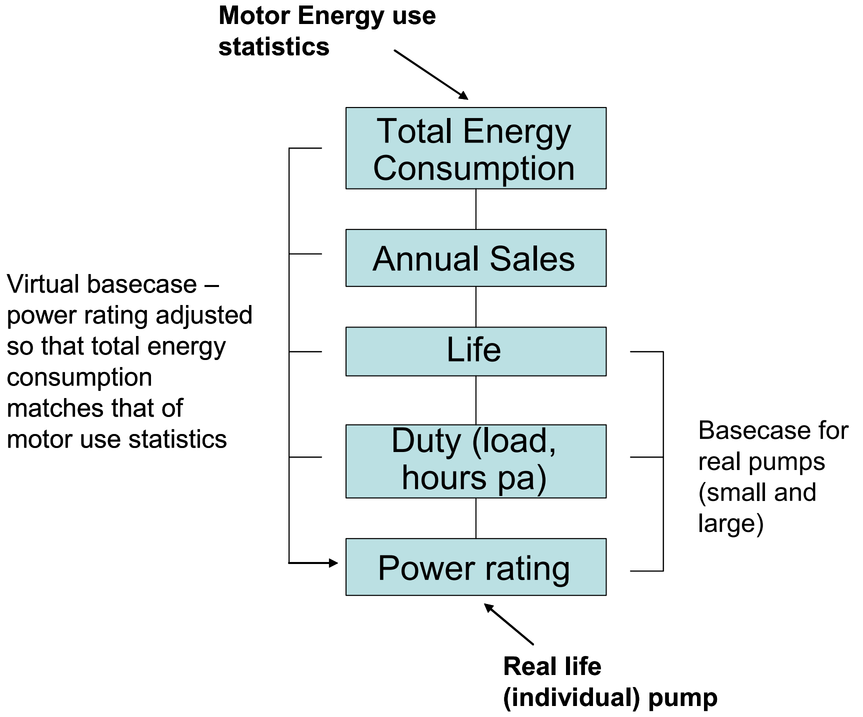

Figure 2 is an attempt to show the relationship between the power rating of an individual pump and the total energy consumption of that type of pump. Some observations:

- "Top down" and "Bottom up" calculations rarely match, and so parameters need to be revised until they do so. It is not unusual for there to be a factor of 2 or 3 of difference between the two methods on the first runs.
- The corollary to this is that it is very dangerous to rely on just one method for doing calculations, as there is no double-check.
- Changes in any factor will mean that for the same answer, another factor must change by a corresponding amount to balance things out.
- Whatever is the unknown (in this case the power rating of the virtual basecase pump), will be parameter that is adjusted to make the calculation give the "right" answer.
- For this type of work, it is thought that the total energy consumption is the most robust figure, as it comes from the motors study, which is based on many years of cumulative experience, and so the total energy used by pumps is not unreasonable. This determines that the "Top down" method takes precedence.

The procedure for calculating the virtual basecase model is as follows:

Virtual Basecase kW rating

The annual energy consumption for the total stock of pumps is calculated as:

Energy pa = Rated power x Stock x hours pa x average load.

(Where stock = Sales pa x lifetime.)

Virtual basecase power rating (kW) = Energy (kWh pa) / (hours pa x average load x number$_{tot}$)

Virtual Basecase Bill of Materials

This is derived from calculating the weighted average of materials content from the two basecase sizes. . OR We could develop a BOM of a real pump corresponding to this kW rating.

The virtual basecase is here calculated on a notional sales weighted basis (shown here for the ESCC pump.)

Material	Unit	Small Basecase	Large Basecase	Sales weighted average
Bulk plastics	g	1,000	3,000	1,400
TecPlastics	g	-	-	-
Ferro	g	15,200	8,688	13,898
Non-ferro	g	-	-	-
Coating	g	8	16	10
Electronics	g	-	-	-
Misc.	g	328	568	376
Total		16,536	12,272	15,683

NB We have not yet run the MEEUP model with this virtual basecase model.

Energy Consumption figure

Section 4.3 shows the method used for calculating a single annual energy consumption figure for each basecase model of pump, which takes detailed account of the typical flow profiles of real life use. To avoid undue complexity, the proposal is that in this study we retain this calculation method for the analysis of individual small and large pumps only. OR we could just do the analysis on the virtual basecase.

An important point is that in this study there are now two methods used for calculating total energy use. The first is this simple statistical average based on average power consumption, the second uses a detailed consideration of real life flow profiles, as used in the MEEUP model. The two give very similar results, but the results from the MEEUP model are used in later parts of the report and so are the figures that should be quoted.

4.1 Data on the production phase

The detailed Bill of Material (BOM) data lists all materials, by weight, for each basecase pump. The basecase is seen as being representative of current “best sellers”. The method of derivation varies for each type, but is generally based on a single real model, with some parameters adjusted in consultation with industry to be more widely representative of all models.

In all cases, the selection of the basecase model was a best guess. The subsequent analysis will verify the correctness of this choice. But even if it is shown that this is not quite correct, it should not matter, providing that it is clear where in the performance range of all pumps it belongs. The importance of having “real” small and large basecase models is that it is easy to identify the practical impact of design options – something which might be lost if just using the single virtual basecase.

When there was any doubt, the model BOM was assigned a material content at the higher end of the range of estimates. This was to make sure that any emissions from the production phase are if anything exaggerated. This is because on an initial exploratory run of the model it was clear that the production phase was actually only of minor impact.

It is noted that wood, widely used for packaging crates, is absent from this list. However, consultation with eco-analysis experts (at AEA) is that wood is a fairly benign product, and so this omission is not important in terms of the overall eco-impact.

4.1.1 Bill of Materials for Single Stage Close-coupled (end suction close coupled)

ESCC Small (25m^3/h, 25m)

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

ESCC Large (125m^3/h, 25m)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Impeller	12000.0	3-Ferro	23-Cast iron
2	Casing	55000.0	3-Ferro	23-Cast iron
3	Adapter/bearing housing/feet	35000.0	3-Ferro	23-Cast iron
4	Shaft	4000.0	3-Ferro	25-Stainless 18/8 coil
5	Metal fixings, seals, bearings	2000.0	3-Ferro	25-Stainless 18/8 coil
6	Paint	200.0	5-Coating	39-powder coating
7	User instruction manual	100.0	7-Misc.	57-Office paper
8	Pallet	7000.0	7-Misc.	56-Cardboard
9	Protective covering	3000.0	1-BlkPlastics	1-LDPE
10	CONSUMABLES - Seals - 3 assumed at 200g each	600.0	3-Ferro	25-Stainless 18/8 coil
11	CONSUMABLES - lubricant over life (no field for grease)	0.0	7-Misc.	57-Office paper

4.1.2 Bill of Materials for Single Stage Close-coupled (end suction own bearings)

ESOB Small (25m^3/h, 32m)

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	20000.0	3-Ferro	23-Cast iron
4	Shaft	4000.0	3-Ferro	25-Stainless 18/8 coil
5	Metal fixings, seals, bearings	3000.0	3-Ferro	25-Stainless 18/8 coil
6	Paint	50.0	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	500.0	1-BlkPlastics	1-LDPE
10	CONSUMABLES - Bearings - 3 assumed at 600g each	1800.0	3-Ferro	25-Stainless 18/8 coil
11	CONSUMABLES - Seal - 3 assumed at 100g each	300.0	3-Ferro	25-Stainless 18/8 coil

ESOB Large (125m^3/h , 32m)

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	20000.0	3-Ferro	23-Cast iron
4	Shaft	4000.0	3-Ferro	25-Stainless 18/8 coil
5	Metal fixings, seals, bearings	3000.0	3-Ferro	25-Stainless 18/8 coil
6	Paint	50.0	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	500.0	1-BlkPlastics	1-LDPE
10	CONSUMABLES - Bearings - 3 assumed at 600g each	1800.0	3-Ferro	25-Stainless 18/8 coil
11	CONSUMABLES - Seal - 3 assumed at 100g each	300.0	3-Ferro	25-Stainless 18/8 coil

4.1.3 Bill of Materials for Submersible multistage well pumps

Small (SP8)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Suction interconnector	800.0	3-Ferro	25-Stainless 18/8 coil
2	Impeller	550.0	3-Ferro	25-Stainless 18/8 coil
3	Lower chamber	240.0	3-Ferro	25-Stainless 18/8 coil
4	Chamber int.	1160.0	3-Ferro	25-Stainless 18/8 coil
5	Chamber upper	180.0	3-Ferro	25-Stainless 18/8 coil
6	Shaft kp.	385.0	3-Ferro	25-Stainless 18/8 coil
7	Metal fixings (screws)	50.0	3-Ferro	25-Stainless 18/8 coil
8	Valve casing	560.0	3-Ferro	25-Stainless 18/8 coil
9	Strap	1180.0	3-Ferro	25-Stainless 18/8 coil
10	Cable guard	110.0	3-Ferro	25-Stainless 18/8 coil
11	Packaging materials	1350.0	7-Misc.	56-Cardboard
12			3-Ferro	25-Stainless 18/8 coil

Large (SP17)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Impeller	600.0	3-Ferro	25-Stainless 18/8 coil
2	Casing	3500.0	3-Ferro	25-Stainless 18/8 coil
3	Stage casing	1900.0	3-Ferro	25-Stainless 18/8 coil
4	Shaft (part of motor)	500.0	3-Ferro	25-Stainless 18/8 coil
5	Metal fixings (screws)	500.0	3-Ferro	25-Stainless 18/8 coil
6	Paint	0.0	5-Coating	39-powder coating
7	User instruction manual	100.0	7-Misc.	57-Office paper
8	Pallet	1000.0	7-Misc.	56-Cardboard
9	Protective covering	100.0	1-BlkPlastics	1-LDPE
10	Static seals	100.0	2-TecPlastics	16-Flex PUR
11	CONSUMABLES - mechanical seals (5 x 50g)	250.0	3-Ferro	25-Stainless 18/8 coil
12	CONSUMABLES - Bearings (5 x 300??)	1500.0	3-Ferro	25-Stainless 18/8 coil

4.1.4 Bill of Materials for Vertical multistage pumps

Vertical multistage (small)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Impeller	600.0	3-Ferro	**25-Stainless 18/8 coil**
2	Casing	1600.0	3-Ferro	**25-Stainless 18/8 coil**
3	Stage casing	1100.0	3-Ferro	**25-Stainless 18/8 coil**
4	Shaft (part of motor)	500.0	3-Ferro	**25-Stainless 18/8 coil**
5	Metal fixings (screws)	500.0	3-Ferro	**25-Stainless 18/8 coil**
6	Paint	0.0	5-Coating	**39-powder coating**
7	User instruction manual	100.0	7-Misc.	**57-Office paper**
8	Pallet	1000.0	7-Misc.	**56-Cardboard**
9	Protective covering	100.0	1-BlkPlastics	**1-LDPE**
10	Static seals	100.0	2-TecPlastics	**16-Flex PUR**
11	CONSUMABLES - mechanical seals (5 x 50g)	250.0	3-Ferro	**25-Stainless 18/8 coil**
12	CONSUMABLES - Bearings (5 x 300??)	1500.0	3-Ferro	**25-Stainless 18/8 coil**

Vertical multistage (Big)

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Impeller	600.0	3-Ferro	**25-Stainless 18/8 coil**
2	Casing	3500.0	3-Ferro	**25-Stainless 18/8 coil**
3	Stage casing	1900.0	3-Ferro	**25-Stainless 18/8 coil**
4	Shaft (part of motor)	500.0	3-Ferro	**25-Stainless 18/8 coil**
5	Metal fixings (screws)	500.0	3-Ferro	**25-Stainless 18/8 coil**
6	Paint	0.0	5-Coating	**39-powder coating**
7	User instruction manual	100.0	7-Misc.	**57-Office paper**
8	Pallet	1000.0	7-Misc.	**56-Cardboard**
9	Protective covering	100.0	1-BlkPlastics	**1-LDPE**
10	Static seals	100.0	2-TecPlastics	**16-Flex PUR**
11	CONSUMABLES - mechanical seals (5 x 50g)	250.0	3-Ferro	**25-Stainless 18/8 coil**
12	CONSUMABLES - Bearings (5 x 300??)	1500.0	3-Ferro	**25-Stainless 18/8 coil**

4.2 Data on the distribution phase

No definitive data exists on this, and so in consultation with stakeholders the following was agreed upon as representing the mileage incurred in the distribution of each product. It was found that this was actually hard to estimate, as the actual mileage varies tremendously according to location of the pump and nearest service agent, the pump duty and the servicing policy of the site. However, because it was found not to be a very significant factor, no further work was done on this, as any greater refinement of data will not greatly affect the outcomes.

Table 1 Average distance for maintenance by pump type

Style	Basecase	Average distance for maintenance (km)
End Suction Own Bearings (ESOB)	Small	300
	Large	100
End Suction Close Coupled (ESCC)	Small	150
	Large	300
Submersible Multistage	Small	1
	Large	1000
Vertical Multistage	Small	1000
	Large	1000

The differences between pumps are large, and are accounted for by the following factors:

Actual distances vary, as it is a function of the number of times maintenance is required and the assumed number of repairs tolerated before a pump is scrapped.

Multistage pumps need regular specialist maintenance, and hence the distance is high.

The only exception to this is the small submersible multistage pump that would usually be replaced rather than repaired, and hence the average distance is set to a minimum.

4.3 Use phase (product)

The MEEUP model states that this should be calculated based on actual and test standard conditions. However, there is currently no test standard condition.

Therefore a new "energy-weighted" approach is being developed and adopted for all pumps in this study, which represents the actual standard condition. This is the subject of ongoing work between the study team and University of Darmstadt to develop both the weightings and a method of analysis. Over 500 pump data point have now been collected and processed, with final results due June 2007.

In order to derive the basecase model, an assumed weighting was used, based on the experience of the study team, shown in table below. Note that once data from the large pump data collection exercise has been collected and analysed, it is expected that this scheme will change. This is because it is hoped that a final suggestion for an implementing measure should ideally be based on a scheme that is simple to apply but robustly backed up by detailed data. The hope is therefore that it may be technically valid to only consider two or three flow points, but this will not be know until the data has been analysed in month 17.

Table 2 Proportion of time the pump is assumed to operate at each flow.

% of BEP flow	% of time at this flow
50	25
75	50
100	20
125	5

GRAPH TO BE INSERTED HERE to show the above graphically

The energy performance of each pump was then calculated using a new worksheet added to the MEEUP spreadsheet. This was calculated by summing the annual energy consumed at each of the above duty points, which will most importantly include the efficiency at each point.

As an example, consider a small End Suction Close Coupled pump (as shown in Fig 4.3.1).

- Look up the rated efficiency at the 4 selected flow points. *Eg At 75%, this is 61%.*
- Subtract a nominal amount (here 3%) to allow for lifetime decrease in efficiency. *(61 – 3)% = 58%.*
- Calculate the power consumption at each flow point. Ie Power = Flow (m^3/s) x head (m) x specific gravity of fluid (kg/m^3) / efficiency (%) x 3600

(25 x 0.75) x 38 x 1000 x 3600 / 0.58 = 3.3kW.

- For each flow point, multiply the power by the number of hours pa. This is calculated as a percentage of time spent operating pa. This gives the total energy consumption for each flow point.

3.3 x (0.25 x 2,000) = 1,489 kWh pa

- This is repeated for each of the four flow points, and totalled to give total annual energy consumption for the pump under assumed operating conditions.

1,489 + 3,344 + 1,405 + 243 = 6,481 kWh pa

Data on Use Phase for End suction close coupled pumps (ESCC)

End suction close coupled (small)

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	2,000	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	1,489
75	61	58	3.3	50	3,344
100	65	62	3.5	20	1,405
125	59	56	2.4	5	243
Total annual energy consumption					**6,481**

End suction close coupled (large)

Quantity	Units	
Operating efficiency of the pump selected at the requested duty point	72	%
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	31	m
Flow at BEP	132	m3/h
Flow at BEP (l/s)	36.7	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	11.1	kW
Mechanical (shaft power) at BEP flow	15.3	kW
Annual running hours	2,600	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	59	56	13.5	25	8,759
75	72	69	14.8	50	19,295
100	73	70	15.9	20	8,275
125	72	69	10.4	5	1,354
Total annual energy consumption					**37,682**

4.3.1 Data on Use phase for End suction own bearings pumps

End suction own bearing pump (small)

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	30	m
Flow at BEP	30	m3/h
Flow at BEP (l/s)	8.3	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	2.5	kW
Mechanical (shaft power) at BEP flow	3.8	kW
Annual running hours	1,800	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	3.6	25	1,608
75	61	58	4.0	50	3,612
100	65	62	4.0	20	1,423
125	59	56	2.9	5	263
Total annual energy consumption					**6,905**

End suction own bearings (large)

Quantity	Units	
Operating efficiency of the pump selected at the requested duty point	72	%
Average end of life efficiency decrease due to wear	10	%
End of life efficiency to average life efficiency conversion	0.6	
Mean lifetime efficiency decrease	6	%
Head at BEP	32	m
Flow at BEP	125	m3/h
Flow at BEP (l/s)	34.7	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	10.9	kW
Mechanical (shaft power) at BEP flow	14.9	kW
Annual running hours	2,200	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	59	53	13.5	25	7,415
75	72	66	14.7	50	16,163
100	73	67	16.3	20	7,151
125	72	66	10.3	5	1,134
Total annual energy consumption					**31,864**

4.3.2 Data on Use phase for submersible multistage pumps

Submersible multistage (small)

Quantity	Units	
Operating efficiency of the pump selected at the requested duty point	63.1	%
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	59.2	m
Flow at BEP	8.5	m3/h
Flow at BEP (l/s)	2.4	l/s
Head at 50% BEP flow	80	m
Head at 75% BEP flow	70	m
Head at 125% BEP flow	45	m
Density of water	1,000	kg/m3
Gravity	10	m/s2
Hydraulic power output at BEP flow	1.4	kW
Mechanical (shaft power) at BEP flow	2.2	kW
Annual running hours	1,200	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	53	50	1.9	25	555
75	58	55	2.2	50	1,325
100	63.1	60.1	2.3	20	547
125	58	55	2.4	5	142
Total annual energy consumption					**2,570**

Submersible multistage (big) SP17

Quantity	Units	
Operating efficiency of the pump selected at the requested duty point	65	%
Average end of life efficiency decrease due to wear	3	%
End of life efficiency to average life efficiency conversion	0.6	
Mean lifetime efficiency decrease	1.8	%
Head at BEP	42	m
Flow at BEP	10	m3/h
Flow at BEP (l/s)	2.8	l/s
Head at 50% BEP flow	75	m
Head at 75% BEP flow	60	m
Head at 125% BEP flow	30	m
Density of water	1,000	kg/m3
Gravity	10	m/s2
Hydraulic power output at BEP flow	1.1	kW
Mechanical (shaft power) at BEP flow	1.8	kW
Annual running hours	2,500	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	50	48.2	2.1	25	1,324
75	60	58.2	2.1	50	2,631
100	65	63.2	1.8	20	905
125	50	48.2	2.1	5	265
Total annual energy consumption					**5,124**

4.3.3 Data on Use phase for vertical multistage pumps

Multistage pump (Big)

Quantity	Units	
Operating efficiency of the pump selected at the requested duty point	65	%
Average end of life efficiency decrease due to wear	3	%
End of life efficiency to average life efficiency conversion	0.6	
Mean lifetime efficiency decrease	1.8	%
Head at BEP	42	m
Flow at BEP	10	m3/h
Flow at BEP (l/s)	2.8	l/s
Head at 50% BEP flow	75	m
Head at 75% BEP flow	60	m
Head at 125% BEP flow	30	m
Density of water	1,000	kg/m3
Gravity	10	m/s2
Hydraulic power output at BEP flow	1.1	kW
Mechanical (shaft power) at BEP flow	1.8	kW
Annual running hours	2,100	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	50	48.2	2.1	25	1,112
75	60	58.2	2.1	50	2,210
100	65	63.2	1.8	20	760
125	50	48.2	2.1	5	222
Total annual energy consumption					**4,304**

Multistage pump (Small)

Quantity	Units	
Operating efficiency of the pump selected at the requested duty point	60	%
Average end of life efficiency decrease due to wear	3	%
End of life efficiency to average life efficiency conversion	0.6	
Mean lifetime efficiency decrease	1.8	%
Head at BEP	45	m
Flow at BEP	4	m3/h
Flow at BEP (l/s)	1.1	l/s
Head at 50% BEP flow	75	m
Head at 75% BEP flow	60	m
Head at 125% BEP flow	30	m
Density of water	1,000	kg/m3
Gravity	10	m/s2
Hydraulic power output at BEP flow	0.5	kW
Mechanical (shaft power) at BEP flow	0.8	kW
Annual running hours	1,800	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	45	43.2	0.9	25	425
75	55	53.2	0.9	50	829
100	60	58.2	0.8	20	303
125	54	52.2	0.8	5	70
Total annual energy consumption					**1,628**

4.4 Use phase (system)

It is important here to understand the interactions of the product with the system that it is operating in.

These aspects are discussed elsewhere, but in summary comprise:

- Impact of the system design and use on pump wear and maintenance requirements.
- The maintenance benefits of working close to the BEP.
- The energy saving benefits of variable speed operation.

The impacts of these interactions in terms of data entered into the model comprise:

- Better maintenance will both reduce wear and reduce the time between maintenance when it is working at lower efficiency due to degradation of pump performance.
- Better maintenance will reduce the likelihood of unplanned failure and the attendant financial consequences.
- Variable speed control means that the pump will be operating at its BEP efficiency even when operating at reduced flow.
- When operating at reduced flow, the head will be reduced, and so there will be significant additional energy savings.

4.5 End of Life phase

The default values adopted are those discussed and presented in section 3.

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