REPORT

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INTERNATIONAL MARKET REVIEW OF PUMPS AVAILABLE FOR GROUNDWATER ABSTRACTION

Project acronym: OptiWells-1

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Colophon

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Content

Chapter 1
Introduction

1.1 Objectives and scope

1.1.1 Objectives

As a part of well field optimization the pump, as a key component in water extraction systems and its energy saving potentials have to be checked. In addition to the *project deliverable D2.1* "*Literature review on theoretical pump and motor efficiency of submersible pump systems*" the availability of innovative and energy saving submersible pumps on the market has to be verified. Therefore, the market has been scanned and evaluated.

The purpose of this document is to present the results of the market analysis for efficient pumps and to assess realistic energy saving potentials that are achievable with today's technology.

This achievement can be reached by either selecting more efficient centrifugal pumps or motors (evaluated in this study), or by considering some boundary conditions such as losses in power supply cables, operating mode or the use of variable speed drives. These accompanying conditions were also discussed at the workshop and are presented as a short summary in the last chapter of this paper.

→ *More information about the project OptiWells-1 and more detailed information on submersible pumps and the fluid-mechanical background is given in the project deliverable D2.1 "*Literature review on theoretical pump and motor efficiency of submersible pump system*"*

1.1.2 Scope

The scope of this study is defined as three main objectives:

- Presenting a brief overview of the available manufacturers for submersible pumps
- Showing the current efficiency of submersible pumps as given by the manufacturers
- Showing the technical approaches manufacturers see for increasing efficiency
- Showing estimates for saving energy

Chapter 2
Market review

2.1 Description of suppliers

This chapter provides a brief overview of the worldwide market and the companies that compete in this market of submersible pumps.

The market for submersible pumps is subdivided into five major segments for different applications. These are in general:

- Agriculture
- Water
- Mining
- Offshore
- General Industry

The few major competitors divide a market volume of about 2.000 MIL USD. The biggest share is the market for 4-inch pumps with more than 50% of the worldwide turnover for submersible pumps. In general, they are designed with a canned motor. The remaining 900 MIL USD is the portion for pumps >4".

	Pump groups	Drives	
$ MIL	Market size	Market size	$ MIL
4" pumps :	1.100	750	4" drives
6" pumps :	300	200	6" drives
8" pumps :	200	75	8" drives
10" pumps :	100	35	10" drives
>10" pumps :	300	225	>10"drives
Total :	2.000	1285	

Fig. 1: Market share and turnover for submersible pumps – distinction by size

	Location	WAT	AG	MIN	OFF	GI	Sales [`000US$]	Remarks
Franklin	US	X	X				100.000	standard
Grundfos	Denmark	X	X			X	100.000	standard
Flowserve	USA Germany	X	X	X	X	X	60.000	standard/ engineered
ITT	USA	X	X	X	X	X	50.000	standard/ engineered
Caprari	Italy	X	X			X	40.000	standard
KSB	Germany	X	X	X	X	X	30.000	standard/ engineered
Oddesse	Germany	X	X			X	15.000	standard/ engineered
Others	Italy,India, Americas etc.	X	X				505.000	standard

Fig. 2: Pump manufacturers and market position (pumps above 4")

The competitors are mainly located in Western Europe and the U.S.

2.1.1 KSB (Germany)

The company KSB was 1871 founded in Frankenthal (Germany) by KLEIN, SCHANZLIN & BECKER and is one of the world's leading manufacturers for pumps, valves and accessories. The product range comprises equipment for industrial use, building services, water and wastewater transport. According to the annual report dated 31.12.2010, the company employs 14,697 employees with an annual revenue of 1,939.3 million Euro.

2.1.2 Grundfos (Denmark)

Grundfos was founded in 1945 and is named Grundfos since 1967. The revenue for the year 2010 shows a volume of sales of 2.624 million Euro with a number of 16,609 employees in 55 countries.

2.1.3 Flowserve / Pleuger (USA / Germany)

Flowserve came to existence with the merger of BW/IP and Durco International in 1997 and by acquisition of Ingersoll Dresser Pumps (IDP) in 2000. The corporation is also one of the leading manufacturers for pumps, valves and accessories and sealing technology for industrial flow management.

Flowserve employs over 14,000 people in 56 countries with an annual revenue of 3,200 million Euro (dated 2008). Pleuger is part of the corporation since the year 2000. It was founded in 1929 to manufacture submersible pumps with the Pleuger-patented water-filled submersible drives.

2.1.4 ITT / Xylem (USA)

ITT was founded in 1920 as a telecommunication company that developed a worldwide system of interconnecting phone lines. Today ITT has a staff of over 40,000 employees and realises an annual revenue of about 8,000 million Euro. The brands ITT Lowara and ITT Vogel belong to the leading manufacturers of pumps, valves and accessory for industrial solutions. In 2011 the water and wastewater section emerged from ITT to a standalone company Xylem.

2.1.5 Lubi (India)

With 2,500 employees and a volume of sales of 79,3 million Euro, the Lubi-Group belongs to the smaller suppliers of pumps and equipment, but it is focused on submersible pumps and offers a wide range of different submersible pumps especially for small diameters.

2.1.6 Calpeda (Italy)

The Calpeda-Group was founded in 1959 in Italy and is one of the smallest companies with only 500 employees and an annual revenue of 85 million Euro.

2.1.7 Caprari (Italy)

The Caprari Group was founded in 1945 and with the brand SWM S.p.A it is one of the world's most important manufacturer of submersible drives. The Caprari Group employs 700 employees and generates a volume of sale of about 100 million Euro per year.

2.1.8 Oddesse (Germany)

"Oddesse Pumpen- und Motorenfabrik GmbH" was founded in 1854 and has been manufacturing stream pistons and centrifugal pumps since 1897. Since 1935 Oddesse also supplies submersible pumps. With only 88 employees and an annual revenue of 9 million Euro Oddesse is the smallest company providing submersible pumps.

2.1.9 SAER (Italy)

SAER Elettropompe S.p.A. was founded in 1951 and is focused on submersible pumps and submersible drives for the diameters of 4 to 14 inches. With an annual revenue of 70 million Euro and 500 employees it belongs to the smaller companies.

2.2 Efficiency of submersible pumps

One main objective of this market study was to collect data on the efficiency for presently available submersible pumps with the size ranging from 4 to 14 inches. For the evaluation of efficiency, the following attributes were collected in a database:

- Size of pump
- Manufacturer
- Flow rate
- Hydraulic head
- Efficiency of pump
- Efficiency of drive
- Total efficiency
- Number of stages
- Type of drive
- Type of impeller
- Material
- Tolerance acc. to DIN EN ISO 9906

Size in "	Manufactu	Pump	Q_opt	H_max_c	max η_{stage}	η_{motor}	η_{total}	Number of	Drive	Type of impe	Material	Tolerance class
6	KSB	UPA 150C 16	16m³/h	8,1m	75%	70%	52,5%	1	DN 100 - 0,75	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	16,2m	75%	73%	54,75%	2	DN 100 - 1,5	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	24,5m	75%	75%	56,25%	3	DN 100 - 2,2	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	32,6m	75%	76%	57%	4	DN 100 - 3,0	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	40,8m	75%	76%	57%	5	DN 100 - 3,0	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	48,6m	75%	77,5%	58,125%	6	DN 100 - 3,7	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	56,5m	75%	76,5%	57,375%	7	UMA 150D 5/21	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	56,5m	75%	76,5%	57,375%	7	DN 100 - 5,5	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	65m	75%	76%	57%	8	UMA 150D 5/21	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	65m	75%	76,5%	57,375%	8	DN 100 - 5,5	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	73m	75%	75,5%	56,625%	9	UMA 150D 5/21	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	73m	75%	76,5%	57,375%	9	DN 100 - 5,5	radial	Edelstahl	Annex A
6	KSB	UPA 150C 16	16m³/h	82m	75%	77,5%	58,125%	10	UMA 150D 7/21	radial	Edelstahl	Annex A

Fig. 3: Extract of database

The data was extracted from catalogues that either included tables with the required data or diagrams that could be used to read off the required data. Due to the common procedure of manufacturers to add the tolerances according DIN EN ISO 9906 to the measured efficiency of the pumps, it is necessary to deduct those values from the data acquired in the catalogues or diagrams. The efficiency tolerance for class 1 certified pumps is 3% for, class 2 pumps 5% and pumps only classified according to Annex A have a efficiency tolerance of 7%.

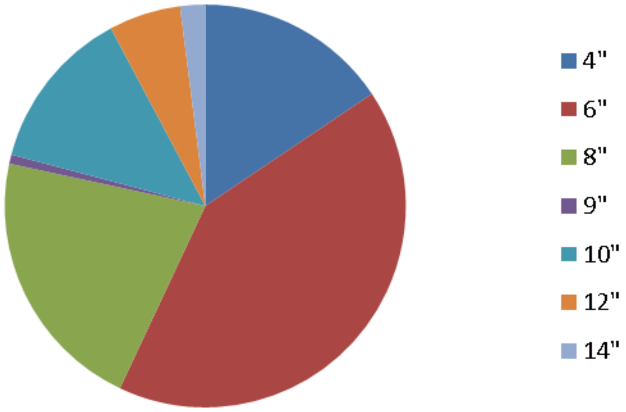
For further evaluation, the gathered pump data is subdivided in:

- Pump size (the common sizes are 4, 6, 8, 10, 12 and 14 inches)
- Flow rates (<25m³/h, 25-50m³/h, 50-100m³/h, 100-250m³/h, >250m³/h)
- Power classes (<15kW, 15-75kW, 75-150kW, >150kW)

The Database comprises technical information of over 4500 pumps. This includes different pump models and their combination with different numbers of stages and different motors. These pumps have been divided into separate classes according to flow rate, size and power consumption.

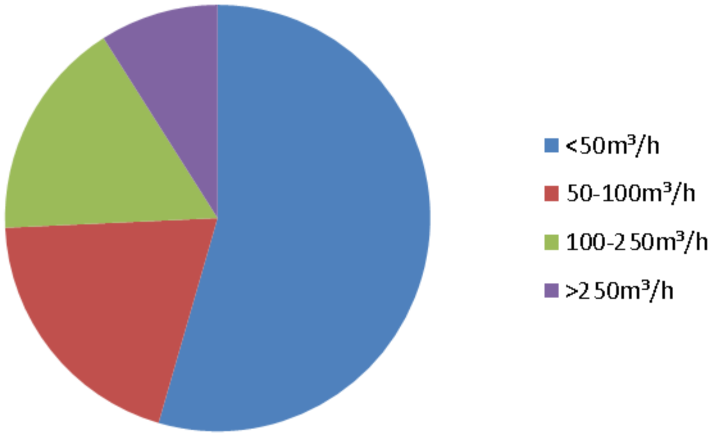
Pumps between 4“ and 14“: 4537

4“	→ 708
6“	→ 1878
8“	→ 970
9“	→ 33
10“	→ 594
12“	→ 262
14“	→ 92



Pumps divided according to their flow rates:

<50 m³/h	→ 2467
50-100 m³/h	→ 896
100-250 m³/h	→ 757
>250 m³/h	→ 408



2.2.1 Pump and motor efficiency

The following section briefly explains the most commonly used efficiency definitions.

→ *More detailed information are given in the project deliverable D2.1 "*Literature review on theoretical pump and motor efficiency of submersible pump system*".*

Pump efficiency

The efficiency of a pump is a measure of the conversion of mechanical coupling power into hydraulic power at the discharge port. It is defined as:

$$\eta_{pump} = \frac{P_{fluid}}{P}$$

with P_{fluid}, the hydraulic output and *P* the coupling power.

Motor efficiency

The efficiency of a motor is a measure of the conversion of the electrical to mechanical power.

$$\eta_{motor} = \frac{P}{P_{electrical}}$$

with $P_{electrical}$, the electric power demand and *P* the usable shaft power.

Total, global or overall efficiency

The total efficiency of a pump aggregate is a measure of the conversion of electrical power to hydraulic power at the discharge port. It includes the pump and the motor.

$$\eta_{global} = \frac{P_{fluid}}{P_{electrical}} = \underbrace{\frac{P_{fluid}}{P}}_{\eta_{pump}} \times \underbrace{\frac{P}{P_{electrical}}}_{\eta_{motor}}$$

2.2.2 Influences on pump and motor efficiency

Pump efficiency

The pump efficiency is influenced by a number of parameters that are described in *the project deliverable D2.1 "Literature review on theoretical pump and motor efficiency of submersible pump system".* However, for a better understanding of this paper some should be mentioned in this section:

Pump size

The efficiency of a pump increases with increasing pump size. This results from the following effects:

- Ratio of wetted surface to flow rate:
  The influence of friction is reduced due to the decreasing ratio of impeller surface and impeller channel volume.
- Decreasing gap clearance losses:
  Larger pump sizes allow smaller gap clearances in relation to over-all dimensions. This results in reduced volumetric losses in relation to the higher flow rates.

Flow rate

Pumps designed for larger flow rates are commonly equipped with mixed-flow impellers. The decreasing flow deflection losses in the impeller allow for higher efficiencies of mixed-flow impellers.

Motor efficiency

The efficiency of motors increases with increasing motor size and increasing power class.

Motor size

- Influence of mechanical losses reduces with increasing size
- Better ration of diameter and active packet length:
  Especially for submersible motors, the larger size motors have a better ratio of diameter to active packet length. This results in reduced iron losses due to the longer core in relation to the diameter and a reduced influence of wining losses.

2.2.3 Normal distribution for pump size

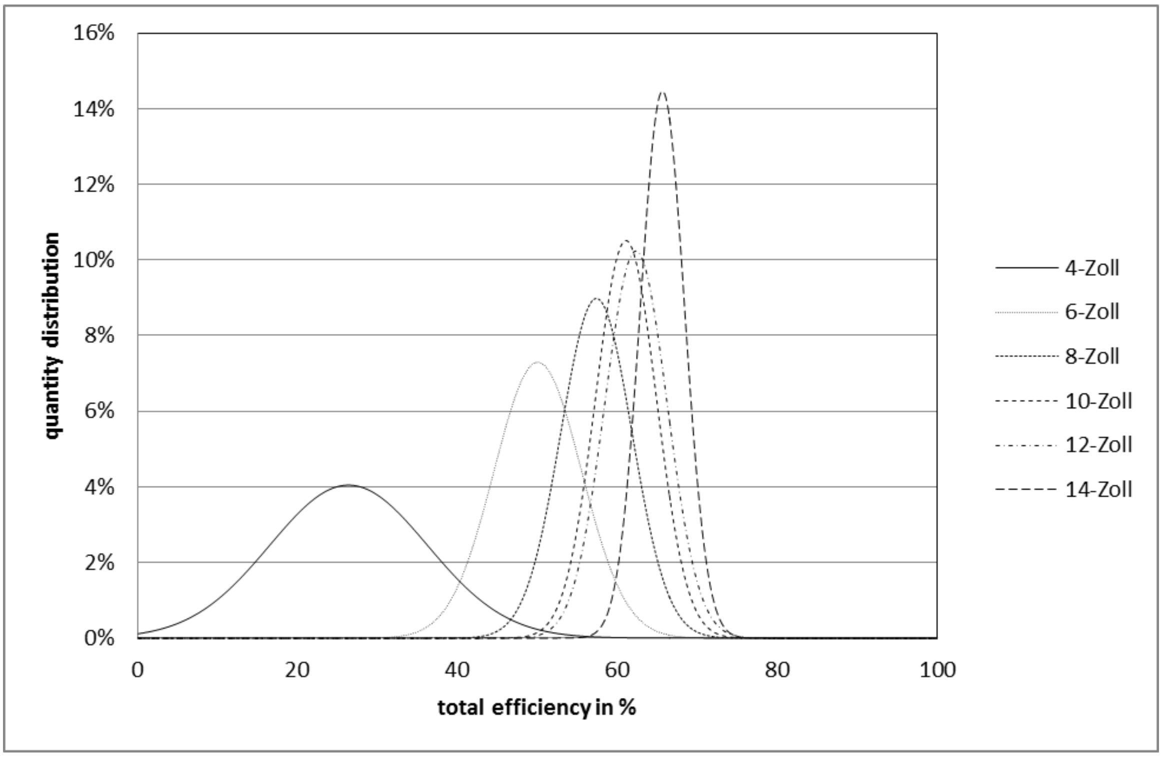


Fig. 4: Distribution of total efficiency after deduction of tolerances for pump sizes

This diagram shows the normal quantity distribution according for the considered pumps sizes. Three main observations can be made:

- The scatter band of efficiency narrows for increasing pump size
- The total efficiency has a large offset between small and large pumps
- The total efficiency rises with increasing pump size

Manufacturing larger pumps aggregates allow a better ratio of tolerances to over-all dimensions this also includes electrical losses. The statistical deviation of efficiency for different pumps even of the same type is therefore reduced for larger pumps and shows in a narrow scatter band in the quantity distribution.

The large offset in efficiency between large and small pumps is based on the same reasons as the increasing efficiency with increasing pump size. This characteristic is expected as mechanical, hydraulic and electrical losses have a decreasing influence on the over-all performance with increasing pump size.

The most important conclusion is the increasing efficiency with increasing pump size and motor, as described in (2.2.1).

Another important conclusion is the different assessment of efficiency. While a 4'' pump with a total efficiency of 40% has to be considered highly efficient, the same efficiency would barely be acceptable for a 6'' pump.

2.2.4 Normal distribution for different flow rates

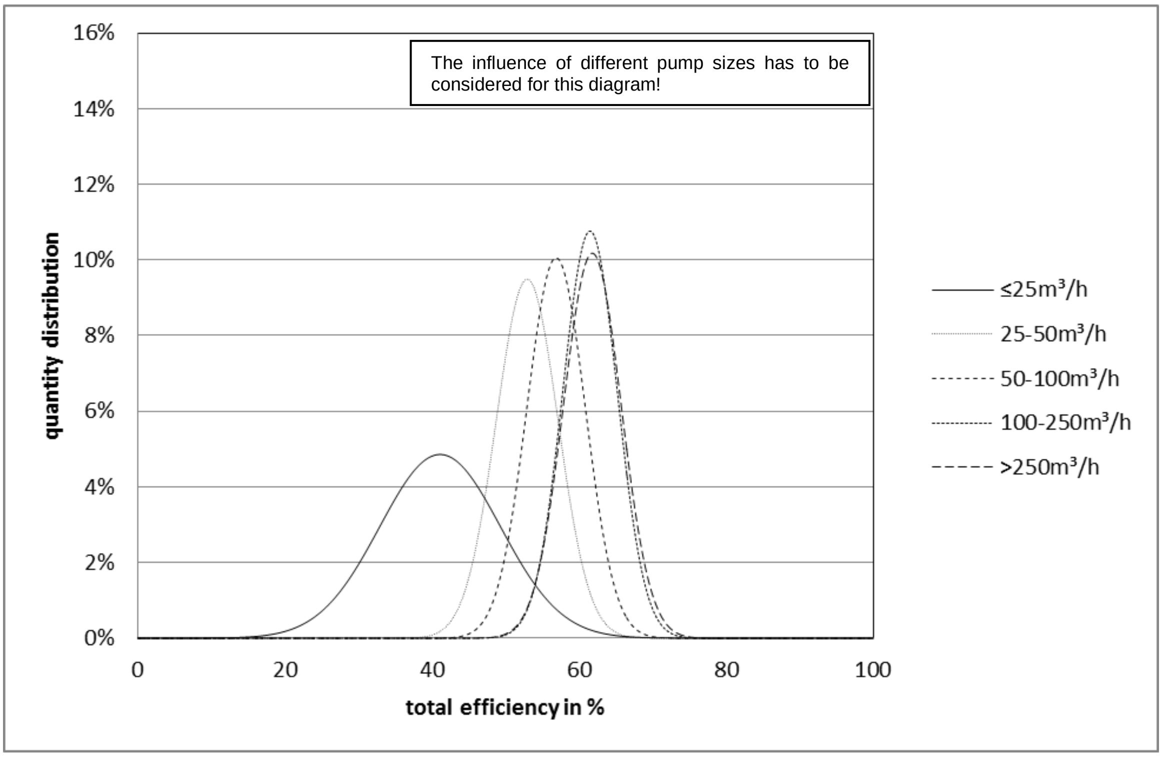


Fig. 5: Distribution of total efficiency after deduction of tolerances for different flow rates

The above diagram shows the normal quantity distribution for different flow rates. The distribution of total efficiency for different flow rates shows the same characteristics as it does for the different sizes:

- The scatter band of efficiency narrows for increasing pump size
- The total efficiency has a large offset between small and large pumps
- The total efficiency rises with increasing flow rates

Basically the pump size is a good indicator for the attainable flow rates, but for all flow rates the data is a combination of adjacent pump sizes. E.g. the lowest class of flow rates is mostly a combination of 4'' and 6'' pumps with small number of 8'' pumps, thus showing a slightly higher efficiency for the lowest flow rate class than for the smallest pump size and showing a broader scatter band. This effect shows inversely for the high flow rates, as the number of different pump types decreases with increasing pump size. The influence of highly efficient 14'' pumps on the quantity distribution is therefore reduced. This effect is even more obvious for the quantity distribution for different power classes.

Another important parameter is the impeller type (see 2.2.1).

2.2.5 Normal distribution for power classes

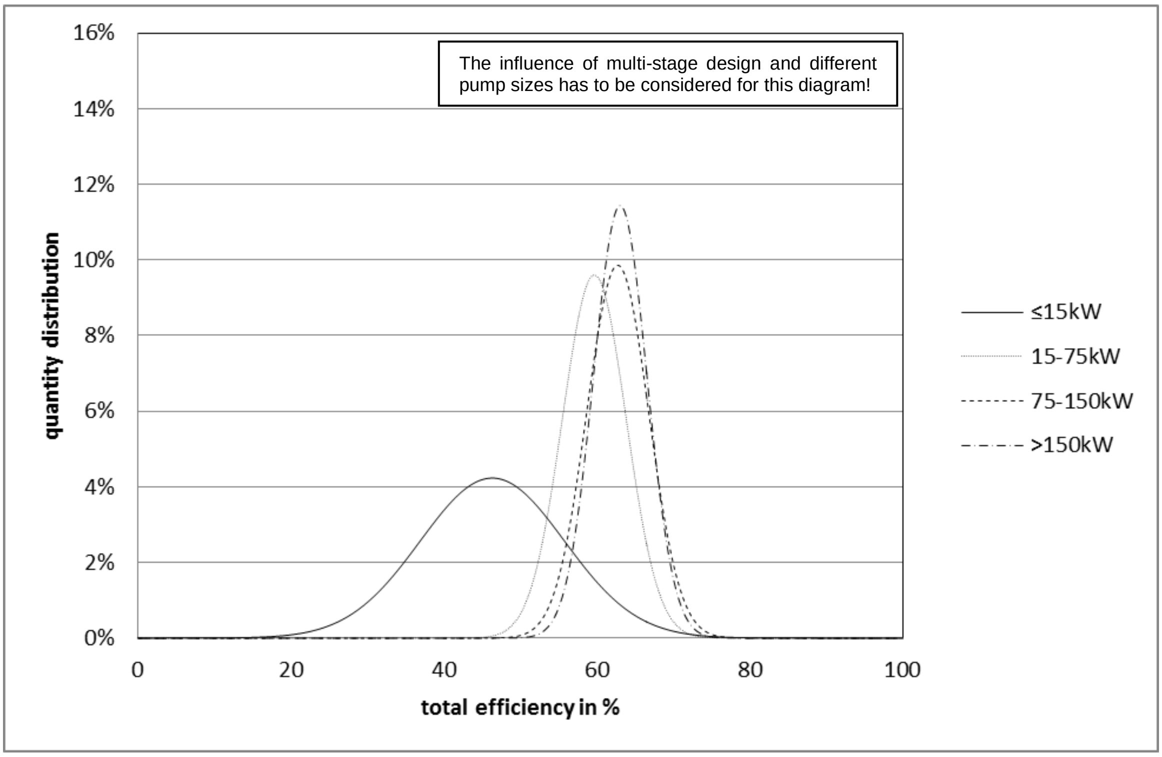


Fig. 6: Distribution of total efficiency after deduction of tolerances for power classes

Fig. 6 shows the quantity distribution of total efficiency for different power classes. Three observations can be stated:

- Two clusters of mean efficiencies can be observed
- The scatter band of efficiency narrows for the high power classes
- The total efficiency rises for the high power classes

This distribution shows a slightly different behavior than it does for size or flow. High power classes show the higher total efficiencies and the narrower scatter bands.

In deviation to the previous results there is no smooth transition from the low efficiency of low power classes to the higher efficiency of higher power classes.
The diagram shows a superposition of the effect of mixing different pump sizes and the influence of the number of impeller stages.

The lowest power class consists mostly of single or multi stage 4'' or 6'' pumps or single stage pumps of higher sizes. This results in a data mix ranging from small single stage pumps with little efficient motors up to 12'' single stage pumps with high hydraulic efficiency and highly efficient drives. A very broad scatter band in the diagram shows consequently.

For the high power classes ranging from 75kW to greater than 150kW the diagram shows mostly the same pumps with only different numbers of stages. For a better understanding of this fact: The Pleuger QN122 pump in a single stage design has a rated power of 47kW, two-stage design 93kW, three-stage design 140kW up to 280kW for a 6-stage design. As a result the total efficiency range is mostly alike.

2.2.6 Evaluation of efficiency for different hydraulic power classes

For the evaluation of the efficiency of submersible pumps according to their hydraulic power output, the pumps are divided in different power classes. The graphs shows for all manufacturers (Fig. 7) and then for each manufacturer separately (Fig. 8-16) the median efficiency in the hydraulic power classes 0-15kW, 15-75kW, 75-150kW and greater than 150kW. Additionally the maximum deviation of total efficiency is shown for each class.

For most manufacturers the mean of the total efficiency rises with increasing power class and the deviation between minimal and maximal efficiency decreases.
According to 2.2.5 - the subdivision of pumps in power classes might not be as meaningful as subdivision in size.

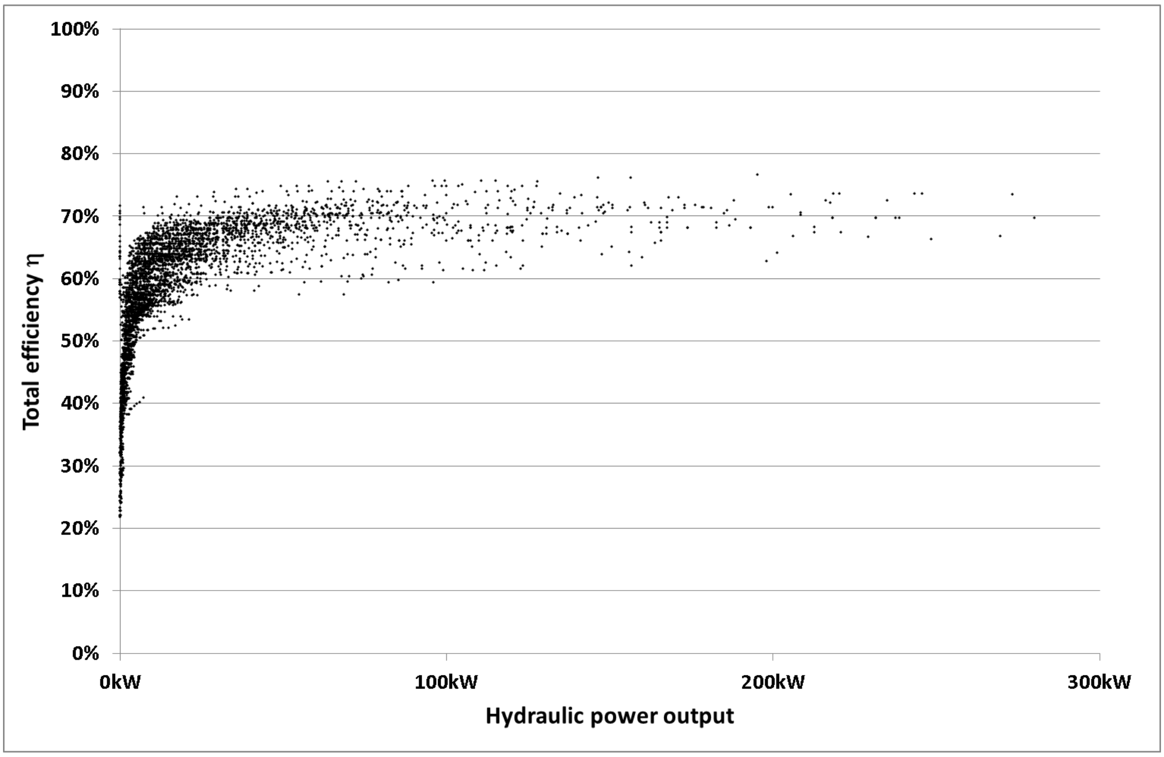


Fig. 7: General: Total efficiency vs. hydraulic classes output (not sorted by manufacturer)

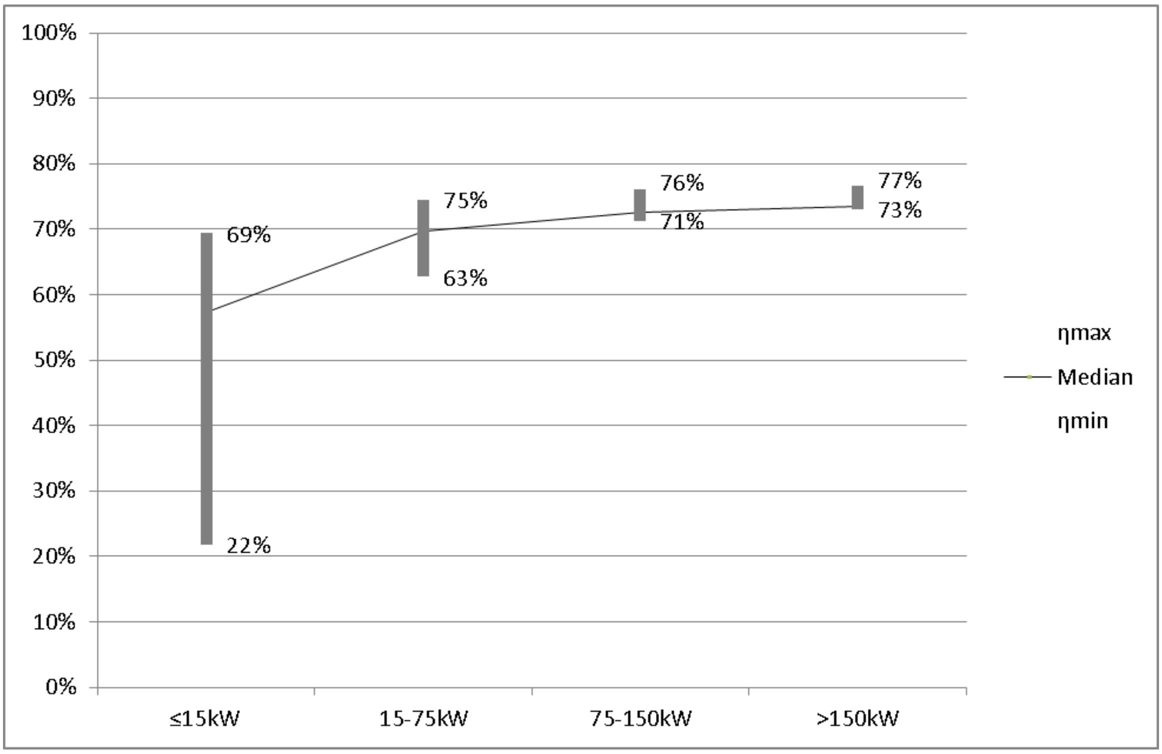


Fig. 8: KSB: efficiency for different hydraulic power classes

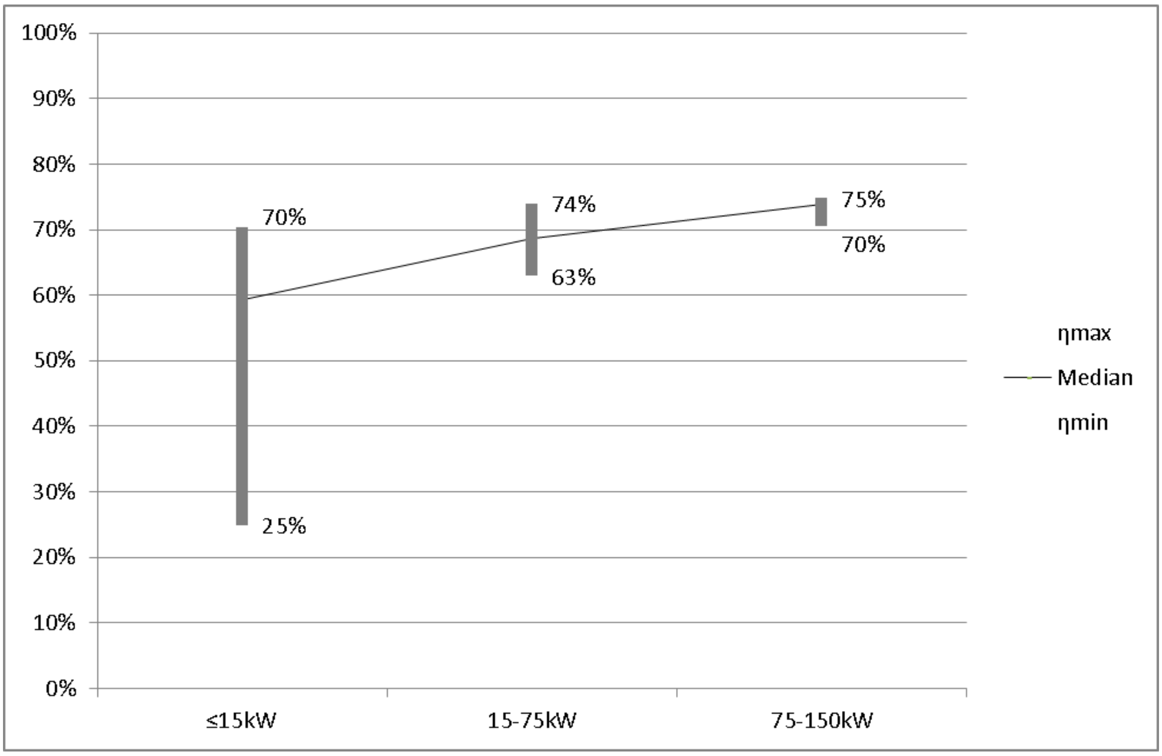


Fig. 9: Grundfos: efficiency for different hydraulic power classes

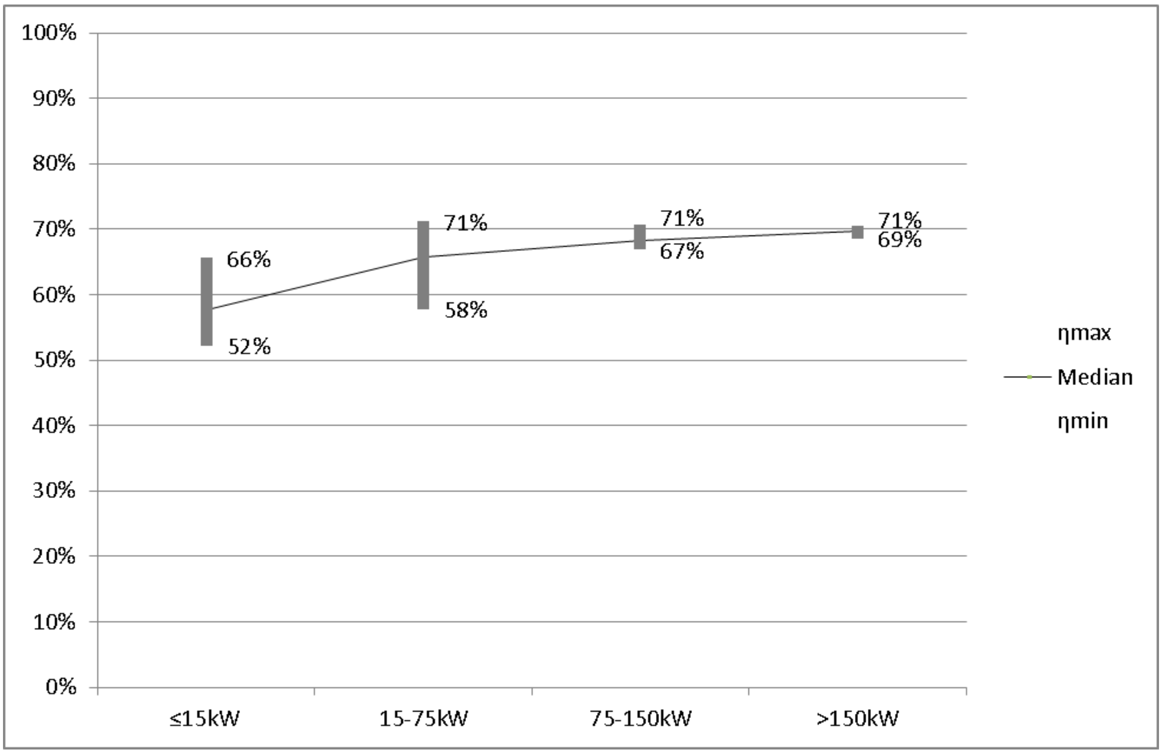


Fig. 10: Flowserve / Pleuger: efficiency for different hydraulic power classes

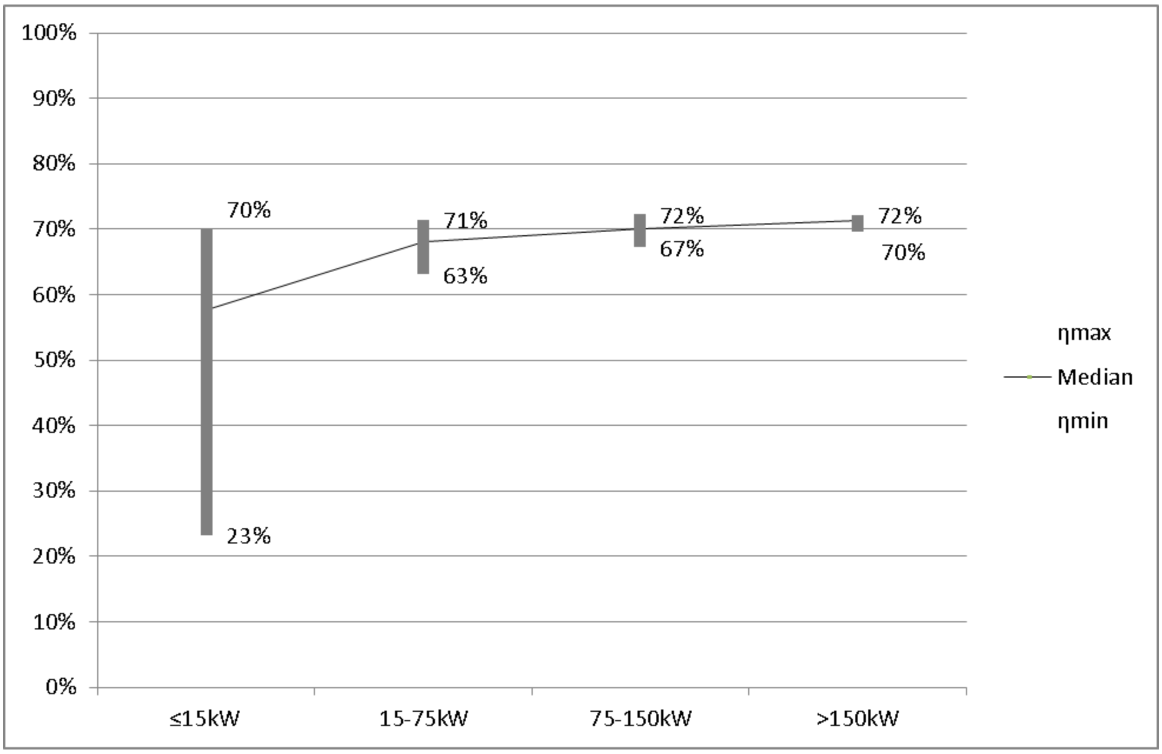


Fig. 11: ITT: efficiency for different hydraulic power classes

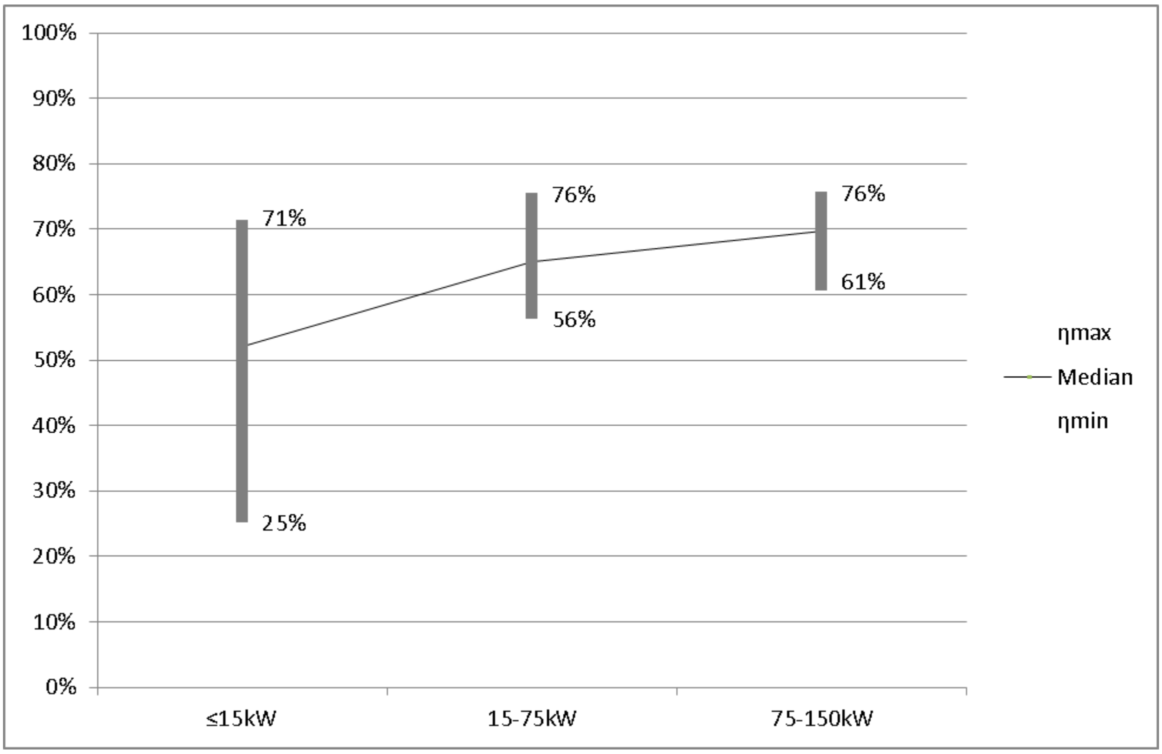


Fig. 12: Lubi: efficiency for different hydraulic power classes

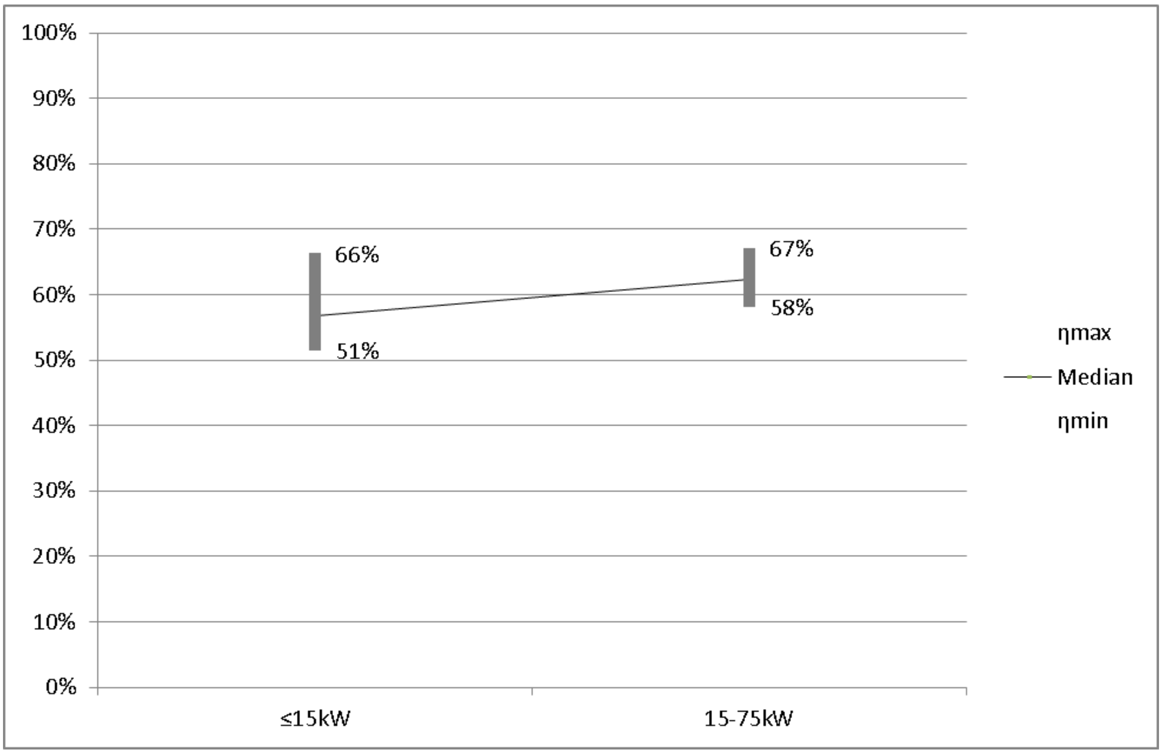


Fig. 13: Calpeda: efficiency for different hydraulic power classes

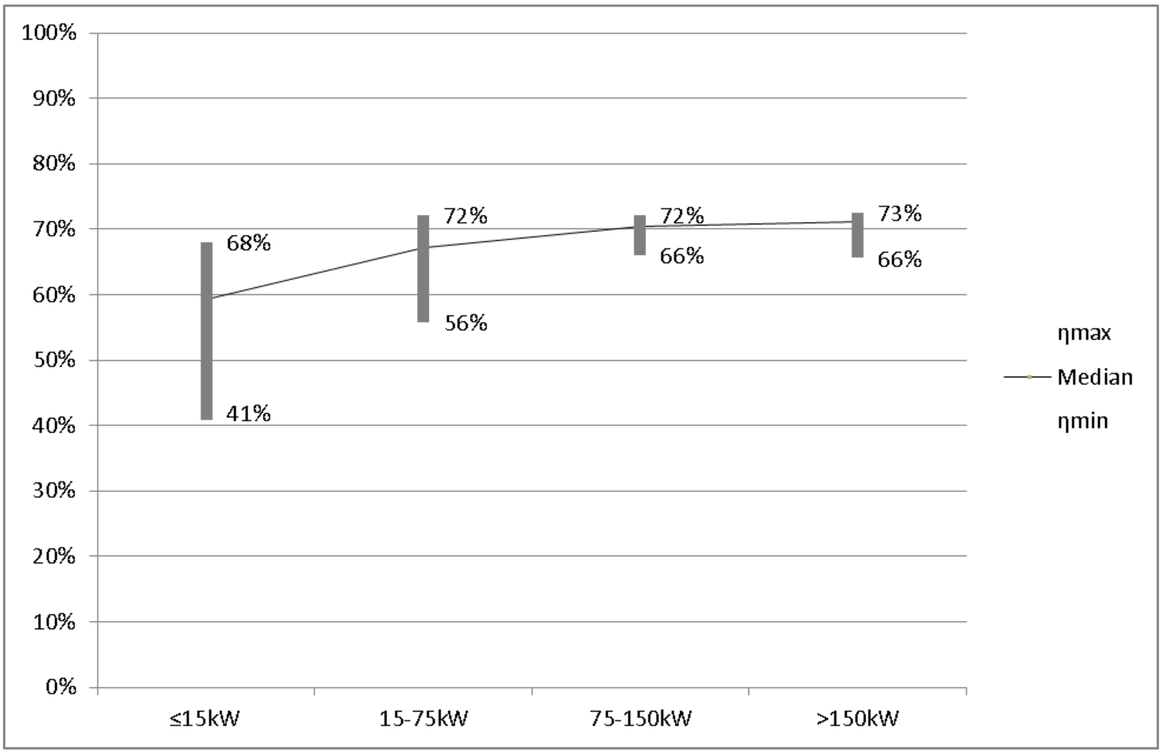


Fig. 14: Caprari: efficiency for different hydraulic power classes

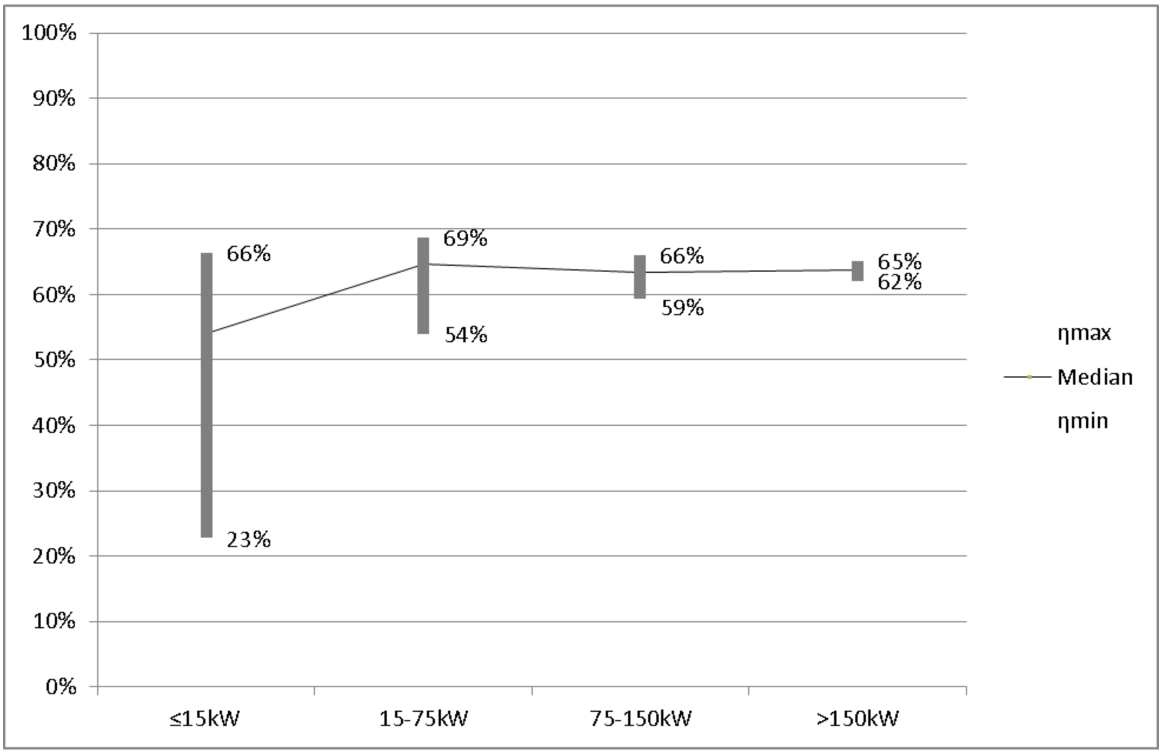


Fig. 15: Oddesse: efficiency for different hydraulic power classes

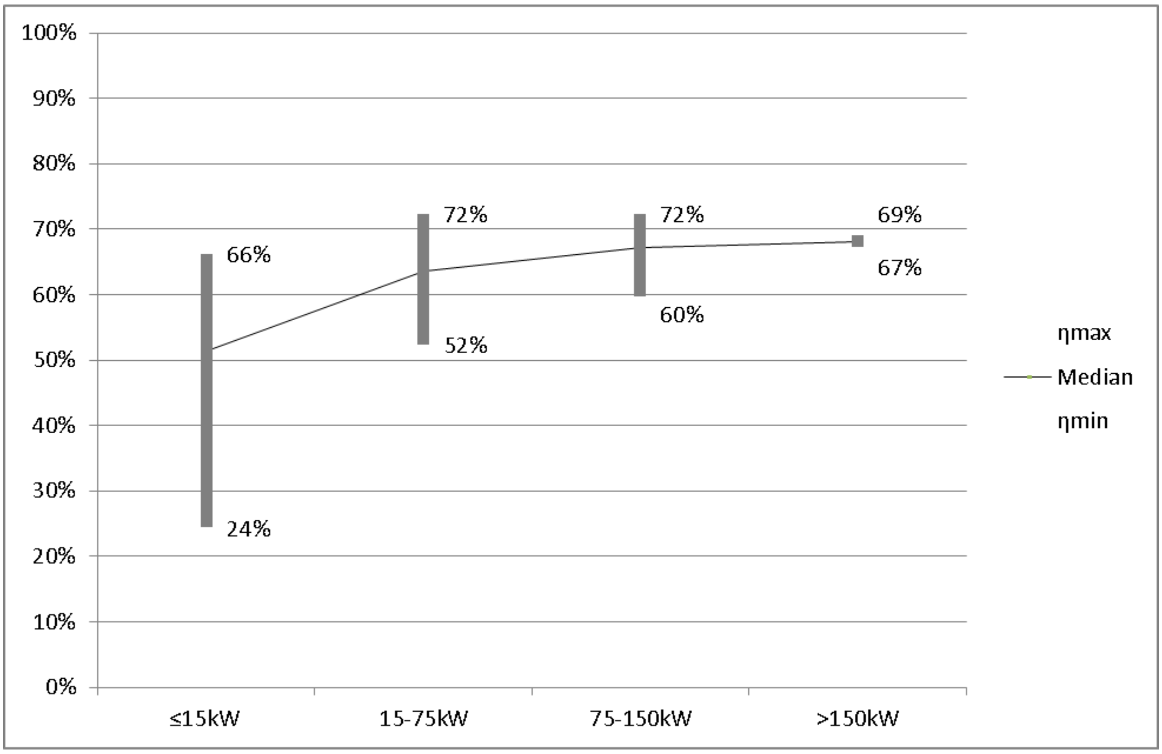


Fig. 16: SAER: efficiency for different hydraulic power classes

2.2.7 Efficiency and flow rate

For the evaluation of the efficiency of submersible pumps according to their flow rate, the pumps are divided in different power classes. The graphs show for all manufacturers (Fig. 17) and then for each manufacturer separately (Fig. 18-26) the median efficiency in the flow rate classes 0-25m³/h, 25-50m³/h, 50-100m³/h, 100-250m³/h and greater than 250m³/h. Additionally, the maximum deviation of total efficiency is shown for each class.

Similarly, to the hydraulic power, the total efficiency rises with greater flow rate for all manufacturers.

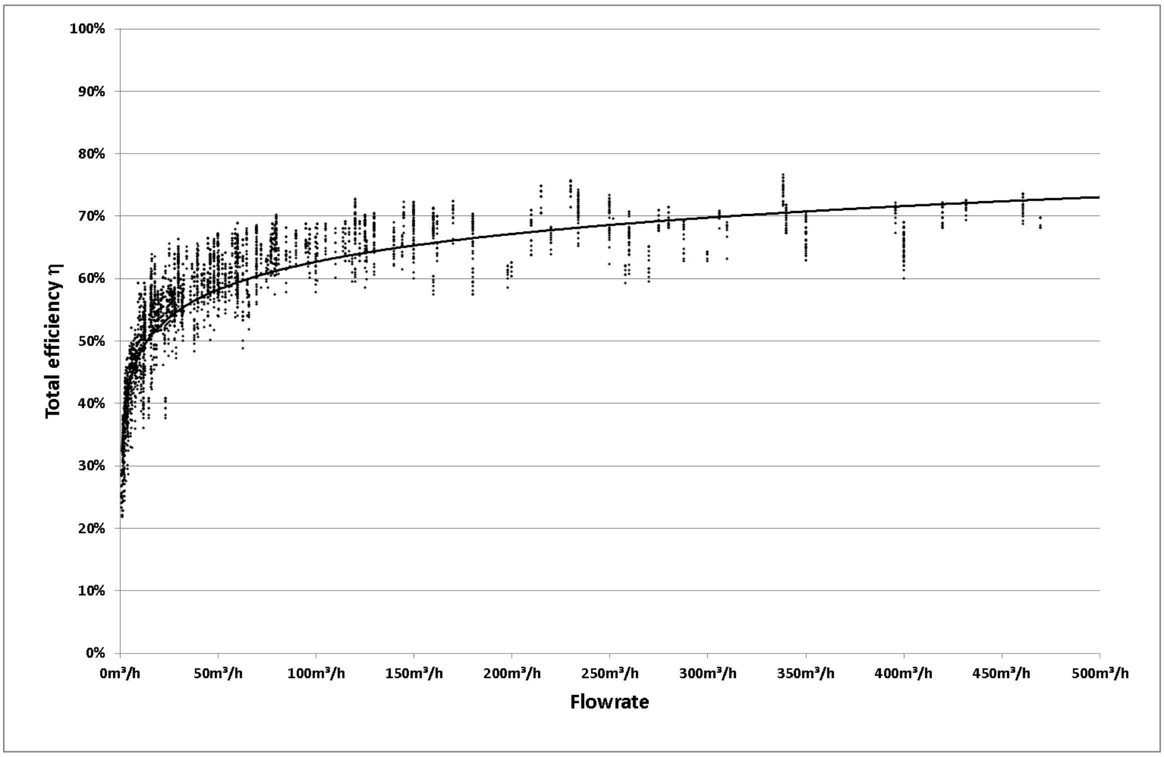


Fig. 17: General: Total efficiency vs. different flow rates (not sorted by manufacturer)

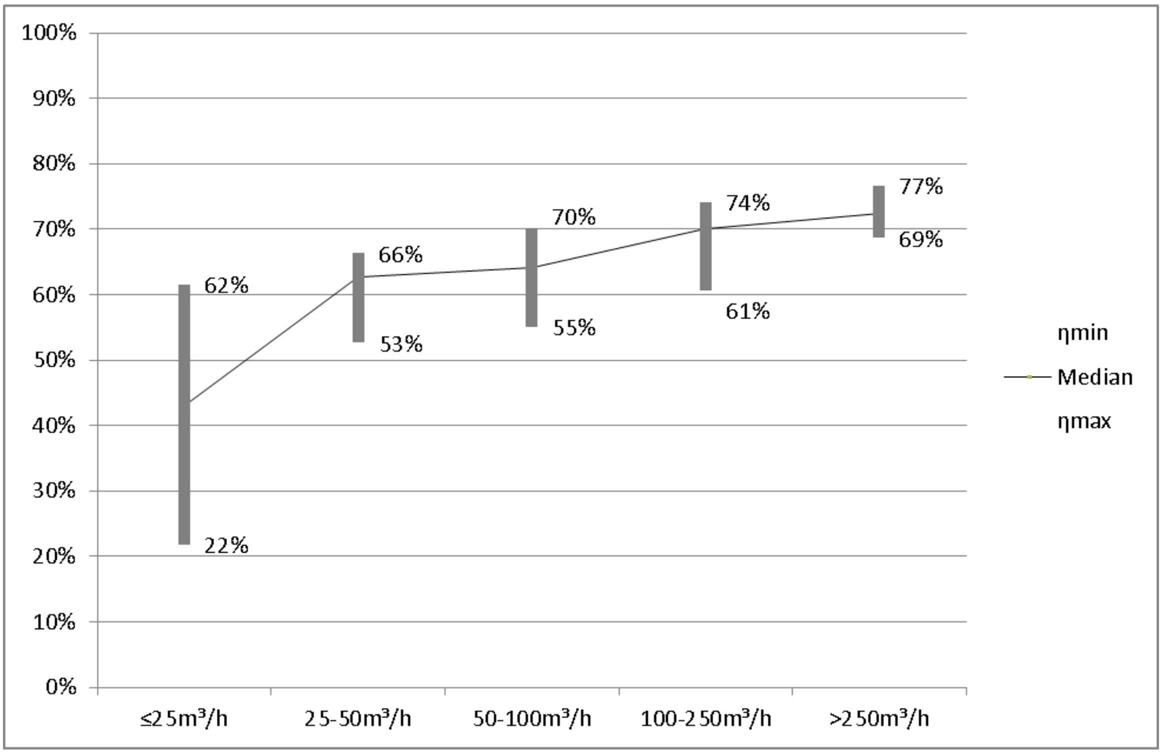


Fig. 18: KSB: efficiency for different flow rate classes

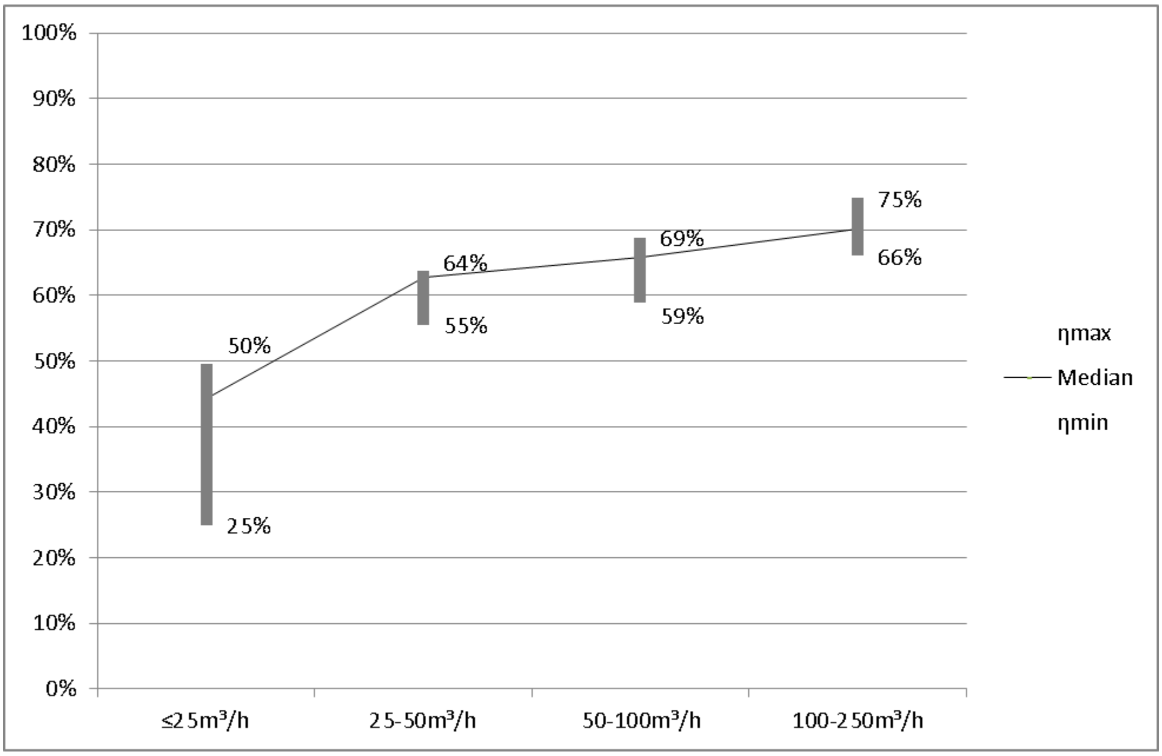


Fig. 19: Grundfos: efficiency for different flow rate classes

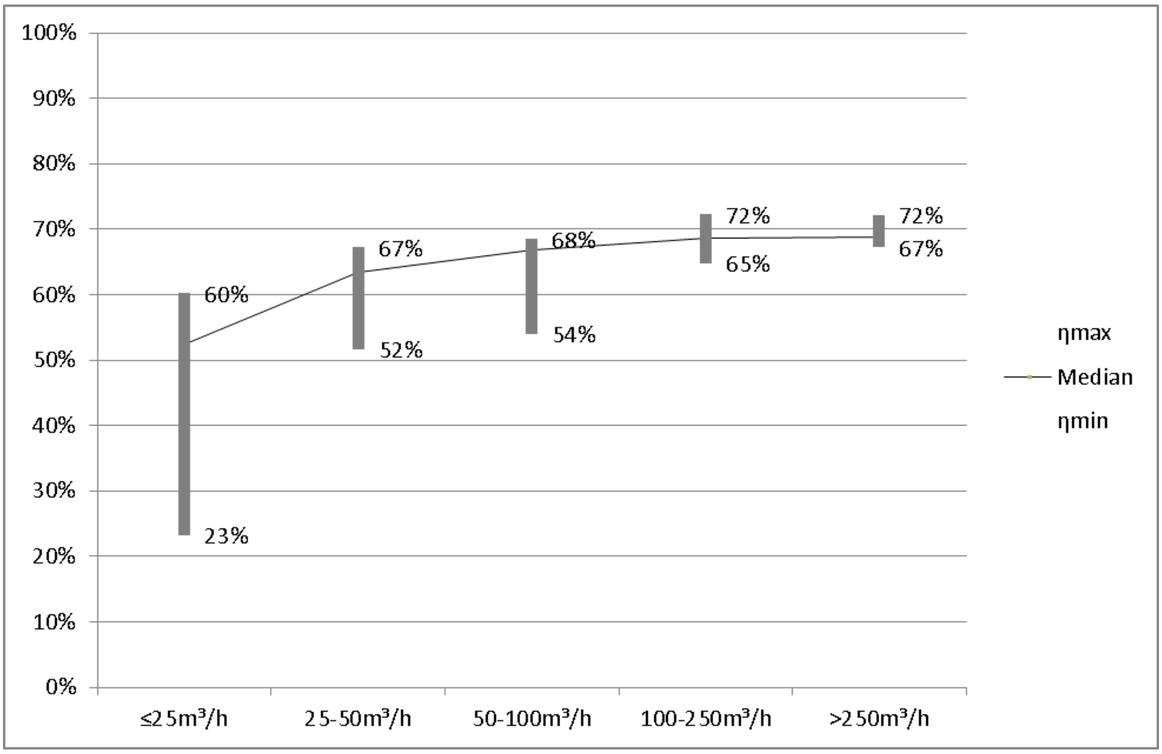


Fig. 20: ITT: efficiency for different flow rate classes

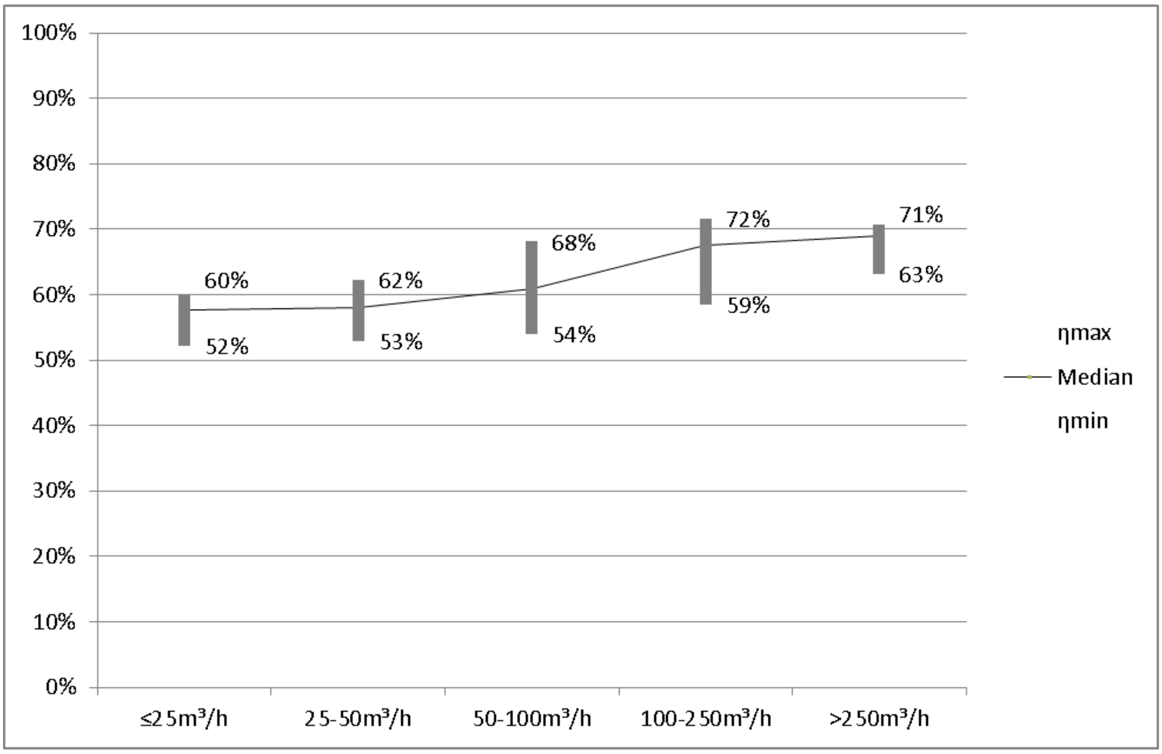


Fig. 21: Flowserve / Pleuger: efficiency for different flow rate classes

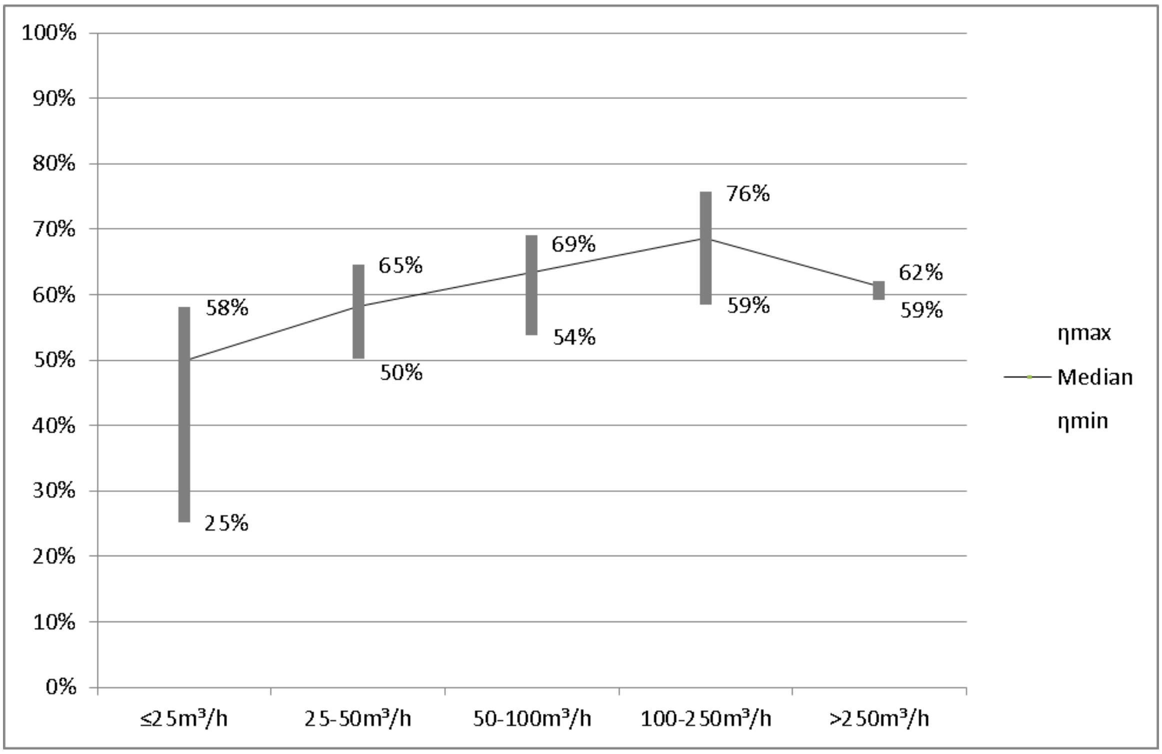


Fig. 22: Lubi: efficiency for different flow rate classes

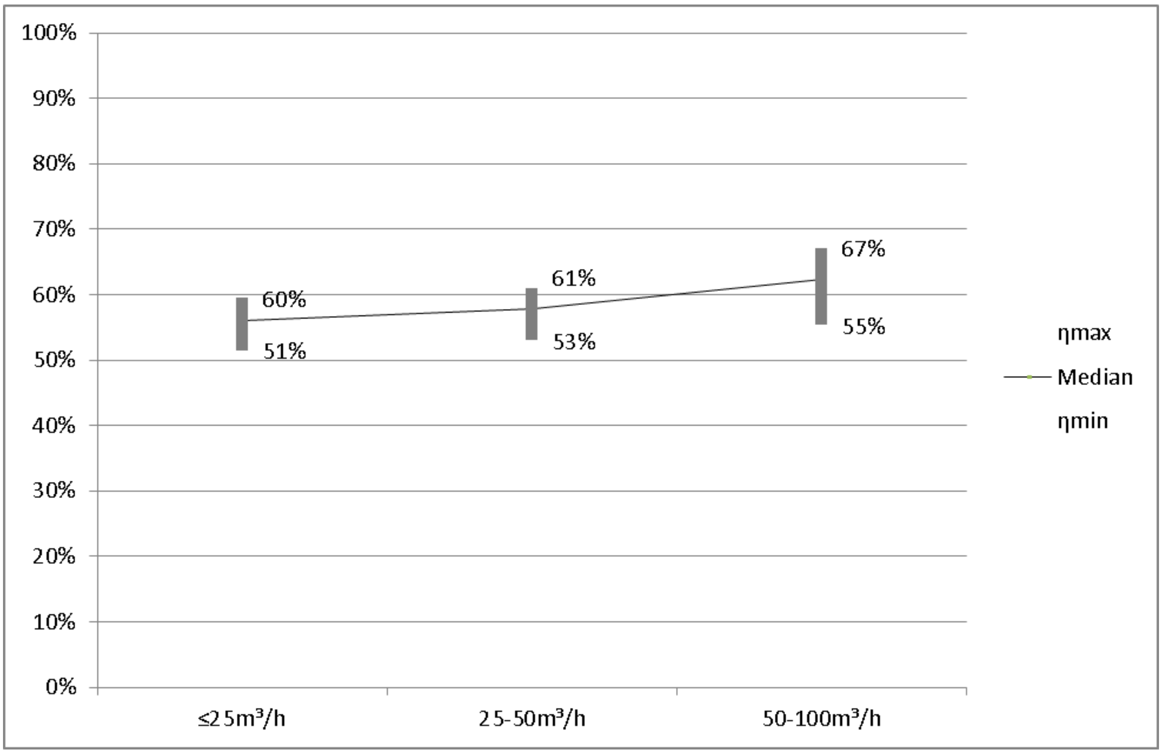


Fig. 23: Calpeda: efficiency for different flow rate classes

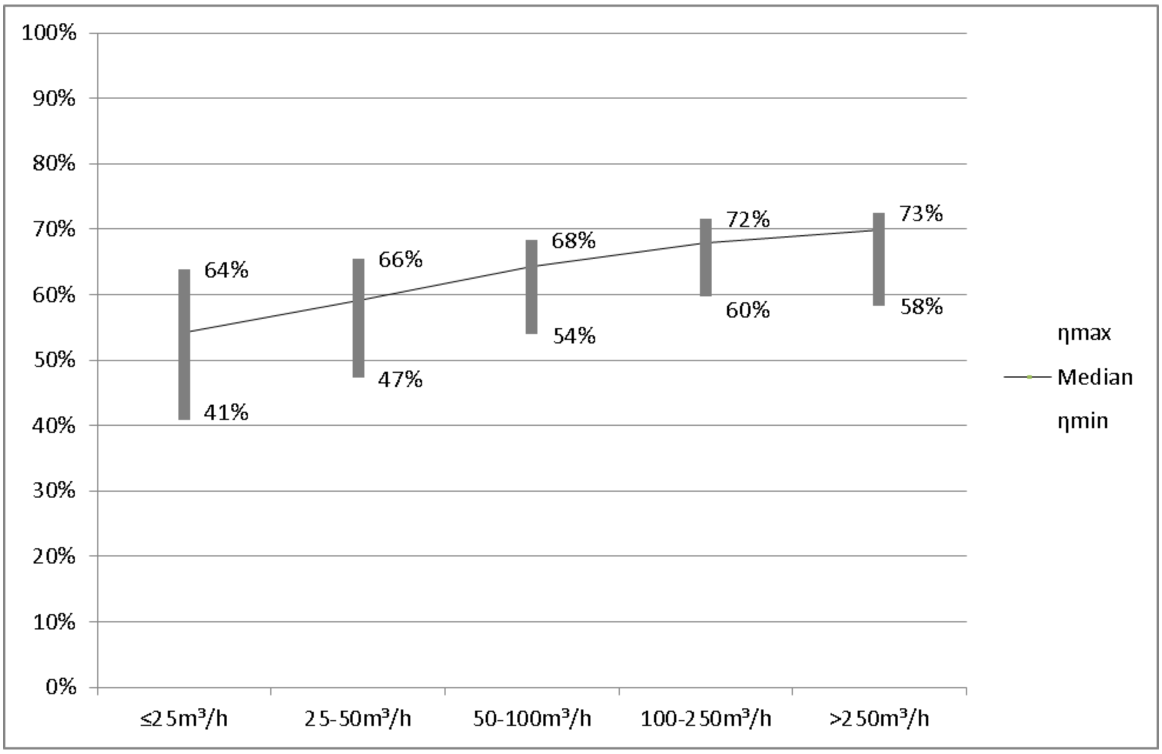


Fig. 24: Caprari: efficiency for different flow rate classes

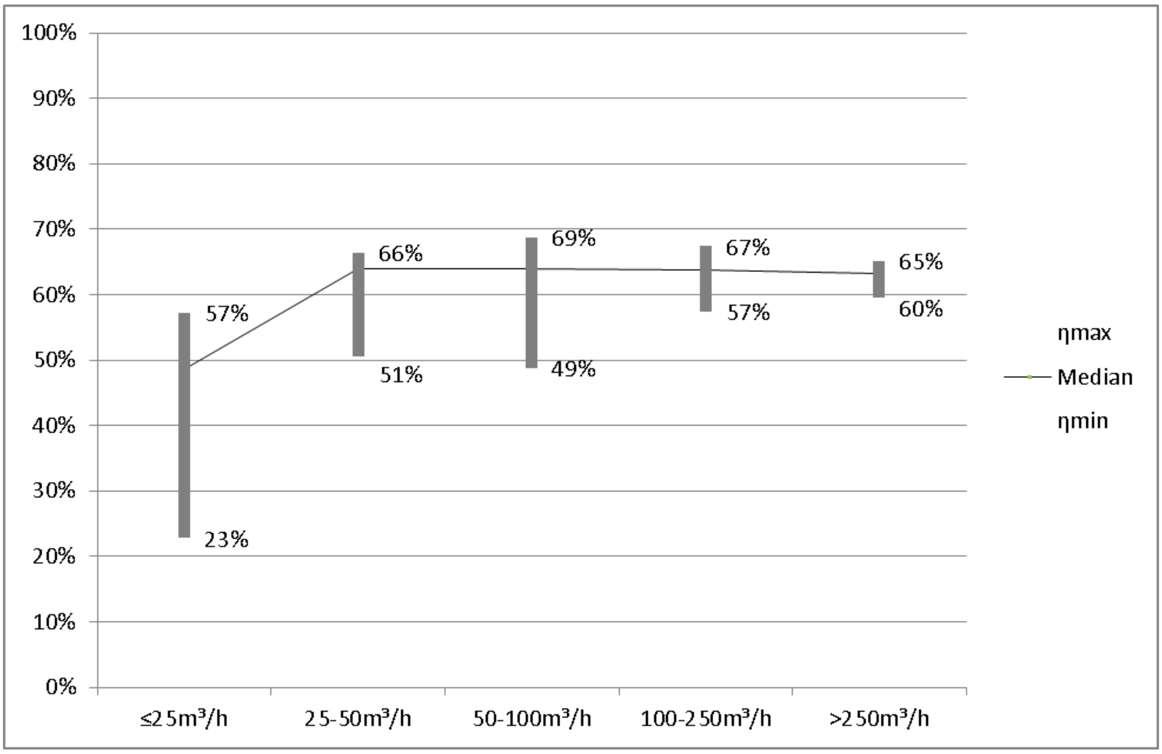


Fig. 25: Oddesse: efficiency for different flow rate classes

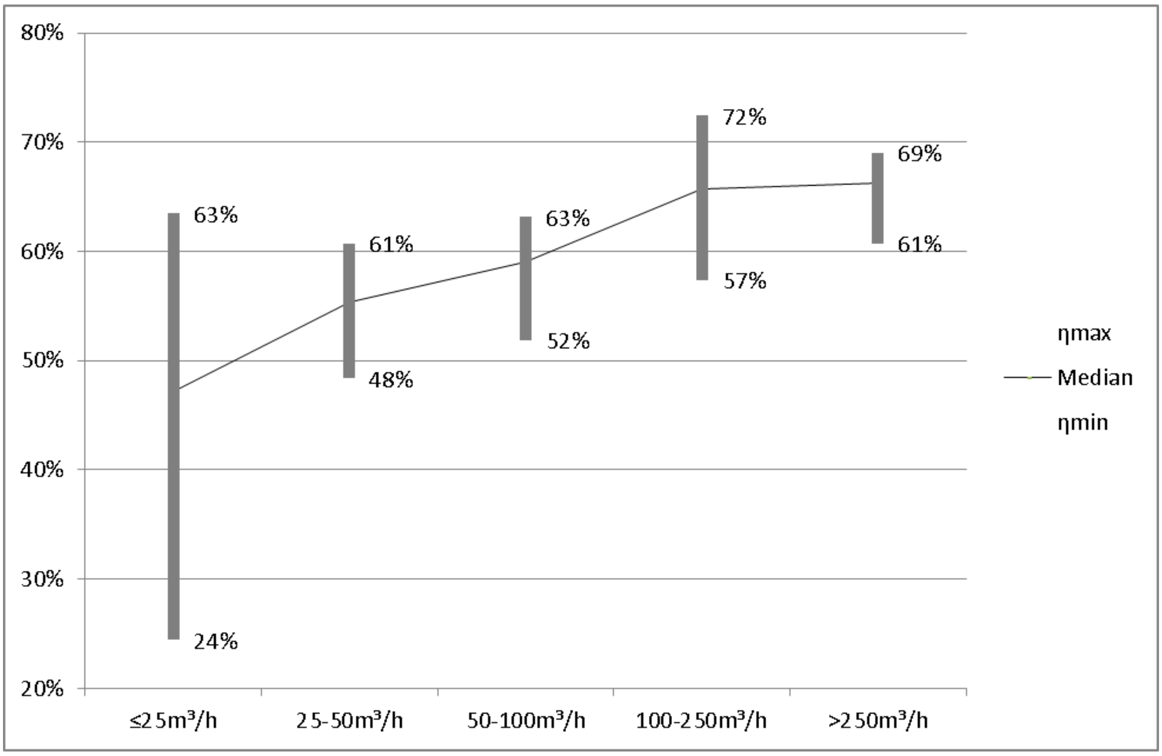


Fig. 26: SAER: efficiency for different flow rate classes

Chapter 3
Energy saving approaches

Manufacturer specific energy saving concepts realised in product portfolio.

Efficiency increase resulting from:

- use of up to date production methods resulting in high surface finish
    - improving wear resistance
    - smooth surface
- use of synthetic materials such as fibreglass-reinforced resin
    - no corrosion
    - very smooth surface
    - very thin impellers blades, reducing internal losses
- impeller coating or other materials with higher surface finish
    - reducing hydraulic losses
- trimming impeller to optimal diameter for specific application or operation point
    - adjusting operating point to best efficiency
- attuning motor and pump
- use of high efficiency motors (equivalent to IE 3)
- low-loss check valves
    - reducing minor losses
- replaceable or dynamic wear rings
    - reducing volumetric losses
    - reducing wear in the clearance between impeller and casing
- oil- or water-filled motors
    - cooling the motor results in efficiency increase
- increasing motor voltage
    - reducing losses in electrical power cables
    - reducing deviation in driving speed → influencing the operating point

General energy saving concepts for pump operation

Efficiency increase resulting from:

- application for the specific pump selection
  - detailed knowledge of system characteristic curve is needed
- use of variable speed drives (if regulation required by the system)
  - can increase the efficiency of pumping system but is limited by conveying task (very site specific)
- parallel pump operation
- predictive maintenance depending on motor temperature monitoring

→ *Additional information on possible technical improvements is given in the project deliverable D2.1 "*Literature review on theoretical pump and motor efficiency of submersible pump system*". A general overview of overall savings is also given in the project deliverable D4.1 "*OptiWells-1 Synthesis Report".

Chapter 4
Key messages

4.1 Market review

For this market review, the pumps were classified and evaluated according to flow rate, power class and size. As a result, the following key messages can be stated:

1. The over-all trend for a data is an increase of efficiency for higher flow rates, higher power classes and larger pump sizes.

2. A very large deviation of efficiencies can be observed especially in the low flow rate and low power classes and for small pump sizes.

3. Different pump sizes cover the same range of operation, thus allowing the use of more efficient pumps for same operating point

4. Efficiencies attained in previous literature analyses (D2.1) are confirmed by this study.

Table 1: Comparison of literature efficiency values[1] (based on D2.1) and efficiency values[2] of available pumps (D2.2)

Efficiency	Depends upon	Range theoretical max η (Europump)	Range[1] literature review	Range[2] available
Pump efficiency η_{pump} (-)	- rated power - impeller type and diameter - load	71-89%	65-85%	33-86%
Motor efficiency η_{motor} (-)	- manufacturing quality - cooling performance - load	-	75-90%	51-92%

→ *A general overview of attainable system savings is also given in the project deliverable D4.1 “*OptiWells-1 Synthesis Report”.

4.2 Workshop

A workshop with pump manufacturers was organised to discuss potentials and actual innovation on pump units including motor and auxiliaries. Representatives of all significant pump manufacturers were invited to a workshop including not only manufacturers[1], but also experts of the field and members of research centres.
In addition to the market review, the following approaches on increasing total pump efficiency were drafted:

5. Increasing the motor efficiency through optimal design

    - Electrical Design of motor
    - Reduction of iron and copper losses
    - Optimization layout of sheet metals (stator / rotor design)
    - Optimisation of motor cooling

    These measures may allow to increase the motor power by 25% using the same diameter.

    More powerful motors have higher efficiencies and realize higher rates of power factor. The use of highly efficient industry motors can reduce motor warming and thus increasing the total efficiency.
    These measures could increase efficiency by 2-5%.

6. Increasing pump efficiency through coating

    Coating of impellers can increase the efficiency by 2-3% and double or even triple the life span. The water quality (loading with abrasive material) and operation of pump (cavitation) could harm the coating over long-term operation.

7. Energy saving through optimal matching pump and motor

    Through optimized matching of pump and motor, an increase of efficiency up to 4% could be realised, with payback times of about two years.

8. Increasing efficiency through electrical optimisation of the pump system

    Higher voltages reduce the electrical losses in cables and allow smaller cable diameters thus resulting in cost reduction. Using 1000V operational voltage instead of 400V could reduce Cable cost by 75 percent. Anyhow, further investment costs for transformer and switching stations have to be considered.

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[1] Representatives of ANDRITZ, KSB, FLOWSERVE, Oddesse and WILO SE were present at the workshop in Berlin.

4.3 Conclusion

The market review shows high potentials for energy savings by several approaches, but in particular in their combination. The customer has the opportunity to influence the energy consumption and the resulting operating cost with carefully considered pump selection.

Some rules of thumb can be stated: choosing larger pump, larger motor, larger power cable and improving the impeller surface finish will decrease the operating costs. For optimum savings, a detailed knowledge of the system characteristic curve is necessary and the possible use of variable speed drives has to be investigated.

Although the purchasing costs will be higher, this should pay off through lower life cycle costs.

While pump systems are probably the most well-known equipment of the well field system, it has to be clearly mentioned that most of the capacity of performance improvement of pumping facilities lies in the optimization of operation:

- Selection of equipment adapted to the system
- Use of VSD if (and only if) regulation is required
- Proper monitoring of performance and mechanical parameters to adapt the maintenance plans.

Table 2: Energy saving potentials estimated by participants of the Optiwells Workshop

<table>
<tr><td rowspan="8">Percentage points</td><td>Larger pump size</td><td>+3%</td></tr>
<tr><td>Larger motor</td><td>+2-5%</td></tr>
<tr><td>Coatings</td><td>+2-3%</td></tr>
<tr><td>Reducing power cable losses</td><td>+2%</td></tr>
<tr><td>Overall</td><td>+9-13%</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Pump selection
Operating mode
Variable speed drives</td><td>20-30%</td></tr>
<tr><td>(Reducing wear and iron clogging)
To be reviewed</td><td>-</td></tr>
</table>

Chapter 5
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