This article is based on presentations in a workshop at Clima 2013 Conference, June 2013, Prague

Achieve superior energy performance of hydronic systems by enabling the latest pump technology

CARSTEN ØSTERGÅRD PEDERSEN
Business Development Manager, Grundfos Holding A/S, cpedersen@grundfos.com

ANDERS NIELSEN
Application Manager, Grundfos Holding A/S, anders@grundfos.com

Introduction

Energy improvements can be achieved in many ways, but especially optimisation of hydronic systems has proven to offer a remarkably quick return on investment. However, ultimate energy performance is achieved only by utilising intelligent products and components throughout the total hydronic system.

Accordingly, this article will revolve around how innovative pump technology can significantly improve the energy efficiency of the total hydronic system, but also that of the pumps itself.

EuP goals and requirements for pumps and motors

The Eco-design requirements of the directive for **E**nergy **u**sing **P**roducts (Directive 2005/32/EC)* are very ambitious and determined on reducing the energy consumption of a wide range of products. Surprisingly for many, 10% of all electrical power consumption in Europe is used by motors that drive pumps.

Annual Saving potential by 2020 with regulations based on Eco-design of energy using products directive:

Motors	135 TWh (EC 640/2009)
Circulator pumps	23 TWh or 11 million tonnes CO_2 (EC 641/2009) (EU 622/2012)

* Editors note: This directive was replaced in 2009 with Eco-design of Energy Related Products Directive (2009/125/EC)

This will be achieved by gradually increasing the energy efficiency demands:

For motors without frequency drive

- Large motors (7.5 kW-375 kW): IE3 efficiency demand in 2015.
- Smaller motors (down to 0.75 kW) IE3 efficiency demand in 2017.

IE2 motors must be fitted with frequency drives (integrated or external)

Energy efficiency index for circulators

- 2013: EEI ≤ 0.27
- 2015: EEI ≤ 0.23

Act NOW and achieve profitable energy savings immediately

Behind the great savings potential lies the fact that about 2/3 of all pumps run at full speed all the time, when the actual need for full speed is only 4-5% of the time. By optimising water pump systems, energy savings up to 60% can be achieved. Within circulation of water for heating, energy savings of up to 75% are possible, simply by replacing out-dated circulator pumps with new ones that automatically adapt to the variable flow. These savings can be achieved with a relatively low investment. In fact, the return on investment is most often as short as 1-3 years.

The EuP legislation will undoubtedly result in massive energy savings, but not realised until the natural replacements happen due to tear and wear. So, the EuP savings process is relatively long-term.

Accelerate the process

If energy renovations of pump (and hydronic) systems are accelerated NOW, the energy savings will also be achieved much faster.

> **"Just by switching to high-efficiency pumps, 4% of the world's total electricity consumption can be saved – equivalent to the residential electricity consumption of 1 billion people!"**

Achieving the EU triple 20 energy-efficiency target also requires an extra effort within energy renovation, as it must contribute with 15% out of the 20% energy reductions. Optimising the hydronic energy performance could be an obvious and profitable place to start.

Complete system optimisation – the new MAGNA3 pump

The EuP legislation was of course an obvious reason for developing the new MAGNA3 pump (**Figure 2**), and one of the results was an amazing reduction of energy consumption. The new Grundfos MAGNA3 uses only 25% of the electricity (**Figure 1**) compared to a typically installed circulator (standard UPS). What's more, the new MAGNA3 use 40% less that than what is required from Jan 2013 in EuP regulations.

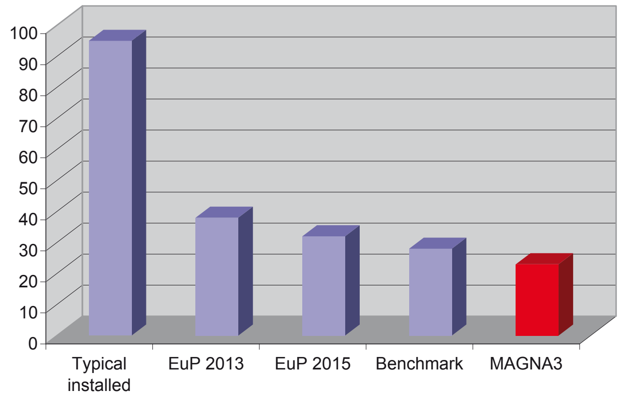

Figure 1. Relative energy use with the existing, new and latest pump generation.

Thus, the pump alone accounts for significant energy savings. Combined with the latest pump technology features of MAGNA3, it is possible to improve the efficiency of the entire hydronic system, and therefore achieve even higher energy savings.

Utilisation of a built-in heat energy meter

The new MAGNA3 pump (**Figure 2**) is equipped with the Grundfos patented direct sensor, which constantly monitors both the media temperature and the differential pressure, across the pump. Doing so, makes it is possible to measure the circulating flow in the system. And by adding a second temperature sensor to the return pipe, the delta T and the energy flow can be calculated (**Figure 3**). ▶

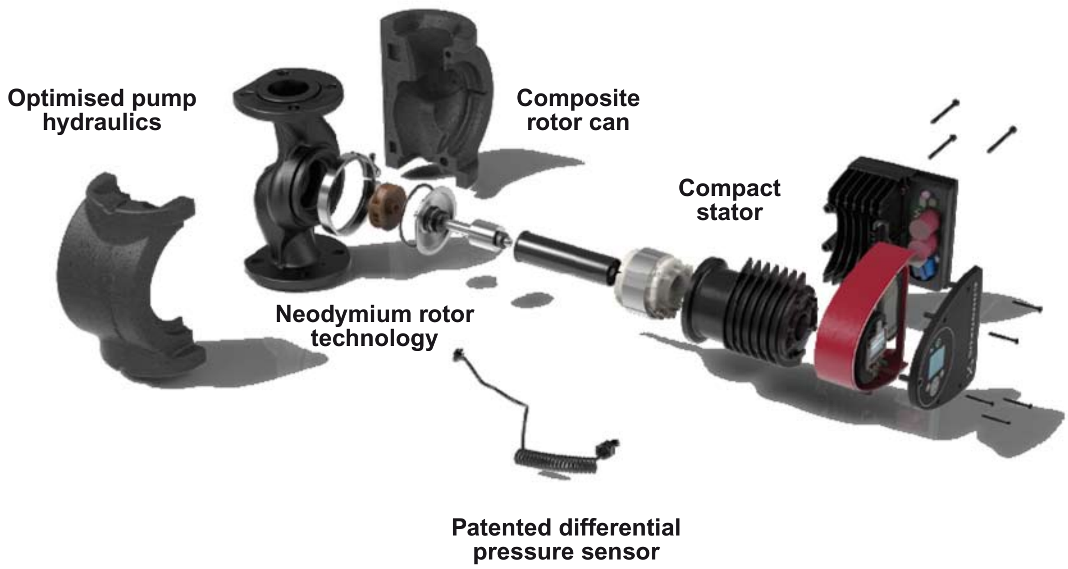

Figure 2. Components of the MAGNA3 pump.

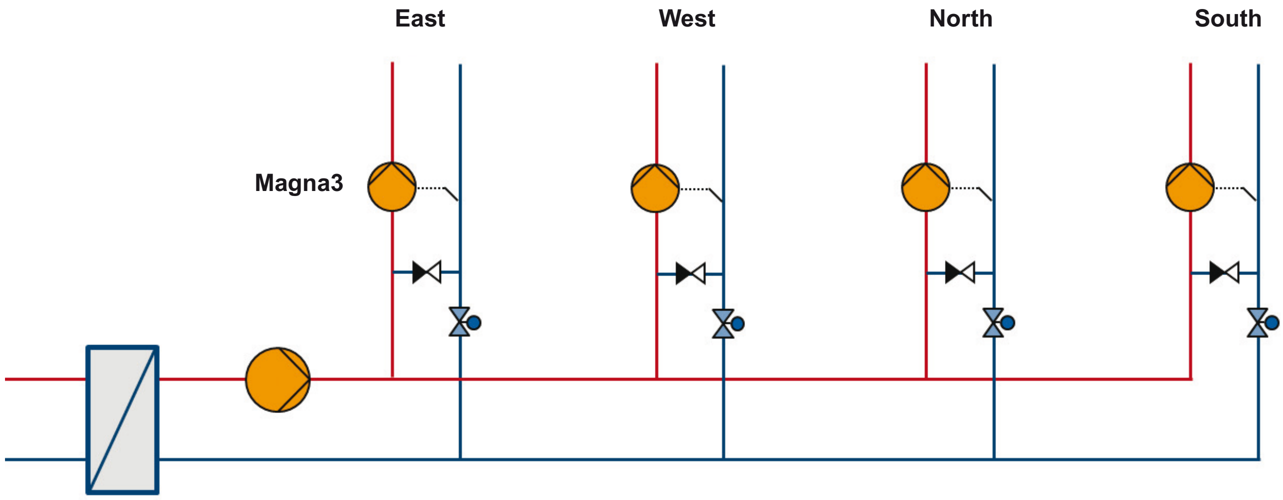

Figure 3. Illustration of how the MAGNA3 pump is installed in a heating system.

Renovation case showing the importance of hydronic systems – an example

According to Prof. Dušan Petráš from the Slovak University of Technology**, looking at the hydraulic balance in the buildings has a huge impact on the energy performance. Below are the savings data of a Romanian renovation case, consisting of a 32 apartment building with 9 floors.

Intelligent functions to improve the energy performance in hydronic systems

Until now, valid information about energy flows in hydronic systems have only been obtainable by investing in costly metering systems. However, the latest pump technology offer functionalities such as integrated energy metering and flow limit control modes that can:

- improve the quality of commissioning (and reduce the costs),
- increase the overall hydraulic balance
- reduce risk of by-pass flow
- make pump throttling valves redundant.

All these benefits have a significant impact on the overall efficiency of hydronic systems.

** Successful retrofitting of dwellings, Presentation REHVA Annual Conference, Timisoara, 2012.

Table 1. Comparison of renovation activities and return on investment in a Romanian renovation case.

Energy efficient measures	Investmens (€)	Yearly savings (€)	Share of yearly savings	ROI*** (years)
Insulation façade	83 590	3 448	24%	24.2
Insulation roof	23 510	603	4%	39.0
New windows	22 218	1 664	12%	13.4
Hydraulic balance	**13 146**	**7 508**	**53%**	**1.8**
Temperature set back	2 618	905	6%	2.9

Nominal interest rate = 5%, inflation = 4.2% *** Return on Investment.

Controlling the flow without throttling valves

Monitoring the circulating flow with the built-in differential pressure sensor enables users to set a maximum flow for each branch served by the MAGNA3 pump. In the past, (and still today) this was accomplished by adding a pump-throttling valve, which was both costly and complicated to operate. With the new FLOWLIMIT feature in the MAGNA3 this is easily set by either a smart phone or directly on the pump display.

In addition to user-friendly benefits, there are also savings in pump operations to be harvested. The power needed to operate pumps can be explained by the following equation: $P = q \times \Delta p$ (hydraulic power consumption = flow x pressure), which means that the more pressure/head needed, the more power will also be needed for the pump operation.

Saving of pumping energy by avoiding throttling and using high efficiency pump – an example

In this example a standard three speed pump is compared with the new MAGNA3. The flow demand is 22.5 m³/h x 4.1 mVc (the orange dot in **Figure 4**) and the duty point is just between speed two and three. If nothing is done, the actual flow in the system will be 24 m³/h by approximately 4.9 mVc. To ensure not to exceed the desired 22.5 m³/h, a pump throttling valve is usually installed and partly closed, which increases the resistance in the system. So the new duty point, illustrated by the blue dot, will be 22.5 m³/h x 5.2 mVc. The associated additional pressure, 1.1 mVc leads to an extra 0.14 kW, every hour the pump is in operation.

So as "all head/pressure comes at a cost", an additional cost of 0.14 kW will be added every hour the pump is operating. If this is an "all-year-situation", the additional cost will be 1 226 kWh/year.

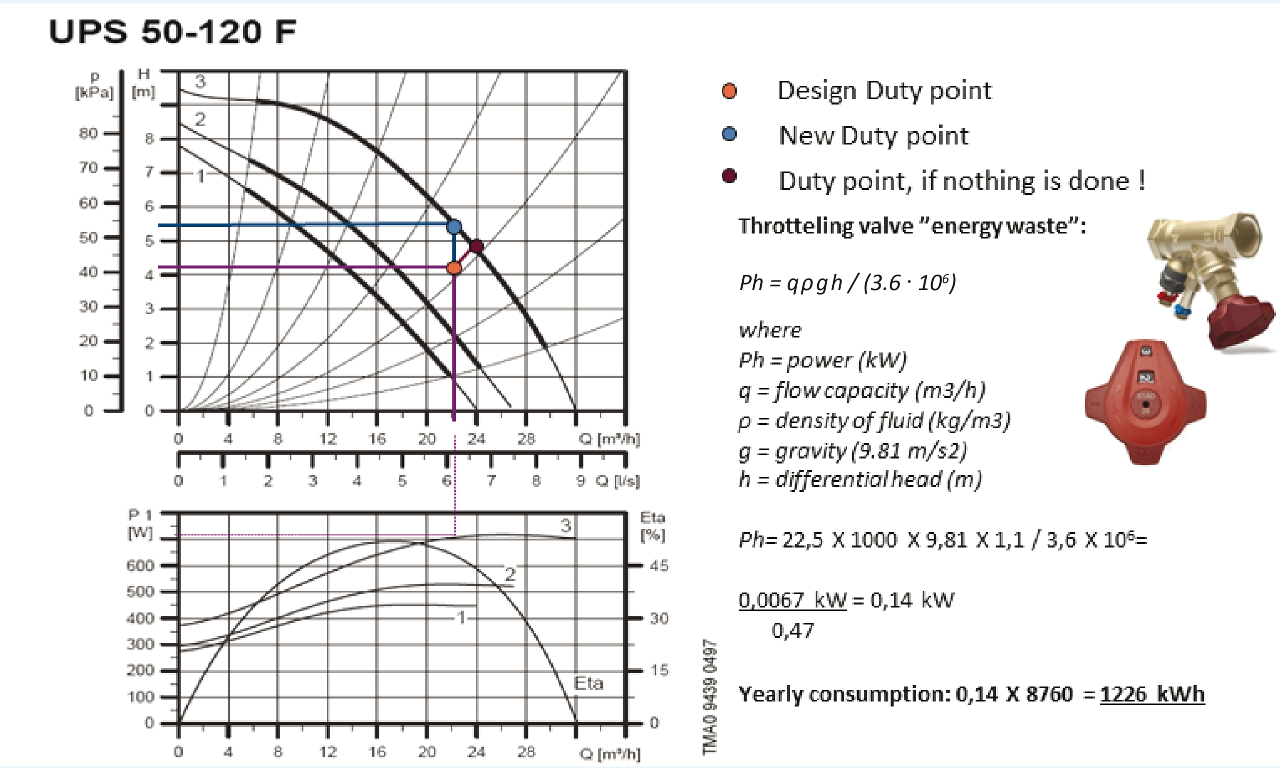

Figure 4. Calculation of energy consumption in a throttling valve.

With the MAGNA3 pump this can easily be eliminated by setting the FLOWLIMIT to the exact needed flow (22.5 m³/h). The red vertical line illustrates the FLOWLIMIT, which is easily set, either directly on the pump or by a smart phone.

Another benefit is the overall increased efficiency by the MAGNA3 that has an annual power consumption of 3,124 kWh (**Figure 5**). Compared to the standard UPS pump this gives energy savings of 3,008 kWh/year or 49%. So of the 6,132 kWh the standard pump consumes yearly, 20% is related to overcome the resistance in the throttling valve.

On top of this, the savings would have been even greater if the application had been with variable flow, which most often would be the case. So, what this example also shows is that a variable flow is no longer a pre-requisite for having higher energy efficiency on an electronic and variable flow controlled pump – with FLOWLIMIT it also goes for constant flow!

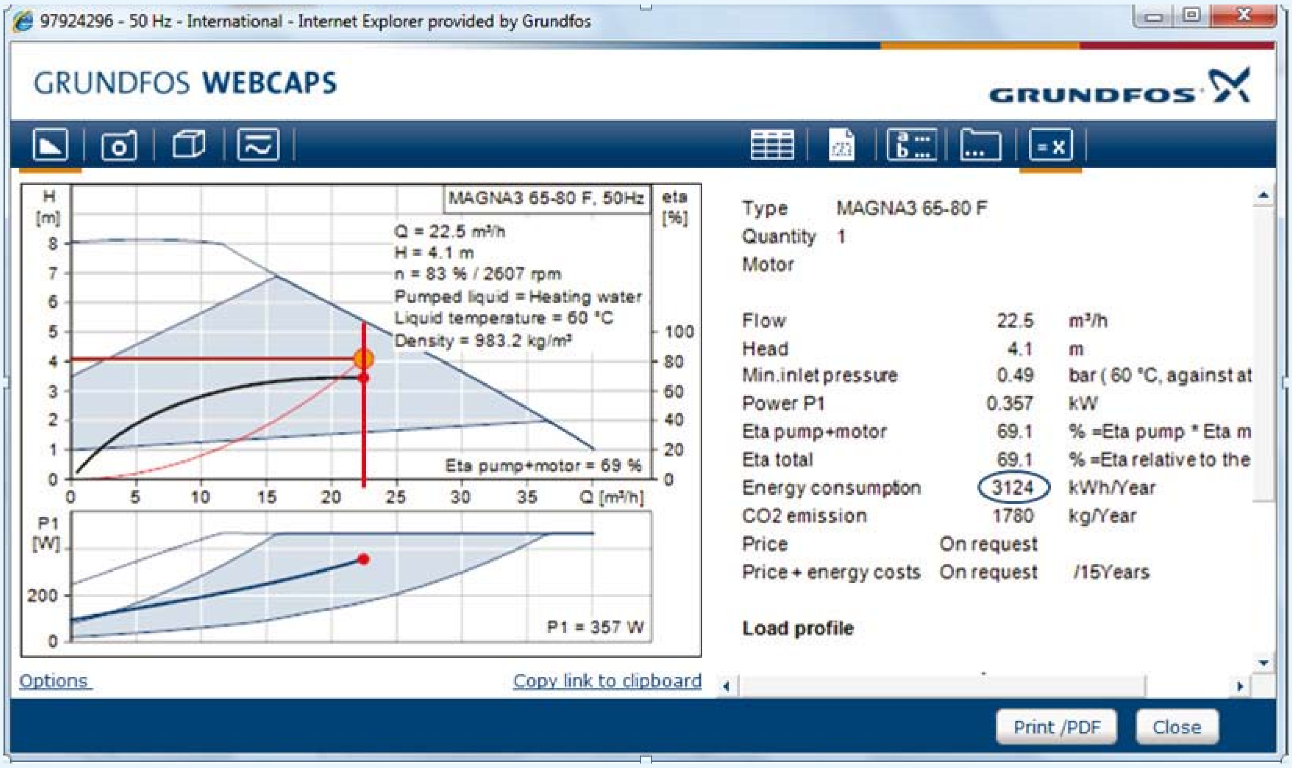

Figure 5. MAGNA3 characteristics.

Table 2. Summary of MAGNA3 pump application benefits.

MAGNA3 built-in heat energy meter	Benefits
• Monitoring of heat energy distribution and consumption within the system. • Temperature input from sensor on return pipe. • Flow limitation function. • Advanced logging.	• Information will help tracking imbalances in the system and that way avoid excessive energy bills. • Save cost of a separate energy metering device in the system. • Easy commissioning • Throttling valves redundant • Work log (3D) makes it possible to see the actual duty points of the pump over time to be used in replacement situations, for building extensions etc.

Future challenges for designers and installers

Maybe the biggest challenge for designers in the coming years will be to utilise the different features (see **Table 2**) in sophisticated products to the maximum, in order to secure cost optimum solutions for users. Accordingly, designers, consulting engineers, and installers will have to work closely together to secure the highest user satisfaction at the lowest possible costs. ■