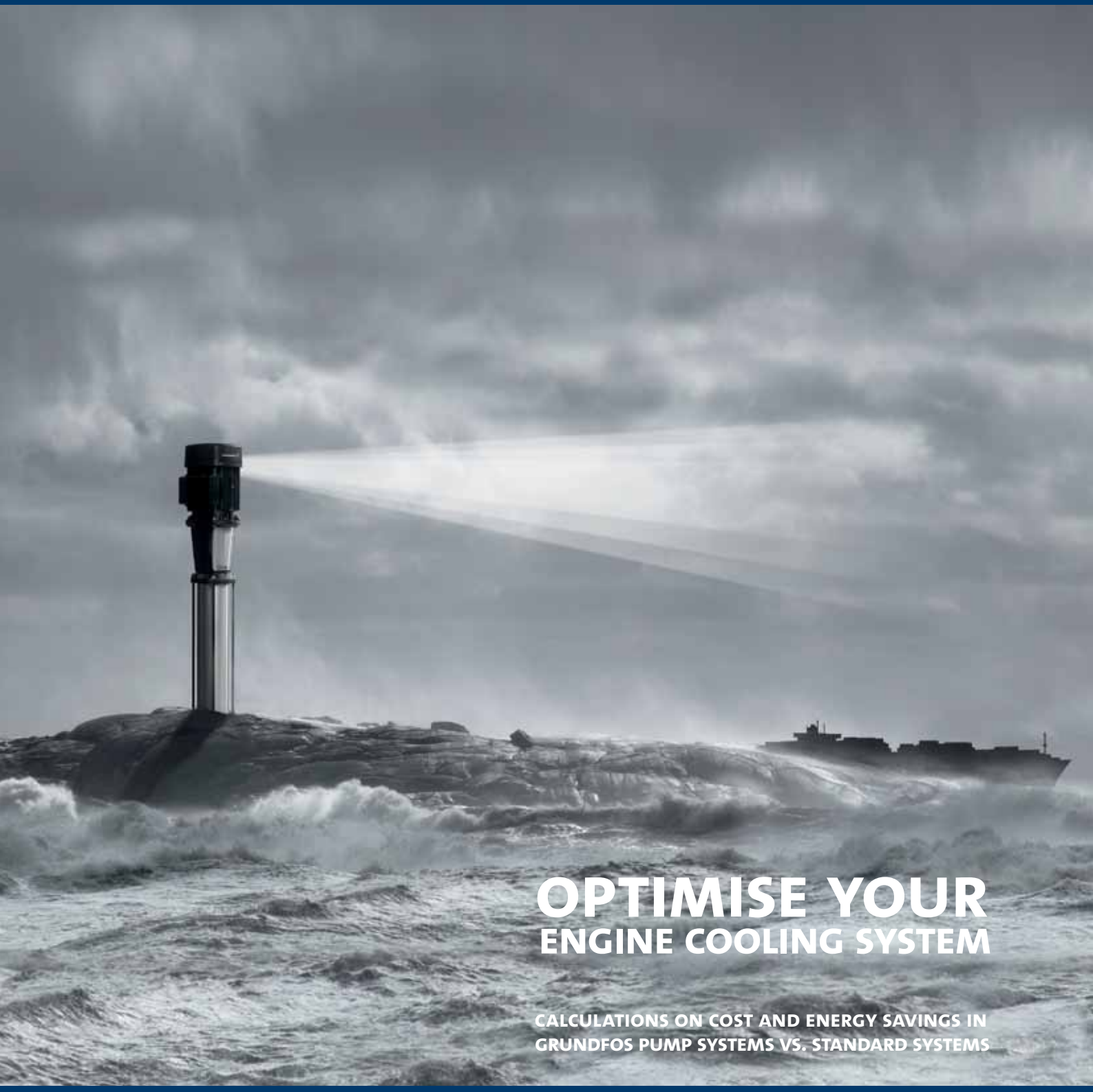
GRUNDFOS **INDUSTRIAL SOLUTIONS**
MARINE



OPTIMISE YOUR ENGINE COOLING SYSTEM

CALCULATIONS ON COST AND ENERGY SAVINGS IN GRUNDFOS PUMP SYSTEMS VS. STANDARD SYSTEMS

BE › THINK › INNOVATE ›

GRUNDFOS

TABLE OF CONTENTS

COPYRIGHT 2011 GRUNDFOS MANAGEMENT A/S
ALL RIGHTS RESERVED

Copyright law and international treaties protect this material.
No part of this material may be reproduced in any form or by any means without
prior written permission from GRUNDFOS Management A/S.

All reasonable care has been taken to ensure the accuracy of the content of this material:
However, GRUNDFOS shall not be held liable for any losses whether direct or indirect,
incidental or consequential arising out of the use of or reliance upon on any content of this material.

OPTIMISE YOUR ENGINE COOLING SYSTEM

Save both energy and money with Grundfos pump control units

Vessel owners can optimise engine cooling systems with a Grundfos solution that controls pump speed according to seawater temperature and load on main engine and auxiliaries, saving up to 50-90% in energy and its related costs, as this study shows.

Marine engine cooling system pumps run at full speed all the time regardless of operating conditions. Whether a vessel sails in the warm Persian Gulf or the cold Atlantic Ocean and regardless of whether the vessel is slow steaming or operating at full speed, the pumps carry a constant flow of seawater to the cooling system. Most importantly, it means that vessel owners waste both energy and money.

How it works

In the main propulsion engine on a ship, standard cooling systems begin with a seawater cooling cycle. The system's pumps bring in seawater, chilling a closed, freshwater circuit.

Marine classification rules require system design to be based on 32 °C. When the seawater is colder, the system needs less of it. If the seawater is 15 °C, for instance, the cooling system needs less water flow. By controlling the operation of the cooling water pumps according to your actual needs, you save a lot of energy and money. Marine classification rules require system design to be based on a sea water temperature of 32 °C and 100% full speed on main engine and auxiliary equipment. When the seawater is colder and/or the load is less than 100% full speed, water can be reduced and money saved.

Big savings

Grundfos intelligent pump control units use frequency converters to control the speed of a vessel's cooling pumps according to the temperature of the sea. The units can be mounted to existing cooling systems and can control the speed of any Grundfos pump, new or old, irrespective of size and power range.

This paper presents the results from a study showing potential savings on two different engine cooling systems – on a 4700 TEU container vessel and a 17000 dwt vessel.

GRUNDFOS ENGINE COOLING SOLUTIONS

Expertise leads the way

Speed control with frequency converters has been part of the Grundfos portfolio for 25 years. The advanced controls are part of Grundfos' comprehensive E-solution programme of speed-controlled pump systems, developed to make way for more energy-efficient operations.

Cost-efficient, superior features

The Grundfos pump controls offer:

- Automatic speed-control of cooling pumps according to seawater temperature
- Annual savings of up to 50-90%
- Unmatched performance and reliability
- Easy installation (plug and play)
- Low life cycle costs
- User-friendly interface

VLS
Ideal for seawater and freshwater cooling.

FREQUENCY CONVERTER
Designed for speed control.

GRUNDFOS PUMP CONTROL UNIT
Reduces energy use with frequency converters, which control the speed of a vessel's cooling pumps according to the temperature of the sea.

OPTIMISED ENGINE COOLING IN A 4700 TEU CONTAINER VESSEL

Here, we calculate the potential energy and costs savings with a Grundfos cooling water system aboard a 4700 teu container vessel.

The vessel's main engine is MAN 6S80 ME, Tier II. The vessel has five auxiliary engines.

The basis for determining the pumps' sizes is based on the cooling requirements for the main engine and the auxiliary engines only.

STANDARD SYSTEM VS. GRUNDFOS OPTIMISED SYSTEM

The standard engine cooling system consists of both a sea water cooling cycle and two fresh water cooling cycles. Each cycle has two pumps, one duty and one standby. The pumps in this system operate continuously at 100% load and the temperature of the cooling water in each freshwater cycle is controlled by the two 3-way valves.

In the Grundfos optimised system the cooling pumps are controlled by frequency drives, along with additional valves and instruments. Furthermore the operating profile is divided into two: seagoing and harboring. When the vessel is at sea, the main engine and two auxiliary engines are cooled. When harboring, only two auxiliary engines are cooled.

The standard system is designed to ensure sufficient cooling of the engine at sea water temperatures of 32 °C.

The Grundfos optimised system fulfils requirements for 32°C and 100% load but is optimised to control and maintain a constant cooling temperature of the engine according with the water temperature. For example if the water temperature drops to 20 °C, the Grundfos optimised system only uses half the energy compared to full capacity at 32 °C. The sea water temperatures are often lower than 32 °C, which means the cooling system needs less water flow. By controlling the operation with a frequency converter according to your needs, you can save both energy and money.

To optimise power consumption, the pump configuration changes from 2x100% (two pumps running 100% of the time) to 3x50% for both seawater and freshwater pumps.

The calculation is based on the assumptions that:

THE FUEL PRICES ARE:

Heavy Fuel Oil:	$630/ton – $0.135/kWh
Low Sulphur:	$950/ton – $0.205/kWh

The specific fuel consumption on typical aux. engine is 215 g/kWh.

The annual operating hours are 8,000, divided between sea going (6,000 hours) and harboring (2,000 hours).

CASE 1: 4700 TEU VESSEL

POTENTIAL SAVINGS

	Standard system		GRUNDFOS			
			Seagoing		Harboring	
Operation coasts	**Specifications**	**Total**	**Specifications**	**Total**	**Specifications**	**Total**
Sea water pumps	2 x 1.250 m³/h x 25 mWc* – power consumption: 120 kW Power consumption: 8,000 hours/year x 120 =	960,000 kWh	Required flow: 550 - 750 m³/h Power consumption at 650 m³/h: 12 kW: 6,000 hours/year x 12 kW =	72,000 kWh	2 x 1.250 m³/h x 25 mWc – power consumption: 120 kW Power consumption: 8,000 hours/year x 120 =	20,000 kWh
Freshwater pumps	2x1140 m³/h x 30 mWc – power consumption: 122 kW Power consumption: 8,000 hours/year x 122 =	976,000 kWh	Required flow: 750 m³/h Power consumption at 750 m³/h: 34 kW 6,000 hours/year x 34 kW =	204,000 kWh	2x1140 m³/h x 30 mWc – power consumption: 122 kW Power consumption: 8,000 hours/year x 122 =	30,000 kWh
Total cost per year		**1,936,000 kWh**				**326,000 kWh**
Annual cost	Seagoing: (6,000/8,000hours) x 1,936,000 kWh x $0.135 =	$196,020	276,000 x $0.135 =	$37,260	50,000 kWh x $0.205 =	$10,250
	Harboring: (2,000/8,000hours) x 1,936,000 kWh x $0.205 =	$99,220				
Total per year		**$295,240**				**$47,510**

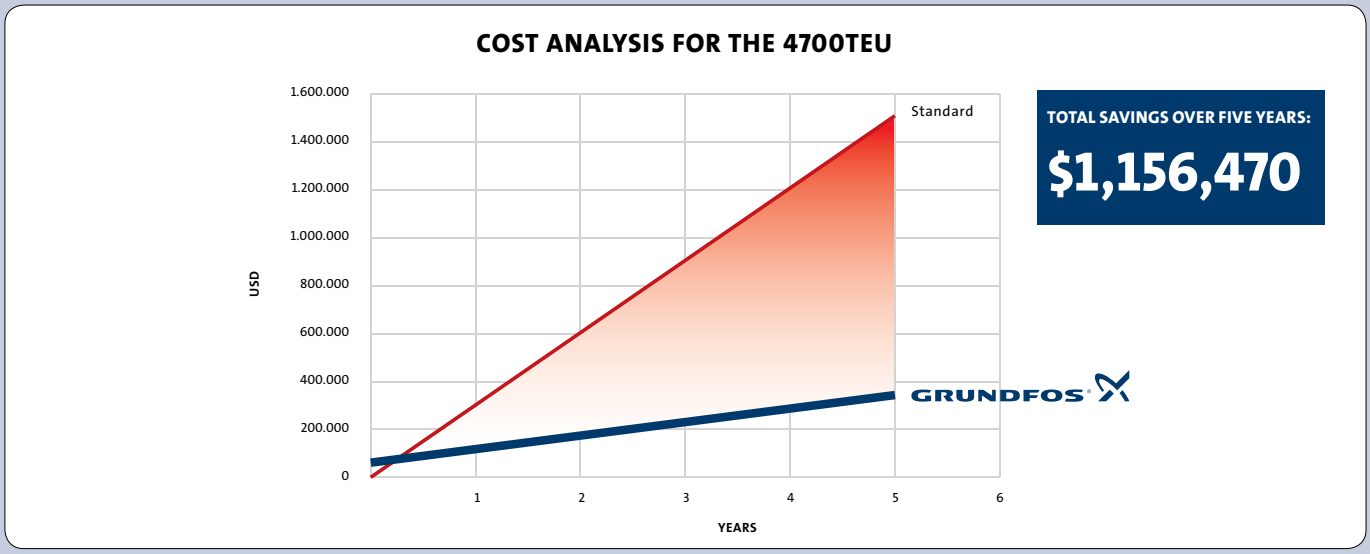
Annual Potential savings with Grundfos optimized systems

Cost savings	$295,240 - $47,510 = **$247,730**
Energy savings	(1,936,000 kWh - 236,000 kWh) / 1,936,000 kWh x 100 = **83%**

*mWc = Meter of Water Column (pressure unit)

COST ANALYSIS

This graph illustrates the cost savings achieved by this system optimisation. Over five years, the standard system will cost $1,476,200, whereas the Grundfos system will cost $319,730. A total saving of $1,156,470.



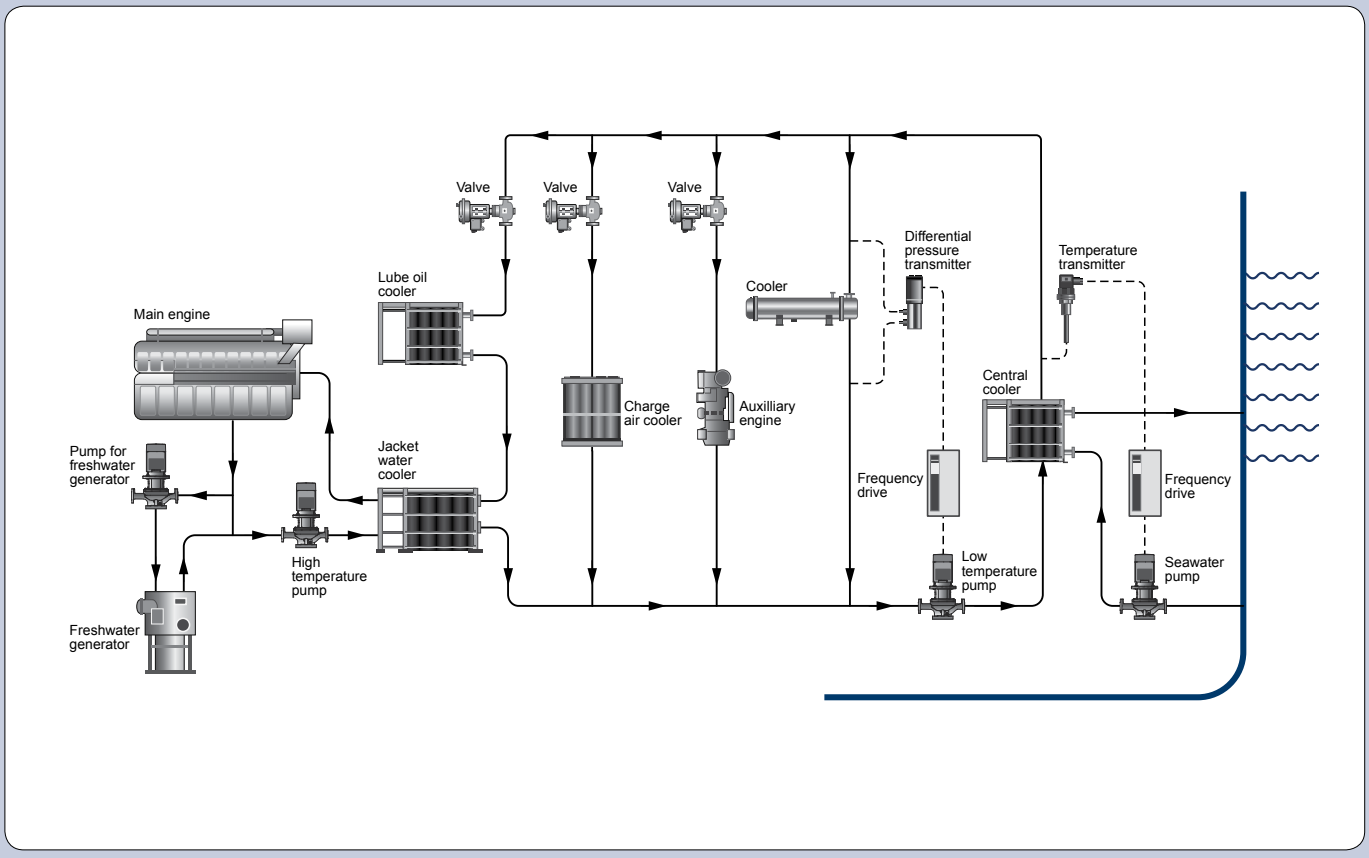
CASE 1: 4700 TEU VESSEL

The principle for the pump control:

Seawater pumps will be controlled so that the freshwater temperature is maintained at 36 °C.

On the freshwater side, the water flow to the main engine and the auxiliary engines is controlled by on/off valves, while the flow to the lube oil cooler is controlled by a control valve. With this equipment installed in the system, the freshwater pumps will be controlled to maintain a constant pressure in the system. The flow in the system is based on requirements and the power consumption is significantly reduced.

Below is a principle diagram of the Grundfos optimised system layout:



OPTIMISED ENGINE COOLING IN A 17000 DWT VESSEL

On these pages, we calculate the potential energy and costs savings with a Grundfos-optimised engine cooling system aboard a 17000 dwt vessel. The vessel's main engine is MAN 6S50MC6.

STANDARD SYSTEM VS. GRUNDFOS OPTIMISED SYSTEM

The standard engine cooling system consists of both a sea water cooling cycle and two fresh water cooling cycles. Each cycle has two pumps, one duty and one standby. The pumps in this system operate continuously at 100% load and the temperature of the cooling water in each freshwater cycle is controlled by the two 3- way valves.

In the Grundfos optimised system the cooling pumps are controlled by frequency drives and additional valves and instruments are installed. Furthermore the operating profile are divided into two, seagoing and harboring: When the vessels are seagoing the main engine, one auxiliary engine, the atmospheric condenser and the air conditioning units is cooled. When harbouring the major consumers will be two auxiliary engines and the air-conditioning units.

The standard system is designed to ensure sufficient cooling of the engine at sea water temperatures of 32 °C. The Grundfos optimised system fulfils requirements for 32 °C and 100% load but is optimised to control and maintain a constant cooling temperature of the engine according with the water temperature. For example if the water temperature drops to 20 °C, the Grundfos optimised system only uses half the energy compared to full capacity at 32 °C. The sea water temperatures are often lower than 32 °C, which means the cooling system needs only half as much water flow. By controlling the operation with a frequency converter according to your needs, you can save both energy and costs.

The calculation is based on the assumptions that:

THE FUEL PRICES ARE:

Heavy Fuel Oil:	$630/ton – $0.135/kWh
Low Sulphur:	$950/ton – $0.205/kWh

The specific fuel consumption on typical aux. engine is 215 g/kWh.

The annual operating hours are 6,000, divided between sea going (5,000 hours) and harboring (1,000 hours).

The principle for the pump control:

Seawater pumps will be controlled so that the freshwater temperature is maintained at 36 °C. On the freshwater side the water flow to the main engine and the auxiliary engines will be controlled by on/of valves, the flow to the atmospheric condenser will be controlled by a self-regulating valve and the flow to the air conditioning units will be adjusted by frequency drives for the booster. With this equipment installed in the system the freshwater pumps will controlled to maintain a constant pressure in the system. The flow in the system is based on requirements and the power consumption is significantly reduced.

CASE 2: 17000 DWT VESSEL

POTENTIAL SAVINGS

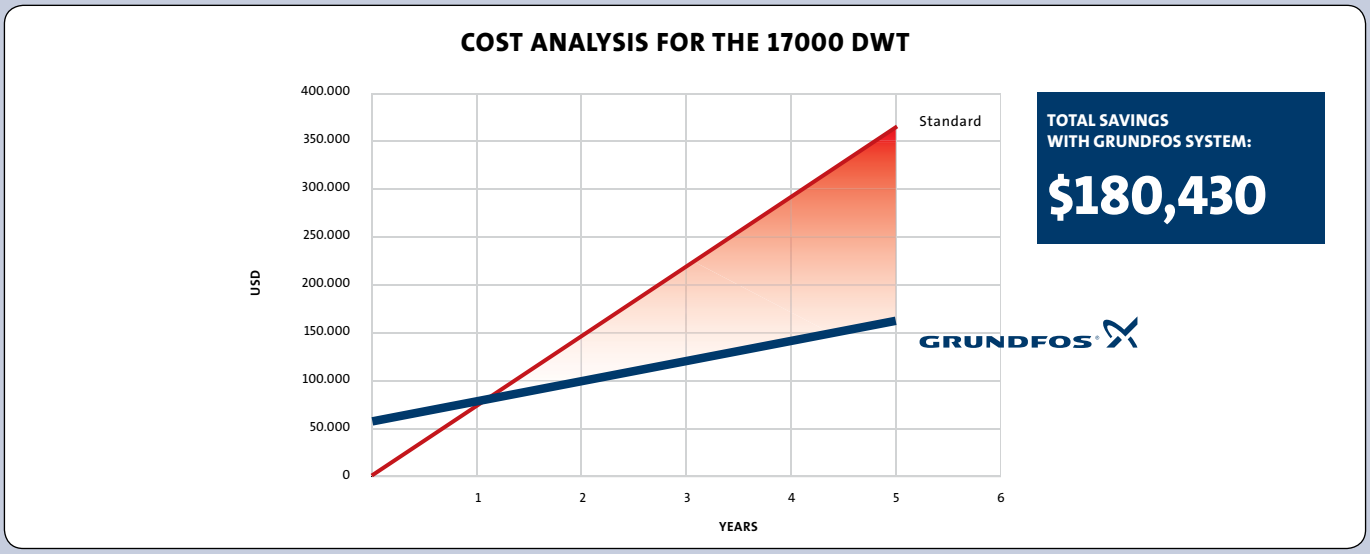
	Standard system		GRUNDFOS			
			Seagoing		**Harboring**	
Operation coasts	**Specifications**	**Total**	**Specifications**	**Total**	**Specifications**	**Total**
Sea water pumps	2x230 m³/h x 20 mWc – power consumption 17.2 kW. Power consumption: 6,000 hours/year: 2 x 17.2 kW x 6,000 hours/year =	206,400 kWh	Required flow: 200 m³/h Power consumption at 200 m³/h: 10 kW: 5,000 hours/year x 10 kW =	50,000 kWh	Required flow: 15 m³/h Power consumption at 15 m³/h: 2 kW: 1000 hours/year x 2 kW =	2,000 kWh
Freshwater pumps	3x230 m³/h x 25 mWc – power consumption 22.0 k. Power consumption: 2 x 22 kW x 6,000 hours/year=	264,000 kWh	Required flow: 310 m³/h Power consumption at 310 m³/h: 16 kW: 5,000 hours/year x 16 kW =	80,000 kWh	Required flow: 150 m³/h Power consumption at 150 m³/h: 4.5 kW: 1000 hours/year x 4.5 kW =	4,500 kWh
Booster pumps	2x30 m³/h x 20 mWc –power consumption 4.8 kW. Power consumption: 4.8 kW x 6,000 hours/year =	28,800 kWh	Required flow: 15 m³/h Power consumption at 15 m³/h: 1.5 kW: 5,000 hours/year x 1.5 kW =	7,500 kWh	Required flow: 15 m³/h Power consumption at 15 m³/h: 1.5 kW: 1000 hours/year x 1.5 kW =	1,500 kWh
Total cost per year		**499,200 kWh**				**145,500 kWh**
Annual cost	Seagoing: (5,000/6,000) x 499,200 x $0.135 =	$56,160	137,500 x $0.135 =	$18,563	8,000 kWh x $0.205=	$1,640
	Harboring: (1,000/6,000) x 499,200 x $0.205 =	$17,056				
Total per year		**$73,216**				**$20,203**

Annual Potential savings with Grundfos optimized systems

Cost savings	$73,216 - $20,203 = **$53,013**
Energy savings	(499,200-145,500)/499,200 x 100 = **71%**

COST ANALYSIS

This graph illustrates the cost savings achieved by this system optimisation. Over five years, the standard system will cost $336,080, whereas the Grundfos system will cost $155,650. A total saving of $180,430.



BE › THINK › INNOVATE ›

Being responsible is our foundation
Thinking ahead makes it possible
Innovation is the essence

GRUNDFOS HOLDING A/S
Poul Due Jensens Vej 7
DK-8850 Bjerringbro
Tel: +45 87 50 14 00

www.grundfos.com

The name Grundfos, the Grundfos logo, and the payoff Be–Think–Innovate are registrated trademarks owned by Grundfos Management A/S or Grundfos A/S, Denmark. All rights reserved worldwide.

GRUNDFOS®