Manual:

Fuel Saving Techniques and Strategies

Final Report of the Weserfaehre within the I-Transfer Project

Weserfaehre GmbH

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European Union The European Regional Development Fund

The Interreg IVB North Sea Region Programme

Investing in the future by working together for a sustainable and competitive region

iTransfer

sustainable ferry travel

Weserfähre GmbH Bremerhaven

This Project was developed within the I-Transfer Program for sustainable ferry design, which is part of the Interreg IV B North Sea Reagion Program.

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1. Introduction

Based on the continuously rising gas oil prices and the implicitness of our ecological responsibility, the reduction of fuel consumption seems to be the logical consequence. Therefore, we - Team Weserfaehre - decided to participate in an EU-Project for a modern and sustainable ferry, designed especially for the North Sea region. This manual is dedicated to all parties and suppliers interested. It explains the planning and implementation, but also the problems we had during the realization of this project.

2. General Information

2.1 I-Transfer Project:

The I-Transfer Project is part of the European Interreg IV North Sea Region Projects and stands for „Innovative TRANSport solutions for Fjords Estuaries and Rivers". The Project has a total budget of approx. 2 Mio. €. The subsidization is based on 50 percent co-financing by the partners. The project started mid 2010 and will last 48 months. Lead partner is the "Institute of Sustainability" in London. The defined goal of the project is the improvement of economical and ecological efficiency and the sustainability of sea going conveyance around the North Sea region. The Weserfaehre was a official partner of the project until September 2013.

2.2 Weserfähre:

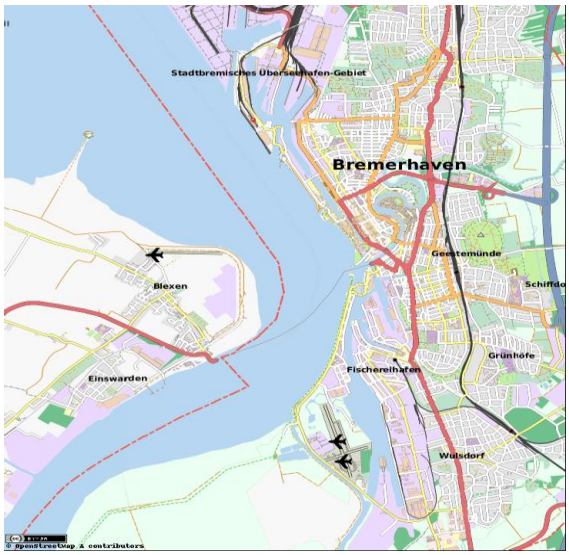


Fig.1: map of Bremerhaven Nordenham

The Weserfaehre serves the 2,8 km long route between Bremerhaven (GE) and Nordenham (GE) over the river "Weser", continuous since 1911. The Weserfaehre GmbH is part of the municipal transport service of the city Bremerhaven. The company is state subsidized. One part, by the city Nordenham and two parts by Bremerhaven. The ferry line is part of the federal road Nr. 212.

After the opening of the Wesertunnel in 2004 the carryings, especially cars and lorries, decreased dramatically, however, the numbers are recovering slowly, scince the detour becomes less cost- efficient- due to rising fuel costs. During the last years we transportet about 10000 lorries and 500.000 pedestrians yearly.

On weekdays, from 05:00 am to 10:00 am, the ferry Bremerhaven serves the route in a 30 minute tact. Between 10:00 am and 6:00 pm the ferry Nordenham is also in service.

During this period both ferries sail in a 40 minute tact, so the maximum waiting time on each side is no longer than 20 minutes. During normal duty we have one helmsmen and one cashier on each of the vessels. Weekdays we also have 2 motormen working on the vessels, who accomplish the maintenance work. The engine works automatically and watch free.

At the moment we to have two double end ferries in duty. Both ferries are driven by a two "Voith Schneider Propeller" one at each end the vessel.

Fig.2: Ferry Bremerhaven

Bremerhaven: was built in 1998, Length over all: 59 meters, beam: 13,4 meters, draught 2,9 meters, the vessel was equipped with two Typ 8 V 4000 M 60 engines, until spring 2013. Due to the upcoming regulations concerning green house gas emissions the next generation of engine type was installed, in May 2013.

The maximum capacity of the ferry is 300 persons and a maximum of 35 cars. The vessel is also approved as a firefighting support vessel and registered for transportation of dangerous goods.

Nordenham: built in 1957 and overhauled in 1998 Length over all: 56 meters, beam:12,7 meters, draught: 3 meters, two Type 12 V 2000 M 60 MTU engines.
The Nordenham can carry as many passengers as her sister, but less cars and no DG lorries.

Fig.3: Ferry Nordenham

3. Project Implementation

The main target of the Weserfaehre GmbH, concerning the I-Transfer Project, was and is the reduction of fuel consumption, by training and sensitization of our crew members and also increasing effectiveness during our daily work. This concern was accomplished by installing a flow-meter on each of the engines, combined with a digital gauge on the bridge.

Hence the helmsmen can read the current and daily fuel consumption and relatethis data directly to their maneuvers. We also have the opportunity to analyze the data.
Besides that, we adapted the propeller pitch, in order to gain more efficiency.
The Training we initiated is based on a simulator, which was actually designed for the ferry “Bremerhaven” and a study lesson, concerning the technical and physical basics of the motor and propeller.

3.1 Pilot Investments

3.1.1 Flowmeter

The company “Kral” provides a great amount of different flow meters. After consulting the motor company “MTU”, which provides the common rail Type 8V 4000M60 engines, we decided to use a Type OMG32 flowmeter for the intake and a Type OMG 20 flowmeter for the outtake of the engine. Relevant for this choice was the maximum flowrate and resistance at the mountings and also the long term reliability. The data of each flowmeter is scrambled in a Type BEM 500 evaluation unit. The backflow is subtracted from the inflow, so the actual fuel consumption is sent to the BEM 500 on the bridge, where the data of both engines is summed up.

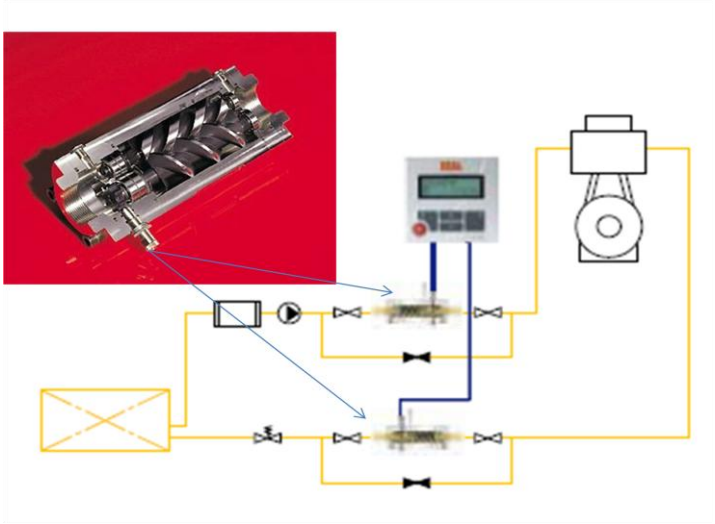


Fig.4: Scheme of flow meter installation

For safety reasons we installed a by-pass solenoid valve on the in- and outtake of the engine. The valves are controlled from the bridge. The installation of the flowmeters was carried out by “Profimess”. They also provide the software for the data-logger, which is also located on the bridge.

3.1.2 Data logger and digital gauge

The data logger is located on the Bridge and can be exported via a notebook with a specially developed software. Since the measuring of the fuel consumption happens in real time, the data recording can be adjusted according to the requirements. When the software was installed the technical department decided to use a 10 minute frequence, in order to balance the loggers storage capability and reasonably analyzable data.

The digital gauge is located at the bridge panel. The simple scroll menu is operated with 4 buttons. So the helmsmen are able to switch between the real time-, but also hourly and daily rate of fuel consumption.

Fig.5: Digital gauge at the bridge (light grey box)

Fig.6: flow meter installation (blue tubes)

3.1.3. Maintenance of installed components

The installed hardware, such as flow- meter, pipes and hoses are subject of the conventional maintenance plan for the engine and require no special treatment.
The data from the logger are downloaded fortnightly, while the gauge is maintained and set to the default value, by our engineers, regularly. The safety by-pass valves are checked every day.

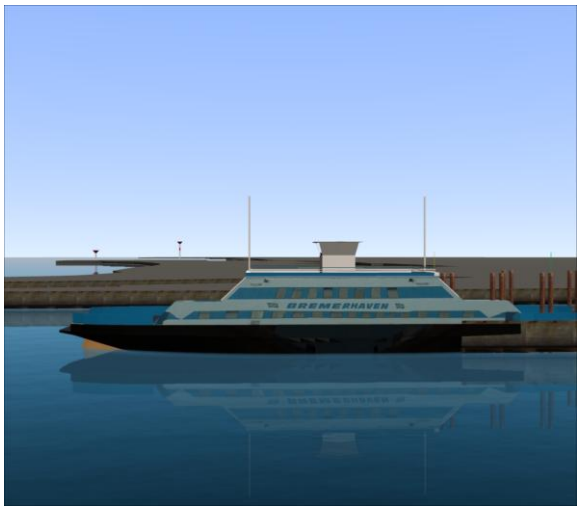
3.2 Simulator

The Simulator, which was developed by Voith Turbo (DE), is based on the Simflex Navigator System, developed by Force Technology. The software and hardware are based on an already existing simulators for tug boats. The hardware is usually located in Heidenheim (DE), but can be transported. It exits of several computers, monitors and a console, which can be used for several types of ship, but was modified to fit our specific conditions. Several data-aspects, such as engine rounds, speed, propeller pitch and the fuel consumption are displayed at a separate monitor while driving.

Fig.7: helmsmen at the simulator

The simulation is recorded, which makes it possible to create training videos, but also to analyze the relevant data during training sessions.

In order to program the simulator, Voith Turbo took a diversity of data from board and also relevant data from the estuary, such as tides and currents.
These were mainly provided by the "Water and Shipping Directorate" and "bremenports", the local port operator.



The data collection on board was focused on the dimensions of the ship and the estuary, but also the speed, chosen route, duration of sailing and the current loads of the engine.

Fig.7: graphics from simulator (ferry Bremerhaven)

However the graphics of the landscape and surroundings were minimized, Voith did a great effort, to implicate important nautical orientation marks, referred to nautical charts and the advices of our helmsmen.
In addition to this Final Report we also present a short video that shows the simulator.

3.3 Training

The simulator training and the associated study lesson, was carried out by an experienced navigational officer, sent by Voith. The lesson is focused on the technical and physical characteristics of the propeller. By different animations and models the helmsmen were trained in the cohesion between speed, water displacement, efficiency of the propeller and fuel consumption.
The study lesson included a general information manual, and also a specific presentation concerning the characteristics of a two- end ferry.

The training at the simulator itself was divided into an independent training of the helmsmen and a variety of modulated training sections. The animation on a separate screen allowed the helmsmen to see the corresponding fuel consumption according to the maneuvers. The training took one day and was carried out at the University of Applied Science in Bremerhaven. The simulator is now back at the Voith Headquarters, but still useable for the crew.

Fig.8: control display picturing fuel cons, pitch, speed etc.

4. Influencing Factors on Fuel Saving Efficiency

The following passage is based on the analysis Voith made and was recorded in the " Weserfaehre Report", which describes the detailed implementation of the simulator program.

" The analysis […] shows, that there is quite some variation regarding tracks and speed of the ferries crossing the river Weser. Obviously there are many reasons for the deviations. Some of them are inevitable, e.g. schedule of operation or traffic, whereas others might be due changing weather conditions. And finally some fractions of the deviation show just more or less efficient ways to cross the river within the given limits.

All options that might be benefical for fuel efficiency need to be checked for their influence on the safety and quality of service.

In the following paragraphs the different options that have been considered to improve fuel efficiency are presented. Although many of these issues are common knowledge and described in many textbooks, it has been found that it is beneficial to repeat them." [Weserfaehre Report]

4.1 Traveling Speed

"Resistance of the Weserfaehre was found to increase roughly by the power of three by increasing speed, which is typical value- This means, that an increase of speed through water from 8kn to 10 kn almost doubles the necessary thrust. Whenever possible the speed should be chosen, such that there is just enough time for unloading and loading at the berth." [Weserfaehre Report]

4.2 Pitch and RPM

"For any controllable pitch (CP) propeller it is clear, that within certain limits and for a given ship speed several combinations of pitch and rpm lead to the same thrust. Unlike other CP propellers the pitch of the Voith Schneider Propeller is very fast adjustable in two dimensions and this is used to control the magnitude and direction with VSPs. However this flexibility comes with great responsibility for fuel efficiency since the efficiency grade of the engine and the propeller is heavily influenced by the choice pitch and rpm.

As a rule of thumb, which is easy to follow during ship handling, the efficiency grade of both engine and VSP increases with lower rpm and higher pitch as overload conditions are avoided. If in exceptional situations, e.g. severe weather conditions, a better responsiveness is needed, this can be achieved by increasing the rpm.

The Weserfaehre has four different rpm settings 750, 1100, 1400 and 1800, where 750 is used as idle setting only. It was found, that in most situations after unberthing with 1100 rpm the pitch should be increased with moderate speed to full ahead on bouth propellers. And then as the speed increases rpm can be increased in steps to 1400 or 1800 until the desired traveling speed is reached." [Weserfaehre Report]

4.3 Additional Factors on Fuel Saving Efficiency

Regarding to their analysis Voith also made additional suggestions, in order to gain more Fuel efficiency:

- Turn of engines during loading and unloading
- auto pilot setting
- different speed pitch fore and aft
- steering in wind and current: drift angle vs. strict heading
- Better coordination with Weser Traffic to avoid encounters and give way manoeuvers.

5. Realization of additional fuel saving Measures at the Weserfaehre

Since the awareness of the technological relations and the influence through manoeuvering to the fuel saving potential, was presented to our helmsmen during the training program, the Weserfaehre, in cooperation with Voith Turbo and MTU, verified the feasibility of the additional provisions.

5.1 Adjustment of Propeller Pitch

In February 2012 the technical department of the Weserfaehre asked the motor company MTU for opportunities to reduce the rpm for every single speed setting, in order to keep the same thrust of the propeller into the water, while setting back the propeller pitch to 100 %. As the moment of torque at the shaft will increase under these circumstances, MTU made the necessary calculations. In September 2012 the readjustments took place.

5.2 Turning of engines during berth

However, during berth, the ferries are locked in place by the lifting bridge, so we refrained from turning off both engines, due to safety issues. Especially on the Nordenham berth the current develops up to 8 kn flow velocity. It is not possible to tie the ferry during the short berthing periods, so our helmsmen are advised to use the aft propeller to stabilize the vessel, depending on the conditions.

5.3 Auto pilot setting

The installed system at the Weserfaehre is *no* GPS supported Auto- Piloting- System. It is controlled by the compass and will control and adjust the triggered course. During the Training Program and our Interviews with the helmsmen some of them declared to make significant use of this tool. In the case that the Auto Piloting System is not repeatedly readjusted by the helmsmen, it has the effect of a zigzag route and increases the distance over the river.
In order to change certain behavior, we specifically pointed this aspect out, during our captains meeting.

5.4 Better communication to Wesertraffic

Wesertraffic is the local authority coordinating the harbour traffic, the locking of ships, but also smaller boat traffic along the river. Important for the business of the Weserfaehre is the so called "Doppelschleuse", a twin lock, at Bremerhaven site. These locks are used by greater ships, but also sport boats. Especially during spring and summer several vessels cross the route of the ferry. During the last years we increased our efforts even more, to communicate with the lock-control, to avoid waiting periods. Therefore river crossings at high speed could be reduced to a minimum.

5.5 Optimizing Loading Processes

During certain periods of the day, for example in the early morning and later afternoon, the ferry is highly frequented by commuters. But also during summertime, or special events we have to load the vessels to maximum capacity. As we regularly have only one cashier on board we continuously try to optimize the loading process and efficiency. Within the last 10 years the Weserfaehre GmbH installed a diversity of payment alternatives, but finally stuck with the common hand to hand method. Although it takes more time, this model proved best. For that reason our helmsmen are further advised to support the cashier during the loading.

During the interviews we conducted with the staff, but also during the captains and crew meetings, we discussed strategies to load and unload cars and lorries even faster, but also how to increase safety for pedestrians and avoid accidents.

6. Crew Interview and Captains Meeting

When starting the Project in 2011 the management of the Weserfaehre GmbH decided to incorporate the staff into the development of fuel saving strategies, to complement the technical installations and training toolkit. Therefore we initiated a frequent dialogue especially with the helmsmen, regarding the project, but also recommendations and achievements.

6.1 Questionnaire

Is October 2011 we submitted a questionnaire to the helmsmen, which was divided in 4 parts:

- nautical issues
- technical issues
- micromanagement
- training

The questions within the separate parts aimed mainly for suggestions at behalf of the helmsmen. But we also asked for favorite routes, problems with traffic, the influence of the tide and current to the steering and if the technical installation, such as the digital gauge, influenced their manoeuvering behavior. Many of the recommendations, like the readjustment of the engine, a new radar system with GPS, or the improved communication to "Wesertraffic" have already been accomplished. Some will be part of upcoming projects.
Almost all of our helmsmen approved that the technical assistance and simulator training developed their awareness of the fuel consumption.
Parts of the outcome of the questionnaire were offered to Voith, in order to improve the training program.

6.2 Captains Meeting

In March 2013 we initiated a captains meeting to discuss the project outcomes, such as our overall fuel savings during the last three years, but also outstanding issues. Since the assistance for the project, will end in September 2013, main topic was the management of the project in the future. We all agreed, that especially for new crewmembers, the Training Program should be part of an additional education. Also the communications of any further outcomes to partners and interested parties should be guaranteed. The captains meetings will be proceeded on a routined base.

6.3 Psychological Training

As a consequence of the conflict with the working council (see 7.1) we established a psychological training in order to regain the harmony within the company, resolve the misunderstandings and explain the necessity of our fuel saving strategy. The Training lasted one day and was presented by a psychologist specialized in company needs. The feedback from this training unit was overall positive and a great achievement.

7. Issues during the Implementation of the Project

During the project we had several issues that had to been solved. All technical problems could be fixed during the first month of the project.

7.1 Conflict with working council

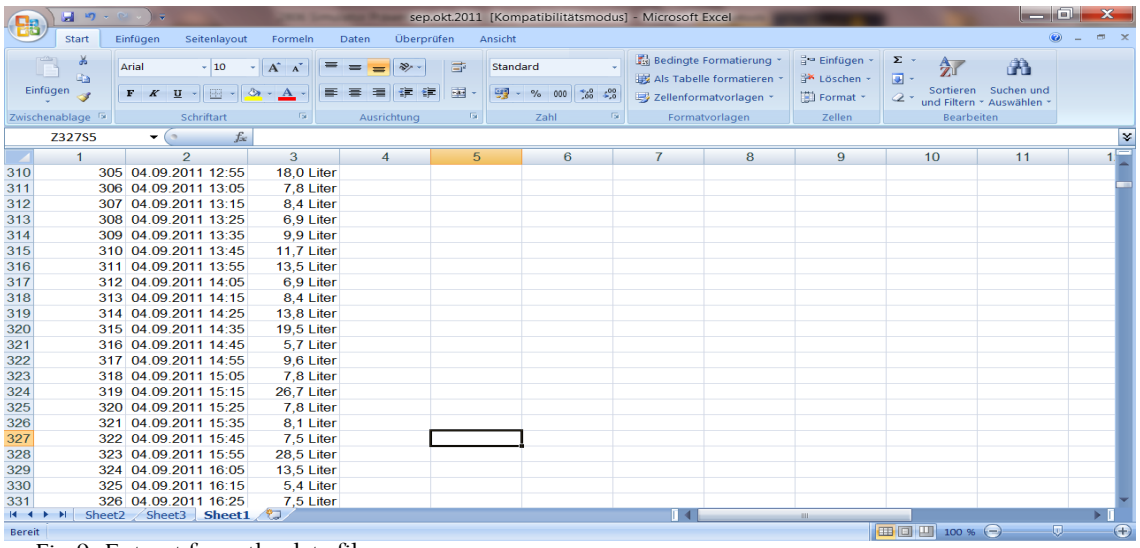
Due to the veto of the working council, we were not allowed to save data. The council was afraid that the data and the following arrangements, such as extra training, or reward could disrupt the “peace” within the crew. Since data saving and its evaluation seemed to be one of the crucial aspects of the project, the management decided to consult a lawyer on the problem. In October 2010 the affair was settled by an arbitration board. As a result we are allowed to plot the data, but under the constrained, that no personal data is saved and all data is compressed after a certain time.

7.2 Software Database

Since we had some problems at the beginning of the measurement, we are still working on optimizing the software. The data collection and compression is time intensive. Our former partner was not able to generate a functional database, yet. Within the next months we are looking forward to Voith creating such a program.

8. Outcomes in Fuel Saving over the Period of 2011 to 2013

During the last two years, since the fuel measuring equipment was installed and adjusted, we permanently plotted the data. The signal frequently was adjusted to 10 minutes, in regards to the storage capability of the plotter.



	1	2	3
310	305	04.09.2011 12:55	18,0 Liter
311	306	04.09.2011 13:05	7,8 Liter
312	307	04.09.2011 13:15	8,4 Liter
313	308	04.09.2011 13:25	6,9 Liter
314	309	04.09.2011 13:35	9,9 Liter
315	310	04.09.2011 13:45	11,7 Liter
316	311	04.09.2011 13:55	13,5 Liter
317	312	04.09.2011 14:05	6,9 Liter
318	313	04.09.2011 14:15	8,4 Liter
319	314	04.09.2011 14:25	13,8 Liter
320	315	04.09.2011 14:35	19,5 Liter
321	316	04.09.2011 14:45	5,7 Liter
322	317	04.09.2011 14:55	9,6 Liter
323	318	04.09.2011 15:05	7,8 Liter
324	319	04.09.2011 15:15	26,7 Liter
325	320	04.09.2011 15:25	7,8 Liter
326	321	04.09.2011 15:35	8,1 Liter
327	322	04.09.2011 15:45	7,5 Liter
328	323	04.09.2011 15:55	28,5 Liter
329	324	04.09.2011 16:05	13,5 Liter
330	325	04.09.2011 16:15	5,4 Liter
331	326	04.09.2011 16:25	7,5 Liter

Fig.9: Extract from the data file

Furthermore the data fuel consumption was accumulated per day and divided through the actual minutes of engine running hours under load. In order to easily recognize any deviations we inserted a graphic right next to the daily consumption.

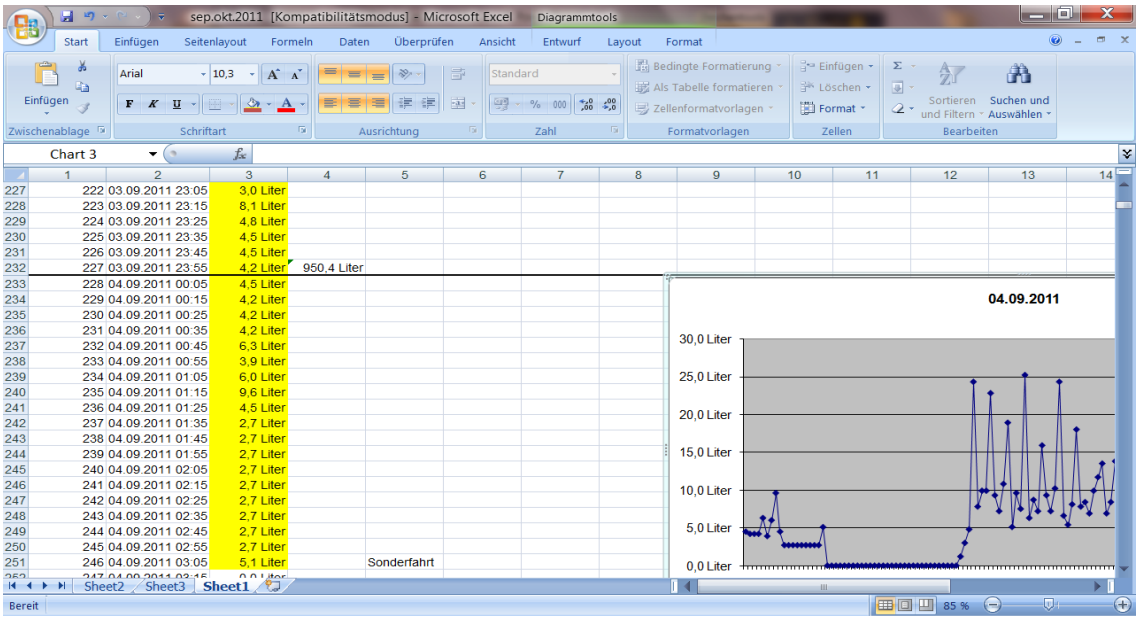


Fig.10: Extract from the data file, including calculations and graphics

Regarding the Conflict with the working council, we were not allowed to use such data. For that reason we expanded the average fuel consumption "Liter per hour", over the period of a week.

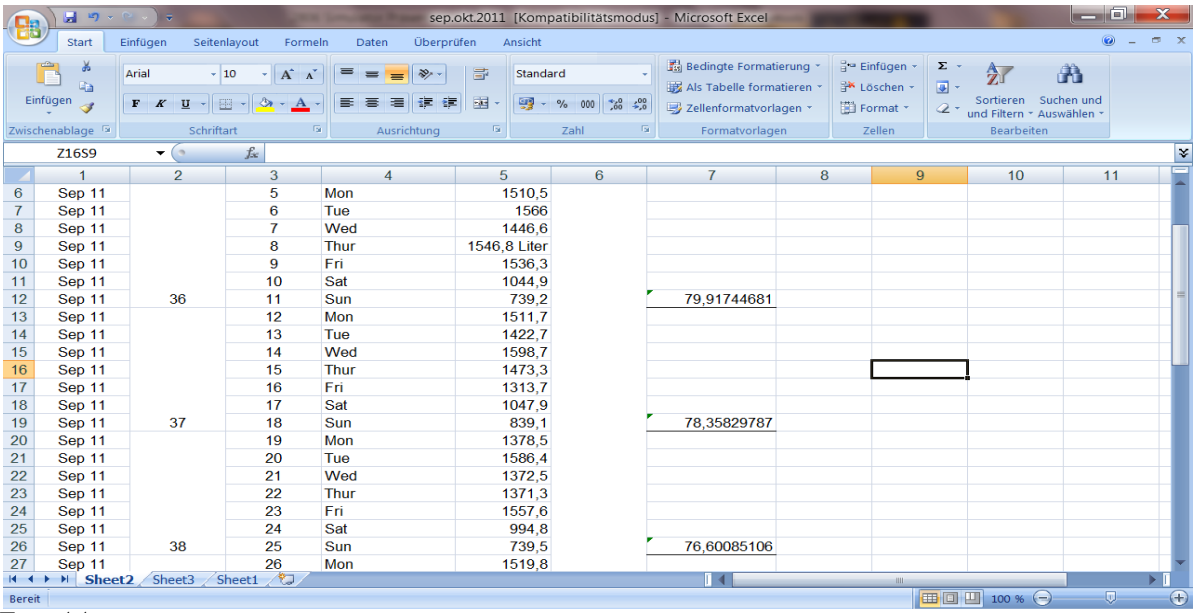


Fig. 11: Extract from the data file, including calculations, weekly average consumption L/h

At those bases we calculated the average fuel consumption of the main engines on the ferry Bremerhaven in L/h.

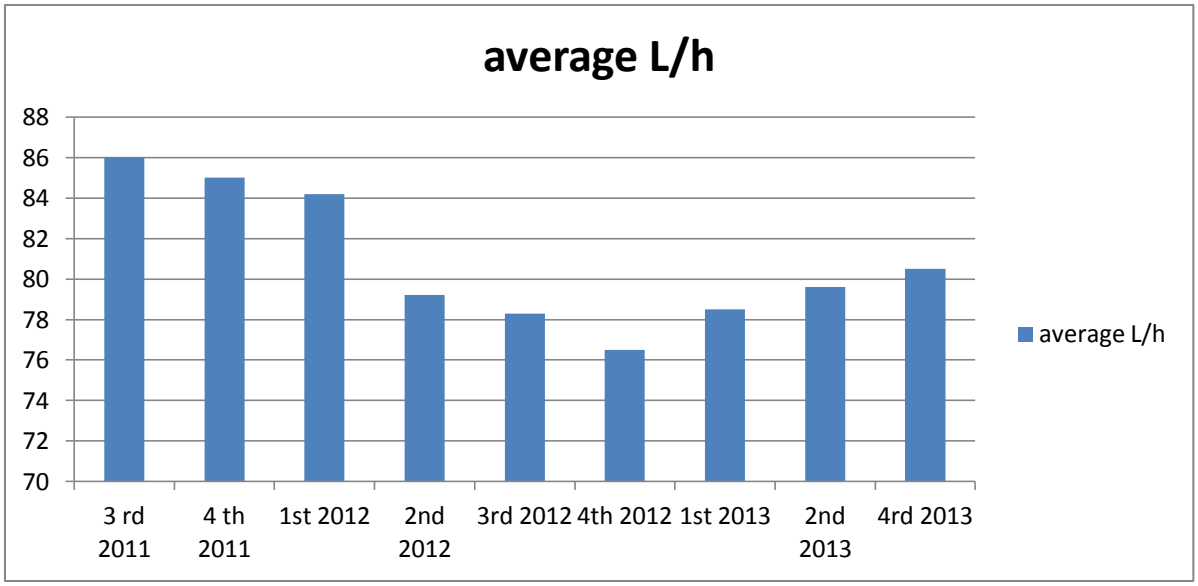


Fig.12: Shows the average fuel consumption of main engines quarterly per year

Before the project started the calculation of the average fuel consumption included the consumption of the main and auxiliary engines, plus the heating unit. Since we were able to differentiate between those figures it was possible to calculate the actual fuel consumption of the main engines for the years 2002 up to now.

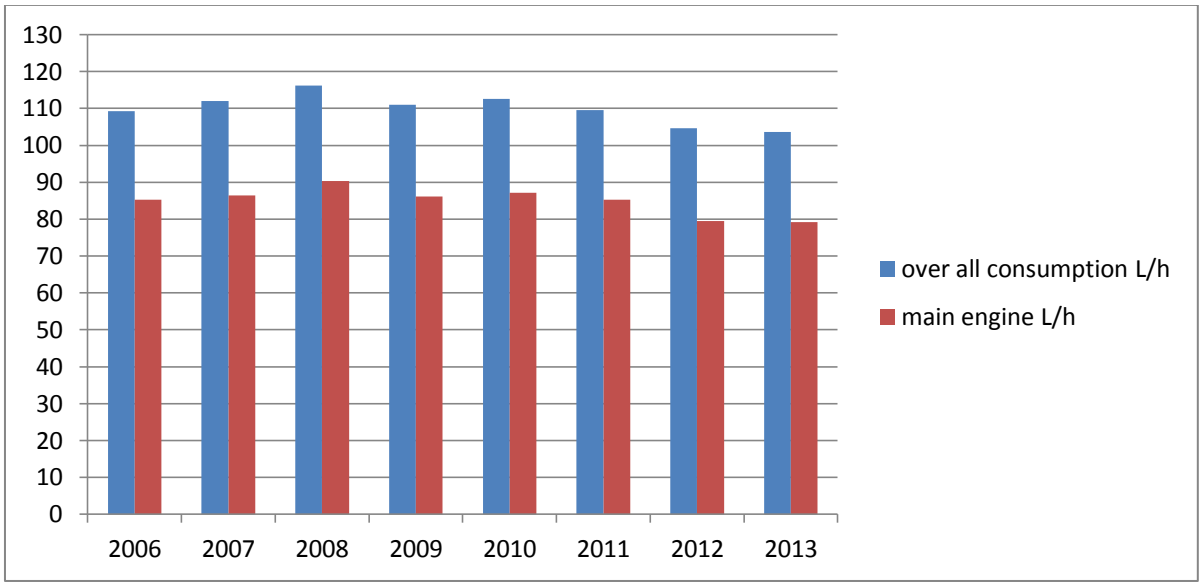


Fig.13: Fuel consumption L/h over the last years over all/ only main engines

The following figure shows the average consumption within the respective years. Resultant, is the fuel saving, since the beginning of the project, to be estimated with *8-10 percent*. Considering deviations during the recording period.

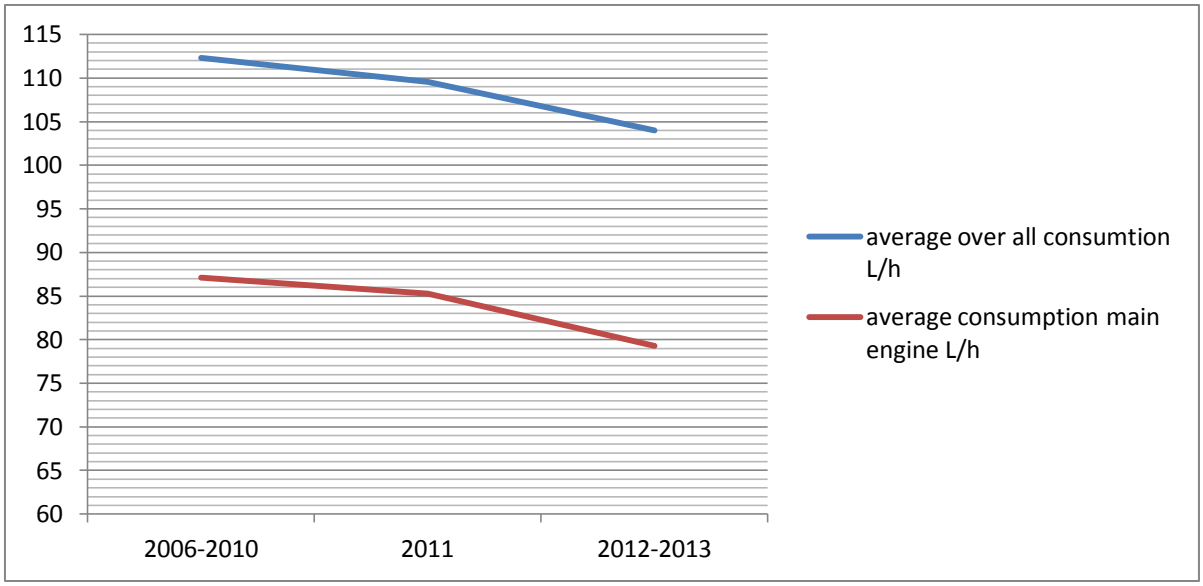


Fig.14: Average consumption: overall and main engine

9. Outcomes in Green house gas emissions savings over the Period of 2011 to 2013

Besides the beneficial economical value of fuel saving the reduction of green house gases is as much as important. Above all, CO^2 is considered one of the significant green house gases, which is responsible for the Global Warming. Especially the fast increase of almost 35 % during the past hundreds of years, is concerning.

Therefore the reduction of CO^2 is one of the major aspects of the I-Transfer Project.

At the Weserfaehre is no CO^2 sensor installed, so we calculated the exhaust gas emission by references to the fuel savings and gas oil lab analyses. The Engines on both ferries are driven by Marine Diesel Oil for inland shipping, which is regulated by the "10. BImSchV", a German regulation, based on the ISO 8217.

To consider the acceleration period, which cannot be determined, but is crucial for the calculation of the emissions, we consulted the University of Bremerhaven. After various considerations we decided to add the multiplication factor of 0,35 to the basis value.

- Total fuel consumption of main engines on ferry Bremerhaven 2011- 2013:

  1522800 Liter

- Ten percent Gas Oil reduction by 8 Percent:

$$1522800 \times 0{,}08 = 121894 \text{ Liter}$$

- by 2,73 kg/Liter Gas Oil

$$121894 \times 2{,}73 = 332580 \text{ kg}$$

- multiply factor for acceleration

$$(332580 \text{ kg} \times 0{,}35) + 332580 \text{ kg} = 448983 \text{ kg}$$

- $448983 \approx 450$ metric ton

9.1 Additional Savings at the ferry "Nordenham"

Surprisingly we also observed a dramatic decrease of fuel consumption on the ferry "Nordenham", which means, that our helmsmen transfer their behavior. In conclusion of several discussions we lead this back to the remarkable efforts made by Voith and their training team. Since we do not have any scientific data from the vessel Nordenham, we assume a fuel saving capacity from the main engines by 5-6 percent. As basis for this presumption we took the bunker record books.

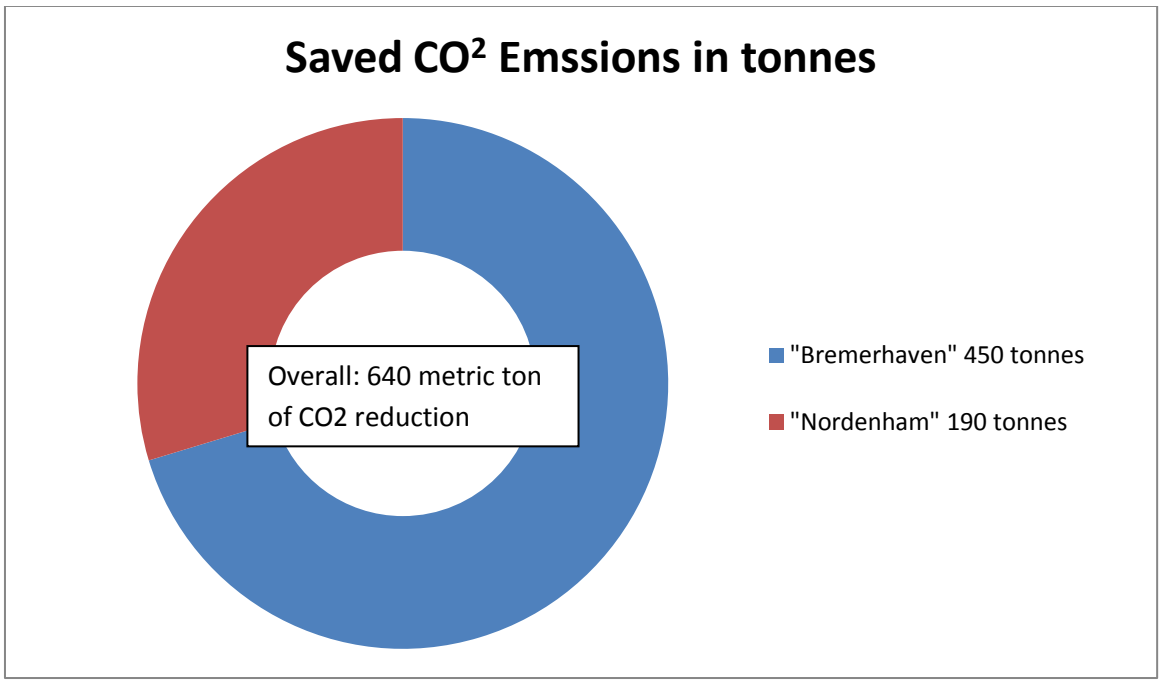


Fig.15: Shows the overall CO^2 emission reduction between 2011 until 2013

10. Communication and Promotion

After participating at the kick off meeting, we were proud to invite the I-Transfer partners to Bremerhaven. The first time we presented a preliminary result of our project to our I-Transfer Partners, was in the “March Report I-Transfer Weserferry” for the partner meeting in Hamburg.

The Weserfaehre GmbH also participated at the partner meetings in Gorinchem, Edinburgh and the final partnership meeting in Bremen, where we could present our "Final Report" and outcomes of the Project not only to the partners, but also to representatives from the EU.

In December 2011 the I-Transfer Project, but also our specific provisions and outcomes were presented to the “Bugsier Reederei”, a German tug boat company. They showed interest, mainly on the hardware, which was installed on the ferry “Bremerhaven”, in order to equip some of their tug boats.
The greatest achievement we made as to PR, was presenting our results to the German Ferry Association, in March 2011.

In cooperation with the managing committee we established a round table to discuss the pros and contras of this pilot investment. Everyone agreed that the training program would be practicable, even for smaller ferry companies.
We also contacted various of our long term partners to present the progress and outcomes of the project, such as Pundsack, MTU and Kral, but also to the students and part of the staff at the University of Bremerhaven, especially to upcoming ship engineers.

11. Conclusion

We would like thank our I-Transfer Partners for good and interesting cooperation. Special Thanks also goes to Voith and MTU, which had a great influence for the success of the Project.

Because of the great achievements in fuel saving the Weserfaehre GmbH was able to graduate the increasing fuel prices and guarantee a consistent, costumer friendly and affordable service.

Besides we are thankful to make a contribution towards an environmentally friendly transportation possibility within the region.

Last but not least, through the extended communication among our staff, we could increase the awareness of suggestions, problems and needful adoptions.

We are looking forward that our achievements, we made during the Project, will reach every interested party and supplier. We hope this Report could give you a clear perspective of the work we have done. Trough this theme is very complex you can contact us, or any of our partners, in order to gain more and detailed information.

12. Table of Contacts

Partner	Address	Contact
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MTU	MTU Friedrichshafen GmbH Försterkamp 9 21149 Hamburg (DE) Fon: +4904079700301	Mr. Damm
Voith Turbo	Voith Turbo Voith Propulsion Alexanderstraße 18 89522 Heidenheim (DE) Fon: +497321372827	Mr. Singer
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