Institute for Sustainability

iTransfer
sustainable ferry travel

Sustainable ferry travel

Innovative ferry design

Koninklijke N.V. Texels Eigen Stoomboot Onderneming

TESO

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

European Regional Development Fund
Investing in your future

Sustainable Ferry Travel

Innovative ferry design

Executive summary

TESO has been operating the ferry service between Den Helder and Texel since 1907. Most of the 3,100 shareholders are Texel residents. TESO's objective has not changed since the company was founded: to provide a quality, affordable ferry service between Texel and the mainland. Any profits made are invested primarily in safety, quality, continuity and sustainability. The designing and building of a new ferry gives the opportunity to use new insights to obtain even more sustainability. TESO hopes that, because of the investigations and the use of these new insights, other ferry operators will be able to benefit from this in their future operation and will be able to carry on the investigations for yet more new options.

The activity undertaken by TESO in iTransfer contributes to the demonstration of innovative, new passenger ferry designs, reduced fuel consumption by ferries, and the delivery of environmental benefits. It addresses the need to demonstrate improved sustainability and increased habitat sensitivity in line with increasing passenger expectations.

The main lesson is that there are a number of exciting new developments in the area of sustainability, 'green' ferry design and operations. It is worth the effort to investigate these to ensure that the new generation of vessels in service will be more environmentally-friendly. Increased efficiency has been part of the design process to reduce exhaust gas emissions and achieve fuel savings, which in turn can lead to cost savings which justify the investment.

The lessons learned have been incorporated in TESO's sustainable new ferry *Texelstroom*. The design of the hull has been optimized to reduce drag and to save fuel. The ferry will be dual fuel, powered by both low-sulphur gas oil and compressed natural gas (CNG). As an integral part of the advanced energy management system for the vessel, more than 700 square meters of solar panels will also be installed, which will charge electric batteries to supplement the other energy sources.

TESO is looking forward to sail with the *Texelstroom* in 2016 and is happy to share its experience with other organizations to progress the introduction of more sustainable ferry vessels and operations across the North Sea Region and more widely.

This report is part of iTransfer, a North Sea Region Interreg programme project, which is funded by the European Regional Development Fund. For more information visit www.itransferproject.eu

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Introduction

iTransfer (Innovative Transport Solutions for Fjords, Estuaries and Rivers) aims to make ferry transport more freely accessible and sustainable, and encourage more people to travel by water. In areas in the North Sea Region (NSR) there are opportunities to replace existing vehicle routes with passenger ferries as a viable alternative. Travelling by ferry is more sustainable, easier and quicker. It can also provide lifeline services to remote communities.

Texels Eigen Stoomboot Onderneming (TESO) is building a new sustainable ferry, the *Texelstroom*, to operate on the route between Den Helder and the island of Texel in the Netherlands from the start of 2016. The project aimed to investigate a number of measures to produce a cutting-edge, energy efficient, sustainable ferry design:

- Save at least a quarter of the energy consumption compared to the *Dokter Wagemaker* which is currently the main ferry in service, by investigating alternatives for the hull design, engines and hotel load;
- Enlarge the vehicle capacity by 10% over the *Dokter Wagemaker* without losing the goal of making the new vessel more sustainable;
- Investigate the use of gas (Liquefied Natural Gas, or LNG, and Compressed Natural Gas, or CNG) as an alternative fuel. Because of the lack of LNG infrastructure in the Netherlands, the use of CNG has been investigated, especially as this seems to be more environmentally-friendly than LNG;
- Investigate the use of solar panels. After investigations through this project, a total of 700 m2 of solar panels will be installed on *Texelstroom,* producing 40% to 50% of the energy used for hotel load on-board;
- Investigate water savings. On the *Dokter Wagemaker* the toilets are already waterless to save drinking water, but all sewage still has to be biological treated. On *Texelstroom* the treated water will be re-used for flushing toilets. TESO expects to save 70% of drinking water in this manner;
- Investigate the use of LED-lights, sensors, day time dimmers, more efficient armatures and locker switches to reduce energy consumption for lighting;
- Look at environmentally-sensitive alternatives for anti-fouling measures for the hull, especially taking account of the fact that TESO is operating in the Waddenzee, an UNESCO world heritage area; Also, investigate the use of ultrasonic sensors at the docking station in the harbour facility of Texel to delay growth underneath the waterline between cleanings;
- Investigate the storage of thermal (hot) water in an insulated tank to reduce the waste of energy. The excess heat in the cooling water will be used for heating purposes and for keeping the engines warm on stand-by during the night when *Texelstroom* is not sailing.

The funding provided by iTransfer has been used to co-finance the project-management and the hiring of external experts to investigate all of the above mentioned measures and to implement them into the design and building of the new ferry, *Texelstroom.*

Texelstroom, design by C-Job Naval Architects and Vripack

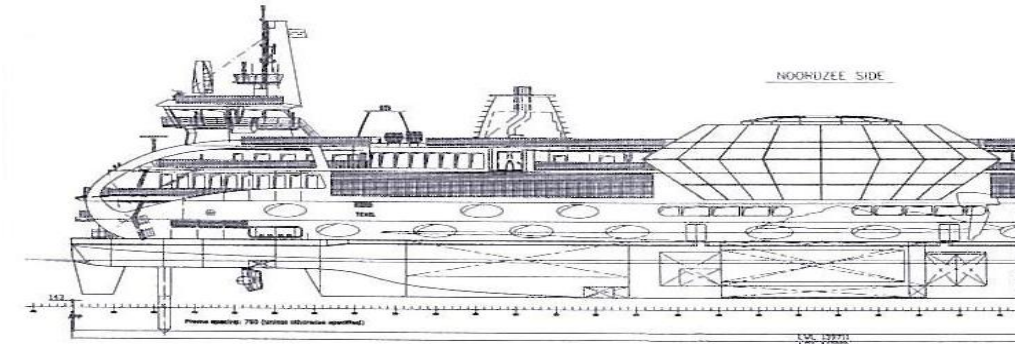
It has also enabled key TESO staff to attend iTransfer meetings and workshops, facilitating exchange of knowledge and ideas in the development and operation of sustainable ferries.

Background/challenge

TESO has been operating the ferry service between Den Helder and Texel since 1907. Most of the 3,100 shareholders are Texel residents. TESO's objective has not changed since the company was founded: to provide a quality, affordable ferry service between Texel and the mainland. Any profits made are invested primarily in safety, quality, continuity and sustainability. For example, in 2007 TESO was the first shipping company worldwide to use the relatively clean GTL (Gas To Liquids) where natural gas is converted into liquid diesel oil. TESO is a company which has great care for the environment. Sustainability is one of the fundamental values and they are always seeking ways to enhance sustainability in transportation.

The designing and building of a new ferry gives the opportunity to use new insights to obtain even more sustainability. Therefore, TESO joined the iTransfer project with the objective of extending the possibilities for testing the feasibility of several sustainable approaches to the design of a new vessel. An important part of this project is the sustainable ideas that emerged from a community engagement exercise used to inform the subsequent vessel design.

In total, more than 600 suggestions for the design and operation of the new vessel were made by crew, operational management, TESO shareholders, other users of the service, students and interested stakeholder organizations.



Reduce lighting power consumption by making more use of daylight

The sustainable ideas have been assessed, reviewed and followed up in three areas of activity:

I. **Power consumption on board:** 30% of power on board is used by the 'hotel load' (i.e. non propulsion) and investigations will explore how this can be reduced, looking at use of solar PV, wind energy, frequency convertors, daylight armatures, led lighting with sensors.

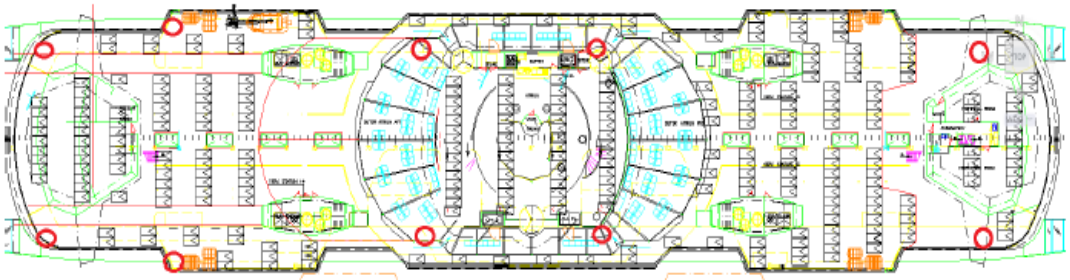


FIGURE 24. POSSIBLE ARRANGEMENT FOR COMBINED PV-PANEL (BLACK LINE SQUARE) AND WT (RED CIRCLE).

II. **Reducing emissions in power generation**: the present vessel is diesel-electric, and the electricity demand is produced by four type 3608 Caterpillar diesels. Each of them has a maximum continuous power output of 2.7 MW on the shaft. The engines normally run in pairs to provide the correct level of power during normal weather conditions (for 80% of services). Three or all four engines are required during heavy storms. The engine operation is rotated to ensure roughly equal service from all engines. Investigations will focus on reduction of fuel consumption and emissions, specifically: alternative fuels (LNG or CNG), use of batteries, propeller efficiency, etc.

The present vessel 'Dokter Wagemaker'

III. **Other environment and sustainable aspects of operations on board the vessel:** e.g. reduction of water use, using recycled and recyclable materials, improved waste management.

This activity builds on the iTransfer work package outputs undertaken by Damen and Doeksen. These partners, and their activity to develop sustainable ferry design to date, have already demonstrated that technological developments in this field can occur rapidly. Innovations and technology available for use in marine design have developed quickly, and market ready sustainable solutions can change quickly.

Project partners will benefit from the additional feasibility and design work, and the dissemination of the latest innovations available in the market. Sustainable solutions and the impact these may have on vessel design can rapidly change, so the project's vessel design work package has benefitted from continued design activity during the project extension as executed by TESO, and the added value that this addition has brought to the project.

Illustrations shown during the design workshop on the 1st of May, 2014

A transnational design workshop on the 1st of May 2014, including a demonstration of the new auto-mooring system, enabled collaboration between partners and also highlighted how the technology market has progressed since the previous design workshop was hosted by Damen for the Doeksen vessel design.

The new Cavotec auto-mooring system

TESO hopes that, because of the investigations and the use of these new insights, other ferry operators will be able to benefit from this in their future operation and will be able to carry on the investigations for yet more new options.

The activity undertaken by TESO in iTransfer contributes to:

- the demonstration of innovative, new passenger ferry designs,
- reduced fuel consumption by ferries,
- the delivery of environmental benefits,
- addressing the need to demonstrate improved sustainability and increased habitat sensitivity in line with increasing passenger expectations.

Activity, method

TESO involved several external experts and national and international research institutes to produce the insights that were needed to come to adequate decisions to be able to fulfil the ambition to produce a cutting-edge, energy efficient, sustainable ferry design. Certain necessities have to be fulfilled while at the same time trying to achieve the project goals:

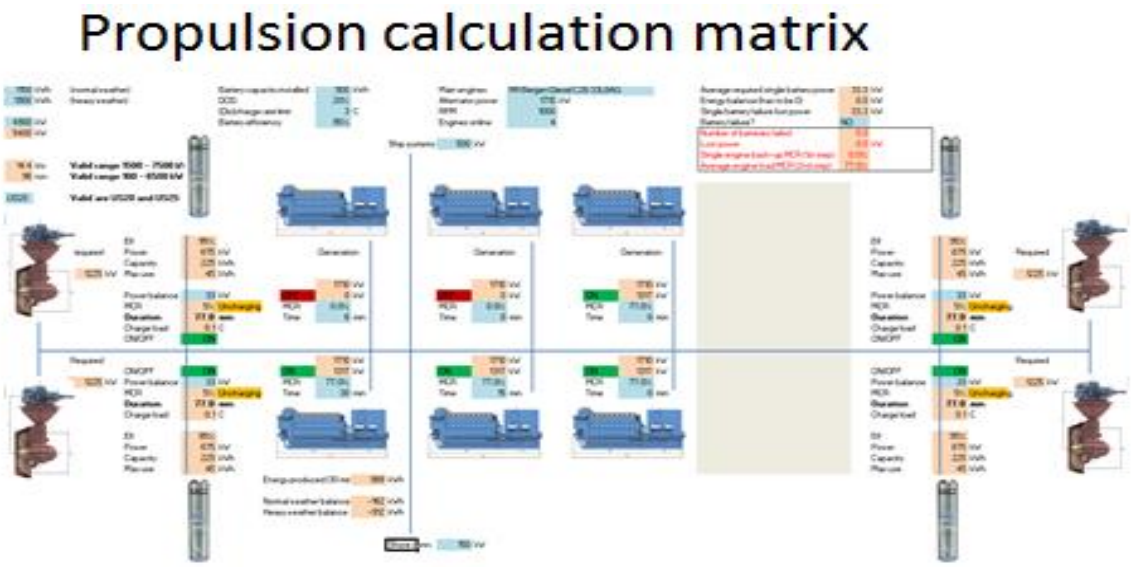
- ✓ The safety and comfort level cannot be compromised
- ✓ Payback period for the equipment installed does not exceed its lifetime

The project approach follows the *trias energetica* model developed by Delft University of Technology which makes it clear that establishing significant energy savings is the first principle. In *trias energetica,* only when a design has first been undertaken to minimise energy loss should the focus shift to renewable energy solutions, such as solar panels or heat exchange and recovery systems. Reducing power consumption on board is applied by installing intelligent sensors for lighting, installing energy saving lamps (the current vessel *Dokter Wagemaker* has 2408 lamps inside the ferry of various types), introducing a more efficient ventilation strategy and the use of heat recovery. The second principle is used to satisfy auxiliary electricity of the vessel by renewable energy sources. TESO made a choice of photovoltaic (PV-panel) panels. From a technical point of view, it is found that only a small portion of the total electricity consumption can be achieved by PV-panels. However, it seems to be worth the effort because the local circumstances promise a satisfying return on investment. Electricity required at night, when the vessel is on stand-by in the port of Texel, can be supplied by the local grid of Texel and thereby lower the use of fossil fuel. Some of this electricity can be stored in the batteries that will be installed in the new vessel. The third principle of *trias energetica* is the efficient conversion of fossil fuels and reducing emissions in power generation. The engine fuel efficiency of the *Dokter Wagemaker* is about 38%, depending on its load. The remaining 62% is heat (it is assumed 50% in cooling water and 50% in exhaust gases). The use of LNG or CNG has been analysed to investigate the possibilities of replacing the current (bio)diesel fuel with a dual-fuel solution, as well as reducing the total fuel consumption through peak shaving by the use of batteries: Ferries

need most power when they sail, accelerating after leaving the dock, sailing and using extra energy when manoeuvring and closing in at the ramp, but significantly less, when they are at the terminal.

The following simulations have been conducted in this project:

- Propulsion calculation matrix developed by naval architect C-Job.



This matrix was used to determine how much generator power is needed combined with the battery capacity during normal sailing. This energy storage system enables TESO to specify smaller generators, as the batteries can be used to provide short power-up and power-down capabilities.

- Computational fluid dynamic (CFD) analyses of wind behavior by Van Oossanen Naval Architects to determine the lateral wind force and to come to adaptions of the design to reduce this force. The outcome of the design change based on this CFD is that the drag coefficient could be reduced by at least 2%.

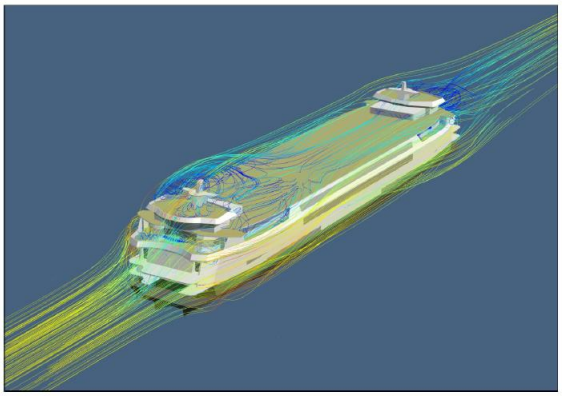
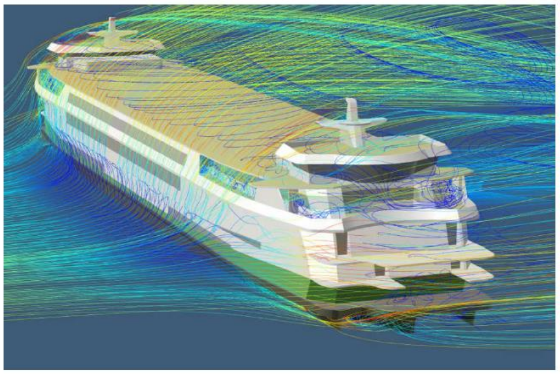
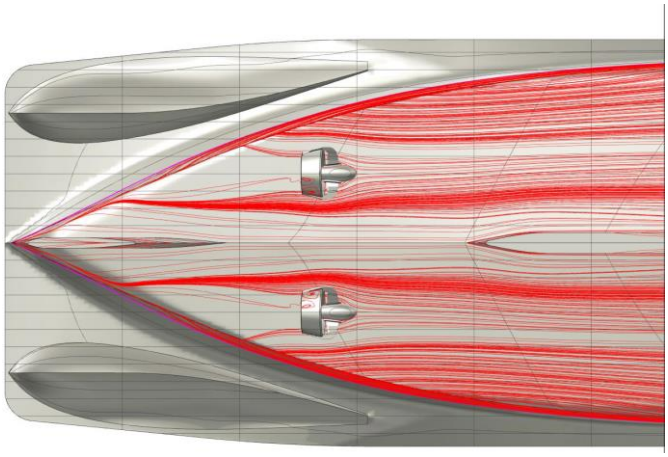


Figure 3.10 Streamlines around the superstructure as seen from starboard aft

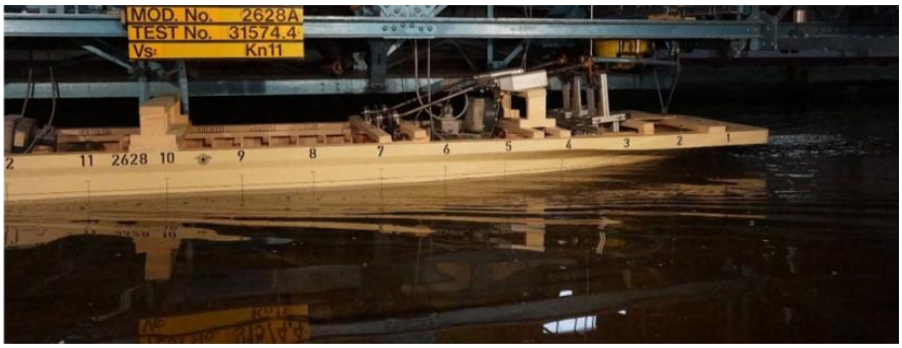


Figuur 3 CFD aanzicht Texelstroom met zijwind

- Computational fluid dynamic (CFD) analyses of hull behavior by Van Oossanen Naval Architects. The hull shape is optimized to lower the water resistance.

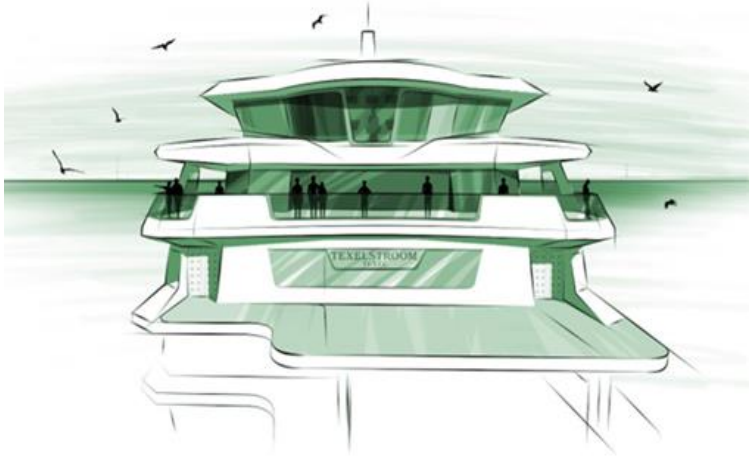


- Model testing by Schiffbautechnische Versuchsanstalt Vienna Model Bassin. This testing was executed to verify the outcome of the CFD analysis. One of the main conclusions was that the outriggers, engineered tot reduce slamming, have a negative effect on the water resistance of the hull.



Results

The design of the hull has been optimised to reduce drag and to save fuel. The ferry will be dual-fuel, powered by both low-sulphur diesel oil and compressed natural gas (CNG). Dual fuel provides TESO with fuel flexibility during operation. Switching between fuels is easy and not technology intensive. This contributes to better emission compliance and this is a technologically proven system. Natural Gas is available as LNG and CNG. LNG and CNG are clean burning fossil fuels which overall, compared to marine diesel fuelled systems of similar propulsion capacity, produce 20% less CO2, 90% less SOx, 80% less NOx and 100% less particulate matter (PM). LNG contains much more energy per m3 compared to CNG. The preference for a dual fuel engine prompted a study into the feasibility of operating on LNG. However supply of the liquid gas could become a complex and costly affair: This has to be taken care of either almost daily by trucks from the LNG distribution harbour in Zeebrugge, or by ship from there. However, such an infrastructure is not yet available. Additionally, there were insufficient guarantees about the security of supply.



An alternative for LNG was found by using a compressor station on shore near the ferry port of Texel with a connection to the Dutch gas network. The gas will be stored in several cylinders on board. These cylinders are divided over two containers. At night, the containers are coupled to the compression station, where all the cylinders are filled to a pressure of 200 bar. The *Texelstroom* can sail almost a whole day with the contents of one container. TESO has opted for two dual fuel engines that can run on CNG and diesel, each delivering 2000 kW. The required volume of gas is based on the gas oil consumption of *Dokter Wagemaker*:

three million litres of gas oil per year. On the basis of an energy value of 36 MJ/litre, this volume is equivalent to 108 million MJ per year. Assuming that 1 kWh equals 3.6 MJ is the annual volume of gas equivalent to 30,000 MWh of natural gas per year.

TESO expects the batteries to have enough capacity to supply the required peak power for acceleration out of the harbour. For 80% of the time it will then be enough to have one generator running.

As an integral part of the advanced energy management system for the vessel, more than 700 square metres of solar panels will also be installed. These will charge electric batteries to supplement the other energy sources. The *Texelstroom* rooftop solar panels will together provide about 150 kilowatt hours (kWh). This is less than 10% of the total battery capacity, but because of this renewable energy source *Texelstroom* might just avoid the need to start a second engine.

With the cooling of the dual fuel engines, *Texelstroom* heats a water tank of 90 cubic meters up to around 85 degrees Celsius. This heated water is used overnight for heating the vessel when this is not sailing, and it is expected that only when the outside temperature drops below 0 degrees, will the boiler be needed to help out.

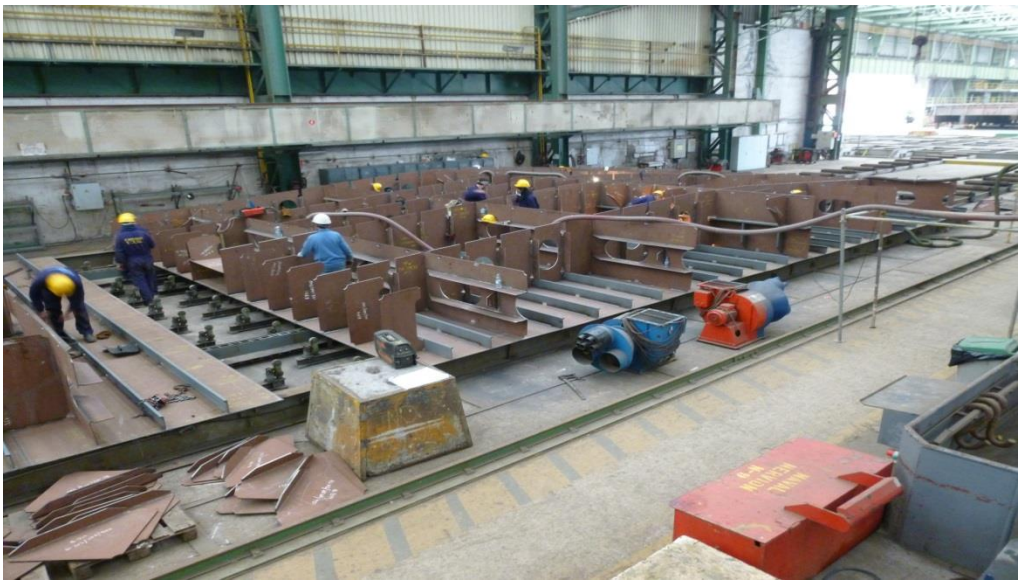
Interior design for the saloon deck of the vessel by Vripack

TESO also expects to save energy with ventilation of the car decks, especially by consciously using the wind the ship creates under its own speed. During summer, the upper part of the doors of the lower car deck will be opened. Even if the car deck doors are closed, the use of the natural air flow will be optimised. The fans will only be switched on when it is necessary because of the air quality or temperature. These fans are reversible, so they can

be adapted to the direction of the highest wind force. That could save 30% of the energy used for the ventilation of the car decks.

A more sustainable design is demonstrably more efficient with fuel/energy savings, which in turn can lead to cost savings which justify the investment. This larger vessel provides space for about 40 additional cars, but the new vessel is no heavier than the vessel *Dokter Wagemaker* and it will be more energy efficient. The new ferry has no atrium on the upper deck, features two smaller chimneys, and the wheel houses were put in a lower position. Through these measures, the stability and wind sensitivity of the Texelstroom is similar to that of the *Dokter Wagemaker*.

The lessons learned have been incorporated in TESO's commissioning of the Spanish shipyard LaNaval to design and build a new, more sustainable ferry, which will accommodate growing traffic between the port of Den Helder and the island of Texel. Increased efficiency has been part of the design process to reduce exhaust emissions and achieve fuel savings.



Building of the new ferry Texelstroom started on the 1st of September, 2014

All full reports that are a result of the studies partly financed through the iTransfer project are available at the TESO office. TESO is an open and forward-thinking company and has learned the benefits of co-operation and knowledge-exchange. TESO is happy to share these ideas and designs with other companies and organisations to progress the introduction of more sustainable ferry vessels and operations across the North Sea Region, and more widely.

Recommendations and conclusions

The main lesson to highlight is that there are a number of exciting new developments in the area of sustainability and 'green' ferry design and operations. It is well worth the effort to investigate these to ensure that the new generation of vessels in service will be more environmentally-friendly. This is a fast-moving sector of the shipping industry and TESO has been able to take forward developments and proposals made by other iTransfer partners.

Future work and wider impacts

Although TESO joined the iTransfer project at a later stage, TESO representatives have found the meetings with other project partners, with their different backgrounds, to have been very useful and interesting. Bert de Jonge, the Project Manager from TESO overseeing the development of the new ferry, presented an in-depth insight into the design process in May 2014 at a transnational workshop for iTransfer partners hosted by TESO on Texel.

By sharing the experience, this sustainable model could be replicated across the region and beyond. On the other hand, TESO has learned from the activities, knowledge and experience of other iTransfer partners: sustainable ferry design through Damen and Doeksen, fuel-efficient operations through Weserfähre and Maid of the Forth, accessible landings through Gravesham and others, more general operations, marketing, etc, through Bremerhaven and their sub-partners.

Comparison of fuel cost per kWh (WP 3.2)

iTransfer is part funded by the North Sea Region programme, part of the EU Inter-regional (Interreg) initiative. Investing in the future by working together for a sustainable and competitive region, Interreg is financed through the European Regional Development Fund (ERDF).