EIBIP

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EU-Wide Strategy for Innovation Uptake in IWT

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EIBIP Secretariat
Address: Vasteland 78; Rotterdam; The Netherlands
Phone: +31 10 78 98 930
Email: info@eibip.eu

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Executive summary

Within the framework of the 'European Inland Barging Innovation Platform (EIBIP)' an EU wide strategy for the uptake of innovation by the Inland Waterway Transport (IWT) sector in the EU is defined in this report. A strategy for the uptake of innovation specific where innovation is hampered by a demonstrated market failure in particular for ship-owners/operators, by identifying and addressing barriers and facilitating market transfer of innovation, covering technological, organisational and financing aspects. A strategy based on input of the Innovation Centres and recent studies by PLATINA-II and PROMINENT and in line with the objectives set by the European Commission on the reduction of energy consumption and air pollutant emissions and to support ongoing policy issues (e.g. CESNI), and the ambition indicators for EIBIP and the ICs, described in the EIBIP Inception report (May 30th, 2016).

This document is a living document. The concepts as well as the priorities of the EU-wide strategy will be reviewed and updated frequently with a minimum of once a year, after consultation of the stakeholders and in particular the EIBIP advisory board.

A necessary and important element for an acceleration in the implementation of the innovation technologies is financial support for the needed investments.

The innovation technologies cover two innovation pillars: 1.) 'Greening the fleet'; and 2.) 'New logistic and vessel concepts'; each with three innovation areas.

1.) *Greening the fleet*:
   a) Alternative fuels;
   b) Energy consumption;
   c) Air pollutant emission reduction;

2.) New logistic and vessel concepts:
   a) New logistic concepts;
   b) New cargo flows;
   c) New vessel concepts.

Six priorities have been identified for the EU-Wide Strategy for Innovation Uptake in IWT:

1. New engine concepts and optimisation for an efficient and green propulsion

1a.- For the smaller vessels with low power sailing performance and/or using a low amount of gasoil per year, low power engines fulfilling NRMM regulations may be used in combination with after treatment or marinised EURO VI truck engines, both direct drive or in a hybrid/ diesel electric configuration;

1b. LNG as a fuel for propulsion is an interesting concept for the inland vessels that use more than 500m^3 of gasoil per year;

1c. Hybrid/ diesel-electric propulsion and full electric sailing may be a promising concept for green and efficient sailing most probably in combination with after treatment for the vessels in-between '1a' and '1b'. Also marinised EURO-VI truck engines may be used to drive the generator.

2. Structural financing formats

Structural financing formats as setting up a sustainability fund at European level need to be explored, to push and accelerate the required investments for innovation of the inland vessels for the reduction of GHG and the environmentally harmful emissions like NO_x and PM produced by the IWT sector.

3. Next generation; low carbon solutions

Low carbon and renewable fuels as bio-fuels (diesel/ methane/ ethanol/ methanol/ etc.) including hydrogen is the next generation fuels for propulsion for inland vessels. The use of these fuels for inland vessels is new and need to be explored including the technical feasibility along with the viability considering the economic, environmental, and socio-economic benefits. In that way, fuel infrastructure and powertrain technologies can be shared and sufficient economies of scale can be achieved.

4. Logistic optimisation of inland waterway transport

Optimisation of inland waterway transport by means of a further utilisation and integration of digital and IT tools, contributing to cost reduction (energy-efficient navigation in combination with route planning and optimal cargo load, auto piloting) and service improvement (track and tracing, information systems on route as well as cargo). This should result in the full integration of IWT in a synchromodal network and a shift of cargo flows to inland waterways.

5. Active promotion of the modal shift towards IWT

Provision of logistic advise to cargo-owners and logistic service providers on the use of IWT in their logistic chains, actively promoting the possibilities of it by means of dissemination materials (handbooks, brochures or online) on the (success stories of the) use of IWT as well as case-to-case advice.

6. Stimulation of the development of new markets

Stimulation of the development of new markets for IWT, new types of cargo flows, new sailing areas. Direct contact with the authorities of countries, regions with under-utilised waterways, active dissemination of best practices of the use of small and urban waterways and involvement of countries with under-utilised waterways in EIBIP. Provision of guidelines and dissemination materials on the development of new markets.

List of abbreviations

AIS	Automatic Identification System
B2G	business-to-government
CEMT	Conférence Européenne des Ministres des Transports (English: European Conference of Ministers of Transport), used as classification of European inland waterways (CEMT Class I–VII)
CESNI	Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure
CH_4	Methane
CO_2	Carbon dioxide
CLINSH	Clean Inland Shipping
CNG	Compressed Natural Gas
Covadem	Collaborative Waterdepth Measurements
EC	European Commission
EIBIP	European Inland Barging Innovation Platform
EN590	European Standard (EN) for ultra-low sulphur diesel
DG MOVE	Directorate-General for Mobility and Transport
DINA	Digital Inland Waterway Area
DMN	Digital Multimodal Nodes
DME	Dimethyl Ether
DPF	Diesel Particulate Filter
DTLF	Digital Transport & Logistics Forum
EGR	Exhaust gas recirculation
ESD	Emergency Shutdown
ESI	Environmental Ship Index
ETA	Estimated time of arrival
FAME	Fatty-acid methyl ester
FWE	Fuel Water Emulsion
GHG	Greenhouse gas(es)
GTL	Gas-To-Liquid
HVO	Hydro-treated Vegetable Oil
ICE	Internal combustion engine
IWT	Inland Waterway Transport
LNG	Liquefied Natural Gas
MECA	Manufacturers of Emission Controls Association
NO_x	Nitrous oxide
PLATINA II	Platform for the Implementation of NAIADES II
PM	Particulate matter
PoR	Port of Rotterdam
PROMINENT	Promoting Innovation in the Inland Waterways Transport Sector
RIS	River Information Services
SCR	Selective Catalytic Reduction
TKI	Top consortium Knowledge and Innovation
Tkm	Tonne-kilometre

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1 Introduction

This strategy report was prepared within the framework of the 'European Inland Barging Innovation Platform (EIBIP)' to promote the uptake of innovation by the Inland Waterway Transport (IWT) sector, specific where innovation is hampered by a demonstrated market failure in particular for ship-owners/operators, by identifying and addressing barriers and facilitating market transfer of innovation, covering technological, organisational and financing aspects.

This report is a deliverable as described in the service contract with DG-MOVE with contract number MOVE/B3/SER/2015-224/S12.720217: "*Elaborate an EU-wide strategy for fostering the uptake of innovation by the inland waterway sector and coordinate contribution of the Innovation Centres participating in the Platform to the implementation of this strategy*".

This strategy will be updated regularly during the course of the EIBIP project, based on input provided by (topic-related) panel discussions and work groups (e.g. financing, technologies).

1.1 Objective

The objective is a strategy for the uptake of innovation by the IWT sector in the EU, based on input of the Innovation Centres and recent studies by PLATINA-II and PROMINENT. The strategy will be in line with the objectives set by the European Commission on the reduction of energy consumption and air pollutant emissions and to support ongoing policy issues (e.g. CESNI).

1.2 Document guide

Chapter 2 describes the approach for assessing the innovation technologies to two innovation pillars each with three innovation areas. A necessary and important element for the implementation of the innovation technologies is financial support for the needed investments. A Sustainability Fund for Inland Shipping is discussed in Chapter 3. The innovation technologies related to the pillar 'Greening the fleet' are described and assessed in Chapter 4, each with their own typical barriers and measures, followed by the innovation technologies related to the pillar 'New logistic and vessel concepts' in Chapter 5. In Chapter 6 'Conclusions' priorities have been identified for the EU-Wide Strategy for Innovation Uptake in IWT that will contribute to achieving these objectives and ambition indicators, described in the EIBIP Inception report (May 30th, 2016).

2 Approach

The innovation actions described in the tender 'Innovation facilitation for inland waterway operations' have been transformed into two Innovation pillars 'Greening the fleet' and 'New logistic and vessel concepts', each with three innovation areas as shown in Table 1.

Table 1: Two Innovation pillars each with three areas

Greening the fleet			***New logistic and vessel concepts***		
Alternative fuels	Energy consumption	Air pollutant emission reduction	New logistic concepts	New cargo flows	New vessel concepts

The innovation technologies of each innovation area are assessed in relation to:

- The barriers why the uptake of innovation is hampered whereas six barrier types were evaluated (used for the assessment in PROMINENT):
  - Technical Barriers caused by immaturity of technology or operational requirements;
  - Legal Barriers caused by regulations and laws;
  - Financial Barriers caused by access to capital or business case;
  - Knowledge Barriers caused by a lack of expertise or skills;
  - Market Barriers caused by market conditions, infrastructure, and the supply chain;
  - Cultural Barriers caused by behavioural routines;
- The measures and instruments to overcome these barriers and to get the innovation technology implemented;
- The actors needed for the uptake of the innovation technology;
- How to demonstrate/ implement the measures and instruments;
- With which projects can be cooperated to demonstrate and implement these measures and instruments;
- What are the actions of EIBIP and the related time frame if this can be provided?

Review and update of the EU-wide strategy

This document is a living document, which means that the description of the concepts as well as the priorities of the EU-wide strategy will be reviewed, more elaborated (as e.g. time frames) and updated at least once a year. This will be done after consultation of stakeholders and in particular the EIBIP advisory board.

3 Sustainability Fund for Inland Shipping

A structural approach is required to push for the reduction of GHG emissions and the environmentally harmful emissions like NO_x and PM produced by the IWT sector. The desired acceleration of innovation of the inland waterway vessels requires a set of measures, of which a financial support instrument for the needed investments is a necessary and important element.

The investment for updating and greening the inland vessels has to date been limited, and this in turn limits all efforts to make the IWT sector more sustainable. For this reason, the financial possibilities are explored as setting up a sustainability fund and/or other forms of financial support at European level.

Three considerations that underlie the proposal to establish a sustainability fund are:

- Structural support for greening the inland vessels;
- Bundling resources for the greening of inland navigation;
- Facilitating the fragmented IWT sector in getting the resources for greening.

Two options for establishing such a sustainability fund are:

- A "narrow" based fund, primarily from public sources. In this option public funds will be made available by local/ national authorities, governments and the EC. Preferably, the fund has a European dimension because of the level playing field. The possibility that neighbouring countries contributes to own ‘Funds’ needs further exploration. The effect should be examined in more detail if neighbouring countries will give own contributions to the sustainability fund;
- A "wide" supported sustainability fund. Besides public sources the sustainability fund may also acquire additional resources from private sources for financing the greening of the IWT sector. In addition to grants, the sustainability fund may provide loans, backed with guarantees. Both private investors and Governments may therefore contribute to the sustainability fund in a kind of public-private partnership.

The sustainability fund may grant the access to international financing and funding programmes if investment projects are bundled. This also may generate economies of scale for the suppliers (the make-industry of environmental techniques and yards).

4 Greening the fleet

In this chapter the existing innovation technologies related to the pillar 'Greening the fleet' described and assessed to the items listed in Chapter 2. The pillar 'Greening the fleet' is split into three innovation areas:

1. Alternative fuels with technologies for the reduction of pollution, see Section 4.1;
2. Energy / fuel consumption, affecting the carbon footprint, see Section 4.2;
3. Air pollutant emission reduction, reducing the pollution through cleaner exhaust gases, see Section 4.3.

4.1 Alternative fuels

The use of other fuels than diesel fuel, the so called alternative fuels, have proven to significantly reduce local air pollution and therefore will contribute to a greener IWT. The alternative fuels are discussed in this section starting with Liquefied Natural Gas (LNG)/ Compressed Natural Gas (CNG), followed by Gas-To-Liquid (GTL), Biofuels (HVO, biodiesel), Methanol, Ethanol and closes with Hydrogen.

4.1.1 LNG/CNG

It is widely known that natural gas (methane) is the cleanest of all fossil fuels and is increasingly chosen as the "go-to" electric generation energy source (e.g. LNG generators). Natural gas emits lower levels of nitrogen oxide (NO_x) and also emits lower levels of particulate matter (PM) than conventional diesel (EN590). The drawback of methane is that the greenhouse gas (GHG) effect of CH_4 emissions is twenty five times worse compared to CO_2[1]. For that reason any spill of natural gas in nature as methane slip should be avoided.

Compressed natural gas (CNG) is made by compressing natural gas to less than one percent of the volume it occupies at standard atmospheric pressure. It is stored and distributed in containers at a pressure of 200 to 250 bar usually in cylindrical or spherical shapes. Liquefied natural gas or LNG is natural gas that has been converted to a liquid form for the ease of storage and transport by cooling natural gas to approximately −162°C. Afterwards, it is stored at low pressure, up to 10 bar. Liquefied natural gas takes up about one six hundredth of the volume of natural gas in the gaseous state at atmospheric pressure or about 2.5 times less volume than CNG at 250 bar pressure, but about three times more than diesel fuel.

Since the construction of the motor tank vessel Argonon as first LNG fuelled inland vessel in 2011, five other inland vessels (status end 2016) have been equipped with LNG configurations. Three are equipped with dual fuel engines in combination with single fuel LNG en diesel engines and three have only single fuel LNG en diesel engines on board. More LNG inland waterway vessels are being built and the expectation is to have forty vessels around the year 2020.

LNG power offers a number of engine configurations for inland waterway vessels. The following engine suppliers offer LNG(gas)-powered engines: Wärtsilä, Caterpillar, MAK, Rolls Royce, MAN, ABC, MTU, Mitsubishi, Hyundai, DAIHATSU , Deutz, Scania, Agco Power, Dresser-Rand Guascor. These engine manufacturers each have their own engine configurations. More engines may become available in the future. The existing configurations are as follows:

- Dual fuel engine: 80% LNG and 20% diesel:
  Dual fuel engines are based on diesel engines. The engines have been converted so they can also be powered by LNG fuel. The fuel is a mix of 80% LNG and 20% diesel. This type of engine

[1] *https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane*

was applied on the first LNG fuelled inland vessel, but will most probable not be applied anymore in newly equipped vessels.

- Dual fuel/ pilot diesel engine: 98% LNG and 2% diesel:
  In this case the engine is fully optimized for natural gas combustion. This LNG dual fuel system has already been in use for more than ten years in coastal and ocean shipping. The engines are now also supplied for inland shipping. The LNG dual fuel engines are specifically designed as dual fuel systems, so only a limited quantity of pilot fuel is required but needed for combustion. This involves proportions of 2% diesel and 98% LNG. The dual fuel engine can n also run fully on diesel.
- Spark ignition natural gas engine:
- The gas-electric drive is a system in which an inland waterway vessel uses one or several gas engines (Spark ignition natural gas engine) that drive generators (gensets) that generate electricity. This electricity goes to electric motors that drive the vessel.
- Gas-electric engine:
  The gas-electric drive is a system in which an inland waterway vessel uses one or several gas engines that drive generators (gensets) that generate electricity. This electricity goes to electric motors that drive the vessel.

Besides the engine, special safety provisions (crew training, bunkering requirements) and additional equipment are required to propel an inland waterway vessel on LNG, such as:

- CNG/LNG storage tank;
- Tank connection space;
- Power management system;
- Gas treatment system;
- ESD or gas safe engine rooms.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  The application of LNG in inland waterway transport is still in an experimental phase, as it is applied on only six vessels and applicable to large units only. These vessels have been equipped with highly tailor made and experimental configurations and can be considered as not being representative for the potential fleet that could convert to LNG as well.

  Safety issues also exist in the on-board storage facilities: LNG itself accounts for a twice larger volume than gasoil. Needed tank space might be three times larger than a gasoil fuel tank. LNG propulsion may reach an eight times larger requested room taking into account the circulation space, the safety devices, etc.

  These concepts lack a standardisation and are overdesigned with regards to safety. These issues can be overcome in future LNG vessels. There are solutions needed to reduce the methane slip emissions. At least one engine manufacturer already achieved EU Stage 5 NRMM without after treatment. Besides, there are other technological challenges, such as improved engines, cheaper tank solutions made from e.g. new 'light-weight' material, the efficient use of space and volume and more advanced boil-off management. The main challenge for IWT is affordable LNG retrofit solutions, as it is difficult to implement standardised LNG configurations for retrofit.
- Legal (Barriers caused by regulations and laws):

  Legislation is just recently adopted (European & national).
- Financial (Barriers caused by access to capital or business case):

At the moment the LNG conversion is completely custom made (case by case) and therefore requires high investments. Especially, there are high investment costs for the LNG tank and propulsion system. Difficulties in finding financing for these investment costs in combination with uncertainties concerning the development of fuel prices, prevent ship owners from making a solid investment in transition to LNG.

- Market (Barriers caused by market conditions, infrastructure, and the supply chain): Parties waiting for each other (stalemate/ chicken-and-egg), which causes a paradox of vessels lacking sufficient (structural) bunkering locations and bunkering locations lacking sufficient consumers (LNG vessels).

Measures & instruments to overcome these barriers

- Insight into the total costs of ownership;
- LNG-bunkering infrastructure along inland waterways;
- Improve the power management system (for LNG injection and timing performance of engines) to reduce methane slip;
- Cost reduction: Until present, LNG vessels have been built on a case-by-case design, which leads to a multitude of solutions and parts. This leads to higher cost and negatively influences the scale on which LNG ships will be built. Cost reduction can be achieved by creating economies of scale to reduce costs by:
  - Standardising parts;
  - Standardising legal procedures;
  - Standardising requirements (e.g. safety);
- Standardising and modernising the financial and the business-client relations.

Actors:

- Fuel suppliers;
- Suppliers (engines, cryogenic tanks);
- Shipyards & engineering consultants;
- Ship-owners/Ship owning companies;
- Cargo owners;
- European, national authorities and river commissions;
- Classification societies;
- Knowledge centres;
- Training institutes;
- (Inland) ports and transhipment terminals.

Demonstration & implementation of measures & instruments:

- Current and future LNG vessels;
- Sustainability fund for IWT (EICB/Port of Rotterdam/Dutch Ministry of Infrastructure and the Environment), see Chapter 3.

Cooperative project:

- LNG Masterplan (TEN-T: Pro Danube);
- PROMINENT (H2020: Amongst others Wärtsilä, Pro Danube, EICB);
- LNG Breakthrough (CEF: EICB, engine and fuel suppliers);
- CONNECT2LNG (CEF: Amongst others Unilever, ENGIE);

- TKI GAS (Top sector Energy (NL): EICB);
- National LNG Platform (NL/BE: EICB);
- Project MariGreen (MARIKO):
  - Plug and Play Energypack for Inland Shipping and Shortsea;
  - Low Pressure LNG Tank and Bunker Storage Solutions;
  - Standard Modular LNG System for Fishing and Shortsea Vessels;
  - Methane Catalyst for LNG Engines;
  - Training Technologies for LNG.
- Project MariTIM (MARIKO): ECO2 Inland Vessel;
- LNG Initiative Nordwest (MARIKO).

Actions of EIBIP and time frame:

- Create awareness for LNG and CNG;
- LNG conferences (LNG for river cruise industry in Q4/17 Vienna; CNG (LNG) for passenger & cargo vessels (ferries, lakes, rivers) in Q2 in Strasburg);
- Support deployment projects;
- LNG-related innovation audits (business-related, via experts);
- LNG-related innovation transfer consulting (project related);
- Research-technological consulting (with the assistance of experts);
- Advice on financing and funding programs.

4.1.2 GTL

Gas-To-Liquid (GTL) technology converts natural gas into high-quality liquid products that would otherwise be made from crude oil. These liquid products include transportation fuels, motor oils and the ingredients for everyday necessities like plastics, detergents and cosmetics. GTL products are colourless, odourless and contain almost none of the impurities, such as sulphur, aromatics and nitrogen.

GTL Fuel is an alternative fuel for use in diesel engines. GTL fuel may be used in existing diesel engines for inland vessels without modifications of the engine, allowing for easy switchover from conventional diesel fuel to GTL Fuel. GTL Fuel is already in daily commercial use in Germany and the Netherlands. GTL is especially useful for conventional diesel engines. For future Stage V diesel engines, the emission reduction will be very small, although it may be useful to reduce diesel particulate filter problems and maintenance costs.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements): After-treatment is still needed to meet the requirements of NRMM Stage V but the use of Urea in the Selective Catalytic Reduction (SCR) could be up to about 20% lower when applying GTL in comparison with the use of standard diesel fuel.
- Legal (Barriers caused by regulations and laws):
  Legal frame (European & national) needs to be updated to include GTL as an alternative fuel.
- Financial (Barriers caused by access to capital or business case):
  The financial barriers for GTL fuel are strong. Although there are no investment costs, GTL is, and is expected to remain, between 5 to 10% more expensive compared to standard

fossil fuel. Ship owners using GTL for propulsion are competitively disadvantaged, because the price premium is not covered by lower operating costs and only marginally by lower maintenance costs.

- Market (Barriers caused by market conditions, infrastructure, and the supply chain): The market is still under development and GTL is not yet widely available. Currently GTL is only distributed along the lower Rhine and in Hamburg and only by one supplier.

Measures & instruments to overcome these barriers

The price gap needs to be lower. The environmental benefits (in lower air pollutant emissions) and the ease of implementation speak in favour of the widespread adoption of GTL fuel for inland waterway vessels, but support in the higher operational costs is needed. Without a supportive legal and a financial framework to include subsidising the high cost of GTL fuel, ship owners are less likely to bunker GTL.

Current river conventions hinder the introduction of fuel charges that could act as financial incentives for cleaner fuels (as they do in the passenger car sector). This is important because the financial barriers to uptake are considerable.

On-board measurements of emissions and fuel consumption in full operation are needed to investigate and prove the potential reduction and are useful to facilitate incentive programs. Further investigation is also needed to show the engine performance and the lifecycle costs.

Actors:

- Fuel suppliers;
- Monitoring suppliers;
- Ship-owners/ Ship owning companies;
- Private financial institutions;
- Cargo owners;
- European & National authorities, and river commissions
- (Inland) ports and transhipment terminals.

Demonstration & implementation of measures & instruments:

- Demonstration projects & Knowledge dissemination.

Cooperative project:

- Modal Shift & Low-carbon fuel;
- Dual Fuel (combination with LNG);
- Hybrid (combination with electric);
- New sailing concept: ‘Sail on fuel reduction’;
- Subsidy ‘Innovatie Duurzame Binnenvaart’ (Dutch Ministry of Infrastructure and the Environment: EICB);
- Clean Inland Shipping/CLINSH (LIFE: Shell, Provincie Zuid-Holland, and EICB).

Actions of EIBIP and time frame:

- Awareness raising activities promoting the integration of GTL Fuel into existing incentive schemes
- Development of an up to date fuel price index as preparation for future activities targeted towards closing the price gap
- Collate and apply industry data to the Greening Tool and the Innovation Radar.
- Maintain Greening Tool with current statistics (Medium priority, Short term).

4.1.3 Biofuels

Biofuels come in various forms and can meet a number of different energy needs. The class of biofuels is subdivided into two generations:

- First Generation Biofuels: First generation biofuels are made from sugar, starch, or vegetable oil differ from "second generation biofuels" in that their feedstock (the plant or algal material from which they are generated) is not sustainable/green are primary vegetable oils and therefore require arable land for growing. If used in large quantity, they would have a large impact on land use. First generation biofuels are the "original" biofuels and constitute the majority of biofuels currently in use. Technically, Fatty-Acid-Methyl-Ester (FAME)-type biodiesel has limited potential because of issues with degradation and corrosion. It can best be used in low blends up to 5% or 7% with diesel fuel. With good fuel housekeeping (filters, vents, and water separation) no problems with degradation are to be expected. The GHG reduction efficiency is dependent on the feedstock (type and origin of the plant oil). With some feedstock high ILUC emissions are expected. This can lead to higher GHG emission than with diesel fuel.
- Second Generation Biofuels: Second generation biofuels are more sustainable in that they are made from more sustainable feedstock. In this use, the term sustainable is defined by the availability of the feedstock, the impact of its use on GHG emissions, its impact on biodiversity, and its impact on land use (water, food supply, etc.). Next to sustainable, advanced second generation biofuels are technically equal or superior to fossil diesel. An example of a commercial product of this type is HVO (Hydro-treated Vegetable Oil) produced from waste oils or industrial residues. Fuels produced from woody biomass and agricultural residues are under development and expected to reach the market place within five years. It is already used on certain types of trucks.

This report will consider only to the biofuels (biodiesels) suitable for diesel engines.

HVO does not contain any oxygen. According to the company Goodfuels that is already active with some pilot projects for inland waterway vessels, the NO_x reductions achieved by the use of biodiesel is 10% to 30% compared to fossil diesel, while PM emissions are reduced by 30% to 70% compared to fossil diesel. Both reduction percentages are dependent on engine type, where in general higher reductions are achieved in older engines. HVO is similar to FAME usually produced from plant oil, although it can also be produced from animal fat. The GHG-footprint is dependent on the feedstock and can be significantly reduced by up to 80%.

Barriers

- Financial (Barriers caused by access to capital or business case):

  The costs of biofuels are two to three times higher compared to diesel and ship owners are not willing to pay a higher price.
- Knowledge (Barriers caused by a lack of expertise or skills):

  Knowledge of advanced biofuels vs FAME is needed. Unclear about claims to existing incentive scheme (e.g. Environmental Ship Index (ESI)/Green Award).
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  Shared bunker locations (with fossil fuel suppliers) are needed.

Measures & instruments to overcome these barriers

- CO_2 reduction targets for the sector;
- Incentives/ CO_2 funding;
- Education on advanced biofuels;
- Simple system for fuel administration.

Actors:
- Fuel suppliers;
- Suppliers of on-board monitoring systems;
- Ship-owners/ Ship owning companies;
- Cargo owners;
- European & National authorities;
- (Inland) ports and transhipment terminals.

Demonstration & implementation of measures & instruments:
- Show and disseminate the results of demonstration projects on the application of:
    - Modal Shift & Low-carbon fuel;
    - Dual Fuel (combination with LNG);
    - Hybrid (combi with electric);
    - New sailing concept: 'Sail on fuel reduction'.

Cooperative project:
- Subsidy programme 'Innovatie Duurzame Binnenvaart' (Dutch Ministry of Infrastructure and the Environment: EICB);
- Clean Inland Shipping/CLINSH (LIFE: Shell, Provincie Zuid-Holland, and EICB).

Actions of EIBIP and time frame:
- Raising the Awareness. Communication and integration of biofuels for propulsion to existing incentive schemes may in particular be a role for EIBIP;
- No action in closing the price gap;
- Collate and apply industry data to the Greening Tool and the Innovation Radar.
- Maintain Greening Tool with current statistics (Medium priority, Short term).

4.1.4 Methanol

Methanol (CH_3OH) is mostly produced by catalytic oxidation of methane from natural gas. There are also good options in producing bio-methanol from renewable feedstock such as (waste) wood, from black liquor in pulp and paper mills or crude glycerine (a waste from FAME production). For use in a diesel engine methanol can be converted to dimethyl ether (DME), which can be used as a diesel fuel. However is does require an entirely new, rather complex fuel injection system. Commercial engines for DME are not available. A conversion to methanol is probably simpler. Similar to natural gas, methanol can both be used in a dedicated spark ignition engine as well as in a dual fuel engine. Methanol is currently applied on a ferry of Stena Line, the Stena Germanica, and in dual fuel in trucks (in China). There are some studies (e.g. EffShip, SPIRETH) performed on the use of methanol as marine fuel, until present only on seagoing vessels to comply with low sulphur fuel requirements. Methanol is currently (usually) used in a dual-fuel engine in combination with diesel.[2] There are limited problems of storage, unlike LNG.

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[2] *Used as sources for this factsheet and the technology description:*

Panteia, Planco, viadonau, SPB, CCNR (2013), Contribution to impact assessment of measures for reducing emissions of inland navigation
viadonau, SPB, DST, TNO, Pro Danube, Ecorys, STC-Nestra (2015), PROMINENT - D 1.2 List of best available greening technologies and concepts
Huang, Y. (2015), Conversion of a pilot boat to operation on methanol. Chalmers University of Technology.
Moirangthem, K. & D. Baxter (2016), Alternative Fuels for Marine and Inland Waterways. European Commission - Joint Research Centre.
Andersson, K. & C.M. Salazar (2015), Methanol as a marine fuel report. FCBI Energy for Methanol Institute.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Methanol is not available yet for inland vessels. In PROMINENT, it was concluded that the current TRL level is 3 (viadonau et al., 2015). Adaptation of the diesel engine is needed, which is highly complex, or the installation of new methanol engines. The energy content of methanol is much lower than of low-sulphur diesel and it requires some space for the fuel tank. Methanol has probably the same low emissions potential as natural gas, but the actual emissions will be dependent on the combustion system type (single fuel spark ignition and type of dual fuel). Stage V emission levels are probably achievable with relatively simple after-treatment.
- Legal (Barriers caused by regulations and laws):

  Methanol has a low flashpoint (11 to 12°C), flames are invisible, it is toxic in contact with skin and if inhaled and has a denser vapour than air. (DNV GL, 2014; Huang, 2015). This safety issues make the use of methanol in inland vessels complex from a legal point of view.
- Financial (Barriers caused by access to capital or business case):

  Uncertainty of the investment. The fuel costs of methanol itself are slightly higher than those of LNG.
- Knowledge (Barriers caused by a lack of expertise or skills):

  The lack of knowledge concerning the use of methanol and the complexities in getting permission or an exemption to use the fuel.
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  No (bio-)methanol bunkering infrastructure, although methanol requires limited storage capacity.

Measures & instruments to overcome these barriers

Research needed in the use of methanol in inland vessels.

Actors:
- Engine manufacturers;
- Ship-owning companies;
- Forwarders, loaders, shipping companies, logistics companies
- Shipyards, suppliers and maritime services
- Port authorities and relevant regulatory bodies
- Universities and learning institutes
- Classification societies and associations
- Politics and administration at the municipal-, state-, federal- and EU-levels
- Media

Demonstration & implementation of measures & instruments:
- Research and demonstration of methanol are done in current and upcoming research projects.

Cooperative project:
- LeanShips (H2020: Ghent University, Damen Shipyards, Netherlands Maritime Technology): On the use of methanol as alternative fuel;
- Further research in upcoming H2020 calls

Actions of EIBIP and time frame:

- Input for the research agenda on potential of these technologies (Low priority, Long term).

4.1.5 Ethanol

Ethanol or ethyl alcohol (C_2H_5OH) is a flammable, colourless liquid with a slight chemical odour. Bio-ethanol is currently produced in large quantities as a blend fuel for petrol vehicles. The combustion of pure ethanol with oxygen produces carbon dioxide and water:

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Bio-ethanol can be produced from sugar crops (first generation, therefore with a limited sustainability) or from cellulosic materials (wood and plant residues, second generation). Ethanol is an excellent fuel for spark ignition engines (similar to natural gas and methanol) due to its high octane number. In Brazil, it is also used as a pure fuel (100%) for spark ignition car engines. Scania has an ethanol-HD engine, which is mostly used for city buses. This is a diesel-cycle engine. Ignition is achieved by adding an ignition improver to the ethanol. Natural gas engines for IWT can probably be quite easily adapted to ethanol, either as single fuel with spark ignition or as dual fuel with diesel (pilot) injection to initiate the combustion. There is currently no ethanol bunker infrastructure for IWT. This might not be very complex due to the existing infrastructure of ethanol for the automotive sector.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Ethanol needs some reengineering on the engine and fuel tank part (fuel injection system, ignition type). Fuel tank, fuel supply and injection system need to be made from corrosion resistant materials.
- Legal (Barriers caused by regulations and laws):

  Ethanol has a low flashpoint of 12°C, flames are less visible than diesel. This safety issues make the use of methanol in inland vessels complex from a legal point of view.
- Financial (Barriers caused by access to capital or business case):

  Fuel costs much higher compared to diesel.
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  No (bio-)ethanol bunkering infrastructure.

Measures & instruments to overcome these barriers

Research needed in the use of ethanol in inland vessels

Actors:

- Engine manufacturers
- Inland waterway shipping companies and ship owners, including passenger shipping
- Forwarders, loaders, shipping companies, logistics companies
- Shipyards, suppliers and maritime services
- Port authorities and relevant regulatory bodies
- Universities and learning institutes
- Classification societies and associations
- Politics and administration at the municipal-, state-, federal- and EU-levels
- Media

Demonstration & implementation of measures & instruments:

- Scania produces ethanol engines for city busses amongst others in Sweden and The Netherlands.

Cooperative project:

- Not known certainly in the shipping area

Actions of EIBIP and time frame:

- Input for the research agenda on potential of these technologies (Low priority, Long term)

4.1.6 Hydrogen

Hydrogen can both be used as fuel for fuel cells or as a fuel for an internal combustion engine in the vessel. Paul Dieges patented in 1970 a modification to internal combustion engines which allowed a gasoline-powered engine to run on hydrogen. The combustion of hydrogen with oxygen produces water as its only product:

$$2H_2 + O_2 \rightarrow 2H_2O$$

However, hydrogen engines are currently not available for inland cargo vessels, and the rational of using hydrogen for a combustion engine, as opposed to a good biofuel, is very questionable. Hydrogen can be produced from many sources, sustainable (wind mills) or not (coal gas conversion). The main focus for application of hydrogen is on powering through fuel cells (100kW to 1000kW in the USA). A fuel cell is an electrochemical energy conversion device that uses a chemical reaction of hydrogen and oxygen ions with the use of an electrolyte and electrodes to convert their chemical energy into mainly electricity, with heat and water as the only by-products. A fuel cell is more efficient in generating electricity than a combustion engine, although for the large ship engines the difference may be small. With water and heat being its only emissions, the use of a hydrogen fuel cell is much cleaner than burning fuel like diesel in a combustion engine. The volume and weight of H_2 storage on board of a ship is large. They are about twelve times higher than for diesel fuel, for cryogenic H_2 storage. For compressed H_2, this number would even be higher. Due to this, H_2 as a fuel would be more suitable for regional and national transport up to several hundred kilometres. Good examples would be ferries, work boats and short range canal & river cruise and short range cargo transport.

<u>**Barriers**</u>

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Hydrogen internal combustion engines and fuel cells are currently not available for inland vessels;

  Although hydrogen would cancel almost all PM & unburnt fuel, it may generate more NO_x emissions than a traditional fuel, because the explosion point may be higher (to be checked);

  Only in combination with electric propulsion and power packs;

  High volume and weight for H_2 storage on board of the vessel
- Legal (Barriers caused by regulations and laws):

  Storage of hydrogen on board of vessels need to be arranged in regulations. Hydrogen may also be stored in liquid or gas (350 & 700 bars).
- Financial (Barriers caused by access to capital or business case):

  High costs are expected. The actual investment and operational costs are unknown, making it uncertain if there will be a positive business case for the application of fuel cells.
- Cultural (Barriers caused by behavioural routines):

End users are reluctant to the use of hydrogen on-board of a vessel. Hydrogen is flammable and for that reason it has the potential to react violently with oxygen in the air (catching on fire, or even exploding).

- Market (Barriers caused by market conditions, infrastructure, and the supply chain):
  Very complex and non-existent bunker infrastructure

Measures & instruments to overcome these barriers

R&D work needed in the use of hydrogen in inland vessels.

Arrange legal acceptance.

Actors:

- Engine manufacturers;
- Inland waterway shipping companies and ship owners, including passenger shipping;
- Forwarders, loaders, shipping companies, logistics companies;
- Shipyards, suppliers and maritime services;
- Port authorities and relevant regulatory bodies;
- Universities and learning institutes;
- Classification societies and associations;
- Politics and administration at the municipal-, state-, federal- and EU-levels;
- Media.

Demonstration & implementation of measures & instruments:

- Demonstration of the use of Liquid Organic Hydrogen Carriers (LOHC) with land-based power supply;
- More compact on-board storage facilities.

Cooperative project:

- Power to flex (Interreg5A: Amongst others Hanzehogeschool Groningen, Hochschule Emden-Leer): On the use of hydrogen in mobility;
- e4ships (German Federal Ministry of Transport and Digital Infrastructure): On the use of fuel cells in the maritime industry.

Actions of EIBIP and time frame:

- Input for the research agenda on potential of these technologies (Low priority, Long term);
- Conference on Fuel cells (Q3/17 D-ZIB Duisburg).

4.2 Energy consumption

The image of inland waterway transport as the most environmental friendly mode of transport is mostly caused by its low energy consumption per tonne-kilometre. However, there is still room for improvement. This improvement can be achieved in different ways, starting with improving the hydrodynamics of a vessel, its propulsion and – in the use of it – by navigating in the most energy efficient way. In the most ideal situation, the optimisation of a vessel, its design and the propulsion are done in line with the operational profile of the vessel. All these measures can result in a lower energy and fuel consumption. This leads not only to a reduced carbon footprint, but also to reduced operational costs and often a positive business case of applying these measures.

This section starts with ‘Energy-efficient navigation’ in Section 4.2.1. followed with ‘Energy efficient ship design’ in Section 4.2.2. Hybrid/Diesel-electric propulsion and Electric propulsion are assessed in respectively Sections 4.2.3. and 4.2.4.

4.2.1 Energy-efficient navigation

Energy-efficient navigation or smart steaming is the concept of navigating in the most optimal way. This can be done by taking into account the interactions between vessel and engine characteristics, fairway parameters and vessel speed. Energy consumption can be reduced by adaption of the speed profile of the vessel to the waterway profile, considering the following measures:

- Speed (power) adaption in dependence of water depth, fairway width and (counter)-current;
- Choice of the optimum sailing track, i.e. the path with the best optimum between water depth and stream velocity;
- Provision of the needed information to the skipper in an efficient and user-friendly way. [3]

One of the best-known examples of a programme stimulating energy-efficient navigation is 'Voortvarend Besparen'. Voortvarend Besparen was established by the Dutch government to create awareness on the possibilities of energy-efficient navigation. Part of this programme was the implementation of a training for skippers, a competition on fuel reduction and a subsidy for the purchase of fuel consumption meters. Since 2011, this programme has been managed by EICB. New elements created by EICB were the development of the training in an e-learning course and a smartphone app (Econaut) for the registration and monitoring of the fuel consumption and carbon footprint (in CO_2 per tkm) of a vessel.

In several other projects also activities were initiated regarding energy-efficient navigation. In Germany, Topofahrt is a training in energy-efficient navigation, coordinated by DST. Similar to the class-room training Voortvarend Besparen, the training consists of a theoretical and a practical part. The latter performed on a ship simulator. Recently, DST has performed a research project 'Smart steaming', aiming at the 'development of a relation-oriented control system for the reduction of fuel consumption in inland navigation'.

Actual water depth measurements are important for energy-efficient navigation. Measurements were done in projects like NEWADA DUO. The concept of an advising tool for the skipper was part of research performed in former research projects, like CREATING (advising tempomaat) and MoVe-IT! / COVADEM (Economy Planner and collaborative water depth measurement). Until present, only tools were developed which only partly cover the concept of energy-efficient navigation.

Within the European research project PROMINENT, it is foreseen to develop an energy-efficient navigation tool as well as an e-learning course. In the tool the actual hydrologic data will be taken into account to give a skipper advice on the best track and speed. As part of the research an ex-ante cost-benefit analysis was performed. This analysis was based on the outcomes of the before-mentioned projects, assuming an average fuel savings of around (up to) 14%.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Lack of real-time, on-board support tools for skippers. Until present, several attempts to come to such a tool (e.g. Advising Tempomaat and Economy Planner), however not yet a fully integrated tool has been developed;
- Knowledge (Barriers caused by a lack of expertise or skills):

  Energy-efficient navigation tool requires 3D hydrologic data to give advice on the right track (place in water);

[3] *viadonau et al. (2015), D2.4 Ex-ante cost/benefit analysis of business cases for energy-efficient navigation. PROMINENT.*

Lack of a European-wide (e-learning) training on energy-efficient navigation with the possibility of simulator.

Measures & instruments to overcome these barriers

- Further development of an e-learning course (Voortvarend Besparen and PROMINENT);
- Sharing of knowledge and tools across Europe is needed which would need cooperation of more education &training institutes;
- Development of energy-efficient navigation tool (Econaut and Energy-Efficient Navigation Tool), providing advice on:
    - Ballast water optimisation;
    - Trajectory advice.

Actors:

- Educational & Training institutes ;
- Research institutes;
- Fairway authorities.

Demonstration & implementation of measures & instruments:

- Energy-efficient navigation tool;
- Econaut;
- E-learning course.

Cooperative project:

- PROMINENT (H2020: amongst others Pro Danube, viadonau, TNO, DST and EICB): on the use of an advising tool for energy-efficient navigation and the development of an e-learning course;
- Voortvarend Besparen (SPB/STC): on creating awareness for energy-efficient navigation and the use of the (e-learning) course and the Econaut app;
- Topofahrt (DST): on the use of the course and the principles of energy-efficient navigation;
- Smart Steaming (IPRI/DST): on the use of an advising tool for energy-efficient navigation;
- Covadem (amongst others MARIN, Deltares and Autena Marine): on the use of collaborative water depth measurements in energy-efficient navigation;
- Project MariTIM (MARIKO): ECO2 Inland Vessel;
- Project MariGreen (MARIKO):
    - Optimized Vessel Condition and Condition-based Maintenance and Simulating Transport in a Co-Modal Logistic Environment.

Actions of EIBIP and time frame:

- Promotion and dissemination of various project results:
    - Econaut (short-term);
    - Voortvarend Besparen and Topofahrt (short-term);
    - Use the outcomes of PROMINENT (energy-efficient navigation tool and e-learning course) (medium-term);
- Conference on Energy-efficient navigation (BATELIA, Strasbourg or Paris)
- Development and implementation of an advisory program for inland navigation (including ‘Digital Consulting’ on board);
- Building and provision of a web-based ‘knowledge pool’ of innovations, technologies and innovative service providers in inland waterway transport;

- Development and use of measuring tools (e.g. Econaut CO_2 calculator, Greening Tool, Total Cost of Ownership Tool, etc.);
- Information sharing about new technologies and concepts (e.g. through events);
- Generation and dissemination of 'innovation best practices' for inland waterway transport;
- Building and provision of a web-based 'knowledge pool' of innovations, technologies and innovative service providers in inland waterway transport;
- Support of the further development of inland waterway training with regard to training modules on the topic of innovation;
- Initiating and developing training programs for inland waterway transport.

4.2.2 Energy efficient ship design

Hydrodynamic improvements or energy efficient ship designs are needed to reduce resistance. In the FP7 research project MoVe-IT! (Modernisation of Vessels for Inland waterway Transport) several forms of hydrodynamic improvements were identified. [4] Hydrodynamic improvements are used to reduce resistance. These improvements start with understanding of the hydrodynamic results of a hull design, which can be done using CFD (Computational Fluid Design) and towing tank tests (e.g. DST, MARIN). Not only the hull design can lead to reduced resistance, there are also experiments with the application of air lubrication or air chamber systems (ACES), reducing the surface with direct contact with water and thereby the resistance.

The hull design is interesting for new built vessels, however difficult (or even impossible) for retro-fit solutions. For retro-fit, there are only some options in alternative propeller, tunnel and rudder configurations and concepts, such as the Pump propeller and the adjustable tunnel.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Increasing the performance of an existing inland vessel is not easy, most of these improvements are for new built vessels;
- Knowledge (Barriers caused by a lack of expertise or skills):

  For air lubrication and alternative configurations of propeller, tunnel and rudder configurations: Not demonstrated, unknown effect or the possibilities are unknown in the market.

Measures & instruments to overcome these barriers

- Demonstrate and disseminate possibilities for alternative configurations;
- Towing tests and CFD for new built vessels.

Actors:

- Research institutes;
- Shipyards;
- Ship design bureaus;
- Propeller suppliers.

Demonstration & implementation of measures & instruments:

- Vessel Ecoliner of Damen – using the air lubrication system;
- Pump propeller (BATELIA/ Shipstudio);

Cooperative project:

[4] *DST et al. (2014), Guidelines on Modernisation of Inland Ships – Hydrodynamic improvement.* MoVe-IT!.

- Project MariTIM: ECO2 Inland Vessel;
- Project MariGreen: Optimized Vessel Condition and Condition-based Maintenance.

Actions of EIBIP and time frame:

- Guidelines MoVe-IT! in Innovation radar (short-/medium-term)

4.2.3 Hybrid/ Diesel-electric propulsion

Hybrid vessels sail using two or more energy sources separately or at the same time. Main engines and generators using a fuelled power source are combined with an integrated electrical energy storage in the form of batteries/power packs, to hybridize either the energy production to ease up the main engine optimization. A way forward to full electric propulsion (future) the electrical energy may be generated from fuel cells.

Full hybrid

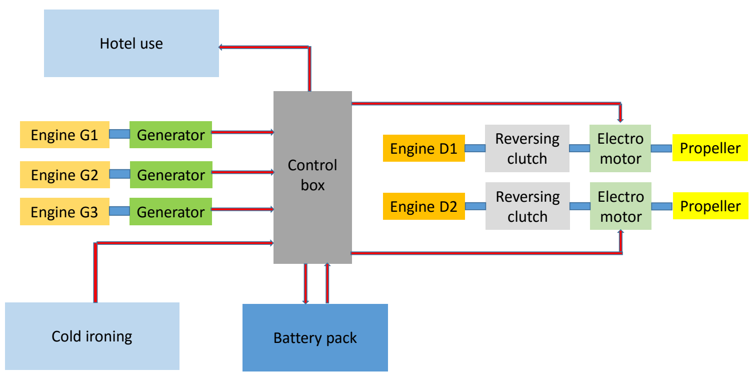


Figure 1: Diagram of a full hybrid energy system for propulsion and hotel use, including 'Cold-ironing'.

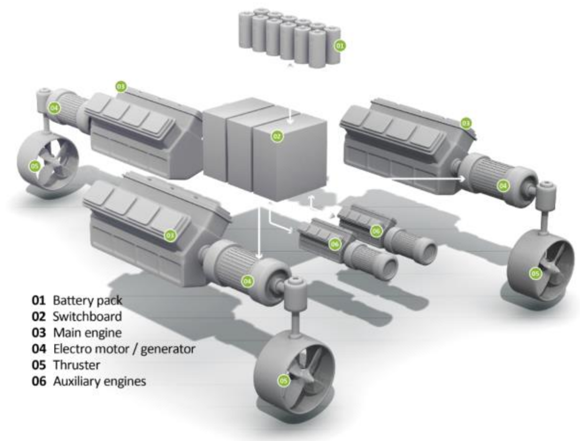


Figure 2: Diagram of a full hybrid energy system for propulsion and hotel use, including 'Cold-ironing[5]'.

Sailing may be achieved by direct propulsion and/or electric propulsion.

[5] *(Source: part of the figure in http://www.groenervaren.nl/hybrid-and-diesel-electric-did-you-think-those-concepts-are-exactly-the-same/)*

Direct propulsion: The fuelled power source is the only source for propulsion and is directly connected to the propeller through the clutch.
Electric propulsion: Electricity is the only power source for propulsion. The electric energy may come from the battery/power packs and/or the generator sets. The power packs may be used for load levelling or peak shaving or for full electric propulsion, e.g. in areas where zero emissions is required.

The benefits of hybrid propulsion could be:

- Improved vessel flexibility and performance amongst other from a better operational profile;
- Lower fuel consumption, optimised engine performance;
- Reduced emissions due to lower fuel consumption (and optimised use of engine);
- Lower operating costs due to lower fuel consumption;
- Lower maintenance costs;
- Reduced noise levels.

Hybrid propulsion makes it possible to use the fuelled power sources more efficiently, by switching the source on only when needed. The fuel power will perform in a higher fuel efficiency area. This is also very beneficial to a proper operation of engine emission control systems such as an SCR catalyst and a Diesel Particulate Filter (DPF).

It is however limited by the diesel engines rather low performance: hybrid would lead to 5% to 15% savings, for a 1,3 to 2,0 times higher investment cost. Simply using electronic injection diesel engines instead of old engines would already lead to 15% savings.

In case the fuel power source is used to generate electricity, energy losses occur due to conversion from mechanical to electric power and from electric power back to mechanical power to generate the propulsion. For that reason it is very important to know the sailing profile in detail before fitting a hybrid system into a vessel.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Systems need to be customized to suit the vessel. New vessels are relatively easily equipped with hybrid propulsion systems. Retrofitting a vessel with hybrid/diesel (or gas)-electric propulsion systems requires a considerable overhaul.

  Diesel-electric hybrid propulsion does not aim to reduce emissions. The fuelled power sources (diesel engines) will still need SCR and DPF techniques to the requirements.
- Financial (Barriers caused by access to capital or business case):

  The costs are higher and this might be a barrier.
- Knowledge (Barriers caused by a lack of expertise or skills):

  Lack of insight in the performance of hybrid configurations. The benefits are not sufficiently known and it is unclear whether the benefits outweigh the costs, which limits the interest to invest.

Measures & instruments to overcome these barriers

- Performance measurements to demonstrate the benefits of hybrid propulsion;
- Dedicated modelling and simulation tools for hybrid vessel configurations.

Actors:

- Monitoring suppliers
- Technology providers

- Inland waterway shipping companies and ship owners, including passenger shipping
- Shipyards, suppliers and maritime services
- Universities and learning institutes
- Classification societies and associations

Demonstration & implementation of measures & instruments:

- Sustainability fund (EICB/Port of Rotterdam/Dutch Ministry of Infrastructure and the Environment), see Chapter 3.
- Show the results of current vessels with diesel-electric or hybrid configuration, such as the motor vessels Nadorias (with two generator sets), Semper Fi and Duandra

Cooperative project:

- PROMINENT (H2020: Amongst others ADS Van Stigt, TNO, Pro Danube, EICB): On the development of a tool for right-sizing and hybrid configurations;
- Clean Inland Shipping/CLINSH (LIFE: Provincie Zuid-Holland, Port of Antwerp, EICB): On the demonstrations and monitoring of diesel-electric vessels;
- E-Binnenschiff (NRW: DST): On the research on electric configurations;
- Project MariTIM (Interreg DE-NL: MARIKO): ECO2 Inland Vessel;
- Project MariGreen (Interreg DE-NL: MARIKO): Plug and Play Energypack for Inland Shipping and Shortsea.

Actions of EIBIP and time frame:

- Activities which promote hybrid propulsion powertrains in combination with smaller engines e.g. with marinised EURO-VI engines may contribute to an efficient and green sailing. (Medium priority, Medium term);
- Promote the use of modelling and simulation tools for the design of the vessel specific configuration (electric motor, gensets and power-pack) for Hybrid/Diesel-electric propulsion and full electric sailing including the link to the total cost aspect (Medium priority, Medium term);
- Promote the use of total energy management systems for the power-pack and generators for an efficient sailing (Medium priority, Medium term);
- Promote the greening tool (Ongoing);
- Organise a symposium on Hybrid/Diesel-electric propulsion in the third quarter of 2017 to create awareness for the topics listed above.

4.2.4 Electric propulsion

Full electric vessels sail only using electrical energy stored in batteries/power packs. By definition a full electric vessel does not use a fuelled power source. This may be called ‘Battery electric’.

Another definition is that a full electric vessel does not use an internal combustion engine (ICE). In that case fuel cells may be added to the system to generate electric power for sailing (Fuel cell electric). In practise – due to battery size and costs – a battery electric ship has a maximum autonomy in the range of one or two hours up to about 15 hours. As a result battery electric ships are only suitable for ships which can be charged daily (e.g. during night) or multiple times per day (for example 10 minutes for each crossing of a river ferry). Electric powered ships would also suit better passengers’ transportation, where the ship remains lighter than loaded with cargo. The overall design of electric powertrain, batteries and charging system needs to be designed and optimised for the operational profile. It is also recommended to reduce the power requirements for example by a lightweight aluminium or composite ship design. Generally speaking, if a diesel powered ship would require one kW per ton-kilometre of freight, then E-powered ship would require only 0,5 [kW/t.km]. But this E-power will require 130 times larger batteries, with a plus or minus ten times higher use cost compared to diesel.

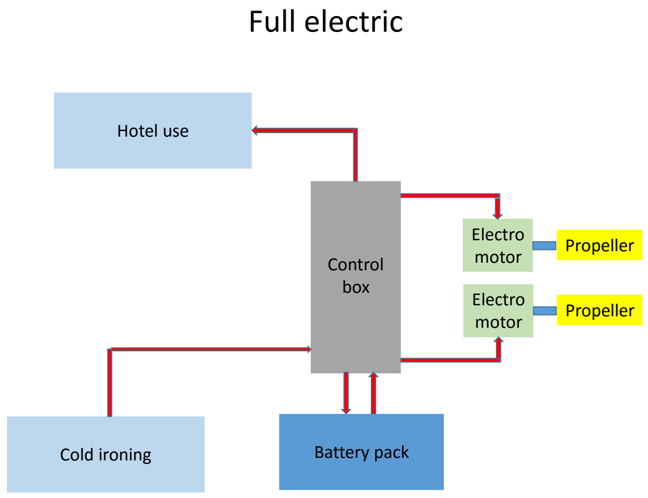


Figure 3: Diagram of a full electric energy system for propulsion and hotel use, including 'Cold-ironing'.

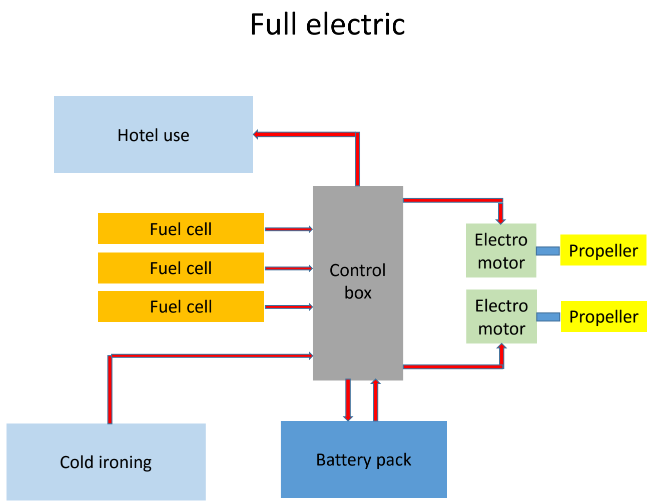


Figure 4: Diagram of a full electric energy system for propulsion and hotel use, including 'Cold-ironing' and 'Fuel cells'.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  A full electric propulsion system without an on-board fuel cell needs to be charged by cold ironing, meaning the vessel needs daily or even multiple times per day re-charging time at shore.
- Financial (Barriers caused by access to capital or business case):

  Generally speaking, investment cost is very high, due to batteries prices.

Charging infrastructure is costly especially for high power charging up to 1000 kW.

- Market (Barriers caused by market conditions, infrastructure, and the supply chain):
  Due to the limited capacity of the battery pack, only short sailing distances are possible and this forms a potential acceptance issue for vessel owners.

Measures & instruments to overcome these barriers

- Reduced power and energy requirements, for example by light weight ship design
- The handling associated with frequent re-charging can be overcome by automatic conductive or inductive connectors installed in a mooring device (holds ship in place).
- A fuel cell system can be added to extend the autonomy to one or two days.

Actors:

- Technology suppliers
- Inland waterway shipping companies and ship owners, including passenger shipping
- Shipyards, suppliers and maritime services
- Universities and learning institutes
- Classification societies and associations

Demonstration & implementation of measures & instruments:

- Sustainability fund, see Chapter 3.
- Show the possibilities of full electric sailing by disseminating the results of demonstration projects, examples are the full electric car ferry in Norway, the electric canal cruise vessel Barlaeus in Amsterdam and the ferry Movitz in Sweden.

Cooperative project:

- E-Binnenschiff (NRW: DST): On the research on electric configurations;
- MariTIM (MARIKO): Passenger Vessel;
- MariGreen (Plug and Play Energypack)
- Siemens project ‘Schwimmende Stromer’: On the use of a ferry with an electric propulsion
- DNV GL project ReVolt: On the concept of an unmanned, zero-emission, shortsea vessel

Actions of EIBIP and time frame:

- Development of support actions for full electric sailing for local vessels.

4.3 Air pollutant emission reduction

A technology for affecting the burning process is mixing fuel with water, resulting in a homogeneous emulsion before it enters the cylinder. Fuel water emulsion may result in cleaner exhaust gases. The technology is covered in Section 4.3.1 ‘Alternative technologies’. The burning process of the fuel will also be affected through new engine technologies and/or more intelligent engine management systems and may contribute to clean exhaust gases. Reduction of air pollutant may also come from a more efficient use of fuel. These ‘New engine concepts/ optimisation’ are discussed in Section 4.3.2. A final way of reducing the air pollution is cleaning the exhaust gasses with after treatment systems, discussed in Section 4.3.3.

4.3.1 Alternative technologies

Fuel-water emulsion

Fuel-water emulsion is an example of alternative technologies. With the concept of fuel-water emulsion an add-on system emulsifies and mixes fuel with water, which results in a homogeneous emulsion. This emulsion consists of oil droplets with a water nucleus, which is injected into the engine. A 'micro-explosion' divides each fuel oil droplet in numerous smaller fuel oil droplets, as these smaller fuel oil droplets ignite and burn easier than the bigger droplets. This results in the reduction of potential particle matter and soot creation zones, a cooling down of the combustion chamber temperature and a reduction of fuel consumption.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  FWE needs to be combined with SCR to further reduce NO_x emissions and DPF to further reduce PM emissions to achieve more ambitious emission standard but FWE will result in a reduction of the urea consumption of the SCR.
- Financial (Barriers caused by access to capital or business case):

  Investment costs are 135€/kW for smaller engines and 100€/kW for larger engines (>1.000kW).
- Knowledge (Barriers caused by a lack of expertise or skills):

  Unknown technology. There are some uncertainties regarding the maintenance of the system and the engine.
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  FWE is available for the IWT sector, applied on a few inland vessels but only supplied by one company. Furthermore, the use of this system requires the consultation of the engine supplier, especially concerning the warranty on the engine.
- Cultural (Barriers caused by behavioural routines):

  There is concern among stakeholders regarding the application and the potential threat of engine corrosion, extensive maintenance would be required and defects of fuel injection systems could occur, which can result in voiding warranty on the engine and especially the fuel injection equipment.

Measures & instruments to overcome these barriers

- Measure the real performance and emissions of these technologies.
- Calculate the costs and benefits of the application of them.

Actors:

- Technology suppliers
- Monitoring suppliers
- Ship-owning companies

Demonstration & implementation of measures & instruments:

- Show and disseminate the results of demonstration projects (mentioned under cooperative projects)

Cooperative project:

- Clean Inland Shipping / CLINSH (LIFE: Provincie Zuid-Holland, Port of Antwerp, NRW, EICB): On the demonstration of FWE.
- Innovation Lab (Provincie Overijssel, Port of Rotterdam: Exomission, EICB): On the demonstration of FWE
- Subsidy 'Innovatie Duurzame Binnenvaart' (Dutch Ministry of Infrastructure and the Environment: EICB): On the demonstration of FWE
- Project MariTIM (MARIKO, Reederei Deymann): ECO2 Inland Vessel

Actions of EIBIP and time frame:

- Support involved parties / demos (Medium priority, short term).
- Update and promote Greening Tool (Medium priority, short term).
- Establishment and maintenance of an 'Innovation Network for Inland Waterways' in Germany, through which targeted contacts between the members can lead to innovations;
- Development and implementation of an advisory program for inland navigation (including 'Digital Consulting' on board);
- Building and provision of a web-based 'knowledge pool' of innovations, technologies and innovative service providers in inland waterway transport.

4.3.2 New engine concepts/ optimisation

Both EURO VI and NRMM Stage IV came into effect in 2014, with the tightest emissions levels to date ($NO_x < 0.4$ [g/kWh], PM < 0.01 resp. 0.025 [g/kWh]). To meet the regulations, OEMs have resorted to the after-treatment technologies like SCR, and/or EGR, with a DPF. Besides the after-treatment systems the EURO VI and Stage IV engines were further developed on:

- Fuel injection systems have moved from low-pressure systems, to electronic, high-pressure systems reaching up to 2,700 bar;
- Combustion pressure is up to more than 200 bar;
- The turbochargers are now variable-geometry models, which help driveability as well as meeting emissions standards.

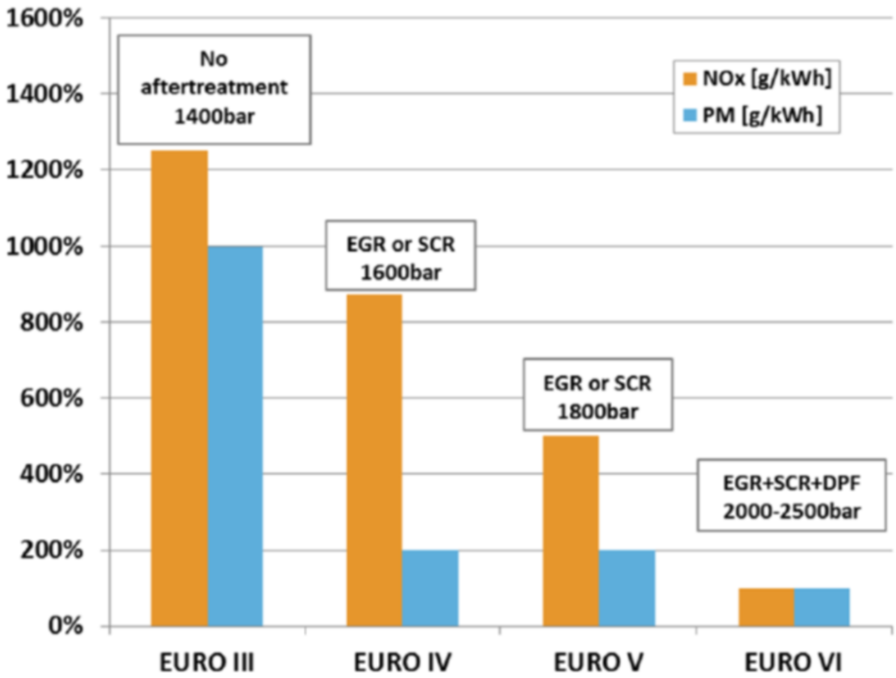


Figure 5: Progression of PM and NO_x from EURO III to EURO VI

The OEMs have adopted two types of after-treatment system concepts for EURO VI requirements:

- SCR, DPF in combination EGR;
- SCR-only (High Efficiency SCR).

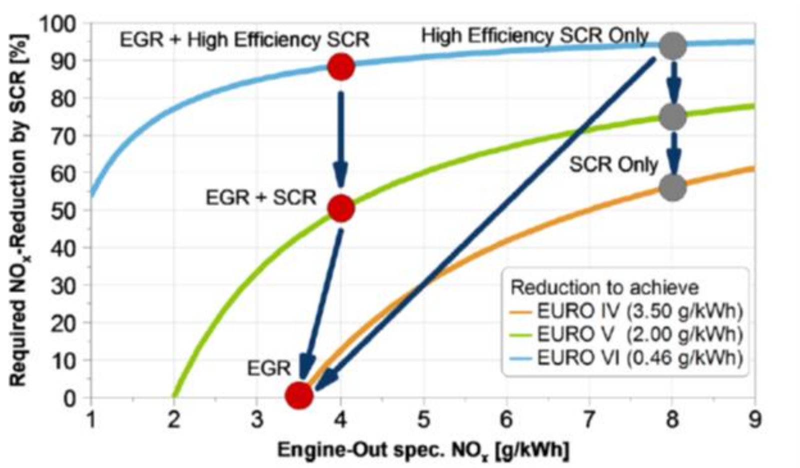


Figure 6: Concepts for De-NO$_x$ of exhaust gas with and without usage of EGR to achieve Euro IV requirements

The SCR-only solution offers some advantages over the EGR system:

- Increased engine efficiency and reduced particulate matter (PM) produced by the combustion;
- Compact and lean design, both of the engine and the High Efficiency after-treatment system, lowering weight and installation space;
- No combustion products back into cylinder;
- No additional cooling requirements;
- Lower specific fuel consumption [g/KWh].

The disadvantage of the higher NO$_x$-emissions is that it requires increased usage of AdBlue, influencing the operational costs.

Real new engine concepts are scarce, basically in all sectors. The largest changes for the past decades are the addition of EGR, SCR and DPF and minimising the negative impacts of this. These are possible loss of efficiency, wear, fouling and maintenance costs. The addition of EGR to IWT marine is not expected, because it ads complexity to the engine and it is not needed to achieve the Stage V levels.

Low compression engines would be an alternative (Mazda, Iveco) as well as LNG operated engines, which do not pollute at all (no NO$_x$, no PM, no unburnt fuel).

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  The average load of ship engines is higher than for truck engines, which may result in durability problems when a truck based engine is used for inland ships. Also the desired life time of ship engines is somewhat higher: about 30.000 hrs for ships compared to 20,000 to 25,000 hrs for truck engines
- Legal (Barriers caused by regulations and laws):

  Both inspection bodies and classification societies have requirements for engines and propulsion system for inland waterway use that differ from the requirements for road. So, further modifications of the engine are also required from this safety requirements
- Knowledge (Barriers caused by a lack of expertise or skills):

  Modification (marinisation) of truck engines for IWT use, is a well-known solution. However, in practice only up-to Euro III engines are being modified to meet at maximum CCNR Stage-II requirements. For engines from Euro IV on, the engines became more complex and no suppliers are known for this type of engines.

Measures & instruments to overcome these barriers

- Marinisation of EURO VI engines, as described in the report LNG for trucks and ships: fact analysis; Review of pollutant and GHG emissions;
- Engine manufacturer can increase life time by design improvement. A number of engines are already designed for sufficient durability for several application segments;
- Stage V NRMM may stimulate the use of smaller engines due to lower requirements for engines smaller than 300kW. These engine are more likely to be based on shared platforms for land based NRMM and Euro VI from which low emissions versions (NO_x < 0.4 g/kWh, PM < 0.01 or 0.025 g/kWh) were already developed.

Actors:

- Engine manufacturers and suppliers;
- Ship-owners/ Ship owning companies;
- Ship builders;
- Cargo owners;

Demonstration & implementation of measures & instruments:

- Demonstration of extremely low emissions (NO_x < 0.4 g/kWh);
- The application of shared platforms for different segments is happening but not really visible;

Cooperative project:

- Project MariGreen: Plug and Play Energypack for Inland Shipping and Shortsea;
- LNG Initiative Nordwest: Motor Safety.

Actions of EIBIP and time frame:

- Promote the development and implementation of marinised EURO-VI Truck engines for NRMM environment. These engines might perfectly fit to be used in genset in Hybrid/Diesel-electric propulsion.
- Organise a conference on Euro VI engines for inland waterway vessels in the fourth quarter of 2017m (BATELIA Brussels);
- Discuss incentives or greening programs focused on extremely low emissions (NO_x < 0.4 g/kWh). This will stimulate the use of Euro VI and land-based Stage IV engines.

4.3.3 After-treatment

Selective Catalytic Reduction of NO_x (SCR deNO_x) is a technology applied on diesel engines to reduce the NO_x emissions, by injecting a urea-water solution (AdBlue) into the exhaust gas upstream of the SCR catalyst, generating ammonia (NH_3). This is absorbed onto the catalyst, converting NO_x in diatomic nitrogen (N_2) and water (H_2O).

A Diesel Particulate Filter (DPF) reduces the particulate matter emissions from the engine exhaust gases. The most efficient DPF is the wall flow DPF, commonly made from ceramic materials with a honeycomb structure with alternate channels plugged at opposite ends. According to the Manufacturers of Emission Controls Association (MECA), particulate matter is captured by interception and impaction of the solid particles across the porous wall. The filter is designed to hold a certain quantity of soot. During the course of its operational hours, it gets loaded due to the high deposition of soot. This can result in increased back pressure on the engine and when not properly acted upon may lead to clogging of the filter. Therefore, it is important to maintain a sufficiently high average temperature such that the stored particle matter is regenerated (converted to CO_2) and the filter is kept clean. This is needed to prevent it from becoming blocked and its function thereby being affected. Alternatively a special active regeneration system can be installed, which increases the filter temperature periodically to high temperature for fast filter regeneration. In the DPF also inorganic materials are collected such as metal based oil additives from the engine lubricant. These cannot be removed by regeneration, so they need to be removed mechanically by opening the filter and blowing them out. This needs to be done every one or two years.

SCR and DPF are often combined because then all gaseous as well as particulate emissions are reduced (by 70% or more) and usually the most stringent (future) emission legislation can be met. SCR and DPF often work together nicely leading to an increased SCR efficiency. One of the technical options is the “SCR on DPF technology”, where the DPF part acts as an SCR catalyst as well. This can lead to a more compact configuration.

There are some other alternatives, such as water tanks and recirculation of pollutants within the engine, without any EGR.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):
  Required space in the engine room;
- Legal (Barriers caused by regulations and laws):
  Needs changes in legal frame (units technical specifications);
- Financial (Barriers caused by access to capital or business case):
  No return on investment;
  OPEX is relatively high and required space even harder when needed to meet the requirements of NRMM directive.

Measures & instruments to overcome these barriers

- Insight into the total costs of ownership.

Actors:

- Engine manufacturers and suppliers;
- After treatment equipment suppliers;
- Ship-owners/ Ship owning companies;
- Cargo owners;
- European & National authorities and river commissions;
- Classification societies;
- Knowledge centres.

Demonstration & implementation of measures & instruments:

- Show and disseminate the results of demonstration projects;
- On board monitoring to demonstrate the technology.

Cooperative project:

- Clean Inland Shipping / CLINSH (LIFE: Provincie Zuid-Holland, Port of Antwerp, DCMR, EICB): On the on-board monitoring of vessels;
- COBALD;

- INNOVATION LAB;
- PROMINENT;
- Project MariGreen: Methane Catalyst for LNG Engines;
- LNG Initiative Nordwest: LNG Motor Safety;
- Carbon Capture, Utilization and Storage.

Actions of EIBIP and time frame:

- Promote the proven after treatment technology
- Stimulated the application trough funding programs.

5 New logistic and vessel concepts

Inland waterway transport is able to offer a high variety for freight forwarding solutions. However, this variety is not always used in an optimal way. Besides, it is not always recognised by the cargo owners or logistic operators and so not always considered as an adequate part of the logistics chain. In spite of the ambitions set in the White Papers on Transport (2001 and 2011), to shift especially long-distance freight transport from road to rail and waterborne transport, the European Court of Auditors (2015) observed no significant improvement in the modal share of inland waterway transport (fluctuating around 6%).[6]

For this segment, EIBIP follows a threefold approach, in which new logistic and vessel concepts might result in an optimisation of IWT and lead to a revitalised image among the stakeholders by means of demonstrating reliability and predictability – next to the well-emphasized cost-effectiveness and environmentally friendliness. These two aspects also contribute to the acquisition of new cargo flows (the third aspect of EIBIP's approach).

The first section of this chapter deals with 'New logistic concepts', which focuses on the optimisation of inland waterway transport in the logistic chain, not exclusively for new types of cargo, but also leveraging the possibilities of digitalisation. Section 5.2 describes 'New vessel concepts', which is the optimisation on-board of a vessel. Finally, Section 5.3 'New cargo flows' focuses on the acquisition of new cargo flows (achieving a modal shift).

5.1 New logistic concepts

New logistic concepts in IWT shall enable the better use of the existing and free capacities of the operators. A major element of the concepts shall be supported by value added information services that (re)-use and top up already existing data. With the introduction of River Information Services (RIS), a large amount of data has been started to be gathered and used for information provision services. However, these services were focussing on traffic management purposes, implemented by governmental organisations, whereas the transport management side was lacking behind. The following sub-chapters of the EIBIP EU-Wide Strategy for the uptake of innovation give an insight on three different aspects of logistic concepts that might support the community to introduce new services:

- Synchromodality;
- RIS as transport management tool;
- Digital market places for cargo flows.

5.1.1 Synchromodality

In the recent years, synchromodality has been developed as a new concept of multimodal transport. The Dutch platform 'Synchromodaliteit' defines synchromodality as 'the optimally flexible and sustainable deployment of different modes of transport in a network under the direction of a logistics service provider, so that the customer (shipper or forwarder) is offered an integrated solution for his (inland) transport.' As its name already suggests, synchromodality requires an integrated approach in which also the other modes of transport are involved. A shipper allows the logistic service provider to make a choice between these modes of transport, depending

[6] *European Court of Auditors (2015), Inland Waterway Transport in Europe: No significant improvements in modal share and navigability conditions since 2001.*

on aspect such as availability and time. It requires the synchronisation of transportation networks and an efficient transport planning method.

Synchromodality requires digitalisation, so concepts as mentioned under 4.1.2 and 4.1.3 are needed. Logistic operators use and continuously deploy their ICT solutions that support their internal processes and provide services for the end-users. For the end-users the most important information is the reliable position of the cargo and the estimated time of arrival. Whereas the logistic service providers need reliable fairway information for route / voyage / loading plans and harmonised digital tools to minimise the workload to fulfil the reporting duties. Information needed are also the clearance of the cargo at the location of the sender or the loading terminal and the slot availability at the terminals. All these can be supported by planning tools that (re)-use RIS information (as mentioned under 4.1.2) and seamlessly exchange relevant information among the stakeholders with keeping all information security rules and procedures. Furthermore, commercial users have to be motivated to provide content contribution besides enjoying the foreseen benefits provided by the fairway authorities.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Requires the integration of IT systems of IWT with the other modalities and the logistic service provider and the control tower.
- Legal (Barriers caused by regulations and laws):

  Different reporting duties (e.g. customs) for different modes of transport.
- Financial (Barriers caused by access to capital or business case):

  Operators are overloaded with administrative requirements that can cause cost and administrative disadvantages compared to other modes of transport
- Knowledge (Barriers caused by a lack of expertise or skills):

  The concept of synchromodal transport needs further development.
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  Requires standard loading units (containerisation);

  The synchronisation of trimodal connections is needed.
- Cultural (Barriers caused by behavioural routines):

  The “outside world” considers IWT as partly inefficient and unreliable mode of transport due to negative news on the media such as limitation of navigation due to low water levels;

  Logistics stakeholders are reluctant to use IWT in their logistics chains as they fear to suffer from the lack of information and thus they are not able to serve their customers

Measures & instruments to overcome these barriers

- Integration of the ICT solutions in the field of IWT with the ICT solutions of other modes of transport and logistic service providers;
- RIS and other ICT solutions in the field of IWT shall be used as good practice examples, success stories to demonstrate the supporting information services which can result in trust from the logistics stakeholders;
- Logistics stakeholders shall be provided with on-line, real-time access to cargo position information and the estimated time of arrival (ETA). For this the following RIS key technology shall be implemented (mostly done) and value added, harmonised services shall be provided:
  - Vessel tracking and tracing with triggers that let the cargo owner follow the route and the ETA;

- Link with 4.1.2: IWT operators shall be provided with reliable and real-time fairway information that not only tell limitations, but provide compact supporting information where the certain convoy can pass. For this the following RIS key technologies shall be implemented (mostly done) and value added, harmonised services shall be provided:
  - Inland electronic navigational charts and their continuous updates;
  - Notices to skippers and the provision of information well in advance;
  - Water level information with reliable predictions;
  - Use of tracking and tracing & electronic reporting information to reduce waiting times and locks;
  - Use of tracking and tracing & electronic reporting information to speed up administrative procedures when passing EU / Schengen borders
  - Reservation services for terminals / berths;
- IWT operators (freight forwarders) shall be provided with minimised, harmonised and digitalised reporting possibilities. For this the following RIS key technology shall be implemented (mostly done) and value added, harmonised services shall be provided:
  - Electronic reporting services offering one-stop-shop services for voyage and cargo reporting; support for ordering, invoicing etc.;
- Support of the IWT sector for cooperative depth measurements, meaning the provision of echo sounder data back to the fairway administrations so they can react quicker on negative changes in the fairway. Currently, in projects like CoVadem and PROMINENT studies and pilots on this topic are performed;
- Provision of feedback from the IWT sector on the available RIS Services and their quality. This could be achieved through an online survey tool or a customer interaction centre for RIS Users, which is not provided by the fairway authorities or RIS Providers, but by an independent entity that represents the interests of the commercial IWT stakeholders. Feedback on the RIS Services would help the fairway authorities to improve their services;
- Establishment of public – private cooperation for the production of basic RIS data that require the input of the commercial sector. For example the RIS Index including the encoding of commercial terminals, or the ENCs for commercial ports areas, etc.

Actors:

- Logistic service providers
- Cargo owners/shippers
- Fairway authorities
- Other relevant authorities (e.g. customs)
- RIS providers and operators
- Logistics stakeholders
- Fleet owners / operators

Demonstration & implementation of measures & instruments:

- Transport logistics services offered by DoRIS in Austria
- International exchange of notices to skippers messages via the web service interface
- Exchange of electronic reporting information between The Netherlands and Germany

Cooperative projects:

- EGS Network (ECT)

- CoRISMa (TEN-T)
- RIS COMEX (TEN-T / CEF)
- FAIRway Danube (TEN-T / CEF)
- DaHar (SEE Programme)
- DAPhNE – Danube Ports Networks (Danube Transnational Programme)
- Project MariGreen: Simulating Transport in a Co-Modal Logistic Environment
- Seacon Control Tower (developed in IDVV)
- Information platform (Mepavex)
- Smart Data platform (TNO, BCTN)
- SynchroMania (TNO)
- Hub-and-spoke (Danser, BCTN)

Actions of EIBIP and time frame:

- Dissemination of synchromodal possibilities (gamification as in SynchroMania, demonstration projects as the above-mentioned) (medium term, low priority)
- Research on the use of IWT in synchromodal logistic chains (cooperation with TNO, Dinalog) (medium term, high priority)
- The Innovation Centres (ICs) shall point out the possibility of seamless information exchange for the logistics stakeholders to promote the usage of IWT in their logistics chains
- The ICs shall support the national authorities and information providers to make all relevant and necessary information available for operators in standardised, harmonised and real-time way
- The ICs shall support relevant initiatives, expert groups and projects that strive for the use of digital fairway / cargo etc. information

5.1.2 RIS as supporting tool for transport management

RIS are defined and in the Directive 2005/44/EC of the European Parliament and of the Council as following:

*River information services (RIS) means the harmonised information services **to support traffic and transport management in inland navigation**, including, wherever technically feasible, interfaces with other transport modes. RIS do not deal with internal commercial activities between one or more of the involved companies, but are open for interfacing with commercial activities. RIS comprise services such as fairway information, traffic information, traffic management, calamity abatement support, information for transport management, statistics and customs services and waterway charges and port dues.*

RIS is implemented or is being implemented in all EU Member States and non-Member States (such as Serbia and Ukraine) that are affected by the above quoted RIS-directive. RIS key technologies – that enable the provision of the services – are defined in the directive and specified in the relevant commission regulations (among other the RIS Guidelines).

The RIS Guidelines define services to support transport management, however, this is not yet exploited in an extent that was expected by the stakeholders. RIS authorities and providers have been focussing on the traffic management services in the past years. Several reports have been elaborated in the past years to evaluate the deployment and operation of RIS, whereas the most recent approach is being made with the lead of TNO in the MOVE/B3/SER/2015-224/SI2.720619 **Lot2** - Towards Digital Inland Waterway Area and Digital Multimodal Nodes: waterborne digital services between maritime and inland ports. TNO has defined three main **problem fields** in IWT:

1. Reduced overall cost-competitiveness due to the lack of waterway maintenance in certain countries and inefficient navigation and traffic management;
2. Limited use of inland waterways - particularly in multimodal chains - as the integration of IWT in logistics processes is currently inefficient;
3. High administrative burden and workload to comply with safety-related legislation.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  It is difficult to integrate existing River Information Services in a data sharing infrastructure;
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  A data sharing infrastructure for smart navigation and traffic management is lacking. As a result, lots of barges sail empty, and this results in higher operations costs, and therefore cuts IWT competitiveness;
  There are no electronic services to support stakeholders in finding, booking and tracking of IWT services;
  Integrated electronic business-to-government (B2G) reporting services are lacking;
  The specific characteristics of the sector (e.g. diverse level of availability of IT equipment at stakeholders, attitude towards new technologies) make it difficult to govern the advance of digitalisation in inland waterway transport.

Measures & instruments to overcome these barriers

- Offer value added services for logistics stakeholders, particularly related to the real-time position of the cargo and the estimated time of arrival (ETA). This with two purposes : 1st enable terminals operators to optimize their handling equipment operations, 2nd to avoid as much as possible empty voyages;
- Minimise, harmonise and digitalise reporting requirements throughout Europe;
- Offer and operate software interfaces towards existing systems of the logistics stakeholders and integrate with information systems of other modes of transport;
- Enable international exchange of RIS data (on river information as well as track and tracing);
- Follow and contribute to the works of the relevant organisations and initiatives such as Digital Transport & Logistics Forum (DTLF), Digital Inland Waterway Area (DINA), Digital Multimodal Nodes (DMN), eIWT (e-SRB and eLogbook), PIANC working groups;
- Involve the logistics sector in the development process of new services.

Actors:

- Port, European, national authorities and river commissions;
- Logistics stakeholders (logistics service providers, terminal operators, operators of other modes of transport)
- Fleet owners / operators
- Shippers
- CCS operators
- DG MOVE

Demonstration & implementation of measures & instruments:

- AIS transponder carriage requirements (amended with the obligation for electronic chart display system in the CCNR regime)
- Electronic (dangerous) cargo reporting solutions operational on the Rhine and in the some Danube countries
- Transport logistics services offered by DoRIS in Austria

- TRIUMPH project in Ennshafen (AT) to use RIS information for just-in-time logistics operations
- Electronic provision of passenger list for Schengen controls in Hungary
- Mobile RIS applications
- Simplified charging of fairway dues in France based on RIS information

Cooperative projects:

- National RIS deployment projects (TEN-T, CEF, national funding schemes)
- The series of the IRIS Europe (TEN-T) projects that provide the technical basis for RIS operations
- PLATINA-II
- CoRISMa (TEN-T: Amongst others viadonau, Rijkswaterstaat, BMVI)
- RIS COMEX (TEN-T / CEF: Amongst others viadonau, VNF, Rijkswaterstaat, RSOE)
- AEOLIX (H2020: Amongst others ERTICO, CONNEKT, viadonau)
- DANTE (Danube Transnational Programme)

Actions of EIBIP and time frame:

- EIBIP shall follow the outcomes of the proceedings of the update of the RIS-directive and the related commission regulations
- The Innovation Centres (ICs) shall support their regional logistics partners to channel their needs and demands into the projects (ref RIS-Comex)
- The ICs shall – based on the competencies – participate in the relevant projects as at least in an observer status
- The ICs shall follow the expert discussions (e.g. DINA Task Force, Common Issues Meeting, RIS Expert Groups) and phase in / align the industrial needs
- The ICs shall – where possible and relevant – integrate RIS into the initiatives taken together with the stakeholders

5.1.3 Digital market places for cargo flows

Freight forwarding in inland waterway transport is still done in a relatively traditional way. The cargo of a shipper (or its freight forwarder) are linked by a charterer or an IWT operator to a vessel. In this logistic chain, there are differences between liner business (as done for containers and also some dry and liquid bulk) and spot market. Digital market places can replace or support the work of a charterer or an IWT operator, bringing together supply and demand. This is especially interesting for the spot market, bringing together supply and demand. About 55% of the assignments in Western Europe is traded on the spot market. [7]

There are several websites with digital market places, in which a ship-owner and a shipper or freight forwarder can subscribe. One of the oldest examples is Bargelink, founded in 2001 and since then also extended with a similar market place for rail cargo. Currently, there are also other, newer platforms (e.g. River Transport Market Place in France), working with different systems, types of cargo (TEU Booker only for container transport) or market parties (Imperial with its own system IFMS). TEU Booker is a good example of optimisation, currently mainly operating in the Rotterdam port area. It facilitates terminal and container operators to move container between container terminals in the Maasvlakte area, using vessels already operating between these terminals.

Barriers

[7] *WVL, STC, PANTEIA, BDB (2015), D1.5: Analysis of Possibilities to Enhance Market Transparency and Synergistic Actions. PLATINA II.*

- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  The barriers for digital market places are in line with the other logistic concepts, there are still many shippers and freight forwarders unfamiliar with the benefits of inland waterway transport in a logistic chain. The current projects are done on a small basis and aren't yet synchronised with digital platforms for other modalities. There are different, small suppliers, which doesn't solve the fragmentation of inland waterway transport. For shippers or freight forwarders unfamiliar with inland waterway transport, it is not transparent which of these different platforms can give them a right solution. The added value of such platforms remains limited if there is no interface with a tracking/tracing system, which provides real time information on load capacity.

Measures & instruments to overcome these barriers

Cooperation between the different online market places platforms or at least an overview of (the working of) these platforms. Interfacing such a logistics online platform with a tracking/tracing system (e.g. AIS) would also enable ship-owners to find out real time cargo opportunities, and therefore reduce the number of their empty voyages (needs to adapt shippers/ship-owners contracts and require ship-owners' agreement to use AIS data for some other purpose than the initial one - safety).

Actors:

- Suppliers of digital services;
- CCS operators;
- Logistic chain (shipper, charterer, IWT operator, ship-owning company);
- IW authorities (to possibly use AIS data for logistics purposes).

Demonstration & implementation of measures & instruments:

- Different platforms (examples under cooperative projects)

Cooperative project:

- Bargelink
- TEU Booker
- IMPERIAL Freight Management System
- 4shipping
- Project MariGreen: Simulating Transport in a Collaborative Co-Modal Logistic Environment

Actions of EIBIP and time frame:

- Disseminate an overview of digital market places (short-/medium-term);
- Follow and link the initiatives with each other and other modalities.

5.2 New vessel concepts

The introduction of new vessel concepts is needed to facilitate new cargo flows or use under-utilised sailing areas or for a more efficient operation of existing cargo flows. New sorts of vessels are needed to use small inland waterways efficiently and optimisation of the use of vessels, by automatization of the operations (navigation, but also in the loading procedure).

5.2.1 Vessel concepts for the efficient use of small inland waterways

In its study on the small inland waterways, EICB showed the importance of new concepts for the efficient use of small inland waterways. [8] This means the use of the current capacity on the small inland waterways and developing new concepts for new cargo flows. This resulted in several concepts, like Q-Barge, Barge Truck and Watertruck, in which small push boats are used in combination with self-powered barges. After a first study into the Watertruck concept (the fleet development and potential of push boats and barges for CEMT class IV canals) between 2011 and 2014, in 2015 the Watertruck + project has been launched in Flanders. This project aims at building 21 units in 2017 - 2018. In France, there is also a project of an innovative class IV unit (pushed barge) dedicated to transport of out-of-gauge goods (heavy lift).

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):
  This requires the building of new vessels, custom-made for the small inland waterways.
- Financial (Barriers caused by access to capital or business case):
  The freight rates on small waterways are relatively low, resulting in a negative business case.
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):
  These concepts should not lead to market distortion.

Measures & instruments to overcome these barriers

- Identification of the need and business cases of the use of these vessels.

Actors:

- Engineering consultants
- Shipyards,
- Ship-owners,
- Shippers (to express their requirements)
- Fairway authorities / river commissions
- Registration authorities

Demonstration & implementation of measures & instruments:

- The vessels within Watertruck+

Cooperative project:

- Watertruck+ (CEF)

Actions of EIBIP and time frame:

- Team up with projects on this topic and disseminate on their results.

5.2.2 Optimal cargo load

With the right (water level) information, it is possible to optimise the cargo load of a vessel (e.g. need water depth for bulk, height bridges for containers). This can be integrated in the concept of an energy-efficient navigation tool, which also requires the hydrologic data. In COVADEM and PROMINENT research is done to study the possibilities of integrating this in an advice tool.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

[8] *www.informatie.binnenvaart.nl%2Fdocumenten%2Fdoc_view%2F156-plan-van-aanpak-klein-schip*

Needs real-time hydrologic data;

Currently, there is no link between an energy-efficient navigation tool and a stowage planning programme (like ContainerPlanner).

Measures & instruments to overcome these barriers

- Additional feature of an energy-efficient navigation tool;
- Integration in stowage planning programme.

Actors:

- Ship-owning companies;
- Waterway authorities;
- Suppliers of stowage planning programme;

Demonstration & implementation of measures & instruments:

- As additional feature on an energy-efficient navigation tool.

Cooperative project:

- COVADEM
- PROMINENT

Actions of EIBIP and time frame:

- Link with projects PROMINENT and Covadem, disseminate outcomes.

5.2.3 Automation of navigation / vessel-trains

Under 4.1 - new logistic concepts several concepts of digitalisation were described in order to optimise the logistic chain. Also on board of a vessel, there can be benefited from the digitalisation. With the automation of navigation (e.g. by the use of vessel-trains or autopilot), it is possible to optimise the operation of a vessel. Most likely, this will be developed as an automation of currently developed advising tools, with some elements of auto piloting. In the Horizon 2020 project NOVIMAR, this will be further developed towards a concept of vessel trains.

There are some research and demonstration projects with (mostly small) autonomous floating vessels. One of these is a collaboration of the Massachusetts Institute of Technology (MIT) and the Amsterdam Institute for Advanced Metropolitan Solutions (AMS Institute) with researchers from Delft University of Technology (TUD) and Wageningen University and Research (WUR): http://www.ams-institute.org/news/roboat/ Besides, there has been a project tested in Flanders (by WenZ).

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):

  Automation of navigation is still in research stage (extremely experimental).
- Legal (Barriers caused by regulations and laws):

  Legal and security issues need to be elaborated.

Measures & instruments to overcome these barriers

- Research and development needed.

Actors:

- Ship-owning companies;
- Suppliers;
- Software suppliers;

- Authorities
- Class societies.

Demonstration & implementation of measures & instruments:

- Research within Horizon 2020 needed before dissemination to the market.

Cooperative project:

- NOVIMAR (H2020: Amongst others Netherlands Maritime Technology, EICB, Pro Danube);
- Ro-Boat

Actions of EIBIP and time frame:

- Support initiatives with the frameworks for this concepts, such as the barriers for automation and an identification of market demands.

5.3 New cargo flows

The introduction of new logistic and vessel concepts is meant to achieve a higher modal share of inland waterway transport. As mentioned in the introduction of this chapter, the modal share of inland waterway transport in Europe is around 6%. [9] An increased modal share can be achieved by expanding the share of inland waterway transport in existing cargo flows, but also in shifting cargo flows - which are currently performed by other modes of transport - to inland waterway transport. This can be done by facilitating the transport of new types of cargo or operating in new or under-utilised sailing areas.

There are still many under-utilised sailing areas. Currently, most of the European inland waterway transport (68%) is performed on the Rhine, with only 14% on the Danube, 16% on the north-south corridor (the Netherlands-France) and 2% on the east-west corridor (Germany-Poland). [10] Some projects focus on the use of these underdeveloped waterways, e.g. the Interreg-project EMMA (coordinated by the Port of Hamburg) proposed demonstrations on inland waterways in Germany, Poland, Lithuania, Finland and Sweden. Cooperation with such projects and the authorities in these countries are important for increasing the European modal share of inland waterway transport.

For both under-utilised as well as the main waterways, there is the possibility to attract new types of cargo. In exploring the opportunities to acquire new types of cargo, it is important to bear in mind that the sort of new types of cargo can differ between the different European sailing areas. For example, the transport of (maritime) containers by inland vessels is relatively common on the Rhine, between the Dutch and Belgian seaports and the Dutch, German and Swiss inland terminals, while containers aren’t yet transported by inland vessels on the Danube or the French canals. On the Rhine, there is the challenge of acquiring also continental container flows.

The degree of utilisation of the different sailing areas also differ between the different waterways, but – in general – there is an under-utilisation of small waterways and the use of inland waterway transport to supply city centres.

5.3.1 New cargo flows – Find your (water)way

The biggest potential has the shift of existing cargo flows from road or rail transport to inland waterway transport, in which inland waterway transport is fully integrated in the multimodal mix with the other modalities. There are several reasons that inland waterway transport is not yet been used for cargo flows. If focused on road transport, shippers and logistic operators are focussed on

[9] European Court of Auditors (2015), Inland Waterway Transport in Europe: No significant improvements in modal share and navigability conditions since 2001.
[10] NEA et al. (2011). Medium and Long Term perspective of IWT for the EU. DG MOVE.

this mode of transport, lacking the knowledge of the possibilities and the benefits of transporting by inland waterway transport. In the case of a shift to inland waterway transport, it is even mostly required to adjust the (internal) logistics of a company. A good example of this is the case of Heineken, transporting its export flow in The Netherlands from its brewery in Zoeterwoude via a new inland terminal in Alphen aan den Rijn to Rotterdam, by inland vessel.

Because of the scale, it is often needed to bundle the cargo flows of more shippers on the same vessel. In the Netherlands, a team of logistic experts (Maatwerk Voorlichting Verladers) has showed results in bundling flows from different shippers, giving them logistic advice in the optimal use of inland waterway transport and achieving modal shift in mainly container flows. On European level, within ELAN (European Logistics Advisory Network) a team of logistic experts gave advice to shippers and logistic service providers, in order to shift cargo to inland waterways. Gathering flows from several shippers is also being studied within the Seine-Scheldt project, especially to balance the new canal building materials flows.

Besides this active approach of shippers and freight forwarders, there are information portals in which ship-owning companies and charterers can be found (e.g. Blue Pages in the Danube region). Important is to advise on all types of cargo, containers, dry and liquid bulk.

Barriers

- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  It requires the bundling of cargo flows and a close cooperation with other modalities;

  Infrastructure: There are still some bottlenecks on some waterways (e.g. Danube) and in the facilities in the ports. Annual low water levels also require a multimodal approach.
- Cultural (Barriers caused by behavioural routines):

  To convince cargo owners, logistic operators, who are not familiar with IWT, needs a case-by-case approach.

Measures & instruments to overcome these barriers

- Advise on modal shift and bundling of cargo flows (e.g. Maatwerk Voorlichting Verladers, Connekt);
- Handbook for the use of IWT in the logistic chain (adopt the terminology of the logistic managers);
- Improvement of infrastructure, in line with ‘Good navigation status’ (PLATINA-II).

Actors:

- Shippers
- Logistic service providers, freight forwarders
- Charterers / IWT operators
- Ship-owning companies

Demonstration & implementation of measures & instruments:

- Maatwerk Voorlichting Verladers
- ELAN

Cooperative project:

- Maatwerk Voorlichting Verladers
- Connekt Lean & Green
- Synchromania serious game

- EMMA (pilot projects on inland waterways in Baltic sea)
- TEN-T Infrastructure projects
- FAIRway Danube
- DAPhNE – Danube Ports Networks (Danube Transnational Programme)
- Project MariGreen: Simulating Transport in a Co-Modal Logistic Environment
- PLATINA-II (over end 2015).

Actions of EIBIP and time frame:

- Stimulate the use of information pages or logistic experts
- Handbook on modal shift (adopting terminology of logistic manager)
- Logistic advice team

5.3.2 (Containerised) LNG as cargo

As LNG is seen as a promising alternative fuel, as mentioned in section 4.1.1, all the core inland ports are required to build LNG refuelling stations in the coming years. [11] As a result of the development of LNG infrastructure along the European inland waterways, it will become more and more important to develop ways of transporting LNG from the seaports to the hinterland. Because of the requirements of Clean Power for Transport directive for inland ports, it will offer a major opportunity for the use of inland waterway transport. LNG can be transported in two ways, with a tank vessel or in tank containers with a container vessel. Currently, this is mainly focussed on the transportation of LNG with tank vessels and there is very little experience in carrying LNG in tank containers. However, standardisation and mobility offer opportunities to transport LNG in tank containers.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):
  It requires the development of LNG tank vessels and LNG tank containers.
- Legal (Barriers caused by regulations and laws):
  Lack of a clear regulatory framework for the transportation of LNG by waterways and a very restrictive regulation for inland ports which don't enhance projects related to LNG transportation.

Measures & instruments to overcome these barriers

- Support to and dissemination of initiatives developing LNG tank vessels and LNG tank containers.
- Support in the development and implementation of the regulatory framework.

Actors:

- Authorities (regional, national and European);
- Shipyards;
- Container suppliers;
- Ship-owning companies;
- Gas suppliers;
- Inland ports.

Demonstration & implementation of measures & instruments:

[11] Clean Power for Transport directive
https://ec.europa.eu/transport/themes/urban/cpt_en

- LNG projects, e.g. in France, the national strategic development frame provides, until 2025, that LNG will be developed on the five major waterways corridors and along the three maritime facades. VNF will identify actors and structures that manage these major LNG development projects in France and will take part of it in order to overcome the different barriers mentioned earlier.

Cooperative project:

- Several projects in the north of France, linked to the methane gas terminal recently launched at the port of Dunkirk
  – https://www.edf.fr/en/the-edf-group/industrial-provider/production-map/dunkerque-lng-terminal/introduction -
  may need a support to be handled as a global project (VNF may help in uniting local stakeholders in the northern French region);
- A more structured initiative for the Rhône valley linked to the Marseille port;
- LNG Masterplan (TEN-T: amongst others Pro Danube): On the legislative framework of the transport of LNG;
- Breakthrough LNG Deployment in Inland Waterway Transport (CEF: amongst others EICB): On LNG tank containers.

Actions of EIBIP and time frame:

- Study on the global development strategy of LNG transportation on the inland waterways in northern France (VNF, 2017);
- Dissemination of cases of LNG transportation.

5.3.3 Cold/food chain transport

Reefer transport has a growing potential in seaports, on which IWT has a role to play. Important in this transport is providing shippers and logistic service providers real-time information on the track and conditions of the container. [12] However, there is a shortage of reefer containers, which results in high lead time, while this is essential due to high detention costs. Creating terminals specialised in the transhipment of perishable cargo is important, one example is the cool port programme of the Port of Rotterdam. [13]

The transport of orange juice by inland vessel is also mentioned in former studies [14](D1.9 Market Potential – PLATINA-II) and can be done in tank containers.

Barriers

- Market (Barriers caused by market conditions, infrastructure, and the supply chain):
  Shortage of reefer containers, leading to high detention costs.

Measures & instruments to overcome these barriers

- Improvement of the availability of loading units.

Actors:

- Cargo-owners;

[12] *There are several container operators applying this, e.g. Maersk: http://www.maersk.com/en/the-maersk-group/about-us/publications/group-annual-magazine/2015/smart-containers-listen-and-talk*
[13] *https://www.portofrotterdam.com/sites/default/files/downloads/Rotterdam%20Cool%20Port.pdf*
[14] *For example recently in the PLATINA-II report 'D1.9 Market Potential', but also before in FP6-project CREATING and the master thesis 'Barge hinterland transport of orange juice in Europe' (A. Sergio Ellero, 2009)*

- Logistic service providers;
- Terminal operators;
- Container operators;
- Ship-owning companies.

Demonstration & implementation of measures & instruments:

- Orange juice in tank barges
- Demonstration of reefer transport

Cooperative project:

- Cool Port Programme (Port of Rotterdam)
- Project MariGreen: Simulating Transport in a Co-Modal Logistic Environment
- Orange juice transport

Actions of EIBIP and time frame:

- Team up with operators, who already apply these concepts.
- Disseminate on the possibilities of IWT in these cargo flows.

5.3.4 Continental cargo flows

Container transport is a relatively new type of cargo flow for inland waterway transport and – due to the increased containerisation of cargo – one of the biggest growth markets. The oldest and most developed sailing area is the Rhine with container services since the 1970s, with container operators operating own inland terminals and liner services. More recently, container transport on an inland vessel has also been used for shorter distances, with the domestic transport of containers (inland terminals in the Netherlands since the 1990s) and feeder transport between the ports of Antwerp and Rotterdam. All these cargo flows are related to the transport of maritime containers, in which containers are transported between (mostly one) inland terminal and a terminal in a seaport. However, with this dense network of inland and sea terminal, there has been created a potential for inland water transport to increase their modal share: continental cargo. [15] To reach that goal, the 45’ pallet-wide container would increase inland transport capacity, and there is some innovation to be carried out on IW units to accommodate those large containers. In PLATINA-II, it was concluded that the potential container cargo flow amounts around 8.7 million TEU. The potential regions are North-East of France (Upper-Rhine), North-West (Lille, Dunkirk) and a lot of potential available in Austria, Slovakia, Hungary, Poland and the Czech Republic. [16]

Barriers

- Market (Barriers caused by market conditions, infrastructure, and the supply chain):

  It requires a lot of resources like special equipment and additional capacity needed for looking for new clients.

  Hard to get return cargo flows.

  Limited capacity on IW units to carry PW45’ containers.

Measures & instruments to overcome these barriers

[15] *PBV, STC, BDB (2016), D 1.8: Outline of market organisation and structure for continental transport chains. PLATINA- II.*
[16] *PANTEIA/NEA (2015), D 1.6: Macro analysis of market potential in the continental cargo market. PLATINA-II.*

- Introduction of hub and spoke solution[17]
- Digital tools for identification return cargo flows (e.g. “WeConnekt” app to identify shippers who are connected on the same transport route, Zeeland Connect is performing pilots on this)

Actors:

- Container operators;
- Ship-owning companies;
- Terminal operators;
- Logistic service providers.

Demonstration & implementation of measures & instruments:

- Adopt new logistic concepts which can facilitate continental flows, such as a hub-and-spoke system.

Cooperative project:

- Zeeland Connect

Actions of EIBIP and time frame:

- Dissemination on solution for continental container flows.

5.3.5 City logistics

With city logistics inland waterways are used for the transport to, in and from city centres, to avoid accessibility problems (road congestion, delivery time windows). This can be used for several different types of cargo, such as construction materials and industry, distribution to supermarkets, shops, hotels and restaurants, service trips, courier and express services and waste and return logistics. [18]

There have been several initiatives on the use of IWT in urban logistics in e.g. Amsterdam (Mokum Maritiem, DHL), Utrecht (Beer Boat), London (food transport to Sainsbury’s supermarkets), Lille, Lyon (waste transportation) and Paris (Franprix, Velib, Vert Chez Vous, paper recycling). This concept can be interesting for cities situated near waterways.

Barriers

- Technical (Barriers caused by immaturity of technology or operational requirements):
  New vessel concepts needed in some sailing areas (e.g. city canals), size, equipment;
- Legal (Barriers caused by regulations and laws):
  Differences in the legal status of transport by vessel within city centres.
- Knowledge (Barriers caused by a lack of expertise or skills):
  Relatively new segment of IWT, lacking information on this concept.
- Market (Barriers caused by market conditions, infrastructure, and the supply chain):
  Most cities lack a dense waterway network;
  Need loading facilities on quay or on-board (cranes);
  Small initiatives (only one city, one or a few shippers);
  Different ways of transport (containerised, palletised, parcels).

[17] *As studied in the IDVV research programme of Dutch Rijkswaterstaat: http://www.beterbenuttenvaarwegen.nl/ENG+English/ENG+Projects/314893.aspx?t=Hub+and+Spoke*
[18] *M. Janjevic & A. B. Ndiaye (2014), Inland waterways transport for city logistics: a review of experiences and the role of local public authorities. In: Urban Transport XX, p. 12.*

Measures & instruments to overcome these barriers

Overview of best practices and possible cities for these concept. Existing IW city logistics services must be studied on their business case, in order to replicate them in other cities.

Actors:

- Cargo owners established in city centres/urban areas;
- Freight forwarders organizing such complex services (e.g. XPO for Franprix in Paris);
- Ship-owning companies with these concepts;
- Public/municipal authorities.

Demonstration & implementation of measures & instruments:

- In several projects.

Cooperative project:

- Mokum Maritiem;
- Pallet shuttle barges.

Actions of EIBIP and time frame:

- List of best practices of city transport (handbook city transport on water);
- Actively promote city transport on water towards local authorities.

6 Conclusion

The objective of this document is to come to a strategy for the uptake of innovation by the IWT sector in the EU, based on input of ICs and recent studies by PLATINA-II and PROMINENT. The strategy is in line with the objectives set by the European Commission on the reduction of energy consumption and air pollutant emissions and to support ongoing policy issues (e.g. CESNI). EIBIP set two major ambitions for the inland waterway transport sector: 1.) Greening its fleet; and 2.) Increasing its share in the modal split. Resulting from these two ambitions are the two pillars, as described in Chapter 4 and Chapter 5. For each of the two pillars, three innovation areas were identified, see Table 2. This resulted in objectives for EIBIP and ambition indicators for its ICs, as described in the EIBIP Inception report (May 30th, 2016), which are in line with the objectives set by the European Commission.

Table 2: Pillars – Innovation areas – Objectives EC (2030) – Objectives EIBIP (2020) – Ambition indicators ICs.

Pillars	***Greening the fleet***			***New logistic and vessel concepts***		
Innovation areas	***Alternative fuels***	***Energy consumption***	***Air pollutant emission reduction***	***New logistic concepts***	***New cargo flows***	***New vessel concepts***
Objectives EC (2030)	Clean power for Transport directive	↓15%	↓50%	White Paper: 30% of road transport ≥300km → Rail + IWT		
Objectives EIBIP (Project Proposal: 2020)	10% of fuel consumption by alternative fuels	↓5%	↓20%	6.7% → 8% modal share IWT		
Ambition indicators (Inception report)		CO_2: 23.84 → 21.90 g/tkm = ↓1.94 g/tkm	NO_x: 0.338 → 0.177 g/tkm = ↓0.1607 g/tkm PM: 0.013 → 0.007 g/tkm = ↓0.0064 g/tkm			
	7 LNG / CNG vessels	230 persons trained in Smart steaming	31 vessels equipped with after-treatment	13 new vessel/logistic concepts		
	1 vessel with alternative fuels	16 hybrid/diesel-electric vessels	25 vessels with other technologies			
			160 users of tools like Econaut and Greening Tool			

This EU-Wide Strategy will be reviewed and updated at least once a year after consultation of stakeholders and in particular the EIBIP advisory board.

To contribute to achieving these objectives and ambition indicators, six priorities have been identified for the EU-Wide Strategy for Innovation Uptake in IWT:

1. New engine concepts and optimisation for an efficient and green propulsion

1a.- For the smaller vessels with low power sailing performance and/or using a low amount of gasoil per year, low power engines fulfilling NRMM regulations may be used in combination with after treatment or marinised EURO VI truck engines, both direct drive or in a hybrid/ diesel electric configuration. The right configuration can be simulated using a modelling and simulation tool.

- Contributing to concepts:
  - Section 4.3.2 New engine concepts/ optimisation;
  - Section 4.3.3 After-treatment;
  - Section 4.2.3 Hybrid/ Diesel-electric propulsion;
  - Section 4.2.4 Electric propulsion.
- Target groups:
  - Suppliers of EURO VI engines;

1b. The use of LNG as a fuel for propulsion is an interesting concept for the inland vessels that use more than 500m^3 of gasoil per year.

- Contributing to concepts:
  - Section 4.1.1 LNG/CNG;
  - Chapter 3 Sustainability Fund for Inland Shipping;
  - Section 4.3.3 After-treatment.
- Target groups:
  - Fuel suppliers;
  - Suppliers and manufacturers (engines, cryogenic tanks);
  - Shipyards & engineering consultants;
  - Ship-owners/Ship owning companies;
  - Cargo owners;
  - European, national authorities and river commissions;
  - Classification societies;
  - Knowledge centres;
  - Training institutes;
  - (Inland) ports and transhipment terminals;
  - After treatment equipment suppliers;
  - Banks

1c. For the vessels between 1a. and 1b. hybrid/ diesel-electric propulsion and full electric sailing may be a promising concept for green and efficient sailing most probably in combination with after treatment. Also marinised EURO-VI truck engines may be used to drive the generator. The right configuration can be simulated using a modelling and simulation tool.

- Contributing to concepts:
  - Section 4.2.3 Hybrid/ Diesel-electric propulsion;
  - Section 4.2.4 Electric propulsion;
  - Section 4.3.2 New engine concepts/ optimisation;
  - Section 4.3.3 After-treatment.
- Target groups:
  - E.g. Suppliers;

2. Structural financing formats

Structural financing formats as setting up a sustainability fund at European level need to be explored to accelerate the required investments for greening the inland vessels for the reduction of GHG and the environmentally harmful emissions like NO_x and PM produced by the IWT sector. Furthermore, fleet modernisation support schemes integrated in national operational programmes will provide another incentive to the innovation and greening of IWT sector.

- Contributing to concepts:
  - Chapter 3 Sustainability Fund for Inland Shipping;
  - Section 4.1.1 LNG/CNG;
  - Section 4.2.3 Hybrid/ Diesel-electric propulsion;
  - Section 4.2.4 Electric propulsion;
  - Section 4.3.3 After-treatment.
- Target groups:
  - Financial institutes;
  - European / national authorities

3. Next generation; low carbon solutions

Low carbon and renewable fuels as bio-fuels (diesel/ methane/ ethanol/ methanol/ etc.) including hydrogen is the next generation fuels for propulsion for inland vessels. The use of these kinds of fuels for inland vessels is new and need to be explored including the technical feasibility along with the viability considering the economic, environmental, and socio-economic benefits.

In that way, fuel infrastructure and powertrain technologies can be shared and sufficient economies of scale can be achieved.

- Contributing to concepts:
  - Section 4.1.3 Biofuels;
  - Section 4.1.4 Methanol;
  - Section 4.1.5 Ethanol;
  - Section 4.1.6 Hydrogen;
- Target groups:
  - E.g. Suppliers;

4. Logistic optimisation of inland waterway transport

Optimisation of inland waterway transport by means of a further utilisation of existing electronic information and integration of digital and IT tools, contributing to cost reduction (energy-efficient navigation in combination with route planning and optimal cargo load, auto piloting) and service improvement (track and tracing, information systems on route as well as cargo). This should result in the full integration of IWT in a synchromodal network and a shift of cargo flows to inland waterways.

- Contributing to concepts:
    - 4.2.1 Energy-efficient navigation
    - 5.1.1 Synchromodality
    - 5.1.2 RIS as supporting tool for transport management
    - 5.1.3 Digital market places for cargo flows
    - 5.2.2 Optimal cargo load
    - 5.2.3 Automation of navigation / vessel-trains
    - 5.3.1 New cargo flows – Find your (water)way
    - 5.3.3 Cold/food chain transport
- Target groups:
    - Suppliers (on the integration of digital tools);
    - Authorities (on the use of RIS);
    - Ship-owners / IWT operators (on the use of on-board tools);
    - Ongoing project consortiums such as RIS projects, DINA, PROMINENT, Covadem (on the demonstration and development of these concepts).

5. Active promotion of the modal shift towards IWT

Provision of logistic advise to cargo-owners and logistic service providers on the use of IWT in their logistic chains, actively promoting the possibilities of it by means of dissemination materials (handbooks, brochures or online) on the (success stories of the) use of IWT, better inclusion of IWT in the logistics education as well as case-to-case advice.

- Contributing to concepts:
    - 5.1.1 Synchromodality
    - 5.1.2 RIS as supporting tool for transport management
    - 5.1.3 Digital market places for cargo flows
    - 5.2.1 Vessel concepts for the efficient use of small inland waterways
    - 5.3.1 New cargo flows – Find your (water)way
    - 5.3.2 (Containerised) LNG as cargo
    - 5.3.3 Cold/food chain transport
    - 5.3.4 Continental cargo flows
    - 5.3.5 City logistics
- Target groups:
    - Cargo-owners / logistic service providers (on the use of IWT)

6. Stimulation of the development of new markets

Stimulation of the development of new markets for IWT, new types of cargo flows, new sailing areas. This stimulation will be done in direct contact with the authorities of countries, regions with under-utilised waterways, in which best practices of the use of small and urban waterways will be disseminated actively and these countries will be involved in EIBIP (in line with establishing (pre-existing) innovation centres in these regions). Furthermore, guidelines and dissemination materials on the development of new markets will be provided by EIBIP.

- Contributing to:
    - 5.2.1 Vessel concepts for the efficient use of small inland waterways
    - 5.3.1 New cargo flows – Find your (water)way
    - 5.3.2 (Containerised) LNG as cargo
    - 5.3.3 Cold/food chain transport
    - 5.3.4 Continental cargo flows
    - 5.3.5 City logistics
- Target groups:
    - Authorities (on the development of inland waterways);
    - Ship-owners / IWT operators (on the development of new markets);
    - Cargo-owners / logistic service providers (on the use of IWT);
    - Education & training institutes.

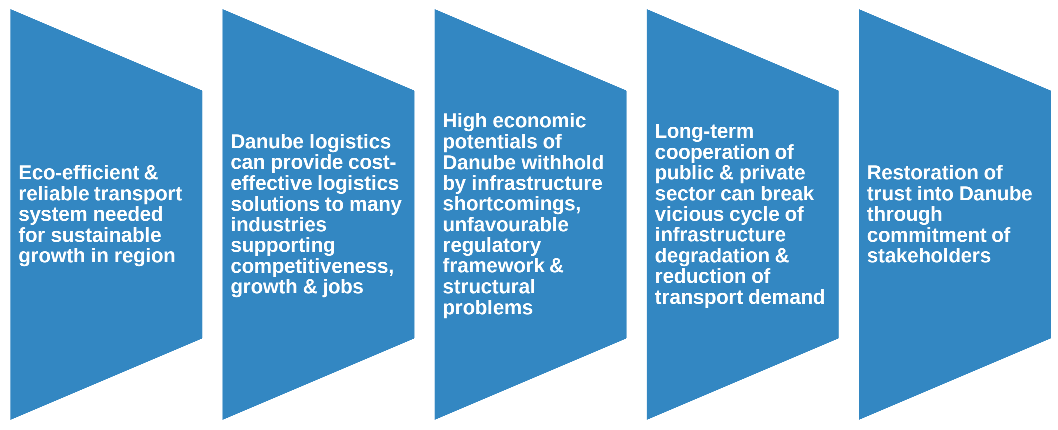
ANNEXES

Annex A	Innovation Uptake Strategy INDanube;
Annex B	Innovation Uptake Strategy D-ZIB;
Annex C	Innovation Uptake Strategy BATELIA;

Annex A. Innovation Uptake Strategy INDanube

Since the economic crisis in 2008/2009, the Danube IWT sector did not recover financially and severe negligence of waterway infrastructure as well as poor maintenance of the Danube fairway deprived the sector over many years from making profits. The lack of profitability of the Danube IWT business explains the extremely low level of investment into Danube fleets as well as port infrastructure and superstructure. In addition to the difficult economic and financial situation of the service operators, with the exception of Austria and to some extent Germany, Danube IWT is not a specific target of national innovation policies which means that there are no public financial incentives provided to develop and implement innovations in the IWT sector. Whereas almost all Western European countries have State Aid Schemes in place to support the modernisation of the inland fleet as well as the upgrade of the inland port infra- and superstructure, no Danube country east of Austria disposes of such a policy instrument.

Due to this situation, INDanube not only aims to generate and to facilitate innovation projects through its services but will be engaged also in building-up a policy framework which enables innovation in Danube IWT. This policy framework shall be embedded in the existing initiatives of the European Commission which foster the further development of the inland navigation sector in Europe especially such of the TEN-T, the EU Strategy for the Danube Region (EUSDR) and NAIADES II. This political initiative creating the framework for innovation carries the name "**Green Deal for Danube River Transport**" (see Figure A-1 for rationale & concept).

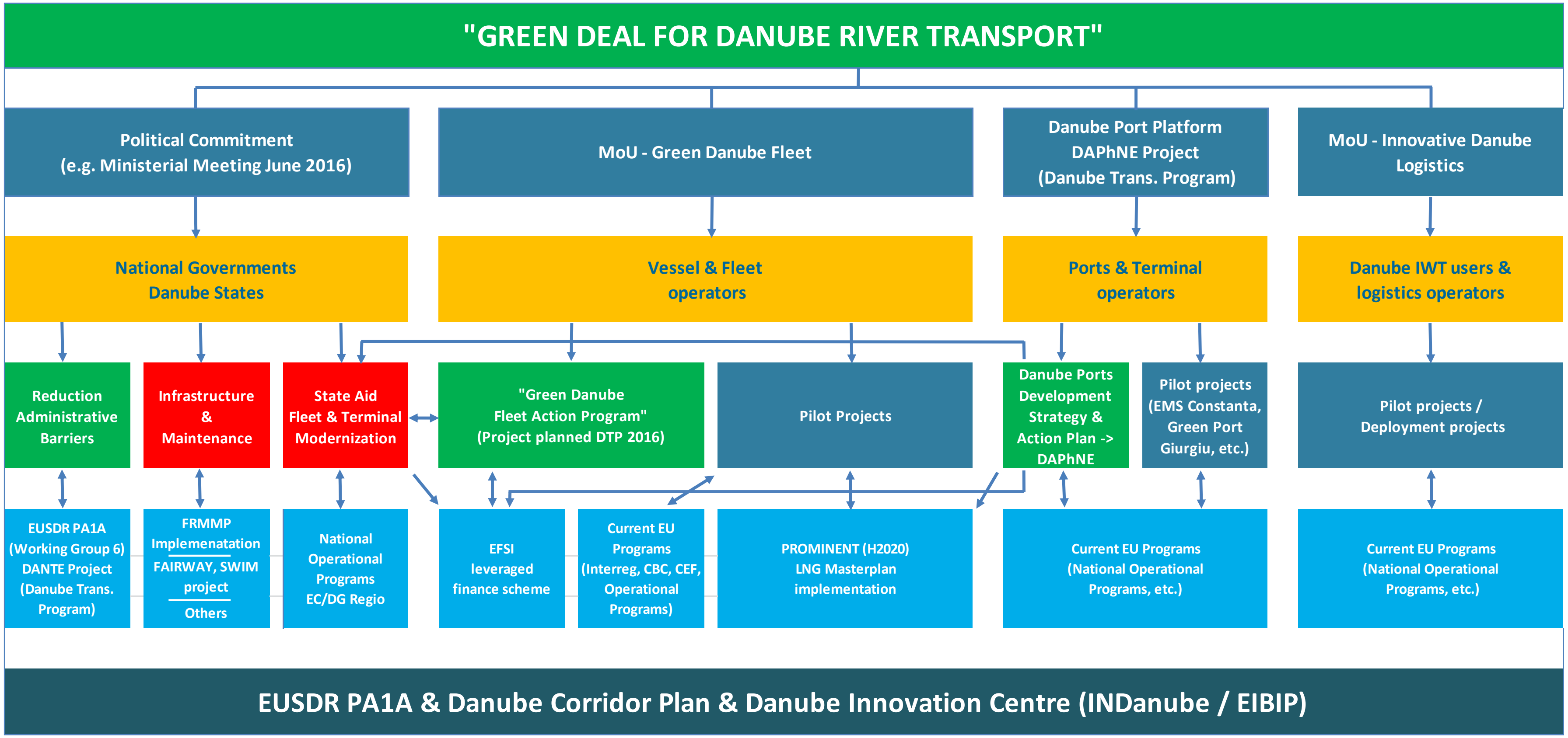


Green Deal for Danube River Transport

- Intensive, coordinated cooperation of public and private
- Improved efficiency & environmental performance of Danube logistics
- Tangible results supporting sustainable economic growth

Figure A-1: Green Deal for Danube River Transport – Rationale & Concept

The Green Deal for Danube River Transport is a policy initiative developed by Pro Danube for the build-up of the innovation framework for IWT in the Danube Region. Green Deal proposes good practice examples inspired from innovative models adopted in Western Europe, with dedicated focus on the modernisation of Danube fleet and the reduction of environmental impact. Based on four (4) main pillars, see Figure A-2, the Green Deal brings together governments/ administrations of the Danube States, fleet and barge operators, port and terminal operators as well as industrial users of the Danube waterway together with their logistics service providers.



Legend:

- Red: Pre-condition for innovation
- Green: Project platform in preparation by Pro Danube

Status: March 2016

Figure A-2: Structure of the Green Deal for Danube River Transport

The following key-elements are being addressed:

- Reduction of administrative barriers;
- Infrastructure and maintenance;
- State aid schemes for fleet and terminal modernization;
- Pilot project / deployment projects;
- Development strategies and Action Plans.

The EIBIP enables the INDanube to start creating the framework conditions for the Green Deal and its implementation. The tasks defined in EIBIP will be used to implement the Green Deal pillars that are the driving instruments to achieve the EIBIP indicators. EIBIP will also provide the framework to set up the cooperation with the Danube and give the opportunity to connect to other organisations in the Danube Region in case they are set up and operational, e.g. in Croatia and Serbia. Thus as the added value, EIBIP gives the mandate and project background for Pro Danube and its Danube partners to create and roll out the policy initiative (Green Deal) that shall be the basis of uptake of innovation in the Danube Region.

Political commitment of national governments

Pre-condition for the success of the Green Deal is the commitment of the Danube States to rehabilitate existing and to invest into additional infrastructure and to provide a state-of-the-art fairway maintenance ensuring the implementation of the Fairway Rehabilitation and Maintenance Masterplan.

Essential elements of this pillar are:

- Dialogue with key stakeholders to receive the political commitment of national governments, in particular (1) national authorities and administrations and (2) EC services
  Outcomes: MoU of Danube States;
- Rehabilitation of existing and investments into additional infrastructure and state-of-the-art fairway maintenance ensured by national governments ;
  Outcomes: Pilot projects like FAIRWAY[19], SWIM[20], others;
- Elimination of extensive bureaucracy creating administrative barriers imposed by border, navigation, port, canal, waterway and other authorities;
  Outcomes: Simplification – Harmonisation – Digitalisation considering PDI concept "Same River – Same Rules";
- Creation of Fleet and Port Modernisation support schemes in Danube States (e.g. State Aid Schemes);
  Outcomes: Fleet and port modernisation support schemes to create an economically favourable environment for investments in Danube IWT;
- Facilitation of (cooperation) projects that will generate best-practice and model project contributing to stepwise implementation of the Green Deal;
  Outcomes: (cooperation) projects like DANTE[21].

Target groups

- National Authorities & Administrations;

[19] *FAIRway Danube (07/2015-06/2020), https://ec.europa.eu/inea/sites/inea/files/fiche_2014-eu-tm-0219-s_final.pdf*
[20] *SWIM - SMART Waterway Integrated Management (07/2016 - 12/2020), https://ec.europa.eu/inea/sites/inea/files/fiche_2015-ro-tm-0366-w_final.pdf*
[21] *DANTE "Improving Administrative Procedures and Processes for Danube" IWT (01/2017 – 06/2019), www.interreg-danube.eu/approved-projects/dante*

- EC Services.

Green Danube Fleet Platform

Fleet and barge operators will elaborate a “Green Danube Fleet Action Program” which will list the fleet investments foreseen in the period until 2023, create a pipeline of modernisation projects and thus helps to define volume and focus of the national Fleet Modernisation support schemes and basis for other EU funding programmes (EFSI / Fleet Investment Fund / ERDF & Cohesion / wide scale deployment).

Essential elements of this pillar are:

- Dialogue with key stakeholders to receive the commitment of major fleet/vessel operators for elaboration of a “Green Danube Fleet Action Programme”;
  Outcomes: Commitment of key stakeholders (vessel / fleet owners and operators) and MoU after consultation with industry stakeholders;
- Establishment of the permanent working platform of Danube fleet / vessel operators;
  Outcomes: Danube Fleet Working Platform;
- Elaboration of a “Green Danube Fleet Action Programme” and its promotion;
  Outcomes: Fleet investment overview as part of the Programme creating list of future investment projects and serving as basis for the fleet modernisation support schemes;
- Facilitation of Europe wide research and innovation projects concerning the greening of fleet – with focus on technologies and their deployment);
  Outcomes: supported / facilitated projects like proposal in H2020 Call 2017 “INNOWATE – Innovations for energy efficiency and emission control in waterborne transport”;
- Facilitation of cooperation and pilot projects that will generate best-practice and model project contributing to stepwise implementation of the Green Deal, including promotion of such model projects & concepts;
  Outcomes: supported / facilitated projects of individual applicants or consortiums like planned Danube Fleet Platform project in Danube Transnational Programme (DTP).

Target groups

- Vessels & Fleet Operators;
- Transport Users & Logistics Operators.

Innovative Danube Ports Platform

The Green Deal facilitates cooperation between public and private entities along the Danube to ensure a balanced development of Danube Ports as eco-friendly, well accessible multimodal hubs for the transport system of the region and to turn them into buzzing economic centres functioning as catalysts for economic growth and creation of high value jobs. This shall be enabled by establishment of a well-managed working platform which tackles the most urgent insufficiencies with the help of guidelines, recommendations and concrete pilot activities based on good practices leading into an overall development strategy and action plan for the Danube ports. The activities will aim to improve port legislation, funding of port investments (State Aid Schemes and PPP models), port administration processes, port business strategies as well as port infrastructure and industrial development strategies. Special attention will be paid to human capacity building and eco-improvement options for the port sector.

Essential elements of this pillar are:

- Dialogue with key stakeholders to receive the commitment of major fleet/vessel operators for elaboration of a “Danube Ports Development Strategy & Action Plan”;

Outcomes: Commitment of key stakeholders (port / terminal operators, transport users and logistics operators, authorities) based on meetings and workshops;

- Establishment of the permanent working platform of Danube ports (private & public) consisting of ministries, port administrations, port users, logistics companies and other stakeholders;
  Outcomes: Danube Ports Working Platform;
- Elaboration of a "Danube Ports Development Strategy & Action Plan";
  Outcomes: Danube Ports Development Strategy & Action Plan serving as basis for the port modernisation support schemes and as a pipeline of projects;
- Facilitation of cooperation and pilot projects that will generate best-practice and model project contributing to stepwise implementation of the Green Deal, including promotion of such model projects & concepts like "High-Performance Green Danube Port Concept[22]" elaborated in TEN-T Programme ;
  Outcomes: (cooperation) projects like DAPhNE [23] or planned pilot project "Green Port Constanta".

Target groups

- Terminal & Port Operators / Authorities.

Innovative Danube Logistics

The commitment of transport users to use green IWT services as well as setting-up innovative Danube IWT logistics services shall be demonstrated with the help of a MoU and the generation of related projects. The Green Deal partners shall use the existing EU programs to generate best practice and model projects in order to prepare the stepwise implementation of the Green Deal strategy.

Essential elements of this pillar are:

- Dialogue with key stakeholders to receive the commitment of major transport users and logistics operators;
  Outcomes: Commitment of key stakeholders (transport users and logistics operators) and MoU after consultation with industry stakeholders;
- Increase the awareness for IWT among transport users and logistics operators (cargo shippers and logistics service providers) and prepare basis for the cooperation with logistics stakeholders to gain their commitment to use of inland navigation;
  Outcomes: Continuous information sharing with transport users and logistics operators about the Danube transport and innovation activities and organisation of a dedicated innovative logistics session as part a major IWT event;
- Facilitation of research and innovation projects as well as (cooperative) pilot projects along (intermodal) logistics chain addressing new logistics concepts, new cargo flows and new vessel concepts that will generate best-practice and model project contributing to stepwise implementation of the Green Deal;
  Outcomes: supported / facilitated projects.

Target groups

- Transport Users & Logistics Operators.

[22] *High-performance Green Port Giurgiu (07/2013 - 08/2015),* *https://ec.europa.eu/inea/sites/inea/files/fichenew_2012-eu-18089-s_final.pdf*

[23] *DAPhNE - Danube Ports Network (01-2017 – 06-2019),* *www.interreg-danube.eu/approved-projects/daphne*

Indicative work program for 2016 - 2018

The indicative work program of INDanube for 2016 – 2018 is defined in line with the Green Deal for Danube river transport, being summarised with the related actions of the IC in Table A-1.

Table A-1: Work program of INDanube for 2016 – 2018 in line with the Green Deal for Danube river transport

Indicator	Priority	INDanube	Contributing INDanube activities	Related INDanube milestones
Number of ships being equipped with a differentiation for the various green technologies Corresponding Green Deal pillar: • Green Danube Fleet	LNG/ CNG	5	Based on analysis of suitable EU funding options, support to grant applications in suitable programs will be provided for companies on individual basis or in consortia structure	Depending on timeline of CEF Synergy Call, CEF Call 2016 and Call 2017, Call timeline in POIM Program of Romania, call timeline in relevant CBC programs
	Hybrid/diesel-electric	10	Based on preparatory work as part of "Green Deal" initiative, support to decisions regarding engine major overhaul or replacement	Identification of relevant investments as part of "Fleet Renewal Action Plan"/Green Deal in 2016, identification of suitable public support schemes and submission of grant applications in 2016, submission of grant applications in 2017 and 2018
	After-treatment	1	Identification of barge operator willing to participate in real-life test as part of EU grant program application and submission of the project application	Depending on timeline of CEF as well as H2020 calls 2016. 2017 and 2018
	Alternative fuels	-	--	-
	And other technologies (Smart Steaming)	20	Based on the results of the "efficient navigation" pilot activities carried out in the PROMINENT H2020 project, a deployment project shall be developed and submitted for co-funding in a suitable EU/national funding scheme	Grant application in a suitable EU program for a group of companies deploying smart steaming applications, depending on call options and respective timelines project submission planned for Q2/2017 - Q2/2018
Emissions reduced by applying the technologies and by energy-efficient navigation (due to tools and training provided through EIBIP) Corresponding Green Deal pillar: • Green Danube Fleet	Weighted average fuel saved and reduction of CO_2 [g/tkm]	3,18		
	Weighted average NO_x reduction [g/tkm]	0,0770		
	Weighted average PM reduction [g/tkm]	0,0034		
Impact (in number of persons) of the tools and services provided through EIBIP Corresponding Green Deal pillars: • Green Danube Fleet • Danube Port Platform	Number of persons using tools/applications like ECONAUT and the Greening tool provided through EIBIP	60	Real life use of greening tools will be part of planned "efficient navigation" deployment project	Project applications planned to be submitted in Q2/2017-Q2/2018 depending on timeline of suitable EU funding programs
	Number of persons trained on green technology (including by web based tools like Smart Steaming training)	100	Training of green navigation tools and technologies will be part of planned "efficient navigation" deployment project	Project applications planned to be submitted in Q2/2017-Q2/2018 depending on timeline of suitable EU funding programs
	Number of new vessel concepts/new logistic systems, including the degree of deployment	2	Identification of interested transport users/logistics service providers/barge operators as part of "Green Deal" initiative and development of a project for EU/national funding application	Identification of projects Q2/2016 onwards, submission in suitable funding programs in 2016/2017 according on respective program timelines
Value of the economic effects	Value of total investment [M€] in the application of technologies and	11,3		

Indicator	Priority	INDanube	Contributing INDanube activities	Related INDanube milestones
Corresponding Green Deal pillars: • Political commitment of national governments • Green Danube Fleet • Danube Port Platform	vessel/logistic concepts			
	Value of private investment [M€] by the sector in the application of technologies and vessel/logistic concepts	7,5		
	Number of generated funding schemes (Regional, National, …..)	3	State Aid Fleet Modernization Schemes shall be initiated in close cooperation with most interested Danube States as part of the "Green Deal"; based on a widely harmonized draft model scheme it is expected that at least three Danube States will start the elaboration of a funding scheme which will be included into EU programs; working platform with Danube States administrations to be set up in the framework of PA1A; interaction with activities in NW Europe regarding launch of Fleet Investment Fund /use of EFSI funds	Start of work with at least 3 interested Danube States as from Q3/2016 to Q2/2017 as part of EUSDR/PA1A activities; achieving political commitment at the latest in Q3/2017; preparation of draft funding scheme for fleet modernization as part of EU funded project until Q4/2017; inclusion of funding schemes in national operational programs until Q2/2018
	Size of generated funding schemes [M€] (Regional, National, …..)	50		
Impact on the cooperation and commitment of external partners Corresponding Green Deal pillars: • Political commitment of national governments • Green Danube Fleet • Danube Port Platform	Number of consortia <u>with</u> clear commitment for investment in greening and the value of their commitment (in money, the amount of resources and tools, etc.)	3	Conclusion of MoU of Danube Fleet operations to set up "Green Danube Fleet Action Plan" Conclusion of MoU of transport users & Logistics service providers to set up innovative Danube waterborne logistics concepts Set up project consortia for grant application in Danube Transnational Program (DTP) Call 2016	MoU Fleet Operators Draft concluded end 2016 MoU Transport Users & Logistics Service Providers concluded until Q2/2017 DTP application submitted autumn 2016 (depending on program timeline)
	Number of partners <u>with</u> clear commitment for investment in greening and the value of their commitment (in money, the amount of resources and tools, etc.)	30	as partners of the planned MoUs and grant applications	according timeline of respective planned activities
	Number of projects initiated, requesting for support of EU, National, Regional funding, bringing innovation to the market	15	company projects which might be consolidated according to needs of funding programs	according timeline of respective planned project application
	Amount of grants realised	12		
	Value of grants realised [M€]	60		

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Annex B. Innovation Uptake Strategy D-ZIB

D-ZIB has developed an Innovation Uptake Strategy to define in concrete terms the contribution it will make to reach the combined goals of EIBIP. Part of the strategic development process has been to identify the instruments and measures that will support innovations in inland waterway transport and how they can be implemented.

An initial workshop was carried out on 13th October 2016 to serve as a first brainstorming session on the following topics:

- Define the objectives of D-ZIB;
- Define the status of the innovation activities in the inland waterway sector in Germany;
- Develop ideas for possible measures to be implemented by D-ZIB;
- Identify the framework conditions for implementation of these measures;
- Define the next steps for this strategy development.

These questions were discussed in the workshop through a sequence of strategy-related questions and answers. The outcomes are documented in this presentation.

General Goals of D-ZIB:

- Increase the capacity for innovation in inland navigation and support actions in this area;
- Develop solutions to overcome market barriers to environmentally friendly inland waterway transport and improve the efficiency of inland waterway transport;
- Support the market introduction of innovative technologies in the inland waterway sector;
- Reinforce the economic and environmental importance of inland waterway transport across other modes of transport through innovation;
- Develop innovative solutions to promote modal shift from road to IWT;
- Contribute to increasing the political value and recognition of inland navigation in Germany;
- Establishment D-ZIB as a central point of contact and a neutral advisory centre for innovative stakeholders in inland navigation;
- Establish D-ZIB as a source of information and act as an ‘antenna’ for innovative developments in inland navigation.

Concrete Goals of D-ZIB:

1. Support the development of efficient and ‘green’ technologies for inland waterway transport;
2. Support the development of innovative logistics solutions for inland navigation;
3. Support the development of innovations in the area of safety;
4. Support the development of innovative financing models for inland waterway transport;
5. Develop cooperation between inland waterway vessels and knowledge institutes;
6. Initiate and coordinate innovation projects for inland waterway transport;
7. Network inland waterway operators with a view to innovation development;
8. Strengthen applied research and development for inland navigation;
9. Prepare ‘best practice’ examples of innovation uptake in inland navigation;
10. Improve the accessibility and receptiveness of IWT operators to innovation-oriented activities;
11. Promote academic and non-academic education and training for inland navigation operators;
12. Develop project development competence for operators of inland navigation.

Below is a detailed summary of strategic themes discussed during the expert workshop held on October 13th, 2016.

Target Groups of D-ZIB

Key stakeholders of the Inland waterway transport sector in Germany, defined accordingly:

- Enterprises in the field of inland waterway transport and industry (primary target group);
- Knowledge institutes for (inland) shipping;
- Parties responsible for inland waterways;
- Other related actors.

In concrete terms, the stakeholders identified above encompasses:

- Inland waterway shipping companies and ship owners, including passenger shipping;
- Forwarders, loaders, shipping companies, logistics companies;
- Shipyards, suppliers and maritime services;
- Port authorities and relevant regulatory bodies;
- Universities and learning institutes;
- Classification societies and associations;
- Politics and administration at the municipal-, state-, federal- and EU-levels;
- Media.

The current state of innovation in inland navigation in Germany can be described accordingly:

- Innovation in shipping is less developed than in other sectors;
- Within the shipping sector, there is below-average innovative performance in inland navigation;
- While there has been market-driven innovation uptake in recent years, there has been no continuous tendency towards innovation and only a small number of innovation activities have been published;
- Innovation thresholds typical for the industry (e.g. from single-hull to double-hull vessels);
- There are only a few innovative inland waterway shipping companies (‘first movers’) in Germany;
- There are few drivers of innovation from the fields of science and research (e.g. DST) for inland shipping in Germany;
- Innovations are more ‘the exception rather than the norm’ created out of economic necessity or personal interest;
- There is limited transfer of innovative solutions from other sectors or industries
- Transfer between innovators-givers and innovators-receivers is not structurally anchored in the area of inland navigation in Germany (approaches in NRW)
- There is no general analysis available of the innovation in inland navigation in Germany (only specific findings);
- So far there is no central office in Germany with an overview of the innovations in the inland navigation and access to knowledge (even a fleet overview is not available).

The main barriers to innovation in inland navigation in Germany can be summarized accordingly:

The identified barriers relate to the companies and the structure of the inland waterway:

- Limited availability (and time) of IWT operators make engagement of ship operators difficult;

- There is a split/fragmented ownership structure for inland waterways vessels;
- Low technological knowledge on behalf of ship operators;
- Little openness to innovation and low perception of support that is available for the market uptake of innovation;
- Limited capacity for research and development;
- Limited equity available for innovation;
- Long life cycles of inland vessels and long terms of ship financing;
- Return of invest in innovation is uncertain and difficult to calculate;
- Limited market perspectives for innovations due to limited number of parts and comparatively low standardization (e.g. in engine technologies);
- Little awareness about existing funding options and scepticism about application procedures.

New legal regulations could be more effective in driving innovation (e.g. exhaust gas limits for engines of inland waterways vessels by the EC Stage 5 "Non Road Mobile Machinery" -EU Directive, which will come into force on January 1st, 2019 and January 1st, 2020.

Until now there is no structure to support for innovation in inland navigation in Germany.

<u>In which areas is innovation most necessary?</u>

- Technologies for emission reduction;
- Propulsion systems to improve engine efficiency;
- The use of alternative fuels;
- IT and telecommunications solutions;
- Port development and logistics solutions;
- Education and training concepts.

<u>Possible innovation-promoting measures of D-ZIB:</u>

1. **Single Business Advice:**
- Innovation consulting (project-related);
- Innovation audits (business-related);
- Innovation transfer consulting;
- Research-technological consulting (with the assistance of experts);
- Advice on financing and funding programs;
- Energy advice (via experts);
- Organization-, logistics- and IT-consulting (also for ‘smart procedures’ in ports).

2. **Project Support:**
- Initiation of cooperation and innovation projects;
- Development of cooperation and innovation projects, possibly leading to funding application/s;
- Management of cooperation and innovation projects.

3. **Information measures:**
- Information sharing about new technologies and concepts (e.g. through events);
- Generation and dissemination of ‘innovation best practices’ for inland waterway transport.

4. **Networking:**
- Establishment and maintenance of an ‘Innovation Network for Inland Waterways’ in Germany, through which targeted contacts between the members can lead to innovations.

5. **Innovation Instruments:**

- Development and implementation of an advisory program for inland navigation (including 'Digital Consulting' on board);
- Building and provision of a web-based 'knowledge pool' of innovations, technologies and innovative service providers in inland waterway transport;
- Development and use of measuring tools (e.g. Econaut CO2 calculator, Greening Tool, Total Cost of Ownership Tool, etc.).

6. Education and Advanced Training:

- Support of the further development of inland waterway training with regard to training modules on the topic of innovation;
- Initiating and developing training programs for inland waterway transport.

<u>Possible Accompanying Measures of D-ZIB:</u>

a) Innovation Monitoring:

- Establish a baseline analysis of the innovative performance of German inland navigation (student work);
- Continuous identification and presentation of innovations from German inland navigation on the 'Innovation Radar' of the website;
- Establishment of an expert panel for the innovation performance of German inland waterways with regular (e.g. semi-annual) workshop meetings.

b) Innovation Policy:

- Participation in relevant public and political bodies for inland navigation;
- Influence and participation in (funding) programs for inland waterway transport.

c) Innovation Strategies:

- Establish and update an innovation strategy for German inland navigation;
- Participation in the European Inland Waterway Strategy.

d) Innovation Studies:

- Centralized commissioning of (technology) studies for the industry, also as a research study.

Development of a guide for the development.

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Annex C. Innovation Uptake Strategy BATELIA

Batelia has been worked out in 2016 an innovation roadmap, whose purpose is to point out which challenges IWT faces in France, of various sorts like technical & organisational challenges which may be solved by innovation. This roadmap also contains several experiments which Batelia will support, as they match with priorities identified within this roadmap. Table C-1 shows a list of relevant technologies from BATELIA's innovation road map.

Table C-1: List of relevant technologies from BATELIA's innovation road map.

Device	Energy Savings	Possible cost	Comments
1- Optimum hull & stern design (CFD 3D + towing tank)	50% (engine power from 1 to 2)	50k€ to 200 k€ studies per vessel	As much as studies for a whole vessel ! restricted water sciences to be developed
2 - Diesel with electronic injection	12% à 15%	D (*) ROI about 8 years	Modern vessels already fitted
3 –H_2 fuel enhancement for diesel engines (« H_2 kit »)	5-7% : elec. injection 10-25% : old diesel	<0,05D	Small companies – no large industry (p) less pollutants: -20/-40%:HC,PM,NOx
4 – « classic » Nozzle propellers (Ka+N19, Ka+N37 etc...)	30% (20% - 50% depends on speed)	0,3D – 0,35 D ROI : 2-3 years	Modern vessels already fitted : Rhine, Danube, ...(CFT, Lafarge ... in France)
5 – «Pump Propeller» Advanced nozzle propeller	40% / naked propell. 15% /classic nozzle	0,35D - 0,45D ROI : 2-3 years	15% fuel savings compared to « classic » nozzle propeller, cost quite close
6 – High efficiency diesel (exhaust heat recovery system)	7%	1,05 – 1,2 D	Rankine Cycle + Thermoelectricity (to be developped with engine manufacturers)
7 – Hybrid propulsion (incl.present Diesel-Electric systems)	5 – 20%	1,1 - 1,5 D diesel-elec: 1,3D	Savings mainly during maneuvers & locks, none or little while «cruising»
8 – Eco-pilot system	5 – 20% up to 30%	<0,1 D	Efficient on a varied route : savings depend on the waterman
9 – GNL	- 30% on FOD cost (when Oil is expensive)	>2 - 2,5D - Example Rhine vessel : 2M€	(p) Removes also pollutants : HC, PM removed, -10% NOx
10 –Diesel de – contamination DPF+SCR/ H_2 Kit + inland scrubbers	economy on pollutants external costs	From 20-30 €/kW to 100-130 €/Kw	DPF+SCR (road technology):100-130 €/kW Kit H_2 + inland scrubber (R&D): 20-30€/kW
(*) D = Present cost of a complete new Diesel room		*(**) To be created, developed, industrialized possible cost of final equipment excluding R & D*	*PJPompée 2015*

Technical and organisational challenges

1) Technical challenges

- A good energy performance (can still be improved) (200 to 460kJ/Tkm depending on the boats, compared with 1000 at more than 4000kJ/Tkm by road, from the motorways to the outskirts of the cities);

  Realistic target: 30% - 50% improvement.

- A poor environmental performance: engines to be decontaminated: fine particles, NO_x, unburnt hydrocarbons:
  - Environmental standards in preparation (EMNR regulation);
  - Road transport has made significant progress in terms of environmental performance;
  - Rather few "off-the-shelf" solutions: exhaust gas treatment facilities, LNG;
  - Logistical efficiency: empty runs, high handling costs.

2) <u>Challenges IWT industry faces</u>

- A non-standard technical domain at a meeting point of several fields of application, with a high & always underestimated level of complexity:
  - Navigation in confined areas: boat-construction interaction;
  - Size of intermediate components between the road vehicle (< 300kW) and the large maritime vessel (> 2MW); 1% only of the engines produced (10% of the engines fitted for marine environments etc.).
- A lack of finance support in knowledge and engineering:
  - Maritime architects are relatively unfamiliar with confined navigation;
- The production series that are too small
  At a unit cost of one to five million Euro, it is difficult to make technical progress break even on a small production series (car 100,000 units, aviation 100 to 1000 units) or on a large unit (large maritime vessel at 200m€, including 20m€ of studies).
- A scattered sector that is predominantly low-tech or made up of SMEs with a culture of individualism.

State of the art

<u>Challenge no. 1 –</u>

Reduce the consumption of boats

<u>Challenge no. 2 –</u>

Reduce polluting emissions

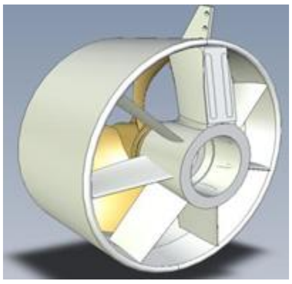
Experiment 1 (OBJECTIVE N° 5): propeller pump

<u>Challenge:</u> Reducing the energy consumption by 15% to 40%, depending on the case.

<u>Principle:</u> Improving the propulsion performance (*), and reducing the consumption.

<u>Ideal configuration :</u> Push tug (including with jet nozzles) for example 2x1000 HP, 2m propellers, consumption of 600 to 800 000 L per year; 75m to 90m barge 1200 to 1800 TPL, 800HP to 1200HP engine (propeller diameter 1.50m to 1.60m) on a regular route with enough water beneath the keel.

<u>Action plan:</u> Identifying the shipper / boat, setting up the contracts, planning the setup & measures; there is already a project diagram and complete contractual document, which can be improved, that has been established for a ship-owner by Shipstudio with ADEME (French environmental agency). Final objective: standard waterway series diameters of 1.5m to 2,0m, power of 400kW to 1500kW (*) "propulsion performance": ratio of the towing power to the engine power.



Experiment 3 (OBJECTIVE N°10): Decontamination kit

Challenge: Reduce polluting emissions, according to the regulations, including those for existing engines.

Principle: Mainly exhaust gas scrubbing complemented by the H_2 kit for reducing the size of the scrubber (from 20% to 40%) and possibly an additional SCR to improve the elimination of NO_x gases Configuration to be found: barge equipped with an engine (800HP to 1200HP), sustained activity (large number of hours per year).

Ideal: Very typical medium-power CAT C32 or C3512 type engine.

Entire project to be developed: Study – installation – measures before and after – follow-up for 6000 hours.

Key points:

- Based on the temporary navigation measures which have not yet been approved by VERITAS: possibility of a CCNR accreditation per unit;
- Future approval conditions in accordance with the new European regulations per unit (existing engine) or per series (new engines).

Experiments

The purpose is to provide innovation projects stakeholders with a positive technical & financial assistance. The following projects have been identified:

- Implementation of a propeller-pump on a RHK-type vessel on the river Seine ; consortium is currently being formed, between the propeller-pump manufacturer, a ship-owner, the French national environmental agency & VNF both providing subsidies;
- Implementation of a EURO-VI compliant diesel truck engine on a IWT vessel;
- Dissemination on the results of a Flexfuel after-treatment kit implemented on 20 IWT vessels in 2014 (subsidies provided through the French IW fleet modernization program),
- Implementation of a hydrogen-battery hybrid pusher on the river Rhone (Promovan 2).

Private projects support

- Hybridation of a RHK-type self-propelled unit « Auxerrois »;
- On-line dissemination of various solutions, after comparative analysis.

BATELIA management

- Formation of a BATELIA advisory board;
- Two to three meetings to hold in 2017.

Communication

- Organisation of an EIBIP workshop with Mariko in Strasburg about alternative fuels;
- Organisation of EIBIP/BATELIA workshops within Riverdating (November 29th & 30th, 2017, in Paris, France).

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