Interreg
EUROPEAN UNION
Danube Transnational Programme
DAPhNE

New Markets Studies

Act. 5.4

Output 5.1 Port investments guidelines & New markets studies

Work Package 5 – Port Development

PP responsible: HFIP

11 December 2018

Final 1.0

Project co-funded by European Union funds (ERDF, IPA)

Danube Transnational Programme
DAPhNE

Document History

Version	Date	Authorised
Draft 0.1	26.10.2018	HFIP
Draft 0.2	15.11.2018	HFIP
Final 1.0	11.12.2018	HFIP

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Source Documents

Name	Date	Authorised
Best practice examples regarding industrial ecology	29.06.2018	HFIP
LNG as cargo in the Danube ports	29.06.2018	PDI
Danube Ports and the Physical Internet	15.10.2018	FHOO
Container Market Report	17.10.2018	EHOO

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Executive Summary

The **DAPhNE – Da**nube **P**orts **Ne**twork project aims to facilitate **a balanced development of Danube ports as eco-friendly, well-accessible multimodal hubs** for the transport system of the region, turning them into **buzzing economic centres functioning as catalysts for economic growth and the creation of high value jobs.** The role of this document is to make a report about the contents of all deliverables elaborated in Activity 5.4 – Innovation & new market opportunities, in order to provide **a general overview of the innovative markets** that are relevant for the Danube in the upcoming period: industrial ecology, LNG as cargo, the Danube container market and Physical Internet.

Industrial ecology is **a closed loop system** – if a manufacturing activity generates **by-products and waste** beside the main product, those **must be handled and reused** by other units **to** avoid, or at least **reduce** the volume of **pollution**.

Several different factors influence industrial ecology in inland ports: the **labour force**, **supportive legislation** (regulations, limited administrative barriers), **governmental pressure** (the engagement of managing authorities/ministries) and **economic motivators**. Industrial ecology can only be profitable, if **the prices are market-oriented and affordable** – the ports also need to have **manufacturers and processing companies settled near** them for this to work. The target groups involved depend on the size of the port and the nature of its logistics services.

Liquefied natural gas (LNG) is an **alternative fuel source**. Its achieved **energy density is higher** than in the case of compressed natural gas (CNG) which makes LNG cost-efficient over long distances – **specially designed cryogenic sea vessels** (LNG carriers) are used in its marine transport.

The most relevant factor driving the research regarding LNG is the **legal framework** behind it – several EU- and lower level directives make its use necessary. In order to establish a consistent infrastructure, some preconditions have to be ensured:

- a predictable **legal and regulatory foundation**, which facilitates LNG deployment;
- **governmental support** (i.e. national level funding programmes);
- sufficient **training**/educational infrastructure concerning LNG;
- **information campaigns** for fleet owners and the general public;
- **competitive costs**; and
- emphasis on **a "bio" component** (LBG).

Several different sectors must be involved and informed about the benefits of LNG: e.g. gas companies, logistics service providers, freight transport companies in all modalities, consumers, the responsible public and private authorities.

Containerization revolutionized maritime transport in the 1970s. A **full container load** (FCL) is loaded and unloaded under the account of one shipper and one consignee, with lower freight rates than in the case of an equivalent weight of cargo in bulk. A **less-than-container load** (LCL) shipment is not large enough to fill a standard cargo container – different quantities of materials from different shippers or to different destinations are carried in a single container for efficiency.

There are only a few loaded container transports on the Danube due to **environmental** (unstable navigational conditions), **infrastructural**, **institutional**, **economic** (competitive shuttle train connections), **legislative** (lack of financial support) and **political** (past wars)

difficulties. There is **a demand for the New Silk Road to create a connection to the Danube Region** and a need for establishing and developing **full container liner services** to offset the currently insufficient railway capacity. An alternative opportunity is the **empty container traffic**. Nevertheless, the railway prices are critical benchmarks that have to be reached in order to get **a cost structure, which can survive under market conditions**. While the expansion of spot traffic seems more efficient and economical in the short term, the offer of an empty container liner service should remain a part of the long-term strategy for the Danube.

In maritime and inland waterway transport, the **Physical Internet** refers to **the combination of digital transportation networks** – the main idea is that shipments are transported anonymously and organized on their own through a constant data exchange between the involved stakeholders (similar to sending an e-mail).

Since transport is expected to triple by 2050 over the next 30 years, the continent needs to accommodate the new transport flows using all available transport modes. By applying the concept of **synchromodality**, ports can counteract the current bottlenecks with the **strategic use of** their **existing capacities** – the Danube has an advantageous location in Europe for this to work. The Physical Internet also creates a scenario in which the **three perspectives of sustainability** (society, economy and ecology) are respected and improved. The demand for **time efficiency** and **multimodality** drives its development, but the **lack of security, robustness and trust** act as major barriers. Implementing it helps ports to reach the 5^{th} level of their development: a **Customer-centric Port Platform**, where everything is standardized, and the focus is on the optimum satisfaction of the customers. The conducted study summarized the critical success factors into seven categories: awareness/**mental shift**, network/cooperation/**trust**, **ICT**/ITS technologies, **physical infrastructure**, **sophisticated planning**, **legal**/political **framework** and **pricing**/cost/service.

Studying the emerging opportunities regarding these new markets makes it clear that there are – at least – two important **connection points** between them:

1. Several development plans focused on **industrial ecology** include a component concerning alternative fuel sources, specifically, **LNG**. Although **the use of LNG** does not eliminate all contamination and waste, it is eco-friendly and sustainable – a study shows that it **leads to a reduction of 35% of the operational costs and 25% of CO_2 emissions**, proving itself to be a smart choice both economically and ecologically.
2. The **Physical Internet** has effects on both **industrial ecology** and **containerization**. It can be used to **monitor the capability and condition of different types of equipment remotely**, therefore, if one of them becomes obsolete, it can **support its retrieval and recycling**. Within the **ATROPINE project** (Fast track to the Physical Internet), some current ideas were identified for a **Physical Internet container**.

Due to the implementation of these intertwined markets, current **jobs** at ports **will change** and **new job opportunities** will open up. As a result of this, the respective **training needs have to be adopted** and the current logistics education should take the changing environment into account.

1 Introduction

Most of the Danube ports on the middle and lower river sections are still struggling to compete with their Upper Danube counterparts in terms of cargo types, infrastructure and logistics facilities. The **DAPhNE – Da**nube **P**orts **Ne**twork project aims to facilitate **a balanced development of Danube ports as eco-friendly, well-accessible multimodal hubs** for the transport system of the region, turning them into **buzzing economic centres functioning as catalysts for economic growth and the creation of high value jobs**. To achieve this goal, 23 partners – ministries, port administrations, port users, specialized consultancy firms, logistics companies, NGOs and universities – teamed up from 9 countries (Austria, Bulgaria, Croatia, Hungary, Moldova, Romania, Serbia, Slovakia and the Ukraine) to **establish a 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. As part of the project, new markets were analysed in the framework of **Work Package 5 – Port Development**. The role of this document is to make a report about the contents of all deliverables elaborated in **Activity 5.4 – Innovation & new market opportunities**, in order to provide **a general overview of the innovative markets** that are relevant for the Danube in the upcoming period: industrial ecology, LNG as cargo, the Danube container market and Physical Internet.

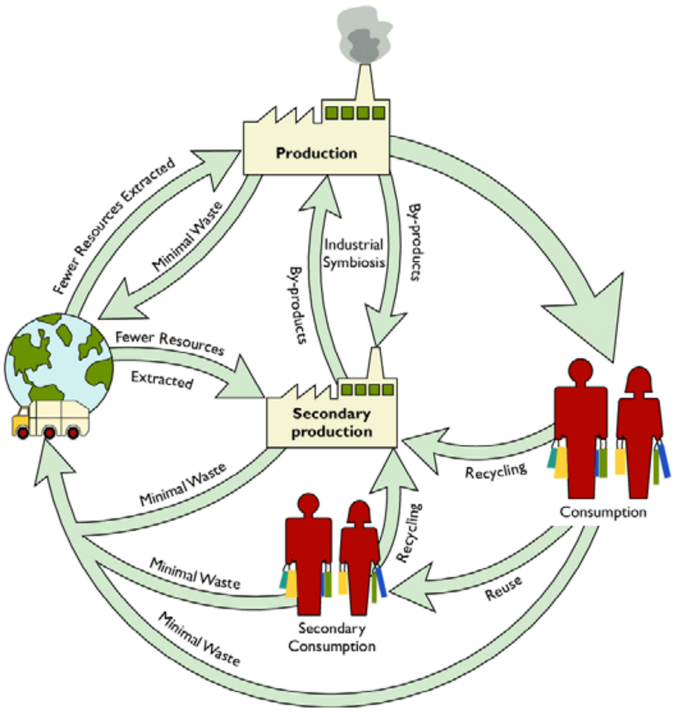


Figure 1 – Closed loop of a circular economy
Source: ResearchGate 2018

Industrial ecology – a.k.a. circular economy – is a multidisciplinary model that seeks to understand the behaviour of complex integrated human/natural systems. There is an emerging shift from traditional linear industries to **a closed loop system** – if a manufacturing activity generates **by-products and waste** beside the main product, those **must be handled and reused** by other units **to** avoid, or at least **reduce** the volume of **pollution** *(see Figure 1)*. Although economic actors promote inland waterway transport (IWT) as an eco-friendly mode of transportation, the share of it in the modal split is the lowest in comparison to other modes (road and rail). Implementing the system of industrial ecology in a port can contribute to:

- strengthening the picture of sustainability;
- attracting additional partners and clients to the sector;
- and creating more jobs by adapting eco-innovative solutions.

Furthermore, **managing the environmental risks** and **using renewable energy production** – therefore, **protecting the environment** – are important priority areas of the EU Strategy for the Danube Region (EUSDR).

Due to the fact that the transport sector represents almost a quarter of the GHG (greenhouse gas) emissions in Europe with a dependency on oil, it is important to identify and focus on **alternative fuel sources**. **Liquefied natural gas** (LNG) is a colourless, odourless, non-toxic and non-corrosive liquid, which forms when **natural gas is cooled to -162°C, shrinking its volume** to 1/600th of the gaseous state, thus making it easier – and safer, since it will not ignite – to store and ship. The achieved **energy density is greater** than in the case of compressed natural gas (CNG) which makes LNG **cost-efficient over long distances – specially designed cryogenic sea vessels** (LNG carriers) are used in its marine transport. All EU member states have to integrate LNG into their energy supply within the Sustainable Energy Security Package and as a part of the EU Strategy for liquefied natural gas and gas storage. Furthermore, **sustainable energy** is one of the priority areas of the EUSDR.

Containerization revolutionized maritime transport in the 1970s – it reduced the costs of transport and congestion in ports, shortened the shipping time and supported international trade/globalization. A full container load (FCL) is loaded and unloaded under the account of one shipper and one consignee, with **lower freight rates than in the case of an equivalent weight of cargo in bulk**. A less-than-container load (LCL) shipment is not large enough to fill a standard cargo container – different quantities of materials from different shippers or to different destinations are carried in a single container for efficiency. Since shipping containers have a **considerable potential for combined transport**, the container market is a significant factor in **intermodality**, supporting the EUSDR's 1st Priority Area.

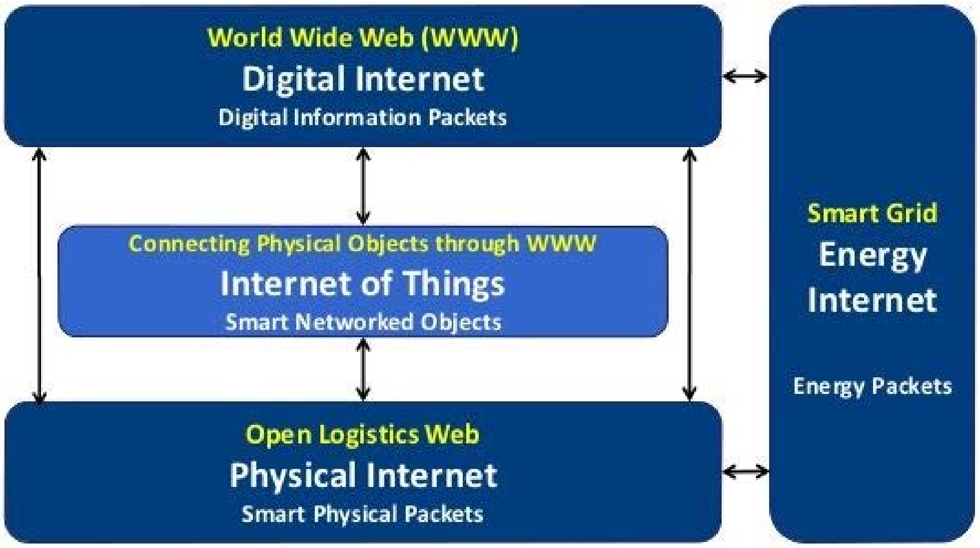


Figure 2 – Schematics of the Internet
Source: Physical Internet Manifesto

In logistics, the **Physical Internet** is an open global logistical model founded on physical, digital and operational interconnectivity, through encapsulation, interfaces and protocols.[1] In maritime and inland waterway transport, it refers to the combination of digital transportation networks – the main idea is that **shipments are transported anonymously and organized on their own through a constant data exchange between the involved stakeholders** (similar to sending an e-mail). As a way of facilitating a smoother transport process, applying the Physical Internet's principles and using it contributes to the 1st pillar of the EUSDR – Connecting the Region.

To reach conclusions grounded in reality, a list of questions was determined by the project partners. Once this **interview guideline** was ready, target groups had to be defined – port owners, port managers, port authorities, port operator companies, shipping companies, etc. The organisation responsible for this deliverable (HFIP) asked the other partners to **contact** these **stakeholders on the phone and via e-mail** about the survey, **inviting them to share their knowledge and experience.** The main topics of the study – to be summarized one by one in the separate chapters of this document – were the following:

- market opportunities (and their environmental background);
- the attractiveness of the market (a supply/demand analysis);
- cost structure and available infrastructure;
- success factors; and
- target audience.

[1] Montreuil, Benoit (2012): Physical Internet Manifesto. In http://www.physicalinternetinitiative.org/, 6 February 2013

2 Market opportunities

This chapter discusses the **environmental framework** (society, politics, legislation, economics and institutions) that triggers the deployment and further extension of the above-mentioned four markets.

2.1 Industrial ecology

Industrial ecology research usually focuses on the following areas:

- **material and energy flow studies**, describing the material and energy turnover of industrial systems;
- **eco-industrial parks**, committed to industrial symbiosis where businesses cooperate with each other and the local community to reduce waste and pollution, efficiently share resources and achieve sustainable development;
- **dematerialization** (doing more with less) **and decarbonization** based on power sources that have a minimal output of greenhouse gas emissions;
- **eco-design**, a design approach to reduce the overall environmental impact of a product, process or service;
- **life-cycle planning**, design and assessment – a technique accompanying a product's life from material extraction through processing, manufacture, distribution, use, repair/maintenance and disposal/recycling;
- **extended producer responsibility**, promoting the integration of environmental costs into the market price of products/services;
- technological change and the environment;
- product-oriented environmental policy; and
- **eco-efficiency** (based on the concept of creating more goods and services with fewer resources and less pollution).

Several different factors influence these topics – and eco-innovative solutions in general – in inland ports: most importantly, the **labour force**, **supportive legislation** (regulations, limited administrative barriers) and **governmental pressure** (the engagement of managing authorities/ministries).

In the business parks surrounding ports, there exists a very broad variation of industries, therefore, **all kinds of professions and expertise are necessary to maintain day-to-day operations** (container handling, cargo handling, etc.). To achieve **industrial symbiosis** (through the establishment of eco-industrial parks), the management/administration personnel, the cleaning staff and the crane drivers must be **equally responsible for protecting the biosphere** when making decisions or completing operational tasks. A **close partnership** and **clarified responsibilities** among every stakeholder are also prerequisites when adapting the model of industrial ecology in a port.

Some specific measures regarding industrial ecology in ports can be:

- **noise protection**;
- permanent improvement of **water purification**;
- technical advancement of infrastructure for the **rapid processing of goods** to avoid congestion in the city connected to the port;
- business models to reduce traffic in the city;

- construction of renewable energy plants; and
- networking with decision-makers through an **urban mobility lab** to develop innovation in the green logistics sector.

In most cases, **economic motivators** – like in the field of taxation – are not tailored to cater to circular economies but **national and other grant agencies** (AWS – Austria Wirtschaftsservice Gesellschaft mbH, CEF – Connecting Europe Facility, etc.) support some previously mentioned measures, like noise reduction.

There are several development projects and initiatives that can be analysed as good practices:

- **S-PARCS** (H2020) – Envisioning and Testing New Models of Sustainable Energy Cooperation and Services in Industrial Parks
  S-PARCS presents a sound concept for **reducing energy costs and energy consumption** in industrial parks, while – at the same time – **increasing renewable on-site energy production**. Seven "Lighthouse Parks" from Spain, Portugal, Italy and Austria participate in joint energy actions **– the use of waste heat**, for example –, many of which are transferrable to the community of S-PARCS Followers in the UK, Sweden, Turkey, Russia and Norway.
- **ENERGY BARGE** (DTP) – Building a Green Energy and Logistics Belt
  The main objective of the project is to **exploit the potential for green energy in the form of biomass along the Danube river** in a sustainable way, thereby increasing energy security and -efficiency in the nearby countries. With a **cross-sectoral approach**, ENERGY BARGE brings together stakeholders from the bioenergy industry, Danube ports as well as relevant public authorities and policy makers. Its promotion of **ports as locations for processing, handling and storing biomass** supports port development.

2.2 LNG as cargo

The most relevant factor driving the research regarding LNG is the **legal framework** behind it – several EU- and lower level directives make its use necessary, accelerate the speed of infrastructure development and provide more information on the safety requirements.

- **Clean Power for Transport**
  The Clean Power for Transport package aims to facilitate the development of a single market for alternative fuels in Europe by **gradually replacing oil with LNG** (among others) and **building up the necessary infrastructure**. Policy makers hope that investing in this area will boost economic growth and create a wide range of jobs. As mentioned in the introductory chapter, EU member states are required to develop national policy frameworks for the market development of alternative fuels and their infrastructure according to the following timeline:

	Coverage	Timing
LNG for heavy-duty vehicles	Appropriate number of points along the TEN-T core network	by the end of 2025
LNG at maritime ports	Ports of the TEN-T core network	
LNG at inland ports		by the end of 2030

Figure 3 – Clean Power for Transport package timings regarding LNG
Source: European Commission, Directive 2014/94

- **Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RED)**
  This directive plans to limit GHG emissions and promote cleaner transport. It sets **national binding targets** for every member state with the overall aim of making renewable energy sources account for 20% of the total EU energy use (and for 10% specifically in the transport sector) by 2020. RED II, the revised version of the document would like to raise this value to 27% by 2030.
- **NAIADES II**
  The "Towards quality inland waterway transport" package stresses that the IWT sector must become greener and more sustainable in order to remain a viable competitor with other transport modes – **LNG offers a cost-efficient alternative to diesel**.
- **Regulation and Requirements for LNG-powered Vessels**
  Directive 2016/1629 identifies the **technical requirements** for inland waterway vessels, including crafts operating on fuels with a flashpoint equal to or lower than 55°C.
- **Guidelines for ports regulations**
  There are **ISO standards** available for the bunkering of vessels and truck fuelling.

Worldwide **economic trends** are also triggering further research and development. Studies show that natural gas usage grows strongly which – in turn – increases its global availability. In Europe, **LNG will make the gas market more flexible**: it can be traded on spot-markets and compete with the existing long-term contracts of pipeline gas. In time, LNG will get a "bio" component – **liquefied bio-gas** (LBG) will become the state of the art.
LNG as cargo can bring **economic, socio-economic and ecological/environmental benefits** to the Danube Region by:

- increasing the market flexibility for the adjustable natural gas demand;
- contributing to European energy security through diversification; and
- raising the demand for alternative fuels in order to reduce the environmental impact of the transport sector (i.e. air and noise pollution, *see Figure 4*).

Emissions	**LNG fuelled truck**	**LNG fuelled vessel**
NO_x	-54%	-85%
CO_2 (depending on the bio-methane share)	-10% to -80%	-25% to -80%
Particle emissions	-100%/not measurable	-100%/not measurable

Figure 4 – Ecological benefits of LNG
Source: Iveco for trucks & LNG Masterplan for vessels

In line with these advantages, there are developments in progress to have **more LNG terminals** in the Danube Region (a planned Floating Storage and Regasification Unit in Croatia, for example). In addition, more and more **truck manufacturers have natural gas fuelled models available**, which have both an economical and environmental edge compared to diesel trucks. Natural gas fuelled models are produced by the following companies:

- **Iveco Stralis**: NP CNG, NP CLNG, **NP LNG**
- **Scania**: P/G 280/340 CNG, **P/G 280/340 LNG**
- Renault: D Wide CNG
- **Volvo**: FE CNG, **FH LNG**

Ennshafen – the port of Enns – is a good example for LNG market development. In cooperation with RAG (a regional exploration/production company with Europe`s 4th largest gas storage capacity), Ennshafen became a logistics centre for three different modes of transportation, and an important business location for the whole region, therefore, it is an ideal location to be **a natural hub for future LNG storage, transhipment and bunkering/fuelling activities**.

2.3 The Danube container market

Intermodal transport is an increasingly important part of the logistics sector; its pre-requisite, **freight unitization** – using standardized packaging units – makes transferring goods between transport modes easier. The main types of these standardized packaging or **intermodal transport units** (ITUs) are containers, swap bodies and trailers/semi-trailers. Therefore, **the container market is a focal point of developing intermodality**; the transport of containerized freight might bring an increase to inland waterway transport by 2020 or in the following decade. However, there are only a few loaded container transports on the Danube currently due to several difficulties:

- **environmental** – unstable navigational conditions (high- and low water seasons, natural disasters, etc.);
- **infrastructural** – most terminals are geared towards utilizing the railway system for a much shorter transit time (as well as in the case of road delivery);
- **institutional** – there is no reliable liner service on the Danube;
- **economic** – longer transport due to passing through more than 60 locks, lock maintenance, competitive shuttle train connections, the engagement and financial power of the property owners and the shipping companies;
- **legislative** - lack of financial support (funds) for waterways compared with the road/railway system; and
- **political** – past wars (the two crises in the former Yugoslavia and the Balkans).

Nevertheless, the increase of the global container market's share brings the Danube container market's hidden potential to the surface. **Barges and RoRo** (Roll on – Roll off) **vessels are already used for container transportation** on the river, which drives further investment and innovation for combined cargo transhipment. **Bulk goods** such as steel remains, biomass, wood chips and round wood – originally transported loose in ships – are now also **transported in containers**. The EU's **decarbonizing strategy** calls for sustainable freight transport and **all forecasts assume that the railway infrastructure will soon be overloaded**. Taking these into account, inland waterway transport and containerization will be of high value and get a strategic focus in the future.

In line with the facts, several studies were dealing with the cargo shift from road and railway to IWT in the past, too:

- The **COLD-study** was an assessment of the opportunities and risks of container transport on the Danube between Austria and the Black Sea Region. It confirmed that **the cost benefits** of using it **are significant and the frequently mentioned possibility of long transport times is not a severe issue** – moreover, **the environmental impact** of IWT **is good**, creating a win-win scenario for all stakeholders.

- The **KoLEG Study** in 2012 presented a **business plan** for a combined regular service *(see Figure 5)* – designed to support the transport of mass and bulk goods, containers or high and heavy products – between Ennshafen (Austria) and the port of Galati (Romania). Unfortunately, all liner services stopped their operation due to the above-discussed obstacles or ownership reasons.

Figure 5 – Connections of the combined regular service between Enns and Galati

2.4 Danube ports and the Physical Internet

Since transport is expected to triple by 2050, **the continent needs to accommodate the new transport flows using all available transport modes**. The European Commission aims to shift freight transport to sustainable ones such as inland waterways or rail, and to accommodate this desired modal shift, different transport concepts have emerged in the last few years *(see Figure 6)*.

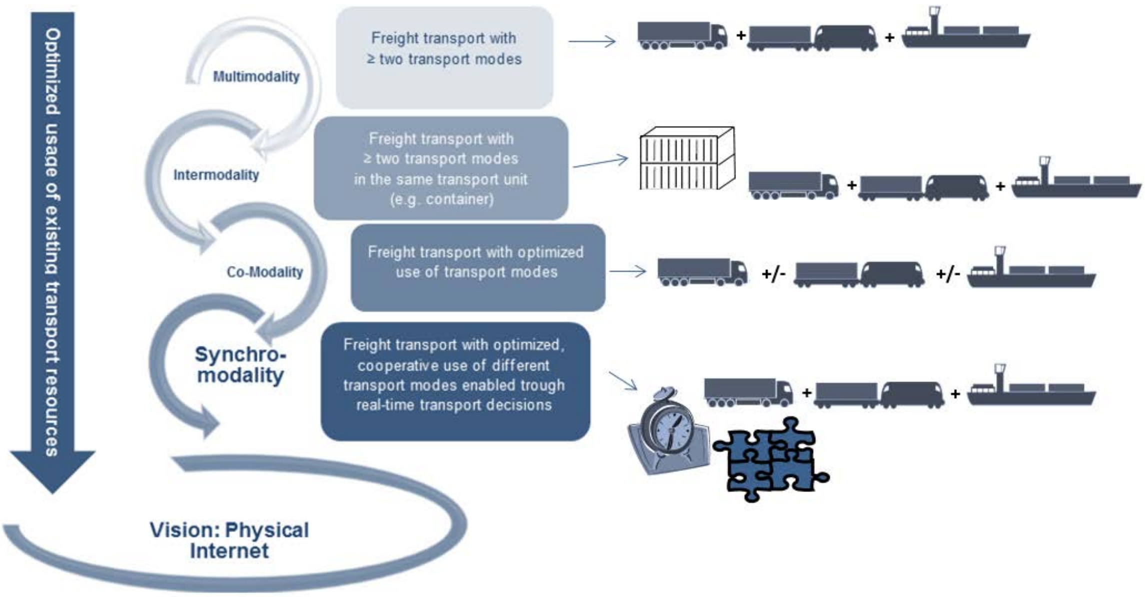


Figure 6 – Innovative transport concepts
Source: "SynChain" project report (2015)

Inland ports play a crucial role as regulators of the freight flows in the supply chain. In the past years, they have evolved to broad logistics zones, but still **lack the necessary infrastructure** to efficiently handle cargo and the ever-increasing transport volumes from seaports cause further challenges in terms of **limited capacities** and **the quality of the logistics services.** **By applying the concept of synchromodality, the ports can counteract the current bottlenecks with the strategic use of their existing capacities.** Of course, to realize this vision, **infrastructural and technical measures** will have to be implemented.
As **economic background**, it can be said that the **Danube** has an advantageous location in Europe, **connecting ten countries** and important economic regions. Moreover, the connection via the Rhine-Main-Danube Canal to **five other European countries** further highlights the importance of the river as a transport axis on both a national and an international level. The trend of digitalization seems to be a perfect opportunity for inland ports to **position themselves as important information and logistics hubs** in the European freight transport industry, supported by the implementation of synchromodality and the Physical Internet. All in all, the Physical Internet creates a scenario in which the **three perspectives of sustainability** (society, economy and ecology) are respected and improved.
In the following paragraphs, two best practice examples are presented:

- **Hamburg**
  The Port of Hamburg is the third largest container port in Europe. The Hamburg Port Authority makes its operation as efficient as possible through **the interaction of sensor technology, analysis, forecasting and information systems** ("smartPORT – the intelligent harbor"). The goal is to optimize land transport due to limited road capacities by linking traffic and freight, therefore, know when a container needs to be moved. The process functions on **a cloud-based IT platform** that connects all transport and logistics partners to share relevant information about e.g. specific route sections.
- **Rotterdam**
  The Port of Rotterdam is the largest port in Europe by container handling. It tries to **generate products and services through digitization**, thereby increasing efficiency and reliability in the logistics chain, using several methods, for example:
  - Pronto
    An application that allows shipping companies, terminals and other service providers to **optimally plan, execute and monitor all activities during a port call based on a standardized data exchange –** this allows vessels to save up to 20% of the waiting time.
  - Bunker App
    The Port of Rotterdam is also one of the first ports in Europe to bunker LNG. Through **digitalization**, they make **information flow in real time** to the approximately 20,000 bunker supplies **via VHF messages**, available in an app.

3 Attractiveness of the market

This chapter will provide a comprehensive image of **the demand and supply for new services** in the region that lead to the deployment of these new markets – the **barriers** to making them expand and the **competitive powers** that can positively influence their expansion.

3.1 Industrial ecology

Industrial ecology attracts innovation and creates an investment climate for developing innovative services. Companies can work together and use each other's by-products as raw materials, increasing their efficiency and profit, driving new investments. However, without **governmental support** and with **administrative barriers**, investments are expensive and only remunerative on a very long term.

There are several good practices where the role of supporting legislation can be observed. In Germany, fuelling vessels pay **environmental product fees** based on the 'polluter-pay' principle, charging everyone who purchases gasoline and using the revenue **to support inland green ports** that collect used oil, waste, etc. These fees also guarantee that vessels can **deposit** their **waste for free** at these ports. A similar collection system is in progress in Austria, too. In Budapest, a military boat was reconstructed to receive social and household wastes, serving primarily passenger cruise ships. Port operators and logistics service providers settled near the Public Port of Baja deposit dangerous waste annually, communal waste monthly and general waste and by-products weekly – the latter is due to the agricultural activities of the nearby companies. Nylon, acids, oil and packing materials (and many others) are loaded onto pallets, which an elevator and a forklift takes to the processing plant.

Administrative barriers can become a hindrance in some cases. For example, there are 35-40 tons of dust generated in silos in the Port of Baja that could be used in a biomass-based unit – this amount would be enough to supply heat for several offices. Nevertheless, the **administration process** for getting a license to operate a unit like that is **complex and expensive** – as a result, usually the entire amount is thrown out as waste. Bioethanol production from sewage water (deposited by passenger cruise ships) is another eco-innovative waste management process, which – due to **complicated and inflexible legislation** – cannot be implemented.

All in all, four different levels can be identified as major barriers and – with changes – excellent opportunities concerning industrial ecology in ports:

- **regulatory level** (e.g. changing the status of waste and other by-products, developing environmental certifications; regulating new jobs/activities);
- **economical level** (e.g. abolishing taxes for waste export, creating new jobs/activities);
- **organizational level** (e.g. establishing a committee from different stakeholders of the port complex and the industrial platform to improve regional communication, foster interconnection and manage resources); and
- **technical level** (e.g. setting up wastewater treatment plants, pooling different infrastructures together).

3.2 LNG as cargo

The BP Energy Outlook 2018 highlights the factors shaping the global energy transition until 2040. It shows that **the supply of natural gas to Europe depends mainly on the Russian pipelines** – this dependence will only increase in the future, while local production decreases (*see Figure 7*).

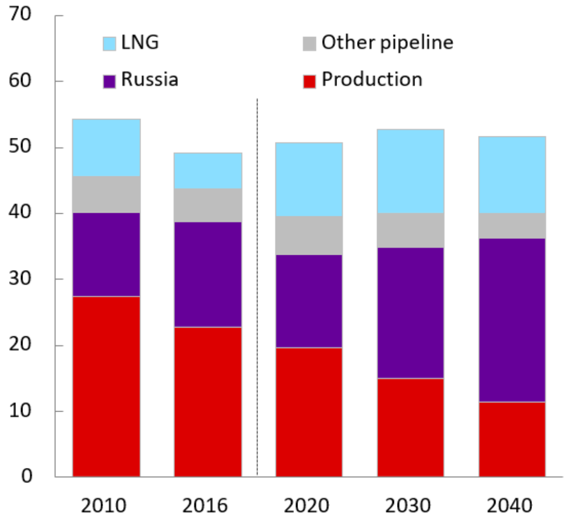


Figure 7 – European gas supply market
(unit: bfc/d – billion cubic feet per day)
Source: BP Energy Outlook 2018

However, the liquefaction of natural gas will also become an extremely important issue, especially in IWT. **Most terminals in the Danube Region are only suitable for the regasification process**, not the creation of more, but their scattered locations at least guarantee that LNG can – theoretically – be transported anywhere. The LNG terminal in Rotterdam is a particularly interesting alternative for local production.

The demand of LNG in the Danube Region **varies between the different countries**.

- **Germany**
  Studies show **a highly rising demand in every transport mode** until 2035. **LNG ships** (the MS Ostfriesland car ferry and the projected LNG-electric ferries between Jork and Wedel) and **bunkering possibilities** (in Mannheim, Regensburg and Cologne) already exist or are in their planning stages. In the road transport sector, there is a need for more **LNG fuelling stations**.
- **Austria**
  As in the case of Germany, there is an increased demand for LNG fuelling stations, but for inland navigation, **no demand is expected in the short term**.
- **Slovakia**
  Currently, there is no LNG facility in the country, but there are **ongoing projects to implement LNG as fuel** – one of them will establish a small-scale **liquefaction plant** in the port of Bratislava by the end of 2019. These infrastructure developments will certainly drive the demand side of the market.

- **Hungary**
  Prior demand analyses mostly argue for LNG as cargo using the **Diesel-LNG price gap** (LNG is estimated to have the price of natural gas in Hungary), nevertheless, the **infrastructure has not been realized** for practical application so far. The swiftness of market penetration **depends on the ongoing EU financed projects** in the field.
- **Croatia**
  To satisfy the **rising energy/natural gas demand** in the region, there is an **LNG Import Terminal** in progress in Krk: Phase 1 is the development of the already mentioned **Floating Storage and Regasification Unit**, while a supply option is planned for Phase 2 to further distribute LNG as a transport fuel.
- **Romania**
  There is **no available supply infrastructure** for road vehicles or ships, but the Romanian Ministry of Transport – due to the efforts of the local stakeholders – took note of the need, in line with the relevant EU directives. Two **potential development projects were taken into consideration**: an LNG terminal on the southern dock of the Constanta port and an LNG Berth D99 power station (and stationary platforms). The Galati river and seaports will also have to be equipped with an LNG supply system.
- **Bulgaria**
  The situation is similar to Romania: the actual demand cannot be quantified, but there is **strategic interest to develop a nationwide LNG fuelling infrastructure**. To achieve this, Bulgaria elaborated a strategy with the overall goal to significantly reduce the use of fossil fuels by introducing new energy sources instead (LNG, electricity, hydrogen, etc.). This would benefit the country in an additional way, lessening its dependency on the Russian natural gas imports.
- **Moldova**
  At present, there are **no activities** to facilitate LNG demand and supply.

3.3 The Danube container market

The Danube Region contains a catchment area of around 100 million people, therefore, it has the potential to become one of Europe's most famous logistics hubs. To achieve this, there is **a demand for the New Silk Road to create a connection to the Danube Region** and thus to trimodal hubs/transfer points. **Business opportunities arise** at the traffic connections of the numerous industrial companies on the outer borders of Europe to the European rail network.

In some areas in the Danube Region, there is **a need for establishing and developing full container liner services** due to the currently **insufficient railway capacity** – downstream from Budapest to Constanța, for example. It would be prudent to use this demand to precede the potential railway development projects – as soon as the railway network expands, IWT's competitive edge will significantly decrease in terms of market price and handling time. However, **full container transport "to the west"** (i.e. from Austria via the locks in the Rhine-Main-Danube Canal established in Germany) **is not a viable option**.

An alternative opportunity is the **empty container traffic**. Establishing an empty container liner service is **a complex – and expensive – process**, but it could be realized with appropriate handling times and potentially economic conditions. To raise the chances of success, the following recommendations must be kept in mind:

- investigate the **feasibility** of the model on the Danube in more detail with potential implementing partners;
- examine and initiate the creation of the **transport policy framework** in comparison to the railway system;
- expand or attract the **spot traffic system** – it can react quickly and easily to specific customer inquiries; and
- develop **common waterway and railway concepts** as a contribution to the decarbonization strategies in freight transport, with the objective of reducing emissions and the burden on roads.

A service like this can be counted on to:

- **increase the attractiveness of the Danube Region**, in particular the inland ports and terminals on the river;
- **strengthen the gateway function** of the terminals at the Danube sites; and
- **balance the increasing capacity bottlenecks on the railway system** in the long term (e.g. in the eastern Danube countries and metropolitan areas).

The transport of empty containers certainly has a realistic chance of being established on the whole Danube waterway, moreover, **concrete steps can be taken quickly**. The offer to **substitute and supplement further capacities** – which the railway system does not have currently and in the near future – should be the goal of every long term transport and infrastructure development plan. Under the precondition of marketability, an empty container liner service would **provide a location advantage for the participating ports**.

3.4 Danube ports and the Physical Internet

Several drivers can be identified which enable the development of the Physical Internet:

- Some means of transport (e.g. trucks) are only partially full and packing materials take up a lot of space – with a carefully organized approach, they can be **loaded more efficiently**, and empty runs should be reduced. **Saving time** like this will result in **better working conditions** – truck drivers are on the road for long stretches of time which causes **family and health problems** but saving time can improve this situation.
- When products are not stored at the place of consumption that leads to **high inventory costs and long delivery times**. Additionally, transport distances are increasing: **efficient transhipment** and a combination of the different transport modes – **multimodality** – are required to coordinate them, with a respect for urbanization and sustainability.

Unfortunately, as in the case of every other new market, there exist potential barriers:

- At the moment, transport networks lack **security and robustness** which makes collaboration between the different stakeholders even more difficult, beside **the lack of trust**.

- The Physical Internet is still a new area; therefore, it is rife with **uncertainty** – **a mind shift is necessary** to encourage its integration into companies. One main concern is **the idea of sharing**:
    - assets such as trucks and warehouses which leaves less property and thus, less control for one company; and
    - information about the customers, shipping routes and markets.

  Consequently, it is not surprising that many organisations are **afraid of losing their economic advantage** and behave close-minded in the face of collaboration.
- Having a network instead of one-to-one agreements makes **transhipment** complicated and difficult if the products/containers are not **standard**/modular.

To build on the above-mentioned drivers and overcome the obstacles, **a complex networking system is needed** – the Physical Internet provides this complexity *(see Figure 8)*. The standardized physical objects and processes are linked in a logistics web similar to the Internet, and based on a **global universal interconnectivity**, all elements are able to communicate with each other. However, innovations in technology, business models and infrastructure are necessary to implement all preconditions for a functioning Physical Internet.

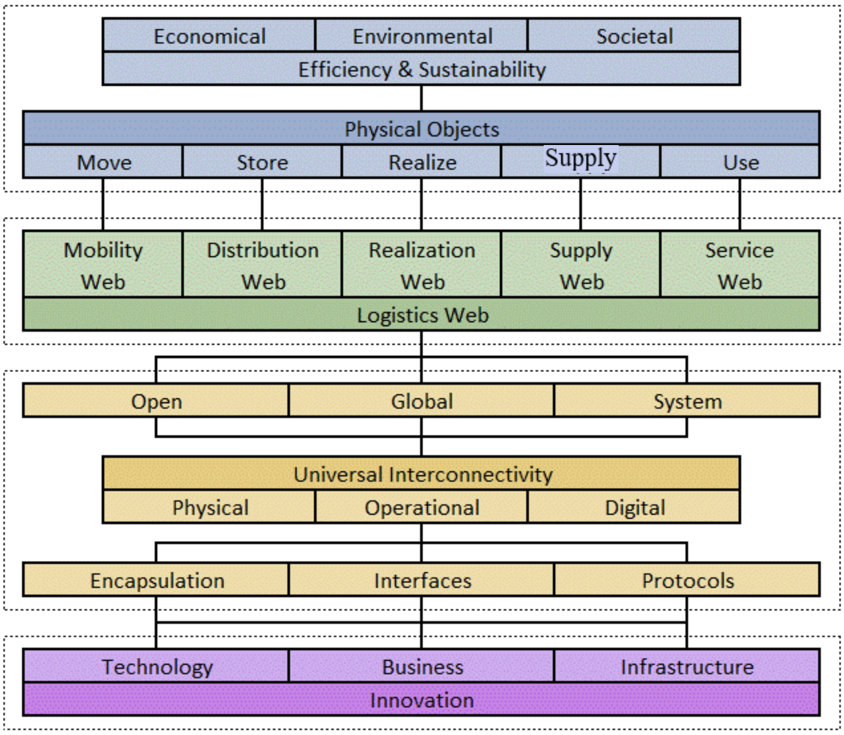


Figure 8 – Fundamental components of the Physical Internet
Source: Montreuil et al. 2012

4 Cost structure and available infrastructure

In order to determine the key success factors of these markets, **a general view on the costs** is needed, associated with their deployment. This chapter will also discuss the **available infrastructure elements** in the region and the **new investments** (or legislative framework) needed.

4.1 Industrial ecology

Since the EU member states have different socio-economic backgrounds resulting from various policies and market conditions, it is almost impossible to define the exact sums to invest in or run certain ports and compare them with each other. Nevertheless, the project partners can still **estimate the expenditures** of managing their ports in a more environmentally sustainable way.

For instance, the overall sum invested in industrial ecology and environmentally sustainable solutions in **Ennshafen** in the last five years is approximately €500,000 – this covers noise reduction and water surface treatment measures, among others. For comparison, the annual operational cost of the Baja Green Port is €3,000 – €4,500. The current infrastructure in Ennshafen is built upon heat supply and the export for district heating. Raw materials in the supply chain include small amounts of waste products – the recycling procedure is managed by several companies settled near the port: VFI GmbH (a vegetable and fat processing company) produces press cake out of oil press, for example, later used by the feeding stuff producer company, Fixkraft. The waste water management of the vessels is the responsibility of an external disposal company – the costs are covered by the vessels' owners. Wood chips are exported outside the port for energy and other industrial usages. All in all, **industrial ecology can only be profitable, if the prices are market-oriented and affordable** – the **ports** also **need to have manufacturers and processing companies settled near them** for this to work.

Regarding the available and planned infrastructure, the following Danube ports should be mentioned:

- **Duisport**, Germany
  The Duisburg port is the largest inland container port in the world. It prides itself on applying sustainable methods: **noise and light reduction**, the protection of the **water quality**, waste and wastewater disposal through **modern waste management**, the economical **use of raw materials** and **minimizing pollutants** of all kinds. It operates its own **solar power system** to reduce the use of fossil fuels. The port is also committed to creating the infrastructure necessary to **use LNG**.
- **Port of Antwerp**, Belgium
  The Port of Antwerp is the second busiest container port in Europe, striving to eradicate all forms of contamination and pollution from its operation by investing in circular economy. As a home of many different companies (in waste processing, too), it has several opportunities to **foster the creation of a closed-circuit system** between them (residual heat converted into heating, wood chips turned into biomass, etc.). Antwerp is the first port in Europe to adapt the **"Zero Pellet Loss" initiative** – as a main hub for producing, handling and distributing polymers (in the form of tiny pellets), it tries to prevent any spillage of them – especially into the water.

- **Ennshafen**, Austria
  The port of Enns – as previously discussed – invested significant funds in **noise reduction**, **water quality control** and a **district heating service** based on biomass processing and waste reusing. In the framework of the S-PARCS project, the port improves its energy efficiency and reduces its emissions. This purpose is also supported by **LNG terminals**, providing a more environment-friendly fuel.
- **Port of Vienna**, Austria
  The Port of Vienna has investments in green logistics, renewable energy production and the reduction of energy and waste usage – it has a **windmill** and a **hydroelectric power station** and provides the necessary conditions for the **import, storage and transhipment of biomass** (as a project partner in the ENERGY BARGE project).
- **Public Port of Baja**, Hungary
  As one of the largest public ports in the country, Baja managed to install the first **Green Port** in Hungary – the new institution serves vessels that want to deposit their waste, bilge, oil barrels, etc. in an environmentally responsible and safe way.

4.2 LNG as cargo

The **transportation of LNG via containers** – a 40 feet long intermodal container with a payload between 19 and 22.5 tons of LNG, for example *(see Figure 9)* – is an already existing technology. The most important reference point of the process is the **"hold time"**, which is – at least in the case of the above-mentioned container – 65 days at a pressure level of 10 bar. The price for a 40'ISO LNG container is approximately €150,000 – €160,000.

Figure 9 – LNG ISO container
Source: Chart Industries

Figure 10 – Existing and planned LNG infrastructure in the Danube Region

Figure 10 shows the existing and planned LNG infrastructure in the Danube Region:

- **LNG fuelling station for trucks** since 2017 in Ennshafen (Austria)
  There are plans for 5 new LNG and 2 LNG/L-CNG[2] stations in the country, a bunkering facility in Enns, and creating the conditions for the liquefaction of domestic natural gas.
- **LNG Terminal** since 2016 in Ruse (Bulgaria)
  This was the first port on the Danube to be equipped with LNG infrastructure – the implementation was executed within the LNG Masterplan. The port can store LNG in four 250 m^3 vertical tanks. It also includes a vessel unloading and loading facility, a truck-loading station and a truck/vessel fuelling station.
- **Truck to Ship bunkering** in Mannheim (Germany)
  This facility is the closest good example of bunkering near the Danube Region.
- LNG projects in **Slovakia**: an LNG fuelling open access point for road transport, 15 LNG mono-fuelled buses, a small scale LNG production plant, 3 large LNG stations for filling vehicles along the core TEN-T corridors, 14 L-CNG stations along the D1 and D2 highways, a pilot fleet with 50 LNG fuelled vehicles and a mobile LNG supply for Truck to Ship bunkering;
- LNG projects in **Hungary**: a small scale liquefaction plant based on fossil gas wells and bio-methane sources, 5 L-CNG fuelling stations, a fuelling station for trucks (and possibly for locomotives) and retrofitting the existing vessels for LNG propulsion;
- LNG projects in the **Visegrad Countries**: a Liquefied Bio-gas (LBG) and Liquefied Natural Gas (LNG) production facility, a network of 6 L-CNG fuelling stations (3 in Slovakia, 3 in the Czech Republic) and a fleet of 75 LNG and L-CNG trucks;
- LNG project in **Croatia**: an LNG import Terminal in Krk;

[2] Station serving CNG vehicles from an LNG tank.

- LNG project in **Bulgaria**: LNG infrastructure on the core TEN-T port network to fulfil the relevant EU directive for alternative fuel development; and
- LNG projects in **Romania**: fuelling stations and vehicles (LNG-fuelled buses and trucks), an LNG Terminal (including a bunker station for maritime and inland vessels), LNG-fuelled ferries to Georgia and a small scale liquefaction plant based on bio-methane sources.

4.3 The Danube container market

The cost requirement have only been investigated in the case of the empty container market, since it is more relevant and widely applicable to the Danube Region, but **the infrastructure component is the same as with fully loaded containers** (enough space for handling them, ship-to-shore cranes, direct connection between the container terminals in the ports, etc.). According to the results of the interviews, the ports the project involve have the necessary infrastructure to proceed with the development of the Danube container market.

As a general outline, it can be said that **the empty container business is highly volatile**, even if it is organized well. The market is dominated by shipping companies, terminals and operators – only a limited amount of support can be expected from them due to their lack of potential benefits in a competitive environment.

If one assumes scheduled liner services as a starting point, then – even in view of the limited number of routes, the longer journey time and higher costs in the ports – **the ship price tends to be below the railway price**: the selling price of the operator to the ship-owner could be close to the shipping costs, but certainly not lower. However, in case of competition or on a last-minute basis, EVU (individual transport companies) and operators can sell well below these costs if full utilization of the trains can be achieved. **A waterway liner service that requires base load capacity is barely marketable as long as the rail capacity is sufficient.**

	Train costs with paired utilization	
Budapest – Enns	€7 000	€100 at 80% utilization
Freudenau – Enns	€4 000	€60 at 80% utilization

Figure 11 – Purchasing costs of the operator per TEU on the basis of estimated costs for combined traffic block trains

As a good practice, in the framework of the EU-notified aid system to offset the external costs not internalized in road traffic, **Austria pays aid** in combined transport to the "train-ordering EVU", **providing an incentive to shift freight transport from road to rail.** Unfortunately, **there is no similar aid for IWT.** The fund is paid per rail-transported container, depending on the distance, weight and dimension of it (container, swap body or semi-trailer) – for example, the fund for a 40′ empty container (in Austria) is the following (depending on its travel route):

- Wien Freudenau – Enns: €49.8
- Regensburg/Bratislava/Budapest – Enns: €43.1

These prices are **critical benchmarks that have to be reached in order to get a cost structure which can survive under market conditions**.

4.4 Danube ports and the Physical Internet

The cost structure for the Physical Internet can be identified as quite variable, depending on the investments in infrastructure and technology. To understand the scope of the infrastructural factor and market value of the Physical Internet for inland ports, its development process should be considered:

1. **Standardized containers, parcels, warehouses and turnover points** need to be installed to guarantee barrier-free and seamless transportation.
2. **Transhipment and other processes can be standardized** at this stage, which minimizes the risk of discrepancies.
3. These standardized transport units and processes will lead to a **reliable and resilient smart network** in which the units communicate almost independently, open to all supply chain stakeholders on a global level.
4. If the transport units choose the best transport route on their own, this makes simplification and standardization possible and makes **human interaction almost unnecessary**.

The concept of a smart transport network represents the 5th level of port development:

- Level 1: Pure Cargo Port
- Level 2: Logistics Port including warehouse services
- Level 3: SCM (Supply Chain Management) Port with bilateral information flows
- Level 4: Globalized SCM Port
- **Level 5: Customer-centric Port Platform**

Nowadays, inland ports are usually at Level 3 – at the start of digital coordination, with a mutual exchange of information between the customers and the port administration already taking place. At Level 4, the extent of the information exchange becomes more advanced, but the focus is still mainly on the port's own profitability. At Level 5, **the port puts the interests of the community in the foreground** in order to be a part of a seamless transport chain – the focus shifts to the optimum satisfaction of the customers.

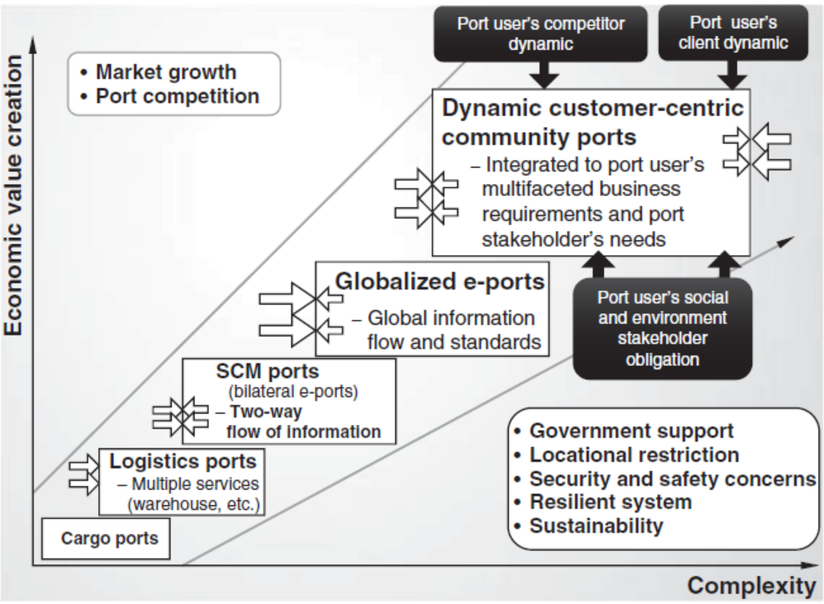


Figure 12 – Development process of ports
Source: Lee and Lam (2016)

As can be seen in *Figure 12*, **the economic value creation is expected to increase** from one level to the next – but also the complexity. The market on which the port operates becomes larger, thus, the **competitive pressure** is rising. Due to the same **increase in the number of market players and stakeholders**, the **complexity of the day-to-day processes** is heightened – complex supply chains and higher volumes also require **higher security standards and better protection** of the entire network, while the aspect of sustainability has to be respected at all times. This complexity makes disruptions – like strikes or accidents – appear more severe, causing a serious impact.

5 Success factors

This chapter analyses the different **factors that can help with the expansion of the four markets.** They include – but are not limited to – the following items: abilities to achieve economies of scale, technological progress, reduced environmental impact.

5.1 Industrial ecology

There are several factors that facilitate industrial ecology or eco-innovative technology investments for inland ports:

EXTERNAL SUCCESS FACTORS

- **Legislative background**
  Regulations can facilitate eco-innovative solutions to an extent. Investing in them will never be profitable if the **administration costs** are expensive and the **process** is complicated – an unsupportive legal framework makes any development impossible, regardless the technological background, the capacities and the financial situation of a given company. To be widely accessible, waste, bilge, sewage water and used oil disposal must be **free of charge or at least cheap** (with national support).
- **Labour force**
  Depending on the chosen methods and services of eco-friendly technologies, specified water, soil and air quality controllers, environmental engineers and certified producers will be needed, **creating new job opportunities**. As the industrial ecology model becomes a vital part of the day-to-day operation of the port, **training programmes must be available** to all port operators and port managers on how to govern their institution in an environmentally and economically sustainable way.
- **Market demand**
  Since freight forwarding **companies are obligated to comply with certain ecological requirements** (choosing the type of fuel their fleet uses, reducing emissions, needing e-chargers for their vehicles, accessing waste deposits, etc.), **they will seek out inland ports that can offer the required tools.** Therefore, investing in industrial ecology increases the given port's attractiveness to port users, port logistics service providers and shipping companies.
- **Institutions**
  The success of circular economy hinges on **cooperation** – when investing in it, the port's management should involve companies within and out of the sector, including R&D and academic institutions, both in the public and private sphere. Depending on the port's size (its annual turnover, physical territory, number of tenants and companies), the port owner can become **a lead partner in joint investment projects, facilitating, encouraging and coordinating** port operators and port users to use eco-innovative solutions.

INTERNAL SUCCESS FACTOR

- **Critical mass of companies**
  Various companies can be settled down in a port area to jointly develop environmentally sustainable solutions, but in the case of a circular economy, these companies' **activities** must **link together** somehow:
  - A grain handler company with large silos will generate tons of dust while processing cereals – this by-product can supply agricultural residue-based biomass boilers.
  - Excess renewable energy and heat production could be a power and heat supply for establishments (e.g. warehouses, offices) within the port area (or outside of it through cooperation with the local municipality, the district heating company and other public institutes).
  - A high-level waste management process – reusing and not simply recycling raw materials – will guarantee that companies can use each other's generated waste (depending on its type and volume).

5.2 LNG as cargo

The LNG market is a complex system that must be studied and understood properly to plan a successful development project concerning the field *(see Figure 13)*.

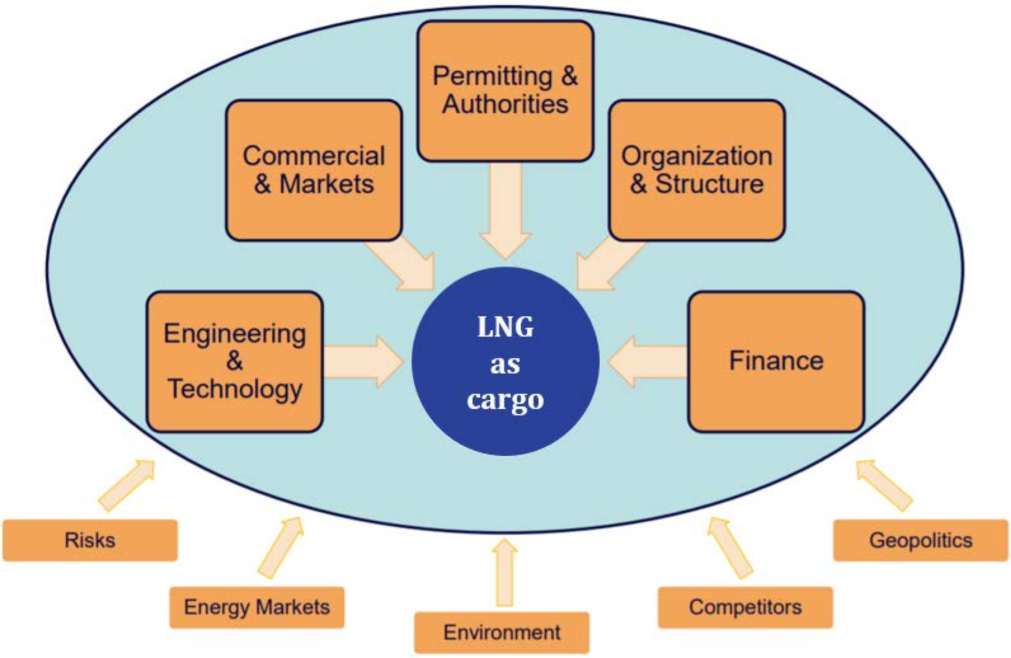


Figure 13 – LNG market
Source: REPSOL – GAS NATURAL LNG

In order to establish a consistent LNG infrastructure in the Danube Region, some preconditions have to be ensured:

- a predictable legal and **regulatory foundation**, which facilitates LNG deployment with supplementary benefits – the EU has already brought about important legislation for an effective LNG trading market, including ship fuel regulations and the ban on destination clauses;

- **governmental support** (i.e. national level funding programmes supporting the transition of fleets);
- sufficient **training**/educational infrastructure concerning LNG;
- **information campaigns** for fleet owners and the general public to overcome possible bottlenecks in the supply, organized by strategic platforms in the Danube Region;
- **competitive costs**; and
- emphasis on a **“bio” component** (LBG) to improve the CO_2 performance of the transport sector.

5.3 The Danube container market

As in the previous related chapters, this paper only discusses **the crucial success factors of the empty container business** since it has the most realistic chance of being established in a medium/long term on the whole Danube waterway – the other possibilities (full container liner services, for example) bring a lot of problems and obstacles with them, making identifying their success factors difficult at the moment. While **the expansion of spot traffic seems more efficient and economical in the short term**, the offer of an **empty container liner service** should remain a **part of the long-term strategy for the Danube** – and so is the **adaptation of the required framework conditions**. This strategy should include the following:

Figure 14 – Success factors of a long-term strategy for the Danube

Initial pilot projects should be developed – a waterway offer that has already been prepared can help in the short term if the need arises. In the regional/transregional industrial regions along the Danube, individual **“Hub & Spoke” nodes** have to be considered and developed. Due to an increased container throughput at the southern ports (i.e. Trieste, Koper, Rijeka), a **strong rail connection to the Danube** and the **redistribution/collection of full containers** via the river is conceivable – this is quite relevant for the Hungary-Slovakia-Austria area.

Through **agreements with shipping companies** to jointly establish a continuous, closed combined offer (with a combined price from sea transhipment and IW route transport), the final product can have **a competitive market price**.

5.4 Danube ports and the Physical Internet

The following aspects may be seen as success factors to implement the Physical Internet in inland ports:

- adequate **infrastructure** for an efficient transhipment;
- reliable **hinterland connections**;
- real-time **communication** between all inland ports and other relevant transhipment sites;
- the **time and cost** of the transport processes and their communication to customers and other relevant stakeholders;
- a seamless **integration** of inland navigation into national and international transport;
- the international **expansion and maintenance** of the transport infrastructure;
- the **political promotion** of ship transport by inland waterways; and
- **standardized** technical equipment, **networking** port infrastructure, superstructures, traffic routes, carriers and means of transport.

The conducted study summarized these aspects into **seven categories**, the first four of which were also examined in detail *(see Figure 15)*:

1. **Awareness**/mental shift
2. Network/cooperation/**trust**
3. **ICT**/ITS technologies
4. **Physical infrastructure**
5. **Sophisticated planning**
   This can be seen as an element of the 3rd critical success factor (ICT/ITS technologies).
6. **Legal**/political **framework**
   The legal/political framework refers to those external conditions that cannot be directly influenced by the stakeholders involved in this study (i.e. port authorities and companies).
7. **Pricing**/cost/service
   This category can be viewed as a determinant for achieving the 2nd critical success factor (Network/cooperation/trust).

Coverage	Description
Awareness/mental shift	To achieve an ideal modal split, the stakeholders' **expectations and favourable perception** of sustainable transport and innovative transport concepts represent a fundamental requirement.
Network/cooperation/trust	In a Physical Internet network, **data sharing, privacy and data ownership** are very important topics, which have to be respected. Since various stakeholders with different relationships are included, trust between the participants involved is a crucial element.

Coverage	Description
ICT/ITS technologies	**Real-time data** are essential to respond to unexpected situations – ICT/ITS technologies are able to provide them through the use of tracking, tracing containers, monitoring the environment and enabling regular communication between the members of the network.
Physical infrastructure	The most important prerequisite is an existing infrastructure to carry out transport services and use the different transport modes. These can be **stationary** (i.e. roads, rails, inland waterways, transshipment nodes), or **moving resources** (i.e. trucks, trains, barges, etc.).

Figure 15 – Critical success factors for synchromodality

6 Target audience

This chapter describes briefly the profile of the **entities** that are most likely to start **using the services** linked to these new markets.

6.1 Industrial ecology

When investing in industrial ecology, the target groups involved **depend on the size of the port and the nature of its logistics services** – managed by one company, or through numerous market players with the port authority only engaged in basic administration processes and infrastructure maintenance (landlord model).

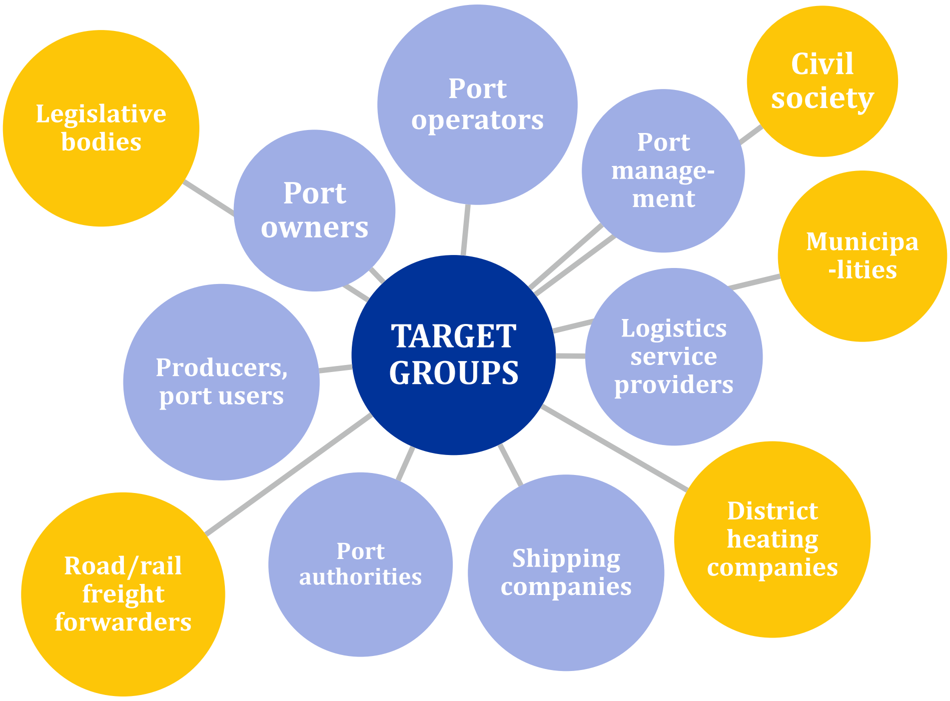


Figure 16 – Target groups linked to industrial ecology

However, the possible **core target groups** using eco-innovative services include *(see Figure 16, in blue)*:

- port owners;
- port management;
- port authorities;
- port operators;
- shipping companies;
- logistics service providers; and
- producers, port users.

Furthermore, there are several **other organizations, companies and institutions outside port areas with a special interest in influencing the local/regional/national economy**, such as *(see Figure 16, in yellow)*:

- district heating companies;
- nearby municipalities;
- the civil society;
- freight forwarders on road and rail (with an aim to reduce the emission of their fleet and/or switch to electric vehicles); and
- regional, national governments and policy-makers, legislative bodies (providing a supportive legislation framework for investing in eco-innovation and sustainable solutions).

6.2 LNG as cargo

Several different sectors must be involved and informed about the benefits of LNG: e.g. **gas companies, logistics service providers, freight transport companies in all modalities, consumers, the responsible public and private authorities**. They all should have a knowledge of the following main topics – a **basic curriculum** – in order to increase the safety conditions for all stakeholders in the supply chain:

BASIC KNOWLEDGE OF LNG

- specific characteristics – physical/environmental properties, risks – of LNG
- the impact of these characteristics on the design and structure of the vessels
- the need of protecting the structure of the vessels against the brittleness of steel
- background information (e.g. regarding LNG markets)

EQUIPMENT

- cargo tanks, pressurized tanks and membrane tanks
- isolation types and the reasons to protect isolation
- heat transmission coefficients
- the 'holding time' principle and its calculation method for each journey

MAINTENANCE

- how to start up, cool down and shut down the LNG equipment for a shipyard visit

SAFETY

- the functioning of the safety relieve valves
- the use of the correct PPE (Personal Protective Equipment)
- safety devices during bunkering
- dangerous situations and adequate countermeasures
- MSDS (Material Safety Data Sheet)
- safety culture

DOCUMENTS AND REGULATIONS

- applicable international and national regulations
- reception/loading documents (e.g. bunkerage log book)

COMMUNICATION AND COOPERATION

- the definition of the roles and responsibilities

6.3 The Danube container market

If the final goal is to provide sustainable, decarbonized transport opportunities for a competitive price, **the shipping industry has to set itself up for it in time** – CO_2 targets must be determined, and the certificate costs should be included in the price of the services, even without outside pressure, through a **strong self-commitment**. These actions will undoubtedly lead to an expansion of the waterway transport routes and an increase in the container business on the Danube. Points of particular influence appear on the route by which the CO_2 prices will actually end up in the transport processes:

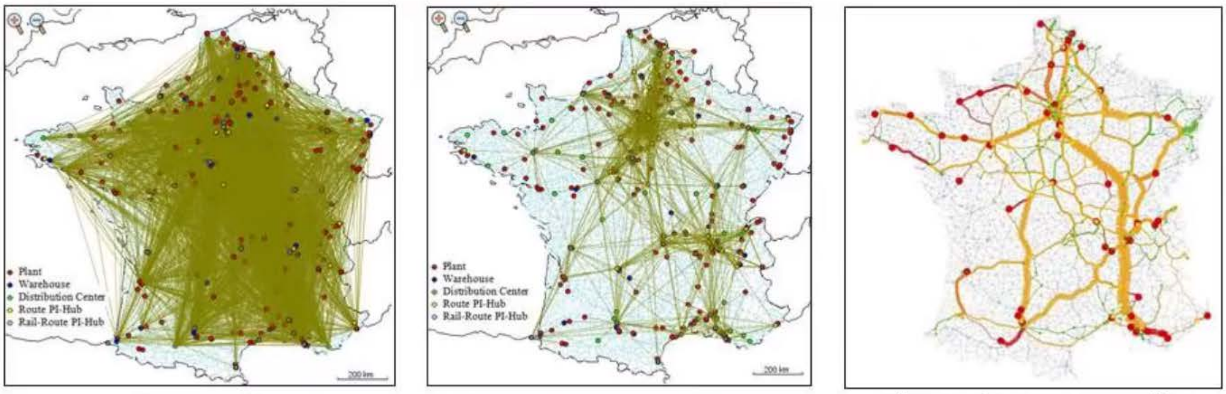
- at the **transporter** itself;
- at the **freight forwarders**; or
- at the **shipping companies**.

Considering a wider target audience, the structure of *Figure 16* should apply here, too.
Therefore, it is recommended to get into contact with **ports and IW-operators** and **other actors within the transport chain** (i.e. major carriers) to **establish a "general CO_2 certificate of economics" – and also combi-products**, to develop these topics together before other modes of transport occupy them and establish a strong position on the market.
In order to be attractive for ship owners and customers as receiving and dispatch terminals, **each terminal** part of the site competition – in cooperation with its operators – **should aspire to manage its own versatile container depot** and bind owners as exclusively as possible to the location. The general conditions on the Danube (i.e. the difficult situation west of Regensburg and the low demand-density south of Budapest) perpetuate the assumption that – as a **set-up phase** – **an empty container liner service** on the river between Regensburg and Budapest could be feasible. In the event of success and emerging market demand, **a frequency and service expansion** could be considered in the **roll-out phase**.

6.4 Danube ports and the Physical Internet

As its definition suggests, the Physical Internet is based on the idea of **interconnectivity** and **encapsulation**. The former means the existence of **universal standards** – both in the infrastructure and the offer of services: containers should connect without any difficulty with each other, no matter what the product is inside; they should fit on the conveyor and into the lift; and handoffs should be easy processes throughout the whole supply chain. The latter refers to the fact that **the Physical Internet only deals with packages of goods**, or more specifically, **packets of information**. The main goal is to **keep everything moving, using all available capacities** (or as many as possible).
As a target audience, this new market should involve **every stakeholder of the supply chain** (under the requirements of data security, of course) – these actors can be extrapolated from *Figure 16*. It is important to keep in mind that the key issue of the Physical Internet is **optimizing flows** *(see Figure 17)*. Some of it can be implemented to a certain degree in one company but the concept aims to take things further, relying on **a collaboration between companies/relevant stakeholders who are willing to share their information and work with each other in order to create an optimized service.**

Interreg
Danube Transnational Programme
DAPhNE



Current flows | Physical Internet flows | Physical Internet traffic

Figure 17 – Simulation based on the distribution flow of two top retailers in France
Source: Benoit Montreuil

7 Interdependencies between the four markets and conclusions

7.1 Connections between the four markets

Studying the emerging opportunities regarding these new markets makes it clear that there are – at least – two important connection points between them:

1. Several development plans focused on **industrial ecology** include a component concerning alternative fuel sources, specifically, **LNG**. As previously mentioned, Ennshafen in Austria is invested in sustainable transport and protecting the environment: their mission is supported by a district heating service based on biomass processing and waste reusing, but also LNG terminals, since **the latter is a vital part of a sustainable environment, just as the existence of a circular economy**. The same is true to the Duisburg port. Although **the use of LNG** does not eliminate all contamination and waste, it is eco-friendly and sustainable – a study shows that it **leads to a reduction of 35% of the operational costs and 25% of CO_2 emissions**, proving itself to be a smart choice both economically and ecologically.[3]
2. **The Physical Internet has effects on both industrial ecology (and as a related field, on the use of LNG) and the Danube container market.** The intertwined nature of these new markets is elaborated in detail in the following subchapter.

7.2 The effects of the Physical Internet and digitalization

The Physical Internet can be easily implemented parallel to industrial ecology, since the Internet of Things (IoT) has an enhancing effect on the latter. One major aspect of the IoT is that **physical devices are connected via sensors to collect and exchange data** – this can be used to **monitor the capability and condition of different types of equipment remotely**, therefore, if one of them becomes obsolete, **the IoT can support its retrieval and recycling**. The Physical Internet also enables a **leasing model** – instead of selling expensive machinery, manufacturers can lease them to their customers and monitor their status to dynamically repair them when needed. The same monitoring concept can be extended to other assets of a port, buildings, for example. One limitation of this technology can be the **governmental lag hindering innovation**. In several countries, like China and Russia, cross-border reverse supply chains are prohibited due to a lack of legislation on perceiving the differences between a re-manufactured and a used product. Of course, the data collected by the IoT brings up several questions about **privacy and security**:

- Who owns the collected data?
- How reliable are these IoT systems?
- What is the level of vulnerability of these new innovations/technologies to hackers and people looking for an opportunity to do harm?

These are important concerns, which the stakeholders and users of these systems must discuss in the future, but it is clear that the possible profit and performance growth predict an enormous amount of potential for the Physical Internet in industrial ecology.

[3] Burel, F. (2013): Improving Sustainability of Maritime Transport through Utilization of Liquefied Natural Gas (LNG) for Propulsion. Energy, vol. 57, pp. 412–420

The **Danube container market** – and standardized transport units – can be defined as **a key element of the Physical Internet**. From an IoT point of view, a container has to be modular, robust and sustainable to manufacture and use – some of these requirements can be quite contradictory in nature. Furthermore, international standards and guidelines must also be considered (i.e. ISO). Within the **ATROPINE project** (Fast track to the Physical Internet), some current ideas were identified for a Physical Internet container:

- **Joint Modular Intermodal Container**
  The Joint Modular Intermodal Container (JMIC) was developed by the US Defense Standardization Department – their aim was to better use the capacity of 20 and 40-foot containers. A JMIC unit contains side and back supports (to provide enhanced protection for cargo) and interlocks with other units (to guarantee safe transport) vertically and horizontally. They can also be equipped with RFID tags.

Figure 18 – A JMIC with solid side panels
Source: TechLink 2018

- **Tworty Box**
  A Tworty Box is a 20-foot ISO container which can be combined with another to form a 40-foot ISO container. The main objective is to make logistics for shipping companies more efficient, cost-effective and sustainable by reducing the number of empty container transports (i.e. merging or decoupling two Tworty Boxes).

Figure 19 – Tworty Box in a 40-foot configuration
Source: Co

- **CHEP**
  CHEP is one of the world's leading suppliers of pallet and container pooling – they also invented the **quarter-pallet**: it can be picked up and transported from all sides and stored in a space-efficient way. The latest generation added some innovative improvements such as displays which can be securely and quickly attached to it and it is also lighter than its predecessor.

Figure 20 – CHEP Quarter Pallet
Source: German Design Award 2018

- **Cargoshell**
  In June 2009, a Rotterdam-based entrepreneur presented a new concept: a **fold-up shipping container** made of composite and aluminum. If the container is transported empty, it requires only a quarter of its original space and can be folded in 30 seconds by one person using a forklift truck. Additionally, the containers are easy to clean and more environmentally friendly to manufacture.

Figure 21 – Collapsible Shipping Container
Source: TrendHunter 2018

7.3 Physical Internet and human resources

Due to the implementation of the Physical Internet, current **jobs** at ports **will change** and **new job opportunities** will open up:

- **Data scientist** – they are responsible for analyzing the data gathered in ports in order to improve efficiency;
- **Shore-control-centre operator** – they are responsible for monitoring vessels and checking their position and performance;
- **Land-based crew** – they monitor and maintain the vessels from the port;
- **Multimodal traffic controller** – their main job is to optimize the transport flows in ports by analyzing historical and real-time data;
- **Port energy manager** – they monitor the power consumption and production in ports and match the supply and demand;
- **Officer in the Port Authority's nautical command centre** – this person is responsible for the safety of the vessels in the port area (based on radar systems and vehicle-to-vehicle/infrastructure communication);
- **Port infrastructure manager** – they monitor the mobile and stationary port infrastructure by using drones.

During a workshop within the DAPhNE project (Activity 4.3 – Human Resources Development), the **changing working conditions** for port employees in the future were discussed, including the topic of **diversity** – an inclusive working environment is already playing an important role and will continue to do so. In addition, **a potential new job profile** was developed during the meeting *(see Figure 22)*. The **maintenance manager** will be responsible for **monitoring the performance of the port and its infrastructure**, which will be made possible by the high level of digitalization, **using a remote device** (e.g. tablet, smartphone).

Job: Maintenance Manager

- male/female
- 35-40 years old
- married or divorced
- commuter
- work-life balance is an important factor
- fully networked (tablet, smartphone, etc.)
- salary: country-dependent (75% of the CEO's, but it may change over time)

BIOGRAPHY

- technical/commercial training (understanding the total cost of ownership/lifecycle of products)
- flexible working hours (home office is possible – fully networked and with VR glasses: remote diagnosis, contact with local staff)
- salary: 70% fix, 30% variable
- high availability (24/7, to react in case of an emergency)
- professional carrier: coming from a technical job (e.g. crane manufacturer)
- further education is mainly used in the area of social competence
- tasks: negotiating with suppliers (new purchases) and concluding contracts

COMPETENCES/SKILLS

- technical/commercial know-how
- languages (English, German, Chinese)
- stress resistance
- social competence
- assertiveness
- love/passion for technology
- networking skills (knowing important people)!

CHANCES

- freedom of design in the job

CHALLENGES

- pressure → keeping the shutdowns short, staying in the budget

Figure 22 – Maintenance Manager

7.4 Training needs for the markets' expansion

As a result of these changes in the necessary human resources of the new emerging markets, the respective **training needs have to be adapted** and **the current logistics education should take the changing environment into account**. One thing is certain: qualifications will become more important in the future; therefore, **lifelong learning** should become a priority area in the sector – also due to the fact that the constantly updating technologies and new innovations require it.

For the current port operators and managers, new **training programmes** need to be offered **on how to govern the ports in an environmentally and economically sustainable way at the same time**. In some cases, **highly focused and specified courses** will be needed – for example, in the topic of LNG: **one of the previous subchapters** contains a preliminary curriculum for a possible training course in the field, regarding:

- some basic knowledge about LNG (its risks, what vessels are needed to transport it, information about the market opportunities, etc.);
- the important details of the necessary equipment (cargo tanks, heat transmission coefficients, isolation types, etc.);
- regular maintenance;
- the most crucial safety requirements (relieve valves, how to use the PPE, what are the possible dangers, etc.);
- the current legislation and regulations; and
- communication and cooperation.

To better prepare the labour market, **every new job profile must be disseminated** to the potential future port employees to make them aware about the changing situation and help them prepare for it in advance. To identify the gaps in the current job structure of the ports, **transnational workshops** can be organized where stakeholders from different ports and companies are present to brainstorm and exchange their know-how.