The NEEDS project has received funding from
Horizon Europe research and innovation programme
under grant agreement No 101056938

Needs

Dynamic Techno - Economical Scenario
Simulation Model for Sustainable
Waterborne Activities and Transport

D 4.1 Socio-economic impact assessment

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Document information	
Short description	The document provides a detailed analysis of the socio-economic impact of transitioning waterborne transport to climate-neutral practices. Focusing on two cases—the Rhine and Greece—the study examines the economic effects of scenarios such as retrofitting existing fleets, building new vessels, and changing energy sources.
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Executive summary

The document provides a detailed analysis of the socio-economic impact of transitioning waterborne transport to climate-neutral practices. Focusing on two cases—the Rhine and Greece—the study examines the economic effects of scenarios such as retrofitting existing fleets, building new vessels, and changing energy sources.

In the Rhine case, the analysis shows how these changes have a positive impact on shipbuilding demand, employment, and the supply chain. The study emphasizes the importance of considering long-term trends rather than short-term peaks.

Similarly, the Greece case analysis explores the economic consequences of retrofitting, constructing new ferries, and altering energy sources. The assessment highlights the broader economic benefits, including increased employment and consumer spending.

The document also looks at the reduction in external costs, particularly in CO_2 emissions, signalling positive environmental and societal outcomes.

Overall, the socio-economic impact assessment provides valuable insights for decision-makers navigating the complexities of transitioning to sustainable waterborne transport, emphasizing the interconnected nature of economic factors in this transformative journey.

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List of abbreviations

BAU	Business As Usual
CAPEX	Capital Expenditures
CO2	Carbon Dioxide
CO2e	CO2 equivalent emissions (also known as CO2eq)
ECA	Emission Control Area
GHG	Greenhouse gases
H2	Hydrogen
HFO	Heavy Fuel Oil
HVO	Hydrotreated Vegetable Oil
ICE	Internal Combustion Engine
LNG	Liquified Natural Gas
LPP	Length between perpendiculars
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MWh	Megawatt hours
NOx	Nitrogen Oxides
OPEX	Operational Expenditures
OPS	Onshore Power Supply
PM	Particulate Matter
RES	Renewable Energy Sources
SO_2	Sulfur Dioxide
SRIA	Strategic Research and Innovation Agenda
TRL	Technology Readiness Level
WTW	Well-to-Wake

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1. Introduction

The transition of waterborne transport towards climate-neutrality is an ambitious and challenging process for all stakeholders involved. The NEEDS techno-economic simulation model assumes the total costs of ownerships as the main decision factor for shipping companies (see Deliverable 1.1), which reflects the importance of the economic viability of any transition pathway towards net-zero emissions in order to cope with upcoming legislation and changing market demands for waterborne transport.

On the other hand, the transition of waterborne transport is also affecting other maritime stakeholders: A potentially increasing demand for retrofitting the existing fleet or to partly substitute the existing fleet with climate-neutral new build ships could increase the production value of new building- and repair yards in Europe. If so, the complete value chain including maritime equipment manufacturer would see an increasing demand with positive effects on production value, value added and employment.
In addition, the transition towards alternative energy carriers also impacts the energy production and energy distribution sector. New production facilities have to be built, new distribution vehicles and bunkering infrastructure in ports need to be established. The investments also trigger additional production value, added value and employment in the corresponding industries.

The economic impact on certain industries including the associated employment will induce additional economic effects with an increased demand for other goods and services based on a higher employment rate and potential additional production capacities, which causes additional positive economic impact.

Besides the economic impact and its positive impacts on employment, the transition to climate-neutral waterborne transport will reduce harmful emission substantially and therewith contribute to human well-being and a reduction of external costs.

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2. Socio-economic impact assessment

The socio-economic impact assessment pursues to quantify the direct, indirect and induced impact of the techno-economical scenario simulation models for the Rhine- and the Greece case. Thereby, the analysis considers the whole supply chain, including energy production, energy supply in regional ports, energy converter and equipment manufacturers, newbuilding and repair-yards, ship owners, ship operator and customers. Based on the simulation results of WP 2 (Greece case) and WP 3 (Rhine case), a wide range of KPIs including regional GDP growth, direct, indirect, and induced employment, reduction of external costs are computed based on available statistics form EUROSTAT, OECD and national statistic bodies. In the next chapter, the underlying methodology will be explained.

2.1 Methodology

The starting point are the simulation results of both scenarios, which are available for download in the NEEDS-Dashboard (https://needs.application.marin.nl/)(see Figure 1).

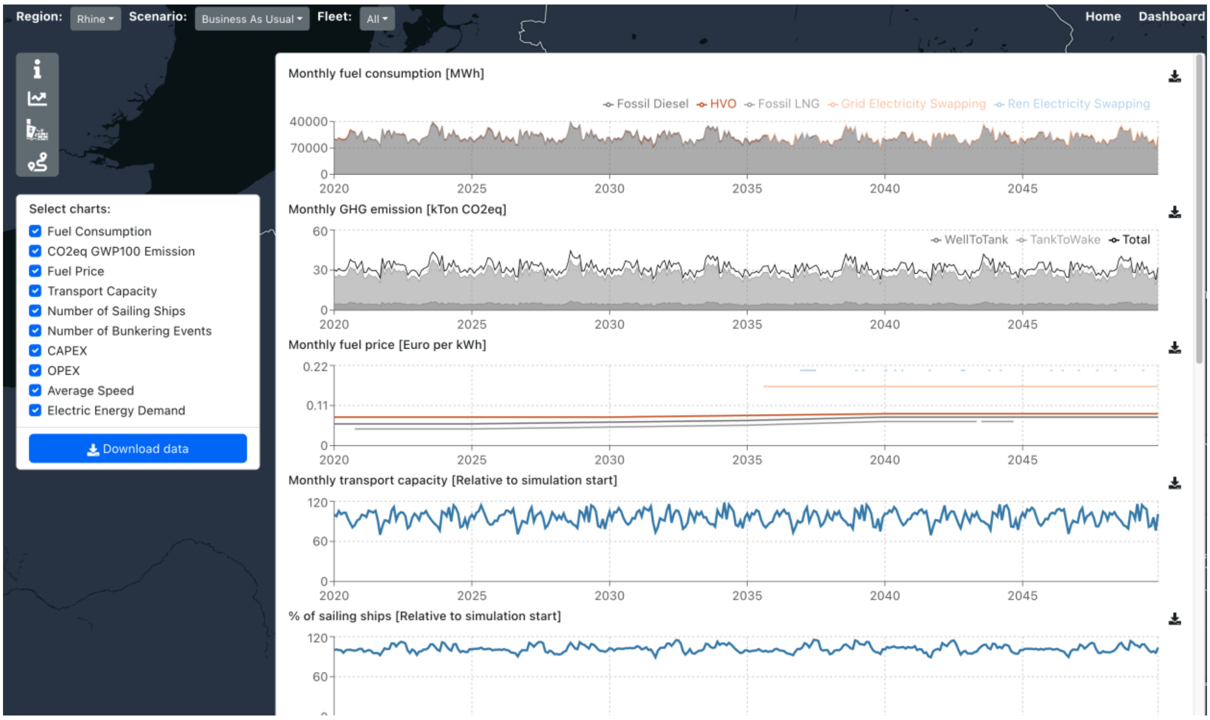

Figure 1: NEEDS simulation results dashboard and result download

The simulation results already contains a number of relevant results for the impact assessment for download, including:

- CO_2-Emissions (Well to tank and tank to wake)
- Energy consumption
- Energy prices
- Transport capacity
- Number of ships

- Capital expenditure
- Operational expenditure

All values are available as a timeseries on a monthly basis for each scenario. Figure 2 illustrates the way of calculating the direct, indirect, and induced impacts.

Based on the simulation results, the following further calculations are performed:

- **Retrofitting of ships:** The capital expenditure includes the costs for retrofitting ships for other energy carriers, but don´t include the investment into new ships. The investment into retrofitting is mapped to the structural business statistics (SBS) of EUROSTAT to analyse the value added at the repair yard and to deduct the value of intermediate products from the supplier.

- **New building of ships:** With the given assumption of a constant transport capacity, the transition to other energy carriers causes a loss of transport capacity on fleet level since alternative energy carriers need more storage space. Based on the loss of transport capacity, the number of new build ships is derived in the model and considered as additional demand for new building yards. In the next steps, the value added and the number of intermediate products form maritime Equipment supplier is analysed based on SBS of EUROSTAT.

- **Maritime Equipment supplier:** The maritime equipment supplier provide many intermediate products and services to new building yards and repair yards. Available purchase statistics and Input-Output tables are utilised to structure the intermediate products and derive the amount of value added in each supplying industry.

- **Energy production and supply:** The energy prices are including the depreciation costs of the alternative fuel production facilities and distribution assets.

- **Associated employment:** The determination of the employment related to the different industries involved in the process are based on the value added to employment ratio of SBS (EUROSTAT) for the respective industry.

- **External costs:** The CO_2 emission results of the simulation model is utilised to calculate the external costs of 237 € / t of CO_2 based on the 2022 assessment of the German Umweltbundesamt (Umweltbundesamt 2022).

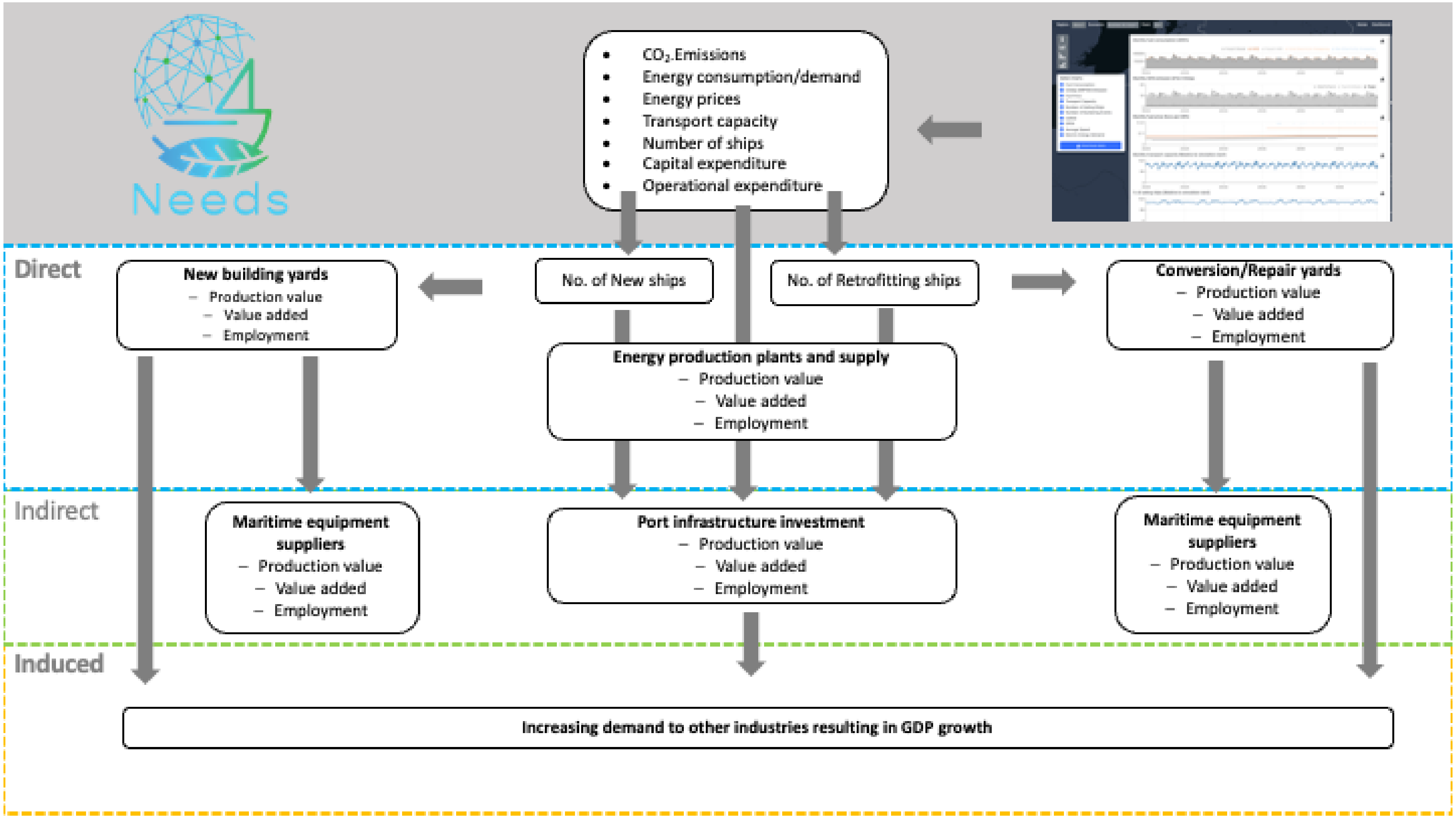

Figure 2: Calculation methology for the socio economic impoact assessment

3. Impact assessment for the Rhine case

The Rhine case is developed, simulated, and documented within WP 3 and focuses on the Inland waterway transportation. Overall, nine different scenarios have been developed and assessed. In the following chapter, the methodology described in chapter 2 will be applied for all 8 scenarios to determine the socio-economic impact.

The transition towards net-zero waterborne transport triggers three streams of direct economic impact:

1. Demand for converting the existing fleet
2. Demand for alternative energy sources
3. Demand for additional vessels

3.1 Retrofitting the current fleet

The NEEDS simulation model calculates the number of conversions to other energy sources including the associated conversion costs for each scenario (see Deliverable 1.2). The results are presented as CAPEX in the NEEDS dashboard and represent the starting point for the further analysis.
The total CAPEX for ship conversions varies for each scenario as depicted in Figure 4.

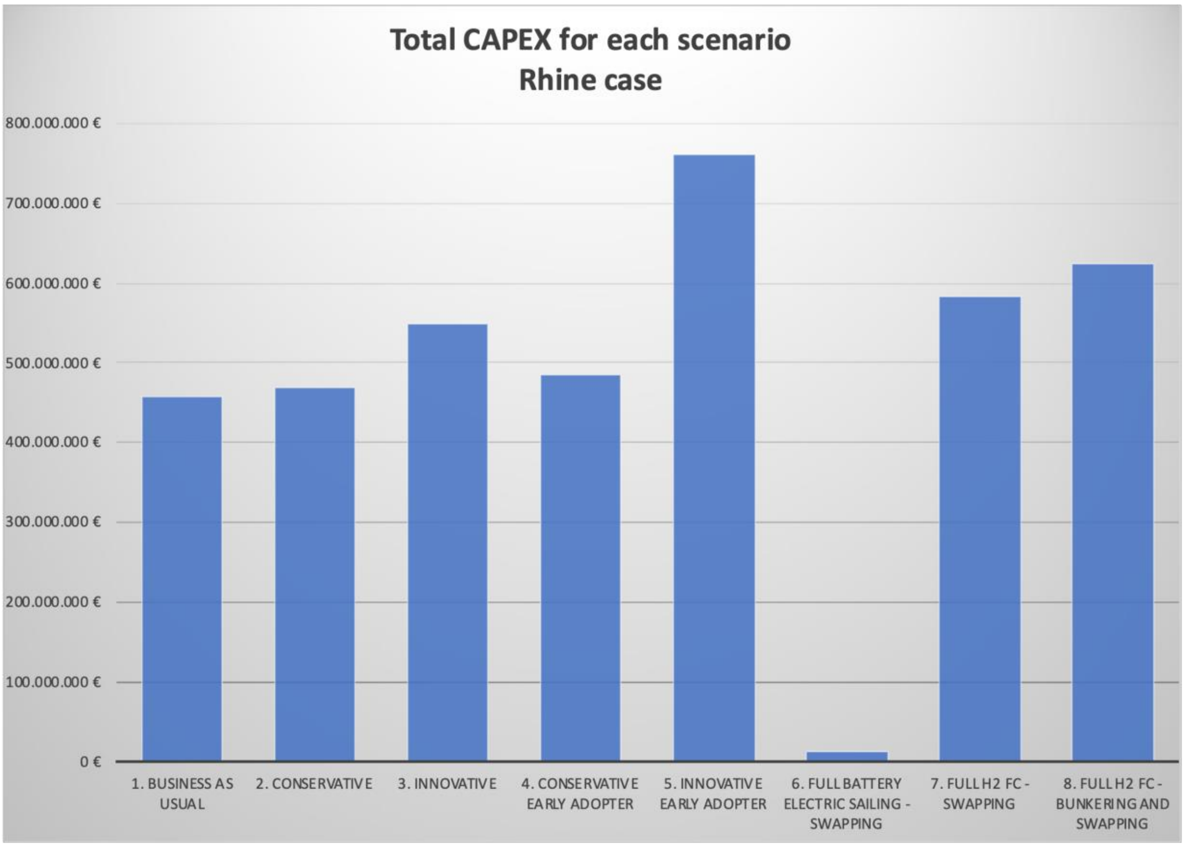

Figure 3: Total CAPEX for each scenario of the Rhine case

With the exception of scenario 6, all other scenarios activate substantial investments of more than 400 Mill. EURO and therewith demand for the shipbuilding sector. However, this fluctuates substantially in the timeline towards 2050 as illustrated in Figure 4.

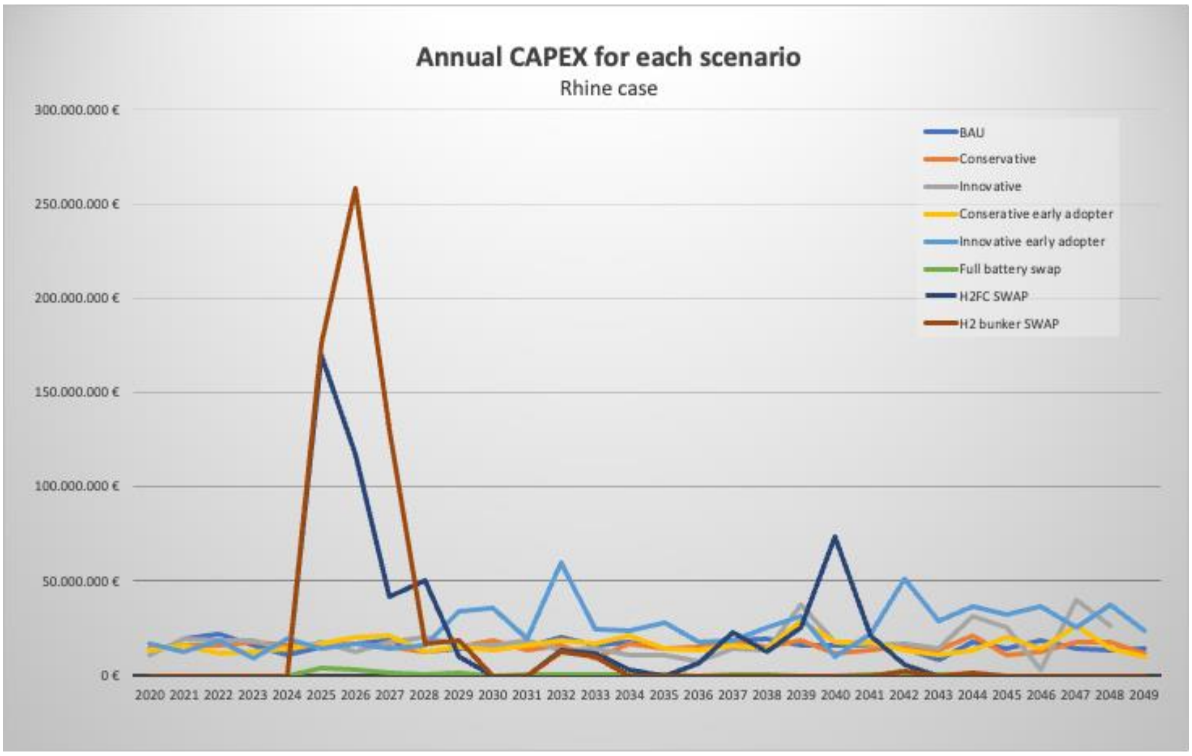

Figure 4: Annual CAPEX for each scenario in the Rhine case

While some of the scenarios initiate a relatively stable long-term demand like the conservative or conservative early adopter scenario, other scenarios have a high volatility like the H2FC SWAP or a short-term, intensive peak demand like the H2 Bunker SWAP scenario. Consequently, the associated value added and employment will also vary proportionally, which underlines the importance of time series analysis instead of peak value comparisons.

In order to serve this demand, the shipbuilding industry will perform the conversions and add value at the shipyard (Direct impact) and intermediate products like maritime equipment and other supplies (Indirect impact.) For the analysis of the direct impact at the shipyard, the EUROSTAT SBS has been consulted. Figure 5 shows the relation between production value and value added for the business as usual scenario. In this way, the value added for each of the eight scenarios of the rhine case has been computed as a timeseries towards 2050.

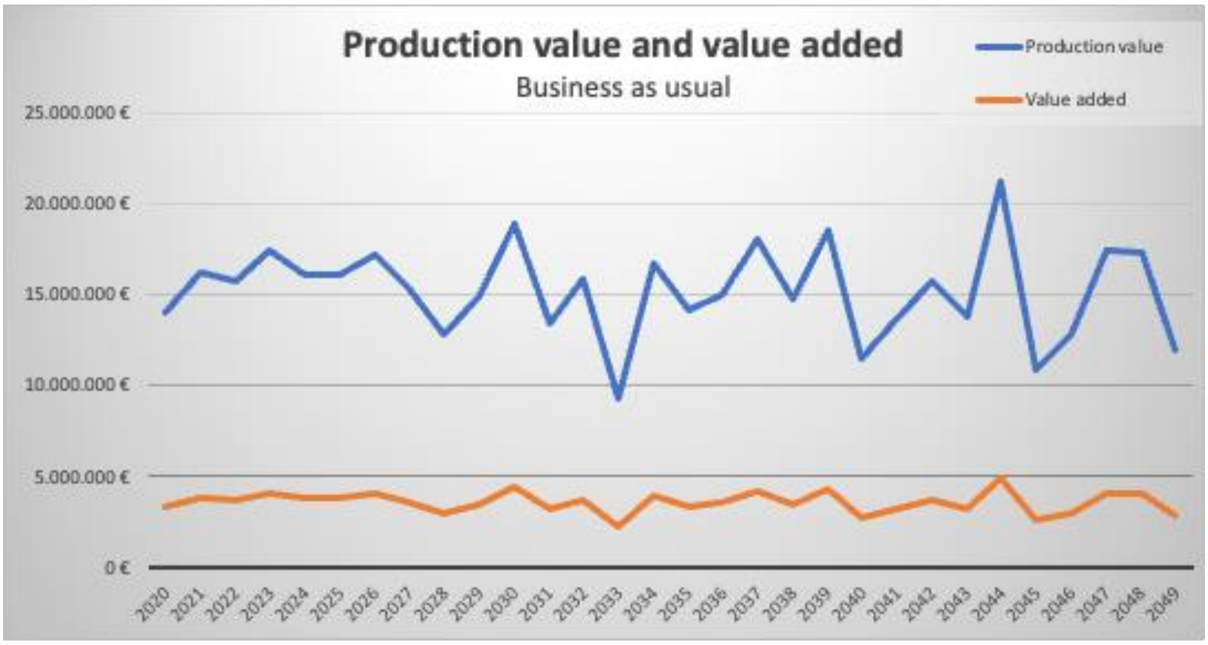

Figure 5 Production value and value added at shipyards in the business as usual scenario

In total, in each of the investigated scenarios with the exception of scenario 6 – Full Battery Electric Sailing, more than 100 Mill. EURO of added value would be conducted at shipyards (see Figure 6).

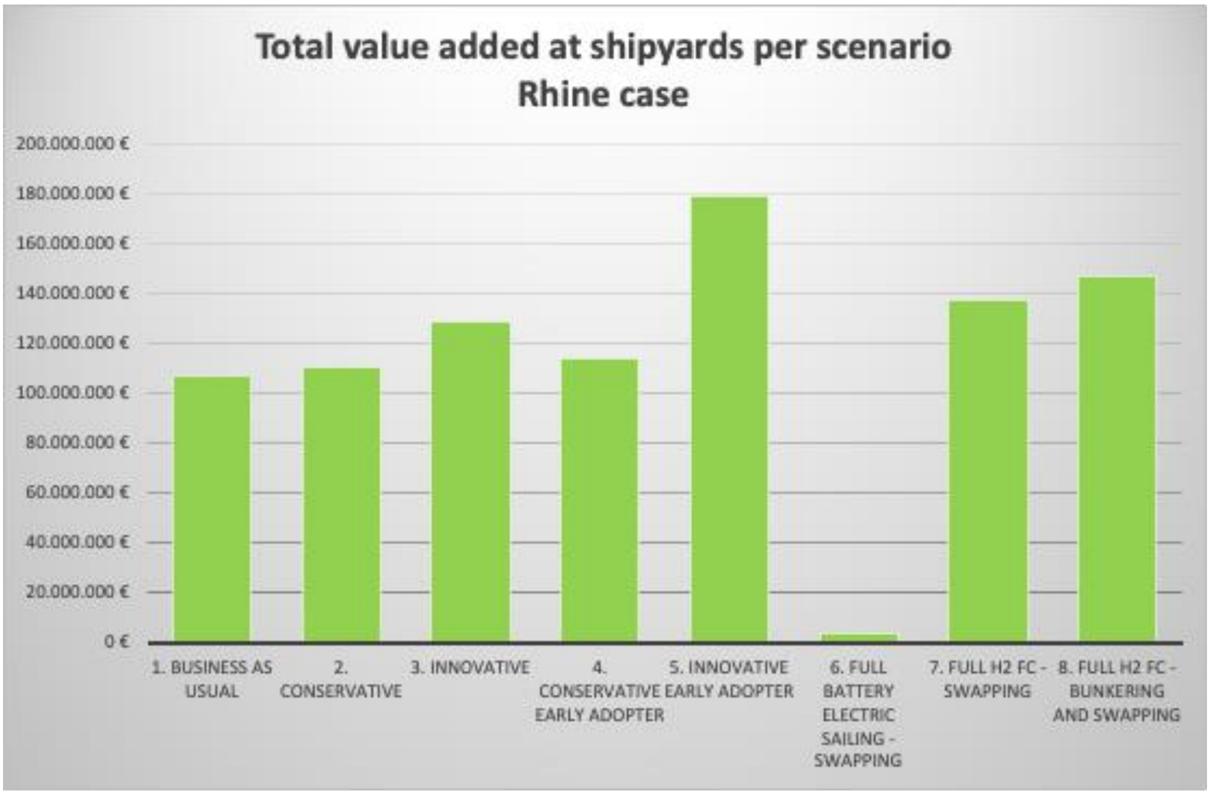

Figure 6: Total value added at shipyards per scenario

The total value added will be added to the ship in the timeline 2020 – 2050 in line with the CAPEX development for each scenario (see Figure 4). Therefore, the value added time series is the basis to compute the number of employees in combination with EUROSTAT SBS statistics. For each resulting time series, the average number of employees was calculated, which represents the average number of additional employments for the time period until 2050. Figure 7 presents a result overview for each scenario.

Figure 7: Number of new employees in shipyards per scenario

3.1.1 Indirect impact of retrofitting

The conversion of the existing fleet triggers also indirect economic impact by increasing the demand for intermediate products and services by conversion/repair yards. Thereby, the assessment of the indirect impact of the new ship production is based on a comprehensive analysis of available statistics for the purchase structure of intermediate goods and services of shipyards (see References SBS 2023 and Deutsche Wareneingangsstatistik).

As a result, the demand for intermediate products for retrofitting is calculated for each scenario (see Figure 8). The results show clearly the dependency of the intermediate products demand and the total investment costs.

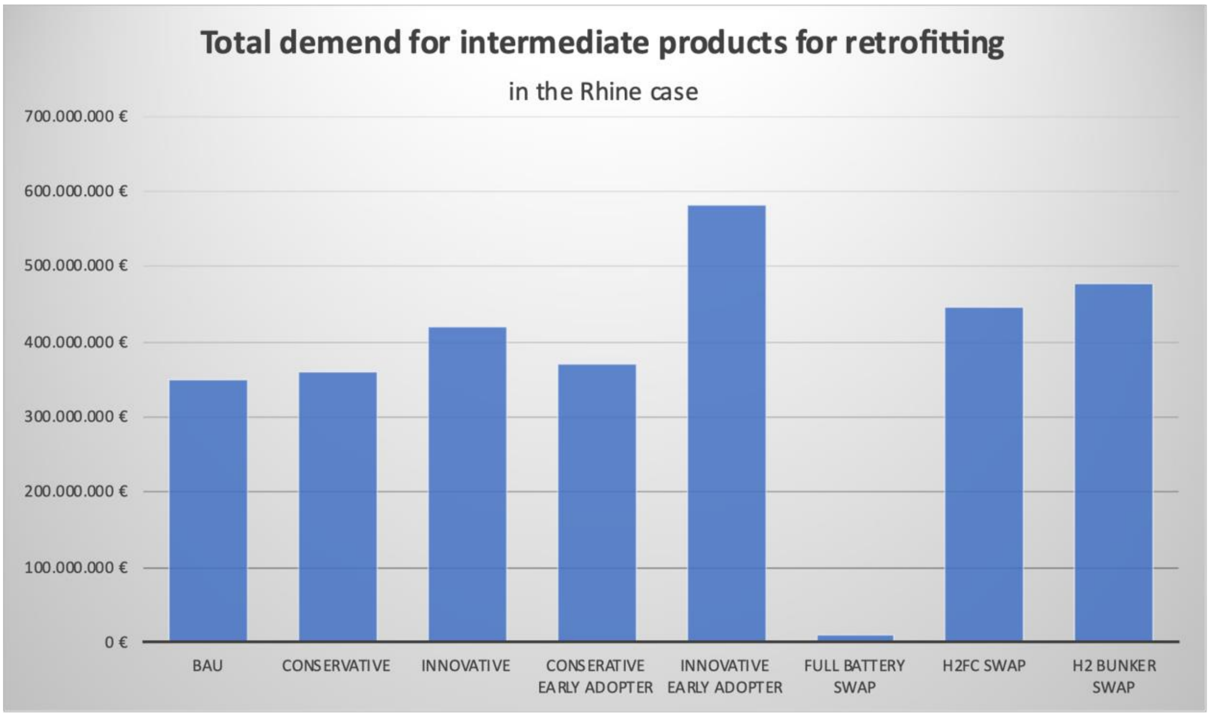

Figure 8: Total demand for intermediate products for retrofitting until 2050

The production of the intermediate products initiates value added and employment alongside the supply chain. Therewith, the indirect employment associated with retrofits in annual FTEs is highest in the scenarios with high investments and vice versa.

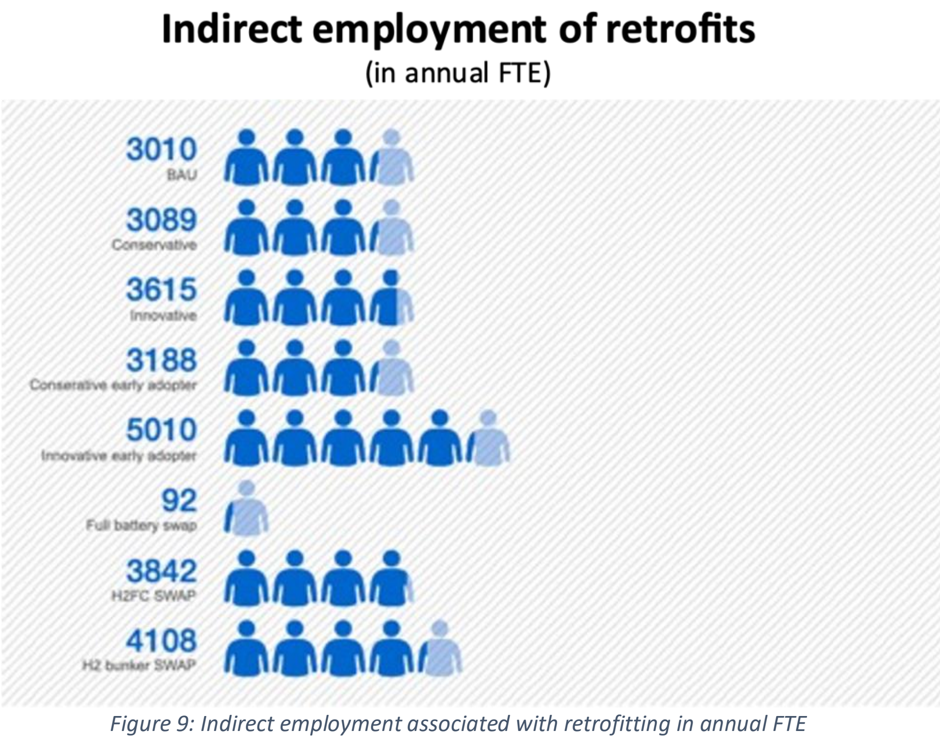

Figure 9: Indirect employment associated with retrofitting in annual FTE

3.2 Demand for additional IWT-vessels

The transition to alternative fuels affects the transport capacity of each vessel. For most of the considered alternative energy carriers, the volumetric energy density is comparatively lower to Diesel. Therefore, the energy storage requires more volume in the ship and therewith decreases the transport capacity.
In the simulation of the Rhine case, the transport capacity of the fleet is assumed to be kept constant until 2050. As a result of the lower transport capacity of vessels converted to alternative energies, there is a demand for additional vessels in the fleet to keep the transport capacity constant. Therefore, the development of the fleet size and the transport capacity of the simulations have been analysed for each scenario. Table 1 summarised the results for each scenario in the Rhine case.

Scenario	Number of additional vessels
BAU	0
Conservative	5
Innovative	13
Conservative Early Adopter Increase	61
Innovative Early Adopter Increase	125
Forced Electric	51
Forced hydrogen swap	28
Forced hydrogen	84

Table 1: New vessels for each scenario in the Rhine case

The required additional vessels to keep the transport capacity on the same level are creating an additional demand for new build ships. It is assumed that the fleet composition remains the same, so the triggered demand will affect all vessel types of the fleet (see Deliverable 2.2 and 2.3 for details). The number of vessels and the existing fleet composition is combined with up-to-date data on the insured capital value of the inland vessels used in the Rhine case simulation and literature research on technology and installation costs of alternative energy carriers (see DST, EICB (2021)). Table 2 presents the overall investment costs for the new, additional vessels for the Rhine case fleet until 2050.

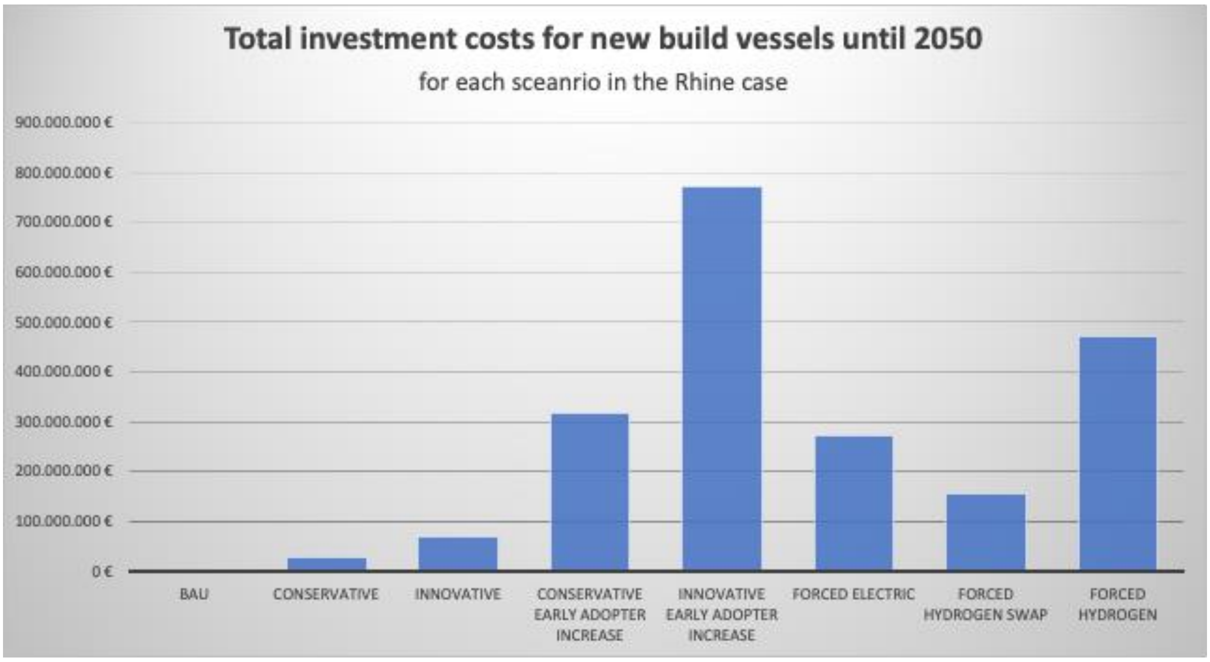

Table 2: Total investment costs for new build vessels until 2050

In accordance with the speed of the energy transition in the various scenarios described in Deliverable 3.3, the scenarios BAU, Conservative and Innovative show a slow transition and hence only a minor loss of transport capacities, resulting in a comparatively low demand for additional vessels. On the other hand, scenarios with a high level of energy transition are facing a significant loss of transport capacity and therewith an increasing demand for additional vessels.

The additional demand for vessels leads to additional value added and employment effects at new building yards. Assuming all new building activities are performed in Europe, the production of new inland waterway vessel will induce additional value added and employment. Figure 10 illustrates the direct employment effect in annual FTEs of the additional demand for IWT-vessel in each scenario for the complete timeframe until 2050.

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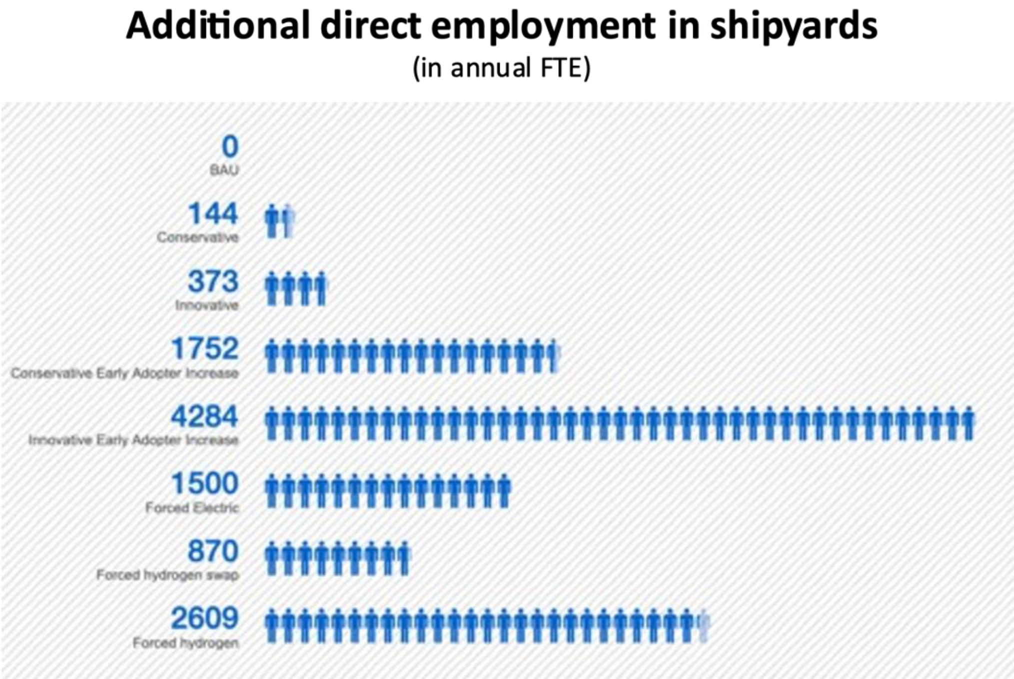

Figure 10: Additional direct employment in shipyards for each scenario

The employment effects can be translated into number of long-term full time equivalent employees for the timeframe until 2050 as depicted in Figure 11.

In accordance with the total investment costs for new IWT-vessels, the BAU, Conservative and Innovative scenario trigger the least employment due to the comparatively low rate of vessel conversion and the resulting low demand for additional, new IWT-vessels. On the other hand, scenarios with a high rate of vessel conversions, especially the Innovative Early Adopter Increase-Scenario, lead to a high demand for new IWT and consequently to more substantial employment effects.

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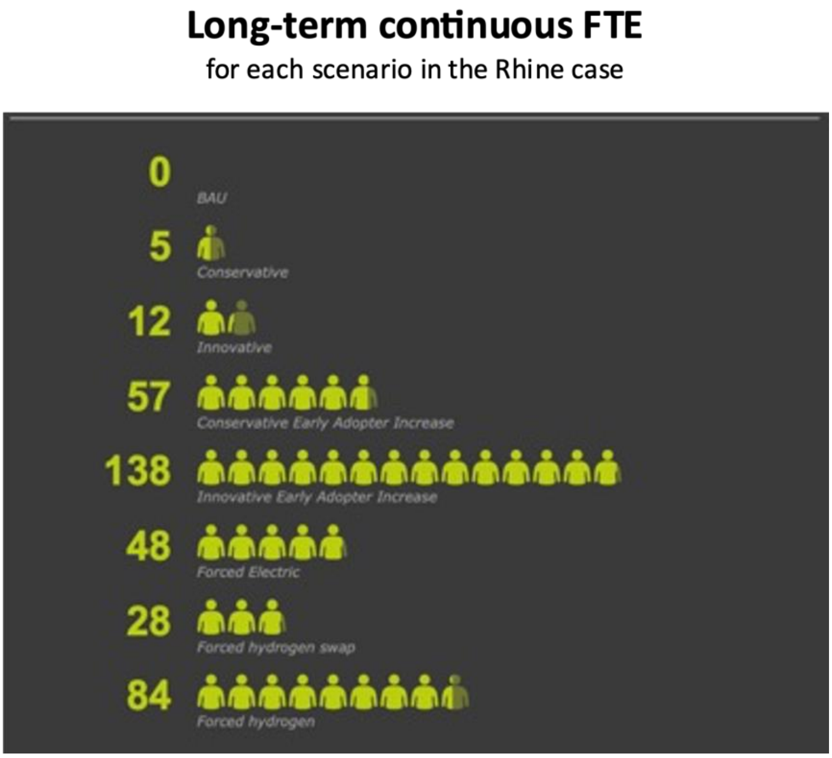

Figure 11: Long-term continuous FTE for each scenario in the Rhine case

3.2.1 Indirect impact of demand for additional IWT-vessels

The production of additional IWT-vessels leads to an additional demand for intermediate products by the shipyards. Most of these products are marine equipment, like engines, propellers, navigation equipment, Coatings, etc. Thereby, the same approach as in the indirect impact of retrofitting was applied (see chapter 3.1.1).

As a results of the analysis, the total demand for intermediate products in the supply chain of shipyards until 2050 is depicted in Figure 12. In accordance with the previous steps of the assessment, scenarios BAU, Conservative and Innovative trigger comparatively low demand for intermediate products, while other scenarios induce substantial additional demand for intermediate products from the supply chain of shipyards.

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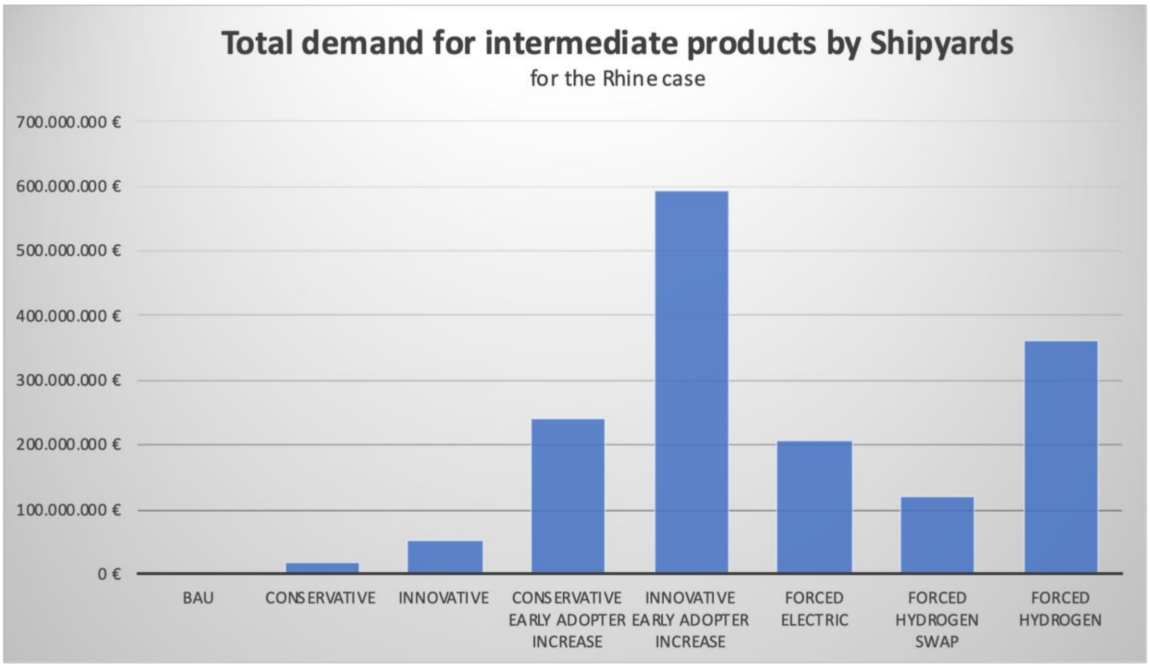

Figure 12: Total demand for intermediate products by shipyards

The production of the intermediate goods and services creates added value and therewith additional employment effects in the supply chain. Following down the supply chain and analysing the value added for multiple stages in the supply chain, the different levels of investment into IWT-vessels for each scenario and still visible. Figure 13 summarises the employment effect results for each scenario in the Rhine case.

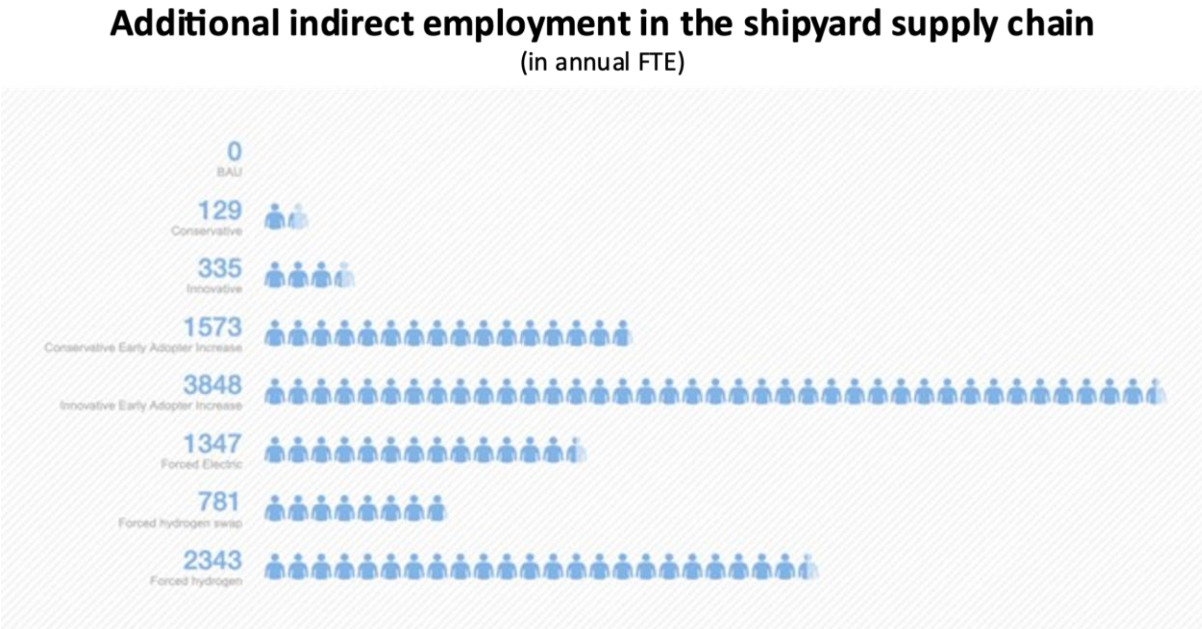

Figure 13: Additional indirect employment in the shipyard supply chain

3.2.2 Demand for energy sources

The simulated energy consumption and energy price are the starting point for the economic impact assessment. Therewith, the operational expenditures for energy varies for each of the investigated scenarios. In order to investigate the impact of the energy transition, the difference between the BAU-Scenario and the other 7 scenarios is determined as depicted in Figure 14.

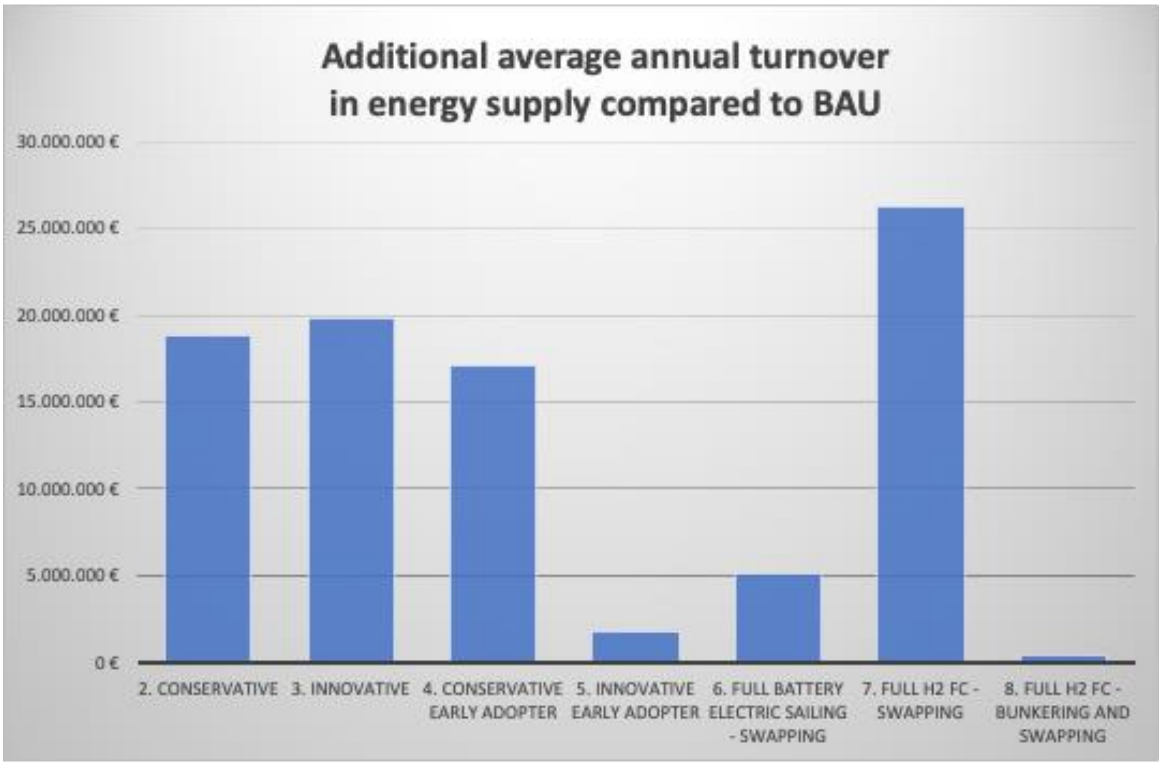

Figure 14:Additional average annual turnover in energy supply compared to BAU

While the average annual turnover is simulated to increase substantially for scenarios 2-4 and 6, the difference for scenarios 4, 5 and are rather marginal. However, the additional turnover is expected to induce additional value added in the energy production. With a higher value added, a higher employment is expected due other transport and distribution frequencies as well as additional administration. The assessment concludes a direct and indirect employment effect of more than continuous 350 FTEs as presented in Figure 15.

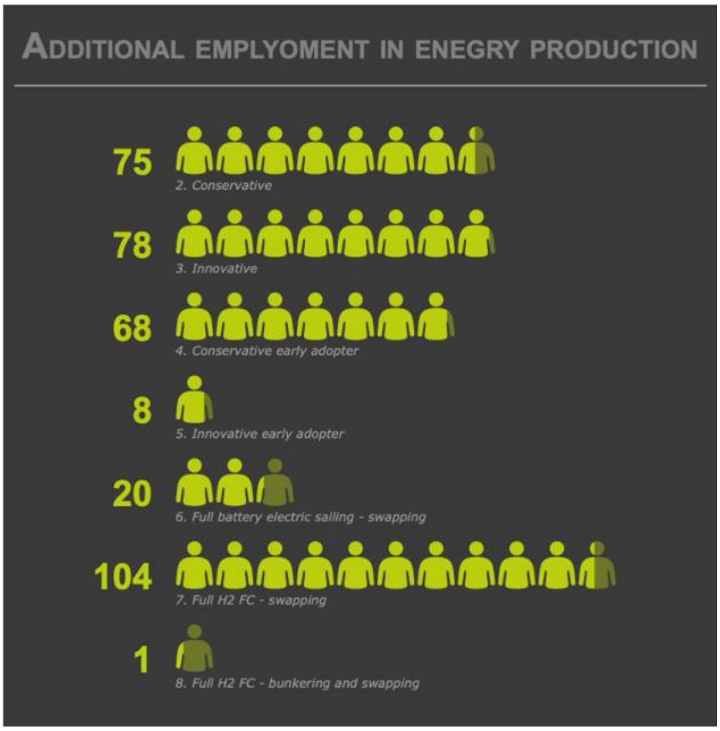

Figure 15: Additional employment in energy production and distribution

3.3 Induced impact

The increased number of employees based on the converting the existing fleet and building additional vessels including the associated employment effects in the supply chain induce additional economic impacts, since all employees will utilise parts of their income for consumer spending and therewith create additional demand.

In order to assess the induced impact, Input-Output tables for Rhine countries are analysed to derive the amount of employee compensation of the value added of all stages in the supply chain. Considering an average savings rate leads to the overall spendings of the employees for things of their daily life, including food, clothes, rent, sport, entertainment, etc. Based on the overall spendings, the associated number of employees producing and serving this demand is derived and illustrated in Figure 16 for each Scenario of the Rhine case in annual full time equivalent (FTE).

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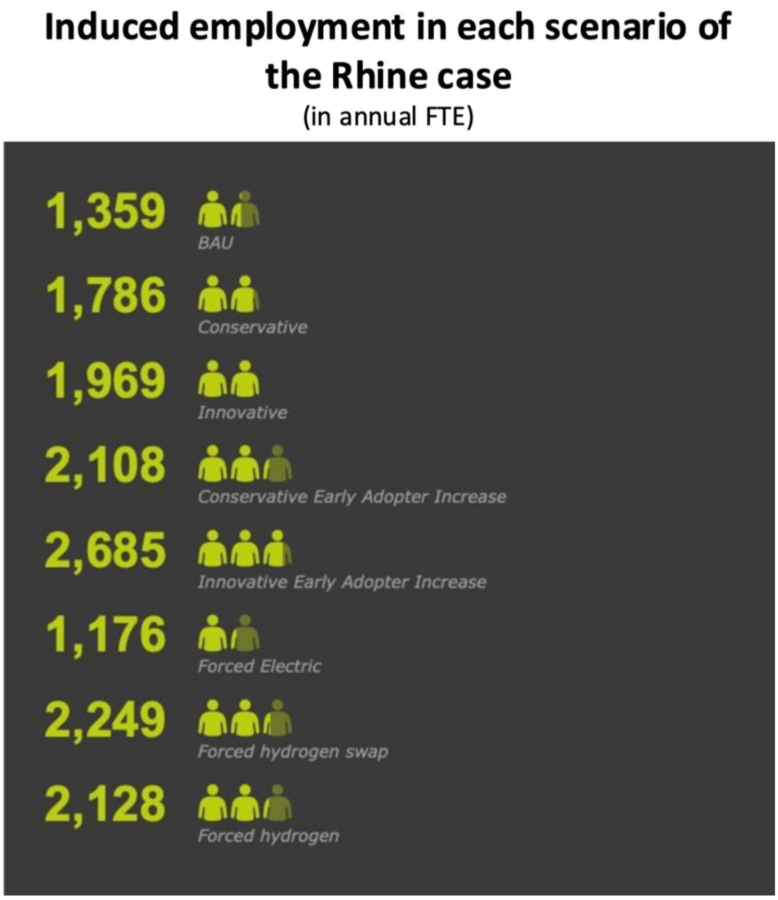

Figure 16: Induced employment in each scenario of the Rhine case until 2050 in annual FTE

3.4 External costs reductions

External costs, or externalities, are unintended consequences of economic activities affecting third parties. These unaccounted-for side effects, positive or negative, are not reflected in the prices of goods or services, leading to market inefficiencies. Negative externalities, like greenhouse gases or air pollution harm third parties, resulting in damage costs. With the simulated reduction of CO_2 emissions based on the energy transition in the Rhine case, these external costs can be reduced. Within this analysis, the CO_2-redcution for each scenario is compared to the business as usual scenario and is calculated with an external costs rate of 237 € / ton (Umweltbundesamt 2022). Figure 17 presents the results.

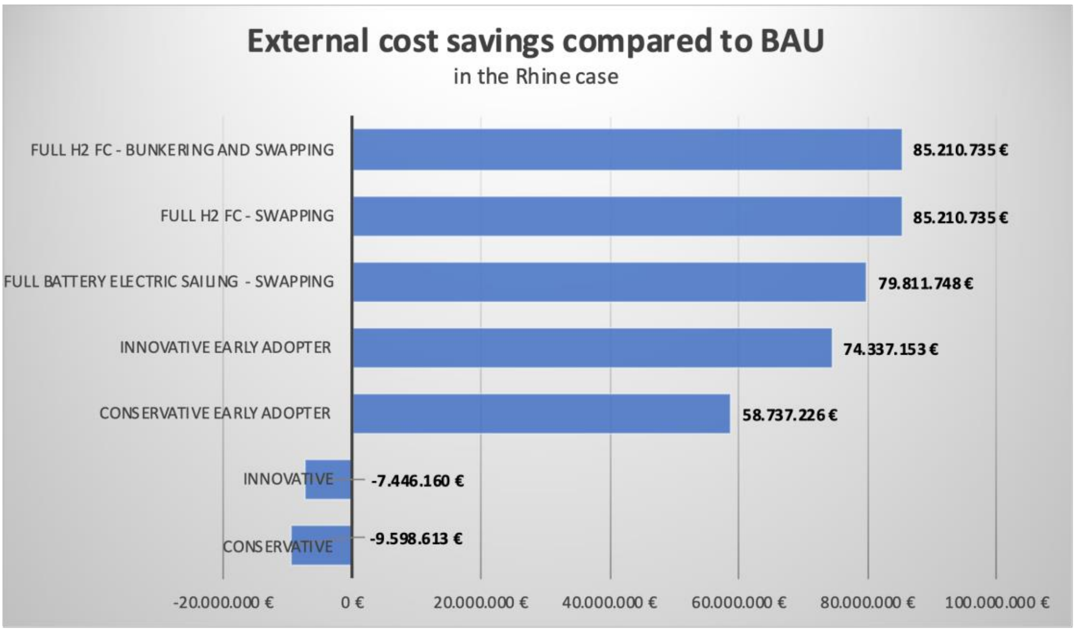

Figure 17: External cost savings compared to the BAU scenario until 2050

The scenarios Conservative and Innovative show a negative external costs reduction, since the simulated CO_2emission are increasing compared to the BAU-scenario and therefore the external costs are even higher. All other investigated scenarios result in a substantial reduction of external costs in the timeframe until 2050 in the range of 58 – 85 mill. EURO.

4. Impact assessment for the Greece case

In general, the energy transition towards net-zero waterborne transport triggers three streams of direct economic impact:

1. Demand for converting the existing fleet
2. Demand for alternative energy sources
3. Demand for additional vessels

As in the Rhine case, the simulation models of the Greek case have been analysed to determine the socio-economic impact for each scenario (a more detailed description of the scenarios can be found in NEEDS Deliverable 2.3).

4.1.1 Retrofitting the current fleet

The NEEDS-simulation model for the Greek case computes the investment costs for retrofitting the fleet for the green energy transition. Thereby, different scenario have been simulated and the results for every scenario are presented in Figure 18.

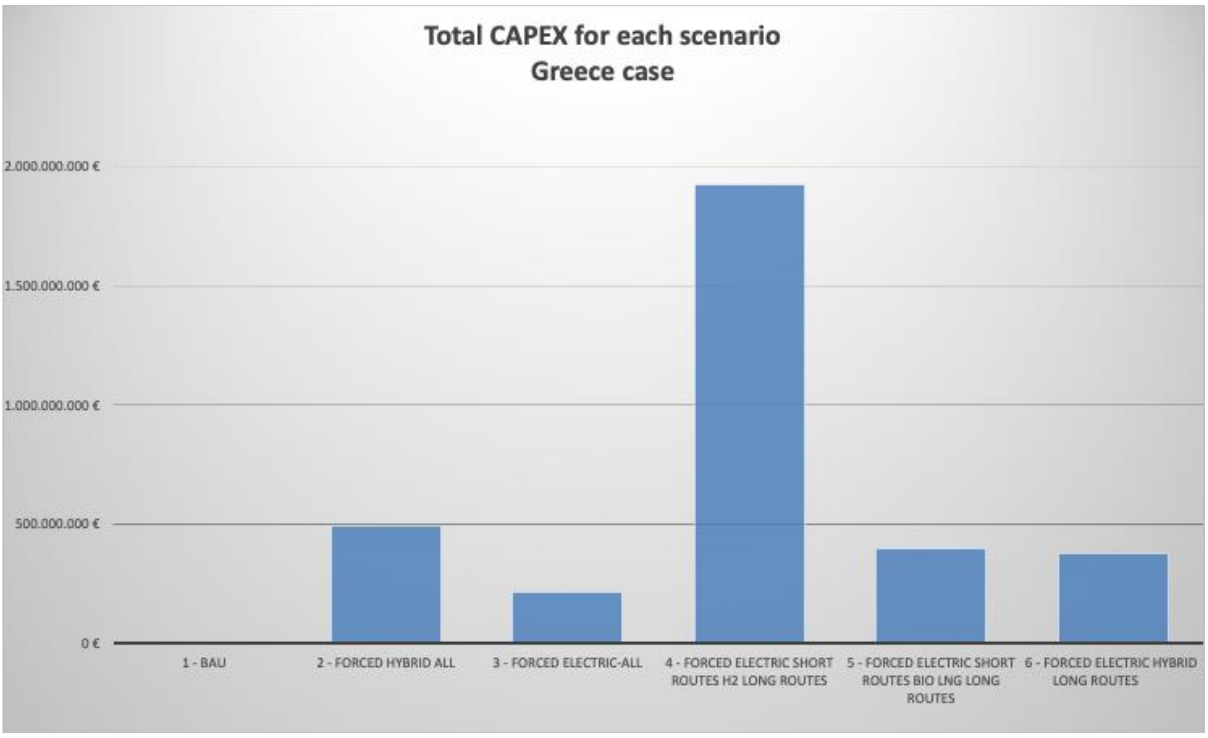

Figure 18: Total CAPEX for each scenario in the Greece case

While in the BAU-scenario, not vessel is converted, all other scenario trigger investment into retrofitting. Most noticeable is scenario 4 “Forced electric short routes and H2 long routes”.

The simulation model also computes the point in time for retrofits. Figure 18 displays the investment time series for each scenario. In this perspective, several peak demands for retrofitting are observed, especially in for scenario 4 “Forced electric short routes and H2 long routes". These peaks are linked to the simulation logic applied (see Deliverable 1.2), which reacts promptly on the achievement of certain criteria and causes this peak demand Transferring these simulation results into the maritime world, it is doubtful if the required retrofit capacity would be available at these point in times.

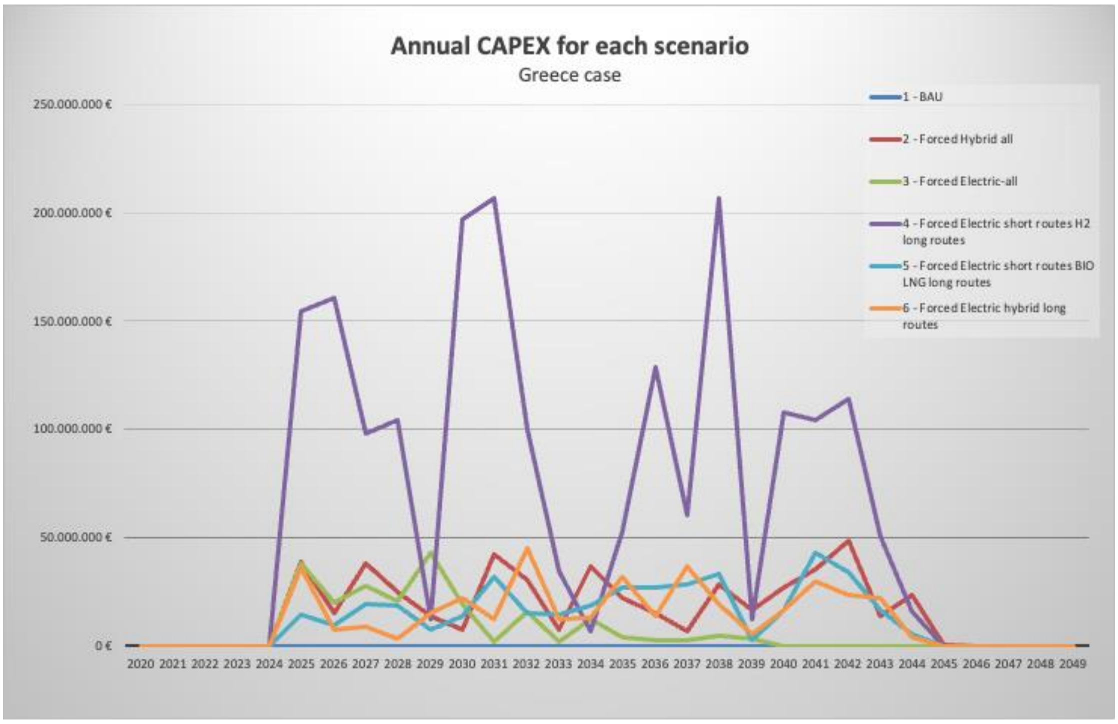

Figure 19: Annual CAPEX for each scenario

For the further analysis it is assumed, that the total retrofit investments are distributed equally over the timeframe until 2050.

The demand for retrofitting creates value added and additional employment. Figure 20 summarises the additional employment for each scenario of the Greek case until 2050. Based on the comparatively high investment costs, scenario 4 is expected to activate the most additional employment.

Figure 20: Additional direct employment in shipyard in the Greek case in annual FTE

4.1.2 Indirect impact of retrofitting

The demand for retrofitting the existing fleet towards zero emission waterborne transport will also strengthen the demand for intermediate products and services of the conversion yard. Figure 21 provides an overview of the demand for each scenario in the Greek case.

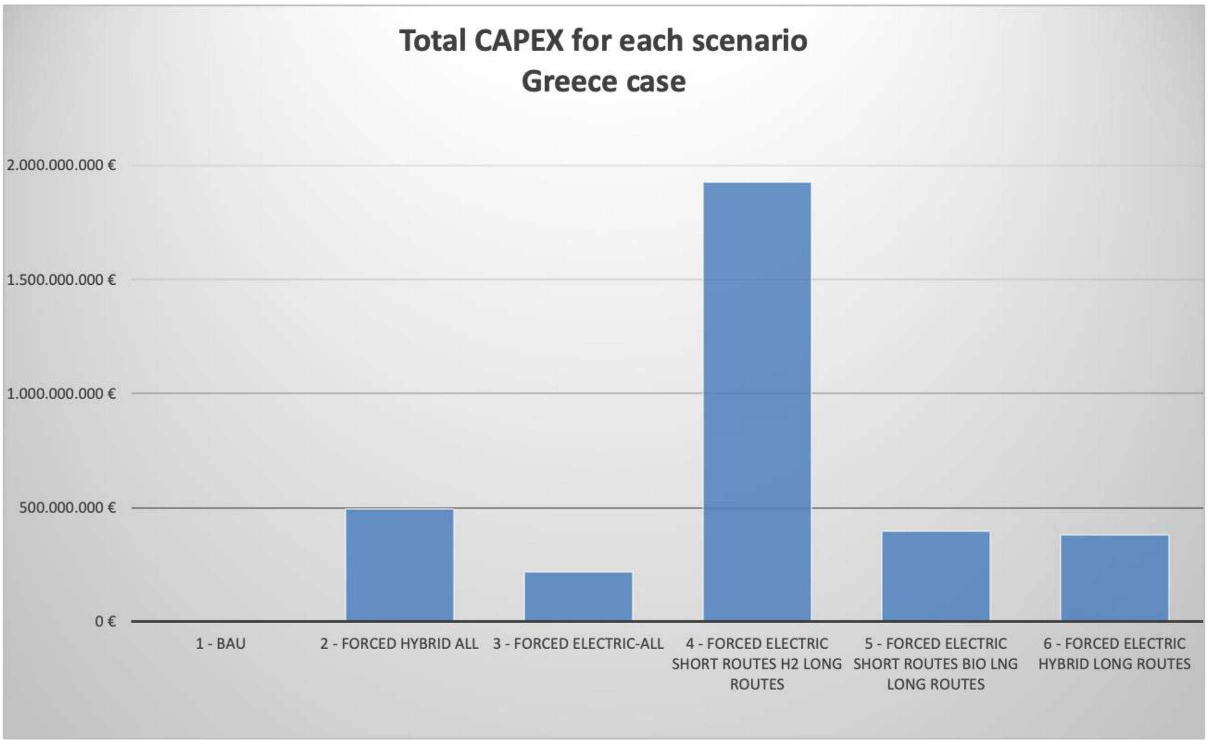

Figure 21: Total demand for intermediate products for retrofitting in the Greek case

The production of the intermediate goods and services creates added value and therewith additional employment effects in the supply chain. Following down the supply chain and analysing the value added for multiple stages in the supply chain, the different levels of investment into vessels for each scenario and still visible. Figure 22 summarises the indirect employment effect results for each scenario in the Greek case.

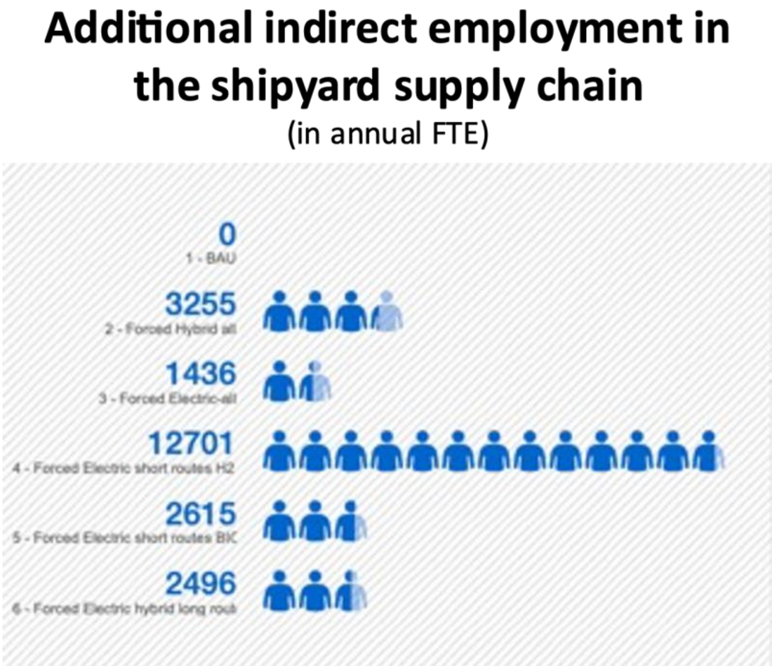

Figure 22: Additional indirect employment in shipyard supply chain

4.1.3 Demand for additional Ferries

As described in the Rhine case, the transition to alternative energy carriers decrease the transport capacity of a ship and fleet. With the condition of keeping the transport capacity of the fleet constant, the transition to alternative fuels leads to a demand for additional ferries in the Greek case. The analysis of the simulation results concludes with the number of additional ferries as presented in Table 3.

Scenario	Number of additional vessels
1 - BAU	4
2 - Forced Hybrid all	11
3 - Forced Electric-all	13
4 - Forced Electric short routes H2 long routes	11
5 - Forced Electric short routes BIO LNG long routes	12
6 - Forced Electric hybrid long routes	13

Table 3: Additional ferries for each scenario of the Greek case

In the next steps, the investment cost for new ferries are determined by desktop-research (HOLISHIP (2018)) in combination with expert interviews. Figure 23 shows the additional investments into for new build vessels until 2050. Thereby, especially all other scenarios than BAU trigger significant investments to keep the transport capacity on the same level with substantial economic impact.

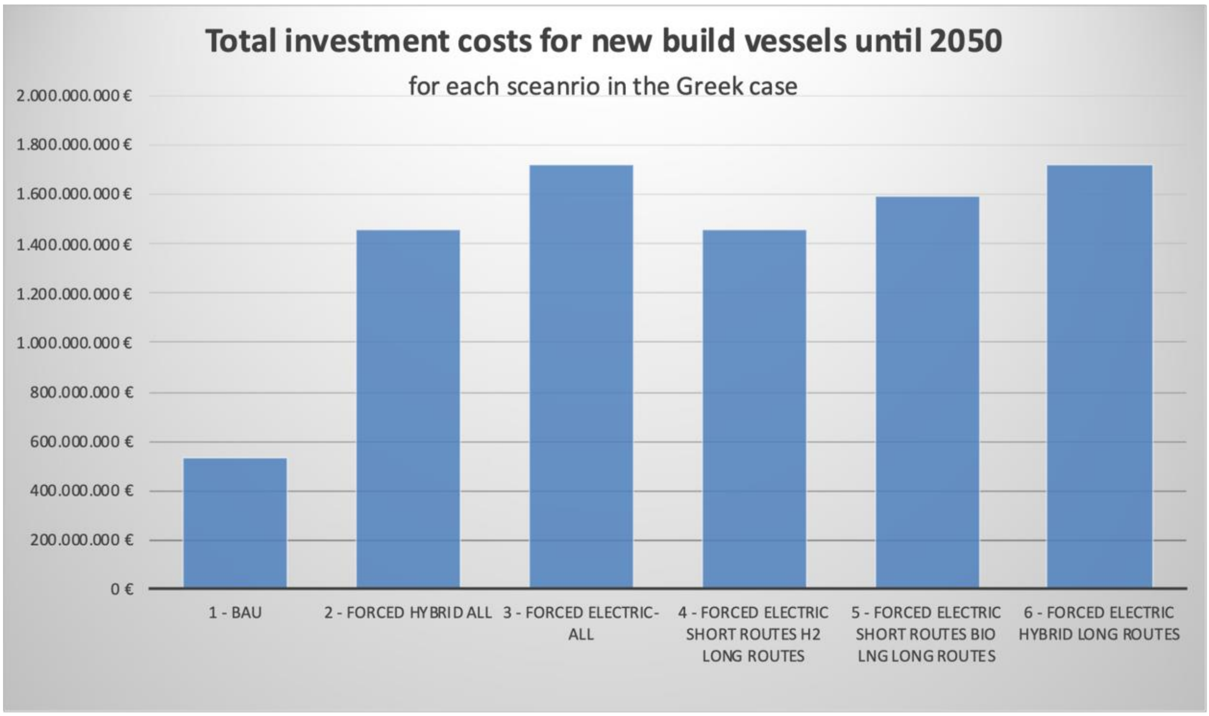

Figure 23 Total investment costs for new build vessel until 2050

The investment into new ships creates also a sizeable amount of additional direct employment at the shipyards, as presented in Figure 24.

Figure 24: Direct employment in shipyards in the Greek case

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4.1.4 Indirect impact of demand for additional ferries

The investments into new vessels also increase the demand for intermediate products as depicted in Figure 25.

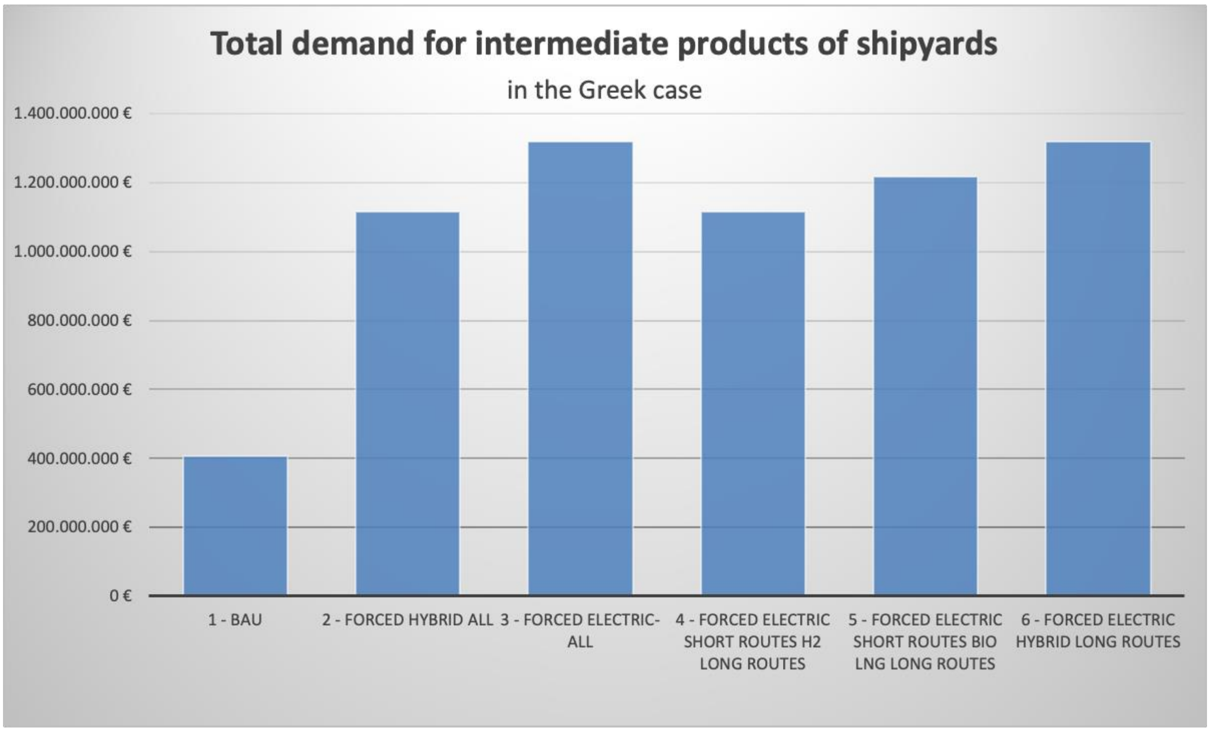

Figure 25: Total demand for intermediate products of shipyards

Moreover, the creation of intermediate products and services activates a significant number of additional employees as shown in Figure 26.

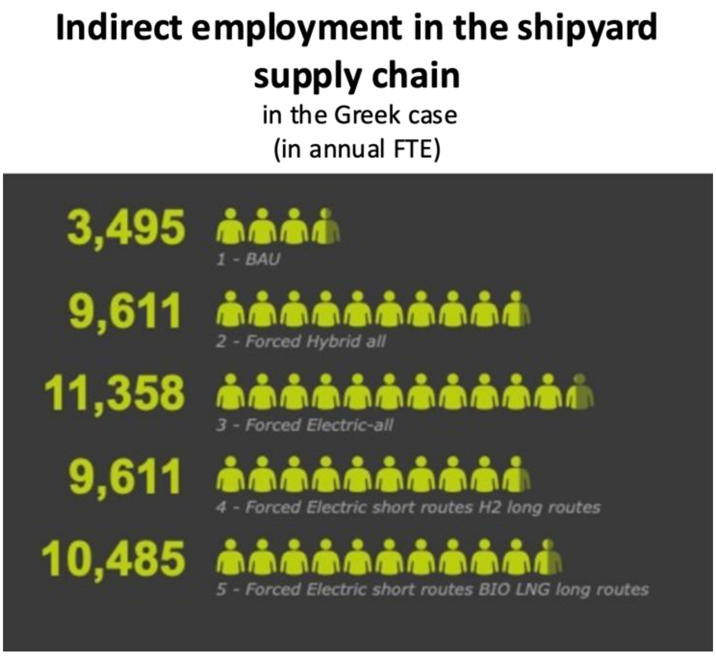

Figure 26: Indirect employment in the shipyard supply chain

4.1.5 Demand for energy sources

The simulated energy consumption and energy price and therewith the operational expenditure for energy varies for each of the investigated scenarios. Figure 27 presents an overview of the total energy demand for each scenario until 2050. An interesting result of the analysis is that every alternative scenario is simulated with overall lower total energy costs. Especially scenario 3: “Forced electric all” is substantially lower compared to the BAU (-25,86%), while the other scenarios are reduced by round about -10%.

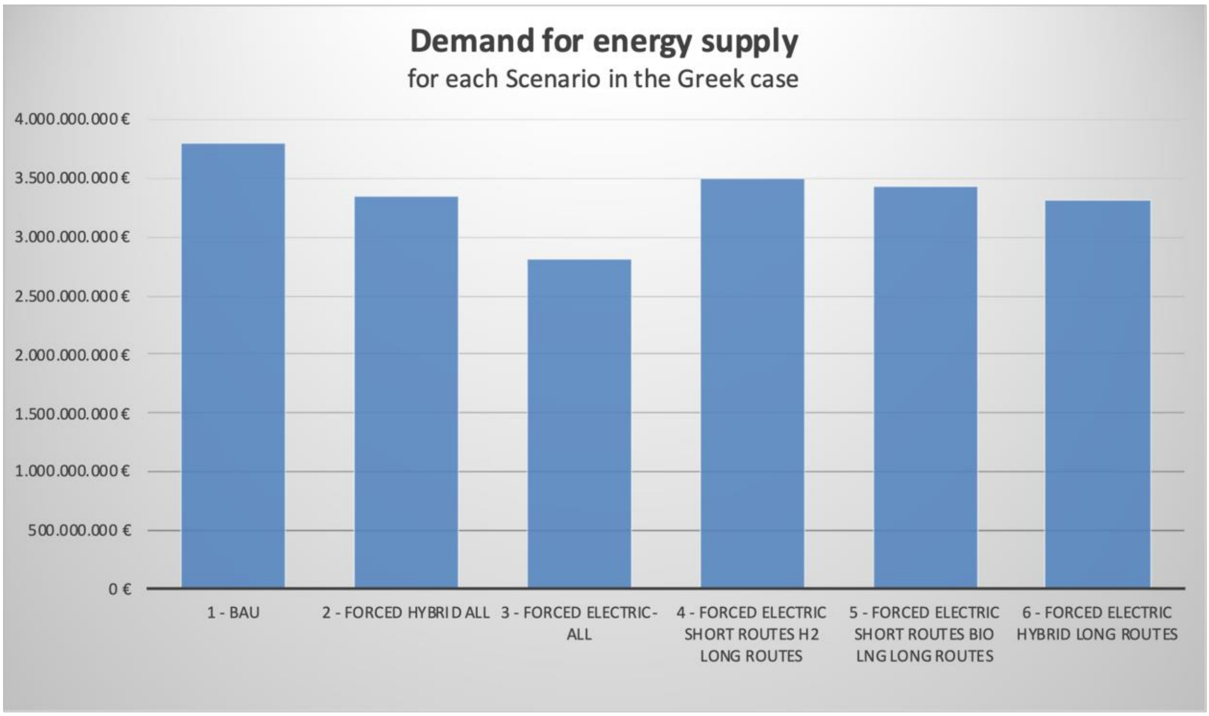

Figure 27: Demand for energy supply in the Greek case until 2050

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The lower monetary demand in production and supply translates into in lower employment rate as presented in Figure 28.

The NEEDS project has received funding from Horizon Europe research and innovation programme under grant agreement No 101056938

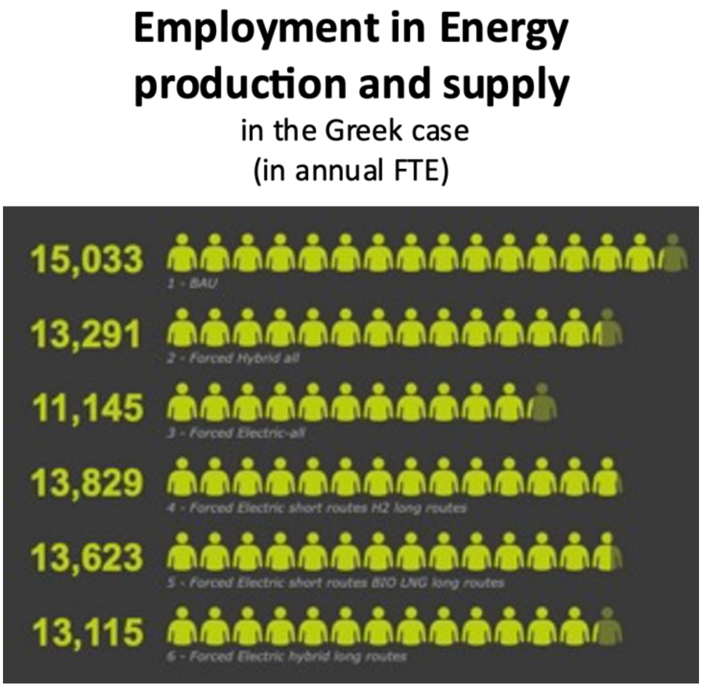

Figure 28: Employment in energy production and supply in the Greek case

4.2 Induced impact

The calculation of the induced impact follows the same argumentation and approach as described in chapter 6.3. Figure 29 presents the induced employment based the retrofitting, the newbuild vessels as well as the energy production and supply.

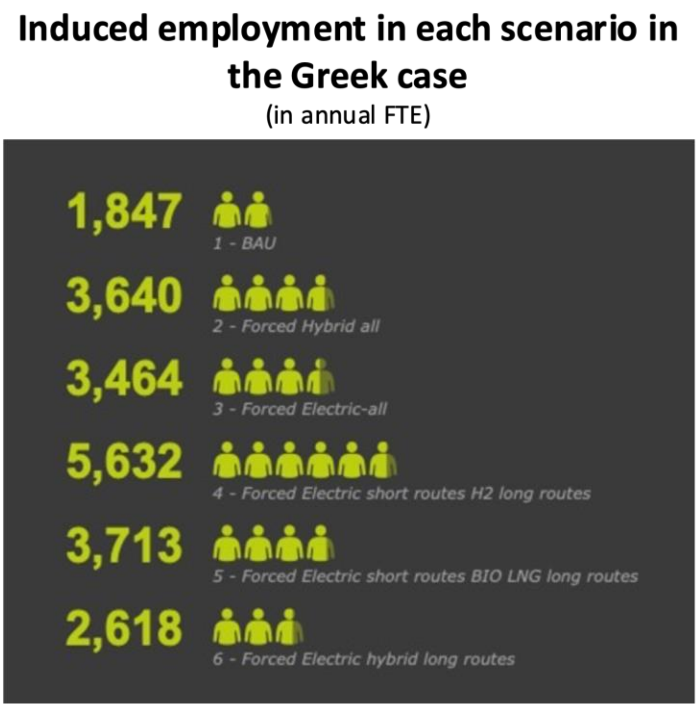

Figure 29: Induced employment in each scenario in the Greek case

4.3 External costs savings

The reduction of CO_2 is translated into an external costs comparison for each scenario of the Greek case. A detailed description of external costs can be found in chapter 6.4. In the Greek case, all scenarios lead to a considerable external cost reduction (see Figure 30), which improves the quality of life of society in general and lowers the financial burden of society specifically. Specifically, scenario 4 “Forced electric all” leads to the most emission- and therefore also the biggest external cost reduction.

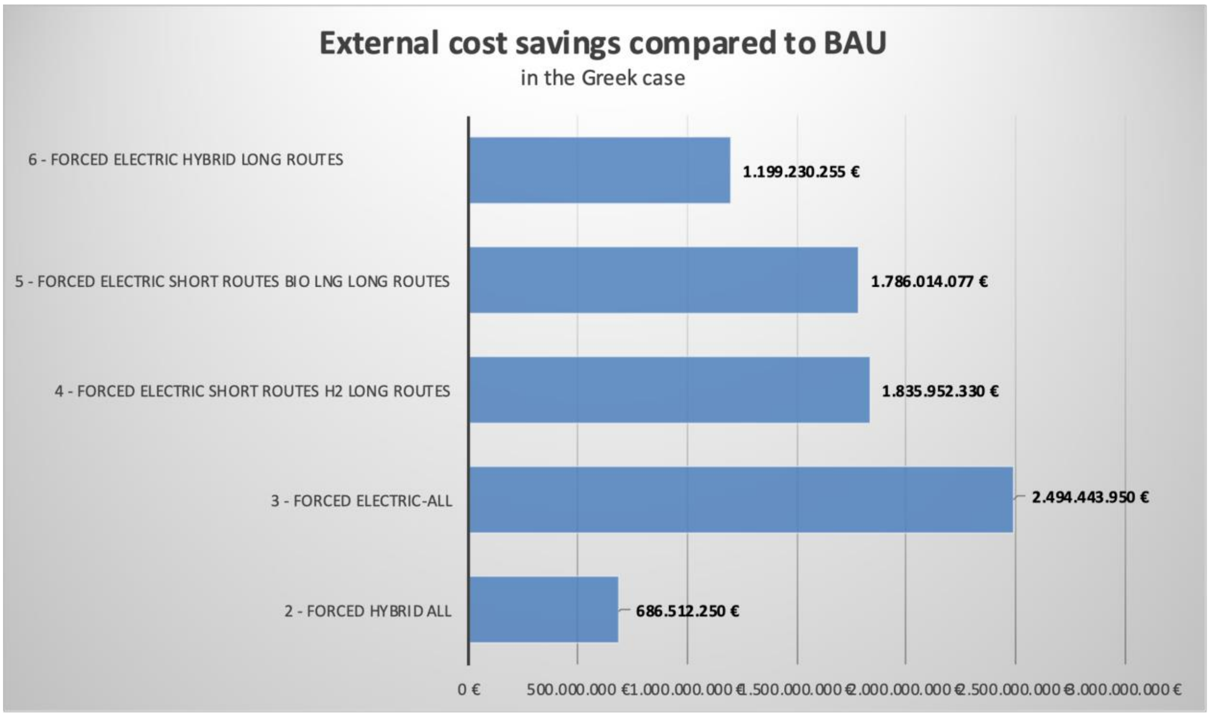

Figure 30: External costs savings compared to BAU in the Greek case

5. Conclusions

In conclusion, the socio-economic impact assessment conducted in this document provides valuable insights into the potential ramifications of transitioning waterborne transport toward climate neutrality. The comprehensive analysis with two distinct cases—the Rhine and Greece—explores the direct, indirect, and induced impacts of various development scenarios. Therewith the detailed methodology, utilizing simulation results, timeseries analysis, and statistical data, enables a nuanced understanding of the potential economic shifts.

Oftentimes, the focus of the discussion is the economic viability of the transition towards climate-neutral for shipping companies. The NEEDS socio-impact assessment reveals also the other side of the coin: The transition includes multiple positive economic implications, affecting industries throughout the supply chain, from retrofitting existing fleets to building new vessels and adapting energy sources and activating additional employment in many different industries. In these terms, high investments into the green transition triggers many positive economic and social effects.

In the Rhine case, the impact of retrofitting the current fleet and introducing additional vessels results in a varied demand for shipbuilding and intermediate products demonstrates how positive economic effects are enabled by investment for the Rhine area.

Similarly, the Greece case analysis highlights the positive economic consequences of retrofitting, constructing new ferries, and altering energy sources. The induced impact assessment underscores the broader economic benefits stemming from increased employment and consumer spending, painting a comprehensive picture of the potential societal advantages of the transition.

Moreover, the Deliverable examines the external costs reduction associated with the reduction in CO_2 emissions, indicating a positive contribution to environmental sustainability and public well-being. However, it is crucial to note that certain scenarios may lead to increased external costs, underscoring the need for carefully considered strategies in the transition process.

In essence, this socio-economic impact assessment highlights the potential economic shifts. As stakeholders navigate this transformative journey, the findings provide a foundation for informed decision-making, acknowledging the complexity and interdependence of economic factors in the pursuit of sustainable maritime practices.

6. References

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