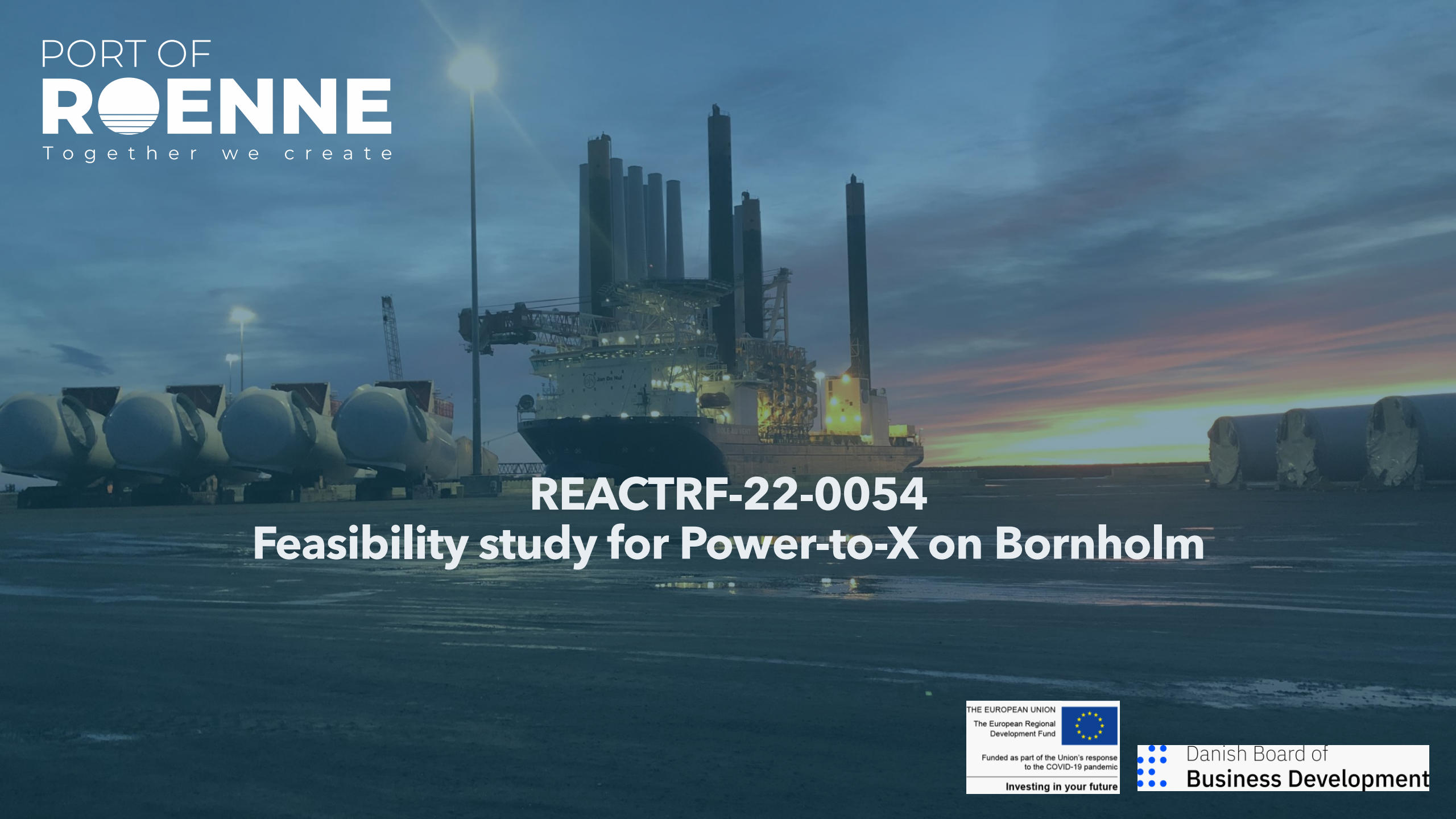

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REACTRF-22-0054
Feasibility study for Power-to-X on Bornholm

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REACT-22-0054

Project Summary

In June 2022, Port of Ronne started REACTRF-22-0054 - Feasibility study for Power-to-X on Bornholm which is a project funded by the European Regional Development Fund and Danish Board of Business Development. The purpose of the study is to lay the analytical foundation for future large-scale production of Power-to-X products at Bornholm by investigating in further detail the possibility of establishment. This is highly relevant to investigate in conjunction with the establishment of Energy Island Bornholm with 2-3 GW offshore wind and HVDC interconnectors to Zealand and Germany, as a Power-to-X project can help maximize the value of the new energy island and can at the same time support the political goals on the green transition with 70% reduction of GHG in 2030 and ambitious plan for power-to-x in Denmark.

The project is executed in partnership with Ørsted Hydrogen Holding, Skovgaard Energy, Topsoe, Danfoss Power Electronics, Ramboll, Bornholms Energi & Forsyning, Bornholm Municipality, DTU Management, DTU Wind and Energy Systems and Gate 21.

This study is divided into six main work packages (WPs) which will analyze the potential sources, technologies, products, and out takers, as well as the integration of Power-to-X into the energy systems. It will result in a business case for Power-to-X production at Bornholm, which will be finalized by the end of August 2023.

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Work Packages Description

WP1

Input for Power-to-X plant

Map and analyze the local sources, quantities, and prices of these key inputs to Power-to-X production and contribute to sustainable local production of Power-to-X at Bornholm.

WP2

Modelling of scenarios for Power-to-X

WP2 will optimize plant capacities, which will feed into WP4, while WP4 will feed potential income from sales of services to the power grid and of sales of excess heat to the district heating grid. The involved companies will contribute with techno-economic data and functionality of specific technologies, input for the business feasibility analysis as well as input for the definition of the scenarios and discussion of results and functionality of the tool

WP3

Market for products

Establishing Power-to-X production requires large investments and therefore there must be possibilities for selling the products on long-term contracts to make a viable business case for a Power-to-X plant at Bornholm, and hence a market investigation will be performed. The products from a Power-to-X plant will likely be ammonia, hydrogen, oxygen, waste heat, and potentially methanol.

WP4

Integration of Power-to-X into the energy systems

WP4 will investigate how a Power-to-X plant can be incorporated into the wider energy system, including the power grid and the district heating system in Bornholm.

WP5

Location of Power-to-X plant and storage

The decision of a location for a Power-to-X facility can be influenced by several factors, this WP will aim to identify and investigate them to find the optimal site in Bornholm.

WP6

Business case

The business case will cover estimations of the cost of building a Power-to-x plant and the subsequent cost of operation, and hence it is possible to calculate a cost price for the production of the different products. Based on market size, possible sales prices, and estimation of cost prices it is possible to access if it is feasible to build a Power-to-X plant at Bornholm.

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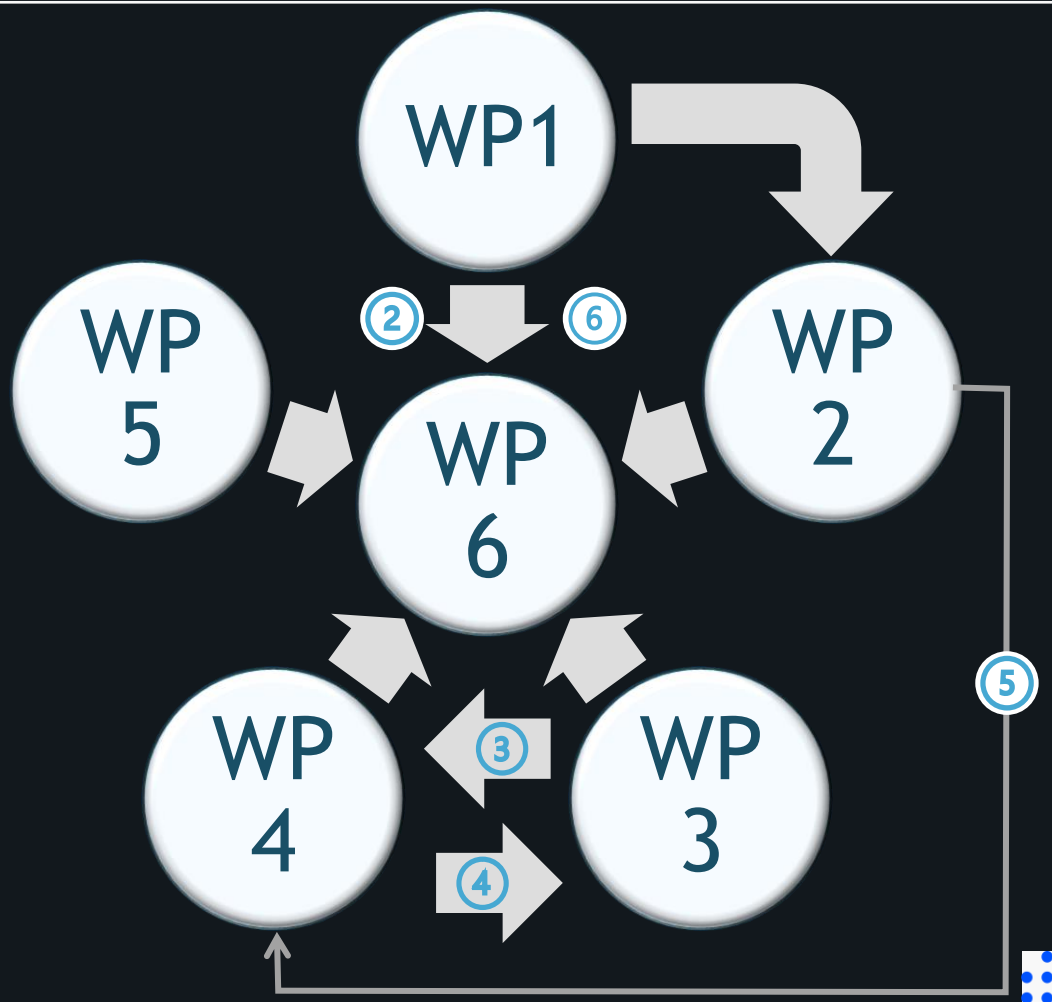
Work Packages Description

WP Dependencies

1. **WP3** & **4** evaluate potential revenue and determine viability.
2. **WP1** provides data and input on relevant resources to **WP2**
3. **WP1** provide input on the cost to the business case in **WP6**
4. **WP3** provides **WP4** the market value of the products.
5. **WP4** estimates for **WP3** the number of products/services technically available
6. **WP2** to **WP4**: Scenario definition and high-level technical characterisation of the power-to-x system (e.g. site, size, types of technologies)
7. **WP1, 2** & **5** to **WP6** will determine the cost of building and operating a plant.



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Work Packages Description

WP 1 Input for Power-to-X plant

WP1

Green power

- Offshore wind from the Energy Island Bornholm wind farms
- Onshore wind power
- Solar power connected directly to the Power-to-X plant
- Green power from the grid

Water

- Purified wastewater
- Stormwater
- Low-quality drinking water.
- Seawater

Biogenic Carbon (CO_2)

- Incorporate and manage new biomass fractions from Bornholm to increase the production of biogas (e.g., waste from the food and butchery industry, Organic fraction of household waste, Sludge, Straw, etc)
- Assess the impact of the implementation of these new biomass fractions in the integrated energy system of the island, accounting for the real data coming from the local biogas plant.
- Analyze the possibilities for methanization, from the CO_2 that is a by-product of purification, and the H_2 produced in the electrolysis plant.

Deliverables

WP 1 Input for Power-to-X plant report

WP2
WP6

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Work Packages Description

WP 2 Modelling of scenarios for Power-to-X

WP1
WP3

WP2

Open source model

- Provide an open-source model with mass and energy balances, which can be used to simulate different scenarios for Power-to-X production based on different technologies and possibilities for the generation of green power.
- The technology partners provide input for the respective technologies to DTU MAN, who further develops the optimization model OptiPlant
- OptiPlant can be used both on Bornholm and any other potential location in Denmark to model different sizes and technical configurations of Power-to-X production depending on the local input and output parameters.

Model Scenarios

- The task will use OptiPlant to simulate 4-5 scenarios for a Power-to-X plant at Bornholm. Different capacities, green power production scenarios, and technical configurations will be modeled to find the optimum for the Bornholm case

Deliverables

Optiplan model

WP 2 Scenarios report

WP4
WP6

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Work Packages Description

WP 3 Market for products

WP3

Ammonia	The Baltic Sea will be a potential market for the produced ammonia. It can either be sold for some of the +60.000 vessels by Bornholm every year, and there are also possibilities of export to vessels calling ports in the proximity of Bornholm.
Hydroge n	Hydrogen is challenging to transport and store because of the low volumetric energy density; therefore, the Power-to-X plant could produce compressed hydrogen for the local market. This could be in industrial use, where green hydrogen could replace the use of LPG for processes that cannot easily be electrified. Another
Oxygen	Oxygen is used in different industrial processes, for example for the aeration of wastewater treatment plants (WWTPs), it will therefore be investigated if oxygen from the Power-to-X plant can be used in local WWTPs. The use of oxygen instead of air will reduce significantly the volume compressed in the WWTPs, thus generating energy savings.
Methanol	The Power-to-X plant can be configured to produce methanol based on biogenic CO2, for example from the local biogas plant. There is a potential for a methanol market in local heavy road transportation in combination with fuel cells for increased efficiency.
Waste Heat	Waste heat from a Power-to-X plant can be sold to for example district heating or industries with a need for heat for the processes. In Bornholm, the waste heat will likely be used for district heating, which is widely implemented on the island. Another possibility is the establishment of new industries, which use heat in the production process.
Grid Services	This task is closely interlinked with task 1.a of WP 4 Integration of Power-to-X into the Energy Systems where the services that a Power-to-X plant can provide to the electricity system is examined, quantified, and valued. This task will collect information about the monetary value of the grid services that a Power-to-X plant can provide.

Deliverables

WP 3 Market for products

WP4
WP6

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Work Packages Description

WP 4 Integration of Power-to-X into the energy systems

WP2

WP4

Modelling (CEE)

- Identification of key parameters & Mathematical modelling
  - Power Integration
  - Heating System Integration
- System optimization

Model conversion into tool

- Model simplification to reach wider audience
- Model conversion iinto open source language
- Definication input / output
- Interface programming
- Writing user guide

Deliverables

Management operation simulation

WP 4. Operations management planning

WP6

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Work Packages Description

WP 5 Location of Power-to-X plant and storage

WP5

- **Location**: Many factors, such as the size of the facility, distance to the land facility of the energy island, access to water, distance to residential houses in the area, the potential for establishing solar power, etc. influence the location of a Power-to-X plant and they will be explored in this task to find a suitable location.
- **Transport**: The products produced at the plant will need to be transported away from the plant. This could be for utilization in other locations at Bornholm for example industry and heavy transportation, or transport to Port of Roenne, where the products can either be used as maritime fuel or potentially be exported. Given the likely size of a Power-to-X plant, the quantities of products will be significant, and therefore suitable, safe, and efficient transport methods need to be explored.
- **Storage**: If fuels should be exported out of the port it will be necessary to establish new storage tanks that can accommodate the fuels, and as the fuels are subject to limits because of their potential danger there will be restrictions on both quantities and locations of the storage
- **Process Mapping**: Building a Power-to-X plant requires approvals from authorities, such as building permits, environmental permits, public planning for industrial areas, and permits to store dangerous goods

Deliverables

WP5 Suitable location for a Power-to-X plant

WP6

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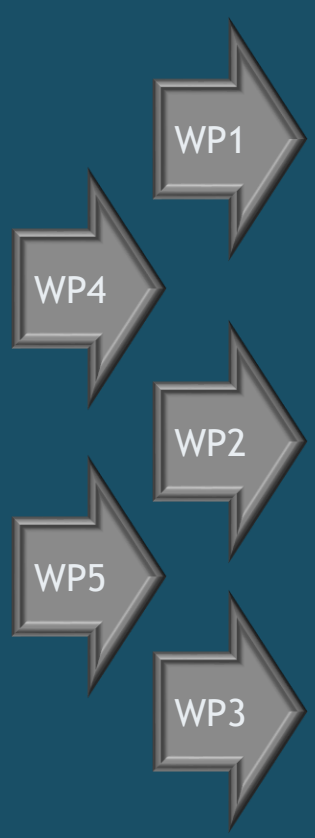
Work Packages Description

WP 6 Business case



WP6

Business Case

Create a business case for building and operating a Power-to-X plant at Bornholm.
- WPs 1, 2, and 5: Determine the cost of building and operating a plant.
- WPs 3 and 4: Basis for accessing the revenue for a plant to estimate if it will be viable to produce eFuels at Bornholm once the energy island is established

Administration

- Port of Roenne: Project lead, responsible for project progress and reporting
- Gate 21: Administrative part of the project, ensuring reporting to Erhvervsstyrelsen

Study Trip

On March 21st, we travelled from Bornholm to Aabenraa and Fredericia to learn about local planning of energy infrastructure, most specifically the planning and preparation required in projects related to PtX.

We also had the opportunity to visit examples of energy infrastructure and sites associated with it, including Kassø solar energy installation and PtX project area, Taulov Dryport, Google Datacenter, Everfuel's site (H2 production) and Crossbridge refinery.

Deliverables

WP6 Business Case

WP6

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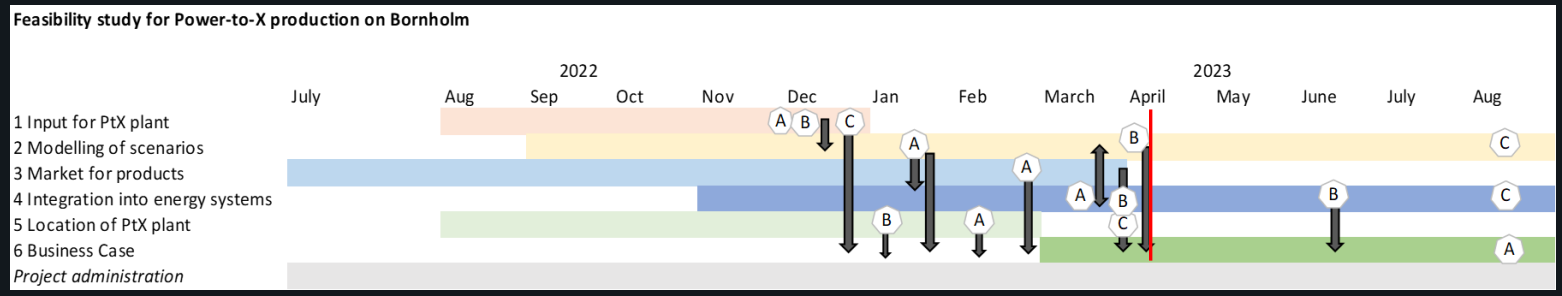
Project status overview



WP	Milestones
1	1A. Input about quantities of available green power to PtX production
	1B. Input about quantities of available biogenic carbon (dioxide) for PtX production
	1C. Input about possibilities of using other sources than regular drinking water
2	2A. Scenarios for PtX production at Bornholm
	2B. Analysis of scenarios and uncertainty analysis of PtX in the future
	2C. Tool: Optimization model for dimensioning Power-to-X production
3	3A. Market potential for produced eFuels
	3B. Potential revenue from excess heat to district heating systems
	3C. Potential reneue from power system services
4	4A. Physical caractherisation of the ptx facility integrated in the power-grid and in the heating system
	4B. Economical caractherisation of the ptx facility integrated in the power-grid and in the heating system
	4C. Tool
5	5A. Identification of possible locations
	5B. Overview of approval process
6	6A. Business case
	Administration
	Study trip

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