Karmsund Port

Karmsund is a large cargo port in south-western Norway, with ambitions for significant expansion and electrification. To accommodate the increased electricity demand, the port plans to install large-scale PV production in combination with battery storage.

The port has three main business areas: cargo terminals, a cruise port, and an offshore and subsea base. The focus here is on the cargo port.

Electricity demand. The current demand is dominated by buildings (max. 150 kW) and onshore power supply (OPS) to a few cargo ships (max. 400 kW). The annual demand is less than 1 GWh. From 2027, the two hybrid cranes, today seldom connected to the grid, will be fully electrified adding an hourly peak demand of 0.6 MW, and annual energy use of 0.2 GWh. More ships using OPS combined with use of electrified cranes can result in a peak demand close to 3.5 MW (**Figure 1**). Plans for expanding the port activities from 2030 will increase the installed electricity demand to over 30 MW with an estimated maximum capacity demand at 16.5 MW, accounting for simultaneity.

Considering the rapid variation in power demand of crane operation and OPS, it is important to map simultaneity and frequency to be able to dimension both the power grid and the total energy system in the best possible way.

Investment options for the port include: solar PV panels, batteries, and increased electric grid transmission capacity. The present grid connection is just enough to cover the demand until 2030 (OPS, electrified cranes). The future demands require an investment to increase the grid capacity, estimated to 1.5 MNOK/MW. This number excludes costs related to expanding the grid capacity outside the port area and is probably underestimated. The port has planned for installation of PV panels on the roofs of two large buildings, with a capacity of 285 kWp. Including five more buildings gives a total roof area of 27,400 m^2 with a maximum capacity of 3.2 MWp, generating approximately 2.3 GWh/year.

Recommended investments: The optimal investment plan depends on spot prices and grid capacity tariffs. To cover the demand before 2030, the only feasible investment is a 100 kWh battery. To cover the demand after 2030, the following investments are recommended:

- **Grid capacity**: around 16 MW
- **Batteries**: 1.0 - 1.8 MWh, the highest capacity at high capacity tariffs
- **PV panels**: 3.2 MWp (maximum) at high spot prices, while only 0.2 MWp with high capacity tariffs.

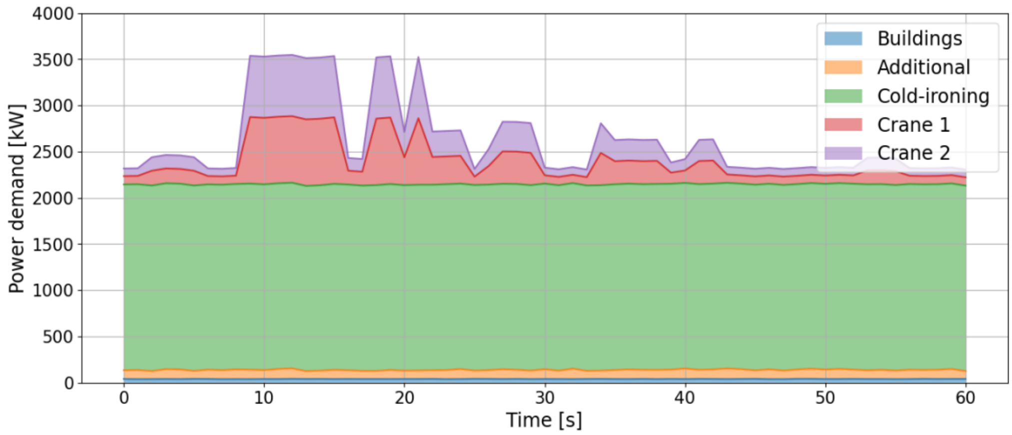

Figure 1: Power demand at sub-hour level in a scenario with 4 ships coupled to OPS and 2 cranes running simultaneously.

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INTERPORT PROJECT

Assessment of **INTERPORT** ***goals*** and ***key performance indicators***

Reduced Carbon Footprint (target 50 % in 2030, 100 % in 2050)

- ***Reduced local CO_2 emissions:*** Up to 100 % in the fully electrified scenario.
- ***Share of renewable energy usage***: 2.5 % with maximum PV installation.

Reduced energy losses (target 20 %)

- ***Recovered energy:*** Not applicable.
- ***Increased total energy efficiency:*** Using OPS and electrified cranes will contribute to increased energy efficiency due to the higher energy efficiency of electrical engines compared to combustion engines.

Lower peak demand *(target 30 %)*

- **Peak load reduction**: Implementing the highest recommended PV and battery capacity allows for a peak load reduction of 0.6 MW (3.2 %).

High flexibility and reliable supply

- **Storage capacity**: Up to 1.8 MWh (batteries).
- **Self-sufficiency ratio**: 2.5 % with maximum PV installation.

Cost-efficiency: annual costs and levelized cost of energy (LCOE):

	Annual costs [MNOK/year]						LCOE
Price scenario	**Investment**	**Electricity**	**Grid tariffs**	**Service**	**Fuel**	**Total**	**[NOK/kWh]**
Baseline	1	43	7	0.02	-	**51**	**0.89**
High spot prices	2	59	7	0.2	-	**68**	**1.19**
High capacity tariff	1	43	10	0.04	-	**54**	**0.95**

Sector coupling

- ***Degree of sector coupling***: -
- ***Stakeholder involvement:*** The port developer is in dialogue with grid and energy companies, and works through the joint venture "Havnekraft" to promote, develop and operate more sustainable energy solutions. Partnerships with local industries, including a circular economy cluster, to develop smart energy solutions. Dialogue with municipalities and public agency to secure funding.

Space utilisation

- ***Increased share of nature areas in the port***: Not considered.
- ***Infrastructure space requirements:*** Implementation of batteries could increase the space demand, unless they are placed inside existing buildings.

Facilitate uptake and use of alternative fuels and energy carriers

- **Supply of alternative energy carriers: -**
- **Port acceptability:** High acceptance for OPS. Uncertainty about future fuels. Uncertain electricity costs. Skepticism towards novel energy solutions among short-sea freight operators, due to cost sensitivity and low margins.
- **Port-city relationship**: Serves as regional employer and industrial hub.

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