Shore Side Electricity Solutions for NSR Ports

Non-standardised mobile onshore power supply

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1. Introduction

1.1 Background and Context

In the Green Supply Chains (GSC) project the Port of Skagen has been working to accelerate the decarbonisation of North Sea Region (NSR) ports through the deployment of Shore Side Electricity (SSE), also known as Onshore Power Supply (OPS).

By enabling pelagic fishing vessels to switch off auxiliary diesel generators while pumping catch to factory at land, OPS reduces emissions of CO_2, NOx, SOx, and particulate matter. This work also supports compliance with international and EU climate regulation while addressing local air quality concerns.

Building on knowledge from related initiatives, the Blue Supply Chains a Baltic Interreg project helped to explore the role of port authorities in green port operations and OPS development, while the Danish EHFAF project provided calculations on fuel savings, emission reductions, and socio-economic impacts of OPS.

Results and outcomes from workshops carried out under Blue Supply Chains and EHFAF have been reused, so that activities in Skagen contribute to and benefit from a wider knowledge base across the North Sea and Denmark. As Denmark's largest fishing port, Skagen quickly realised that standardised OPS solutions are not always directly applicable.

The unique operational patterns of the pelagic fleet, characterised by high energy demands during pumping the landings to land and factory, required flexible and innovative OPS solutions. The pilot therefore focuses on a semi-mobile, semi-automated OPS system specifically designed to serve the pelagic segment. The port has pursued a solution that combines high-capacity power delivery with flexibility and modularity, offering a model that other small and medium-sized ports in the NSR can replicate.

1.2 Objectives and Scope

The pilot in Skagen was initiated with three main objectives. Implementing a semi-mobile OPS system capable of delivering up to 1.5 MW for energy-intensive unloading operations. Establishing a business and governance model that ensures both economic feasibility and accessibility for vessel operators and finally to document and share a roadmap that allows other ports in the NSR to replicate the solution.

In relation to the current deliverable, these objectives gave following activities:

- **Stakeholder and requirement analysis:**
  - Local shipowners and processors have been involved to define user requirements and accessibility conditions.
- **Strategy and action planning:**
  - Rules and regulations, ownership models, technical design, responsibilities, time plan and investment needs have been mapped and aligned with the port's strategy.
- **Pilot preparation:**
  - The port has identified the special requirements of Skagen, developed a technical design and business model, clarified ownership and accessibility, and commenced construction and test runs.
- **Evaluation and roll-out:**
  - Work has started on mapping energy supply and demand, assessing feasible electrification strategies, calculating emission savings, and discussing governance models for transferability.
- **Workshops:**
  - Stakeholder workshops have been held, and a feedback workshop linked to the test run is planned.

The scope of work so far has therefore included requirement analysis, feasibility studies, regulatory mapping, initial technical design, and the first test run of the OPS system. With these elements in place, the Port of Skagen has now moved into implementation, detailed evaluation, and preparation of roll-out concepts.

2. Preparation for testing of non-standardised mobile onshore power supply equipment in Port of Skagen

2.1 Special requirements of small ports in the North Sea Region such as Port of Skagen

From the start it became clear that Port of Skagen faced distinctive challenges compared to large container hubs serving container ships with OPS.

Pelagic vessels in the north part of Europe are normally from 50m to 90m and then docking and unloading catches the mooring position often is changing from landing to landing. The OPS solutions therefore had to be flexible. The port highlighted that the plug-in model must be easy to handle and adaptable to berth variations. In this way a variability in berth spaces, ability and access to OPS is a central part of an efficient port administration.

Another central challenges in the establishment of OPS in Skagen is the cool transport chains needed then catches are pumped to land and factory. Thia means a continuous energy demand for refrigeration and pumping during 10–30 hour then unloading operations takes place. An important element for this is a stable and sufficient delivery of electricity at port side.

Also, the seasonal fishing of pelagic species create congestion in the quay area and push landing facilities and factory capacity to top level. This combined with a difficult infrastructure in the port area and processing plants not optimal positioned plus heavy truck traffic and reduce available space, the practical logistic situation for a new OPS solution is not easy. This situation is requiring a compact and adaptable OPS installations that do not interfere with terminal operations. Due to this an overview of mobile OPS solutions was also considered in the process.

Among the systems investigated but not fulfilling the needs in Port Skagen, fixed OPS units was investigated, compliant with ISO/IEC standards but inflexible for Skagen’s variable berths.

Also containerised movable OPS systems - but labour-intensive and less user-friendly was investigated.

Based on the special requirements for Port of Skagen a Semi-automated Cable Management Systems (CMS) was ultimately chosen. The system allows safe and efficient deployment of cables up to 45m, addressing berth variability and improving user accessibility.

The CMS solution was judged by the port to be the most practical compromise between flexibility, safety, and cost-efficiency.

2.2 Technical design and implementation plan

The OPS system implemented in Skagen consists of following components:

- A dedicated transformer station integrated with the local grid (Nord Energi Net).
- OPS capacity of 1,673 kVA (≈1.5 MW) at 690V/60Hz, ensuring compatibility with large pelagic trawlers.
- Two dedicated quay connection points (FF Skagen and Scandic Pelagic).
- Semi-automated CMS units for each quay.
- Digital monitoring, invoicing, and safety systems provided by PowerCon.

Photos of the components and test run is from page 12 to 14.

Feature	Specification
Max Capacity	1,673 kVA / ≈1,506 kW
Voltage Levels	400V / 440V / 690V
Frequency	50Hz / 60Hz
Connection Points	2 (FF Skagen, Scandic Pelagic)
Cable Management	Semi-automated CMS, 45m reach
Standards Compliance	IEC/IEEE 80005-3

Table 1: Technical specifications of the OPS system

Implementation timeline:

- **Tendering:** December 2023 – May 2024.
- **Construction:** Summer–Autumn 2024 (delayed by permitting and soil contamination issues).
- **Commissioning:** May 2025 (tested with *Lingbank*).
- **Fine-tuning:** Ongoing through 2025.

2.3 Business plan

Due to the fact the Port of Skagen is an economic business unit with a responsible management every investment must be seen in view of economic, social and sustainable expectations.

Based on this and as part of the decision process the Port of Skagen developed a dedicated cost-benefit model. This model compares capital investments, operational costs, and expected revenues with environmental and societal benefits such as reduced emissions and improved air quality. It also allows sensitivity testing for variables such as diesel price development, CO_2 taxation, and OPS adoption rates.

The cost-benefit model developed for the Port of Skagen is designed to evaluate the economic and environmental impacts of different pelagic fishing vessels from diesel-generated electricity to onshore power supply (OPS) while at berth. The model combines vessel energy demand data, fuel consumption, electricity pricing, and CO_2 emission factors to provide a transparent comparison between traditional diesel use and land-based electricity.

Its primary purpose is to:

- Quantify CO_2 and fuel savings from OPS adoption.
- Assess cost implications for both ports and vessel operators under varying fuel and electricity price scenarios.
- Support decision-making by testing the sensitivity of results to future regulatory changes, such as CO_2 taxation.

The cost-benefit model is user-friendly and adaptable, allowing port administration, vessel owners and stakeholders to simulate different operational, technical, based on current market conditions. This makes it a daily practical tool for both local investment planning in Skagen and for knowledge transfer to other ports considering OPS solutions

Cost benefit OPS

Port calls and power demand							
Calls pr. year	10	of hours	24	of kW demand	80	kWh	19.200
Calls pr. year	7	of hours	10	of kW demand	200	kWh	14.000
Calls pr. year	2	of hours	2	of kW demand	300	kWh	1.200
Calls pr. year	10	of hours	20	of kW demand	2000	kWh	400.000
Total calls	29	Avg. hrs at quay	14	Avg. kW demand	645	Total kWh	434.400

Total calls	29	Pr. year
Hours at quay	406	Pr. year
Demanded electricity	434.400	kWh pr. year
Shore power loss	68.440	kWh pr. year
Electricity bought	502.840	kWh pr. year

Environmental assumptions		
Generator consumption, fuel	200	g/kWh
Fuel consumption in port	86.880	kg fuel
CO2 in fuel	3,2	kg CO2/kg fuel
CO2 emission	278.016	kg CO2/year
NOx in fuel	68	g/kg fuel
NOx emission	5.908	kg NOx/year
SOx in fuel	5	g/kg fuel
SOx emission	434	kg SOx/year

Reference points		
CO2 emission from lorry 34 - 40t	675	g/km
Corresponding emission lorry 34 - 40t	411.876	km
Avg. DK power production CO2 emission	142	g CO2/kWh
If power produced by avg. power grid	71.403	kg CO2 pr. year

Economic assumptions		
Electricity price purchase	0,75	DKK/kWh
Electricity mark-up	47%	DKK/kWh
Elctricity price sold	1,60	DKK/kWh
CMS rent	0,13	DKK/kWh
Maintenance costs	37.000	DKK/år
Construction costs	4.133.600	DKK
Interest rate	4,00	%
Depreciation time	20	year
Linear to zero	206.680	DKK/year

Financial result			
Costs:	Purchase of electricity	kr.	-377.130
	Maintanence	kr.	-37.000
	Total	**kr.**	**-414.130**
Revenue:	CMS fee	kr.	56.472
	Electricity sales	kr.	695.040
	Total	**kr.**	**751.512**
Gross income		**kr.**	**337.382**
Depreciation		kr.	-206.680
Operating income (EBIT)		**kr.**	**130.702**
Interest rates year 1		kr.	-165.344
Annual result		**kr.**	**-34.642**

Figure 1: Cost-Benefit Spreadsheet Screendump

The business model is based on transparent, cost-reflective tariffs:

- **Electricity:** DKK 1.60 per kWh.
- **CMS connection/rental fee:** DKK 0.13 per kWh.
- **Total:** DKK 1.73 per kWh.

This tariff is slightly higher than diesel generation (≈1.3 DKK/kWh), but OPS provides benefits including reduced emissions, compliance with greening strategies, and predictable costs. Rising diesel prices and CO_2 taxation are expected to make OPS the cheaper option in the medium term.

Results from the EHFAF socio-economic modelling have supported this business case.

2.4 Risk assessment

Based on the work with the planning, implementation and run of the of the projects some key risks can be identified. Alongside the risk assessment mitigation strategies should include following components:

- **Economic risk:**
  OPS is currently not the cheapest option, but long-term incentives, electricity price stability, and regulatory frameworks will hopefully ensure competitiveness.

- **Technical risk:**
  Delays in permitting and installation (e.g., high-voltage vs. low-voltage debate). Addressed through early involvement of regulators and grid providers.

- **Operational risk:**
  Adoption depends on ease-of-use; CMS was chosen to mitigate complexity for vessel crews.

- **Structural risk:**
  Changes in the pelagic fleet composition (e.g., fewer vessels, shifts in fisheries) could impact OPS demand.

Likelihood ↓ / Impact →	Low Impact	Medium Impact	High Impact
High likelihood	Minor technical glitches (CMS handling adjustments)	Small tariff deviations due to energy price fluctuations – electricity versus diesel prices	–
Medium likelihood	Vessel adoption slower than expected	Permit delays (regulatory clarification, grid connections)	–
Low likelihood	–	–	Structural risk (fleet changes, reduced OPS demand, collapse in pelagic fishing stocks)

Figure 2: Risk Matrix

An awareness at Port of Skagen of these risk components is important in the daily routine of handling the system and price setting towards the users. Short term changes in diesel can have a decisive impact on users' behaviour and loyalty programs may be relevant to develop to address these challenges.

2.5 Definition of ownership

Ownership and governance were clarified as follows:

- **Port of Skagen:**
  Owns and operates OPS and CMS.

- **Nord Energi Net:**
  Provides grid access and solidity in delivery of electricity.

- **Vessel operators:**
  Each vessel operator is responsible for investment in the onboard retrofitting.

- **Accessibility:**
  All users can book OPS in advance through the port's central booking system, ensuring fair and transparent access.

In normal day operations the importance of to the system accessibility cannot be underestimated. The ability to easy plug-in for all users at right time is the most important element in the governance and management system build around the system.

2.6 Accessibility for port users

The system was commissioned in May 2025 and tested with the vessel Lingbank using three cables (631 kW load). Further tests are planned with additional vessels such as Asbjørn. Each vessel must undergo a dedicated test procedure to confirm compatibility and safe handling. Initial tests confirmed that the semi-automated CMS solution functioned as intended.

2.7 Construction of OPS system and test-run in Port of Skagen

The system was commissioned in May 2025 and tested with the vessel Lingbank using three cables (631 kW load). Further tests are planned with additional vessels such as Asbjørn. Each vessel must undergo a dedicated test procedure to confirm compatibility and safe handling. Initial tests confirmed that the semi-automated CMS solution functioned as intended.

	The shore power station at the Port of Skagen The OPS unit and transformer station, which together convert and distribute certified green electricity to the connected vessels.
	The OPS unit from the other side is adjacent to the transformer station that can be seen to the left in the picture.

	Cable Management System (CMS) at the quay The CMS is in place at the landing quay. This semi-automated unit holds 45 meters of cable and connects the vessel to shore power, regardless of vessel size or exact mooring position. Each Zinus unit has two cables and the port of Skagen has two units and hence a total of four cables.
	Connection in Progress – Lingbank Port staff and crew manage the connection of shore power to the vessel HM379 Lingbank during one of the first full-scale OPS operations. The hatch where the cables are coming in has been established for an easy loading of the cables. The connection box at Lingbank is dimensioned to three cables, which reflects its maximum power demand. The largest vessels in the Danish fleet can handle four cables.

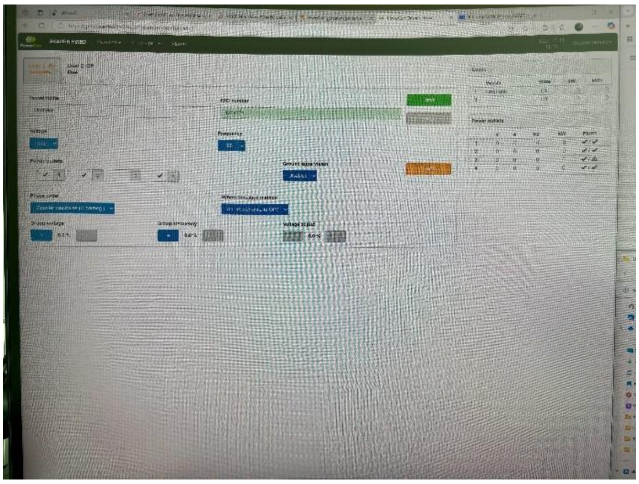	Power Monitoring Onshore The onshore handling configures power output via an terminal at key side, selecting the appropriate voltage and frequency for safe and efficient operation.
	Power Monitoring Onboard The vessel's chief engineer in his control room where power usage is monitored and configuration of power intake via the online interface, is made.
 	The two vessels Asbjørn and Lingbank that are the first two Danish vessels that are ready for OPS – here during fishing operations in the sea.

Figure 3: OPS Commissioning at Skagen (Lingbank test run)

3. Evaluation and roll-out concept for shore side electricity solutions

This section addresses the purpose of ensuring that the pilot results are accessible, transferable, and usable for other NSR ports beyond the Green Supply Chains project lifetime.

3.1 Feasible electrification strategies by combining business cases for multiple clients

The Skagen pilot shows that electrification strategies must be carefully adapted to the specific operational reality of the port and its users. A uniform or generic approach is not feasible; instead, solutions need to be built on detailed analyses of user requirements and technical assessments.

In Skagen, the strategy focused on the pelagic fishing fleet, which represents by far the largest energy users during quay operations. This made it necessary to design a semi-mobile OPS system with sufficient capacity to cover energy-intensive unloading operations of up to 1.5 MW. The OPS is placed directly in front of the two pelagic terminals, where vessels are almost continuously engaged in unloading. For this reason, there are currently no alternative uses for the OPS system beyond the pelagic segment.

The main pathway to further utilisation lies in encouraging more pelagic vessels to retrofit their ships with OPS capability. The long-term strategy is therefore not to diversify into many user groups, but to increase the share of the pelagic fleet that connects to OPS while at berth. In this way, the business case becomes stronger through higher adoption rates, and the environmental benefits are maximised where the demand is greatest.

From a technical feasibility perspective, the OPS system in Skagen has been successfully commissioned and tested with vessels such as Lingbank, showing that the semi-mobile CMS system works reliably under real operating conditions. Tests confirmed that load demands of 600–700 kW can be handled stably, and the system is scalable to larger vessels and longer quay stays. Economically, the cost-benefit model shows OPS can become competitive against diesel generation as fuel prices and CO_2 taxation increase. Business cases remain sensitive to adoption rates, but feasibility improves when more clients are included. Regulatory feasibility was confirmed through compliance with IEC/IEEE 80005-3 standards and Danish permitting requirements, supported by early engagement with the grid operator Nord Energi Net. Overall, feasibility is considered high, though adoption by vessel owners will be required onwards.

3.1.1 Feasibility

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From an economic feasibility perspective:

- The cost-benefit model shows OPS can become competitive against diesel generation as fuel prices and CO_2 taxation increase.
- Business cases remain sensitive to adoption rates; feasibility improves when more clients are included in the model.

From a regulatory feasibility perspective:

- OPS in Skagen has been aligned with IEC/IEEE 80005-3 standards and Danish requirements.
- Engagement with grid operator Nord Energi Net ensured smooth integration into the regional energy system.

Overall, feasibility is considered high, though adoption by additional vessel owners is required to achieve an economic positive business case.

3.1.2 Combined Business plans for multiple clients' cases

In the case of Skagen, the OPS business plan is not based on a shared model across multiple client groups. Instead, the focus remains entirely on the pelagic trawlers, which are the only users of the OPS infrastructure. The system is located directly in front of the two pelagic terminals, and utilisation depends on the extent to which vessels in this segment are retrofitted with OPS capability and actively connect while at berth.

Although there is no combined business case in the sense of including reefer trucks or processing facilities, the two terminal owners – Scandic Pelagic and FF Skagen – are supportive of the OPS investment. Both companies see value in the associated CO_2 emission reductions, which they can highlight in their sustainability reporting and use in marketing to customers and stakeholders. This alignment strengthens the overall business rationale for OPS, as the environmental benefits are recognised not only by the port and vessel operators but also by the wider value chain in Skagen's pelagic sector.

3.2 Exemplary mapping of supply and demand

A central part of the Skagen pilot has been the mapping of current and potential future energy demand at the quay. Demand mapping was initially based on detailed data from two Danish pelagic trawlers, Asbjørn and Lingbank, and extrapolated to a scenario of ten vessels. Measurements showed typical loads in the range of 600–1,000 kW during unloading operations, with annual quay-side demand between 200,000 and 450,000 kWh per vessel. This corresponds to annual savings of several hundred tonnes of CO_2 per vessel when OPS is used instead of auxiliary diesel generators.

Indicator	**Asbjørn**	**Lingbank**	**10-Vessel Fleet**	**Grid Capacity (Nord Energi Net)**
Annual quay demand (kWh)	443,520	192,000	4,200,000	> 5,000,000 kWh
Typical peak load (kW)	900	650	8,500	1,506 kW per OPS unit
OPS coverage	100 %	100 %	80–90 % feasible	Full coverage possible

Table 2: Energy demand and supply mapping in Skagen

On the supply side, the OPS transformer station in Skagen provides 1,673 kVA capacity, which ensures sufficient supply for these peak loads. The installation was carried out in collaboration with Nord Energi Net, which confirmed that the local grid can accommodate OPS demand under current and projected operating scenarios. While the calculations above reflect the Danish pelagic fleet, the potential user base is significantly larger. In addition to the approximately ten Danish vessels, another 20 pelagic trawlers from Great Britain (mainly Ireland), Sweden and Norway call at Skagen regularly during the season. These vessels do not all land with the same frequency, but their presence demonstrates that the potential demand is considerably higher than indicated by the Danish fleet alone. If even a portion of these international vessels retrofit for OPS and connect while at berth, the utilisation rate of the OPS infrastructure could increase substantially, further strengthening both the business case and the environmental impact. This mapping confirmed that Skagen's OPS system is dimensioned correctly for the pelagic fleet and that scaling up to more vessels is feasible with minor grid upgrades.

3.3 Emission savings compared to non-existing systems

Emission calculations were prepared using methods harmonised with the Danish EHFAF project. Switching from auxiliary diesel generators to OPS reduces CO_2 emissions by ≈86% and eliminates NOx, SOx, and particulate matter during the unloading at berth.

Indicator	Asbjørn	Lingbank	10-Vessel Fleet
Diesel saved (litres)	88,704	38,400	840,000
CO_2 saved (tons/year)	270.2	117.0	1,848
NOx saved (tons/year)	4.8	2.1	32.0
SOx saved (tons/year)	0.7	0.3	4.9
PM2.5 saved (tons/year)	0.2	0.1	1.3

Table 3: Annual emission savings from OPS

The results show clear environmental benefits, which also strengthen the social acceptance of OPS investments in fishing ports.

3.4 Governance models covering different use

The governance model developed in Skagen is based on a port-owned, user-pays principle:

- Ownership: The Port of Skagen owns and maintains the OPS infrastructure.
- Access: Vessel operators and processing companies gain access via a transparent booking system.
- Tariffs: A fixed kWh tariff ensures predictability and cost-reflectivity.
- Grid interface: Nord Energi Net ensures reliable supply and compliance with national energy regulation.

Key governance insights:

- Importance of fair management for accessibility to the system cannot be underestimated.
- A transparent tariff structure is essential for user acceptance.
- Early involvement of the grid operator reduces delays and avoids costly redesigns.
- Workshops with users build trust and ensure practical operability.

Transferability recommendations:

- The modular CMS design is replicable in other NSR ports with variable berth usage.
- The governance model can be applied in ports of similar size, provided tariffs are adapted to local energy prices and fleet profiles.
- Results should be disseminated through regional workshops and the Green Supply Chains partner network to maximise uptake.

3.5 Recommendations for transferability

The Skagen pilot demonstrates that non-standard OPS solutions can be successfully implemented in small ports, but transferability depends heavily on whether the local conditions resemble those in Skagen.

Most importantly, the solution is only relevant in ports with a significant level of pelagic unloading activity and where processing factories are located directly at the quay. Without such land-based infrastructure, the high and continuous energy demand that underpins the Skagen business case would not exist, and OPS investments would be far less viable.

From a technical perspective, the semi-automated cable management system and transformer setup are transferable to any port that faces variable berth positions and requires safe and flexible cable handling. The use of international IEC/IEEE standards ensures that vessels retrofitted for OPS in Skagen will also be compatible elsewhere. The cost-benefit model developed for Skagen can likewise be adapted to test feasibility under different tariff structures, energy prices, and adoption scenarios.

However, context remains decisive. In Denmark, very few ports have the necessary combination of large pelagic vessels and quay-side processing factories, which makes direct replication unlikely outside Skagen. In contrast, several ports in Norway, Iceland and the Faroe Islands share these characteristics and could therefore benefit from applying the Skagen model. These locations combine intensive pelagic landings with high-capacity factories and already face regulatory and market pressures to cut emissions.

The Skagen case suggests a clear pathway for transferability:

- OPS deployment should be prioritised in ports with large pelagic fleets and cold chain requirements, since they provide the strongest and most reliable demand base.
- Ports should ensure early involvement of grid operators and processing companies to align investment planning and secure utilisation.
- Business modelling should explicitly account for the value of CO_2 reductions in the supply chain, since processors can use these results in sustainability reporting and marketing.

In conclusion, while the Skagen OPS solution is not universally transferable across all NSR ports, it provides a strong and replicable model for specialised pelagic hubs in the wider North Atlantic region.

4. Recommendations for successful implementation of shore side electricity solutions

The experience from Skagen demonstrates that non-standardised OPS solutions can be successfully introduced in smaller ports with diverse operational patterns.

The lessons learned are directly relevant to other ports in the North Sea Region and can also inform developments beyond.

A few core elements are broadly transferable:

- The use of a semi-automated Cable Management System has proven particularly valuable, as it provides the necessary flexibility for variable berth configurations while ensuring safe handling for crews.

- Equally important has been the governance model adopted in Skagen, where the port retains ownership of the infrastructure and provides access to users on transparent, cost-reflective terms. This creates predictability for vessel operators and ensures equal treatment of all users.

- Another transferable aspect is the early and close involvement of the grid operator. This proved decisive in avoiding delays and securing a robust technical solution that complies with national regulation.

- The cost-benefit modelling approach developed in Skagen can easily be applied in other ports to test the economic feasibility of OPS under different assumptions for energy prices, adoption rates, and CO_2 taxation.

At the same time, the pilot highlights that some factors are highly context specific:

- The business case in Skagen rests primarily on the large pelagic trawlers with very high energy demand during unloading. Other ports may have to adapt the OPS design to different types of clients, such as ferries, container vessels, or inland barges.

- Similarly, grid capacity varies significantly between ports, and while Skagen could be accommodated with only limited reinforcement, other locations may face larger investment needs.

- Local regulation and energy pricing will also influence tariff structures and the attractiveness of OPS.

Taken together, the Skagen pilot suggests a pathway for transferability that begins with a careful analysis of user requirements and fleet composition.

Ports are advised to consider modular and mobile designs when berth use is variable or space is constrained, and to broaden business cases by including secondary users such as reefer trucks or cold storage facilities. By relying on international standards for connections and by sharing governance models, risk assessments, and tariff structures through the Green Supply Chains network, other NSR ports can draw directly on the experiences from Skagen and adapt them to their own local conditions.

5. Executive summary – innovative e-power supply equipment for shore side electricity solutions

The Green Supply Chains project has provided the Port of Skagen with a unique opportunity to develop, test and evaluate a non-standardised, semi-mobile onshore power supply (OPS) solution. The work undertaken under Work Package 1 demonstrates both the feasibility and the challenges of implementing OPS in small and medium-sized ports with specialised fleets, while also producing lessons of wider relevance for other North Sea Region (NSR) ports.

Main achievements

The OPS system in Skagen was commissioned in spring 2025 and has since been tested with vessels from the pelagic fleet, including Lingbank. With a maximum capacity of 1.5 MW, the system is dimensioned to meet the high energy demand during unloading operations, which can last between 10 and 30 hours. The semi-automated cable management system (CMS) enables safe and flexible handling of cables at variable berths, addressing one of the main barriers to OPS deployment in fishing ports.

The pilot has also established a governance and business model in which the port owns and operates the OPS infrastructure while vessel operators pay a transparent, cost-reflective tariff of DKK 1.73 per kWh. This ensures equal access for all users and a predictable framework for investment decisions. A dedicated cost-benefit model was developed, showing that while OPS is currently slightly more expensive than diesel generation, future fuel price developments and CO_2 taxation are likely to make OPS the more competitive option.

Environmental and socio-economic impact

Emission calculations, developed in close alignment with the Danish EHFAF project, show that OPS can reduce CO_2 emissions by approximately 86 per cent compared to diesel-based power generation. For the vessels *Asbjørn* and *Lingbank*, annual savings amount to around 387 tons of CO_2, with the potential to reach nearly 1,850 tons annually if ten vessels from the fleet connect regularly. In addition, OPS eliminates local emissions of NOx, SOx and particulate matter, improving air quality and reducing noise in the port environment. These benefits have been highlighted in stakeholder dialogues as important for the port's social licence to operate.

User involvement and feasibility

Workshops with shipowners and processing companies confirmed that OPS solutions must be tailored to specific operational realities. In Skagen, the high demand from pelagic trawlers was prioritised, but the pilot also showed the potential to include secondary users such as reefer trucks and processing facilities. This would increase utilisation rates and strengthen the business case.

From a feasibility perspective, the OPS system has proven technically reliable and scalable, economically viable in the medium term, and compliant with regulatory requirements. The close involvement of the grid operator Nord Energi Net was crucial for ensuring smooth integration with the regional energy system and avoiding delays.

Transferability and lessons learned

The Skagen pilot has generated several insights that are directly transferable to other NSR ports. The semi-automated CMS technology can be applied wherever berth variability is a challenge. The governance model of port ownership combined with user-pays principles creates a transparent and stable framework. The cost-benefit methodology can be adapted to test different adoption rates, tariff structures and regulatory conditions elsewhere.

At the same time, the pilot has underlined the importance of context. Business models depend heavily on fleet composition, grid capacity, and local regulation. Ports aiming to replicate the Skagen model should therefore start with a detailed mapping of user requirements and local energy infrastructure.

Next steps towards a Strategy and Action Plan

The executive summary provides a foundation for the forthcoming Strategy and Action Plan (SaAP 1.4). For the Port of Skagen, the next steps include continued testing of the OPS system with additional vessels, refinement of tariff structures, and expansion of business models to include multiple user groups. For other ports such as Brest, the summary illustrates how non-standard OPS solutions can be designed, governed and financed, and how they can contribute to wider decarbonisation strategies.

In conclusion, the Skagen pilot demonstrates that OPS is both technically feasible and environmentally impactful in small, specialised ports. By combining innovative technical design with transparent governance and active stakeholder engagement, the Port of Skagen has created a roadmap that others in the NSR can follow, adapt and scale to their own conditions.