# Electrifying the North Sea

## Orcadian's Microgrid Concept

### May 2022

NSMP NORTH SEA MIDSTREAM PARTNERS WÄRTSILÄ ORCADIAN ENERGY

# Electrification of the North Sea's offshore oil and gas platforms

Electrification of offshore oil and gas is not easy – it is neither trivial nor cheap to replace the power from onboard generators – but the imperative to do so is plain for all to see. In response to climate concerns those of us in the oil and gas industry will continue to advocate for cleaner methods of extraction and production. The impetus for change came from the North Sea Transition deal agreed between the industry and the government in March 2021, and one year later, the realities and complexities of delivering on that task have been laid bare.

Through collaboration and challenge, operators from across the North Sea are finding economical and sustainable solutions for power from shore options. The Orcadian consortium, one of three winners of the North Sea Transition Authority's Electrification Competition in September, has completed a study that provides a new approach.

We have designed and described a viable, reliable, off-grid option for powering North Sea platforms. Our approach is founded on power from floating wind turbines, supported by highly efficient and responsive gas-powered reciprocating generators with enough battery power to maintain a reliable supply.

We believe our design can be more effective and cost substantially less than cable from shore. It will deliver an earlier and deeper cut to emissions, and by reducing future costs it can enable mature fields to keep producing longer. All of this enhances the UK's energy security and will ensure that emissions from North Sea oil and gas production remain world leading.

**Advantages of Orcadian approach**

- Emissions reductions – approaching an 80% reduction for offshore facilities.
- Lower costs – saving almost $2 billion and more than 25% cheaper than a power from the UK grid option, when capital and ten years of operating costs are included, for a subset of platforms.
- A practical way for operators to meet their North Sea Transition Deal commitments in terms of both the emission reduction targets and timeframe.
- Deliverable quickly, and in phases, which allows a staged deployment with a steadily improving reduction in emissions.
- Opportunities for re-use or redeployment – provides legacy infrastructure for the grid and/or other users.

This paper lays out the solution in more detail, and we hope operators and partners will feel confident in adopting our proposed concept.

## How are platforms powered now, and where do we want to get to?

When the oil and gas installations, which deliver much of the UK's energy supply were designed, ensuring that electrical power on the platforms would be highly reliable, was foremost in the engineers' minds. That, and a need to minimise the weight of the power plant, were the key drivers, so it is unsurprising that most of the power plants in the North Sea are based on aero-derivative gas turbines. Gas is readily available and, given their provenance, this design of engine – a simple cycle gas turbine – maximises both reliability and power density.

But now, efficiency and emissions matter much more, with industry and government committed to reducing offshore emission by 50% by 2030.

## Why not just plug a wind turbine into the platform?

Whilst the possibility of installing a wind farm and using this supply to power platforms looks an attractive one, it will not have the effect we desire on reducing emissions. The reliability of power is paramount to platform operators and because wind power is variable and unpredictable, a reliable back-up system is essential. Firing up a simple cycle gas turbine takes time, perhaps 10 minutes to get to full power, so gas turbines could never be shut down and would have to continue to provide a spinning reserve, but under low loads. Under low loads, gas turbines are highly inefficient, so emissions are not much reduced in this scenario.

Nevertheless, this approach has been adopted at Hywind Tampen, but only to provide c. 35% of the electrical energy demand, as this minimises low loading of the generators. A different approach with a better back-up system is needed to provide as much power as possible from renewable sources.

### Are batteries the answer?

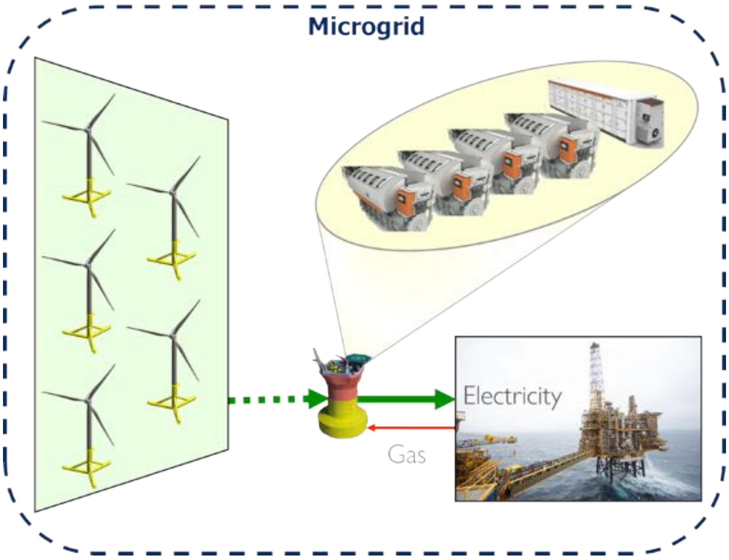
Batteries can be highly responsive but are bulky and heavy. The core CNS platforms in the Central Graben that supply a quarter of the UK's gas have a power demand of about 200MW. The 100MW, 100MWh Minety battery in Wiltshire, pictured, gives a sense of the actual scale of half an hour's worth of battery back-up for those platforms. Batteries have a role, but for seconds, not for hours.

Image: Shell Energy Europe

### How can this be done differently?

Our proposed concept is one which we believe will provide operators with a means to marry intermittent renewable sources of energy with their stringent requirements for a reliable electricity supply and is scalable to groups of platforms and entire North Sea regions. It will also create legacy infrastructure which can provide energy long after the oil and gas facilities are decommissioned.

The concept has three components:




- A wind farm using floating wind turbines. We show costs and emissions reductions based on a wind farm with capacity of about 120% of the platform demand, though this ratio will be further optimised in consultation with operators.
- Floating distribution hubs, which will collect AC power from the wind turbines at 60 Hz and 66kV and distribute power to the platforms at 33kV. The hubs will include energy-efficient, gas fired reciprocating engines with sufficient capacity to deliver all the necessary power during the 10-15% of time when wind power is completely unavailable. There will also be modest battery capacity for frequency control and to minimise the spinning reserve requirement.
- A network of cables to distribute the power to the operators' platforms.

Together we call these "Microgrids".

## Platform modifications and the cable network

Of course, operators will need to make modifications to their platforms to be able to import this power, to replace process heat, to change-out gas compressor drivers, and to decommission existing generators, and these costs are substantial. We have not attempted to optimise this part of the scope, though we have estimated the cost reductions accessible by changing the distribution voltage from 132kV, assumed in power from shore studies, to the 33kV we propose, and there is an opportunity to further reduce the distribution voltage, and hence modification costs, for platforms very close to the proposed distribution hub locations.

Installing more distribution hubs helps reduce the cost of the offshore cable network, and there is a trade-off between the cost of hubs and the cost of cables, which we have aimed to optimise.

## Distribution Hubs

Our preferred concept for the distribution hub is to design a new floating facility, capable of supporting a 6,500 tonne topside, which does not need to weathervane and which is designed from the outset to be unmanned. For the purposes of the report, we describe a buoy based upon Crondall's BPT technology, but other approaches need not be ignored as we progress the engineering definition of the project. Our concept is to design one hub, but to deploy many; we expect six hubs could meet most of the demand in the Central North Sea, including the Outer Moray Firth, and the concept could be replicated in the Northern North Sea and West of Shetland.

Each proposed distribution hub will be designed to meet c. 80MW of demand and will have four or five 7.8MW 14V31DF engines, and the same number of 11.14MW 20V31DF engines, supplied by Wärtsilä; with a 15MW, 1.5 min battery to meet short term fluctuations in supply or demand. The battery minimises, but does not eliminate, the need for physical spinning reserves and contributes to frequency control and power stability. There is scope to optimise costs by reducing the back-up capacity provided, we see three possibilities: firstly the spinning reserve allowance could be reduced from the ±20% level which is typical for offshore facilities; secondly we could reduce engine redundancy; and finally we could enable load shedding for inessential systems (say water injection).

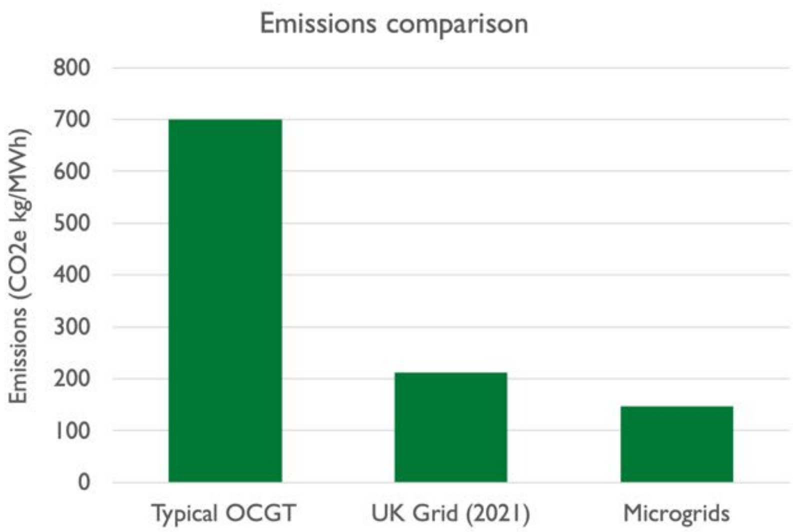
## Windfarms

In the report delivered to the North Sea Transition Authority we laid out a range of costs for constructing and installing the hubs, the cables and the wind farms. The wind farm costs have been prepared after engaging with key players in the floating wind power business and we intend to augment our consortium with an established player in the floating wind business. Our paramount goal has been to lay out a realistic plan to deliver the project and have it in operation by 2027. This goal remains in sight, but it will require potential customers to take up our offer to consolidate our consortium and progress the engineering definition of our solution very rapidly.

The companies we selected to make proposals to design, build and install the wind farm are all Tier One contractors with deep experience of delivering offshore projects and well-developed designs for the floating wind units. However, many alternative floating wind technologies could be deployed here and there is surely an opportunity for trial units of promising floating wind technologies to be included in the scope of this wind farm as a means of accelerating technology development and enabling the proof of the myriad concepts being invented. We have had interest from four floating wind technology developers to be part of this project.

## Emissions Reduction

Our analysis indicates that wind power can meet between 60% and 70% of power demand with the balance being delivered by the gas engines. Scope 1 emissions will be just under 150 kgCO2e/MWh, well below today's grid and substantially below current emissions, perhaps approaching an 80% reduction if the true inefficiencies of offshore simple cycle gas turbines under partial load are taken into account.




## Capital Costs

To provide context for our cost estimates, we present costs for three micrograds, serving nine platforms. We compare this with the costs of a power from shore option for the same platforms, assuming a connection to the UK grid. The costs of the distribution hubs are comparable to, but about 10% less, than the cost of onshore and offshore convertor stations and a cable, but crucially this investment will enable the Operators to source low-cost, zero-emission offshore wind power, rather than pay the price for wholesale electricity from the grid.

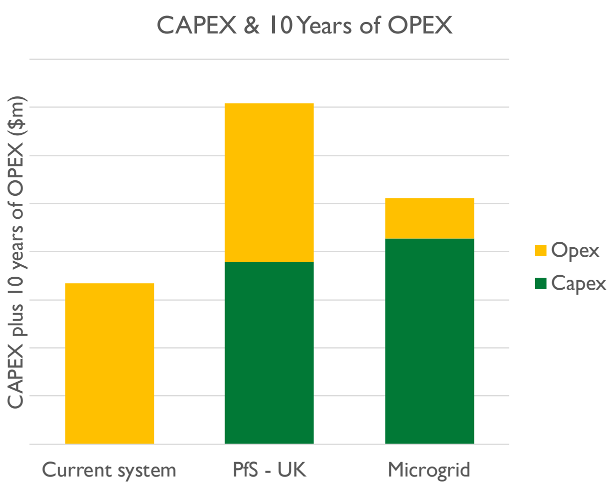
The cost of distribution cables, to and from three hubs located close to the facilities, is substantially reduced (by 40%) from the cost of cables to the same platforms from a single hub. We also estimate that the cost of brownfield modifications to the customer platforms will be modestly reduced. Adding the cost of the wind farm means that overall capex is marginally increased.

## Operating Costs

Importantly, annual operating costs of the system, including fuel for the gas engines, would be drastically reduced, this is largely driven by the cost of purchasing electricity in the power from shore UK option when compared to the operating costs of a wind farm and the distribution hubs.

This includes an allowance for carbon emissions taxes but not including the benefit of any free emissions allowances which Operators may have access to.

An estimate has also been made of the costs of operating the current system of onboard generation, Orcadian does not have access to the detailed information which would be required to estimate this accurately, but we have used parameters which we believe are not unreasonable. However, Operators will be able to make this direct comparison with ease.




## Total Costs

To establish if this concept could be attractive to operators, we have compared the total cost of installing these systems and operating them for ten years with the costs of power purchase from the grid. We compare the total costs of our proposed system with the total costs of an onshore grid tie-in and convertor station, a cable to the offshore convertor platform, cables to the consumers, and the expected costs of brownfield modifications, and of course the cost to purchase power from the grid.

In terms of total capex and ten years of operation, the Orcadian solution is projected to save over 25%, when compared to the power from shore option.

## North Sea Transition Deal – 2030 target

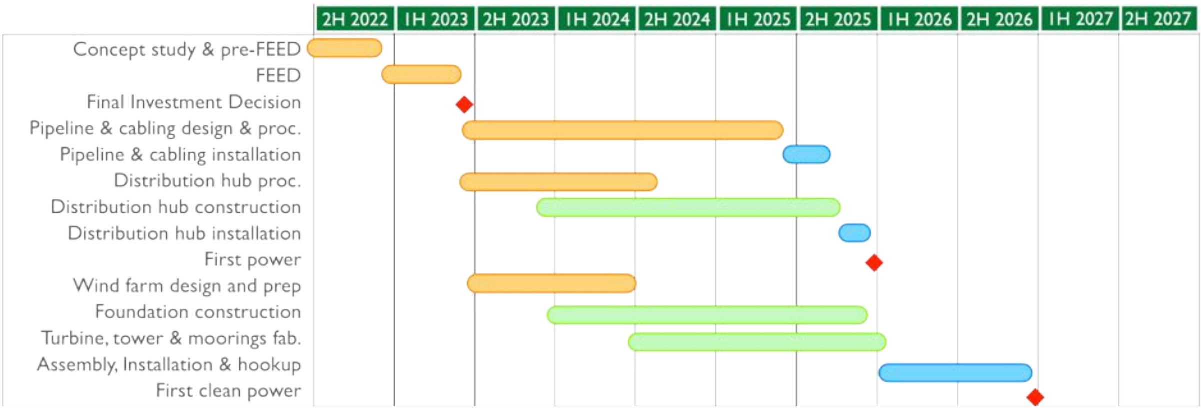
The North Sea Transition Deal requires the offshore industry to reduce emissions by 50% by 2030. To meet this target the NSTA estimated that the entire UK offshore industry must achieve a $CO_2$ abatement of 2 to 3 million tonnes per annum within that timeframe [Ref. Energy Integration Project, 2020]. Implementing six Microgrids, for the CNS and OMF only, would deliver most of the 2030 abatement reduction target for the entire UK offshore industry.

## Energy Security

Adoption of this system further enhances the UK's energy security, by eliminating a new burden on the grid; diversifying power supply to Central Graben fields, when compared with a single cable and by accelerating the deployment of floating wind technologies in line with recent UK Energy Security Strategy goals and Scottish Government's objectives. In addition, providing legacy infrastructure for supply of power to the UK national grid or future offshore industries: green hydrogen, Carbon Sequestration, or the like.

## Schedule

This project can be delivered and be in operation by the beginning of 2027. However, to meet this schedule we would need to have the whole-hearted support of the operators to firstly define the project and secondly to enable the financing of the project, as soon as possible.




Importantly, the first distribution hub could be operational at the beginning of 2026. This will immediately impact power generation emissions, with a potential reduction of up to 35% for the platforms connected, but even before the wind power component is brought onstream; this can be achieved before the wind farm is commissioned because the hub generators and central distribution architecture are much more efficient than open cycle gas turbines located on individual platforms. This will also provide operators an opportunity to reduce power Opex immediately and build confidence in the performance of the system before decommissioning their existing generators.

## Project Delivery

The Orcadian-led consortium proposal would cut through the commercial and financial complexity of large industry joint-ventures by providing field operators and owners with the opportunity to bi-laterally purchase a reliable supply of decarbonised electricity delivered to their platform via a private wire, whilst recognising that customers would be required to supply gas in order to ensure the generation of back-up power.

Key to our approach is the early participation of the supply chain in our consortium, we have benefited from the involvement of Petrofac, Wärtsilä and Schneider Electric in the overall design of the solution and their early engagement gives us confidence that we can structure a project delivery consortium which can underpin the delivery of the project.

## The Orcadian Consortium

Funded by the NSTA, the Orcadian consortium consists of Orcadian Energy, Crondall Energy, Petrofac, Wärtsilä, Enertechnos, and North Sea Midstream Partners and has developed an innovative solution which realises significant emissions reduction through electrification of existing facilities, whilst also breaking down the electrification problem into manageable pieces.

The Orcadian consortium has considered it vital to remember during the conceptual design phase that the needs of the consumer are the priority, and our approach has been to demonstrate a secure, decarbonised, reliable power source that will be relatively easy for operators to incorporate into their facilities.

Development of the microgrid solutions has only been achieved by extensive collaboration between the consortium members, Orcadian Energy, Crondall Energy, North Sea Midstream Partners (NSMP), Wärtsilä, Enertechnos and Petrofac.

- **Orcadian Energy** is the custodian of the microgrid concept, acting as the microgrid system operator, owner of the commercial model, and the technical concept.
- **Crondall Energy** is Orcadian Energy's client engineering team, managing the delivery and development of the Microgrid concept.
- **North Sea Midstream Partners** (NSMP) are an infrastructure investor and are also supporting the development of the commercial model for the microgrid concept.
- **Wärtsilä** is a global leader in innovative technologies and lifecycle solutions for the marine and energy markets. Wärtsilä are a key equipment vendor for the microgrid concept, providing highly efficient, low emissions gas fired engines, as well as the energy storage system.
- **Enertechnos** is a cable technology provider, with their patented cable providing the potential for a significant increase in the transmission distance for MV AC power.
- **Petrofac** is a global energy services company providing expertise on how to implement the microgrid concept from an Engineering Procurement and Construction (EPC) and Operations & Maintenance (O&M) perspective.

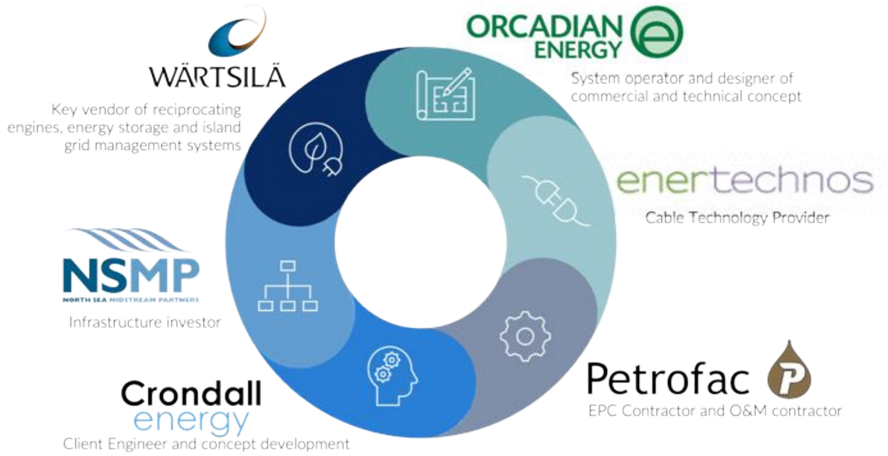



**Figure 1-1: Microgrid consortium**

Additional support has been provided by **Schneider Electric** who assisted with the development of the distribution system and the associated automation system.

Multiple floating wind vendors have been consulted with respect to the wind power generation technology.