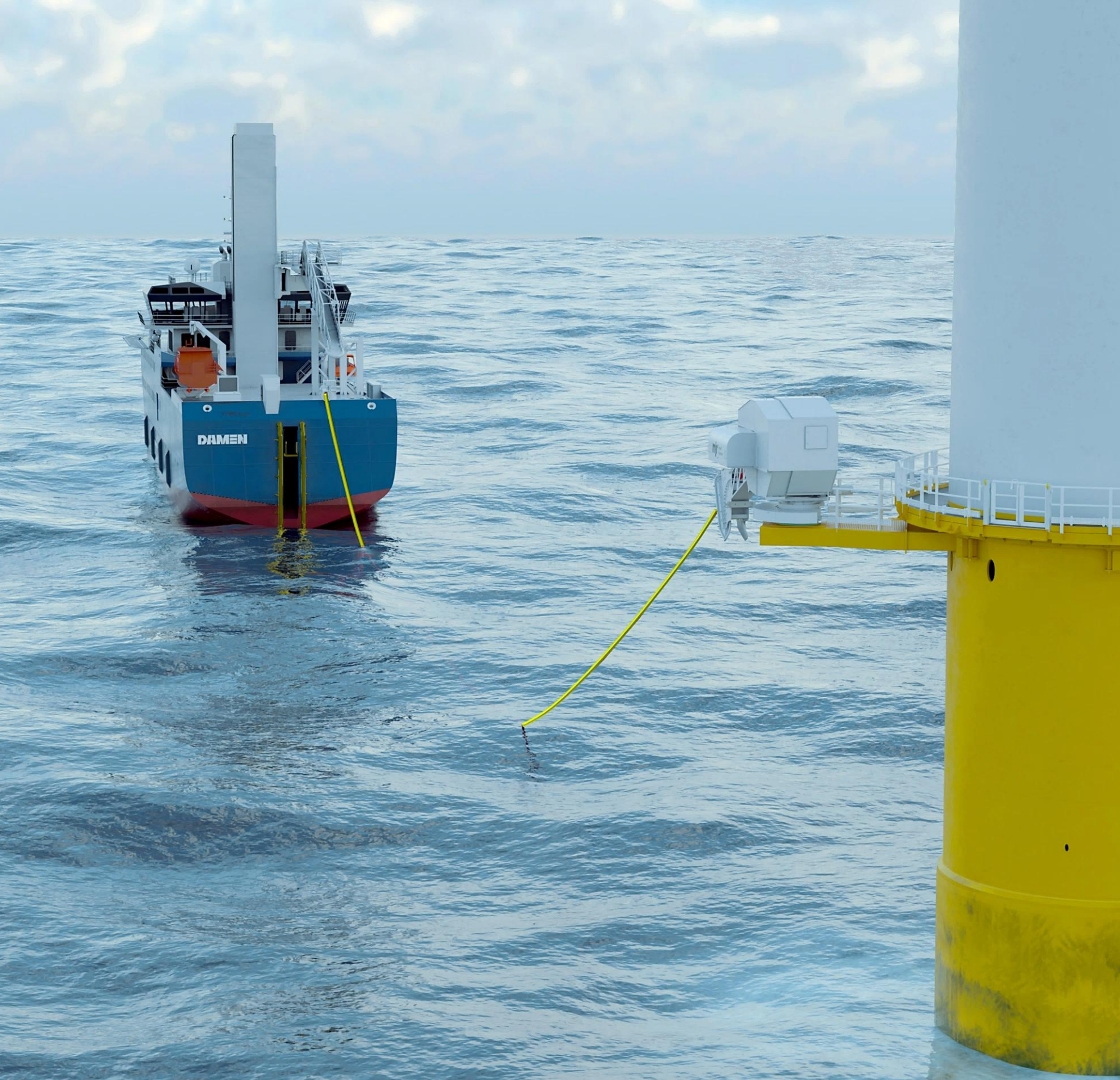

OFFSHORE CHARGING

SOV & CTV O&M FLEET ELECTRIFICATION ENABLER

A White Paper by MJR Power & Automation for Scottish Power Renewables

01 Background

Decarbonisation of O&M fleets operating in wind farms is being gradually implemented because of increasing regulatory constraints forcing reduction in fuel oil usage, coupled with incentives through Contracts for Difference (CfD), grants, subsidies, and the rapid downward trend in technology costs.

The decarbonisation goal is achievable by either burning of alternative and expensive "green" fuels and/or through vessel electrification and the use of batteries charged at regular intervals.

Electrical solutions are particularly suitable for wind farm O&M fleets specific operational profiles, due to the possibility of regular charges directly at offshore energy production sites and at shore-based quay sides.

Electrification is now considered a highly viable solution because of the constant improvement in battery technology and energy density coupled with rapid downward trending of CAPEX costs, as well as because of the gradual availability in the market of economical and reliable onshore and offshore charging solutions.

Additionally, the operational safety track record in marine industry applications, in particular for ferry fleets, are a driver for vessel designers and owners shifting to battery ready O&M assets.

Fast-growing fleets of fully electrical/ hybridised CTVs and e-ready SOVs are now coming to market through Bibby, Damen, Rieber, Edison Chouest, Tidal Transit, NSS & others.

By allowing fast & safe CTV & SOV battery charging at any time while in operation at offshore wind farms, the offshore charging infrastructure, installed on either sub stations, turbines, or other dedicated structures, is deemed to be the technology key enabler in decarbonisation of O&M activities. Battery capacity & CAPEX constraints, as well as vessel's payload limitations will, in most cases, not allow for a full base to base cycle of operation on a single harbour charge, without charging offshore or extensive alternative fuel consumption

Scottish Power Renewables (SPR) has commissioned MJR to produce an in-depth technical and commercial investigation into integration of charging units on the infrastructure of its new windfarms to demonstrate technical feasibility of installing and operating MJR's modular, low maintenance systems, as well as documenting the validity of business cases.

This study is focused on offshore charging for electric CTVs and electric SOVs, with conclusions on:

- Technical and operational feasibility of integrating an offshore electrical charging system at a new built 960MW wind farm, as a base case study. The site is approximately 30NM from the shore base.
- Value and Impact Analysis needed as an input to the business case to move to the next phase of implementation.

More generally, the study objective was to understand the specific risks, requirements, and costs of offshore charging infrastructure, to ascertain feasibility and highlight the necessary design inputs to integrate the technology economically onto future wind farm sites.

Charging CTV batteries @
Parkwind Jera Nobelwind 2024

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02 Executive Summary

2.1 Charger Integration & Installation

Planning the installation of charging units on new build wind farms is relatively straightforward and economical, if a few simple engineered add-ons are considered early at the offshore asset design stage.

Mechanical modifications required to a typical WTG designs are minimal, under the reasonable assumption that the WTG/Pile assembly is structurally capable of taking additional charger loads, representing a very small fraction of the overall turbine weight (15MW WTG >>1,000Te) and with low centre of mass.

WTGs fitted with "Ready for Charging" add-ons, remain operationally identical to the standard design WTGs, with no access and workability limitation for maintenance Vessel operations.

The charger modular design approach allows rapid mobilisation/removal at any stage during the life of the wind farm, without any disruption or risk to field production.

If not installed together with WTG at initial field set up, the "ready for charging" add-ons permit charger installation at a later stage, possibly combined with maintenance campaign for optimum cost control. Allowing ½ day for lifts in position and 1 to 2 days of a small team transported by CTV for hook up of each charger unit.

The offshore charger maximum power rating that can be fitted is driven by the asset's ability to support the necessary step-down transformer to convert the Array High Voltage down to the Charging Medium Voltage requirements. These transformers can range in weight from 5Te for smaller capacity units to close to 16Te for the higher powers.

Noting that:
Retrofitting a charger on WTGs not originally designed with mounting brackets and cable routes required for integration is challenging and, in many cases, not possible for powers above 0.3-0.5MW, as no major modification to WTG structure will likely be permitted offshore to add the charger/step down interfaces.

Additionally, the charger equipment would have to be fitted on cargo landing zones as no other space would be available.

Our recommendation in case of unplanned retro fit is to consider Offshore Sub Station (OSS) integration as there is usually more space, load bearing capability and power availability than on WTGs. Understanding that for the OSS case, contractual and licencing aspects, linked to current UK OFTO and CfD regimes can bring constraints. However, the situation in many of the other EU countries is already far more favourable and evolving quickly in the right direction.

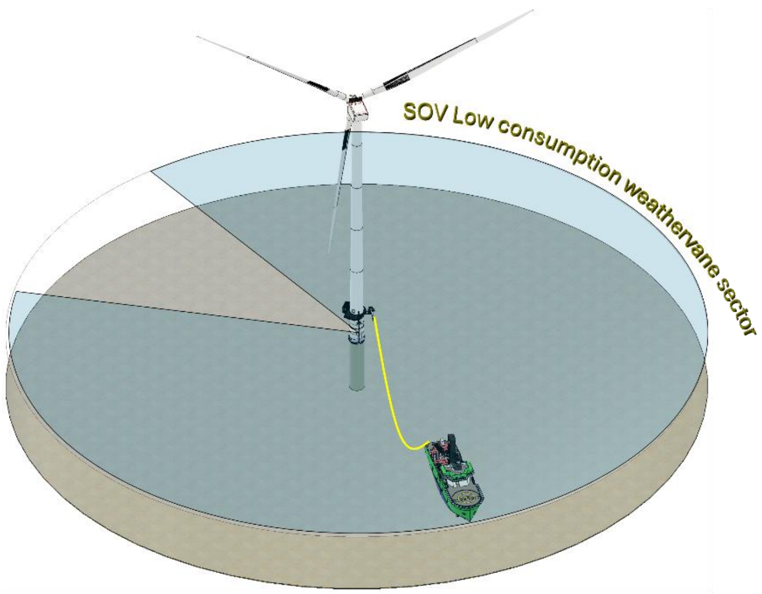
2.2 CHARGER OPERABILITY

The MJR Charging System is designed to service both CTVs or SOVs through simple, safe and ***fully hands-free*** charging processes.

With a wide 0.5MW to 8MW range of power transfer options, the charger can operate from any offshore asset rated for the purpose:
WTG fixed or floating, OSS, Dedicated Mono Pile, or Mothership

MET-OCEAN CHARGING LIMITS:

- Connection of the charger to the vessel is designed to be possible in conditions far worse than the limits for personnel and cargo transfer. Typically, 1.5 to 2m Significant Wave Height (Hs) for CTVs and 3 to 3.5m Hs for SOVs.
- Power transfer and disconnection stages have higher Met-Ocean thresholds with the limit driven mostly by extended footprint station keeping ability for the SOVs.
- The charger's wide sector slew function allows Vessels to safely connect in "blow away from asset" weathervaning ***in all tidal and wind conditions*** (graphic below).

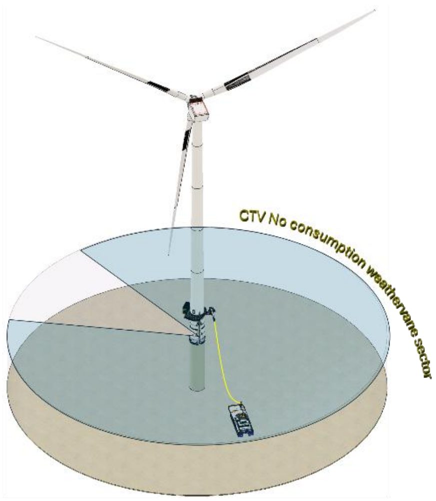


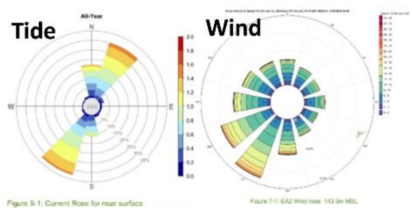
Through connection to the Inter Array network, power to the charger remains available at all times, even if the turbine is shut down or in the rare cases where the field does not produce because of lack of wind.

For electrical in-field operations, CTVs typically require chargers in the 1 to 2MW range.

Larger CTVs and SOVs will require 2 to 8MW chargers, depending on Vessel specific consumption and operational profiles required to cover daily tasks.

If the field is intended to be served by an electrified O&M fleet for the medium or long term, the recommendation is to prepare 2 to 4 "Charger ready" locations on WTGs or OSSs in order to guarantee redundancy as well as flexibility in case of future field extension.





2.3 CAPEX & OPEX INDICATORS

Analysis for the base case 30NM distant field concludes that CTVs fitted with 5.5 MWh battery capacity, combined with a 2.2MW offshore charger provides sufficient electrical power for Zero Emission O&M operation, whilst maintaining adequate safety margin.

Similar analysis for SOV indicates 20 to 25 MWh of battery capacity combined with a 6MW offshore charger allows for full electrical in-field operations, with a single charge during the night time idle period.

VESSELS CAPEX

Q4 2024 electrical systems pricing sets e-CTV vessel construction costs CAPEX at 12-14% higher than diesel powered MGO-CTV. A similar ratio applies to e-SOVs.

VESSELS OPERATING OPEX (Day rate + energy)

e-CTV OPEX is currently estimated to be 13% higher than an MGO fuelled equivalent vessel.

e-SOV OPEX is already competitive for long term charters with Emission Trading System (ETS) enforced from 2027.

CAPEX & OPEX TRENDING

With the steep downward battery systems pricing trend, the CAPEX competitivity of e-SOV and e-CTV will become on par with their MGO powered alternative (Ref. section 11).

OPEX competitivity will be further reinforced by anticipated incentivised onshore and offshore rates through the Contract for Difference (CfD) mechanism, as well as ETS (and possibly IMO) enforcement from 2027 for SOVs. Noting that UK consultation is already initiated to assess ETS extension to full O&M fleet, including vessels below 400 Gross Tonnes (GT).

The charger infrastructure CAPEX can (and already regularly does) benefit from a number of government incentives through CfD, grants & subsidies that will more than likely cover the whole or large part of associated costs (at least for the first pilot projects).

Emergency disconnection @
Parkwind Jera Nobelwind OSS

03 Charger Equipment

The offshore charger enables power transfer at sea from any rated fixed asset to CTVs or SOVs batteries as well as supplying required hotel and propulsion loads throughout the fast-charging process.

All operations are fully automated and remotely managed from the vessel bridge by the Master, DP Officer or any other competent personnel. No manual handling on deck is required at any stage, from connection to disconnection.

The system is dimensioned to transfer between 0.5MW to 8MW of charge power to any vessel fitted with an MJR standardised connector catcher.

By default, the system is delivered to comply with DNV & IEC applicable standards but can be certified to other Marine Classification Societies requirements (LR, ABS…).

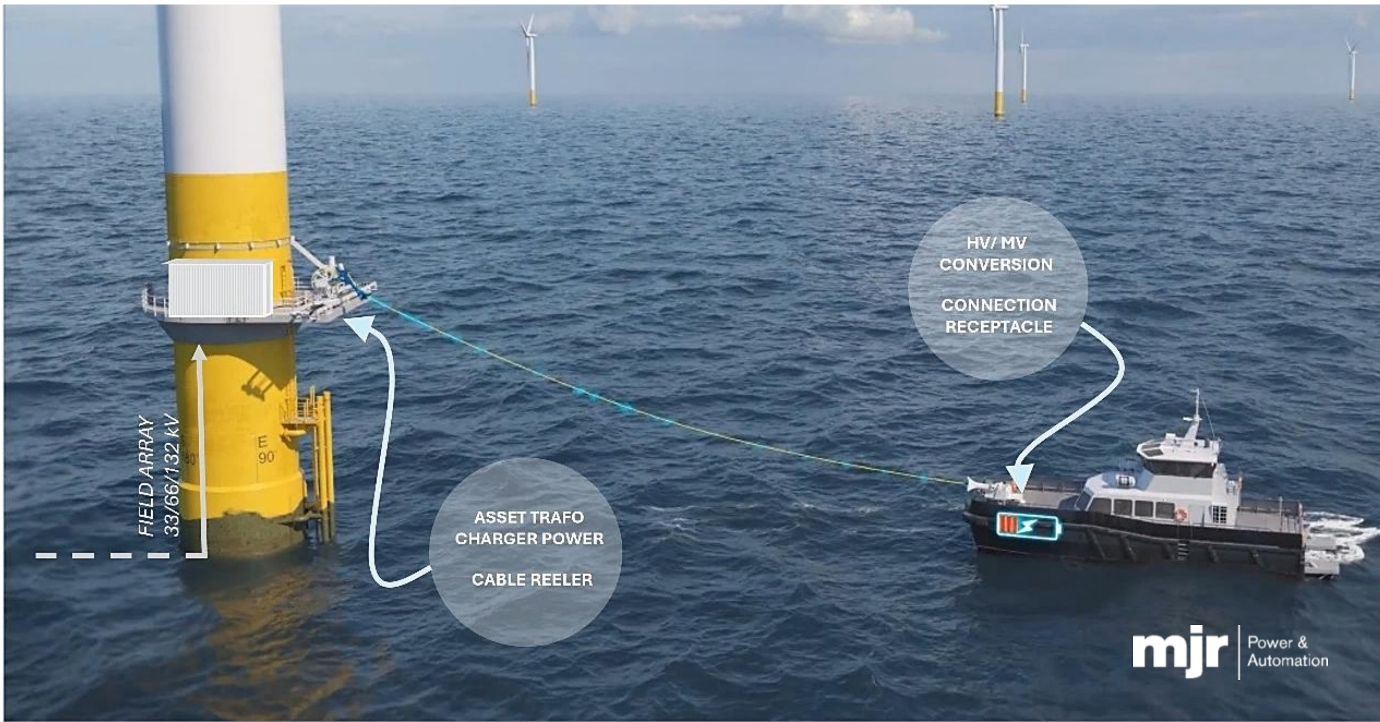
Mechanically, the charger design remains identical for any Vessel type and size.

Electrically, the asset transferred power characteristics may change depending on the charge power requirements and vessel payload limitations to accommodate conversion gear. Typically:

Standard CTVs cannot accommodate heavy transformers without un-acceptable impact on payload capabilities; hence DC medium voltage is transferred from the asset and converted on the vessel.
Large CTVs and SOVs have capacity for on board transformers and can be supplied by a higher AC voltage from the asset.

The asset Array 132/ 66kV or 33kV electrical supply is stepped down, through a purpose-built deck containerised transformer unit, or tertiary winding on existing transformers (for OSS typically), to the voltage level that can practically and safely be transferred to the vessel.
Transferred power characteristics are typically, but not limited to:
-CTVs / SOVs <60m: <=6.6kV for powers 0.5 to 4MW
-Large SOVs > 60m: 11kV for powers 5 to 8MW

The converted power is then transferred through the heavy-duty charger umbilical to the vessel where it is regulated to allow seamless connection to vessel's electrical network.



3.1 Equipment on Asset

The charging unit can be fitted on any suitably rated offshore asset with an available source of power, including: Fixed or Floating WTG, an OSS, a Dedicated Pile, a Mothership etc...

COMPONENTS

1-A ready to hook up power container unit with:
- Step-down transformer converting the High Voltage Field Grid power to the required Medium Voltage for the Charger unit.
- Cable Reeler control and power feed.
- Communication module to vessel & Operator onshore Marine Control Centre (MCC).

2-A Reeler storing and controlling the charge umbilical catenary and tension while in operation. The reeler is fitted with heavy duty umbilical rated for the maximum intended power transfer to the vessel and terminated by robust subsea rated connector arrangement.

RISK MANAGEMENT

The system design and operation has gone through several levels of strict risk assessment (HAZID & HAZOP) to ***guarantee that no mechanical or electrical failure on the charge system or vessel will compromise the integrity of the asset or energy production from the wind farm.***
The charger has already been successfully installed on a live Parkwind Jera Group Offshore Sub Station (OSS) in 2024 with no shut down requirement and delivering multiple power transfers to CTV: Reliability as well as operational safety are field proven and system has reached TRL 8 (on a maximum scale of 9).

3.2 Equipment on Vessel

Compact and easy to mobilise charger connector receptacle can be fitted at vessel transom or bow.

COMPONENTS

1-A receptacle bolted at the edge of the hull structure, clear of personnel transfer and cargo handling zones.

2-A bridge mounted control and communication console allowing the Master or the DP Officer to:
-Book charging slot, with approval from onshore Marine Control Centre, through a web portal application
-Monitor charge parameters on both the vessel and the asset
-Control the reeler, vessel receptacle and charging process

RISK MANAGEMENT

The receptacle is designed with redundant active and passive safety systems ***guaranteeing the charging vessel can instantly be freed from the charge cable*** upon the Master's request, or automatically in case of any overload.
After an emergency disconnection or immersion in water, the connector does not require any maintenance, cleaning or drying and the charger remains fully functional, ready for another charge cycle.

04 Integration to Offshore Asset

The study focussed on a charger installation onto a WTG installed within the base case field, but the conclusions remain valid for any new build sites.
The overall aim is to allow the developer to implement, with minimum modification and at very minimal CAPEX increase, the necessary WTG/OSS add-ons, enabling cost effective future installation of charging units at multiple locations at selected sites.

MJR main **DESIGN DRIVERS** for the charger interface to asset being:

CHARGER INTERFACE DESIGN DRIVERS	
+++ MAXIMISE +++	--- MINIMISE ---
OPERABILITY & RELIABILITY	ASSET STANDARD DESIGN MODIFICATION
MODULARITY: SAME SYSTEM FOR SOV & CTV CHARGING	CAPEX ASSOCIATED W/ INTEGRATION
FLEXIBILITY TO INSTALL CHARGER AT ANY TIME DURING LIFE OF FIELD	OPEX & MAINTENANCE
RAPID MOBILISATION FOR LOW CAPEX	CONSENT COMPLEXITY
LIFE CYCLE ALIGNED WITH ASSET	DISRUPTION TO ASSET OPERATIONS

An MJR produced set of simple interface specification and calculations allow the Developer to integrate the necessary add-ons to the asset at design stage, ensuring Charger installation and operations are safe and will never compromise asset integrity both electrically or mechanically, nor interrupt production at any stage.

Charger equipment specification outline:

COMPONENT	TYPICAL SPECIFICATION
Asset Infeed power	*33/66/132kV AC 50 or 60Hz*
Vessel charge power	*4kV to 6.6kV AC or DC for chargers up to 4MW* *11kV AC for chargers 5MW to 8MW*
On asset step down transformer	*Depending on charger required rating (5Te to 16Te)*
Reeler drive container	*Mounting footprint: 2mx 2m, Weight: 3Te*
On asset Reeler	*Mounting footprint: 2mx 2m* *Weight: 12 Te*
Charge umbilical	*Heavy duty subsea type* *100m nominal (longer lengths possible)*
On Vessel charger receptacle	*Mounting footprint: 1mx 1m* *Weight: 1.5 Te*

05 Consent & Licencing

CONSENT

Charger operation consent is expected to be reasonably straightforward, and far less constraining than for buoy-based charger alternatives.
With on asset equipment:

- Fitting onto the existing decks with no additional seabed occupation licence requirement.
- Representing no additional hazard to navigation.
- Not interfering with seabed.
- Not generating additional noise or environmental disturbance.
- Not requiring dedicated seabed power supply flexible cables or umbilical, Jtube, trenching, rock dumping etc…

LICENCING

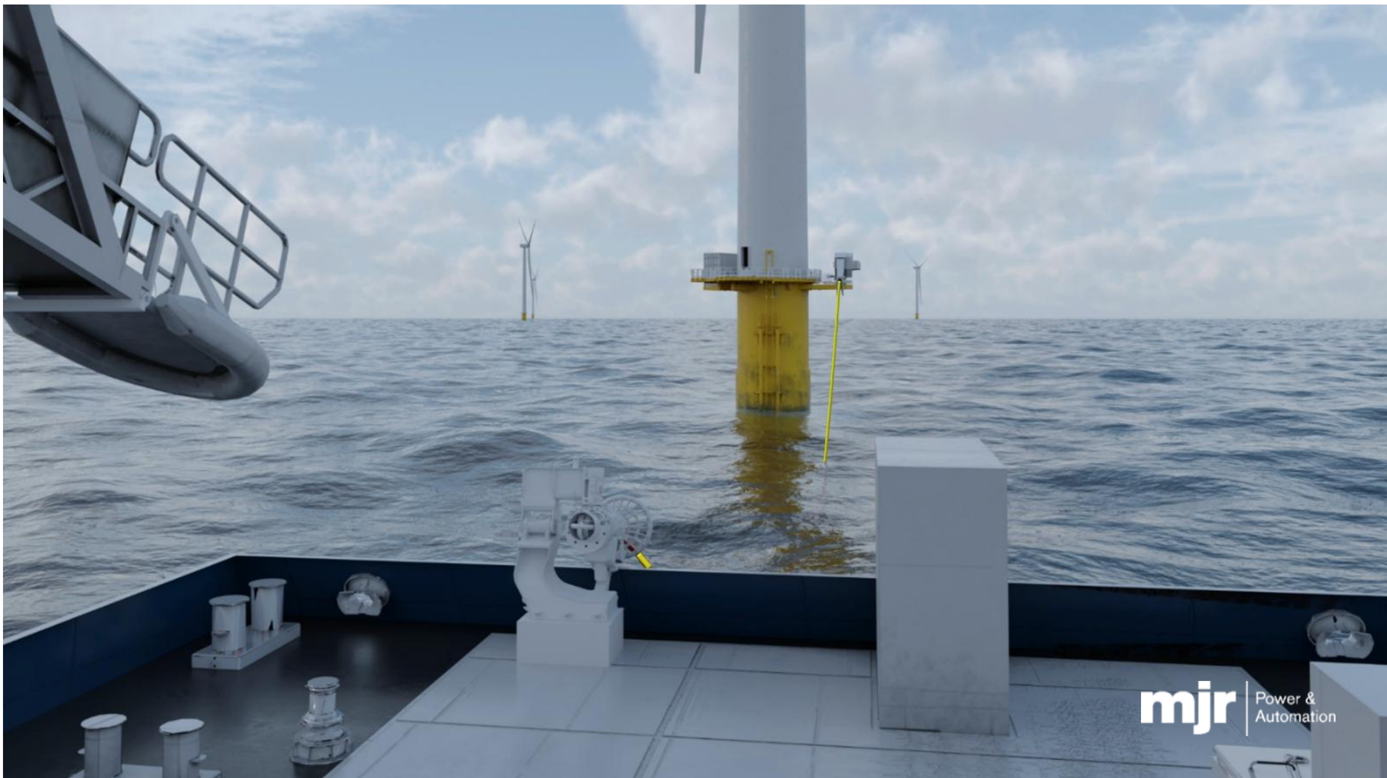
Licencing allowing and regulating offshore power off-take for e-fleets is currently under fast-track discussions and reviews across Europe, with some countries appearing to have largely clarified the matter (Netherlands, Germany and Belgium.), and others not yet (UK, ...).
"Behind the meter" e-fleet power supply from WTGs is understood to be straightforward (with metering requirement for UK fields under CfD).

Tapping from OSS power is in some cases contractually and licence wise more constraining, in particular under Offshore Transmission Owner (OFTO) UK type regimes where the OSS is not necessarily designed nor owned by the wind farm Operator.

Typically, the UK has a set of rules for power off-take from oil and gas infrastructure, but the situation is still not fully legislated for the renewable sector. More specifically for the very low occurrence windless periods where the field does not generate at all, and charge power is drawn from the grid.

But it is anticipated ongoing industry lobbying and consultations will trigger exemptions or favourable arrangements in the very near future, following Dutch and Belgian pragmatic approaches, at least for all new developments.

In anticipation of requirements for charge power metering, the MJR charger is fitted with a robust real time monitoring and logging of energy transferred to vessels while charging as well as industry compliant fiscal metering. The data is always available to the MCC Operator through a dedicated communication channel with option to produce reporting for eventual billing.



06 Sizing & Number of Units in Field

CHARGER SIZING

Charger sizing is driven by the optimised compromise between the desire for the shortest offshore charge time and practicality of integrating the power conversion unit on the offshore asset selected.

Typical profiles for 100% electrical operations in the base case field 30NM from shore base, are:

- CTV with one offshore charge cycle of max 90 minutes /day, in between “drop offs” and “pick up” of personnel. This requires a 2MW charger
- SOV with one offshore charge cycle of max 4 hours during the non-working hours. This requires a 6MW charger.

NUMBER OF CHARGERS IN THE FIELD

It is anticipated in the short to medium term, the O&M fleet will be a mix of traditional diesel powered and fully electrical vessels, with a requirement for one or two chargers per site.

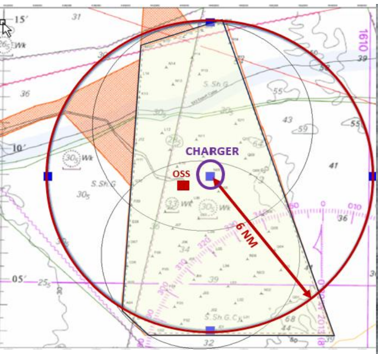
But with expected gradual dominance of the electrical solution as technology proves reliable and battery costs reduce, the fleet will require more chargers to be installed during life of the field.

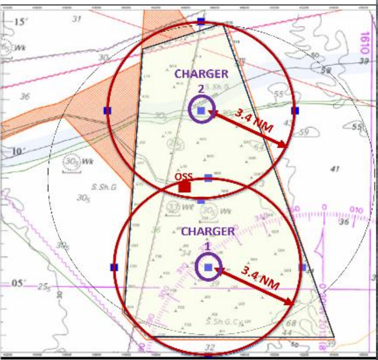
Additionally, if a wind farm goes through extension phases, the charging infrastructure in the vicinity of the new concession could serve several adjacent fields.

Hence our recommendation is to have several WTGs “Charger ready”, even if chargers are not immediately installed at all locations. With understanding the CAPEX increase associated with “Charger ready WTG” is minimal.

Site specific recommendation will be fine-tuned based on the vessel’s expected operational profiles, fleet planned electrification level, redundancy and maximum emergency response time constraints. But as a generic view:

Stage	SOVs / CTVs operating	WTGs “charger ready”	Chargers installed
Proof of concept	1	3	1
O&M electrical fleet	1 SOV or 2 to 3 CTVs		2
Larger e- fleet/ Charger usage extension to nearby fields O&M	2 SOVs or 3 to 5 CTVs		3





07 Mobilisation on Offshore Asset

Equipment is designed to be fully modular for ***fast and low CAPEX offshore hook up & commissioning at any stage during the life of field*** (and not necessarily during the field initial installation campaign).

Design & manufacturing is in strict compliance with relevant DNV & IEC mechanical, electrical and automation system rules and standards for offshore vessel construction. This assures safe operation and charging, guarantees safety of the lifting operations and hook up to asset & vessel system

Our first charger unit was installed and commissioned on a live Parkwind Jera Group OSS in July 2024 within 2.5 days, using only a CTV and the exiting OSS onboard crane.
No shut down nor outage of the installation was required at any stage.

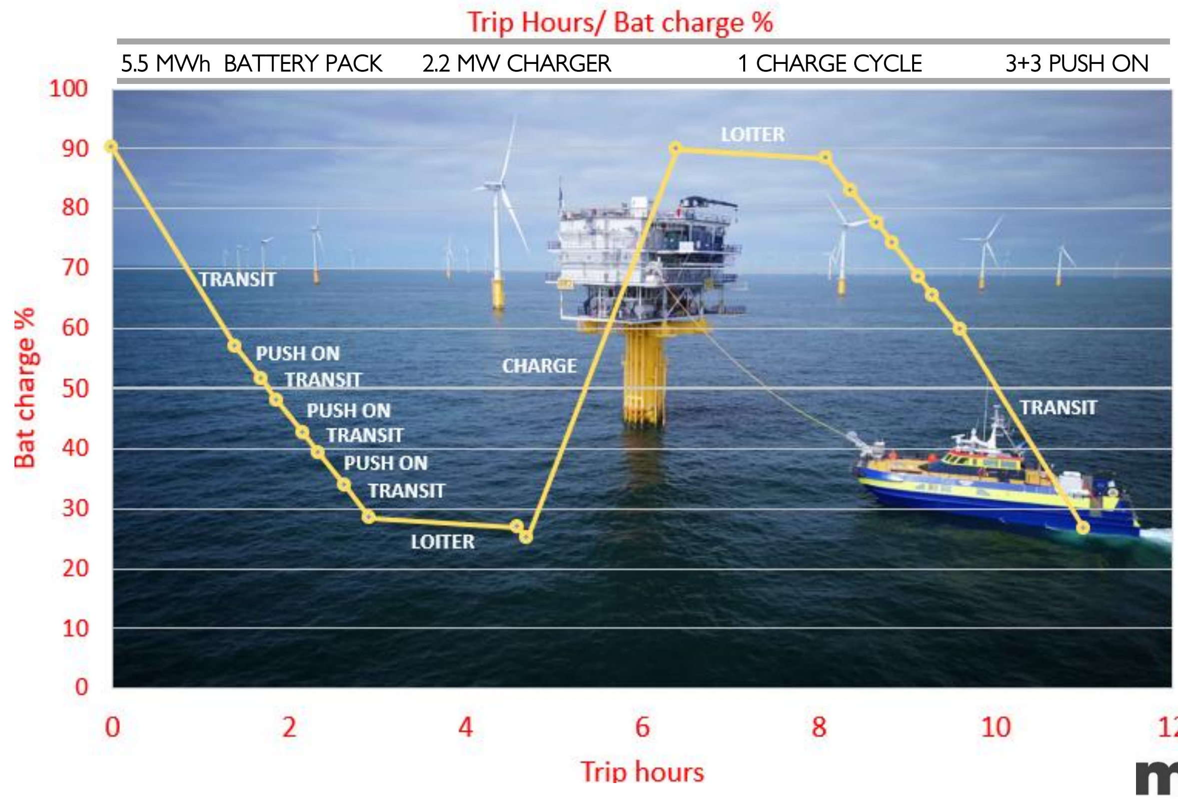
The extended offshore validation campaign including power transfer and full failure mode, effects and criticality testing, provided high confidence in the robustness & practicality of the proposed solution, both in terms of installation & operations.

For Charger installation onto WTG structures (without integrated cranage), component lift can be performed within 1 day by an adequately rated construction SOV, or small economical maintenance jack up. Combining charger installation with a planned maintenance program will allow expenditure to be kept to a minimum through mobilisation cost sharing.
The remainder of the hookup tasks will only need a CTV with a small team of technicians.

08 Charge Operations Overview

1. The vessel books a charging slot and requests Charger access from the onshore Marine Control Centre (MCC).
2. Charger in built compensation and safety functions ***allow by design for connection in Met-ocean conditions above personnel & cargo transfer limitation.***
3. Vessel positions within safe (approx. 15m steel) to steel distance from asset (or “push on” for CTV)
4. Vessel connects, depending on configuration, either by direct connector drop off or with use of Gang Way or 3D crane. No personnel are required on deck at any stage. The process is fully controlled remotely with a high degree of automation to minimise human errors & risk level.
5. Vessel moves to safe downwind charge position, typically 30m for CTV and 80-100m for SOV, while reeler system automatically controls charge cable catenary length.
6. Vessel is now on minimal economical thrust, and Master/DP Operator powers up umbilical remotely to initiate the charge process
7. Reeler ***automatically*** maintains charge cable tension below maximum pre-set threshold to guarantee system is never mechanically stressed and adjusts the catenary dynamically.
8. Reeler slew function permits vessel weather vaning, ***allowing for charging operations in any prevailing weather directions*** and guaranteeing vessel drifts in safe blow away from asset in case of any blackout or other failure.
9. The Master can at any time release the connector to free the vessel. Subsea rated connector is ejected in water and reeled back to asset. Charge process can be immediately re-initiated without any maintenance.
10. In the event of a blackout or malfunction on either the vessel or asset, charge power is instantly shut down and the connector is released by either Master’s command on the console, or passively on overload above pre-set safe threshold.
11. At end of charge cycle, the Master/ DP operator de-energises system and moves towards asset
12. Connector is released and reeled back clear of splash zone
13. Master hands back Charger command to the onshore MCC.

For full visualisation see:
https://www.chargeoffshore.com/



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09 System O&M Requirements

OPEX minimisation and guaranteeing a charger durability equivalent to the field life cycle are key parameters for the on-asset charge equipment. This is achieved through

- Ensuring all equipment is asset mounted and remains easily accessible to maintenance technicians supported only by CTV and on-board asset handling means.
- Mechanical components are well clear of splash zones and protected from UV radiations, birds and weather.
- Sensitive electrical and electronic components are in enclosed climate-controlled areas
- Selection of marine grade proven standard components
- Design based on standard, simple & proven offshore equipment technology.
- Extensive qualification process, DNV witnessed, for main components exposed to high duty cycles.

Several preventive maintenances strategies & means of controlling wear are implemented to anticipate potential failures before they actually happen.

SYSTEM LIFECYCLE

Although it is anticipated that technology changes during the lifetime of the field may call for upgrade of the charging equipment after a certain period, the system is originally designed (with adherence to a maintenance program) to match the windfarm's 25 to 30 year lifetime.

Noting that the Reeler and Step-Down Container modular mobilisation designs allow for easy removal/change out at any stage if required.

MAINTENANCE CYCLES

All Inspection, maintenance and overhaul operations can be managed by CTV and a team of 2 to 3 technicians, depending on operations to perform.

Typical expected maintenance cycles:

- 6 monthly routine functional and wear inspections with a team of 2 techs for ½ day. Noting that optional inbuilt remote access to the system can allow MJR onshore personnel to monitor all charger sensors live and assist inspection team diagnostics as well as implementing remote fixes.
- Yearly preventive maintenance visit for more in-depth verification and eventual parts change out, with a team of 2 technicians for 1 day on site.
- Overhaul and wear parts replacement for the on-asset gear every 3 to 5 years, performed with CTV and 3 technicians.

10 E-fleet CAPEX & OPEX Indicators

The SPR technical and operational analysis for the base case field, combined with data provided by vessel operators, Tidal Transit for CTV and Bibby Marine for SOV, allowed OPEX comparative evaluation for a fully electric versus traditional marine gas oil powered O&M fleet solution.

In terms of vessel construction costs, (taking into account Q4 2024 electrical systems pricing), the e-CTV currently requires 14% more CAPEX than its MGO powered equivalent, with similar ratios applying to e-SOVs.
Looking at the steady trends for battery systems price reducing, coupled with energy density increasing, within a relatively short time the cost difference will be eliminated and will even reverse.

10.1 CTV: OPEX comparison Electrical versus MGO

The technical review concluded that a CTV fitted with 5.5 MWh battery capacity, combined with a 2.2 MW offshore charger provides sufficient electrical power for Zero Emission O&M operation on a field up to 30NM from shore base, while maintaining an adequate safety margin.

e-CTV OPEX competitiveness, in comparison to MGO/Alternative fuel powered CTVs, is expected to become favourable with 2027-28 forecasted battery costs.
Competitiveness will be further boosted by:

- Anticipated incentivised onshore and offshore power off-take rates through CfD & legislative mechanisms.
- Un-availability of competitively priced alternative fuels to replace diesel.
- ETS enforcement from 2027 for SOVs and more than likely on medium term for the whole O&M fleet, noting that consultations have already opened in UK to assess application to vessels under 400 GT.
- Potential IMO regulation enforcement, planning on carbon pricing from \$100 to \$380 per ton of CO2 from 2028 for vessels exceeding quotas (draft April 25 resolution).

The table below outlines Tidal Transits' 27m e-CTV competitive threshold in relation to fuel price (MGO or any other alternative fuel). It highlights price of fuel threshold to achieve e-CTV and MGO-CTV OPEX parity.
Key variables being: Battery system pricing, Offshore & Onshore charge energy pricing and ETS carbon offset costs.

E-CTV COMPETITIVENESS (Day-rate+ energy cost):

OPEX VARIABLES TRENDING (typical)				E-CTV vs MGO-CTV OPEX parity	
BATTERY PRICE YEAR	***OFFSHORE*** ENERGY £/kWh	***ONSHORE*** ENERGY £/kWh	***ETS*** £/T CO2	FROM MGO/GREEN FUEL PRICE THRESHOLD	
2024	Strike rate £0.06/kWh	£0.1/kWh	0	£1.05 /lit	
2027-28	**Strike rate £0.06/kWh**	**£0.1/kWh**	**0**	£0.72 /lit	Battery Price Drop
	Incentivised £0.02/kWh			£0.66 /lit	Offshore £/KWh Incentive
		Incentivised £0.5/kWh		£0.56 /lit	Onshore £/KWh Incentive
			£50	**£0.45 /lit**	ETS Enforced

10,2 SOV: OPEX comparison Electrical versus MGO

Bibby Marine operational assessment for their new 90m e-SOV currently under construction, indicates 25 MWh of battery capacity combined with a 6MW offshore charger allows for nominal full electrical zero emission in-field operations, with a single charge during the night-time idle period.

Current e-SOV CAPEX is 10-15% higher than its MGO equivalent, but OPEX (day rate + energy rate) is already competitive through the significant vessel energy costs savings, in the range of £1M/ year, offsetting the CAPEX delta well within the usual long term charter period & making e-SOVs competitive from 2027 as soon as ETS is enforced.

Noting that e-SOV CAPEX (as for CTV) is on a downward price equalisation trend with MGO units.

Tables below, from Bibby Marine's Feb. 25 energy costs comparative review, is illustrative of the current status. It is based on average emission taxation of $100/ T of Co2 (whether ETS, IMO or FuelEU generated).

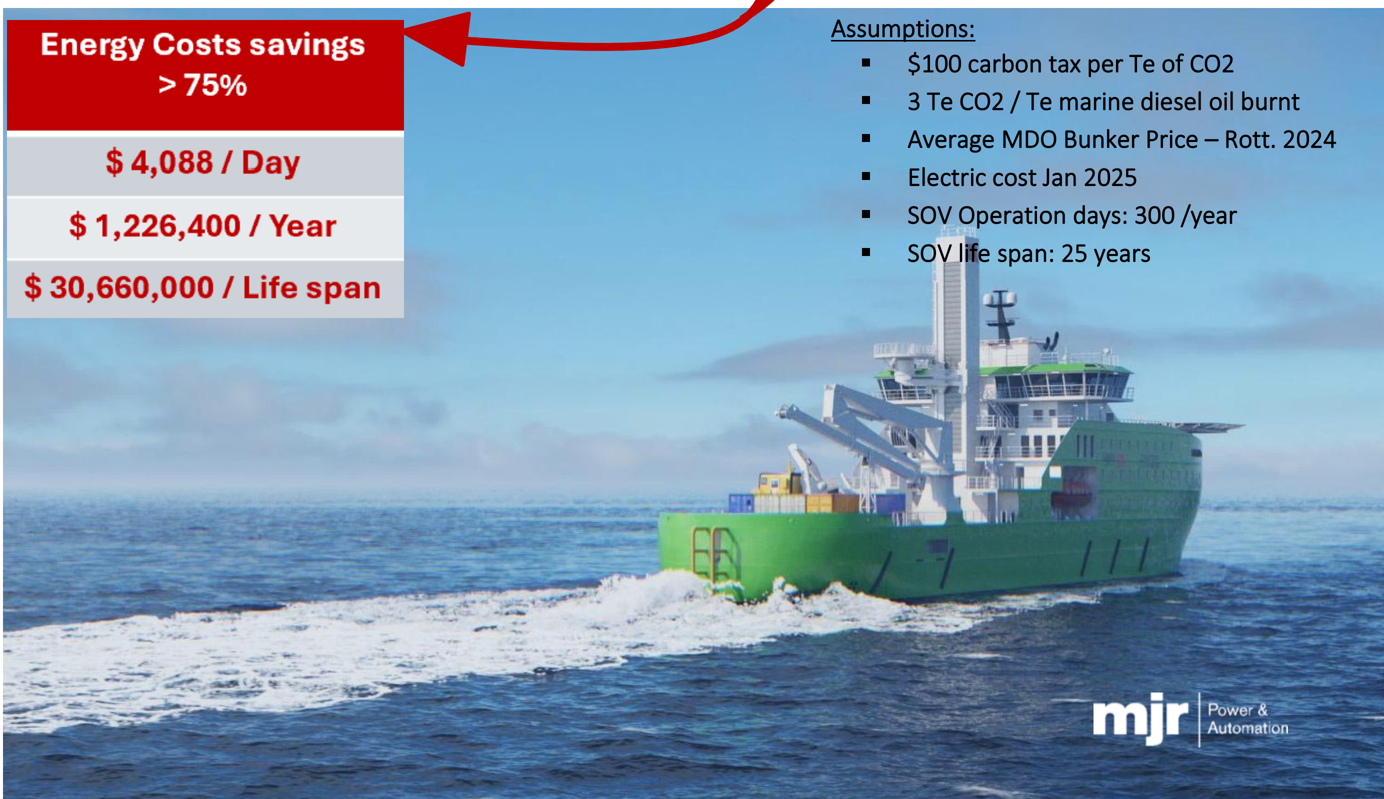
STANDARD SOV Operating on Marine Diesel	
Daily Fuel Consumption	5 Ton
Avg bunker price	$ 750 / Ton
Fuel Cost / Day	$ 3,750 / Day
CO2 emission equivalent	15 Ton / Day
Carbon tax cost / Day	$ 1,500 / Day
TOTAL ENERGY COSTS	**$ 5,250 / DAY**
	$1,575,000 / YEAR
	$ 39,375,000 / LIFE SPAN

e- SOV 100% Electrical operations	
Daily Electrical consumption	16.6 MWh
Avg charge power pricing	$ 70 /MWh (Base case strike rate)
Energy price / Day	$ 1,162 / Day
Carbon tax costs/ Day	Nil
TOTAL ENERGY COST	**$ 1,162 / DAY**
	$ 348,600 / YEAR
	$ 8,715,000 / LIFE SPAN

Energy Costs savings > 75%
$ 4,088 / Day
$ 1,226,400 / Year
$ 30,660,000 / Life span

Assumptions:

- $100 carbon tax per Te of CO2
- 3 Te CO2 / Te marine diesel oil burnt
- Average MDO Bunker Price – Rott. 2024
- Electric cost Jan 2025
- SOV Operation days: 300 /year
- SOV life span: 25 years



11 Key Favourable Trending Indicators

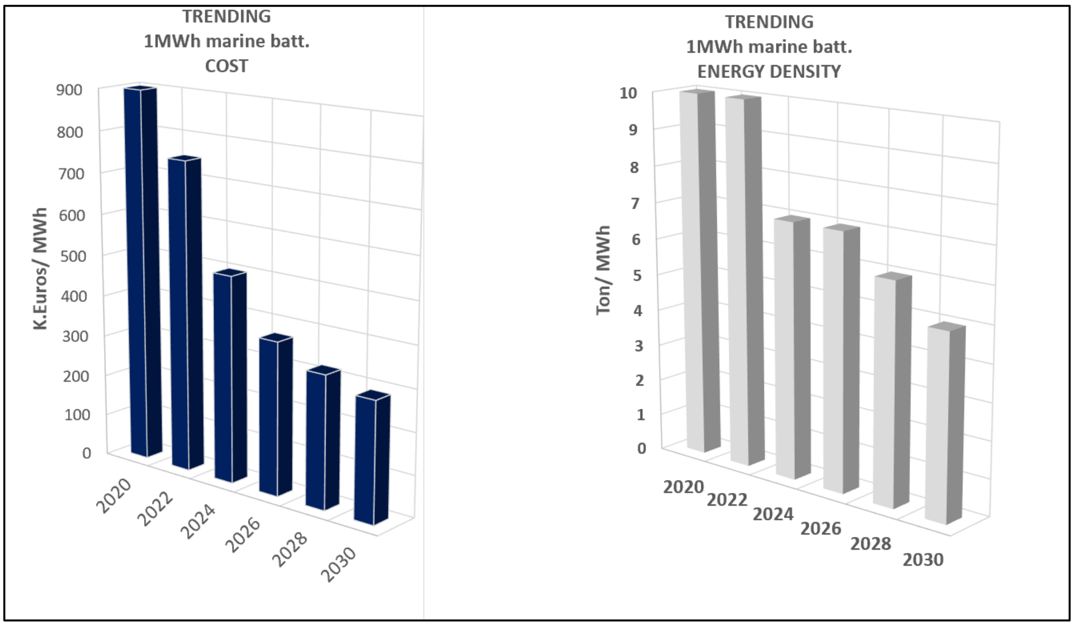
Evolution of several factors listed below is expected to further increase the e-fleet competitiveness in coming years.
Identified factors are typically: Battery cost and technology, diesel based and alternative fuels costs, price of offshore and onshore charging energy and lastly the availability of grants and subsidies.

Trending Factors

<u>1-BATTERY COSTS</u>

Battery cells as well the integration technology for marine applications are already standard on most of near-shore ferry fleets in Norway (and other Northen EU countries) and on many of the larger ocean-going vessels for harbour entry/ exit and peak shaving applications but are also more recently being installed on CTVs and SOVs as well.
Standardisation combined with rapid energy density & chemistry improvements, continue to drive overall electrical systems costs on a sustained downward trend for the foreseeable future, allowing e-vessels CAPEX to narrow the gap with their MGO equivalents, with direct impact on day rate and lowering of Operator OPEX.

Marine batteries average costs and energy density trending:
(Data source: Corvus, ETS Floatech, BYD 2024-25)



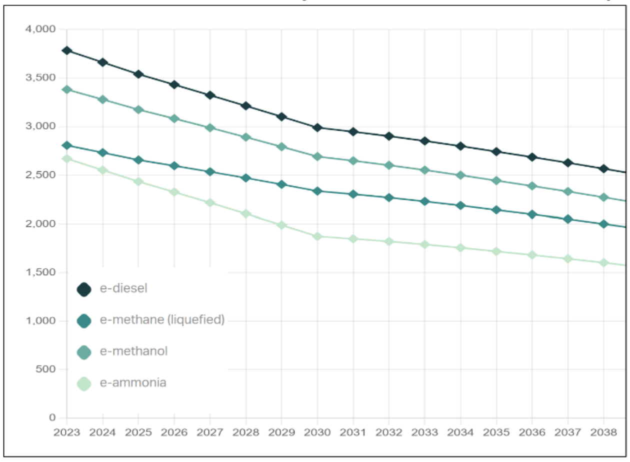
<u>2-FUEL COST</u>

Marine diesel (MGO/MDO etc..) markets have been proven, and remain, far more volatile than the renewable electricity market which is more predictable & reasonably immune to external Geopolitical factors
Fleet electrification allows for almost fully de-risked long term OPEX forecasting, being one of the very few options based in its entirety on locally produced energy and local supply chains with no reliance on non-national infrastructure.

Additionally, OPEX related to operations of MGO powered O&M fleet will significantly increase from 2027 with ETS/IMO regulations penalising various type of emissions through expensive compensation schemes.
ETS enforcement is scheduled from 2027 in EU and 2026 in UK for SOVs above 5000GT, with likely extension to vessels >400GT and finally for all smaller O&M vessels.

Lastly, alternative "Green fuels" intended to replace MGO are far more costly (in energy equivalent) and will remain so for the foreseeable future with a rate well above £990/m3 equivalent LFO ($1.500/T).
The "Bio or Blue Fuels" are reported to be marginally more cost efficient than "Green fuels" but will very likely suffer from insufficient availability and /or further taxation linked to their production methods.

Alternative "Green fuels" Projected Cost in USD/Ton LFO equivalent (Source Maersk-McKinney Moller 2024**)**



- **Higher price than MGO/m3**
- **High infrastructure CAPEX**
- **High OPEX supply chain**
- **Far less efficient sources of energy**

GREEN FUELS LFO EQUIV. PRICING:
>> £ 990/m3
FOR FORESEEABLE FUTURE

<u>3- ONSHORE AND OFFSHORE CHARGE ENERGY OFF-TAKE PRICING</u>
Both are key drivers in the economics of the electrical solution. Lobbying Regulatory Bodies, port authorities, and grid operators et al, for preferential rates is in progress on several fronts, although no clear and standardised position appears to have been adopted in UK as of 2025. It is anticipated situation will soon clarify positively.
Noting that:

- While offshore power off-take billing for O&M vessels remains a grey area in UK, other countries like Belgium & the Netherlands have already made very significant steps towards solving the issue.
- UK energy regulatory body (Ofgem) is well aware of the need for action and working on the subject (although progress is still undocumented), building on a precedent already established for decades for the UK Oil & Gas sector, whereby drill rigs/production platforms and other offshore infrastructure are allowed to consume a defined % of their production at zero cost for their operations.
- In parallel, several recent initiatives and consultations from The Department for Energy have started clarifying & defining a practical workable framework. (Building North Sea's Energy Future, et al)

<u>4-GRANTS, SUBSIDIES & INCENTIVISATION</u>
Grants are regularly available, channelled through Innovate UK, Offshore Wind Growth Partnership, Horizon or other Government & EU level schemes, to partially fund charging infrastructure & vessels electrification projects.
Direct and indirect subsidies are anticipated through CfD type mechanisms and Tender clauses promoting or forcing Zero Emission O&M fleet. Typically, a recent 2024 tender for a French large new development imposed very stringent emission limitation.

12 Conclusions

The Wind Farm O&M electrical fleet is fast becoming a viable option, both technically and financially:

- CAPEX for battery electric vessels is closing the gap with CAPEX for MGO vessels as battery technology rapidly improves. Within the next few years, with economical automotive batteries (BYD, CATL and others) being adapted and certified for marine applications, O&M electric vessels will become cheaper than their MGO alternatives.

- Several well-established vessel operators are now proposing a range of "e-ready" and fully electrified units on charter, with OPEX (day rate + energy costs) already competitive with MGO powered equivalents for SOVs, and fully competitive in a couple of years for CTVs.

- The MJR offshore charger equipment, as a mandatory complement to electrified vessel operations, has now reached a high Technology Readiness Level of 8 out of 9, with a number of competitors also proposing similar solutions (albeit with lower TRLs).

- MJR's successfully completed and extensive offshore validation trails from a Parkwind Jera Group OSS, with multiple transfers of power from a live wind farm to a vessel in real life conditions, has demonstrated that the system is ready for long term pilot projects. A first commercial unit is under completion for deployment in 2026.

- Offshore charger integration FEED studies completed for a number of Tier 1 Operators have demonstrated the practicality of fitting offshore charger units economically to new build wind farms, with minimal addition to the original asset design.

Recommendations to accelerate e-Fleet competitivity & adoption

<u>LOBBYING FOR FAVOURABLE OPERATING FRAMEWORK</u>

For new wind farms at tendering, consent or even design stages, developers & operators as well as vessel owners have a clear leverage to incentivise & facilitate economical deployment of the O&M e-fleet through lobbying of typically:

- Government bodies in charge of new developments for inclusion of favourable tendering clauses incentivising e-fleet through preferential offshore power off-take rates (strike price adjustment), requiring or rewarding use of e-fleet, etc...

- Regulatory bodies & onshore power network owners to favourably rule on conditions for grid power off-take at offshore locations in the rare no wind conditions.

- National and local authorities to promote further deployment of onshore charging infrastructure, battery storage and subsidised onshore charge power rates.

ACCELERATE ADOPTION THROUGH EXTENDED DURATION PILOT PROJECTS

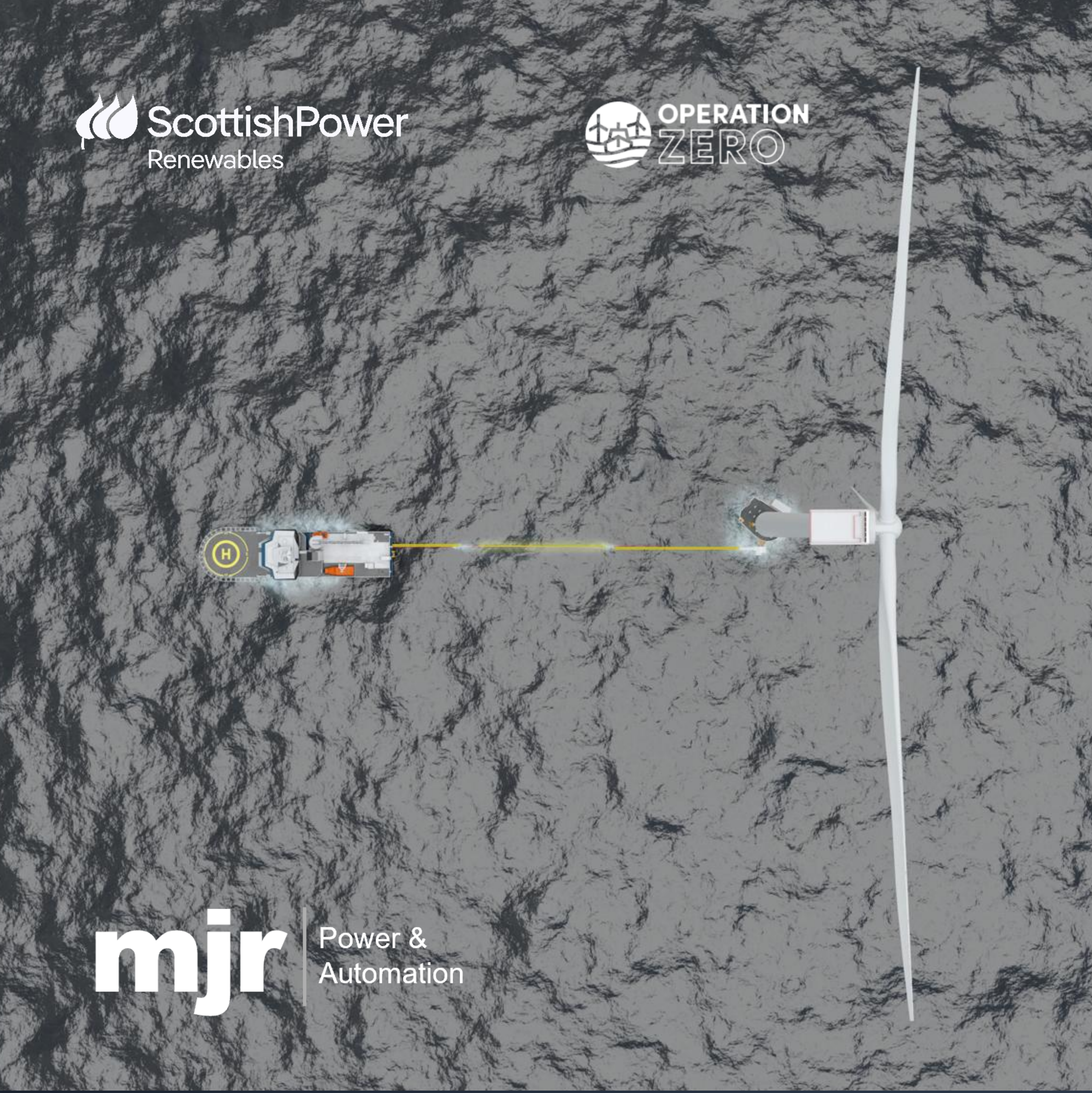
Following the successful offshore validation campaign in July 24, the industry confidence in the O&M e-fleet full operability needs to be ascertained through a series of medium-term pilot projects demonstrating without ambiguity the practicality and reliability of charging electrical vessels at sea.

e-fleet wider adoption will require further collaborative agreements between wind farm operators, SOV/CTV owners and charger manufacturers engaging in contractual agreements, supported economically by potential grants, to install and operate charging infrastructure on assets, vessels & quay sides for extended periods of time.

Charging CTV batteries @
Parkwind Jera Nobelwind OSS

Acronyms

Acronym	Meaning
AC	Alternative Current
ASSET	Offshore Installation: OSS /WTG / Monopile or other
CAPEX	Capital Expenditure
CfD	Contract for Difference
CTV	Crew Transfer Vesel
DC	Direct Current
DNV	Det Norske Veritas: Marine Classification Society
EA2	East Anglia 2
ETS	Emission Trading System
HS	Significant Wave Height
MCC	Field Operator Onshore Marine Control Centre
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
NM	Nautical Mile
OFTO	Offshore Transmission Owners (UK specific)
O&M	Operation & Maintenance
OPEX	Operational Expenditure
OSS	Offshore Sub Station
SOV	Service Offshore Vessel
TP	Transition Piece
TRL	Technology Readiness Level
WTG	Wind Turbine Generator



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