Cover Page

- Title: Complete Project Report
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- Date of Completion: 13/08/2026
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- Project title: Investigation of Operations and Maintenance facilities and associate port infrastructure efficiency and sustainability. (Focusing mainly on the RWE Grimsby O&M Base)

Contents

Executive Summary

Overview:

This document will be split into numerous sections like the one that you are currently reading from. These sections will be covering the areas of:

- Purpose of the report
- Current sustainability position
- Biggest opportunities
- Top 5 recommendations
- Expected benefits

This should hopefully provide a good overview as to what both the project and report are, what they cover, how they do what they do and more.

Additionally, a key idea that I have followed while compiling the response to this investigation is:

""The objective is not simply to introduce new sustainability initiatives, but to standardise proven best practices across RWE's O&M portfolio while strategically investing in innovations that can deliver long-term operational and commercial value."

I believe that if the reader knew this too, it would also benefit them in terms of readability and interpretation.

If there are any concerns regarding when a new subsection is to start and when one is to end, do not fret as this will be clearly laid out and presented to you as you read throughout this document.

The Purpose of This Report:

This report identifies practical and future opportunities to improve sustainability across Offshore Wind Operations & Maintenance (O&M) facilities and associated port infrastructure. Recommendations are categorised into immediate operational improvements, standardised best practice, and future innovations to support RWE's Net Zero ambitions while reducing operational costs

Current Sustainability Position:

RWE Offshore Wind is already a leader in renewable energy and has committed to reducing carbon emissions through the development of offshore wind farms. However, O&M facilities and ports still consume significant energy and generate waste through maintenance activities, vessel operations and daily facility use.

Current sustainability practices may include:

- Use of renewable electricity where available
- Recycling of metals, cables and turbine components
- Environmental management systems
- Electric or hybrid vehicles for site transport
- Monitoring energy use in buildings
- Improved logistics to reduce vessel journeys

Despite these efforts, there are still opportunities to reduce operational emissions and improve efficiency.

Biggest Opportunities:

Some of the biggest opportunities include:

Energy Efficiency

LED lighting, smart building controls and better insulation.

Renewable energy generation

Install rooftop solar panels and battery storage at O&M bases.

Waste reduction

Improve recycling, reuse materials and reduce single-use plastics.

Greener transport

Introduce electric vehicles and use low-emission vessels where possible.

Port redevelopment

Design future ports with sustainable buildings, shore power and climate resilience.

Why Grimsby?

I have selected the Grimsby O&M base to be my specific case study because:

- It is one of RWE's flagship UK O&M hubs;
- It supports multiple offshore wind farms;
- It contains offices, warehouses, workshops and port operations;
- It is exactly the type of facility that my brief fits to.

Top Five Recommendations

1. Standardise a "Net Zero O&M Base" Design Standard

Instead of recommending individual technologies, I propose creating an **RWE O&M Sustainability Design Standard**.

This would require every existing and future O&M base to include:

- Rooftop solar where viable
- Smart Building Management System (BMS)
- EV charging
- Heat pumps where feasible
- Rainwater harvesting
- Standardised recycling facilities
- Energy monitoring dashboards

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2. Create a Digital Energy Control Centre for the O&M Base

Rather than just installing smart meters, a digital dashboard could be created that monitors the following characteristics below:

- Electricity
- Heating
- compressed air
- workshop equipment
- battery charging

- EV charging
- Occupancy

To further refine this, you could also use AI analytics to identify:

- Equipment left running overnight
- Abnormal loads
- Unnecessary HVAC usage
- Maintenance trends

This becomes a management tool rather than simply an energy meter.

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3. Transform the Workshop into a Circular Maintenance Hub

Rather than just suggesting "improve recycling" across facilities, a more interesting suggestion can be the idea of transforming the Workshop into a Circular Maintenance Hub. This means that:

Instead:

Every removed turbine component arriving at Grimsby is assessed under a hierarchy:

1. Reuse
2. Refurbish
3. Remanufacture
4. Recycle
5. Dispose

Some specific examples of the above list could include some of the following components below where rather than just directly replacing you could instead inspect and refurbish these. These are:

- Electrical cabinets
- Yaw motors
- Hydraulic systems
- Cable drums
- Lifting frames

Even turbine blade sections become feedstock for future recycling.

4. Develop a Low-Carbon Port Operations Strategy

Rather than only talking about buildings throughout this report, you could also focus on the operations happening outside of these. Some examples of this could include the current use of:

- Diesel forklifts, telehandlers, cranes, vans and more.
- Marine Gas Oil (MGO) within vessels such as CTVs

Instead of this, a more sustainable route that could be used both in terms of a financial and environmental level can include the electrification of:

- Electric Forklifts
- Electric Telehandlers
- Electric Vans
- Electric Cranes (Where suitable)

The above list only covers land-based solutions, but some marine-based solutions could include:

- Shore Power for Vessels
- Battery Charging for CTVs in future.

Although with the above changes you could also further then optimise logistics. This could be done through reducing several maintenance trips. Some of these can include:

- Using AI scheduling to combine maintenance campaigns.
- Fewer Vessel movement which would result in:
    - Fewer Vessel Movements
    - Lower Fuel Costs
    - Less Downtimes savings.

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5. Introduce an FID Sustainability Scorecard

This suggestion will focus mainly on decision making rather than just infrastructure in comparison to some of the other suggestions listed on this document.

This would mean that with the use of this scorecard, you could score future O&M facilities or redevelopment projects prior to receiving a Final Investment Decision (FID) approval.

Example criteria:

Category	Weight
Operational Cost Reduction	30%
Carbon Reduction	20%
Scalability Across Fleet	20%
Ease of Maintenance	15%
Payback Period	15%

This would allow for RWE Renewables to be able to determine which future and/or existing projects are scoring poorly and if they may need to be redesigned before approval.

This means that sustainability is embedded at the point where investment decisions are made, which aligns directly with the emphasis of being cost competitive and controlling cost during FID as I had learned with the O&M Lead Ed that I had met during my visit at the RWE Swindon Offices.

Bonus Recommendation

Create the UK's First "Digital Net Zero O&M Base

Using Grimsby as the pilot for this idea, this recommendation looks at integrating modernised/future technologies at the core within it such as:

- Digital twin of the entire facility
- AI energy optimisation
- Rooftop solar
- Battery storage
- Smart HVAC
- Rainwater harvesting
- Electric maintenance fleet

- Shore power
- Circular maintenance workshop
- Predictive maintenance analytics
- Live sustainability dashboard visible to management

The objective isn't just reducing emissions. It's demonstrating that sustainable O&M facilities also deliver the **lowest whole-life operating cost**.

If successful, the model could become RWE's standard for every new offshore O&M base in Europe.

Expected Benefits:

The implementation of the proposed recommendations is expected to deliver measurable environmental, operational and commercial benefits while supporting RWE Offshore Wind's long-term strategy of maintaining cost competitiveness and sustainable growth. By standardising proven sustainability initiatives and integrating innovation into future developments, RWE can enhance the performance of its O&M facilities without compromising operational efficiency.

These benefits will be listed through the attributes of:

- Commercial Benefits
- Operational Benefits
- Environmental Benefits
- Strategic Benefits

Each of the above bullet will have its own respective sub-section.

Commercial Benefits

- Reduced operational expenditure through lower energy consumption and improved resource efficiency.
- Lower whole-life asset costs by embedding sustainability into the design and redevelopment of O&M facilities from the Final Investment Decision (FID) stage.
- Standardised sustainability measures across the O&M portfolio, reducing procurement, maintenance and implementation costs.
- Improved return on investment from energy-efficient technologies and renewable energy generation.

Operational Benefits

- Increased efficiency through intelligent energy management and digital monitoring systems.
- Reduced equipment downtime through improved maintenance planning and resource management.
- More resilient and future-ready O&M facilities capable of supporting the continued expansion of offshore wind operations.
- Enhanced consistency of operational practices across RWE's portfolio through standardised best practice.

Environmental Benefits

- Lower operational carbon emissions through improved energy efficiency, renewable energy integration and the electrification of transport and port operations.
- Reduced waste generation by adopting circular economy principles, increasing material reuse and expanding recycling initiatives.
- Improved resource efficiency, contributing to RWE's wider sustainability and net-zero objectives.

Strategic Benefits

- Strengthens RWE's position as a leading offshore wind developer committed to sustainable operations.
- Creates a scalable framework that can be replicated across future O&M facilities and international projects.
- Supports compliance with evolving environmental regulations and stakeholder expectations.
- Demonstrates that sustainability can enhance cost competitiveness and operational excellence, reinforcing RWE's long-term business strategy.

1. Introduction

1.1 Why Operations & Maintenance (O&M) Facilities Matter

Operations and Maintenance (O&M) facilities are critical to the successful operation of offshore wind farms, providing the infrastructure required to support the inspection, maintenance and repair of offshore assets throughout their operational lifecycle. These facilities typically comprise offices, warehouses, workshops, storage areas and vessel support infrastructure, enabling maintenance teams to respond efficiently to planned servicing activities and unplanned equipment failures.

As offshore wind farms continue to increase in size, capacity and distance from shore, the strategic importance of O&M facilities has grown significantly. Well-designed facilities can improve turbine availability, reduce vessel downtime, optimise maintenance activities and minimise operational expenditure (OPEX). Consequently, O&M facilities are no longer viewed solely as operational support centres, but as strategic assets that directly influence the performance, reliability and commercial success of offshore wind projects.

In addition to supporting day-to-day operations, O&M facilities present significant opportunities to improve sustainability through enhanced energy efficiency, resource management and digital optimisation. As a result, improving the sustainability of these facilities has become an increasingly important consideration for offshore wind developers seeking to reduce lifecycle costs while maintaining high levels of operational performance.

1.2 Importance of Ports

Ports form the operational interface between onshore O&M facilities and offshore wind farms, providing the infrastructure necessary for personnel transfer, equipment handling, component storage and vessel operations. Efficient port infrastructure is essential to maintaining safe and reliable access to offshore assets, ensuring maintenance activities can be undertaken with minimal disruption to electricity generation.

The rapid expansion of offshore wind has placed increasing demands on existing port infrastructure. Larger turbine components, increased maintenance requirements and the deployment of next-generation offshore wind projects require ports capable of accommodating greater operational complexity while maintaining efficient logistics.

Alongside these operational demands, ports also represent one of the largest contributors to operational energy consumption and associated emissions within offshore wind support activities. Building services, heavy lifting equipment, transport fleets and vessel operations all contribute to operational costs and environmental impacts. Consequently, integrating sustainable technologies and efficient infrastructure into both existing ports and future redevelopment projects presents an opportunity to improve operational efficiency, reduce emissions and enhance long-term resilience.

1.3 Why Sustainability is Becoming Increasingly Important

Although offshore wind provides low-carbon electricity generation, the supporting infrastructure required to operate and maintain offshore wind farms continues to consume energy, generate waste and produce operational emissions. As the offshore wind industry expands, there is increasing recognition that improving the sustainability of supporting facilities is essential to reducing the overall environmental impact of renewable energy generation.

For organisations such as RWE Offshore Wind, sustainability extends beyond environmental responsibility and is increasingly recognised as a driver of operational excellence and long-term commercial performance. Improvements in energy efficiency, resource utilisation and facility design can reduce operating costs, improve asset performance and strengthen resilience against future regulatory and market pressures.

Furthermore, sustainability considerations are becoming increasingly integrated into project development and investment decision-making. Embedding sustainable design principles during the planning and redevelopment of O&M facilities enables organisations to minimise whole-life costs, improve operational flexibility and avoid expensive retrofit programmes later in the asset lifecycle. As highlighted throughout this report, sustainability should therefore be viewed not as an additional operational cost, but as a strategic investment capable of delivering measurable environmental, operational and financial benefits.

1.4 Scope of the Report

This report investigates opportunities to improve the sustainability of RWE Offshore Wind's Operations and Maintenance facilities and associated port infrastructure through practical, commercially viable and scalable solutions. Using the Grimsby O&M base as a representative case study, the report evaluates current operational practices, identifies areas for improvement and benchmarks existing performance against recognised industry best practice.

Building upon this assessment, the report proposes a series of prioritised recommendations focused on standardising proven sustainability initiatives, improving operational efficiency and integrating sustainability into future facility development. These recommendations are evaluated according to their potential environmental impact, implementation complexity, scalability and contribution to long-term cost competitiveness. Finally, the report presents a prioritisation matrix, phased implementation roadmap and assessment of the anticipated business benefits associated with adopting the proposed measures.

Final Transition Paragraph

The remainder of this report is structured as follows. Section 2 presents a current state assessment of sustainability within RWE's O&M facilities, identifying key strengths and areas for improvement. Section 3 benchmarks current practices against leading offshore wind developers to identify opportunities for enhanced performance. Section 4 develops a series of tiered recommendations ranging from the standardisation of existing best practices to future innovation. These recommendations are subsequently evaluated through a prioritisation matrix and implementation roadmap before the report concludes by assessing the expected business benefits and overall findings.

2. Current State Assessment

2.0 Executive Summary

Purpose

This chapter establishes the current operational and sustainability baseline for offshore wind Operations and Maintenance (O&M) facilities and their associated port infrastructure. It examines how the offshore wind industry currently manages operational energy use, buildings, marine logistics, port equipment, waste, water resources and transport activities, providing an evidence-based assessment of existing practices before identifying opportunities for future improvement.

Although offshore wind generation provides one of the lowest lifecycle carbon intensities of any electricity generation technology, the infrastructure required to operate and maintain offshore wind farms continues to rely upon carbon-intensive support activities. O&M bases function as operational hubs responsible for coordinating technicians, marine vessels, spare parts logistics, warehousing, engineering workshops and operational control systems. Consequently, improving the sustainability and efficiency of these facilities presents an opportunity not only to reduce operational greenhouse gas emissions but also to improve asset availability, reduce operating expenditure and strengthen long-term operational resilience (Offshore Renewable Energy Catapult, 2023).

The assessment presented within this chapter draws upon peer-reviewed literature together with industry guidance published by organisations including the Offshore Renewable Energy (ORE) Catapult, International Renewable Energy Agency (IRENA), International Energy Agency (IEA), DNV, The Crown Estate and the Department for Energy Security and Net Zero (DESNZ). These findings establish an industry benchmark against which the RWE Grimsby O&M Base can subsequently be evaluated.

Executive Dashboard

Table 2.1 – Offshore Wind O&M Sustainability Baseline

Operational Theme	Current Industry Position	Carbon Impact	Industry Maturity	Improvement Potential

Energy Management	High	High	Level 3	Medium
Buildings	High	Medium	Level 3	Medium
Port Infrastructure	Moderate	High	Level 2	High
Marine Operations	Developing	Very High	Level 2	Very High
Waste Management	High	Medium	Level 4	Medium
Water Management	Moderate	Low	Level 2	Medium
Staff & Contractor Travel	Moderate	Medium	Level 2	High

Industry Sustainability Snapshot

The offshore wind industry has demonstrated substantial progress in reducing operational emissions over the past decade. Improvements in energy-efficient buildings, digital maintenance systems, waste segregation and renewable electricity procurement have enabled many operators to significantly reduce the environmental impacts associated with their shore-based operations.

However, operational carbon emissions are becoming increasingly concentrated within marine logistics and port operations. Crew Transfer Vessels (CTVs), Service Operation Vessels (SOVs), heavy lifting equipment and diesel-powered mobile plant remain dependent upon fossil fuels due to operational requirements and the limited commercial maturity of zero-emission alternatives (DNV, 2024). Consequently, many developers—including RWE Renewables—are now investigating technologies such as battery-electric vessels, methanol propulsion, hydrogen fuels, shore power systems and electrified port equipment to support future decarbonisation objectives.

Alongside carbon reduction, operational efficiency has become a major driver for sustainability investment. Digital technologies including predictive maintenance, Building Energy Management Systems (BEMS), Internet of Things (IoT) sensors and digital twins are increasingly used to optimise maintenance scheduling, reduce unnecessary vessel movements and improve facility energy performance (ORE Catapult, 2023). These innovations demonstrate that sustainability improvements frequently deliver parallel operational and financial benefits.

Industry Benchmark

Table 2.2 – Current Industry Benchmark

Theme	Typical Industry Practice	Emerging Best Practice
Electricity	National Grid electricity supply	On-site renewable generation with battery storage
Buildings	Gas heating with efficient insulation	Air source heat pumps with smart BEMS
Lighting	LED lighting	Occupancy-controlled smart lighting
Port Equipment	Diesel mobile plant	Electrified heavy equipment
Crew Transfer Vessels	Marine diesel propulsion	Hybrid-electric or methanol-ready vessels
Warehousing	Conventional storage	Automated inventory management
Waste	Segregated recycling	Circular economy programmes
Water	Potable mains supply	Rainwater harvesting and water recycling
Staff Travel	Private vehicle commuting	Electric fleet and active travel initiatives

Carbon Hotspot Assessment

Table 2.3 – Relative Operational Carbon Contributions

Operational Activity	Relative Carbon Contribution	Priority for Decarbonisation
Crew Transfer Vessel Operations	Very High	Critical
Service Operation Vessels	High	Critical
Heavy Port Equipment	High	High
Buildings	Medium	Medium
Fleet Vehicles	Medium	High
Waste Management	Low	Medium
Water Consumption	Low	Low

Insight

The greatest opportunities for operational carbon reduction are no longer associated with office buildings or lighting systems. Instead, emissions are increasingly concentrated within marine logistics, diesel-powered plant and port infrastructure. Future sustainability investment should therefore prioritise vessel decarbonisation, equipment electrification and integrated energy systems, whilst maintaining the high levels of operational reliability required for offshore wind maintenance.

Mini SWOT Analysis

Table 2.4 – Current Industry Position

Strengths	**Weaknesses**
Low-carbon electricity generation supports cleaner facility operations.	Marine operations remain heavily dependent on diesel fuel.
Widespread deployment of LED lighting and modern building management systems.	Limited electrification of heavy port equipment.
Mature recycling processes for metals, oils and hazardous wastes.	Existing facilities often have limited on-site renewable energy generation.
Growing use of predictive maintenance and digital asset management.	Contractor travel and logistics continue to generate significant emissions.
Opportunities	**Threats**
Shore power infrastructure for vessels.	Increasing fuel costs affecting operating expenditure.
Solar PV and battery energy storage systems.	Tightening environmental legislation and carbon reporting requirements.
Electrification of port equipment and vehicle fleets.	Grid capacity constraints within UK ports.
Alternative marine fuels including hydrogen and methanol.	Supply chain limitations affecting low-carbon technology deployment.

Key Observations

The current offshore wind sector demonstrates a relatively mature approach towards sustainability within its shore-based facilities, particularly regarding building efficiency, waste management and digital operational control. These improvements have been driven by corporate Net Zero commitments, increasing energy costs and the wider decarbonisation of national electricity networks.

Nevertheless, as the sector continues to mature, further reductions in operational emissions will become progressively more challenging. Many of the lower-cost energy efficiency measures have already been implemented, shifting attention towards harder-to-abate activities such as marine transport, heavy equipment and port logistics. These activities now represent the principal barriers to achieving Net Zero operational emissions.

For RWE Renewables, this changing landscape presents an opportunity to move beyond incremental improvements and instead adopt an integrated sustainability strategy encompassing renewable energy generation, electrified equipment, alternative vessel fuels and digital operational optimisation. Such an approach would align with wider industry trends while strengthening operational resilience and reducing long-term operating costs.

Evidence Base

Table 2.5 – Summary of Supporting Evidence

Organisation	Key Findings	Application within this Assessment
Offshore Renewable Energy Catapult (2023)	Digital O&M technologies improve reliability and reduce maintenance costs.	Benchmark for operational efficiency and predictive maintenance.
DNV (2024)	Marine decarbonisation represents one of the largest remaining challenges for offshore wind operations.	Supports emphasis on vessel and port decarbonisation.
International Renewable Energy Agency (2023)	Electrification and renewable integration are critical pathways towards industrial decarbonisation.	Supports renewable energy recommendations for O&M facilities.
International Energy Agency (2023)	Distributed renewable generation and battery storage improve energy resilience and emissions performance.	Supports future energy system integration.
The Crown Estate (2023)	Future offshore wind deployment will require expanded port capacity and modernised infrastructure.	Supports discussion on port redevelopment.
DESNZ (2024)	UK electricity continues to reduce in carbon intensity through increasing renewable generation.	Supports assessment of grid electricity.

References (for this section)

Carbon Trust (2022) *Building Energy Management Systems: Improving Operational Performance*. London: Carbon Trust.

Department for Energy Security and Net Zero (DESNZ) (2024) *UK Energy Trends*. London: DESNZ.

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International Energy Agency (IEA) (2023) *Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach*. Paris: IEA.

International Renewable Energy Agency (IRENA) (2023) *Innovation Outlook: Offshore Wind*. Abu Dhabi: IRENA.

Offshore Renewable Energy Catapult (2023) *Operations and Maintenance Centre of Excellence Annual Report*. Glasgow: ORE Catapult.

The Crown Estate (2023) *Offshore Wind Report 2023*. London: The Crown Estate.

2.1 Energy Assessment

Objective: To evaluate current energy use within offshore wind Operations and Maintenance (O&M) facilities, identify industry best practice, and establish a baseline against which the RWE Grimsby O&M Base can be assessed.

2.1.1 Overview

Energy consumption is fundamental to the operation of offshore wind O&M facilities, supporting office accommodation, workshops, warehouses, control centres, battery charging, vessel support infrastructure and welfare facilities. While the primary purpose of offshore wind is the generation of low-carbon electricity, the facilities required to maintain these assets still consume significant quantities of energy and contribute to operational greenhouse gas emissions.

Historically, sustainability initiatives within O&M facilities focused on improving building efficiency through measures such as LED lighting, improved insulation and high-efficiency heating systems. Whilst these measures remain important, the decarbonisation of the UK electricity grid has significantly reduced the carbon intensity of purchased electricity. As a result, the industry's attention is increasingly shifting towards on-site renewable generation, electrification of equipment, intelligent energy management systems and reducing reliance on diesel-powered backup generation (DESNZ, 2024).

For RWE Renewables, understanding how energy is currently consumed across an O&M base provides the foundation for identifying opportunities that simultaneously reduce carbon emissions, improve operational resilience and lower long-term operating costs.

Figure 2.1 – Typical Energy Uses within an Offshore Wind O&M Facility

Energy End Use	Typical Application	Relative Consumption
HVAC Systems	Heating, cooling and ventilation	High
Workshop Equipment	Engineering maintenance and repairs	High
Office Equipment	IT, communications and administration	Medium

Lighting	Internal and external illumination	Medium
EV & Battery Charging	Fleet vehicles and portable equipment	Increasing
Vessel Support	Shore-side electrical services	Medium
Emergency Systems	Backup power and critical infrastructure	Low (continuous), High (during outages)

2.1.2 Grid Electricity

The majority of the UK offshore wind O&M facilities obtain electricity directly from the National Grid. This approach offers high reliability, established infrastructure and comparatively low maintenance requirements. Importantly, the carbon intensity of UK grid electricity has fallen substantially over the past decade due to increased renewable generation and the progressive phase-out of coal-fired power stations. According to the Department for Energy Security and Net Zero (DESNZ, 2024), renewable sources now account for approximately half of UK electricity generation in favourable periods, significantly reducing indirect (Scope 2) emissions associated with electricity consumption.

For operators such as RWE Renewables, this transition means that improving electrical efficiency now delivers proportionally smaller carbon savings than in previous years. Nevertheless, reducing electricity demand remains financially beneficial, particularly in light of volatile wholesale electricity prices and increasing network charges.

Many offshore wind developers procure renewable electricity through Renewable Energy Guarantees of Origin (REGOs) or corporate Power Purchase Agreements (PPAs), ensuring that purchased electricity supports wider renewable generation. However, renewable procurement alone does not improve operational resilience, leading many operators to investigate complementary on-site generation and energy storage systems.

Notable Observation

The decarbonisation of the UK electricity grid has shifted the focus of sustainability programmes from simply reducing electricity consumption towards improving energy resilience and self-generation. Future investments are therefore increasingly justified on the basis of operational security and cost reduction rather than carbon reduction alone.

2.1.3 On-site Renewable Energy Generation

The large roof areas associated with warehouses, workshops and office buildings make O&M facilities particularly well suited to rooftop solar photovoltaic (PV) installations. Although the UK's solar resource is lower than many European countries, modern PV systems remain capable of generating significant quantities of electricity, particularly during periods of peak daytime demand.

Solar generation is especially attractive within O&M facilities because much of the electricity demand—office occupancy, workshops, battery charging and warehouse operations—occurs during daylight hours, increasing opportunities for direct self-consumption.

Increasingly, battery energy storage systems (BESS) are being integrated alongside solar PV. Battery storage enables surplus electricity generated during daylight hours to be stored for evening use, reducing electricity imports and providing additional resilience during grid disturbances. Furthermore, BESS can reduce reliance on diesel generators during short-duration power interruptions, thereby reducing both fuel consumption and operational emissions (IEA, 2023).

Despite these benefits, adoption across the offshore wind sector remains inconsistent. Existing O&M bases are often constrained by available roof space, structural limitations or historical site layouts that were not designed with renewable generation in mind.

Table 2.2 – Renewable Energy Technologies Applicable to O&M Facilities

Technology	Current Industry Adoption	Carbon Reduction Potential	Implementation Complexity
Solar PV	Moderate	High	Low
Battery Energy Storage	Low–Moderate	High	Medium
Small Wind Turbines	Low	Low	Medium
Heat Recovery Systems	Moderate	Medium	Medium
Smart Energy Management	High	Medium	Low

2.1.4 Diesel Backup Generation

Despite increasing electrification, diesel generators remain standard practice throughout many offshore wind O&M facilities. Critical operational functions—including communication systems, security infrastructure, control centres and emergency lighting—must remain operational during grid outages, requiring dependable backup power.

Diesel generators continue to be favoured because of their proven reliability, relatively low capital cost and ability to operate for prolonged periods provided fuel supplies remain available. However, they contribute directly to Scope 1 greenhouse gas emissions and generate local air pollutants including nitrogen oxides (NO_x) and particulate matter.

Emerging alternatives include battery energy storage systems capable of providing short-duration backup power, particularly when integrated with rooftop solar PV. Although batteries currently lack the endurance required for prolonged outages, hybrid systems combining batteries with smaller diesel generators can substantially reduce fuel consumption and maintenance requirements.

Insight

Emergency power resilience remains essential for offshore operations; however, replacing continuous reliance on diesel-only backup systems with hybrid battery-supported solutions represents one of the most practical near-term opportunities to reduce operational emissions without compromising reliability.

2.1.5 Fleet Electrification

Most O&M facilities operate fleets of vans, pickup trucks and utility vehicles used for transporting technicians, equipment and spare parts around the port estate and to nearby operational locations. Historically these vehicles have been diesel-powered due to operational familiarity and established fuelling infrastructure.

However, the increasing availability of commercial electric vans, coupled with falling battery costs and expanding charging infrastructure, has accelerated fleet electrification across the offshore wind sector. Because daily vehicle mileage within O&M facilities is often relatively predictable, electric vehicles (EVs) are particularly well suited to these operational environments.

Fleet electrification not only reduces greenhouse gas emissions but also lowers operating costs through reduced maintenance requirements and lower fuel expenditure. Integration with on-site renewable generation further enhances environmental benefits by enabling vehicle charging using locally generated electricity.

2.1.6 Lighting

Lighting represents one of the most mature areas of energy efficiency within industrial facilities. The majority of modern O&M bases have transitioned from fluorescent or metal-halide lighting to high-efficiency LED systems.

Compared with conventional lighting technologies, LEDs typically reduce electricity consumption by between 50% and 70%, whilst offering significantly longer operational lifetimes and reduced maintenance requirements (Carbon Trust, 2022). Intelligent lighting systems incorporating occupancy sensors and daylight harvesting controls are increasingly adopted within warehouses and office spaces to minimise unnecessary energy consumption.

Although lighting typically represents a relatively small proportion of overall facility energy demand, its low implementation cost and rapid payback period make it one of the most economically attractive energy efficiency measures available.

2.1.7 Energy Management Systems

The adoption of Building Energy Management Systems (BEMS) has become increasingly common across commercial and industrial facilities. These systems continuously monitor energy consumption, automatically optimise HVAC schedules and identify abnormal electricity demand.

Within offshore wind O&M facilities, BEMS also support operational decision-making by integrating electricity monitoring with occupancy patterns, weather forecasts and maintenance schedules. Digital technologies such as smart metering, IoT sensors and cloud-based analytics enable facility managers to identify inefficiencies that may otherwise remain undetected.

Certification to ISO 50001 further supports continual improvement by providing a structured framework for organisational energy management. Whilst certification alone does not reduce energy consumption, it establishes governance processes that encourage systematic performance improvement.

Table 2.3 – Industry Energy Benchmark

Category	Typical Industry Practice	Best Practice	Maturity
Electricity Supply	National Grid	Renewable procurement with on-site generation	★★★★☆
Backup Power	Diesel generators	Hybrid battery–diesel systems	★★☆☆☆
Lighting	LED	Smart LED controls	★★★★★
Fleet Vehicles	Mixed diesel and EV	Fully electric fleet	★★★☆☆
Energy Monitoring	Smart meters	Integrated BEMS (ISO 50001)	★★★★☆
Renewable Generation	Limited PV	Solar PV + BESS	★★★☆☆

2.1.8 SWOT Assessment – Energy

Strengths	Weaknesses
Decarbonising UK electricity grid	Continued use of diesel backup generators
Mature LED lighting technologies	Limited on-site renewable generation
Increasing deployment of BEMS	Inconsistent battery storage adoption
Renewable electricity procurement	Fragmented site-wide energy monitoring
Opportunities	**Threats**
Solar PV deployment	Rising electricity prices
Battery energy storage	Grid capacity constraints
Fleet electrification	Delays in infrastructure upgrades
AI-driven energy optimisation	Technology obsolescence

2.1.9 Consultancy Assessment

The offshore wind industry has made significant progress in improving the efficiency of energy use within O&M facilities. Building services such as LED lighting, smart metering and efficient HVAC systems are now widely adopted, and the decarbonisation of the UK electricity grid has substantially reduced indirect emissions associated with electricity consumption.

However, the industry's energy strategy is evolving. The focus is no longer solely on reducing electricity demand but on creating resilient, flexible and low-carbon energy systems capable of supporting increasingly electrified operations. Technologies such as rooftop solar PV, battery energy storage, intelligent energy management and electric vehicle charging infrastructure are becoming defining characteristics of modern O&M facilities.

For the RWE Grimsby O&M Base, this indicates that future investment should extend beyond traditional energy efficiency measures towards integrated energy infrastructure capable of supporting long-term operational resilience, fleet electrification and wider corporate decarbonisation objectives.

References (Harvard Style)

Carbon Trust (2022) *Building Energy Management Systems: Improving Operational Performance*. London: Carbon Trust.

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2.2 Buildings Assessment

Objective: To assess current industry practices relating to building performance within offshore wind Operations and Maintenance (O&M) facilities, with a focus on heating, cooling, insulation and HVAC systems, establishing a benchmark for the RWE Grimsby O&M Base.

2.2.1 Overview

Buildings form the operational heart of offshore wind O&M facilities, accommodating engineering workshops, warehouses, offices, welfare facilities, training rooms, control centres and stores. Although buildings are generally responsible for a smaller proportion of total operational emissions than marine logistics, they remain significant contributors to energy consumption through space heating, ventilation, cooling, lighting and domestic hot water systems.

Historically, many UK port buildings were constructed with operational functionality rather than energy performance as the primary design objective. However, increasing energy prices, stricter Building Regulations, corporate Net Zero commitments and growing environmental expectations have accelerated the adoption of more sustainable building technologies. New O&M facilities increasingly incorporate high-performance building envelopes, low-carbon heating systems, smart controls and renewable energy integration to reduce both operational costs and carbon emissions (Carbon Trust, 2022).

For offshore wind developers such as RWE Renewables, efficient buildings not only contribute to environmental objectives but also improve employee wellbeing, reduce maintenance requirements and strengthen operational resilience.

Figure 2.2 – Principal Building Energy Systems

Building System	Primary Function	Typical Energy Demand	Sustainability Importance
Space Heating	Thermal comfort	High	High
HVAC	Indoor air quality and ventilation	High	High
Cooling	Office and server rooms	Medium	Medium

Lighting	Internal and external illumination	Medium	Medium
Domestic Hot Water	Welfare facilities	Low	Low
Building Controls	System optimisation	Low	High

2.2.2 Heating Systems

Space heating represents one of the largest energy demands within UK commercial buildings, particularly during winter months. Traditionally, offshore O&M facilities have relied upon natural gas boilers due to their relatively low installation cost, established infrastructure and reliable performance. However, gas-fired heating contributes directly to Scope 1 greenhouse gas emissions and is increasingly viewed as incompatible with long-term Net Zero strategies.

Consequently, newly constructed industrial and commercial facilities are increasingly adopting air source heat pumps (ASHPs) and, where appropriate, ground source heat pumps (GSHPs). Heat pumps offer considerably higher efficiencies than conventional boilers, typically delivering three to four units of heat for every unit of electricity consumed (IEA, 2023). As the UK electricity grid continues to decarbonise, electrically powered heating systems also become progressively lower in carbon intensity.

Within port environments, however, heat pump performance must be carefully considered due to exposure to coastal weather conditions, high ventilation rates and large industrial spaces with substantial heat losses. Hybrid heating systems, combining heat pumps with supplementary electric or gas heating, are therefore increasingly adopted where continuous operational resilience is required.

Observation

The transition from gas-fired heating to electrified heat pumps is becoming one of the defining characteristics of low-carbon industrial facilities. While capital investment remains relatively high, declining grid emissions and rising carbon costs are improving the long-term business case.

2.2.3 Cooling Systems

Although cooling requirements within UK O&M facilities are generally lower than heating demands, they remain essential for maintaining comfortable working environments, protecting IT infrastructure and ensuring reliable operation of control rooms and server equipment.

Modern buildings increasingly utilise high-efficiency air conditioning systems incorporating inverter-driven compressors, variable refrigerant flow (VRF) technology and intelligent zoning controls. These systems adjust cooling output according to occupancy and thermal demand, reducing unnecessary electricity consumption.

Passive cooling measures are also becoming increasingly important. High-performance glazing, solar shading, natural ventilation and improved building orientation reduce cooling demand by limiting unwanted solar heat gains during summer months (CIBSE, 2021).

For facilities such as the RWE Grimsby O&M Base, where operational continuity is essential, balancing energy efficiency with occupant comfort remains a key design consideration.

2.2.4 Building Fabric and Insulation

The thermal performance of a building is fundamentally determined by the quality of its envelope, including walls, roofs, floors, windows and doors. Effective insulation reduces heat transfer between internal and external environments, thereby lowering both heating and cooling energy requirements.

Current UK Building Regulations (Approved Document L) require significantly improved thermal performance compared with buildings constructed during previous decades. Consequently, newer O&M facilities generally exhibit lower operational energy consumption than older industrial buildings.

High-performance insulation, thermally broken construction details, airtightness measures and double or triple glazing are now considered standard practice for modern commercial developments. In contrast, older port buildings frequently experience excessive heat losses, air leakage and thermal bridging, increasing operational energy demand.

Retrofitting existing buildings with improved insulation remains one of the most cost-effective methods of reducing operational emissions, particularly where major structural redevelopment is not economically viable.

Table 2.4 – Typical Building Fabric Performance

Building Element	Traditional Construction	Modern Best Practice
Roof	Basic mineral insulation	High-performance insulated roof systems
External Walls	Limited cavity insulation	Enhanced insulated cladding systems
Windows	Double glazing	Triple glazing with low-emissivity coatings
Doors	Standard industrial doors	High-speed insulated doors
Air Tightness	Moderate	High-performance airtight envelope

2.2.5 HVAC Systems

Heating, Ventilation and Air Conditioning (HVAC) systems typically represent the largest single energy consumer within commercial buildings. Their primary functions include maintaining thermal comfort, providing fresh air, controlling humidity and protecting sensitive equipment.

Modern HVAC systems increasingly utilise demand-controlled ventilation (DCV), whereby airflow is automatically adjusted according to occupancy levels and indoor carbon dioxide concentrations. Variable speed fans and pumps further improve efficiency by matching energy consumption to operational demand rather than continuously operating at full capacity.

Integration with Building Energy Management Systems (BEMS) enables HVAC performance to be optimised in real time using occupancy schedules, weather forecasts, and internal temperature monitoring. Studies undertaken by the Carbon Trust indicate that intelligent HVAC optimisation can reduce commercial building energy consumption by up to 20% without compromising occupant comfort (Carbon Trust, 2022).

2.2.6 Building Certification and Sustainability Standards

Increasingly, offshore wind developers seek to demonstrate environmental performance through recognised sustainability frameworks. Standards such as **BREEAM**, **ISO 14001**, and **ISO 50001** provide structured approaches to environmental management, energy efficiency, and continual improvement.

For new developments, BREEAM certification is widely regarded as the benchmark for sustainable building design within the UK. Assessment criteria include energy performance, water efficiency, materials, waste management, ecology, and occupant wellbeing.

Although certification itself does not directly reduce emissions, it provides assurance that sustainability considerations have been systematically incorporated throughout design, construction, and operation.

Table 2.5 – Building Sustainability Benchmark

Category	Current Industry Practice	Best Practice	Maturity
Heating	Gas boilers	Air source heat pumps	★★★☆☆
Cooling	Standard air conditioning	Variable refrigerant flow systems	★★★★☆
Insulation	Building Regulations compliant	High-performance building envelope	★★★★☆
HVAC Controls	Programmable controls	Intelligent BEMS integration	★★★★☆
Building Certification	Regulatory compliance	BREEAM Excellent / Outstanding	★★★☆☆

2.2.7 Building Maturity Assessment

Technology	Industry Adoption	Carbon Reduction Potential	Ease of Deployment
LED Lighting	High	Medium	High
Air Source Heat Pumps	Moderate	High	Medium
Smart HVAC Controls	High	Medium	High
High-Performance Insulation	High (new builds)	Medium	Low (retrofit)
Triple Glazing	Moderate	Low	Medium
BREEAM Certification	Moderate	Indirect	Medium

2.2.8 SWOT Assessment – Buildings

Strengths	Weaknesses
Improved thermal performance in modern facilities	Older buildings often have poor insulation
Widespread adoption of LED lighting	Continued dependence on gas heating
Increasing use of intelligent HVAC controls	Retrofit opportunities may be constrained by building age
Improved occupant comfort and wellbeing	High capital costs for heat pump installations
Opportunities	**Threats**
Heat pump deployment	Increasing energy prices
Deep retrofit programmes	Rising construction costs
Smart building analytics	Regulatory changes affecting existing buildings
Renewable heating integration	Disruption during retrofit works

2.2.9 Consultancy Assessment

Building performance within offshore wind O&M facilities has improved considerably over recent years, driven by increasingly stringent building regulations, corporate sustainability commitments and rising operational energy costs. New facilities are generally characterised by efficient building envelopes, LED lighting, advanced HVAC controls, and improved energy monitoring systems.

Nevertheless, heating remains one of the principal sources of operational emissions, particularly where natural gas boilers continue to be used. As electricity generation continues to decarbonise, electrified heating technologies such as air source heat pumps are expected to become the preferred solution for new developments and major refurbishments. At the same time, intelligent building management systems and enhanced insulation will remain essential for minimising energy demand and improving operational efficiency.

For the RWE Grimsby O&M Base, the current industry benchmark suggests that future investment should prioritise the transition towards low-carbon heating, integrated building controls, and fabric improvements where economically feasible. Such measures would not only reduce operational emissions but also enhance employee comfort, lower energy costs, and improve long-term resilience.

Insight

Within modern O&M facilities, the greatest opportunities for improving building sustainability no longer lie in incremental lighting upgrades but in integrated approaches that combine efficient building fabric, low-carbon heating, and intelligent energy management. Facilities designed around these principles are better positioned to support corporate Net Zero commitments while delivering long-term operational savings.

Evidence Base

Organisation	Key Findings	Relevance
Carbon Trust (2022)	Intelligent building controls can reduce energy demand by up to 20%.	Supports HVAC optimisation and BEMS implementation.
CIBSE (2021)	Passive cooling measures significantly reduce cooling demand.	Supports building design recommendations.
IEA (2023)	Heat pumps are central to building decarbonisation.	Supports transition away from gas heating.
UK Government (Approved Document L, 2021)	New buildings require substantially improved thermal performance.	Establishes current building performance benchmark.
BREEAM (2023)	Sustainable buildings deliver operational and environmental benefits.	Supports sustainability certification discussion.

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2.3 Port Infrastructure Assessment

Objective: To assess current industry practices relating to port infrastructure supporting offshore wind Operations and Maintenance (O&M), including marine operations, heavy equipment, warehousing, and logistics, and to establish a benchmark against which the RWE Grimsby O&M Base can be evaluated.

2.3.1 Overview

Ports are fundamental to the successful operation of offshore wind farms, acting as the interface between onshore support facilities and offshore assets. O&M bases facilitate technician deployment, vessel operations, spare parts logistics, warehousing, maintenance activities, and emergency response. As offshore wind farms continue to increase in scale and distance from shore, the operational demands placed upon port infrastructure have become increasingly complex.

Unlike construction ports, which are designed to support turbine installation and major component assembly, O&M ports prioritise operational efficiency, reliability, and rapid response. Facilities typically include vessel berths, operations control centres, workshops, warehouses, storage yards, fuel infrastructure, lifting equipment, and office accommodation.

Although offshore wind contributes significantly to reducing national carbon emissions, the supporting port infrastructure continues to rely heavily upon fossil-fuelled equipment, marine diesel vessels, and energy-intensive logistics operations. Consequently, ports represent one of the largest remaining opportunities for reducing operational emissions across the offshore wind lifecycle (The Crown Estate, 2023; DNV, 2024).

For RWE Renewables, the Grimsby O&M Base supports the operation of several offshore wind farms in the North Sea. As turbine capacity increases and offshore projects expand further from shore, improving the efficiency and sustainability of supporting port infrastructure will become increasingly important for maintaining operational performance whilst achieving corporate Net Zero objectives.

Figure 2.3 – Typical Offshore Wind O&M Port Functions

Operational Function	Primary Purpose	Sustainability Considerations
Crew Transfer Vessel (CTV) Operations	Technician transport	Marine fuel consumption, emissions
Service Operation Vessel (SOV) Support	Offshore accommodation and logistics	Hybrid propulsion, shore power
Warehousing	Spare parts and consumables	Energy efficiency, inventory optimisation
Heavy Lifting	Component handling	Equipment electrification
Workshop Facilities	Maintenance and repair	Efficient energy use and waste management
Quay Infrastructure	Vessel berthing	Shore power and resilient electrical infrastructure

2.3.2 Crew Transfer Vessels (CTVs)

Crew Transfer Vessels are the primary means of transporting technicians between O&M bases and offshore wind farms. Typically operating at speeds exceeding 20 knots, CTVs are designed to maximise technician transfer efficiency whilst maintaining safe access to turbine transition pieces under varying sea conditions.

The global CTV fleet continues to rely predominantly on marine diesel fuel due to its high energy density, operational reliability, and widespread fuel availability. However, these vessels represent one of the largest contributors to operational greenhouse gas emissions within offshore wind O&M activities. According to the International Maritime Organization (IMO, 2023), maritime transport accounts for approximately 3% of global greenhouse gas emissions, highlighting the importance of vessel decarbonisation.

Recognising this challenge, vessel manufacturers and offshore wind operators are actively developing alternative propulsion systems. Hybrid-electric propulsion, battery-assisted systems, methanol-ready engines, and hydrogen fuel cell technologies are increasingly being trialled within the offshore wind sector. Whilst fully electric CTVs remain constrained by battery energy density and charging infrastructure, hybrid systems have demonstrated reductions in fuel consumption of up to 20% through load optimisation and regenerative operation (DNV, 2024).

Insight

Marine logistics now represent one of the largest remaining operational carbon sources within offshore wind. Consequently, vessel decarbonisation is likely to deliver greater carbon reductions than further incremental improvements to office buildings or lighting systems.

2.3.3 Service Operation Vessels (SOVs)

As offshore wind farms continue to move further offshore, Service Operation Vessels (SOVs) are increasingly replacing daily crew transfers for major maintenance campaigns. Unlike CTVs, SOVs remain offshore for extended periods and provide onboard accommodation, workshops, and logistics support for maintenance teams.

Modern SOVs increasingly incorporate hybrid propulsion systems, dynamic positioning technologies, battery-assisted operation, and waste heat recovery systems to improve fuel efficiency. Battery integration enables engines to operate closer to their optimum efficiency while reducing fuel consumption during low-power manoeuvring and harbour operations (IEA, 2023).

Future vessel concepts are expected to utilise methanol, ammonia or hydrogen-based propulsion as these fuels become commercially viable. However, significant infrastructure investment will be required within UK ports before widespread adoption becomes practical.

2.3.4 Shore Power (Cold Ironing)

One of the most significant emerging developments within sustainable port operations is the provision of shore power (also known as cold ironing). Shore power enables vessels to switch off onboard auxiliary diesel generators whilst berthed by connecting directly to the local electrical network.

This approach offers several advantages:

- Reduced fuel consumption
- Lower greenhouse gas emissions
- Improved local air quality
- Reduced engine maintenance
- Lower noise pollution

The European Union's Alternative Fuels Infrastructure Regulation (AFIR) and the UK's Clean Maritime Plan both identify shore power as a key technology supporting maritime decarbonisation. However, implementation remains limited due to high installation costs, vessel compatibility challenges, and local electricity network capacity constraints.

For an O&M facility such as Grimsby, shore power could significantly reduce emissions associated with vessels awaiting deployment or undergoing maintenance.

Table 2.6 – Vessel Decarbonisation Technologies

Technology	Current Adoption	Carbon Reduction Potential	Technology Readiness
Marine Diesel	Very High	Low	Mature
Hybrid Diesel-Electric	Moderate	Medium	High
Battery-Electric	Low	High	Medium
Methanol	Low	High	Medium
Hydrogen Fuel Cell	Demonstration	Very High	Low

2.3.5 Cranes and Heavy Equipment

Port operations depend heavily upon cranes, forklifts, telehandlers, and mobile lifting equipment to move turbine components, maintenance equipment, and logistics supplies.

Historically, these machines have been diesel powered because of their high-power requirements and continuous duty cycles. However, electric alternatives are becoming increasingly available for light- and medium-duty operations.

Electric forklifts have already become common within warehouses, offering reduced maintenance requirements, zero tailpipe emissions and quieter operation. Electrification of larger equipment, including heavy mobile cranes and reach stackers, remains more challenging due to battery size and charging requirements.

Many European ports are now investigating hydrogen-powered heavy equipment alongside high-capacity battery-electric alternatives.

2.3.6 Warehousing and Logistics

Efficient warehouse management plays a critical role in offshore wind O&M by ensuring that technicians have rapid access to spare parts, tools, and consumable materials.

Traditional warehouse operations rely heavily upon manual inventory systems and paper-based documentation. Increasingly, however, digital warehouse management systems (WMS), RFID tagging and barcode tracking enable real-time inventory monitoring and significantly improve logistics efficiency.

Digital inventory management reduces unnecessary transportation, minimises duplicated stock and shortens maintenance response times. Consequently, warehouse optimisation delivers both operational and environmental benefits.

Automation technologies including autonomous forklifts and robotic inventory systems are beginning to emerge within larger industrial logistics facilities, although adoption within offshore wind remains relatively limited.

Table 2.7 – Current Industry Benchmark

Infrastructure Element	Typical Industry Practice	Best Practice	Maturity
Crew Transfer Vessels	Marine diesel	Hybrid-electric / methanol-ready	★★☆☆☆
Service Operation Vessels	Diesel with efficiency measures	Hybrid propulsion	★★★☆☆
Shore Power	Limited availability	Grid-connected shore power	★★☆☆☆
Cranes	Diesel/electric mix	Fully electric where feasible	★★★☆☆
Forklifts	Electric (indoor), diesel (outdoor)	Fully electric fleet	★★★★☆
Warehouse Management	Digital inventory systems	RFID-enabled predictive logistics	★★★★☆

2.3.7 Digital Port Infrastructure

Digitalisation has become one of the defining trends within modern offshore wind operations. Technologies such as Digital Twins, Internet of Things (IoT) sensors, predictive analytics and AI-assisted maintenance planning are transforming how O&M facilities operate.

Digital Twins enable operators to simulate equipment performance, optimise maintenance schedules, and identify potential failures before they occur. Predictive maintenance reduces unnecessary vessel movements, minimises downtime and improves turbine availability (ORE Catapult, 2023).

Similarly, smart port management platforms integrate vessel scheduling, warehouse operations, berth allocation, and weather forecasting, improving operational efficiency whilst reducing fuel consumption associated with unnecessary waiting times.

2.3.8 Maturity Assessment

Area	Industry Maturity	Carbon Reduction Potential	Priority
Warehousing	High	Medium	Medium
Digital Logistics	High	Medium	Medium
Electric Forklifts	High	Medium	Medium
Shore Power	Low	Very High	Critical
Hybrid Vessels	Moderate	Very High	Critical
Hydrogen Infrastructure	Low	Very High	Future

2.3.9 SWOT Assessment – Port Infrastructure

Strengths	Weaknesses
Mature logistics systems	Heavy reliance on diesel vessels
Advanced warehouse management	Limited shore power infrastructure
Increasing digitalisation	High fuel consumption of marine operations
Reliable operational performance	Electrification of heavy plant remains limited
Opportunities	**Threats**
Hybrid and alternative-fuel vessels	Fuel price volatility
Shore power installation	Grid capacity limitations
Electrified heavy equipment	Rapid technology evolution
AI-assisted logistics	Supply chain constraints for low-carbon equipment

2.3.10 Consultancy Assessment

Port infrastructure is emerging as one of the most significant areas for sustainability improvement within offshore wind O&M. While building energy efficiency has matured considerably, marine logistics, heavy equipment and vessel operations continue to dominate operational emissions. Consequently, investment priorities are shifting towards the electrification of port equipment, the provision of shore power infrastructure and the adoption of alternative marine fuels.

Digitalisation further enhances sustainability by reducing unnecessary vessel movements, improving inventory management, and enabling predictive maintenance strategies that optimise both cost and carbon performance. These developments align closely with the wider transition towards smart ports capable of supporting increasingly complex offshore wind operations.

For the RWE Grimsby O&M Base, the current industry benchmark suggests that the greatest opportunities are likely to arise from integrating low-carbon marine technologies with digital logistics systems and electrified landside infrastructure. Such measures would improve operational efficiency while supporting RWE's wider decarbonisation objectives.

Management Insight

The future competitiveness of offshore wind O&M bases will increasingly depend not only on their ability to support reliable turbine maintenance but also on how efficiently they manage marine logistics, energy infrastructure, and digital operations. Ports that invest early in vessel decarbonisation, electrified equipment and smart logistics are likely to achieve lower operating costs, improved resilience, and stronger environmental performance over the long term.

2.3.11 Evidence Base

Organisation	Key Findings	Application
Offshore Renewable Energy Catapult (2023)	Predictive maintenance reduces vessel movements and improves turbine availability.	Supports digital logistics discussion.
DNV (2024)	Hybrid propulsion is a practical short-term pathway for vessel decarbonisation.	Supports CTV and SOV assessment.

The Crown Estate (2023)	Future offshore wind deployment requires upgraded UK port infrastructure.	Supports investment in port facilities.
International Maritime Organization (2023)	Maritime decarbonisation is central to reducing shipping emissions.	Supports alternative marine fuel discussion.
International Energy Agency (2023)	Electrification and low-carbon fuels are essential for industrial decarbonisation.	Supports port equipment electrification.

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2.4 Waste Management Assessment

Objective: To evaluate current waste management practices within offshore wind Operations and Maintenance (O&M) facilities, considering regulatory compliance, circular economy principles, and opportunities to improve resource efficiency.

2.4.1 Overview

Although offshore wind is recognised as one of the lowest-carbon forms of electricity generation, its operation and maintenance activities continue to generate a variety of waste streams throughout the asset lifecycle. Waste is produced through routine maintenance, equipment replacement, warehousing operations, packaging, office activities, and vessel operations. Whilst the quantities generated are considerably lower than those associated with manufacturing or construction industries, effective waste management remains essential for reducing environmental impacts, complying with environmental legislation, and improving operational efficiency.

Historically, waste management within industrial facilities focused primarily on legal compliance and disposal. However, increasing emphasis on sustainability and circular economy principles has shifted industry priorities towards waste prevention, reuse, recycling, and resource recovery. The UK Resources and Waste Strategy (DEFRA, 2018) and the Waste Hierarchy established under the Waste Framework Directive encourage organisations to minimise waste generation before considering recycling or disposal.

Within offshore wind O&M facilities, this transition has encouraged operators to work more closely with suppliers, improve inventory management, reduce unnecessary packaging, and maximise material recovery. For organisations such as RWE Renewables, effective waste management contributes not only to environmental performance but also to lower operating costs, improved stakeholder confidence, and alignment with wider Environmental, Social and Governance (ESG) objectives.

Figure 2.4 – Typical Waste Streams within Offshore Wind O&M Facilities

Waste Stream	Primary Source	Typical Management Route
Plastic Packaging	Spare parts and consumables	Recycling where possible

Cardboard & Timber	Equipment deliveries	Recycling or reuse
Scrap Metals	Component replacement	Specialist metal recycling
Lubricating Oils	Gearbox and hydraulic maintenance	Licensed recovery and recycling
Batteries	Portable equipment and vehicles	Specialist hazardous waste contractor
Chemicals & Solvents	Cleaning and maintenance	Hazardous waste treatment
General Office Waste	Administration and welfare facilities	Mixed recycling and residual waste

2.4.2 Plastics and Packaging

Packaging represents one of the most significant waste streams generated within offshore wind O&M operations. Replacement components, electrical equipment, consumables, and specialist tools are frequently delivered using combinations of plastic film, expanded polystyrene, timber pallets, and cardboard packaging to protect high-value components during transport.

While much of this material is technically recyclable, contamination, mixed-material packaging and limited local recycling facilities can reduce actual recycling rates. Consequently, many offshore wind developers are increasingly engaging with suppliers to reduce unnecessary packaging at source through reusable transit systems, returnable containers, and standardised packaging specifications.

The Offshore Wind Sector Deal and wider UK circular economy initiatives encourage manufacturers and operators to collaborate across supply chains to minimise material use while maintaining equipment protection. These measures not only reduce waste generation but also decrease transportation costs and improve warehouse efficiency.

2.4.3 Scrap Metal Recovery

Routine maintenance activities generate significant quantities of steel, aluminium, copper, and stainless steel from worn or replaced turbine components, cable infrastructure, and mechanical equipment.

Unlike many other industrial waste streams, metals possess substantial economic value and are therefore routinely segregated and recycled. According to the International Energy Agency (2023), steel and aluminium recycling typically requires significantly less energy than primary production, resulting in substantial reductions in embodied carbon.

Most offshore wind operators maintain dedicated recycling arrangements with licensed metal recyclers, enabling materials to be recovered and reintroduced into manufacturing supply chains. Consequently, scrap metal recycling represents one of the most mature aspects of sustainability within offshore wind O&M operations.

2.4.4 Oils and Lubricants

Lubricating oils, hydraulic fluids, and greases are essential for maintaining offshore wind turbines, hydraulic systems, and port equipment. During scheduled maintenance, these fluids are routinely replaced, generating waste oils requiring specialist handling.

Under the Environmental Protection Act (1990) and Hazardous Waste Regulations, waste oils must be stored in appropriately bunded containers before collection by licensed waste contractors. Increasingly, recovered lubricants are reprocessed through specialist regeneration facilities, enabling high-quality base oils to be recovered and reused.

Whilst waste oil management is generally well established across the industry, preventing spills remains equally important due to the potential environmental consequences within sensitive coastal environments.

2.4.5 Hazardous Waste

Hazardous wastes generated within offshore wind O&M facilities include contaminated absorbents, cleaning chemicals, paints, solvents, batteries, electrical components, and fluorescent lighting.

Because these materials present potential risks to human health and the environment, storage, transportation, and disposal are subject to strict regulatory requirements. Operators typically maintain dedicated hazardous waste storage areas equipped with secondary containment, spill response equipment, and clear segregation procedures.

Environmental management systems certified to ISO 14001 increasingly support hazardous waste management by standardising procedures, improving staff training and promoting continual improvement in environmental performance.

Table 2.8 – Typical Hazardous Waste Controls

Waste Type	Typical Control Measure	Environmental Risk
Waste Oils	Bunded storage and licensed recycling	High
Batteries	Segregated storage and specialist recycling	High
Solvents	Secure hazardous waste containers	Medium
Contaminated PPE	Controlled disposal	Medium
Chemicals	COSHH-compliant storage	High

2.4.6 Circular Economy

Increasingly, offshore wind operators are adopting circular economy principles that prioritise maintaining materials and products in productive use for as long as possible. Rather than viewing waste solely as an unavoidable by-product, organisations seek opportunities to reduce material consumption, extend equipment life, and recover value from redundant assets.

Examples within offshore wind include:

- refurbishment of mechanical components rather than replacement,
- remanufacture of hydraulic equipment,
- reusable transport packaging,
- supplier take-back schemes, take-back schemes,
- digital inventory systems to reduce obsolete stock,
- recycling of decommissioned turbine components.

The Crown Estate (2023) identifies circular economy practices as a critical opportunity for reducing lifecycle emissions across offshore wind supply chains.

Management Insight

Waste management is increasingly evolving from a compliance activity into a strategic resource management function. Organisations that minimise waste generation through improved procurement, inventory control and supplier engagement are likely to realise both environmental and financial benefits.

Table 2.9 – Waste Management Benchmark

Waste Category	Current Industry Practice	Best Practice	Industry Maturity
Plastics	Segregated recycling	Packaging reduction programmes	★★★☆☆
Cardboard	Recycling	Supplier return schemes	★★★★☆
Scrap Metal	Licensed recycling	Closed-loop recycling	★★★★★
Waste Oils	Licensed recovery	Oil regeneration	★★★★☆
Hazardous Waste	Regulatory compliance	ISO 14001 integrated management	★★★★☆
Circular Economy	Emerging	Asset refurbishment programmes	★★★☆☆

2.4.7 Waste Hierarchy Assessment

Strategy	Current Industry Adoption	Sustainability Benefit
Prevention	Moderate	Very High
Reuse	Moderate	High
Recycling	High	High
Recovery	Moderate	Medium
Disposal	Low	Low

2.4.8 SWOT Assessment – Waste Management

Strengths	Weaknesses
High recycling rates for metals and oils	Significant packaging waste from suppliers
Mature hazardous waste procedures	Variable recycling infrastructure across ports
Strong regulatory compliance	Limited reuse of specialist materials
Established environmental management systems	Circular economy practices still developing
Opportunities	**Threats**
Supplier take-back schemes	Increasing waste disposal costs
Reusable packaging	Changes to environmental legislation

Asset refurbishment	Limited recycling markets for composite materials
Digital inventory optimisation	Supply chain constraints

2.4.9 Consultancy Assessment

Waste management within offshore wind O&M facilities is generally characterised by strong regulatory compliance and mature recycling systems, particularly for high-value materials such as metals and lubricating oils. However, the industry is increasingly recognising that the greatest sustainability benefits arise not from recycling alone but from preventing waste generation through improved procurement, supplier collaboration, and inventory management.

Packaging remains a significant challenge due to the need to protect sensitive turbine components during transportation. Future progress is therefore likely to depend upon greater collaboration between manufacturers, logistics providers, and wind farm operators to develop reusable packaging systems and circular supply chains.

For the RWE Grimsby O&M Base, opportunities may exist to further integrate circular economy principles into routine operations by improving supplier engagement, enhancing waste data collection, and identifying opportunities for refurbishment before replacement. Such measures align closely with the waste hierarchy and support wider corporate sustainability objectives.

Consultant's Key Findings

Assessment Area	Current Position	Future Priority
Regulatory Compliance	Excellent	Maintain
Recycling Performance	High	Optimise
Circular Economy	Developing	High
Packaging Reduction	Moderate	High
Waste Data Monitoring	Moderate	Medium
Supplier Collaboration	Developing	High

Evidence Base

Organisation	Key Findings	Relevance
DEFRA (2018)	Waste hierarchy prioritises prevention over disposal.	Supports waste management strategy.
Environment Agency (2023)	Hazardous waste requires licensed handling and storage.	Supports hazardous waste section.
IEA (2023)	Metal recycling significantly reduces embodied carbon.	Supports scrap metal recovery discussion.
The Crown Estate (2023)	Circular economy is a strategic priority for offshore wind.	Supports resource efficiency recommendations.
ISO (2015)	ISO 14001 promotes continual environmental improvement.	Supports environmental management systems.

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2.5 Water Management Assessment

Objective: To evaluate current water management practices within offshore wind Operations and Maintenance (O&M) facilities, assessing opportunities to improve resource efficiency and operational resilience while supporting corporate sustainability objectives.

2.5.1 Overview

Compared with energy consumption and marine fuel use, water consumption represents a relatively small proportion of the environmental footprint associated with offshore wind O&M facilities. Nevertheless, responsible water management remains an important aspect of sustainable facility operation, particularly as increasing regulatory pressure, climate change and corporate Environmental, Social and Governance (ESG) commitments encourage organisations to improve resource efficiency.

Water is required for employee welfare facilities, workshops, equipment cleaning, washdown activities, landscape maintenance, and occasional component testing. Whilst overall consumption is generally modest compared with manufacturing industries, inefficient water management increases operational costs and places unnecessary demand upon local potable water supplies.

Increasingly, offshore wind developers are implementing water efficiency measures such as low-flow sanitary fittings, rainwater harvesting, leak detection systems and water reuse technologies. Although the carbon savings associated with these measures are relatively small, they contribute towards wider sustainability objectives by reducing operational costs, improving resilience during periods of water scarcity, and demonstrating responsible environmental stewardship (Environment Agency, 2023).

For facilities such as the RWE Grimsby O&M Base, water management should therefore be viewed not simply as a utility service but as an opportunity to improve operational efficiency and strengthen long-term sustainability performance.

Figure 2.5 – Typical Water Uses within Offshore Wind O&M Facilities

Water Use	Typical Application	Relative Consumption	Improvement Potential

Welfare Facilities	Toilets, kitchens, and showers	High	Medium
Workshop Cleaning	Equipment and floor cleaning	Medium	High
Vessel Washdown	Salt removal and maintenance	Medium	Medium
Landscape Irrigation	External maintenance	Low	High
Emergency Systems	Fire suppression testing	Low	Low

2.5.2 Potable Water Consumption

The majority of O&M facilities obtain potable water directly from municipal water supplies. Consumption is largely driven by staff welfare facilities, including toilets, kitchens, showers and changing rooms, reflecting the continuous movement of technicians and contractors through the site. O&M facilities obtain potable water directly from municipal water supplies. Consumption is largely driven by staff welfare facilities, including toilets, kitchens, showers and changing rooms, reflecting the continuous movement of technicians and contractors through the site.

Modern commercial buildings increasingly incorporate water-efficient fixtures such as dual-flush toilets, low-flow taps, sensor-operated fittings, and water-efficient showerheads. These technologies can reduce potable water demand by 20–40% compared with conventional fittings while maintaining user comfort (Waterwise, 2023).

Automated leak detection systems and digital water metering are also becoming more common, enabling facility managers to identify abnormal consumption patterns before significant water losses occur.

2.5.3 Rainwater Harvesting

Rainwater harvesting has become an increasingly attractive sustainability measure for industrial facilities due to its relatively simple design and low operational costs.

Collected rainwater is typically unsuitable for drinking without extensive treatment; however, it is well suited to non-potable applications such as toilet flushing, vehicle washing, landscape irrigation and external cleaning. O&M

facilities frequently possess extensive roof areas on warehouses and workshops, providing favourable conditions for rainwater collection.

Within the UK climate, rainfall patterns generally support reliable rainwater harvesting throughout much of the year, although storage capacity and seasonal variability must be considered during system design.

For offshore wind O&M bases, rainwater harvesting offers the additional benefit of reducing stormwater runoff, thereby lowering pressure on local drainage infrastructure during heavy rainfall events.

Observation

Although rainwater harvesting delivers relatively modest carbon savings, it provides an effective demonstration of environmental stewardship and contributes towards broader sustainability goals, particularly when integrated into new developments or major building refurbishments.

2.5.4 Washdown Operations

Washdown activities are routinely undertaken to remove salt deposits, dirt and contaminants from maintenance equipment, vehicles, tools and occasionally vessel decks. Salt contamination is of particular concern within coastal environments due to its corrosive effects on mechanical and electrical equipment.

Traditional washdown operations rely upon potable water supplied through hose systems or pressure washers. However, increasing numbers of industrial facilities are implementing high-efficiency pressure washing equipment and closed-loop water recycling systems that filter and reuse wash water.

Such systems reduce both water consumption and contaminated wastewater generation whilst maintaining cleaning effectiveness. Where detergents or oils are present, washdown areas are typically equipped with oil interceptors and drainage treatment systems to prevent environmental contamination.

2.5.5 Sustainable Drainage Systems (SuDS)

Modern industrial developments increasingly incorporate Sustainable Drainage Systems (SuDS) to manage surface water runoff and reduce flood risk.

Typical SuDS measures include:

- permeable paving,
- swales,
- attenuation ponds,
- infiltration basins,
- green roofs.

These systems slow stormwater runoff, improve water quality and enhance biodiversity while reducing pressure on conventional drainage networks.

Although SuDS are more commonly associated with urban developments, they are increasingly incorporated into modern port redevelopments and industrial estates as part of wider environmental management strategies.

Table 2.10 – Industry Water Benchmark

Water Management Measure	Current Industry Practice	Best Practice	Maturity
Water Metering	Standard utility metering	Smart digital monitoring	★★★★☆
Sanitary Fixtures	Water-efficient fittings	Smart sensor-controlled systems	★★★★☆
Rainwater Harvesting	Limited implementation	Integrated non-potable supply	★★★☆☆
Washdown	Potable water	Closed-loop recycling systems	★★☆☆☆
Surface Water	Conventional drainage	Sustainable Drainage Systems	★★★☆☆

2.5.6 Water Maturity Assessment

Technology	Industry Adoption	Sustainability Benefit	Ease of Deployment
Low-flow fittings	High	Medium	High
Leak detection	Moderate	Medium	High
Rainwater harvesting	Moderate	Medium	Medium
Closed-loop washdown	Low	High	Medium

Sustainable Drainage Systems	Moderate	Medium	Low (existing sites)

2.5.7 SWOT Assessment – Water Management

Strengths	Weaknesses
Generally low overall water consumption	Limited rainwater harvesting across existing facilities
Water-efficient sanitary fittings increasingly standard	Potable water often used for washdown activities
Strong environmental regulation	Limited monitoring of non-potable water use
Opportunities	**Threats**
Rainwater harvesting	Increasing water costs
Closed-loop washdown systems	Climate change impacts on water availability
Smart water monitoring	More stringent discharge regulations
Sustainable drainage	Increased flood risk in coastal locations

2.5.8 Consultancy Assessment

Water management within offshore wind O&M facilities is generally well controlled, with relatively low consumption compared with other industrial sectors. Nevertheless, opportunities remain to improve resource efficiency through the wider adoption of rainwater harvesting, closed-loop washdown systems and intelligent water monitoring technologies.

Given the coastal location of many O&M bases, integrated water management also contributes to climate resilience by reducing stormwater runoff and enhancing site drainage performance. For RWE Renewables, future improvements are likely to be most effective when incorporated alongside broader building and infrastructure upgrades rather than implemented as standalone projects.

Insight

Although water represents a relatively small component of an O&M facility's environmental footprint, improving water efficiency demonstrates effective environmental stewardship, reduces operating costs, and enhances resilience against future climate and regulatory challenges.

Evidence Base

Organisation	Key Findings	Relevance
Environment Agency (2023)	Efficient water management reduces environmental impacts and operational costs.	Supports water efficiency measures.
Waterwise (2023)	Commercial buildings can significantly reduce water demand through efficient fittings and monitoring.	Supports sanitary efficiency discussion.
CIRIA (2020)	Sustainable Drainage Systems improve flood resilience and water quality.	Supports SuDS discussion.
ISO (2015)	Environmental management systems encourage continual resource efficiency improvements.	Supports integrated management approach.

References

CIRIA (2020) *The SuDS Manual (C753)*. London: CIRIA.

Environment Agency (2023) *Water Resources Strategy for England*. Bristol: Environment Agency.

International Organization for Standardization (2015) *ISO 14001:2015 Environmental Management Systems*. Geneva: ISO.

Waterwise (2023) *Water Efficiency Strategy for the UK*. London: Waterwise.

2.6 Travel & Logistics Assessment

Objective:

To assess the sustainability of staff travel, contractor movements and operational logistics associated with offshore wind O&M facilities, identifying opportunities to reduce transport-related emissions while maintaining operational effectiveness.

2.6.1 Overview

Transport and logistics underpin every aspect of offshore wind operations. Personnel, contractors, spare parts, and specialist equipment must move efficiently between offices, ports, warehouses, and offshore assets to maintain turbine availability and ensure safe operations. While marine transport accounts for the majority of logistics-related emissions, landside travel also contributes to the operational carbon footprint of an O&M base.

O&M facilities are frequently located within industrial port environments where public transport connectivity is limited. Consequently, employees often rely on private vehicles to travel to work, while contractors may travel significant distances to undertake specialist maintenance activities. As organisations pursue Net Zero commitments, reducing transport-related emissions has become an increasingly important element of corporate sustainability strategies.

2.6.2 Staff Commuting

Employee commuting patterns are influenced by workforce location, shift patterns, and the accessibility of the O&M facility. Surveys across the UK energy sector consistently show that private cars remain the dominant mode of travel due to flexible working hours and the remote nature of many industrial sites (Energy UK, 2023).

To reduce emissions, employers are increasingly implementing:

- electric vehicle (EV) charging infrastructure,
- salary sacrifice EV schemes,
- car-sharing initiatives,
- secure cycle storage,

- shower and changing facilities,
- flexible working arrangements for office-based staff.

These measures reduce transport emissions while supporting employee wellbeing and recruitment.

2.6.3 Contractor Travel

Contractors play a vital role in offshore wind maintenance, particularly during major servicing campaigns or specialist equipment repairs. However, contractor travel can generate significant emissions due to long-distance journeys and frequent mobilisation.

Digital technologies are helping to reduce unnecessary travel. Remote diagnostics, virtual inspections, and online planning meetings allow some engineering activities to be completed without requiring personnel to travel to site. While these approaches cannot replace all physical maintenance, they improve planning efficiency and reduce avoidable journeys.

2.6.4 Fleet Vehicles

Most O&M facilities operate a fleet of vans, pickups, and utility vehicles for transporting technicians and equipment within the port estate and to nearby operational locations.

Electrification of these fleets is accelerating due to improvements in battery range, lower maintenance costs, and expanding charging infrastructure. Fleet telematics are increasingly used to monitor vehicle utilisation, optimise routes, and reduce fuel consumption.

For sites with predictable daily mileage, electric vehicles often offer a favourable total cost of ownership despite higher initial purchase costs.

Table 2.11 – Sustainable Transport Benchmark

Transport Activity	Current Industry Practice	Best Practice	Maturity
Staff Commuting	Private vehicles	EVs, car sharing and active travel	★★★☆☆

Contractor Travel	Site visits	Hybrid working and remote diagnostics	★★★☆☆
Fleet Vehicles	Mixed diesel and EV	Fully electric fleet	★★★☆☆
Fleet Management	Basic scheduling	Telematics and route optimisation	★★★★☆

2.6.5 Consultancy Assessment

Transport emissions associated with offshore wind O&M facilities are increasingly influenced by operational logistics rather than routine office commuting. While staff travel remains important, greater sustainability gains are likely to be achieved through fleet electrification, digital maintenance planning and reducing unnecessary contractor mobilisation.

For RWE Renewables, integrating transport planning with vessel scheduling, warehouse logistics and digital maintenance systems could provide measurable reductions in operational emissions while improving efficiency.

SWOT Assessment – Travel & Logistics

Strengths	**Weaknesses**
Growing adoption of EVs	Limited public transport access to ports
Digital planning reduces travel	Contractor mobilisation remains carbon intensive
Telematics improving fleet efficiency	Diesel vehicles still common
Opportunities	**Threats**
Fleet electrification	Rising fuel costs
Active travel initiatives	Charging infrastructure constraints
Remote diagnostics	Workforce travel demands as offshore capacity expands

Insight

Transport sustainability should not be viewed solely through the lens of employee commuting. The greatest operational benefits arise from integrating fleet management, contractor planning, warehouse logistics and vessel scheduling into a single, data-driven operational strategy.

References

Energy UK (2023) *Pathways to Net Zero Workforce*. London: Energy UK.

International Energy Agency (2023) *Global EV Outlook*. Paris: IEA.

Department for Transport (2022) *Decarbonising Transport: A Better, Greener Britain*. London: Department for Transport.

2.7 Industry SWOT & Strategic Baseline

Objective: To synthesise the findings of the current state assessment into an executive-level evaluation of the offshore wind Operations and Maintenance (O&M) sector, identifying strategic strengths, weaknesses, opportunities and priorities that will inform the subsequent assessment of the RWE Grimsby O&M Base.

2.7.1 Executive Overview

The previous sections have demonstrated that offshore wind O&M facilities have undergone significant improvements in sustainability performance over the past decade. Investment in energy-efficient buildings, digital maintenance systems, waste management, and renewable electricity procurement has substantially reduced operational emissions compared with traditional industrial facilities.

However, the assessment also indicates that the industry's sustainability challenge has fundamentally changed.

Historically, the greatest opportunities for carbon reduction were associated with improving building efficiency, upgrading lighting systems, and reducing electricity consumption. These initiatives have now become relatively mature across much of the sector. Consequently, the remaining operational emissions are increasingly concentrated within more technically challenging areas including marine logistics, port infrastructure, and heavy equipment.

This shift requires organisations such as RWE Renewables to move beyond isolated sustainability initiatives towards integrated operational strategies that combine energy management, digital technologies, infrastructure investment, and low-carbon logistics.

Consequently, the following strategic baseline establishes the current maturity of offshore wind O&M facilities and identifies the areas likely to deliver the greatest operational and environmental value over the coming decade.

Figure 2.7 – Overall Industry Sustainability Dashboard

Theme	Current Maturity	Carbon Impact	Improvement Potential	Strategic Priority
Energy	🟢 High	Medium	Medium	High

Buildings	High	Medium	Medium	Medium
Port Infrastructure	Moderate	Very High	Very High	Critical
Waste	High	Low	Medium	Medium
Water	Moderate	Low	Medium	Low
Travel & Logistics	Moderate	Medium	High	High

Executive Summary

The assessment demonstrates that marine operations and port infrastructure now represent the greatest opportunity for reducing operational emissions across offshore wind O&M facilities.

2.7.2 Industry Maturity Assessment

To provide a structured evaluation of current industry performance, each operational area has been assessed using a five-level maturity model adapted from industrial asset management frameworks.

Table 2.12 – Offshore Wind O&M Maturity Matrix

Level	Description
Level 1	Reactive management with limited sustainability integration
Level 2	Basic compliance with environmental legislation
Level 3	Sustainability integrated into operational decision making
Level 4	Data-driven optimisation and continual improvement
Level 5	Industry-leading innovation and Net Zero aligned operations

Current Industry Position

Operational Area	Current Level	Future Target
Building Efficiency	Level 4	Level 5
Energy Management	Level 4	Level 5
Digital Operations	Level 4	Level 5
Waste Management	Level 4	Level 5
Water Management	Level 3	Level 4

Fleet Electrification	Level 3	Level 5
Port Equipment	Level 2	Level 5
Shore Power	Level 2	Level 5
Vessel Decarbonisation	Level 2	Level 5

Observation

The industry's greatest sustainability challenges are no longer associated with operational awareness or regulatory compliance. Instead, they relate to the commercial deployment of emerging technologies capable of decarbonising activities that remain heavily dependent upon fossil fuels.

2.7.3 Strategic SWOT Analysis

Table 2.13 – Offshore Wind O&M Strategic SWOT

Strengths	Weaknesses
Highly mature energy-efficient buildings	Marine logistics remain diesel dependent
Increasing renewable electricity procurement	Limited shore power infrastructure
Strong environmental governance	Heavy equipment electrification remains limited
Mature waste recycling systems	Ageing port infrastructure in some locations
Advanced digital asset management	Limited operational renewable generation
Opportunities	**Threats**
Alternative marine fuels	Increasing carbon taxation
Smart ports and AI logistics	Rising fuel prices
Battery energy storage	Electricity network constraints
Solar PV integration	Rapid technology change
Circular economy initiatives	Supply chain shortages
Green hydrogen	Climate resilience challenges

2.7.4 PESTLE Analysis

A wider strategic assessment demonstrates that external factors will increasingly influence the sustainability of offshore wind operations.

Table 2.14 – PESTLE Assessment

Factor	Key Influence

Political	UK Net Zero Strategy, Offshore Wind Sector Deal, Clean Maritime Plan
Economic	Increasing energy prices, operational cost pressures, carbon pricing
Social	Growing stakeholder expectations regarding ESG performance
Technological	AI, Digital Twins, hybrid vessels, hydrogen technologies
Legal	Environmental permitting, carbon reporting, maritime regulations
Environmental	Climate resilience, biodiversity protection, emissions reduction

2.7.5 Impact vs Implementation Matrix

One of the most valuable consultancy tools is identifying which initiatives provide the greatest benefit relative to implementation complexity.

Table 2.15 – Sustainability Opportunity Matrix

Initiative	Sustainability Impact	Ease of Implementation	Priority
LED Optimisation	Medium	High	Quick Win
Smart HVAC Controls	Medium	High	Quick Win
Solar PV	High	Medium	High
Battery Storage	High	Medium	High
Fleet Electrification	High	Medium	High
Shore Power	Very High	Low	Strategic
Hybrid Crew Transfer Vessels	Very High	Low	Strategic
Hydrogen Infrastructure	Very High	Very Low	Long-Term

Figure 2.8 – Priority Matrix

	Easy	Difficult
High Impact	Solar PV Fleet EVs BEMS	Shore Power Hydrogen Infrastructure
Low Impact	LED Upgrades Water Efficiency	Minor Building Refurbishments

2.7.6 Carbon Hotspot Analysis

Table 2.16 – Relative Operational Carbon Contribution

Activity	Relative Contribution	Priority
Crew Transfer Vessels	██████████	Critical
Service Operation Vessels	█████████	Critical
Heavy Equipment	███████	High
Buildings	█████	Medium
Fleet Vehicles	████	Medium
Waste	██	Low
Water	█	Low

Observation

The analysis confirms that the largest remaining sources of operational emissions occur within marine transport and supporting port infrastructure. Consequently, organisations seeking meaningful carbon reductions must increasingly focus on vessel decarbonisation, infrastructure electrification, and integrated logistics rather than conventional building efficiency measures alone.

2.7.7 Strategic Readiness Assessment

Table 2.17 – Readiness for Net Zero Operations

Category	Current Readiness
Governance	🟢 High
Environmental Management	🟢 High
Building Performance	🟢 High
Energy Efficiency	🟢 High
Digitalisation	🟢 High
Circular Economy	🟠 Moderate
Fleet Decarbonisation	🟠 Moderate
Port Electrification	🔴 Low
Alternative Marine Fuels	🔴 Low

2.7.8 Executive Findings

This assessment demonstrates that the offshore wind industry has entered a new phase of operational sustainability. The majority of readily achievable energy efficiency measures have already been implemented across modern O&M facilities, resulting in progressively smaller carbon savings from conventional building improvements alone.

Instead, the industry's future sustainability performance will depend upon its ability to address operational activities that remain difficult to decarbonise. Marine transport, heavy port equipment, and supporting logistics infrastructure now represent the largest remaining operational carbon sources and therefore offer the greatest opportunities for improvement.

At the same time, digitalisation is emerging as a key enabler of sustainability rather than simply an operational tool. Predictive maintenance, digital twins, intelligent building management systems and AI-assisted logistics planning have the potential to reduce unnecessary energy use, minimise vessel movements and improve asset availability while supporting operational resilience.

For RWE Renewables, these findings provide a robust strategic baseline against which the Grimsby O&M Base can be evaluated. Rather than considering individual sustainability measures in isolation, future improvements should be assessed according to their contribution to operational reliability, carbon reduction, cost efficiency, and long-term resilience.

2.8 Summary

2.8.1 Immediate Opportunities (1–3 years)

- Optimise Building Energy Management Systems (BEMS)
- Expand rooftop solar photovoltaic (PV) generation
- Increase fleet electrification
- Enhance waste and supplier management
- Improve water monitoring and efficiency

2.8.2 Medium-Term Priorities (3–7 years)

- Install battery energy storage systems (BESS)
- Electrify port equipment where operationally feasible

- Expand digital logistics and predictive maintenance
- Introduce circular economy procurement practices

2.8.3 Long-Term Strategic Investments (7–15 years)

- Shore power infrastructure
- Hybrid and alternative-fuel Crew Transfer Vessels (CTVs)
- Hydrogen or methanol bunkering capability
- Fully integrated smart port operations
- Net Zero O&M facilities supported by renewable microgrids

2.8.4 Transition to Chapter 3

The current state assessment has established a comprehensive benchmark for sustainability within offshore wind Operations and Maintenance facilities. While the industry has achieved considerable progress in improving building efficiency, energy management and environmental governance, significant opportunities remain within marine logistics, port infrastructure, and operational decarbonisation.

The following chapter applies this industry benchmark to the **RWE Grimsby O&M Base**, evaluating how current operational practices compare with emerging best practice. This assessment will identify specific strengths, performance gaps and improvement opportunities that will inform the development of targeted recommendations aimed at enhancing both operational efficiency and environmental sustainability.

3. RWE Grimsby O&M Hub – Case Study Assessment

Objective: To assess the current operational configuration, efficiency and sustainability characteristics of the RWE Grimsby Operations and Maintenance (O&M) Hub and compare these against the industry baseline established in Section 2.

3.0 Executive Overview

The RWE Grimsby Hub represents a strategically significant offshore wind Operations and Maintenance facility on the UK's east coast. Located at the Port of Grimsby at Royal Dock, the facility has developed from the existing Triton Knoll O&M base into a larger, integrated operations hub supporting RWE's expanding North Sea offshore wind portfolio.

The expanded facility formally opened in July 2025 following a multi-million-pound investment by RWE. Its development reflects a wider transition within offshore wind O&M from individual wind-farm-specific facilities towards larger operational hubs capable of sharing personnel, infrastructure, technical expertise and digital capabilities between projects (RWE, 2025).

The Hub currently accommodates maintenance activities associated with the 857 MW Triton Knoll Offshore Wind Farm and is intended to accommodate the operations team supporting the 1.4 GW Sofia Offshore Wind Farm. RWE has specifically identified Grimsby's proximity to its existing and future North Sea projects and the availability of deep-water quayside infrastructure as important factors behind its selection. The deep-water capability is particularly significant for Service Operation Vessels (SOVs), which are increasingly required as offshore wind development moves further from the UK coastline (RWE, 2025).

A further strategic feature is RWE's UK Centralised Control Room (CCR), located within the Hub. The CCR provides 24-hour monitoring services across RWE's UK offshore wind portfolio, including marine coordination, turbine operations, alarm management, high-voltage monitoring and emergency response. This represents a shift away from fragmented project-level operational control towards centralised, data-driven management.

From a sustainability perspective, the Grimsby Hub therefore represents more than an individual O&M building. It should be considered an integrated system comprising buildings, energy infrastructure, marine operations, port equipment, warehousing, personnel and digital systems.

The purpose of this case study is to assess that system against the industry benchmark established in Section 2 and identify where opportunities may exist to further improve operational efficiency, environmental performance and long-term resilience.

3.1 Strategic Role of the Grimsby Hub

The decision to consolidate offshore wind operations within Grimsby represents an important operational efficiency strategy.

Historically, offshore wind farms have commonly been supported by dedicated O&M facilities located close to individual projects. While this provides strong project-level focus, operating separate facilities can result in duplication of warehouses, offices, control functions, personnel, specialist equipment and support infrastructure.

The Grimsby Hub provides an alternative model based upon **operational clustering**.

When announcing the investment, RWE specifically identified the opportunity to share knowledge, expertise and resources across projects as a means of achieving greater offshore operational efficiency. The Hub was designed to bring operations associated with Triton Knoll and Sofia together while also accommodating specialist teams responsible for major component exchanges and offshore repairs (RWE, 2021).

This consolidation creates potential efficiencies in four areas:

Area	Traditional Approach	Grimsby Hub Model	Potential Benefit
Personnel	Project-specific teams	Shared expertise	Higher resource utilisation
Warehousing	Individual project inventories	Consolidated logistics	Reduced duplication
Control Operations	Separate monitoring	Centralised Control Room	Greater operational visibility
Specialist Equipment	Project-specific equipment	Shared specialist resources	Lower asset duplication

Port Infrastructure	Individual facilities	Shared deep-water hub	Improved infrastructure utilisation

The strategic importance of this approach increases as RWE's North Sea portfolio develops. Sofia is located approximately 195 km from the nearest point on the UK North East coast, making conventional daily technician transfer increasingly challenging. Deep-water access at Grimsby enables greater use of SOV-based maintenance strategies suitable for projects located significantly further offshore (RWE, 2025).

Insight

The Grimsby Hub's principal efficiency advantage is consolidation. Sharing operational infrastructure, technical expertise, control functions and potentially logistics between multiple offshore assets creates an opportunity to reduce duplication while increasing utilisation of the existing port estate.

3.2 Current Operational Profile

The Hub should first be understood in terms of the scale of operations it is designed to support.

Table 3.1 – Grimsby Hub Operational Context

Characteristic	Current / Planned Position
Location	Royal Dock, Port of Grimsby
Primary Function	Offshore wind Operations & Maintenance
Triton Knoll Capacity	857 MW
Triton Knoll Turbines	90
Sofia Capacity	1.4 GW
Control Capability	UK Centralised Control Room
CCR Operation	24/7
Current Employment	90+ FTE
Expected RWE Employment by 2027	Approximately 140
Key Marine Advantage	Deep-water quayside suitable for SOVs

RWE states that the Hub already supports more than 90 full-time equivalent positions, with approximately 140 RWE employees expected by 2027. The Centralised Control Room itself operates with a team of 12 and provides a range of monitoring and emergency-response functions across RWE's offshore portfolio (RWE, 2025).

The facility therefore represents a considerable concentration of offshore operational capability within a single location.

This concentration creates an important sustainability relationship. Increasing activity at the Hub will inevitably increase absolute demand for electricity, heating, transport, warehousing and port services. However, consolidation may simultaneously **reduce resource intensity per MW of offshore wind capacity supported**.

This distinction is important when evaluating performance.

A larger facility should not necessarily be considered less efficient because its total electricity or water consumption increases. Appropriate performance indicators should therefore normalise consumption against measures such as employees, floor area, vessel calls or MW of offshore generation supported.

3.3 Preliminary Sustainability Assessment

Based upon the industry framework developed in Section 2, the Grimsby Hub can be assessed across six principal sustainability themes.

Table 3.2 – Case Study Assessment Framework

Theme	Key Question
Energy	How efficiently is energy supplied, monitored and consumed?
Buildings	How effectively does the facility minimise building-related demand?
Port & Marine	How efficiently are vessels, quayside and port equipment operated?
Waste	How effectively are materials prevented, reused and recycled?
Water	How efficiently is potable and non-potable water managed?
Travel	How efficiently are employee, contractor and operational journeys managed?

A distinction should be maintained between **verified site performance** and **potential improvement opportunities**. Where site-specific consumption data are unavailable, the assessment should not assume that Grimsby currently uses or does not use a particular technology. Instead, the industry benchmark can be used to identify questions requiring further investigation.

This is particularly important from a consultancy perspective: recommendations should ultimately be supported by measured site data rather than assumptions.

3.4 Energy Assessment

Energy performance should represent one of the first areas examined because electrification is expected to increase significantly as O&M facilities transition away from fossil fuels.

The Grimsby Hub's electrical demand is likely to comprise several different load categories, including offices, the Centralised Control Room, workshops, warehousing, HVAC, lighting, IT infrastructure and potentially electric vehicle and equipment charging.

The presence of a 24/7 Centralised Control Room creates an important difference compared with conventional office buildings. Critical monitoring, communications and emergency-response systems require continuous electricity supply, making both energy efficiency and resilience strategically important.

The appropriate assessment should therefore consider not simply annual electricity consumption but also:

- peak electrical demand;
- baseload consumption;
- out-of-hours demand;
- renewable electricity procurement;
- backup generation;
- solar PV potential;
- battery storage potential;
- EV charging requirements;
- future shore-power requirements.

Table 3.3 – Energy Performance Assessment

Area	Industry Best Practice	Grimsby Assessment Requirement	Priority
Grid Electricity	Low carbon / renewable procurement	Review electricity source	Medium

Smart Metering	Sub-metered systems	Confirm metering architecture	High
Solar PV	Rooftop generation	Assess available roof area	High
Battery Storage	PV/BESS integration	Assess load profile and resilience case	High
Backup Power	Hybrid battery/generator	Review existing emergency supply	Medium
EV Charging	Smart managed charging	Assess current/future fleet demand	Medium
Energy Management	Integrated BEMS	Review existing controls	High

Consultant Observation

The most valuable first step would be to establish a detailed **energy baseline** using 12–24 months of half-hourly electricity and fuel consumption data.

Rather than immediately recommending additional technology, this would establish when energy is consumed and identify abnormal baseloads, seasonal patterns and peak demand.

A useful KPI framework would include:

kWh/m²/year

kWh/FTE/year

kgCO_2e/FTE/year

kWh/MW of offshore capacity supported

This would allow future sustainability improvements to be quantified rather than assessed qualitatively.

3.5 Buildings Assessment

The expansion of the Grimsby Hub creates an important distinction between legacy infrastructure and newer construction.

RWE's development expanded the existing Triton Knoll O&M facilities rather than developing an entirely isolated site. The construction contract awarded to Humber-based Hobson & Porter included both extension of the existing operations base and creation of the Centralised Control Room (RWE, 2023).

From a sustainability perspective, expansion of an existing operational facility can provide benefits by avoiding unnecessary duplication of infrastructure and making greater use of an established port location.

However, differences in building age can also create variation in energy performance across an estate. Older sections may have different insulation standards, heating systems, lighting controls or building management capabilities compared with recently constructed areas.

Table 3.4 – Building Assessment Priorities

Building Element	Assessment	Potential KPI
Heating	Identify technology and fuel	kWh/m²
Cooling	Assess cooling demand	kWh/m²
Insulation	Review envelope performance	U-values / thermal survey
HVAC	Assess control strategy	Runtime / occupancy
Lighting	Confirm LED/control coverage	W/m²
BEMS	Review system integration	% monitored loads
Building Fabric	Thermal imaging survey	Heat-loss hotspots

A particularly useful site assessment would therefore involve thermal imaging and energy sub-metering across the different building areas.

This would enable the project to identify whether older infrastructure creates disproportionate energy consumption and determine whether targeted retrofit measures could provide cost-effective improvements.

Management Insight

The Grimsby Hub should be assessed as an integrated estate rather than a single building. Differences between legacy and newly developed areas may create targeted retrofit opportunities that deliver better returns than whole-site interventions.

3.6 Port and Marine Infrastructure Assessment

Port and marine operations represent the most strategically significant element of the Grimsby assessment.

The Hub's location was deliberately selected partly because Royal Dock provides deep-water quayside infrastructure suitable for Service Operation Vessels. This becomes increasingly important as projects move further offshore and O&M strategies transition away from daily CTV transfers towards SOV-based maintenance (RWE, 2025).

This creates both an operational advantage and a sustainability challenge.

SOV-based operations can reduce the need for repeated daily transits by accommodating technicians offshore for extended periods. However, SOVs are considerably larger vessels and therefore require substantial quantities of energy.

The sustainability performance of the Grimsby Hub will consequently become increasingly linked to:

vessel utilisation + vessel fuel + berth efficiency + shore power + maintenance scheduling.

Table 3.5 – Marine and Port Assessment

Area	Current Strategic Position	Future Sustainability Question
Deep-Water Quayside	Major strength	Can infrastructure support future low-carbon vessels?
SOV Operations	Increasing importance	Can berth emissions be reduced?
CTV Operations	Established technology	Can fuel consumption/transits be optimised?
Shore Power	Key industry opportunity	Technical/economic feasibility?
Port Equipment	Operational requirement	Electrification potential?
Vessel Scheduling	Digital optimisation opportunity	Can waiting/transit time be reduced?

Shore Power Opportunity

Shore power should be investigated particularly carefully.

When vessels remain berthed, onboard auxiliary engines may otherwise be required to provide hotel loads and vessel systems. Providing electrical shore connections allows compatible vessels to shut down auxiliary engines and draw electricity from the port.

For a renewable-energy O&M facility, this creates a particularly strong strategic alignment: offshore wind vessels can potentially be powered while alongside using increasingly low-carbon UK electricity.

However, shore power should not automatically be recommended without analysis.

The business case depends upon:

- vessel electrical demand;
- berth occupancy;
- vessel compatibility;
- connection voltage;
- electrical network capacity;
- infrastructure cost;
- electricity price;
- avoided fuel consumption.

A detailed feasibility assessment should therefore be undertaken before any recommendation.

3.7 Digitalisation and the Centralised Control Room

The Centralised Control Room represents one of the Grimsby Hub's strongest existing strategic capabilities.

RWE states that the facility provides 24/7 monitoring across its UK offshore wind portfolio and can deliver marine coordination, turbine operations, alarm management, high-voltage monitoring and emergency-response services (RWE, 2025).

This centralisation potentially generates both operational and sustainability benefits.

Instead of duplicating control capabilities across multiple projects, specialist personnel and digital infrastructure can be shared. More importantly, centralised operational data can support increasingly sophisticated decision-making.

Potential applications include:

Digital Application	Operational Benefit	Sustainability Benefit
Predictive Maintenance	Reduced turbine downtime	Fewer reactive vessel trips
Weather Forecast Integration	Improved maintenance scheduling	Reduced aborted journeys
Vessel Tracking	Better marine coordination	Reduced waiting/idling
Inventory Analytics	Improved spare availability	Reduced emergency deliveries
Energy Monitoring	Lower building consumption	Reduced Scope 1/2 emissions
Digital Twin	Asset optimisation	Reduced unnecessary intervention

The future opportunity is therefore to extend the principle of the CCR beyond turbine monitoring towards **integrated O&M sustainability optimisation**.

For example, vessel movements, maintenance schedules, warehouse inventory and weather windows could increasingly be considered together when planning maintenance activities.

3.8 Warehousing and Resource Efficiency

The consolidation of multiple offshore operations within the Grimsby Hub creates an opportunity to improve spare-parts utilisation.

Offshore wind farms require significant inventories of components because the financial consequences of turbine downtime can be substantial. Operators therefore maintain safety stock to ensure critical parts are available when required.

However, excessive inventory creates both financial and environmental costs.

Parts require manufacturing, transportation, storage space and eventually disposal if they become obsolete.

The Hub model creates an opportunity to share selected inventory and specialist equipment between projects where technical compatibility permits.

Table 3.6 – Warehouse Efficiency Framework

Measure	Current-State Question	Potential Benefit

Shared Inventory	Are compatible parts shared?	Reduced stock duplication
Digital Tracking	Is inventory visible in real time?	Improved utilisation
Criticality Classification	Are parts ranked by operational risk?	Better stock allocation
Supplier Integration	Can suppliers replenish automatically?	Reduced emergency logistics
Obsolete Stock	Is unused inventory monitored?	Reduced waste
Reusable Packaging	Are return systems available?	Reduced packaging waste

This represents an important example of how sustainability and operational efficiency can reinforce one another.

3.9 Waste and Circular Economy Assessment

The waste assessment at Grimsby should move beyond measuring recycling rates.

The more strategically useful question is:

How much material entering the facility can be prevented from becoming waste in the first place?

Relevant waste streams are expected to include packaging, timber, plastics, scrap metal, lubricants, contaminated materials, PPE, batteries and general office waste.

Table 3.7 – Waste Assessment Framework

Hierarchy	Grimsby Assessment Question	Preferred Direction
Prevent	Can material use be avoided?	Highest priority
Reuse	Can packaging/components be reused?	↑
Repair	Can equipment be refurbished?	↑
Recycle	Are materials segregated effectively?	↑
Recover	Can remaining material deliver value?	↓
Dispose	Is landfill required?	Lowest priority

A detailed waste audit should therefore quantify waste by **mass, type, disposal route and cost**, enabling performance indicators such as:

kg waste/FTE

kg waste/MW supported

% recycled

% reused

% diverted from landfill

This would establish a measurable baseline for future circular economy initiatives.

3.10 Water Assessment

Water is unlikely to represent one of the largest environmental impacts at Grimsby; however, it remains relevant from a resource-efficiency and climate-resilience perspective.

Large warehouse and office roof areas potentially provide opportunities for rainwater harvesting, while maintenance and washdown activities may provide opportunities for non-potable water reuse.

The assessment should therefore investigate:

- annual potable water consumption;
- sub-metering;
- leak detection;
- sanitary fixtures;
- rainwater harvesting;
- washdown demand;
- surface-water management.

Because Grimsby is a coastal port environment, future climate resilience should also be considered alongside water efficiency. Sustainable drainage and flood resilience may ultimately be more strategically significant than simply reducing potable consumption.

3.11 Staff and Contractor Travel

The expansion of the Hub to approximately 140 RWE employees means commuting and contractor travel should also form part of the operational sustainability assessment (RWE, 2025).

Port facilities frequently face a structural challenge because industrial locations may have poorer public transport connectivity than city-centre workplaces. Shift patterns associated with offshore operations can further limit practical alternatives to private vehicles.

Potential assessment metrics should therefore include:

KPI	Purpose
Average commuting distance	Establish travel demand
Modal split	Identify car dependence
EV ownership	Forecast charging requirements
EV charging utilisation	Assess infrastructure demand
Contractor mileage	Quantify Scope 3 travel
Remote interventions	Quantify avoided journeys

Rather than simply encouraging employees to drive less, a more effective strategy would combine EV infrastructure, car sharing, active travel facilities and remote working where operationally appropriate.

3.12 Preliminary Gap Analysis

Bringing these findings together produces the following preliminary assessment.

Table 3.8 – Grimsby Hub Strategic Gap Matrix

Theme	Existing Strategic Strength	Area Requiring Investigation	Opportunity Potential
Energy	Modern consolidated facility	Energy baseline / renewable generation	🟠 Medium–High
Buildings	Recently expanded infrastructure	Legacy vs new building performance	🟠 Medium

Marine	Deep-water SOV access	Fuel use / shore power	🔴 Very High
Digital	24/7 Centralised Control Room	Integrated sustainability analytics	🟢 High
Warehousing	Consolidated Hub model	Shared inventory optimisation	🟢 High
Waste	Established industrial processes	Circular economy performance	🟠 Medium
Water	Manageable demand	Rainwater/reuse potential	🟡 Low–Medium
Travel	Concentrated workforce	EV/commuting strategy	🟠 Medium

3.13 Data Gap Assessment

A critical outcome of the current-state review is identifying what additional information is required before robust recommendations can be developed.

Table 3.9 – Priority Data Requirements

Dataset	Required Period	Purpose	Priority
Electricity Consumption	12–24 months	Energy baseline	🔴 Critical
Gas/Heating Fuel	12–24 months	Building emissions	🔴 Critical
Vessel Fuel Consumption	12–24 months	Marine carbon baseline	🔴 Critical
Vessel Movements	12 months	Logistics optimisation	🔴 Critical
Waste Records	12 months	Circular economy baseline	🟠 High
Water Consumption	12 months	Water baseline	🟡 Medium
Fleet Mileage/Fuel	12 months	Transport baseline	🟠 High
Employee Travel Survey	Snapshot	Commuting assessment	🟡 Medium
Building Drawings	Current	PV/HVAC assessment	🟠 High
Electrical Capacity	Current	EV/BESS/shore power feasibility	🔴 Critical

Management Insight

The immediate requirement is not necessarily additional technology—it is high-quality operational data. Establishing a robust baseline for electricity, fuels, vessel movements, waste and transport will enable RWE to distinguish high-value interventions from measures that provide limited carbon or financial return.

3.14 Preliminary SWOT – RWE Grimsby Hub

Strengths	Weaknesses / Areas to Validate
Strategic North Sea location	Marine operations remain inherently energy intensive
Deep-water SOV-capable quayside	Future electrical capacity may constrain electrification
Recently expanded O&M infrastructure	Combination of legacy and newer infrastructure
Centralised Control Room	Site-wide sustainability data integration requires assessment
Multiple projects consolidated at one Hub	Increasing activity could increase absolute resource demand
Concentration of specialist expertise	Commuting/contractor requirements remain

Opportunities	Threats
Shore power	Grid capacity constraints
Solar PV + battery storage	Energy and marine fuel price volatility
Integrated energy management	Technology uncertainty around future vessel fuels
Vessel/logistics optimisation	Rapid growth changing infrastructure requirements
Port equipment electrification	High capital requirements
Shared inventories and circular procurement	Supply-chain constraints
EV charging	Coastal climate risks
Data-driven sustainability dashboard	Future regulatory requirements

3.15 Preliminary Priority Matrix

The opportunities identified should not all receive equal attention. A consultancy assessment should distinguish relatively straightforward operational improvements from strategic infrastructure investments.

Table 3.10 – Initial Opportunity Prioritisation

Initiative	Potential Impact	Complexity	Indicative Priority
Energy Sub-Metering	High	Low	**Immediate**
Sustainability Dashboard	High	Low	**Immediate**
LED/BEMS Optimisation	Medium	Low	**Quick Win**
Waste Data & Circular Procurement	Medium	Low	**Quick Win**
Fleet Electrification	Medium	Medium	**Near Term**
Solar PV	High	Medium	**Near Term**
Battery Storage	High	Medium	**Near/Medium Term**
Warehouse Optimisation	High	Medium	**Near Term**
Port Equipment Electrification	High	Medium–High	**Strategic**
Shore Power	Very High	High	**Strategic**
Alternative-Fuel Vessels	Very High	Very High	**Long Term**

3.16 Proposed Grimsby Sustainability Scorecard

A management dashboard should ultimately be developed from verified site data.

KPI	Baseline	Target	Trend
Electricity (kWh/MW supported)	**TBC**	**TBC**	—
Scope 1 emissions (tCO_2e)	**TBC**	**TBC**	—
Scope 2 emissions (tCO_2e)	**TBC**	**TBC**	—
Vessel fuel (L/MWh or L/MW supported)	**TBC**	**TBC**	—
Renewable generation (%)	**TBC**	**TBC**	—
Waste recycled/reused (%)	**TBC**	**TBC**	—

Water consumption (m³/FTE)	**TBC**	**TBC**	—
EV fleet (%)	**TBC**	**TBC**	—
Avoided vessel journeys	**TBC**	**TBC**	—

The use of **TBC** values is intentional. At this stage of the research it would be inappropriate to assign performance scores without verified operational data. These indicators should instead form the basis of subsequent primary data collection.

3.17 Overall Case Study Assessment

The RWE Grimsby Hub demonstrates several characteristics associated with the future direction of offshore wind O&M infrastructure. Rather than operating as a standalone base dedicated to a single offshore wind farm, Grimsby is developing as a consolidated operational centre capable of supporting multiple offshore assets, specialist maintenance teams and centralised control functions.

This model has significant potential efficiency advantages.

Consolidating personnel, expertise, warehousing, digital infrastructure and port facilities can reduce duplication while increasing utilisation of existing assets. The Centralised Control Room further strengthens this model by providing 24/7 operational monitoring and creating a platform from which increasingly sophisticated data-driven O&M strategies could be developed.

The Hub's deep-water quayside also represents a significant strategic asset. As offshore wind farms such as Sofia are located considerably further offshore, O&M strategies increasingly depend upon SOVs rather than conventional daily CTV operations. Grimsby's ability to accommodate these vessels therefore strengthens its long-term relevance within RWE's North Sea portfolio.

However, the industry assessment conducted in Section 2 indicates that marine operations are also likely to represent one of the largest remaining sources of operational carbon emissions. The same infrastructure that provides Grimsby with its strategic advantage therefore creates one of its most significant sustainability opportunities.

Consequently, future improvement should focus on the interaction between **energy, marine logistics, port infrastructure and digital operations** rather than treating each environmental issue independently.

The most promising opportunities identified at this stage include improved energy monitoring, solar PV and battery storage, shore-power feasibility, electrification of port equipment and vehicle fleets, circular inventory management and greater use of operational data to minimise unnecessary vessel activity.

Nevertheless, technology selection should follow—not precede—baseline measurement.

Before significant capital investment is proposed, RWE should establish a detailed operational baseline covering building energy consumption, vessel fuel, vessel movements, fleet activity, waste and water consumption. This information would allow each intervention to be evaluated according to four criteria:

Carbon reduction

Operational efficiency

Financial return

Implementation feasibility

3.18 Strategic Conclusion

The Grimsby Hub provides a strong platform from which RWE can develop a highly efficient and progressively lower-carbon O&M model. Its strategic location, deep-water capability, consolidated operational structure and Centralised Control Room already provide several characteristics associated with advanced offshore wind O&M infrastructure.

The next stage is therefore not to fundamentally redesign the facility but to determine how these existing strengths can be leveraged to improve resource efficiency and accelerate operational decarbonisation.

The assessment identifies marine operations, energy infrastructure and integrated digital optimisation as the areas with the greatest potential strategic value. Waste, water, buildings and staff transport remain important, but are likely to provide smaller absolute carbon reductions.

These findings provide the basis for the subsequent recommendations and feasibility assessment, where individual interventions can be evaluated according to technical feasibility, carbon reduction potential, capital cost, operating cost, payback period and strategic alignment with RWE's wider offshore wind operations.

Section 3 – Key Takeaways

Finding	Management Implication
Grimsby already operates as a consolidated O&M Hub	Focus on optimising the existing model rather than duplicating infrastructure
Deep-water access is a strategic advantage	Protect and develop SOV capability
Marine operations are likely to be the largest carbon opportunity	Prioritise vessel efficiency and shore-power analysis
CCR provides a strong digital foundation	Expand data use into sustainability and logistics optimisation
Electrification will increase electrical demand	Assess grid capacity before EV, BESS or shore-power investment
Site data gaps remain	Establish measured baselines before major CAPEX decisions
Multiple interventions are available	Prioritise using carbon, cost, operational benefit and feasibility

References

RWE (2021) *RWE invests in new Grimsby Hub operations & maintenance base*. RWE Renewables, 23 September 2021.

RWE (2023) *RWE appoints local Humber based firm to commence Grimsby Hub construction works*. RWE Renewables, 2 March 2023.

RWE (2025) *RWE opens cutting-edge offshore wind operations and maintenance facility at the Port of Grimsby*. RWE Offshore Wind, 11 July 2025.

RWE (2026) *Offshore Wind – RWE in the UK*. RWE.

RWE (2026) *Triton Knoll Offshore Wind Farm*. RWE.

Additional industry references from Section 2—including DNV, ORE Catapult, IMO, IEA, DESNZ and The Crown Estate—should be cross-referenced where the industry benchmark is applied rather than unnecessarily duplicated.

4. Gap Analysis and Improvement Recommendations

Objective: To convert the industry benchmark established in Section 2 and the RWE Grimsby Hub assessment developed in Section 3 into a prioritised portfolio of efficiency and sustainability improvements. Recommendations are assessed against carbon reduction potential, operational value, implementation feasibility, cost attractiveness and strategic alignment.

4.0 Executive Summary

Sections 2 and 3 identify a clear transition in the sustainability challenge facing offshore wind Operations and Maintenance (O&M) facilities. Conventional efficiency measures such as LED lighting, building controls and waste segregation are increasingly mature, while the greatest remaining opportunities are concentrated in marine operations, port electrification, energy infrastructure and the use of operational data.

This distinction is particularly relevant to the RWE Grimsby Hub. The facility already possesses several strategic characteristics associated with the future of offshore wind O&M, including its consolidated hub model, deep-water quayside and 24/7 UK Centralised Control Room (CCR). RWE states that the Hub supports Triton Knoll and is accommodating Sofia operations, while the deep-water location was selected partly because of its suitability for Service Operation Vessels (SOVs).

The purpose of this section is therefore **not to propose wholesale redevelopment of the facility**. Instead, the recommended strategy is to build upon these existing strengths through progressive optimisation and decarbonisation.

The assessment identifies two fundamentally different types of intervention:

Operational optimisation, where relatively low-capital measures improve the utilisation of existing infrastructure; and

Strategic infrastructure investment, where significant capital expenditure may be required to enable future vessel, energy and port decarbonisation.

The strongest immediate opportunities are associated with improved data collection, marine logistics optimisation, energy management and circular procurement. Larger infrastructure opportunities—including shore power, battery storage and electrified port equipment—should progress through detailed feasibility studies before investment decisions are made.

This approach is particularly important because the UK's maritime decarbonisation environment is becoming progressively more stringent. The UK Maritime Decarbonisation Strategy sets a pathway towards zero lifecycle greenhouse-gas emissions from domestic maritime by 2050, with interim ambitions of at least a 30% reduction by 2030 and 80% by 2040 relative to 2008. Domestic maritime is also entering the UK Emissions Trading Scheme, while offshore ships meeting the relevant threshold are scheduled for inclusion from January 2027.

The strategic direction for Grimsby should therefore be:

Measure → Optimise → Electrify → Integrate → Decarbonise

4.1 Gap Analysis Methodology

A consultancy-style gap assessment has been undertaken by comparing the current strategic position identified for the Grimsby Hub against the emerging industry best practice established in Section 2.

Five assessment criteria are used.

Table 4.1 – Recommendation Assessment Criteria

Criterion	Weighting	Assessment Question
Carbon Reduction	30%	How significantly could the intervention reduce operational emissions?
Operational Benefit	25%	Does the intervention improve reliability, productivity or asset availability?

Implementation Feasibility	15%	How easily could the intervention be deployed at Grimsby?
Cost Attractiveness	15%	Is the intervention likely to offer favourable whole-life economics?
Strategic Alignment	15%	Does the measure support long-term RWE O&M requirements?

Each intervention is provisionally scored between:

1 – Very Low

2 – Low

3 – Moderate

4 – High

5 – Very High

These scores represent a **strategic screening exercise rather than a final investment appraisal**. Final recommendations should be recalculated using actual RWE energy, vessel, cost and operational data.

4.2 Strategic Gap Assessment

Table 4.2 – Industry Best Practice vs. Grimsby Opportunity

Theme	Industry Direction	Grimsby Strategic Position	Principal Gap / Opportunity
Energy Data	Integrated real-time monitoring	Requires verification	Establish comprehensive energy baseline
Renewable Energy	Solar PV + storage	Requires feasibility assessment	On-site generation opportunity
Building Controls	Integrated BEMS	Requires verification	Optimisation before major retrofit
Marine Logistics	Data-driven scheduling	Strong digital foundation through CCR	Integrate sustainability into scheduling
Shore Power	Increasing industry interest	Deep-water vessel capability	Assess electrical and commercial feasibility
Port Plant	Progressive electrification	Current fleet requires review	Replace equipment at natural renewal points

Vehicle Fleet	EV transition	Current fleet requires review	Smart charging and phased EV conversion
Waste	Circular procurement	Conventional management requires assessment	Move from recycling towards prevention
Warehousing	Shared digital inventory	Consolidated Hub provides strong platform	Reduce duplicate/obsolete inventory
Water	Smart monitoring/reuse	Lower strategic impact	Targeted efficiency interventions
Alternative Vessel Fuels	Emerging	Technology pathway uncertain	Maintain infrastructure optionality

The gap analysis indicates that Grimsby is not necessarily constrained by a lack of individual sustainability technologies. Instead, the most important opportunity is to **integrate operational datasets and infrastructure decisions into a common O&M sustainability strategy**.

The existence of RWE's CCR provides an especially valuable platform. RWE states that the control room provides 24/7 services including marine coordination, turbine operations, alarm management, high-voltage monitoring and emergency response. This creates the possibility of extending an existing digital capability into energy, logistics and carbon optimisation rather than constructing an entirely separate sustainability management architecture.

4.3 Recommendation Portfolio

The following twelve recommendations have been identified.

Table 4.3 – Recommended Improvement Portfolio

ID	Recommendation	Type	Indicative Priority
R1	Site-wide metering and sustainability dashboard	Operational	**Immediate**
R2	Marine and vessel logistics optimisation	Operational	**Immediate**
R3	Solar photovoltaic generation	Infrastructure	**High**
R4	Battery Energy Storage System	Infrastructure	**High**
R5	Shore-power feasibility and phased deployment	Strategic Infrastructure	**Critical Study**

R6	Port equipment electrification	Infrastructure	**High**
R7	Fleet electrification and smart charging	Operational / Infrastructure	**High**
R8	BEMS and HVAC optimisation	Operational	**Quick Win**
R9	Low-carbon heating strategy	Infrastructure	**Medium**
R10	Circular procurement and shared inventory	Operational	**High**
R11	Water efficiency and rainwater reuse	Operational	**Medium–Low**
R12	Alternative-fuel vessel readiness	Strategic	**Long-Term**

4.4 R1 – Site-Wide Metering and Sustainability Dashboard

Recommendation

Develop an integrated environmental and operational data platform covering electricity, heating fuels, vessel activity, fleet fuel, waste, water and on-site renewable generation.

This intervention should be considered the **foundation recommendation** because the value of most subsequent investments depends upon having an accurate operational baseline.

The first stage should establish 12–24 months of historic consumption where available and introduce additional sub-metering where major loads cannot currently be separated.

Relevant electrical loads could include:

- offices;
- CCR;
- warehouses;
- workshops;
- HVAC;
- EV charging;
- external lighting;
- future shore-power connections.

Fuel monitoring should separately identify buildings, vehicles, mobile plant and vessels wherever data availability permits.

Recommended Management Dashboard

KPI	Unit	Reporting Frequency
Electricity Consumption	kWh/month	Monthly
Energy Intensity	kWh/m²/year	Quarterly
Electricity per Offshore Capacity Supported	kWh/MW	Quarterly
Scope 1 Emissions	tCO_2e	Monthly
Scope 2 Emissions	tCO_2e	Monthly
Vessel Fuel	litres / operating hour	Monthly
Vessel Emissions	$kgCO_2e$ / mission	Monthly
Waste Reused/Recycled	%	Monthly
Water Consumption	m³/FTE	Monthly
EV Charging	kWh	Monthly

Rationale

Management cannot effectively optimise resources that are not measured consistently. The dashboard would provide RWE with a single evidence base for identifying abnormal consumption, establishing targets and subsequently verifying whether sustainability investments deliver the expected benefits.

Priority

Immediate – 0–12 months

Management Insight

The first sustainability investment should be information, not infrastructure. A robust performance baseline reduces the risk of investing capital in interventions that appear attractive but provide limited measurable benefit.

4.5 R2 – Marine and Vessel Logistics Optimisation

Recommendation

Use the existing digital capabilities of the Grimsby Hub and CCR to progressively integrate vessel movements, technician requirements, turbine condition, weather windows, inventory availability and maintenance scheduling.

Marine logistics should be prioritised because vessel movements represent a potentially significant operational cost and carbon source.

The objective should be to reduce:

- unnecessary vessel mobilisation;
- aborted missions;
- vessel waiting time;
- inefficient routing;
- reactive maintenance journeys;
- partially utilised transfers.

Digital O&M technologies can reduce the need for unnecessary offshore interventions. For example, ORE Catapult has demonstrated digital and remote-inspection approaches that improve operational planning and can reduce the requirement for technicians to travel offshore.

Table 4.4 – Marine Optimisation Opportunities

Intervention	Efficiency Benefit	Sustainability Benefit
Weather-integrated scheduling	Fewer aborted missions	Reduced fuel consumption
Predictive maintenance	Earlier fault identification	Fewer reactive journeys
Vessel utilisation tracking	Higher load factor	Reduced journeys
Inventory integration	Correct parts available first time	Reduced repeat mobilisation
Technician scheduling	Improved utilisation	Reduced transport requirements
Route optimisation	Reduced journey time	Reduced marine fuel

Priority

Immediate / High

This recommendation is particularly attractive because it builds upon infrastructure already present within the Grimsby Hub rather than requiring significant additional physical infrastructure.

4.6 R3 – Rooftop Solar Photovoltaic Generation

Recommendation

Undertake a detailed technical and commercial assessment of solar photovoltaic (PV) generation across suitable warehouse, workshop and office roof areas.

The assessment should consider:

- roof area;
- orientation;
- shading;
- structural loading;
- annual electricity consumption;
- half-hourly electricity demand;
- export constraints;
- self-consumption;
- maintenance accessibility;
- electrical connection requirements.

Solar PV is particularly valuable where daytime generation corresponds with building, workshop, charging and operational electrical demand.

Indicative Decision Framework

Factor	Preferred Condition
Daytime Baseload	High
Roof Availability	Large/unshaded
Self-Consumption	High
Grid Export Requirement	Low
Roof Remaining Life	Long
Electrical Integration	Straightforward

The objective should not necessarily be to maximise the installed MW of solar capacity. Instead, system size should be optimised against **site demand and self-consumption**.

Priority

Near Term – 1–3 years

4.7 R4 – Battery Energy Storage System (BESS)

Recommendation

Evaluate battery storage alongside solar PV, future EV charging requirements and critical operational loads.

Battery storage should not be considered solely as a renewable-energy technology. At an O&M hub it may provide several potential services:

- solar energy shifting;
- peak-demand reduction;
- resilience;
- critical-load support;
- EV charging management;
- future shore-power demand management.

The strategic importance of electrical flexibility is likely to increase as industrial operations electrify. UK government analysis similarly identifies electrification, low-carbon electricity and on-site generation as central elements of industrial decarbonisation.

Table 4.5 – Potential BESS Value Streams

Function	Potential Benefit
Solar Storage	Increased self-consumption
Peak Shaving	Lower maximum demand
Resilience	Critical-load support
Smart EV Charging	Reduced grid peaks
Future Shore Power	Demand management
Energy Tariff Optimisation	Potential electricity cost reduction

Critical Requirement

A BESS business case **cannot be developed accurately from annual electricity consumption alone**. Half-hourly load data and tariff information are required.

Priority

Near–Medium Term – subject to load-profile study

4.8 R5 – Shore Power

Recommendation

Conduct a detailed shore-power feasibility study for vessels using the Grimsby Hub.

Shore power enables compatible vessels to obtain electricity from the landside network while berthed rather than relying entirely on onboard generation.

The UK government is actively promoting maritime decarbonisation and port infrastructure innovation. Its current Maritime Decarbonisation Strategy targets major reductions in lifecycle maritime emissions, while UK SHORE is receiving £448 million of clean-maritime R&D investment between 2026 and 2030, including support intended to accelerate zero-emission vessels and associated infrastructure.

Grimsby is particularly relevant because RWE specifically identifies its deep-water quayside as suitable for SOV operations.

Shore-Power Feasibility Framework

Technical

- Vessel compatibility
- Connection voltage
- Frequency
- Power demand
- Cable management
- Berth configuration
- Network capacity
- Transformer requirements

Operational

- Vessel berth hours
- Frequency of vessel visits
- Berth occupancy
- Vessel operating patterns
- Future fleet requirements

Financial

- CAPEX
- Electricity tariff
- Avoided vessel fuel
- Maintenance savings
- Carbon cost
- Infrastructure lifetime

Environmental

- CO_2e reduction
- NO_x reduction
- particulate reduction
- noise reduction

Table 4.6 – Shore Power Business Case Logic

Condition	Effect on Business Case
High vessel berth utilisation	Strongly Positive
High auxiliary fuel consumption	Positive
Low-carbon electricity	Positive
Existing electrical capacity	Strongly Positive
Major grid reinforcement required	Negative
Limited vessel compatibility	Negative

Regulatory Relevance

The UK ETS is expanding into domestic maritime. The current policy introduces domestic maritime from July 2026 for vessels meeting the specified threshold, while offshore ships are scheduled to enter from January 2027. The initial threshold is 5,000 GT and is due to be reviewed in 2028.

Not every vessel operating from Grimsby will necessarily fall within the current threshold; nevertheless, the wider direction of regulation strengthens the strategic case for understanding and reducing vessel emissions.

Priority

Critical feasibility study; investment subject to findings

Management Insight

Shore power may offer one of the largest port-side decarbonisation opportunities available to Grimsby, but it is also one of the easiest interventions to over-specify. Investment should be driven by real vessel berth profiles and electrical demand rather than by technology availability alone.

4.9 R6 – Electrification of Port Equipment

Recommendation

Develop a phased programme to replace diesel-powered landside equipment with electric alternatives where operational requirements permit.

Potential assets include:

- forklifts;
- telehandlers;
- small cranes;
- utility vehicles;
- mobile maintenance equipment.

Electrification should primarily occur at **natural asset replacement points** rather than through premature disposal of serviceable plant, unless a clear carbon or financial business case demonstrates otherwise.

Table 4.7 – Equipment Replacement Hierarchy

Equipment Category	Electrification Priority
Warehouse Forklifts	Very High
Utility Vehicles	High

Light Vans	High
Telehandlers	Medium
Mobile Cranes	Medium–Low
Specialist Heavy Plant	Case Specific

The transition should be coordinated with the site's wider electrical strategy because fleet electrification, battery storage and shore power may collectively place significant additional demand on local electrical infrastructure.

Priority

1–5 years, aligned to fleet renewal

4.10 R7 – Vehicle Fleet Electrification and Smart Charging

Recommendation

Transition suitable RWE operational vehicles towards battery-electric alternatives and develop smart managed charging infrastructure.

The suitability of individual vehicles should be evaluated according to:

- daily mileage;
- duty cycle;
- payload;
- towing requirement;
- overnight dwell time;
- charging availability;
- emergency-response requirements.

Vehicles with predictable daily utilisation and extended overnight dwell periods are likely to offer the strongest initial candidates.

Charging Principle

Rather than allowing all vehicles to charge simultaneously at maximum power, smart charging should distribute electricity according to:

vehicle requirement + departure time + site demand + electricity price + renewable availability.

This becomes increasingly valuable if solar PV and BESS are installed.

Priority

Near Term

4.11 R8 – BEMS and HVAC Optimisation

Recommendation

Review existing Building Energy Management System operation before undertaking major HVAC replacement.

Potential low-capital interventions include:

- occupancy schedules;
- temperature set-point optimisation;
- overnight setback;
- zone control;
- ventilation scheduling;
- simultaneous heating/cooling identification;
- sensor calibration;
- weather compensation.

The principle should be:

Optimise first → retrofit second → replace third.

This avoids replacing equipment where poor control rather than poor technology is responsible for excessive consumption.

The assessment should distinguish between newer and legacy areas of the Hub because building age and systems may differ.

Priority

Quick Win – 0–18 months

4.12 R9 – Low-Carbon Heating Strategy

Recommendation

Develop a long-term pathway for transitioning remaining fossil-fuel heating towards lower-carbon alternatives where technically and economically appropriate.

Potential technologies include:

- air-source heat pumps;
- variable refrigerant systems;
- heat recovery;
- electric heating for low-demand spaces.

UK policy continues to promote heat pumps and building electrification as part of building decarbonisation, with UK heat-pump deployment increasing significantly during 2025.

However, heat pumps should not simply replace boilers on a like-for-like basis without first examining:

- building heat loss;
- distribution temperatures;
- ventilation demand;
- operating schedules;
- available electrical capacity.

Reducing heat demand through fabric and control optimisation may reduce the required heat-pump capacity and consequently improve economics.

Priority

Medium Term

4.13 R10 – Circular Procurement and Shared Inventory

Recommendation

Move waste strategy progressively upstream from recycling towards **material prevention, reuse and inventory optimisation**.

The consolidated nature of the Grimsby Hub creates an opportunity to investigate whether spare parts, specialist tools or consumables can be shared across projects where technically permissible.

The following hierarchy is recommended:

Prevent

Reduce unnecessary procurement and packaging.

Reuse

Introduce reusable transport containers and supplier return systems.

Repair

Prioritise component refurbishment where technically acceptable.

Share

Avoid duplicate inventories where compatibility exists.

Recycle

Maintain high-quality segregated recycling.

Dispose

Use only where higher-value recovery routes are unavailable.

Table 4.8 – Circular Economy Opportunities

Initiative	Cost Benefit	Environmental Benefit
Reusable Packaging	Medium	Medium
Supplier Take-Back	Medium	High
Shared Spare Inventory	High	High
Component Refurbishment	High	High
Digital Stock Monitoring	High	Medium
Obsolescence Reporting	Medium	Medium

Management Insight

For a consolidated O&M hub, inventory efficiency can deliver a sustainability benefit and a working-capital benefit simultaneously. Reducing unnecessary stock also reduces manufacturing, transport, storage and eventual disposal requirements.

Priority

Immediate / Near Term

4.14 R11 – Water Efficiency and Rainwater Reuse

Recommendation

Treat water as a secondary sustainability priority and focus investment on low-cost efficiency measures unless site data reveal unusually high consumption.

Recommended actions include:

- leak detection;
- smart water metering;
- efficient sanitary fittings;
- assessment of rainwater harvesting;
- efficient washdown systems;
- surface-water management.

Rainwater harvesting should be considered particularly where large roof areas coincide with consistent non-potable demand.

However, given the relative environmental impacts identified in Section 2, water interventions should not displace investment from higher-impact areas such as marine fuel and energy infrastructure.

Priority

Medium–Low

4.15 R12 – Alternative-Fuel and Zero-Emission Vessel Readiness

Recommendation

Maintain strategic infrastructure flexibility for future vessel technologies rather than selecting a single alternative fuel prematurely.

Potential future solutions include:

- battery-electric propulsion;
- hybrid propulsion;
- methanol;
- hydrogen;
- other low-carbon fuels.

The UK government's clean-maritime programme continues to fund development and commercial demonstration of emerging vessel and infrastructure technologies, confirming that the technology landscape remains under active development rather than fully mature.

The appropriate recommendation for Grimsby is therefore **technology readiness rather than immediate fuel commitment**.

Future port infrastructure decisions should consider:

- electrical capacity;
- available quay space;
- safety zones;
- fuel storage implications;
- modularity;
- future connection requirements.

Priority

Strategic / Long Term

4.16 Multi-Criteria Decision Analysis

The recommendations have been provisionally scored using the methodology established in Section 4.1.

Table 4.9 – Provisional Recommendation Ranking

Rank	Intervention	Weighted Score / 5	Recommendation
1	Marine / vessel digital optimisation	**4.55**	Proceed
2	Site-wide metering & sustainability dashboard	**4.10**	Proceed
3	Shore-power feasibility & phased deployment	**3.85**	Detailed study
4	Port equipment electrification	**3.70**	Phased implementation
5	Alternative-fuel vessel readiness	**3.55**	Maintain strategic option
6	Solar PV	**3.45**	Detailed feasibility
7	Fleet electrification	**3.45**	Phased implementation
8	Battery energy storage	**3.40**	Assess with PV/grid strategy
9	BEMS/HVAC optimisation	**3.30**	Quick win
10	Circular procurement & reusable packaging	**3.30**	Proceed
11	Low-carbon heating	**3.15**	Medium-term study
12	Water efficiency / rainwater reuse	**2.30**	Selective implementation

The ranking should **not** be interpreted purely as a sequence of spending.

For example, shore power scores highly due to its potential environmental and strategic value, but requires significantly more technical investigation than a BEMS optimisation exercise. Conversely, HVAC optimisation scores lower overall but could potentially be implemented much faster.

The portfolio should therefore be separated into **quick wins, enabling projects and strategic investments**.

4.17 Impact vs. Complexity Matrix

Table 4.10 – Portfolio Positioning

	Lower Complexity	**Higher Complexity**
High Impact	Marine logistics optimisation; sustainability dashboard; solar PV; fleet electrification	Shore power; BESS; port-equipment electrification
Moderate Impact	BEMS optimisation; circular procurement	Heat-pump conversion
Lower Impact	Water monitoring; efficient fittings	Major water-reuse infrastructure

QUICK WINS

0–18 months

- Metering and sustainability dashboard
- BEMS optimisation
- Waste-data improvement
- Circular procurement
- Vessel-utilisation analysis
- Fleet telematics

ENABLING INVESTMENTS

1–3 years

- Solar PV
- EV charging
- Fleet electrification
- BESS feasibility
- Port-equipment electrification
- Enhanced digital logistics integration

STRATEGIC INFRASTRUCTURE

3–10+ years

- Shore power

- Major grid reinforcement
- Alternative-fuel vessel infrastructure
- Large-scale port electrification
- Integrated energy microgrid

4.18 Recommended Integrated Energy Architecture

The individual energy recommendations should ultimately be treated as one integrated system.

A possible future architecture is:

Grid Supply

↓

Site Energy Management System

↙ ↓ ↘

Solar PV — BESS — Building Loads

↓ ↓ ↓

EV Fleet — Port Equipment — Shore Power

This approach provides several potential efficiencies.

For example, solar electricity could supply normal building loads during daylight periods, while excess electricity could charge batteries or vehicles. Battery storage could subsequently reduce peak demand caused by simultaneous fleet or vessel charging.

Consequently, investing in each technology independently could result in oversized equipment or unnecessary grid reinforcement.

Management Insight

The principal infrastructure recommendation is integration. Solar PV, batteries, EV charging, port electrification and shore power should be assessed as components of a future Grimsby energy system rather than as unrelated capital projects.

4.19 Recommended Marine Decarbonisation Hierarchy

Vessel decarbonisation should similarly follow a hierarchy.

Stage 1 – Avoid

Can the journey be eliminated using remote diagnostics?

Stage 2 – Optimise

Can several tasks be completed during one mobilisation?

Stage 3 – Reduce

Can routing, speed or vessel utilisation be improved?

Stage 4 – Electrify

Can berth operations or short-duration propulsion use electricity?

Stage 5 – Change Fuel

Does the remaining energy requirement justify an alternative fuel?

This hierarchy prevents the project from immediately focusing on expensive new propulsion technologies while overlooking lower-cost operational savings.

4.20 Financial Appraisal Framework

Before RWE commits capital expenditure, each major recommendation should progress through a consistent business-case framework.

Table 4.11 – Investment Appraisal Requirements

Category	Metric
Capital Cost	£
Annual Operating Saving	£/year
Energy Saving	kWh/year
Fuel Saving	litres/year
Carbon Reduction	tCO_2e/year
Simple Payback	years
Net Present Value	£

Internal Rate of Return	%
Asset Life	years
Operational Availability Benefit	hours/year or £
Implementation Risk	Low / Medium / High

A conventional simple-payback calculation can be expressed as:

[

\text{Simple Payback}=

\frac{\text{Initial Capital Cost}}

{\text{Annual Financial Saving}}

]

However, simple payback should not be the only investment criterion for strategic infrastructure.

Measures such as shore power may deliver value through:

- carbon reduction;
- future regulatory compliance;
- improved air quality;
- reduced vessel maintenance;
- reduced noise;
- infrastructure readiness;
- corporate sustainability objectives.

A multi-criteria business case is therefore more appropriate.

4.21 Carbon Abatement Assessment

Each recommendation should also be evaluated using the cost of carbon abatement:

[

\text{Carbon Abatement Cost}

\frac{\text{Whole-Life Net Cost}}

{\text{Lifetime tCO_2e Avoided}}

]

This allows different interventions to be compared on a common basis.

An intervention that costs £500,000 but eliminates large quantities of marine fuel may potentially offer better environmental value than a £100,000 intervention producing relatively small building-energy savings.

This reinforces one of the central findings of the current-state assessment:

Investment value should be measured by outcome, not simply by capital cost.

4.22 Recommended Implementation Roadmap

Phase 1 – Establish the Baseline

0–12 months

1. Gather 12–24 months of utility and fuel data.
2. Install priority sub-metering.
3. Establish sustainability KPIs.
4. Introduce management dashboard.
5. Map vessel movements and fuel consumption.
6. Complete fleet and equipment inventory.
7. Undertake waste and travel audits.
8. Optimise existing BEMS.

Primary objective: Understand where resources are currently consumed.

Phase 2 – Optimise Existing Operations

6–24 months

1. Integrate vessel and maintenance scheduling.
2. Improve fleet telematics.
3. Implement circular procurement.
4. Optimise warehousing and inventory.
5. Expand smart controls.
6. Improve EV charging provision.
7. Identify low-cost building improvements.

Primary objective: Reduce consumption before installing major new infrastructure.

Phase 3 – Electrify

1–5 years

1. Install viable solar PV.
2. Transition suitable fleet vehicles.
3. Replace suitable diesel plant with electric alternatives.
4. Introduce BESS where commercially justified.
5. Progress low-carbon heating.
6. Upgrade electrical infrastructure where required.

Primary objective: Shift operational energy demand from fossil fuels towards electricity.

Phase 4 – Integrate

3–7 years

1. Coordinate PV, BESS, EV and plant charging.
2. Develop advanced energy-management controls.
3. Integrate energy and operational data with the wider Hub.
4. Progress shore-power infrastructure if viable.

Primary objective: Operate Grimsby as an integrated smart-energy O&M hub.

Phase 5 – Strategic Decarbonisation

5–15+ years

1. Support next-generation vessels.
2. Expand shore-power capability.
3. Prepare for alternative marine fuels.
4. Continue digital automation.
5. Target progressively lower operational carbon intensity.

Primary objective: Maintain Grimsby's competitiveness as offshore wind O&M technology evolves.

4.23 Recommended Governance Structure

Technology alone will not deliver the required improvement. A clear governance structure should support implementation.

Table 4.12 – Suggested Governance Responsibilities

Responsibility	Function
Senior Sponsor	Strategic oversight
O&M Management	Operational requirements
Facilities Management	Buildings and utilities
Marine Coordination	Vessel operations
Procurement	Circular economy and suppliers
Sustainability	Carbon reporting and targets
Finance	Investment appraisal
Engineering	Technical feasibility
Data / Digital	Analytics and system integration

Quarterly performance reviews could assess progress against the sustainability dashboard established under Recommendation R1.

4.24 Proposed Management Dashboard

Grimsby O&M Sustainability Scorecard

Theme	KPI	Baseline	Target	Management Status
Energy	kWh/MW supported	TBC	TBC	◯
Buildings	kWh/m^2	TBC	TBC	◯
Marine	litres fuel/mission	TBC	TBC	◯
Marine	$kgCO_2e$/technician transfer	TBC	TBC	◯
Fleet	% electric	TBC	TBC	◯
Renewable Energy	% onsite generation	TBC	TBC	◯
Waste	% reused/recycled	TBC	TBC	◯
Water	m^3/FTE	TBC	TBC	◯
Logistics	Avoided vessel journeys	TBC	TBC	◯
Carbon	Operational tCO_2e	TBC	TBC	◯

◯ **Baseline required**

● **On target**

● **Intervention required**

● **Significant deviation**

4.25 Strategic Risk Assessment

Table 4.13 – Key Risks

Risk	Likelihood	Impact	Recommended Mitigation
Insufficient grid capacity	Medium	High	Early electrical capacity study
Technology selected too early	Medium	High	Technology-neutral infrastructure planning
Capital investment underperforms	Medium	High	Data-led business case
Vessel incompatibility with shore power	Medium	High	Fleet compatibility assessment
Increasing marine carbon costs	High	Medium–High	Vessel efficiency programme
Additional electrical demand exceeds forecast	Medium	High	Integrated energy modelling
Poor-quality sustainability data	High	Medium	Sub-metering/dashboard
Operational disruption during retrofit	Medium	Medium	Phase installation around O&M requirements

4.26 Strategic Opportunity Statement

The assessment indicates that RWE has an opportunity to develop Grimsby beyond the conventional definition of an offshore wind O&M base.

The existing Hub already combines operational teams, specialist functions, deep-water port access and a 24/7 Centralised Control Room. These characteristics provide a foundation for a more integrated operating model in which buildings, vessels, inventory, energy and maintenance data are considered as elements of the same system.

The strategic opportunity can therefore be summarised as:

From an O&M Base → to an Integrated Smart O&M Hub

Under such a model, the facility would not simply consume resources required to service offshore wind farms. Instead, operational data could continuously inform decisions about energy consumption, vessel deployment, technician movements, spare-parts availability and infrastructure utilisation.

This concept is consistent with the wider direction of digital offshore wind O&M, where AI, remote monitoring and digital twins are increasingly being developed to improve operational decision-making and asset performance.

4.27 Final Recommendations

The analysis identifies **five principal recommendations for RWE management**.

Priority 1 – Establish a measurable baseline

Without reliable energy, vessel, waste and transport data, investment performance cannot be demonstrated accurately.

Priority 2 – Target marine operations

Marine logistics potentially provide substantially greater sustainability value than incremental improvements to already-efficient office systems.

Priority 3 – Optimise before replacing

Digital scheduling, BEMS optimisation and improved asset utilisation should precede expensive technological substitution.

Priority 4 – Electrify as an integrated system

PV, batteries, EV charging, port equipment and shore power should form part of one long-term electrical infrastructure strategy.

Priority 5 – Maintain future flexibility

Alternative maritime technologies are evolving rapidly. Infrastructure decisions should preserve optionality rather than lock Grimsby prematurely into a single vessel-fuel pathway.

4.28 Overall Conclusion

The gap analysis demonstrates that improving the sustainability of the RWE Grimsby Hub does not require a single transformative technology. Instead, the strongest pathway is a coordinated portfolio of operational, digital and infrastructure interventions implemented over different time horizons.

In the immediate term, emphasis should be placed on establishing robust resource baselines, improving digital marine logistics, optimising buildings and strengthening circular procurement. These measures offer relatively low implementation risk and can provide the evidence required for subsequent capital investment.

In the near to medium term, solar PV, battery storage, fleet electrification and port-equipment electrification should be assessed as part of an integrated site-energy strategy. Shore power warrants particular investigation because the Hub's deep-water capability and increasing role in SOV operations could make vessel-at-berth decarbonisation strategically significant. RWE's own rationale for the Grimsby location highlights the importance of deep-water access for SOVs supporting offshore projects further from shore.

Longer-term strategy should retain sufficient infrastructure flexibility to accommodate future battery-electric, hybrid and alternative-fuel vessels as maritime technology develops. This is particularly relevant given the UK's tightening maritime decarbonisation policy, expansion of carbon pricing into shipping and substantial public investment in clean-maritime R&D.

The principal conclusion is therefore that **efficiency and sustainability should not be treated as competing objectives**. Within offshore wind O&M, many of the highest-value sustainability measures—reduced vessel mobilisation, improved inventory management, smarter energy consumption and greater equipment utilisation—also directly support lower operating costs and improved operational performance.

For RWE, Grimsby provides an opportunity to demonstrate how a modern offshore wind O&M Hub can evolve from a collection of buildings and port assets into an integrated, data-driven operational system.

4.29 Management Summary

Recommendation	Carbon	Operational Value	Complexity	Recommended Action
Marine Logistics Optimisation	High	Very High	Low–Medium	**Proceed**
Sustainability Dashboard	Medium	Very High	Low	**Proceed immediately**
Solar PV	Medium–High	Medium	Medium	**Feasibility study**
Battery Storage	Medium–High	High	Medium	**Integrate with energy study**
Shore Power	Very High	High	High	**Detailed feasibility study**
Port Electrification	High	High	Medium	**Phased implementation**
EV Fleet	Medium	Medium	Low–Medium	**Implement through renewal**
BEMS Optimisation	Low–Medium	Medium	Low	**Quick win**
Low-Carbon Heating	Medium	Medium	Medium	**Medium-term strategy**
Circular Procurement	Medium	High	Low	**Proceed**
Water Efficiency	Low	Low–Medium	Low	**Selective implementation**
Future Vessel Fuels	Very High	High	Very High	**Monitor / retain optionality**

References

Department for Transport (2025) *Maritime Decarbonisation Strategy*. London: Department for Transport.

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RWE (2025) *RWE Opens Cutting-Edge Offshore Wind Operations and Maintenance Facility at the Port of Grimsby*. RWE Offshore Wind.

UK Emissions Trading Scheme Authority (2025) *UK ETS Scope Expansion: Domestic Maritime – Main Authority Response*. London: UK Government.

Section 5 – Calculation Methodology

For a management-facing consultancy report, I would remove most of the displayed equations from Section 5. They make the section look more like an engineering textbook than an RWE decision-support report. The calculations can still be undertaken later in Excel or an appendix, while the main report explains **what will be calculated, which inputs are required, and what the result means for management**.

The following content can replace the calculation-heavy parts of Section 5.

5.3 Carbon Assessment Methodology

The environmental performance of each intervention should be assessed against a consistent operational carbon baseline. Electricity, fuel, vehicle mileage and other activity data should be converted into greenhouse-gas emissions using the most recent UK Government greenhouse-gas conversion factors applicable to the reporting year.

For electricity-related interventions, the assessment should compare the site's electricity consumption before and after implementation. For fuel-consuming equipment, vessels and vehicles, annual fuel consumption should be compared with the anticipated consumption following the intervention. Where diesel-powered assets are replaced with electric alternatives, the assessment must account for both the fuel emissions avoided and the additional electricity consumed.

This distinction is important because electrification should not automatically be regarded as zero carbon. Its environmental value depends upon the amount of fossil fuel displaced, the efficiency of the replacement technology and the carbon intensity of the electricity supplying it.

Table 5.3A – Carbon Assessment Inputs

Intervention	Baseline Data Required	Post-Intervention Data	Primary Output
Solar PV	Grid electricity consumption	PV generation and grid imports	Annual tCO_2e avoided

Fleet EVs	Diesel/petrol consumption	EV charging electricity	Annual tCO_2e avoided
Electric Port Plant	Equipment fuel consumption	Electrical demand	Annual tCO_2e avoided
Heat Pumps	Existing heating fuel	Heat-pump electricity	Annual tCO_2e avoided
Shore Power	Vessel auxiliary fuel	Shore electricity demand	Annual tCO_2e avoided
Marine Optimisation	Vessel fuel baseline	Post-optimisation fuel	Annual tCO_2e avoided

The principal environmental output for management should therefore be reported as **tonnes of CO_2 equivalent avoided per year**, supplemented where appropriate by reductions in local pollutants such as nitrogen oxides, sulphur oxides and particulate matter.

5.4 Solar Photovoltaic Feasibility

5.4.2 Energy Performance

The potential output from a solar photovoltaic system should be determined using specialist solar modelling software based on the available roof area, panel orientation, inclination, shading and expected system losses.

The analysis should then compare annual solar generation with the Grimsby Hub's half-hourly electrical demand. This is more informative than considering total annual electricity consumption alone because it identifies how much generated electricity can be consumed directly on site.

Three outputs should be presented to RWE management:

Solar PV Metric	Purpose
Annual Generation (MWh/year)	Establish total renewable electricity production
Self-Consumption (%)	Identify how much solar energy can be used on site
Grid Export (%)	Identify surplus generation
Site Electricity Offset (%)	Demonstrate reduction in purchased electricity

Annual Carbon Saving (tCO_2e/year)	Quantify environmental benefit
Annual Financial Saving (£/year)	Quantify commercial benefit

A system with a slightly smaller installed capacity but a high level of self-consumption may provide a stronger business case than a larger installation that exports significant quantities of electricity.

5.4.3 Environmental Assessment

Solar PV should be assessed according to the quantity of grid electricity it displaces rather than simply the size of the installed system.

The environmental assessment should therefore identify:

- annual renewable electricity generated;
- proportion consumed within the Hub;
- proportion exported;
- reduction in purchased grid electricity;
- associated annual carbon reduction;
- expected lifetime carbon reduction.

Future grid decarbonisation should also be recognised. As UK grid electricity becomes progressively lower carbon, the annual carbon saving attributable to solar PV may reduce over time even though the financial benefit from avoided electricity purchases remains.

5.4.4 Economic Assessment

The solar PV business case should compare installation and lifecycle costs against the financial value generated through reduced electricity purchases and, where applicable, exported electricity.

Table 5.4A – Solar PV Business Case

Cost / Benefit	Assessment Requirement

Initial Capital Cost	Panels, inverters, installation and electrical works
Annual Maintenance	Inspection, cleaning and servicing
Avoided Electricity Cost	Value of electricity consumed directly on site
Export Income	Value of surplus electricity exported
Replacement Costs	Inverters and other major lifecycle components
Asset Life	Expected operational period
Residual Value	If applicable

The preferred management outputs should be **annual financial saving, simple payback period, whole-life saving and Net Present Value**, rather than displaying the underlying equations in the main report.

5.5 Battery Energy Storage System

5.5.2 Environmental Assessment

Battery storage should not be assessed as an independent source of carbon reduction because batteries store rather than generate energy.

Its environmental benefit depends on how the system is operated. A battery charged using surplus solar generation may allow renewable electricity to be consumed later instead of importing grid electricity. Similarly, battery storage could potentially support high-power charging requirements while reducing site peak demand.

Conversely, a battery that repeatedly charges from and discharges back to the grid without a clear operational requirement may provide limited environmental benefit due to conversion losses.

The feasibility assessment should therefore model several operating scenarios.

Table 5.5A – Recommended BESS Scenarios

Scenario	Management Question
PV Self-Consumption	Can surplus solar electricity be retained on site?

Peak Shaving	Can maximum electrical demand be reduced?
EV Charging	Can vehicle charging demand be smoothed?
Port Plant Charging	Can high-power plant charging be accommodated?
Shore Power Support	Can vessel demand peaks be reduced?
Resilience	Can critical loads operate during short-duration interruptions?

The preferred battery configuration should be the option providing the strongest combination of operational resilience, financial return and carbon reduction.

5.5.3 Financial Assessment

The financial value of battery storage should be assessed across all potential services rather than relying on a single source of saving.

Relevant benefits may include:

- increased use of solar electricity;
- reduced peak-demand charges;
- charging during lower-cost electricity periods;
- avoidance or deferral of electrical network upgrades;
- improved resilience;
- optimisation of EV or port-equipment charging.

The economic model should compare these benefits with capital cost, battery degradation, replacement requirements, conversion losses and ongoing maintenance.

Management Output

RWE should be presented with three scenarios:

Low utilisation case – limited PV and charging demand.

Expected utilisation case – forecast site electrification.

High utilisation case – significant future EV, equipment and shore-power demand.

This would demonstrate how sensitive the investment is to the future development of the Grimsby Hub.

5.6 Shore-Power Feasibility

5.6.2 Energy Assessment

The energy requirement for shore power should be established using actual vessel operational data rather than generic assumptions.

For each vessel class, the study should record:

- average electrical demand while berthed;
- maximum electrical demand;
- hours spent alongside;
- number of annual port calls;
- auxiliary-engine fuel consumption while berthed;
- vessel compatibility with shore connections.

This information can then be used to estimate the annual shore electricity requirement and the quantity of marine fuel that could potentially be displaced.

Table 5.6A – Shore-Power Performance Outputs

KPI	Management Purpose
Vessel Berth Hours/year	Establish infrastructure utilisation
Electricity Demand/Call	Determine connection requirement
Annual Shore Electricity	Determine site electrical impact
Marine Fuel Avoided	Determine operational saving
CO_2e Avoided	Determine environmental benefit
Fuel Cost Avoided	Determine commercial value
Electricity Cost	Determine operating cost
Net Annual Saving	Determine financial viability

5.6.3 Environmental Assessment

The environmental comparison should evaluate emissions generated by vessels operating auxiliary engines while berthed against emissions associated with supplying the same energy through shore electricity.

The assessment should report:

- greenhouse-gas reduction;
- nitrogen oxide reduction;
- particulate reduction;
- noise reduction;
- reduction in engine operating hours.

This provides RWE management with a broader assessment than carbon alone and reflects the potential local environmental benefits of shore power within a port environment.

5.6.4 Economic Assessment

The shore-power business case should consider both capital expenditure and vessel-side operational savings.

Table 5.6B – Shore-Power Financial Assessment

Capital Requirements	Operating Benefits
Transformer infrastructure	Reduced marine fuel consumption
Switchgear	Reduced auxiliary-engine hours
Electrical connection	Reduced engine maintenance
Cable management	Potential carbon-cost reduction
Civil works	Reduced local emissions
Vessel modifications	Potential future regulatory benefit

Rather than reporting only a payback period, the final assessment should present a **base case, low-utilisation case and high-utilisation case**, as berth occupancy and vessel compatibility are likely to have a major influence on economic performance.

5.7 Fleet Electrification

5.7.2 Economic Assessment

Fleet electrification should be evaluated using a whole-life cost comparison between existing internal-combustion vehicles and suitable electric alternatives.

The assessment should include:

Cost Category	Conventional Vehicle	Electric Vehicle
Purchase / Lease	✓	✓
Fuel / Electricity	✓	✓
Routine Maintenance	✓	✓
Vehicle Tax / Charges	✓	✓
Charging Infrastructure	—	✓
Residual Value	✓	✓
Replacement Period	✓	✓

The resulting management assessment should identify the **whole-life cost per vehicle**, rather than focusing only on the higher initial purchase price of an electric alternative.

5.7.3 Environmental Assessment

The carbon assessment should compare annual fuel emissions from the existing vehicle with the electricity-related emissions associated with charging the replacement EV.

Key outputs should include:

- annual vehicle mileage;
- fuel currently consumed;
- electricity required after replacement;
- annual carbon reduction;
- carbon reduction over the expected vehicle life.

Vehicles should then be ranked according to both financial attractiveness and carbon-saving potential.

5.8 Port Equipment Electrification

The assessment of cranes, forklifts, telehandlers and other port equipment should focus on operational duty rather than theoretical equipment specifications.

For each asset, RWE should record:

Metric	Purpose
Annual Operating Hours	Understand utilisation
Annual Idle Hours	Identify inefficiency
Fuel Consumption	Establish baseline
Maintenance Cost	Establish whole-life cost
Asset Age	Determine replacement timing
Peak Power Requirement	Assess electric suitability
Charging Opportunity	Assess practical operation

A high-utilisation diesel asset approaching the end of its service life would generally represent a stronger electrification candidate than a low-utilisation asset that has recently been purchased.

The final output should therefore classify equipment into:

Replace with electric at next renewal

Undertake detailed technology review

Retain existing equipment

rather than recommending blanket electrification.

5.9 BEMS, HVAC and Building Optimisation

Measurement and Verification

Building energy savings should be verified against a representative baseline rather than by comparing two raw annual consumption figures.

Energy demand can vary significantly due to:

- external temperature;
- workforce numbers;
- building occupancy;
- operational hours;
- changes in floor area;
- unusual maintenance activity.

The pre- and post-intervention comparison should therefore adjust for major changes in these variables.

Recommended Management KPIs

KPI	Desired Outcome
kWh/m²/year	Reduction
Heating Energy/m²	Reduction
Out-of-Hours Consumption	Reduction
HVAC Operating Hours	Reduction
Peak Electrical Demand	Reduction
Comfort Complaints	No deterioration

This ensures that energy savings are achieved without adversely affecting employee comfort or operational performance.

5.10 Low-Carbon Heating

The heat-pump assessment should be presented through an energy-balance comparison rather than mathematical equations in the report.

The existing heating system should first be characterised according to:

- annual fuel consumption;
- annual heat demand;
- building heat loss;
- winter peak demand;
- operating temperature;
- current heating-system efficiency.

A proposed heat-pump system should then be assessed for:

- estimated annual electricity consumption;
- required capacity;
- seasonal efficiency;
- impact on site peak electricity demand;
- carbon reduction;
- annual operating cost.

Table 5.10A – Heating Business-Case Comparison

Criterion	Existing Heating	Proposed Low-Carbon Heating
Annual Energy Use	TBC	TBC
Annual Operating Cost	TBC	TBC
Annual CO_2e	TBC	TBC
Maintenance Cost	TBC	TBC
Peak Electrical Demand	TBC	TBC
Expected Asset Life	TBC	TBC

This format is considerably more useful to management than displaying the thermodynamic calculation within the main body of the report.

5.11 Marine Logistics and Digital Optimisation

The value of marine optimisation should be quantified through operational performance indicators.

Recommended Baseline

RWE should establish:

- total vessel journeys per year;
- vessel operating hours;
- fuel consumed;
- aborted journeys;
- technician transfers;
- repeat maintenance visits;
- vessel waiting hours;
- maintenance tasks completed per mobilisation.

Performance should then be reassessed following optimisation.

Table 5.11A – Marine Optimisation Business Case

KPI	Baseline	Post-Optimisation	Improvement
Vessel Journeys	TBC	TBC	TBC
Fuel Consumption	TBC	TBC	TBC
Aborted Journeys	TBC	TBC	TBC
Waiting Hours	TBC	TBC	TBC
Technician Utilisation	TBC	TBC	TBC
First-Time-Fix Rate	TBC	TBC	TBC
Annual Vessel Cost	TBC	TBC	TBC
Annual CO_2e	TBC	TBC	TBC

The business case should capture more than fuel saving. Avoiding a vessel mobilisation may also reduce charter costs, technician hours and turbine downtime.

For this reason, marine optimisation may offer a substantially larger operational value than would be apparent from carbon savings alone.

5.12 Circular Procurement and Inventory

Rather than presenting a financial equation, circular procurement should be evaluated using a resource-value framework.

Table 5.12A – Circular Economy Value Assessment

Opportunity	Financial Value	Operational Value	Environmental Value
Avoided Procurement	Reduced purchasing cost	Lower stock requirement	Avoided embodied carbon
Shared Inventory	Reduced working capital	Greater asset utilisation	Reduced material demand
Component Refurbishment	Avoided replacement cost	Longer asset life	Reduced waste
Reusable Packaging	Reduced packaging purchases	Simplified logistics	Reduced waste
Supplier Take-Back	Reduced disposal costs	Simplified waste handling	Improved recycling
Obsolete Stock Reduction	Released warehouse space	Better inventory visibility	Avoided disposal

The final assessment should report:

- purchasing expenditure avoided;
- inventory value released;
- waste-disposal cost avoided;
- materials reused;
- waste prevented.

This demonstrates that circular economy improvements can generate both sustainability and working-capital benefits.

5.13 Water and Rainwater Harvesting

Rainwater-harvesting feasibility should be determined using three practical variables:

available roof collection area;

local rainfall;

non-potable water demand.

The system should only be sized to capture water that can realistically be used.

Table 5.13A – Water Feasibility Assessment

Metric	Required Data
Annual Mains Water Consumption	Utility records
Non-Potable Demand	Washdown/toilets/cleaning
Roof Collection Area	Building drawings
Local Rainfall	Meteorological data
Storage Requirement	System modelling
Mains Water Avoided	Model output
Annual Financial Saving	Tariff comparison

Where non-potable demand is relatively small, simple leak reduction and efficient fixtures may provide a stronger business case than a substantial rainwater-storage system.

5.15 Financial Decision Framework

The financial appraisal should remain rigorous, but the detailed equations can be relocated to an appendix or supporting spreadsheet.

Three primary financial measures are recommended.

Simple Payback Period

This measures how long it takes the accumulated annual savings from an intervention to recover the initial investment.

It is useful because it is intuitive and easy for management to interpret. However, it does not consider savings generated after the payback point or the time value of money.

Net Present Value (NPV)

NPV assesses the total financial value generated by an intervention across its full appraisal period, while recognising that future cash flows are worth less than immediate cash flows.

A **positive NPV** indicates that the investment is expected to create financial value under the assumptions used.

NPV should therefore be the preferred measure for comparing major infrastructure projects with different operating lives.

Internal Rate of Return (IRR)

IRR represents the effective return generated by the investment over its lifetime.

This allows sustainability projects to be compared with other competing capital investments within the organisation.

Table 5.15A – Recommended Financial Outputs

Metric	Management Question
CAPEX	What does the project cost initially?
Annual Saving	What does it save each year?
Simple Payback	How quickly is the investment recovered?
NPV	Does it create whole-life financial value?

IRR	What financial return does the project generate?
Asset Life	How long does the benefit continue?
Carbon Saving	What environmental benefit is delivered?

For an RWE management audience, these metrics should preferably be presented together rather than allowing a single short-term payback threshold to determine investment decisions.

5.16 Carbon Cost Effectiveness

Each project should also be assessed according to the amount of carbon reduction delivered for the investment made.

Rather than displaying the calculation, the report should rank recommendations using a **carbon-abatement cost** expressed in £ per tonne of CO_2 equivalent avoided.

Interpretation

Carbon Abatement Cost	Interpretation
Negative	Intervention saves money while reducing carbon
Low Positive	Cost-effective decarbonisation
Moderate Positive	May require strategic justification
High Positive	Lower financial efficiency; consider other benefits

This metric provides an important counterbalance to simple payback.

A high-capital marine intervention could potentially represent better environmental value than several smaller building interventions if it eliminates substantially larger quantities of fossil-fuel consumption.

5.17 Marginal Abatement Cost Curve

A Marginal Abatement Cost Curve should remain one of the principal management outputs; however, the report does not need to show the underlying calculation methodology.

The final chart should position each intervention according to:

Horizontal dimension – total lifetime carbon reduction

Vertical dimension – whole-life cost per tonne of carbon avoided

This enables RWE management to quickly identify:

- measures that save money and carbon;
- low-cost decarbonisation opportunities;
- capital-intensive strategic measures;
- interventions offering relatively poor carbon value.

Projects appearing below the zero-cost line would represent particularly attractive opportunities because they are expected to generate a net financial saving while reducing emissions.

5.18 Sensitivity Analysis

Rather than presenting a single investment result, each major business case should be assessed under three scenarios.

Table 5.18A – Scenario Framework

Scenario	Assumption
Conservative Case	Higher capital cost, lower utilisation and lower energy-price savings
Central Case	Most likely operating and market assumptions
Upside Case	Higher utilisation and stronger energy/fuel savings

The following variables should be tested where relevant:

- electricity price;
- marine fuel price;

- capital expenditure;
- vessel utilisation;
- berth occupancy;
- equipment operating hours;
- grid carbon intensity;
- discount rate;
- asset life.

The preferred recommendation should remain sufficiently attractive across a reasonable range of assumptions rather than relying upon a single optimistic forecast.

5.20 Recommended Detailed Studies

The feasibility work should therefore produce **management-ready business cases rather than stand-alone engineering calculations**.

Each detailed study should use a common summary page.

Table 5.20A – Standard RWE Investment Summary

Measure	Result
Proposed Intervention	—
Technical Feasibility	Low / Medium / High
CAPEX	£TBC
Annual Saving	£TBC
Carbon Saving	TBC tCO_2e/year
Simple Payback	TBC years
NPV	£TBC
IRR	TBC %
Operational Benefit	Low / Medium / High
Implementation Risk	Low / Medium / High
Recommended Decision	Proceed / Develop / Defer / Reject

This should become the standard format used to compare solar PV, BESS, shore power, fleet electrification, port plant and building improvements.

6. Implementation Strategy and Roadmap

Objective: To translate the technical, environmental and economic opportunities identified in Sections 4 and 5 into a practical implementation programme for the RWE Grimsby O&M Hub, balancing operational continuity, investment requirements, carbon reduction and long-term strategic value.

6.0 Executive Summary

The preceding assessment demonstrates that improving the efficiency and sustainability of the RWE Grimsby O&M Hub should not be approached as a collection of independent technology projects. The strongest outcome is likely to be achieved through a **phased implementation strategy** in which operational improvements are delivered first, followed by targeted electrification and then larger strategic infrastructure investment.

This approach reduces implementation risk and avoids committing capital before a sufficiently robust operational baseline has been established.

The recommended implementation hierarchy is:

Measure → Optimise → Electrify → Integrate → Decarbonise

The first stage focuses on improving visibility of current performance. Electricity, vessel fuel, equipment utilisation, waste, water and transport data should be consolidated into a common management framework. This enables RWE to understand where the greatest operational inefficiencies occur and establish measurable baselines against which future improvement can be demonstrated.

The second stage focuses on optimising existing operations. Opportunities such as Building Energy Management System optimisation, vessel scheduling, inventory management and circular procurement can potentially improve environmental performance without requiring substantial new infrastructure.

Once demand has been reduced and better understood, the third stage introduces electrification through technologies such as solar PV, electric fleet vehicles and electric port equipment. Battery storage and larger electrical upgrades should subsequently be developed as part of an integrated energy strategy.

The final stage addresses harder-to-abate marine emissions through shore power, next-generation vessel technologies and infrastructure capable of supporting future low-carbon marine fuels.

This phased approach provides RWE with a practical pathway from incremental operational efficiency towards a highly integrated and progressively lower-carbon O&M Hub.

6.1 Implementation Principles

Five principles should guide implementation.

Table 6.1 – Recommended Implementation Principles

Principle	Application to Grimsby
Data before CAPEX	Establish the baseline before committing major investment
Optimise before replacing	Improve existing asset performance before technology substitution
Electrify strategically	Coordinate all new electrical loads through one infrastructure plan
Protect operational availability	Sustainability improvements must not compromise O&M performance
Maintain technology flexibility	Avoid premature lock-in to uncertain future marine technologies

These principles are particularly important within offshore wind O&M because asset availability remains the primary operational objective. A sustainability intervention that introduces unacceptable reliability or maintenance risk would not represent an effective operational improvement.

Consequently, sustainability should be treated as part of the Hub's overall asset-management strategy rather than as a parallel environmental programme.

6.2 Programme Structure

A five-phase implementation programme is proposed.

Figure 6.1 – Grimsby Sustainability Transition

Phase 1

MEASURE

0–12 months

↓

Phase 2

OPTIMISE

6–24 months

↓

Phase 3

ELECTRIFY

1–5 years

↓

Phase 4

INTEGRATE

3–7 years

↓

Phase 5

DECARBONISE

5–15+ years

The phases intentionally overlap. For example, feasibility work for solar PV or shore power can begin while operational optimisation continues. The purpose of the framework is therefore not to establish rigid completion dates but to ensure that enabling work occurs before dependent investments.

6.3 Phase 1 – Measure

0–12 Months

The immediate priority should be establishing a verified operational baseline.

This phase requires relatively limited capital expenditure compared with later infrastructure projects but provides the information required to support almost every subsequent investment decision.

Priority Actions

1. Consolidate historic electricity and heating consumption.
2. Obtain half-hourly electricity data.
3. Review electrical sub-metering.
4. Establish vessel fuel and movement baselines.
5. Complete fleet and port-equipment inventories.
6. Audit waste streams and disposal costs.
7. Establish water consumption.
8. Review building operating schedules.
9. Undertake employee and contractor travel assessment.
10. Establish common sustainability KPIs.

Table 6.2 – Phase 1 Deliverables

Deliverable	Output	Management Benefit
Energy Baseline	kWh and £ by major load	Identifies energy hotspots
Carbon Baseline	Scope 1 and 2 operational emissions	Enables reduction targets
Marine Baseline	Fuel, journeys and vessel hours	Identifies marine opportunities

Equipment Register	Fuel, age and utilisation	Supports electrification planning
Waste Audit	Waste by mass, type and cost	Identifies circular opportunities
Water Baseline	Consumption and cost	Identifies abnormal usage
Sustainability Dashboard	Monthly KPIs	Enables ongoing governance

Phase 1 Management Gate

No significant infrastructure project should proceed to final investment decision unless the relevant baseline data have been validated.

6.4 Sustainability Management Dashboard

A digital dashboard should consolidate key operational and environmental indicators.

The purpose is not to create an unnecessarily complicated ESG reporting system. Instead, management should be able to identify areas of deteriorating performance quickly and track whether interventions are delivering expected benefits.

Table 6.3 – Proposed Grimsby Dashboard

Theme	KPI	Reporting Frequency	Direction
Energy	Electricity consumption	Monthly	↓
Energy	kWh/m^2	Monthly	↓
Carbon	Scope 1 tCO_2e	Monthly/Quarterly	↓
Carbon	Scope 2 tCO_2e	Monthly/Quarterly	↓
Marine	Fuel per vessel mission	Monthly	↓
Marine	Aborted vessel journeys	Monthly	↓

Buildings	Out-of-hours demand	Monthly	↓
Fleet	Fuel/electricity per mile	Monthly	↓
Waste	Waste generated	Monthly	↓
Waste	% reused/recycled	Monthly	↑
Water	m^3/FTE	Monthly	↓
Logistics	First-time-fix rate	Monthly	↑

A future version could include financial performance alongside carbon performance, allowing management to see whether reductions in energy, fuel or waste are translating into actual operating savings.

6.5 Phase 2 – Optimise

6–24 Months

Once the baseline has been established, the priority should be improving the utilisation of existing assets.

This stage is likely to offer some of the strongest returns because it focuses on reducing unnecessary consumption before installing additional technology.

6.5.1 Building Optimisation

Building controls should be reviewed to ensure that lighting, HVAC and heating systems reflect actual operational requirements.

Potential interventions include:

- revised HVAC schedules;
- occupancy-based control;
- improved temperature set-points;
- reduction of overnight energy demand;
- ventilation optimisation;
- sensor recalibration;
- external lighting controls.

Because the Hub includes operational functions that may run continuously, optimisation should be based on building zones rather than assuming the entire facility follows standard office operating hours.

6.5.2 Marine Logistics Optimisation

Vessel utilisation should be examined alongside:

- weather windows;
- technician availability;
- maintenance criticality;
- vessel capacity;
- spare-parts availability;
- offshore work packages.

The objective should be to reduce avoidable vessel mobilisation.

A single avoided journey can potentially generate multiple benefits:

less fuel

-

lower vessel cost

-

less technician travel time

-

reduced exposure to offshore transfer risk

-

lower emissions

This makes marine optimisation particularly attractive because operational efficiency and sustainability objectives are closely aligned.

6.5.3 Inventory and Warehousing

The consolidated Hub model provides an opportunity to assess whether certain materials, tools and components are being unnecessarily duplicated.

A digital review should classify stock according to:

Critical

Required immediately to avoid significant turbine downtime.

Strategic

Low-frequency but high-consequence items.

Routine

Regularly consumed stock.

Slow Moving

Low-utilisation items.

Obsolete

Items unlikely to be required.

This analysis may identify opportunities to reduce working capital and warehouse requirements while maintaining operational resilience.

Table 6.4 – Phase 2 Action Matrix

Action	CAPEX Requirement	Implementation Difficulty	Expected Value
BEMS optimisation	Low	Low	High
Marine scheduling	Low–Medium	Medium	Very High
Fleet telematics	Low	Low	Medium–High

Inventory optimisation	Low	Medium	High
Circular procurement	Low	Medium	High
Water efficiency	Low	Low	Low–Medium

6.6 Phase 3 – Electrify

1–5 Years

Once existing resource demand has been reduced and accurately characterised, the programme should increasingly focus on replacing fossil-fuelled activities with electric alternatives.

Electrification should be undertaken through a coordinated site-energy strategy rather than individual equipment purchases.

6.6.1 Solar PV

Where technical and commercial feasibility is confirmed, rooftop solar PV should be one of the first major energy technologies considered.

Its implementation could provide:

- lower grid electricity imports;
- reduced electricity costs;
- lower operational emissions;
- renewable electricity for fleet charging;
- renewable electricity for port equipment;
- future integration with battery storage.

System capacity should be designed around actual daytime demand.

6.6.2 Fleet Electrification

Vehicles with predictable operating patterns should transition first.

Priority Tier 1

- pool cars;
- light vans;
- utility vehicles.

Priority Tier 2

- vehicles with higher payload requirements;
- longer-range vans.

Priority Tier 3

- specialist or emergency vehicles.

Fleet replacement should be aligned with existing asset-renewal cycles wherever possible.

6.6.3 Port Equipment Electrification

An asset-specific replacement plan should be established.

Table 6.5 – Proposed Equipment Transition Approach

Equipment	Current Review	Future Direction
Warehouse Forklifts	Assess age/utilisation	Electric preferred
Utility Vehicles	Assess duty cycle	Electric preferred
Light Vans	Assess mileage	Electric preferred
Telehandlers	Technology review	Electric where suitable
Cranes	Duty-cycle assessment	Case-specific

Specialist Plant	Operational assessment	Technology-neutral

The objective should not be to achieve electrification percentages for their own sake. Equipment should be replaced where the electric alternative meets operational requirements and demonstrates acceptable whole-life value.

6.7 Electrical Capacity Planning

Electrification has an important secondary consequence:

Reducing fossil-fuel demand may substantially increase electrical demand.

The future Grimsby electrical system may eventually need to support:

- existing building loads;
- HVAC;
- heat pumps;
- electric vehicles;
- port equipment;
- battery charging;
- shore power;
- potentially vessel charging.

If each technology is evaluated independently, the combined peak demand could be significantly underestimated.

An integrated future-load model should therefore be developed.

Table 6.6 – Future Electrical Demand Scenarios

Scenario	Description
Current	Existing Hub demand
Low Electrification	EV fleet + limited equipment
Medium Electrification	EVs + plant + heat pumps
High Electrification	EVs + plant + heating + shore power

Future Strategic	Large vessel charging / future marine technologies

This analysis will identify whether existing grid capacity is sufficient or whether reinforcement may eventually be required.

6.8 Phase 4 – Integrate

3–7 Years

The fourth phase should move from individual technologies towards an integrated site-energy and operational system.

At this point, Grimsby could increasingly function as a **smart O&M Hub** in which energy demand is actively managed rather than passively supplied.

6.8.1 Integrated Energy Management

A future energy-management platform could coordinate:

- grid imports;
- solar PV;
- battery storage;
- EV charging;
- port-equipment charging;
- HVAC;
- heating;
- future shore-power demand.

The system could prioritise demand according to operational need.

For example:

Critical CCR load

→ highest priority

Operational equipment

→ high priority

EV charging

→ flexible

Battery charging

→ highly flexible

This allows non-critical loads to be shifted away from site peak periods.

6.8.2 Battery Storage

Battery storage should be introduced where the integrated site model demonstrates sufficient value.

Possible functions include:

- absorbing excess solar generation;
- reducing site peak demand;
- managing fleet charging;
- supporting critical loads;
- smoothing shore-power demand.

Its role should therefore be determined by the final energy architecture rather than defined in isolation.

6.8.3 Smart Charging

Electric vehicles and mobile equipment are particularly suitable for flexible charging because many assets remain parked for extended periods.

Instead of every vehicle charging immediately when connected, a smart system could prioritise according to:

- battery state;
- required departure time;
- renewable generation;

- electricity price;
- site electrical demand.

This reduces pressure on network capacity without affecting vehicle availability.

6.9 Phase 5 – Strategic Marine Decarbonisation

5–15+ Years

Marine operations represent the most difficult element of O&M decarbonisation and should therefore form the long-term strategic phase.

The objective should be to progressively reduce the carbon intensity of vessel activity while maintaining reliable offshore access.

6.9.1 Shore Power

If feasibility work establishes a strong technical and commercial case, shore power should form one of the principal strategic infrastructure projects.

Implementation could be phased.

Stage 1

Prepare electrical infrastructure and berth design.

Stage 2

Provide connections for compatible vessels.

Stage 3

Expand capacity as fleet requirements increase.

This phased approach avoids building excessive capacity before vessel utilisation justifies it.

6.9.2 Future Vessel Technology

The future propulsion mix remains uncertain.

Consequently, long-term port planning should retain flexibility for:

- battery-electric vessels;
- hybrid-electric systems;
- methanol;
- hydrogen;
- other future low-carbon fuels.

Grimsby's strategy should focus on **infrastructure adaptability** rather than predicting a single technology winner.

6.10 Implementation Roadmap

Table 6.7 – Proposed 2026–2040 Roadmap

Workstream	2026–27	2027–29	2029–33	2033–40
Sustainability Baseline	●●●			
Sub-Metering	●●●	●		
Dashboard	●●●	●●	●	●
BEMS Optimisation	●●●	●●	●	
Marine Optimisation	●●	●●●	●●●	●●
Circular Procurement	●●	●●●	●●	●
Solar PV	●	●●●	●	
EV Fleet	●	●●●	●●●	●
Port Electrification	●	●●	●●●	●●
Heat Pumps	●	●●	●●●	●
Battery Storage	●	●●	●●●	●
Shore Power	●	●●	●●●	●●●

Alternative Fuel Readiness	●	●	●●	●●●

● = planning / monitoring

●● = feasibility / pilot

●●● = major implementation

6.11 Programme Workstreams

For management purposes, the implementation programme can be simplified into five workstreams.

Workstream A – Data & Digital

- sustainability dashboard;
- metering;
- vessel analytics;
- predictive maintenance;
- inventory analytics.

Workstream B – Buildings & Energy

- BEMS;
- HVAC;
- heating;
- solar PV;
- battery storage.

Workstream C – Transport & Port Equipment

- vehicle electrification;
- smart charging;
- plant electrification.

Workstream D – Marine

- vessel efficiency;
- shore power;

- future vessel technology.

Workstream E – Resources

- waste;
- circular procurement;
- inventory;
- packaging;
- water.

6.12 Proposed Governance Model

The programme should have clear ownership.

Table 6.8 – Governance Structure

Role	Primary Responsibility
Executive Sponsor	Strategic direction and investment approval
Programme Lead	Overall implementation coordination
O&M Operations	Operational requirements and constraints
Marine Team	Vessel performance and shore-power interface
Facilities Team	Buildings and utilities
Engineering	Technical feasibility and integration
Sustainability	Carbon and environmental performance
Procurement	Supplier and circular-economy initiatives
Finance	Business-case appraisal
Digital/Data	Dashboard and system integration

A cross-functional programme is preferable because many interventions span traditional organisational boundaries.

For example, shore power requires input from marine operations, electrical engineering, facilities, finance and vessel operators simultaneously.

6.13 Decision-Gate Governance

Major projects should pass through formal decision points.

Gate 1 – Opportunity

Is there a measurable problem or opportunity?

Gate 2 – Baseline

Is sufficient data available?

Gate 3 – Feasibility

Can it be delivered technically and operationally?

Gate 4 – Business Case

Does the project deliver sufficient financial, carbon or strategic value?

Gate 5 – Investment

Should capital be committed?

Gate 6 – Delivery

Can implementation proceed safely?

Gate 7 – Benefits Verification

Did the intervention actually deliver the expected outcome?

Management Insight

Benefits verification is as important as project approval. Sustainability projects should remain accountable after installation to demonstrate that projected savings have translated into measured operational performance.

6.14 Benefits Realisation

Each completed project should be assessed after implementation.

Table 6.9 – Benefits Realisation Framework

Expected Benefit	Measurement
Energy Reduction	kWh avoided
Fuel Reduction	litres avoided
Carbon Reduction	tCO_2e avoided
Financial Saving	£/year
Reliability Improvement	downtime avoided
Operational Efficiency	hours/journeys avoided
Waste Reduction	tonnes avoided
Employee Benefit	qualitative/engagement KPI

Performance should ideally be reviewed at:

3 months

6 months

12 months

following implementation.

Where performance falls materially below expectations, corrective actions should be identified.

6.15 Programme KPI Framework

Three KPI levels are recommended.

Level 1 – Executive KPIs

A small number of indicators for senior management.

KPI	Direction
Operational CO_2e	↓
Energy Cost	↓
Marine Fuel	↓
Renewable Energy Share	↑
Operational Availability	Maintain / ↑

Level 2 – Programme KPIs

Used to monitor implementation.

KPI	Direction
% Recommendations Implemented	↑
CAPEX Delivered Against Budget	Target
Annual Carbon Saving Delivered	↑
Annual Financial Saving Delivered	↑
Project Benefits Verified	↑

Level 3 – Operational KPIs

Detailed asset-level indicators.

Examples include:

- fuel per vessel hour;

- electricity per building;
- charging energy per vehicle;
- waste per FTE;
- HVAC runtime;
- equipment idle hours.

This structure prevents senior management from being overwhelmed with excessively granular data while retaining detailed information for operational teams.

6.16 Risk Management

Implementation introduces technical, commercial and operational risks that should be actively managed.

Table 6.10 – Programme Risk Register

Risk	Likelihood	Impact	Mitigation
Poor baseline data	High	High	Improve metering before investment
Grid capacity limitation	Medium	Very High	Early network study
Operational disruption	Medium	High	Phased installation
Technology obsolescence	Medium	High	Modular/technology-neutral design
CAPEX escalation	Medium	High	Competitive tendering and contingencies
Lower-than-expected utilisation	Medium	High	Scenario analysis
Workforce resistance	Low–Medium	Medium	Early engagement and training
Vendor dependency	Medium	Medium	Open architecture where possible
Cybersecurity	Medium	High	Integrate with RWE digital governance
Sustainability benefit not realised	Medium	High	Measurement and verification

6.17 Operational Continuity

Unlike a conventional office sustainability project, work at an offshore wind O&M facility cannot significantly disrupt turbine support activities.

Implementation should therefore follow an **operations-first installation strategy**.

This means:

- scheduling works around maintenance campaigns;
- maintaining redundancy for critical systems;
- avoiding simultaneous disruption to multiple operational functions;
- testing new systems before removing existing capability;
- maintaining emergency backup arrangements.

The CCR and critical communications infrastructure should receive particularly stringent resilience treatment.

6.18 Change Management

Sustainability improvements require behavioural as well as technological change.

For example:

A BEMS cannot save energy effectively if systems are continually overridden.

Smart charging cannot optimise demand if users routinely disconnect vehicles prematurely.

Waste segregation cannot function without appropriate employee and contractor engagement.

Digital logistics tools cannot reduce vessel journeys if planning processes remain unchanged.

Consequently, each workstream should consider:

- employee communication;
- operational training;

- contractor requirements;
- supplier engagement;
- management accountability.

6.19 Procurement Strategy

Sustainability requirements should progressively become embedded within procurement rather than considered after equipment has been purchased.

Potential procurement criteria include:

Category	Example Requirement
Vehicles	Whole-life emissions and energy consumption
Equipment	Electric alternative considered at renewal
Buildings	Energy performance criteria
Packaging	Reusable/recyclable packaging preference
Suppliers	Take-back arrangements
Vessels	Fuel/emissions performance data
Digital Systems	Open data integration capability

A **whole-life cost approach** should be preferred to lowest purchase price where sufficient data are available.

This is particularly relevant for electric equipment, where the initial cost may be higher while operating and maintenance costs can differ materially over the asset life.

6.20 Funding and Investment Prioritisation

Not all interventions require the same investment approach.

Table 6.11 – Investment Categories

Category	Example	Funding Approach
Operational Improvement	BEMS optimisation	OPEX
Small Efficiency Project	Metering	Minor CAPEX
Commercial Investment	Solar PV	Standard business case
Strategic Infrastructure	Shore power	Major CAPEX
Innovation Project	Future vessel technology	Partnership / innovation funding
Asset Replacement	Electric plant	Existing renewal budget

This distinction can make implementation more practical because some sustainability measures may be incorporated into existing maintenance or asset-renewal budgets rather than requiring a completely separate sustainability programme.

6.21 Recommended Annual Review Cycle

The roadmap should be reviewed annually.

Q1 – Baseline Review

- previous-year performance;
- carbon inventory;
- energy/fuel trends.

Q2 – Opportunity Review

- new technologies;
- asset replacement requirements;
- emerging operational needs.

Q3 – Investment Planning

- update business cases;
- prioritise CAPEX.

Q4 – Programme Approval

- confirm next-year delivery programme;
- establish targets.

This creates a continuous improvement cycle rather than treating the report recommendations as a one-off exercise.

6.22 Proposed 2030 Position

If the near-term programme is successfully implemented, the Grimsby Hub could reasonably aim to demonstrate the following characteristics by approximately 2030:

Area	Proposed Strategic Position
Sustainability Data	Fully integrated
Building Energy	Actively optimised
Renewable Generation	Significant onsite contribution where viable
Fleet	Majority low-emission/electric where operationally suitable
Port Equipment	Progressive electrification
Marine Planning	Advanced digital optimisation
Waste	Circular procurement embedded
Battery Storage	Installed where commercially justified
Shore Power	Operational or investment-ready if feasible
Management	Carbon and efficiency integrated into O&M decision-making

This should be viewed as a **direction of travel rather than a fixed quantitative target**, with actual targets established once the baseline has been verified.

6.23 Proposed Long-Term Position

The longer-term ambition should be for Grimsby to evolve into an **Integrated Smart O&M Hub**.

The key characteristics would include:

Energy

Renewable generation, storage and actively managed electrical demand.

Buildings

Low-carbon heating and intelligent controls.

Transport

Predominantly electrified landside operations where technically suitable.

Marine

Optimised vessel deployment, shore power and progressively lower-carbon propulsion.

Digital

Integrated operational, energy and sustainability analytics.

Resources

Circular procurement and reduced material waste.

Governance

Environmental performance embedded directly into operational decision-making.

6.24 Strategic Roadmap Summary

Table 6.12 – Executive Roadmap

Time Horizon	Primary Objective	Key Actions
0–1 year	**Measure**	Baseline, metering, dashboard, audits
1–2 years	**Optimise**	BEMS, vessel logistics, inventory, procurement
1–5 years	**Electrify**	PV, EVs, plant, low-carbon heating
3–7 years	**Integrate**	BESS, smart charging, energy management
5–15+ years	**Decarbonise**	Shore power and future marine technologies

6.25 Management Priority Matrix

	High Operational Value	**Lower Operational Value**
Low Complexity	Sustainability dashboard; marine optimisation; BEMS; circular inventory	Water efficiency; minor lighting controls
High Complexity	Shore power; port electrification; integrated energy system	Large stand-alone interventions with limited utilisation

The preferred investment portfolio should therefore remain concentrated in the **upper-left and upper-right quadrants**, where sustainability interventions provide a direct operational benefit.

6.26 Critical Success Factors

Successful implementation will depend upon five factors.

1. Accurate Data

Decisions must be based upon measured site performance.

2. Operational Ownership

O&M teams should be involved in technology selection and implementation.

3. Integrated Planning

Energy, marine, buildings and logistics should not operate as isolated sustainability workstreams.

4. Financial Discipline

Major interventions should demonstrate clear whole-life value or strategic justification.

5. Continual Verification

Projects should be evaluated after implementation to confirm that the expected benefits have been achieved.

6.27 Management Recommendations

The implementation assessment produces the following recommendations for RWE management.

Recommendation 1

Establish the sustainability baseline as the first programme deliverable.

This provides the evidence required for all subsequent investment.

Recommendation 2

Create a cross-functional Grimsby efficiency and sustainability programme.

The programme should include operational, marine, facilities, engineering, finance, procurement and sustainability representation.

Recommendation 3

Deliver low-risk operational improvements before significant CAPEX.

Vessel optimisation, BEMS improvements and inventory efficiency should be progressed early.

Recommendation 4

Develop one integrated electrical infrastructure strategy.

PV, BESS, EVs, heat pumps, plant electrification and shore power should not be designed independently.

Recommendation 5

Use asset-renewal cycles to accelerate electrification.

Suitable vehicles and equipment should transition as existing assets reach replacement points.

Recommendation 6

Progress shore power through a controlled feasibility and decision-gate process.

Its potential value is high, but investment should follow verified vessel and electrical data.

Recommendation 7

Maintain flexibility for future marine technologies.

Infrastructure should accommodate change rather than lock Grimsby into an immature fuel pathway.

Recommendation 8

Integrate sustainability with operational performance.

The programme should ultimately demonstrate that reductions in carbon, energy and waste can coexist with improved reliability and cost performance.

6.28 Overall Conclusion

The proposed implementation strategy provides a practical pathway for translating the recommendations developed throughout this study into a deliverable programme for the RWE Grimsby O&M Hub.

The strongest immediate opportunity is not major infrastructure investment but the development of a robust operational baseline and the optimisation of existing assets. Improved energy monitoring, vessel planning, building controls and resource management can establish early momentum while generating the data required for larger investment decisions.

The following phase should focus on commercially mature electrification measures including solar PV, electric fleet vehicles and suitable electric port equipment. These interventions should be coordinated through an integrated electrical-capacity strategy to ensure that future energy demand remains manageable.

Battery storage, shore power and larger infrastructure upgrades should subsequently be introduced where detailed feasibility work demonstrates sufficient utilisation and whole-life value. Longer-term infrastructure should remain adaptable to changes in vessel propulsion technologies and wider maritime decarbonisation.

The resulting roadmap therefore avoids both extremes of doing too little and attempting to implement every available sustainability technology simultaneously.

Instead, it establishes a controlled progression:

Measure what matters.
Remove avoidable consumption.
Electrify where practical.
Integrate energy and operations.
Decarbonise the remaining high-impact activities.

If implemented effectively, this approach would allow the Grimsby Hub to improve operational efficiency and environmental performance in parallel, while providing RWE management with a clear, evidence-based framework for future investment decisions.

7. Discussion, Conclusions and Final Recommendations

Objective: To synthesise the findings of the industry assessment, RWE Grimsby case study, gap analysis and feasibility assessment, and provide a clear answer to the central research question: **How can offshore wind Operations and Maintenance facilities and associated port infrastructure become more efficient and sustainable, and what does this mean for the RWE Grimsby O&M Hub?**

7.0 Executive Summary

This research has examined the efficiency and sustainability of offshore wind Operations and Maintenance (O&M) facilities and their associated port infrastructure, using the RWE Grimsby O&M Hub as the principal case study.

The investigation demonstrates that the sustainability challenge facing offshore wind O&M has evolved significantly. Many conventional building-level efficiency measures—including LED lighting, improved controls, better insulation and waste segregation—are now mature technologies. The larger remaining opportunities increasingly lie outside the conventional office or warehouse environment and within **marine logistics, port equipment, electrical infrastructure and integrated operational management**.

This has an important implication for RWE.

Improving the sustainability of the Grimsby Hub should not primarily be approached as a programme of isolated environmental upgrades. Instead, the strongest opportunity is to improve the **efficiency of the overall O&M system**: buildings, vessels, technicians, energy, equipment, inventory and digital information should increasingly be managed as interconnected resources.

This direction is particularly relevant because Grimsby already provides several of the characteristics required for such a model. RWE's expanded

Grimsby facility opened in July 2025 and consolidates offshore wind O&M activities around a strategic deep-water port location. The Hub includes RWE's UK Centralised Control Room, which provides 24-hour monitoring and services including marine coordination, turbine operations, alarm management, high-voltage monitoring and emergency response.

These capabilities mean that Grimsby does not need to begin its sustainability transition from a blank sheet. Instead, there is an opportunity to use the Hub's existing physical and digital infrastructure as the foundation for a progressively more integrated, data-driven and lower-carbon operating model.

The resulting strategic pathway proposed by this research is:

Measure → Optimise → Electrify → Integrate → Decarbonise

Under this approach, reliable operational data are established first; avoidable consumption and vessel activity are then reduced; commercially mature activities are progressively electrified; energy and operational systems are integrated; and the remaining difficult-to-abate marine emissions are addressed through shore power and future vessel technologies.

This approach is consistent with RWE's wider corporate objective of achieving net-zero emissions by 2040 and with the wider direction of UK maritime policy towards substantial reductions in domestic maritime greenhouse-gas emissions.

7.1 Research Question Revisited

The central question underpinning this project can be expressed as:

How can Operations and Maintenance facilities and associated port infrastructure supporting offshore wind be operated more efficiently and sustainably?

The research indicates that there is no single technology capable of answering this question.

Instead, efficient and sustainable O&M infrastructure is characterised by the interaction of several factors:

Strategic Requirement	Meaning in Practice
Efficient demand	Avoid unnecessary consumption before adding new generation
Efficient operations	Reduce unnecessary vessel, vehicle and equipment activity
Electrification	Replace fossil fuels where technically practical
Clean energy	Increase renewable electricity and lower-carbon supply
Digital integration	Use data to optimise operational decisions
Circularity	Reduce material demand rather than managing waste alone
Resilience	Ensure sustainability improvements do not reduce availability
Future flexibility	Avoid technological lock-in as marine technology evolves

The principal conclusion is therefore that **operational efficiency and sustainability should not be treated as separate objectives**.

In many cases, the same intervention contributes to both.

Reducing an unnecessary CTV journey reduces fuel consumption, vessel cost, technician time and emissions.

Optimising warehouse inventory reduces purchasing expenditure, storage requirements, emergency logistics and material waste.

Improving HVAC controls reduces electricity consumption, operational cost and greenhouse-gas emissions.

Electrifying high-utilisation equipment can reduce local emissions while potentially lowering maintenance requirements.

The most attractive interventions are consequently those where the environmental and operational business cases reinforce one another.

7.2 Discussion of Industry Findings

7.2.1 The Offshore Wind Sustainability Paradox

Offshore wind provides low-carbon electricity, but the infrastructure required to maintain offshore assets does not operate without environmental impact.

O&M activities require:

- vessels;
- technician movements;
- warehouses;
- workshops;
- heating and cooling;
- port equipment;
- replacement components;
- road transport;
- waste management.

As wind farms become larger and are developed further offshore, some of these requirements may become more demanding rather than less.

This creates what can be described as an **O&M sustainability paradox**:

Offshore wind is expanding to decarbonise the electricity system, while the industry must simultaneously prevent the operational infrastructure supporting that expansion from becoming unnecessarily carbon intensive.

This is particularly significant for marine operations.

The UK Maritime Decarbonisation Strategy now sets goals for domestic maritime to achieve zero fuel-lifecycle greenhouse-gas emissions by 2050, with at least a 30% reduction by 2030 and an 80% reduction by 2040 relative to 2008.

The direction of travel is therefore clear: conventional marine fuels cannot be regarded as a permanent operating model.

7.3 Buildings Are Important – But Are Not the Whole Answer

One of the key findings from the current-state assessment is the need to place building efficiency in the correct strategic context.

Buildings remain important. Heating, ventilation, lighting and IT systems consume energy throughout an O&M facility's operating life, and poorly controlled systems can produce unnecessary expenditure.

However, many conventional building-efficiency technologies are already technologically mature.

Consequently, the report does **not** conclude that RWE should prioritise large-scale building replacement simply to demonstrate sustainability progress.

Instead, the preferred hierarchy is:

1. Measure

Understand where energy is consumed.

2. Control

Ensure systems operate only when required.

3. Reduce demand

Improve fabric or equipment where a genuine performance gap exists.

4. Decarbonise the remaining energy

Introduce lower-carbon heating and renewable electricity where appropriate.

This is more financially disciplined than beginning with major capital replacement.

For Grimsby specifically, the recently expanded nature of the Hub means the assessment should also distinguish between newer and legacy areas rather than assume uniform performance across the entire estate. RWE's Grimsby development expanded existing O&M operations into the wider Hub model, making an estate-level assessment more appropriate than treating it as a single homogeneous building.

7.4 Marine Operations Represent the Strategic Carbon Challenge

The most important conclusion of this study concerns marine activity.

Buildings can increasingly be supplied by lower-carbon electricity. Road vehicles and many forms of port equipment have commercially available electric alternatives. Lighting and controls are mature.

Marine propulsion is considerably more difficult.

CTVs and SOVs must deliver:

- sufficient range;
- high availability;
- safe offshore operation;
- reliable technician transfer;
- operation in challenging sea states;
- sufficient onboard power;
- rapid refuelling or recharging.

Consequently, conventional liquid fuels remain operationally attractive even as their environmental disadvantages become increasingly significant.

The correct response is therefore **not simply to replace every vessel immediately**.

Instead, this research proposes a marine decarbonisation hierarchy:

Stage	Action	Example
1. Avoid	Eliminate unnecessary activity	Remote diagnostics
2. Consolidate	Complete more work per mobilisation	Work-package optimisation
3. Optimise	Reduce fuel intensity	Routing / utilisation
4. Electrify	Replace feasible energy demand	Shore power / hybridisation

5. Change Fuel	Address residual propulsion	Future low-carbon fuels

This sequencing is important.

There is limited value in replacing a vessel with a lower-carbon alternative if inefficient planning continues to generate avoidable journeys.

Digital technology can therefore be considered a **decarbonisation technology in its own right** when it prevents unnecessary physical activity. ORE Catapult highlights the growing role of AI and digital systems in offshore wind management and has demonstrated digital-twin approaches capable of supporting remote inspection and reducing the need for offshore visits.

7.5 The Strategic Value of the Grimsby Hub Model

The Grimsby Hub model itself can be interpreted as an efficiency opportunity.

Rather than treating every offshore wind farm as an entirely independent operating system, consolidation allows selected resources to be shared.

Potential shared resources include:

- operational expertise;
- specialist engineering teams;
- control functions;
- warehouses;
- spare parts;
- tools;
- port equipment;
- logistics systems;
- training facilities.

RWE describes the Grimsby Hub as a long-term offshore wind O&M location and identifies the facility as supporting specialist activities, while its location provides access to offshore projects from the Humber region.

The efficiency opportunity therefore extends beyond individual pieces of technology.

A useful future performance measure would be **resource intensity per unit of offshore capacity supported**.

For example:

Conventional Absolute Metric	More Strategic Normalised Metric
Electricity consumed	Electricity per MW supported
Warehouse stock	Inventory value per MW supported
Vessel fuel	Fuel per completed maintenance mission
Staff travel	Travel per completed intervention
Waste	Waste per work order / MW supported
O&M facility cost	Cost per MW supported

This prevents increasing activity at a successful Hub from being incorrectly interpreted as declining sustainability simply because absolute consumption rises.

7.6 Digitalisation as an Efficiency Enabler

The role of digital technology is one of the strongest themes emerging from the research.

The offshore wind industry increasingly uses AI, digital twins, condition monitoring and automated analysis to improve O&M decisions. ORE Catapult's current work identifies digital technology and AI as important tools for managing and maintaining the growing offshore wind fleet, while digital-twin applications can integrate operational information to support better maintenance decisions.

For Grimsby, RWE's existing CCR creates a particularly relevant foundation because operational information is already centralised for multiple offshore activities.

The next step should therefore be to connect sustainability indicators more closely with operational decision-making.

A future integrated decision environment could consider:

Turbine condition + weather + vessel location + technician availability + inventory + energy + carbon + cost

rather than considering each variable independently.

This represents one of the most significant opportunities identified by the project.

7.7 Electrification Must Be Planned as a System

A recurring finding throughout Sections 4–6 is that electrification should not be implemented one asset at a time without understanding its cumulative effect.

Future electrical loads at Grimsby could potentially include:

- EV charging;
- electric forklifts;
- electric telehandlers;
- heat pumps;
- battery storage;
- shore power;
- future vessel charging;
- increasing digital infrastructure.

Individually, each intervention may appear manageable.

Collectively, they could create a significantly different site electrical profile.

The principal energy recommendation is therefore not simply:

Install more electric technologies.

It is:

Develop an integrated future electrical architecture capable of supporting progressive electrification.

This should combine demand forecasting with solar PV, energy storage, managed charging and network capacity.

7.8 Shore Power – High Potential, but Evidence Must Lead Investment

Shore power emerged as one of the most strategically interesting opportunities identified within the project.

Its attractiveness is straightforward in principle: a vessel that obtains electricity from shore can reduce the operation of onboard auxiliary engines while berthed.

Potential benefits include:

- lower fuel consumption;
- lower greenhouse-gas emissions;
- reduced NO_x and particulate emissions;
- reduced noise;
- reduced engine operating hours.

However, UK Government evidence on maritime shore power shows that the benefits vary considerably by vessel, route and port and that grid connection costs and infrastructure requirements can create significant implementation barriers.

For this reason, this project does **not** recommend immediate blanket installation.

Instead, it recommends a Grimsby-specific feasibility study based upon:

Required Evidence	Why It Matters
Berth hours	Determines utilisation
Vessel electrical load	Determines system capacity
Auxiliary fuel consumption	Determines fuel saving
Vessel compatibility	Determines usable fleet
Electrical capacity	Determines infrastructure requirement

Future vessel strategy	Prevents stranded investment

This is an example of a wider principle that applies throughout the report:

Sustainability technology should follow evidence, not precede it.

7.9 Renewable Energy and Energy Storage

Solar PV represents a comparatively mature opportunity, particularly where industrial buildings provide suitable roof space and daytime electricity demand is substantial.

However, renewable generation should similarly be sized according to site demand rather than maximum theoretical installation capacity.

The strategic objective is not to install the largest possible renewable system.

It is to maximise the **operational value of renewable electricity**.

This could mean using locally generated electricity to supply:

1. normal building demand;
2. EV charging;
3. port equipment;
4. battery storage;
5. eventually vessel-related loads.

Battery storage may strengthen this model, but its role should be determined after the site's demand profile and future electrification requirements are understood.

A battery installed without sufficient utilisation risks becoming expensive underused infrastructure.

A battery designed as part of an integrated PV–EV–port–shore-power system could potentially provide considerably more value.

7.10 Waste Should Evolve into Resource Efficiency

Another important conclusion is that recycling should not be considered the end point of sustainable waste management.

A highly efficient facility should aim to prevent materials from becoming waste.

The hierarchy proposed by this study is:

Avoid → Share → Reuse → Repair → Recycle → Recover → Dispose

For Grimsby, the consolidated Hub structure creates particular opportunities around inventory and procurement.

For example, where project requirements allow, sharing specialist components or tools could reduce:

- duplicate purchasing;
- warehouse space;
- embodied carbon;
- transport;
- obsolete inventory;
- eventual disposal.

This demonstrates how circular economy principles can support operational efficiency rather than simply environmental compliance.

7.11 Discussion of the Business Case for Sustainability

A key finding of this project is that sustainability proposals should not be judged exclusively on environmental benefit.

RWE management must allocate capital across multiple competing priorities.

Consequently, the strongest recommendations should demonstrate value across several dimensions.

Table 7.1 – Recommended Value Framework

Value Dimension	Example
Carbon	tCO_2e avoided
Financial	Reduced fuel/electricity expenditure
Operational	Reduced vessel journeys
Reliability	Improved asset availability
Safety	Reduced technician exposure
Resilience	Improved energy security
Strategic	Future regulatory readiness
Reputational	Demonstration of industry leadership

This is particularly important for interventions such as shore power.

A conventional payback calculation may capture fuel savings but omit:

- local air-quality improvement;
- noise reduction;
- avoided engine maintenance;
- future carbon exposure;
- infrastructure readiness.

A multi-criteria investment framework is therefore more appropriate for major sustainability infrastructure.

7.12 Alignment with RWE Strategy

The recommendations developed within this project are consistent with RWE's wider corporate direction.

RWE states that its goal is to achieve net-zero emissions by 2040 and that its climate targets align with a 1.5°C pathway.

The recommendations developed for Grimsby support this objective in several ways.

Table 7.2 – Strategic Alignment

Project Recommendation	Strategic Contribution
Energy Monitoring	Improves emissions transparency
Solar PV	Reduces purchased electricity
Fleet Electrification	Reduces direct fossil-fuel demand
Port Electrification	Reduces Scope 1 emissions
Marine Optimisation	Reduces vessel fuel demand
Shore Power	Enables lower-emission port operations
Digital Integration	Improves asset/resource efficiency
Circular Procurement	Reduces material and lifecycle impacts
Future-Fuel Readiness	Supports long-term decarbonisation

The project therefore provides a mechanism for translating corporate sustainability ambition into operational interventions at facility level.

7.13 Final Opportunity Prioritisation

The overall assessment can now be condensed into four management categories.

PRIORITY A – ACT NOW

1. Sustainability Data & Sub-Metering

Establish a reliable operational baseline.

2. Marine Logistics Optimisation

Use digital capability to reduce unnecessary marine activity.

3. BEMS/HVAC Optimisation

Reduce unnecessary building consumption before major retrofit.

4. Circular Inventory and Procurement

Reduce duplicate stock, waste and unnecessary purchasing.

PRIORITY B – DEVELOP NOW, IMPLEMENT WHERE BUSINESS CASE IS POSITIVE

5. Solar PV

Assess suitable roof areas against actual electrical demand.

6. Fleet Electrification

Transition suitable vehicles through natural replacement cycles.

7. Port Equipment Electrification

Prioritise high-utilisation assets with mature electric alternatives.

8. Low-Carbon Heating

Progress where building and electrical conditions are appropriate.

PRIORITY C – STRATEGIC FEASIBILITY

9. Battery Energy Storage

Assess within the integrated site-energy model.

10. Shore Power

Undertake detailed vessel and electrical feasibility.

11. Grid Capacity / Electrical Infrastructure

Prepare for increasing site electrification.

PRIORITY D – MONITOR AND PREPARE

12. Alternative Marine Fuels

Maintain flexibility for future technologies.

13. High-Power Vessel Charging

Monitor vessel-fleet development.

14. Robotics and Autonomous O&M

Track technologies capable of reducing offshore human intervention.

ORE Catapult expects robotics and autonomous systems to play an increasingly important role in offshore wind O&M by 2030, reinforcing the importance of maintaining a forward-looking digital strategy.

7.14 Final Management Priority Matrix

Recommendation	Carbon Value	Operational Value	Financial Potential	Timing
Marine Optimisation	🔴 High	🔴 Very High	🔴 High	**Now**
Data / Dashboard	🟠 Indirect	🔴 Very High	🔴 High	**Now**
BEMS Optimisation	🟠 Medium	🟠 Medium	🔴 High	**Now**
Circular Inventory	🟠 Medium	🔴 High	🔴 High	**Now**
Solar PV	🔴 High	🟠 Medium	🔴 High	**1–3 yrs**
Fleet EVs	🔴 High	🟠 Medium	🟠 High	**1–5 yrs**

Electric Port Plant	🔴 High	🔴 High	🟠 Medium	**1–5 yrs**
Heat Pumps	🔴 High	🟠 Medium	🟠 Medium	**1–5 yrs**
BESS	🟠–🔴	🔴 High	🟠 Case Specific	**2–7 yrs**
Shore Power	🔴 Very High	🔴 High	🟠 Case Specific	**3–10 yrs**
Alternative Marine Fuels	🔴 Very High	🔴 High	🔴 Uncertain	**Long Term**

7.15 Proposed Future State for the Grimsby Hub

The future state identified by the research is not simply a "green building".

The ambition should be considerably broader.

CURRENT O&M HUB

Buildings

•

Warehousing

•

Vessels

•

Technicians

•

Port Infrastructure

•

Digital Control

↓

FUTURE INTEGRATED SMART O&M HUB

Connected operational data

•

Optimised vessel deployment

•

Efficient buildings

•

Renewable electricity

•

Flexible energy storage

•

Electrified landside transport

•

Low-carbon marine infrastructure

•

Circular resource management

The key difference is integration.

7.16 Proposed Definition of a Sustainable O&M Hub

Based upon the findings of this project, a sustainable offshore wind O&M Hub can be defined as:

An operational facility that minimises the resources, energy, emissions and physical interventions required to maintain offshore wind assets while

preserving or improving safety, reliability, turbine availability and whole-life economic performance.

This definition is important because it avoids defining sustainability purely in terms of carbon emissions.

A facility that achieves low building emissions but requires inefficient vessel operations would not represent an optimised sustainable O&M system.

Similarly, a technically low-carbon facility that compromises turbine availability would not represent a successful O&M solution.

Sustainability must therefore be evaluated in combination with operational performance.

7.17 Contribution of the Research

The principal contribution of this project is the development of an integrated framework for assessing offshore wind O&M sustainability.

Rather than focusing exclusively on individual technologies, the research has connected:

- facility efficiency;
- port infrastructure;
- marine logistics;
- buildings;
- energy;
- waste;
- water;
- transportation;
- digitalisation;
- investment decision-making.

This provides a more complete interpretation of O&M sustainability than an assessment focused solely on building energy consumption.

The project also demonstrates the importance of combining **industry benchmarking with site-specific assessment**.

Industry best practice establishes what is technically possible.

Site data determine what is actually valuable.

Both are required for robust recommendations.

7.18 Limitations of the Study

Several limitations should be recognised when interpreting the findings.

7.18.1 Availability of Site-Specific Operational Data

The most significant limitation is the availability of detailed Grimsby operational data.

Publicly available information confirms the strategic role, recent expansion and operating functions of the Hub but does not provide detailed information regarding:

- half-hourly electricity consumption;
- heating fuel consumption;
- individual vessel fuel use;
- berth occupancy;
- equipment operating hours;
- waste tonnage;
- water consumption;
- staff commuting patterns;
- existing EV charging;
- installed renewable generation;
- site electrical spare capacity.

Consequently, several recommendations remain at **pre-feasibility level**.

This is preferable to assigning artificial precision to assumptions that cannot be independently verified.

7.18.2 Rapid Technology Development

Marine decarbonisation technology is developing rapidly.

Battery-electric vessels, hydrogen, methanol and other propulsion pathways continue to evolve, while the UK's clean-maritime innovation programme remains active. The government announced £448 million of R&D investment for UK SHORE over the following five years in 2025, illustrating the continuing development of the technology landscape.

Recommendations concerning future fuels should therefore be periodically reviewed rather than treated as permanent conclusions.

7.18.3 Economic Uncertainty

Energy prices, marine fuel costs, equipment prices, interest rates and technology costs change over time.

Financial analysis should therefore be updated using current supplier quotations and RWE-specific commercial data before capital investment.

7.18.4 Site-Specific Operational Requirements

Some sustainability interventions may conflict with operational requirements not visible within publicly available information.

For example:

- emergency-response vehicles may require operating characteristics unavailable from some EVs;
- specialist plant may have no mature electric equivalent;
- shore-power installation may be limited by lease or port arrangements;
- building modifications may be constrained by existing infrastructure.

Recommendations must therefore remain subject to detailed engineering and operational review.

7.19 Recommendations for Further Research

The following work would significantly strengthen the analysis.

Table 7.3 – Future Research Priorities

Research Activity	Purpose	Priority
12–24 month energy analysis	Establish energy baseline	🔴 Critical
Vessel fuel study	Quantify marine emissions	🔴 Critical
Berth utilisation study	Shore-power feasibility	🔴 Critical
Electrical capacity assessment	Future electrification	🔴 Critical
Staff travel survey	Quantify commuting	🟠 High
Waste composition audit	Circular economy baseline	🟠 High
PV roof survey	Renewable feasibility	🟠 High
Thermal building survey	Identify fabric improvements	🟠 High
Equipment duty-cycle analysis	Electrification	🟠 High
Whole-life carbon analysis	Compare investment options	🟠 High

Particularly valuable would be access to anonymised RWE operational data allowing the provisional matrices developed within this research to be populated with actual performance values.

7.20 Final Recommendations to RWE Management

The entire project can ultimately be distilled into **eight recommendations**.

1. Establish one trusted operational sustainability baseline

Create a common dataset covering buildings, vessels, vehicles, equipment, waste and water.

Why: Without it, investment benefits cannot be measured consistently.

2. Prioritise marine efficiency

Focus on reducing avoidable vessel activity before relying upon future propulsion technologies.

Why: Marine operations represent one of the hardest and potentially largest remaining sources of operational emissions.

3. Use the Centralised Control Room as a digital foundation

Extend the Hub's existing operational intelligence towards integrated vessel, inventory, energy and sustainability optimisation.

RWE's Grimsby CCR already centralises significant offshore operational functions, providing a strong platform from which this capability could evolve.

4. Develop an integrated electrification strategy

Plan EVs, electric port plant, heat pumps, solar PV, batteries and shore power as one electrical system.

Why: Independent electrification decisions risk creating unnecessary peak demand or network reinforcement.

5. Progress shore power to detailed feasibility

Quantify vessel compatibility, berth time, auxiliary load and electrical capacity.

Why: Potential strategic benefit is high, but economic performance is highly site dependent.

6. Embed circularity into procurement

Move beyond recycling towards prevention, repair, sharing, supplier take-back and reusable packaging.

Why: This reduces environmental impact while also potentially lowering inventory and procurement costs.

7. Maintain technology flexibility

Do not prematurely commit major infrastructure to a single future vessel fuel.

Why: Marine propulsion technology and regulation continue to develop rapidly.

8. Measure sustainability through operational value

Report carbon alongside cost, availability, vessel utilisation, reliability and safety.

Why: The most successful O&M sustainability investments will improve several dimensions simultaneously.

7.21 Final Executive Scorecard

What should RWE do?

Question	Research Conclusion
Should Grimsby reduce energy consumption?	**Yes – optimise demand before new infrastructure**
Should onsite renewable energy be investigated?	**Yes – particularly rooftop PV where technically feasible**
Should battery storage be installed immediately?	**Not without load modelling**
Should vehicles and plant electrify?	**Yes – progressively through suitable asset renewal**
Should shore power be investigated?	**Yes – high strategic priority for feasibility**
Should alternative vessel fuels be selected now?	**No – maintain technology flexibility**
Should waste strategy focus on recycling?	**Partly – but prevention and circular procurement should come first**
Should water be a major investment priority?	**Generally secondary unless site data reveal a significant opportunity**
Is digitalisation important?	**Yes – it is a core efficiency and decarbonisation enabler**
What should happen first?	**Establish the baseline and optimise existing operations**

7.22 Final Conclusion

This research set out to investigate how Operations and Maintenance facilities and associated port infrastructure supporting offshore wind could operate more efficiently and sustainably, using the RWE Grimsby O&M Hub as a case study.

The investigation demonstrates that the next stage of offshore wind O&M sustainability must extend beyond conventional building-level interventions.

Energy-efficient lighting, improved insulation, waste segregation and modern HVAC systems remain valuable, but they do not address the full operational system. As offshore wind farms increase in scale and distance from shore, marine logistics, port infrastructure, electrical capacity and digital operational management become increasingly important.

The RWE Grimsby Hub is well positioned within this transition. The expanded Hub opened in 2025 and combines offshore wind O&M activity with deep-water port access and a 24/7 Centralised Control Room, providing a strong foundation for a more integrated operating model.

The research concludes that the most effective pathway is not a single large sustainability project but a phased transformation.

The first requirement is **measurement**. RWE should establish a detailed operational baseline capable of quantifying energy, marine fuel, equipment utilisation, waste, water and transport.

The second requirement is **optimisation**. Unnecessary energy demand, vessel movements, equipment idling and material consumption should be eliminated wherever practical.

The third requirement is **electrification**. Commercially mature activities such as vehicles, selected port equipment and heating should transition progressively towards electricity where operational requirements permit.

The fourth requirement is **integration**. Renewable electricity, energy storage, charging infrastructure, buildings and future shore-power demand should be managed as parts of one energy system rather than independent projects.

Finally, the remaining difficult-to-abate activities—particularly vessel propulsion—must be progressively **decarbonised** through improved operational efficiency, shore-side electrification and future low-carbon vessel technologies.

The principal strategic recommendation from this project can therefore be expressed simply:

RWE should aim not merely to create a lower-carbon O&M facility, but to develop Grimsby into an integrated, data-driven and resource-efficient Smart O&M Hub.

Such an approach directly supports the wider purpose of offshore wind: delivering increasing quantities of low-carbon electricity while ensuring that the infrastructure required to operate and maintain those assets becomes progressively more efficient, resilient and sustainable.

RWE's wider corporate objective is to reach net zero by 2040, while UK maritime policy is simultaneously driving significant long-term reductions in shipping emissions. The Grimsby Hub therefore provides an opportunity to translate these strategic ambitions into practical improvements at operational level.

Ultimately, the strongest sustainability interventions are likely to be those that no longer need to be justified solely as environmental projects because they also make **operational and commercial sense**.

7.23 Final Management Takeaway

The central finding of this project

The sustainable O&M base of the future is not simply a highly efficient building beside a port.

It is an integrated operating system in which **energy, vessels, technicians, equipment, inventory and data are continuously optimised to deliver the greatest offshore availability using the minimum necessary resources.**

For RWE Grimsby, the opportunity is therefore to progress from:

O&M Base

↓

Consolidated O&M Hub

↓

Digitally Optimised O&M Hub

↓

Integrated Smart & Low-Carbon O&M Hub

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Recommended Use of the Peer-Reviewed Literature

The academic papers above should not simply sit in the bibliography. They should be used to strengthen the analytical statements throughout Sections 2–7.

Offshore Wind O&M and Maintenance Strategy

Ren et al. (2021) should be one of the principal academic references throughout the current-state assessment because it provides a broad state-of-the-art review of offshore wind O&M strategy, scheduling, on-site maintenance and environmental considerations.

Shafiee (2015) is particularly useful when discussing O&M logistics, maintenance bases, vessel selection, resource allocation and the strategic importance of port location.

McMorland et al. (2022) provides additional evidence for O&M modelling and decision-support systems.

McMorland et al. (2023) is particularly relevant to opportunistic maintenance and the argument that maintenance interventions should be grouped where possible to reduce unnecessary offshore activity.

Vessel and Logistics Efficiency

Dalgic et al. (2015) directly supports the discussion around advanced logistics planning and the integration of vessel availability, maintenance requirements and offshore accessibility.

Lazakis and Khan (2021) provides a particularly strong academic basis for the proposed marine logistics optimisation recommendation because it examines daily vessel routing and scheduling for offshore wind maintenance.

Besnard, Fischer and Tjernberg (2013) is useful when discussing the optimisation of maintenance support infrastructure and the organisation of offshore wind maintenance resources.

Reliability, Predictive Maintenance and Digitalisation

Carroll, McDonald and McMillan (2016) provides empirical evidence on offshore turbine failure rates, repair times and unscheduled O&M costs and should be used when explaining why rapid access to parts, technicians and vessels is economically important.

Bangalore and Patriksson (2018) supports the use of SCADA information for early fault detection and maintenance-management decision-making.

Xia and Zou (2023) provides a direct peer-reviewed foundation for the discussion of digital twins and their potential role in offshore wind O&M optimisation.

Port Sustainability and Electrification

Iris and Lam (2019) should be a core reference within the port-infrastructure section. Their review links port energy efficiency with operational optimisation, equipment electrification, renewable energy, and energy-management systems.

Abu Bakar et al. (2023) provides one of the strongest academic references for shore power, cold ironing, and the electrification of port-side energy systems.

Shore Power

Stolz et al. (2021) is particularly useful because it investigates shore-side electricity across European and UK ports and quantifies its potential contribution to reducing vessel-at-berth emissions.

Bullock et al. (2023) is especially relevant to the RWE case study because it assesses shore-power project economics at the **Port of Aberdeen**, providing a UK port context rather than relying solely on international case studies.

Lifecycle Sustainability

Arvesen, Birkeland and Hertwich (2013) is useful for demonstrating that vessels, spare parts, and O&M logistics contribute materially to the lifecycle environmental performance of offshore wind, supporting the report's argument that sustainability cannot be assessed solely from turbine electricity generation.

Suggested In-Text Citation Combinations

For a strong academic-consultancy style, use combinations of authoritative industry evidence and peer-reviewed research.

O&M industry baseline

Offshore wind O&M performance is influenced by maintenance strategy, weather accessibility, vessel availability, logistics organisation, and the reliability of turbine components (Shafiee, 2015; Ren et al., 2021; McMorland et al., 2022).

Digitalisation and predictive maintenance

Increasing use of SCADA analytics, condition monitoring and digital twins enables faults to be identified earlier and maintenance activity to be planned more effectively (Bangalore and Patriksson, 2018; Xia and Zou, 2023; ORE Catapult, 2024).

Vessel optimisation

Maintenance-vessel scheduling and routing represent important opportunities to reduce vessel utilisation, maintenance delays and associated operating costs (Dalgic et al., 2015; Lazakis and Khan, 2021; McMorland et al., 2023).

Ports

Port decarbonisation increasingly combines operational energy efficiency, equipment electrification, renewable generation, and integrated energy-management systems (Iris and Lam, 2019; DNV, 2024b; DfT, 2025a).

Shore power

Shore power can reduce emissions from auxiliary engines while vessels are berthed, although its economic attractiveness is strongly dependent upon utilisation, electricity prices, vessel compatibility, and infrastructure costs (Stolz et al., 2021; Abu Bakar et al., 2023; Bullock et al., 2023).

Lifecycle sustainability

Although offshore wind produces low-carbon electricity, vessels and replacement components remain relevant contributors to the lifecycle environmental impact of offshore wind operations (Arvesen, Birkeland and Hertwich, 2013).

RWE Grimsby

The expanded Grimsby Hub consolidates offshore wind O&M capability at the Port of Grimsby and incorporates RWE's UK Centralised Control Room (RWE, 2025a).