Reblade

Decommissioning done right

Novar 1 Wind Farm Repowering Outline Circular Decommissioning Strategy

October 2026

Appendix 1.5, Volume 4

Document History

Document Ref:	25028 Novar 1 Repowering Outline Circular Decommissioning Strategy
Client:	Nadara
Developer/Asset Name:	Novar 1 Wind Farm
Project Stage:	Decommissioning (and Repower)
Prepared by:	Reblade
Document Version No.:	1
Date:	September 2026

Copyright

© Copyright Reblade Limited. All rights reserved.

Disclaimer

The report is specifically for the exclusive use of Nadara and should not be used by anyone else without permission.

Reblade has used reasonable skill, care and diligence in compiling this strategy and no warranty is provided as to the report's accuracy. No liability is accepted by Reblade and Nadara for any use of this strategy, other than the purpose for which it was prepared. The report does not account for any changes relating to the subject matter of the strategy, or any legislative or regulatory changes that have occurred since the strategy was produced and that may affect the strategy. Reblade and Nadara do not accept any responsibility or liability for loss whatsoever to any third party caused by, related to or arising out of any use or reliance on the strategy. Whilst Reblade has made reasonable efforts to keep the information up to date and correct, Reblade makes no representations or warranties of any kind, express or implied about the completeness, accuracy, reliability, suitability or availability with respect to the third-party sources of information, products, services or related graphics contained within this strategy for any purpose. Reblade accepts no responsibility for any documents or information supplied to Reblade by others and no legal liability arising from the use by others of opinions or data contained in this strategy. It is expressly stated that no independent verification of any documents or information supplied by others has been made.

Executive Summary

Nadara's commitment to circular decommissioning

Nadara[1] is one of Europe's leading independent renewable energy generators, committed to delivering sustainable impact and shared value for all its stakeholders through the generation of renewable energy, minimising its impact on the environment and leaving society in a better place. Nadara brings together more than 30 years of combined industry experience to become one of Europe's largest NextGen renewable energy Independent Power Producers (IPP). Nadara has a global operational portfolio of over 4.3GW encompassing 200 onshore wind, solar, biomass, and energy storage plants, including 44 onshore wind farms across the UK and an installed capacity of 768MW in Scotland. The company operates in Europe (notably in the UK, Italy, France, Spain and Portugal; and the US) and has more than 900 employees.

Nadara's success is supported by the confidence and long-term backing of its investors. Their support enables the company to continue to grow its portfolio, delivering renewable energy to households and businesses while creating sustainable value over the long term.

Nadara aims to lead the energy transition, investing in all the elements that are crucial for its implementation: renewable generation, electrification, energy efficiency and more flexible consumption, providing the energy solutions that produce a more sustainable energy system, using the extensive experience and skills of its team.

What differentiates Nadara is its duty of care towards colleagues, clients, the environment, and the communities within which it works.

As an organisation with sustainability built into its purpose, Nadara is committed to minimising the impacts of its operations on the environment and, through a full-lifecycle commitment to both community engagement and energy production, the company aims to build meaningful long-lasting relationships and contribute to local development, while leading the way on industry challenges such as circularity and repowering.

As part of Nadara's wider approach to sustainability, circularity has been identified as one of the key areas of focus to deliver on this commitment, with the aim of minimising waste and maximising resource efficiency by adopting circular principles throughout its operations. For example, at operational sites in the UK, Nadara is looking at ways to source second-hand parts, refurbish and reuse components wherever possible. This not only results in an efficient use of resources and a reduction in associated greenhouse gases but also supports delivery of business objectives.

Novar 1 Wind Farm Repowering

Located in Easter Ross, north-west of Evanton, the Novar 1 Wind Farm (Novar 1) has been a landmark of renewable energy generation since 1997. To help combat climate change and maximise the efficiency of this proven site, Nadara is proposing a comprehensive repowering project. The proposal involves replacing the existing 34 turbines with up to 9 modern, high-capacity wind turbines.

While reducing the total number of turbines, this technological upgrade will significantly increase the site's clean energy output. The proposed repowering project will also include all necessary associated infrastructure, such as internal access roads, onsite substation, and a borrow pit. The repowering of Novar 1 is proposed to be delivered through a single, integrated construction and decommissioning programme executed over an extended period of approximately three-years (36 months). It is possible that some of the existing turbines may be in place whilst the repowered wind farm is being constructed.

Nadara believes that there is a clear opportunity for wind farm decommissioning to be done in a more sustainable way. This is why one of the key objectives of the repowering project for Novar 1 is to achieve maximum recovery of wind farm components and materials.

The decommissioning of Novar 1 occurs at a pivotal moment for the UK's energy transition. As identified in the Regen report, 'A Second Wind' (April 2026), more than 200 wind farms across Great Britain, representing over 3.2 GW of capacity, will face similar end-of-life decisions by 2030.

The company is committed to adopting the following approach for the Novar 1 Repowering Project:

- Exploring circular options for the decommissioning of existing wind farm parts, products and materials.

[1] The Applicant for the Proposed Development is Beaufort Wind Limited, a wholly owned subsidiary of Nadara.

- Where practical and where there are existing and/or scalable new material solutions available, Nadara commits to maximise material recovery (reuse, repurpose, recycle, and recover) and pursue a 'no landfill' approach to composite material waste.
- Working with external experts and internal resources to plan in advance the processes, technical approach and material solutions for circular decommissioning.
- Applying a Life Cycle Analysis (LCA) based approach to decommissioning decision making, helping identify and explore sustainable options that are aligned with the commercial and technical requirements of the project.
- Responsibly sourcing and encouraging circular-minded suppliers and contractors through sustainable tender and procurement practices.
- Enabling positive stakeholder engagement and participation through all stages of development, construction and operation.
- Ensuring circularity practice during construction and decommissioning site works.
- Fostering circular-focused research and development, e.g. by supporting suppliers and contractors that innovate and find new methodologies that will help advance circularity within the sector.
- Supporting the creation of circular jobs, skills and educational opportunities that will allow for long term sustainable employment within the local area as well as the wider region.

To support the development of a sustainable and circular approach to the decommissioning of Novar 1, Nadara is working with Reblade, a company developing environmentally focused methodologies for the management and recovery of wind farm-derived materials through circular innovation. As part of the decommissioning planning process for Novar 1, Nadara and Reblade will explore opportunities to develop a decommissioning strategy that builds upon the commitments set out in this document, with the objective of identifying and implementing circular and sustainable solutions wherever practicable.

Outline Circular Decommissioning Strategy - the purpose?

This Outline Circular Decommissioning Strategy has been prepared to establish a clear and environmentally responsible framework for the decommissioning of Novar 1, supporting the sustainable transition of the Site into repowering. The document demonstrates how Nadara intends to embed circular economy principles, the statutory Waste Hierarchy, and sustainable material management into the project's decommissioning phase. Functioning as a live, iterative document, it sets out an initial decommissioning approach designed to evolve alongside maturing industry technologies and regulatory standards. Liaison with landowners and statutory stakeholders will be critical to ensure any infrastructure of potential benefit to third parties is appropriately factored into agreed removal methodologies and material destinations.

It serves as the preliminary strategy that will be systematically reviewed, updated, and finalised as a detailed Decommissioning and Restoration Plan (DRP) closer to the scheduled cessation of generation at Novar 1. The final DRP will be submitted to the relevant Planning Authority for approval at the appropriate time to satisfy relevant planning consent conditions prior to the commencement of any Novar 1 decommissioning works on site.

Planning for traceability and managing end-of-life blades

Wind turbines nearing end-of-life present a significant recycling challenge, primarily due to the composite composition of their blades. While metallic components (predominantly structural steel) have mature, high-value recycling pathways, the Glass Fibre Reinforced Polymer (GFRP) and Carbon Fibre Reinforced Polymer (CFRP) matrices found in the blades require more sophisticated, non-linear solutions. As the first generation of UK onshore wind assets reach retirement and undergo repowering to support national net-zero targets, the rigorous application of a sector-specific Waste Hierarchy becomes critical.

To address this volume of composite material, Nadara commits to driving all end-of-life blade and nacelle components to the highest possible tier of a self-imposed Waste Hierarchy, wherever commercially and technically feasible. Prior to the commencement of site works, all legacy blades at Novar 1 will undergo a comprehensive structural appraisal to evaluate their viability for direct component re-use and high-value repurposing. Prioritising re-use and re-purposing over lower-tier processing preserves the structural morphology of the material, retains maximum economic value, and delivers significant net-carbon savings. Where viable re-use and re-purposing options have been explored, remaining blade material will be directed to the most suitable recycling and energy recovery solutions available.

Benefits of circular decommissioning

By deploying circular principles, the project aims to optimise resource efficiency and achieve measurable greenhouse gas (GHG) reductions across the decommissioning activities.

Through structured stakeholder engagement and public participation, Nadara aims, where possible, to align material destinations with local community initiatives. This is to ensure the transition of the site yields direct economic and social opportunities and supports local supply chains during the continuous delivery of renewable energy.

Detailed forward planning of all decommissioning activities allows Nadara to map out optimal material pathways from initial design through to site reinstatement. Executing this circular methodology at Novar 1 will demonstrate the tangible advantages of sustainable decommissioning to regulatory bodies and stakeholders.

Core commitments to circularity

Nadara's circular decommissioning approach originated with the Beinn Ghlas Wind Farm Repowering project (Outline Circular Decommissioning Strategy, April 2025; planning ref: 25/01240/PP, August 2025). Building on this foundation, Novar 1 aims to continue to deliver circular value by embedding similar ambitions and demonstrating that sustainable wind farm decommissioning can scale effectively. Nadara's approach remains dynamic, and future project iterations will continuously incorporate maturing technologies, refined circular methodologies, and emerging industry best practices across the portfolio.

By transitioning from traditional dismantling to a circular decommissioning model, Nadara aims to demonstrate that sustainable decommissioning is both commercially and technically effective, as well as aligning with the Clean Power 2030 Action Plan and the Circular Economy (Scotland) Act 2024.

Table of Contents

Contents

1. Wind farm decommissioning - an industry overview 1

1.1. Background 1

1.2. Waste Regulation 1

1.2.1. What is “waste”? 1

1.2.2. The administration of waste management 1

1.2.3. The Waste Hierarchy 2

1.2.4. Prevention or reduction 2

1.2.5. Reuse and preparing for reuse 2

1.2.6. Recycling 2

1.2.7. Recovery 2

1.2.8. Disposal 2

1.3. Traditional decommissioning practices in the energy sector 2

1.3.1. A traditional decommissioning approach 3

1.4. Carbon cutting, net zero & circularity in the wind energy sector 3

1.4.1. Producer responsibility 3

1.4.2. The European Union Critical Raw Materials Act (CRMA) (March 2023) 3

1.4.3. The Onshore Wind Sector Deal (2023) 4

1.4.4. Regen - A Second Wind: Unleashing the Potential of Repowering (April 2026) 4

1.4.5. Great British Energy (GB Energy) 5

1.5. National policies for circularity 5

1.5.1. Department for Energy Security and Net Zero (DESNZ) 5

1.5.2. The Energy Act 2023 5

1.6. Policies for a circular Scotland 5

1.6.1. Circular Economy (Scotland) Act 2024 5

1.6.2. Scotland’s Climate Change Plan (CCP) 2026-2040 (March 2026) 6

1.6.3. National Planning Framework 4 (NPF4): Policy 11 and 12 6

1.6.4. The Scottish Biodiversity Strategy to 2045 (SBS) (2024) 7

1.6.5. The Infrastructure Strategy 2027-2037 (Draft, January 2026) 7

1.6.6. The Energy Strategy and Just Transition Plan (ESJTP) (Draft 2023) 7

1.6.7. Scotland’s Circular Economy and Waste Route Map to 2030 (2024) 7

1.6.8. The Circularity Gap Report 2024 7

1.6.9. Zero Waste Scotland: The Future of Onshore Wind Decommissioning in Scotland 8

1.6.10. The Environmental Authorisation and Mandatory Digital Waste Tracking 8

2. Nadara’s commitment to circular decommissioning 10

2.1. Evolving decommissioning practice 10

2.2. Novar 1 Wind Farm Repowering 10

2.3. Optimising energy production prior to decommissioning 10

2.4. Alignment with traceability & circular reporting 10

2.5. Planning & forecasting for circular decommissioning 11
2.5.1. Evolving approach 11
2.5.2. Practical solutions 11
2.5.3. Optimal & sustainable 11
2.5.4. Stakeholder consultation 11
2.6. Ensuring circular practices during site works 11
2.6.1. Diverse service providers 11
2.6.2. Collaboration 12
2.6.3. Reuse of Assets 12
2.6.4. Steel and other metals 12
2.6.5. Transportation methodologies 12
2.7. Committing to circularity through an LCA approach 12
2.7.1. LCA 12
2.7.2. A 'traffic lights' approach to material management 13
3. Outline Decommissioning Strategy 15
3.1. Overview 15
3.2. Nadara's approach to Bonus B44/600 turbines and components 15
3.2.1. Towers 15
3.2.2. Nacelles and internal components 16
3.2.3. Wind turbine blades 16
3.3. Auxiliary Components 17
3.3.1. Foundations 17
3.3.2. Cables 17
3.3.3. Site roads and crane pads 17
3.3.4. Substation decommissioning and footprint reuse 18
3.3.5. Oil 18
3.3.6. Small electronics 18
3.4. "As-Left" Asset Mapping & Subterranean Liabilities 19
4. Responsibly sourcing circular-minded suppliers & contractors 20
4.1. Environmental management and internal governance 20
4.2. Sustainable Management Plans and Waste Minimisation 20
4.3. Tendering and Sustainable Procurement Practices 20
4.4. Sustainability and Health & Safety 20
4.5. Sustainability and supplier & contractor reporting 20
5. Measuring and capturing the benefits of Novar's circular-focused decommissioning 21
5.1. Overview 21
5.2. Novar 1 Wind Farm 21
5.3. Reporting on carbon emission reductions 21

5.3.1. Stakeholder engagement & circularity 21

5.4. Circular supply chain opportunities 22

5.4.1. Helping support a diverse & circular local supply chain to provide wind farm decommissioning services 22

5.4.2. Circular procurement & local companies 22

5.4.3. Brown jobs with a green twist 23

5.4.4. Measuring additional carbon savings 23

6. References 24

Appendix 1: Wind turbine components and decommissioning 26

1. Wind turbine components and inside a wind turbine 26

1.1. Wind turbine rotor blades 26

1.2. Rotor hub 26

1.3. Stall-tip 26

1.4. Shaft 26

1.5. Gearbox 26

1.6. Generator 26

1.7. Brake 26

1.8. Controller 26

1.9. Nacelle 27

1.10. Tower 27

2. Wind farm site infrastructure 27

2.1. Transformers 27

2.2. Substation and control building 27

2.3. Foundations 27

2.4. Cables & trenches 27

2.5. Wind farm tracks 27

2.6. Crane hard standings 27

3. Wind farm decommissioning practices 27

4. Reuse & repurpose 27

4.1. Wind turbine blades 27

4.2. Nacelles 28

4.3. Other composites 28

4.4. Major components 28

5. Recycling 29

5.1. Overview 29

5.2. Mechanical methods 29

5.3. Chemical recycling 29

5.4. Thermal recycling 29

5.5. Cement kilns 29

6. Recovery 30
6.1. Energy-from-waste 30
7. Disposal 30
7.1. Landfill 30
Appendix 2: Decommissioning skills and benefits 31
1. Circular jobs creation 31
2. Decommissioning skills & education 31
3. Decommissioning-focused training networks 32
Appendix 3: Supporting circular-focused research & development 33
1. Wind turbine end-of-life recycling projects 33
1.1. Pre-treatment methodologies 33
1.2. Fibre reclamation processes 33
1.3. Upgrading (or recycling) of recovered fibres 33
1.4. Recyclable blades 33
1.5. Rare earth magnets 33
1.6. The recycling of composite materials 33
Appendix 4: Glossary of Terms 35
Appendix 5: Key Acronyms / Abbreviations 39

List of Tables

Table 1: Optimal Circular Destinations and High-Value Recovery Tiers
Appendix 2 Table 1: Examples of New and Emerging Circular Economy Job Roles

List of Figures

Figure 1: The Waste Hierarchy
Figure 2: Wind and Materials Forecast
Figure 3: A Typical Product / Service Lifecycle
Figure 4: Turbine Material Treatment Options
Figure 5: Comparison of Reuse and Recycling for GRRP from Wind Turbines
Appendix 1 Figure 1: Wind Turbine Anatomy
Appendix 3 Figure 1: Wind Turbine Blade Morphology

1. Wind farm decommissioning - an industry overview

1.1. Background

Wind power is recognised as a very important source of energy, combined with other clean energy generating sources such as solar power, and more wind farms and more powerful turbines can be expected in the drive to achieve net zero targets.

It is recognised that decommissioning wind farm assets and their associated components and infrastructure should allow for life extension (where practical), refurbishment, reuse and, if the technology exists, recycling. The evolving circular economy approach to wind farm decommissioning contrasts with traditional dismantling and material disposal methods of the past. Circularity offers optimal material management through cutting greenhouse gases and the use of virgin materials, as well as creating significant economic benefits, including the development of sustainable skills and jobs, and the growth of a circular economy supply chain.

Establishing and expanding a sustainable wind turbine decommissioning sector in Scotland requires sustained investment and a commitment to innovation. This includes supporting the development of new processes and technologies, as well as ongoing research and development projects, which are crucial for achieving a truly circular economy for wind turbine components.

1.2. Waste Regulation

1.2.1. What is “waste”?

In many cases the question of whether something is waste or not is straightforward. If a substance, material or product has been discarded by its holder, or there is an intention or requirement to discard it, then it is clearly understood to be waste. The Scottish Environmental Protection Agency (SEPA) provides guidance on the factors that help decision makers define waste [Ref. 1], and refers to the Waste Framework Directive, a European Union directive that seeks to avoid waste generation and to use waste as a resource [Ref. 2].

The definition of waste is not clear when it comes to pollution control because the definition of waste is not necessarily synonymous with actual pollution or harm. A threat to the environment may arise due to the risk of pollution or harm caused by the waste being mishandled or abandoned, and the whole waste cycle requires regulating from the initial production of the waste through to its final management to ensure threats to the environment do not exist or are minimised.

1.2.2. The administration of waste management

Managing the production and disposal of waste is a significant environmental challenge, and a good example of mixed regulation. A range of mechanisms are used to address waste management, including producer responsibility which attempts to manage the causes of waste from its initial production to its final disposal.

The UK's approach to waste management is rapidly evolving, driven by several factors. Existing landfill sites are nearing capacity, and the scarcity of suitable new locations, coupled with the increasing distances required to transport waste, is prompting a shift towards more sustainable solutions. This evolving landscape is also being shaped by new initiatives and policies aimed at reducing landfill reliance.

Furthermore, evolving legislation, with its increasingly stringent targets for waste reduction, recycling, and recovery, is another key driver pushing the UK towards more sustainable waste management practices. The need to reduce landfill has been met with an increase in alternative recovery and recycling routes. There has also been a large increase in waste incineration capacity as well as economic instruments such as taxation and environmental permitting regulations.

While international waste regulations have traditionally focused on domestic waste management and preventing marine pollution (as exemplified by the UN Convention), a more comprehensive approach is emerging. European waste management policy, for instance, emphasises broader principles like the Waste Hierarchy (prioritising prevention, reuse, and recycling) and actively encourages the development of markets for recycled materials [Ref. 3]. This approach reflects a growing recognition of the need for a circular economy in waste management. The Waste Framework Directive sets out objectives and controls over waste in a general sense and establishes a set of high-level principles aimed at dealing with the management of waste.

The key provisions of the Waste Framework Directive are:

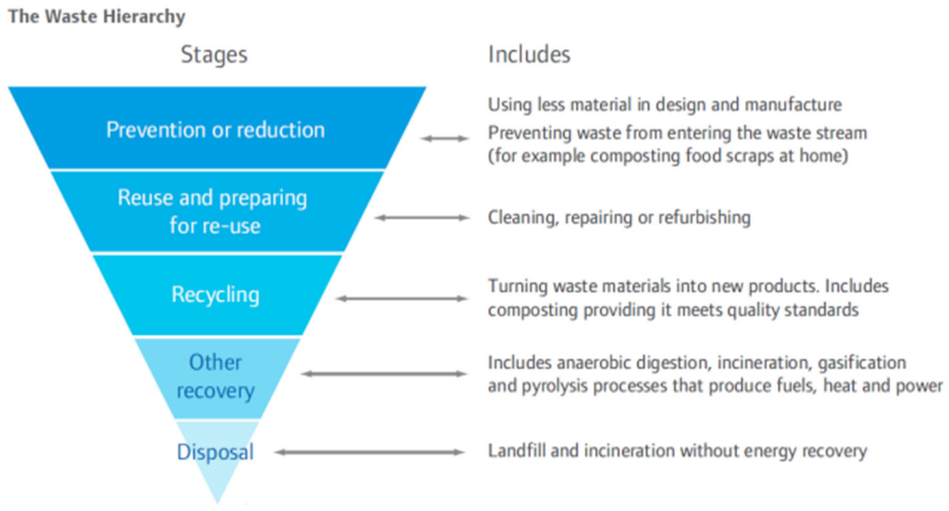
- Without endangering human health and harming the environment.
- Without risk to water, air, soil, plants or animals.
- Without causing a nuisance through noise or odours.

- Without adversely affecting the countryside or places of special interest.

1.2.3. The Waste Hierarchy

The Waste Hierarchy, illustrated in Figure 1, is the cornerstone of all waste law and has been used in UK policy and legislation since the 1990s. Its aim is to provide a hierarchy of waste with policies and laws designed to promote measures as high up the waste hierarchy as possible, with prevention at the top and sending waste to disposal the last resort. It is a legal requirement within the Waste Regulations for all producers of waste to take responsibility and reasonable actions to measure and apply the waste hierarchy in priority order.

Figure 1: The Waste Hierarchy



Reference: London Assembly (2017), [Ref. 3]

1.2.4. Prevention or reduction

The primary aim should be to prevent the creation of waste at source through design and process. This is linked to measurable initiatives such as LCA, clean technology and eco-labelling.

1.2.5. Reuse and preparing for reuse

Reuse is any operation by which any materials or components that are not waste are used again, and preparing for reuse relates to materials and components that can be un-wasted to enable them to be remanufactured, refurbished or reclaimed. The reuse and repurposing of decommissioned wind farm materials is now a viable option with proven real-life examples of IEC certified blade-derived public realm infrastructure in existence, and the incorporation of first-generation site infrastructure, such as access roads and original hardstandings, being designed into new repowering energy projects.

1.2.6. Recycling

Recycling is any recovery method where waste materials can be reprocessed and aims to keep products, materials and components at their highest value and utilisation. Where value is lost following recycling, this is referred to as downsizing, and where it is enhanced, is referred to as upcycling.

1.2.7. Recovery

Recovery methods include energy recovery where materials are sent for incineration.

1.2.8. Disposal

Disposal activities are methods of landfilling of waste, and the incineration of waste that does not recover energy from the waste.

1.3. Traditional decommissioning practices in the energy sector

Traditionally, command and control mechanisms outlined through the Waste Framework Directive have focused on the regulation of activities after waste has been produced and relied on a system not necessarily efficient when it comes to reducing waste and encouraging material reuse, recycling and recovery.

Consequently, there have been many grey areas that have led to uncertainty as to whether the difficult challenge of sustainable asset and related waste management has been addressed. These have included questions that can encourage waste minimisation, such as:

- Whether material which can be reused but is discarded can be classified as waste, for example something that still functions perfectly but is disposed of.
- Whether material that is not wanted remains valuable to someone or something else.
- Whether a residue or by-product from an industrial process that can be used as a replacement for a raw material should be classified as waste.

1.3.1. A traditional decommissioning approach

The decommissioning of a wind farm involves rigorous planning, usually several years in advance of the actual works, with related works permits and approvals required to be in place through local authorities and relevant stakeholders prior to the decommissioning works commencing.

The rapid expansion of onshore wind energy in the 1990s and 2000s understandably prioritised operational efficiency. Consequently, decommissioning methodologies and processes, along with the management of resulting materials, were often assumed to be within the capabilities of existing contractors. Sustainable and circular practices in onshore wind decommissioning are a more recent focus. Historically, large-scale decommissioning efforts have primarily concentrated on recycling the steel from turbine components and towers, while other materials have received less attention.

With the first generation of wind farms rapidly reaching end-of-life and whole site decommissioning projects appearing, the industry is looking at sustainable solutions for the multiple material types arising from the decommissioning. Utilising previous 'traditional' methodologies and material solutions may not be optimal. Material from turbines that have had to be decommissioned early due to an unplanned failure or component swap out, have typically been destructively decommissioned and transported to either recycling facilities where a market value exists, or to landfill where there is no other satisfactory solution, particularly for wind turbine blades.

Landfill was a viable option when disposing of problematic materials including turbine blades and other composites, albeit it was not the best option. In the absence of legislation dictating otherwise, the option that provided an end-of-life waste solution was viewed as a satisfactory solution.

Typically, turbine blades were downsized on site to allow for practicalities of transportation and taken to landfill to be further downsized and buried. Turbine towers would be unbolted and reduced to individual sections for transportation to a recycling facility where the steel has a value, and only some of the components would be recycled or reused, however typically with limited options.

Foundations would be broken up using hydraulic hammers or explosives with the resulting material used throughout the site, and if the turbine was not required to be repowered, the site would be restored to its original condition in accordance with planning conditions and/or land agreements.

Appendix 1 provides a general overview of a typical wind farm and its components, together with a summary of the key options currently being considered and appraised when assessing the decommissioning needs and end-of-life options for wind farm assets against the Waste Hierarchy Directive.

1.4. Carbon cutting, net zero & circularity in the wind energy sector

1.4.1. Producer responsibility

Producer responsibility and the growing emergence of Environmental and Social Governance (ESG) within organisations has created a positive cultural shift that is critically raising awareness for the sustainable management of the planet's resources whilst achieving net zero ambitions. Organisations are taking responsibility for materials and their whole lifecycle, including accounting for design to help support end-of-life recycling and focusing on reuse and recovery. Furthermore, organisations are now committing to imposing self-regulation through setting sustainability targets that are measurable, transparent and publicly reportable.

This approach is supported by SEPA, who have set out an objective to help facilitate the delivery of a sustainable and low carbon economy through their guidance on life extension and decommissioning of onshore wind farms, a document that outlines a hierarchical framework aimed at reducing environmental impacts [Ref. 4].

1.4.2. The European Union Critical Raw Materials Act (CRMA) (March 2023)

The CRMA [Ref. 5] is a regulation that aims to ensure a secure and sustainable supply of critical raw materials (CRMs) and was adopted by the European Commission in March 2023. The Act is considered essential for the European Union (EU) clean-tech economy to ensure access to all the

critical materials for wind and steel, including rare earths, nickel, manganese, copper, aluminium, ferrous scrap and glass fibre fabrics. In summary, the Act supports the domestic production and refining capabilities for these materials and is designed to incentivise circularity and innovation. This is significant to the wind energy sector where steel represents one of the most tangible examples of circularity in decarbonisation and where access to other primary and secondary materials used in wind turbine production will be increasingly required.

1.4.3. The Onshore Wind Sector Deal (2023)

The Scottish Government Onshore Wind Sector Deal (2023) [Ref.6] sets out commitments from the onshore wind industry to deliver 20GW of onshore wind in Scotland by 2030. The Onshore Wind Sector Deal identifies the circular economy creating the opportunity for Scotland to be a world leader in material circularity. It takes cognition of the growing awareness of resource depletion and how this can be tackled through minimisation, reuse and the recovery of materials. This approach contrasts with the traditional management of waste in the sector and addresses the control of environmental risks from the disposal of end-of-life assets to address the opportunity of circularity.

1.4.4. Regen - A Second Wind: Unleashing the Potential of Repowering (April 2026)

The Regen report A Second Wind: Unleashing the Potential for Repowering (April 2026) [Ref. 7] provides a critical evidence base for the circular decommissioning of onshore wind assets across the United Kingdom. It identifies that managing retired materials responsibly is essential for environmental sustainability and can reinforce and strengthen the wind industry's social licence to operate within local communities.

The report's findings directly support circular objectives for wind farm decommissioning by establishing a practical framework for end-of-life pathways. It distinguishes full repowering (where legacy assets are decommissioned and new turbines constructed (often with a different layout, height, and capacity)) from standard decommissioning, which focuses solely on infrastructure removal and site restoration.

The report also reinforces the sector-specific Waste Hierarchy prioritising turbine component maintenance/prevention, reuse, and refurbishment (refurbishing the turbine or reusing parts elsewhere) over lower-tier recycling and disposal. It highlights an increasing industry shift toward Inter-Fleet Component Harvesting and turbine refurbishment (disassembling, restoring, and upgrading whole units or high-value components (such as gearboxes, nacelles, and generators) to extend asset lifespans by up to 15 years and minimise virgin raw material demand.

The report also highlights:

- **Above-Ground Recyclability**: Approximately 85–90% of a wind turbine's total above-ground mass is readily recyclable using mature processing routes (principally steel from towers/foundations, cast iron, copper, and aluminium). However, the composite nature of blades remains a significant industry hurdle, requiring alternative processing routes like mechanical recycling, thermal pyrolysis, or cement co-processing to divert thermoset resins and fibres from landfill or energy-from-waste.
- **Concrete & Subsurface Infrastructure**: Concrete and aggregate (primarily in foundations and access tracks) dominate the total mass of an onshore wind asset, accounting for 70–75%. Due to removal costs and lower material value, foundation concrete is typically not removed entirely. It is dug out to a specified depth below ground level (depending on site and consent conditions) to protect surrounding ground stability and habitats. By prioritising optimal on-site crushing and the reuse of site-won aggregates (where practical) for sub-base fill during repowering, developers can directly address Regen's call to minimise waste, avoid unnecessary off-site haulage, and reduce reliance on virgin mineral extraction.
- **Socioeconomic Value**: Beyond environmental savings, establishing a domestic circular supply chain offers significant economic potential. The report highlights that the UK market for wind turbine refurbishment could deliver £1.6 billion in Gross Value Added (GVA) (£876 million direct) and support over 3,500 full-time equivalent (FTE) jobs by 2035. It also points to direct community repurposing opportunities, such as converting decommissioned blades into outdoor benches, pedestrian bridges, play areas, or bike shelters.

The Regen report identifies a critical "missing business case" for UK recycling infrastructure. As turbine blades represent only 10% of global thermoset composite waste, waste reprocessors face sector-wide uncertainty regarding future feedstock volumes, delivery timelines, and locations, creating a severe risk of supply chain bottlenecks after 2027 as legacy Renewables Obligation (RO) subsidies expire and over 500 turbines reach end-of-life by 2035.

Developers can directly address this industry bottleneck by conducting early materials audits that quantify and schedule anticipated volumes of retired materials. By publishing initial forecast data early and updating it near decommissioning, project strategies provide the long-term visibility required for reprocessors to justify capital investment in domestic recycling infrastructure.

1.4.5. Great British Energy (GB Energy)

Great British Energy (GB Energy) [Ref. 8] is a publicly owned energy company established to invest in and develop renewable projects, with a core mission to secure the UK's energy independence and transition to a "clean energy superpower". Within the context of wind farm repowering projects, GB Energy acts as a strategic driver for circularity by fostering the domestic infrastructure required to manage end-of-life assets responsibly.

GB Energy mandates circularity by tying funding and supply chain support to the use of secondary (recycled) materials and the development of UK-based refurbishment capacity. Through the Supply Chain Fund, it prioritises projects that address bottlenecks in recycling and remanufacturing, helping ensure that the infrastructure exists to handle decommissioned assets like blades and nacelles without relying on landfill.

GB Energy is tasked with reducing the UK's reliance on virgin materials by incentivising the use of secondary (recycled) resources in the clean energy sector. By coordinating a more strategic decommissioning pipeline, GB Energy is providing long-term visibility for waste management companies to invest in specialised technologies for complex materials like composite GFRP blades.

1.5. National policies for circularity

1.5.1. Department for Energy Security and Net Zero (DESNZ)

Under the Clean Power 2030 Action Plan, published by the Department for Energy Security and Net Zero (DESNZ) [Ref. 9], repowering existing wind farm sites is treated as a strategic priority to unlock homegrown, low-cost power and preserve national energy security. As the government department overseeing UK energy policy, DESNZ set the UK wide target to double onshore wind capacity to 27–29 GW by 2030. Supported by the Energy Act 2023, this framework empowers the National Energy System Operator (NESO) to reform connection queues and prioritise infrastructure critical to reaching national net-zero goals. While site waste and technical standards remain governed by Scottish environmental regulations, the DESNZ-led strategy ensures that repowering projects are prioritised for grid connections, accelerating delivery far faster than traditional greenfield developments.

1.5.2. The Energy Act 2023

The Energy Act 2023 (c. 52) [Ref. 10] serves as the overarching statutory pillar that modernises the legal obligations for end-of-life infrastructure management. Its primary relevance to decommissioning lies in the Polluter Pays Principle and the mandate for financial and operational liability. The Act ensures that the retirement of legacy assets is not a linear waste event but a regulated process that prevents environmental debt. This provides the statutory weight behind the commitment to restore sites to a "satisfactory state," bridging 1990s planning obligations with modern waste standards to ensure all hazardous materials and structures are removed responsibly.

Furthermore, the Act facilitates the repowering process by establishing the National Energy System Operator (NESO), which treats the decommissioning of old turbines as a strategic unlocking of grid capacity. Instead of viewing the project as a simple closure, the Act frames it as a system-critical transition, allowing the repowered site to be prioritised for grid reconnection. By incentivising a domestic circular supply chain, the Act also provides the high-level business case for a no landfill goal, supporting the reclamation of high-value materials and the domestic processing of complex components like composite blades within the UK.

1.6. Policies for a circular Scotland

1.6.1. Circular Economy (Scotland) Act 2024

The Circular Economy (Scotland) Act 2024 [Ref. 11] received Royal Assent on 8 August 2024. It serves as the primary legislation and legal mandate to move Scotland toward a circular economic model by 2045, and away from a linear Take-Make-Dispose Model. It establishes a statutory framework that grants Scottish Ministers the authority to set legally binding targets for resource use and, crucially, provides the powers to prohibit the landfilling of valuable turbine components. The Act turns circularity from a best-practice recommendation into a statutory duty, requiring materials be managed according to the legal Waste Hierarchy.

It mandates a five-year strategy cycle, targets for waste reduction and recycling, and powers to curb the disposal of unsold consumer goods, supporting a net-zero, nature-positive, and thriving economy. The Scottish Parliament's Net Zero, Energy and Transport Committee stated in a report published in February 2024 [Ref. 12] that the Circular Economy Bill (prior to assent of the Act) should "encourage behaviour change" and lead through education and awareness raising.

The core strategic objectives of the Act include:

- **Systemic Transition**: To move Scotland towards a circular economy by modernising waste and recycling services and embedding circularity across all sectors.
- **Whole Lifecycle Focus**: To ensure that the production, distribution, and consumption of goods are designed to reduce their environmental impact and whole-lifecycle carbon emissions.
- **Resource Preservation**: To keep materials in use at their maximum value for as long as possible, reducing the demand for virgin resources.
- **Just Transition**: To ensure that the economic shift to a circular model is fair and contributes to "community wealth building" by creating local jobs and sustainable employment.

The Act places several primary duties on the Scottish Ministers to guide national progress:

- **Circular Economy Strategy**: The Scottish Ministers are legally required to prepare, publish, and review a national Circular Economy Strategy every five years.
- **Circular Economy Targets**: The Act requires Ministers to set statutory targets for Scotland's transition, which may include measures for recycling, reuse, and waste reduction.
- **Reporting and Monitoring**: Ministers must report on progress against these objectives and targets at the end of each reporting period.

In setting action priorities, Ministers must focus on sectors most likely to contribute to the circular economy, with energy infrastructure identified as a key area for resource recovery. The Act supports initiatives to reclaim high-value materials (like steel, copper, and aluminium) from decommissioned wind farms to bolster supply-chain resilience.

1.6.2. Scotland's Climate Change Plan (CCP) 2026-2040 (March 2026)

Scotland's Climate Change Plan (CCP) 2026–2040 [Ref. 13] is the legally binding master plan that establishes the legal pathway for Scotland to meet its new system of five-year carbon budgets. These budgets replace previous annual targets with a more consistent framework for measuring progress toward the 2045 Net Zero goal. The plan legally locks in the statutory carbon budgets and sectoral blueprints for a 5-year cycle.

For the first budget period (2026–2030), the CCP mandates an average emissions level that is 57% lower than 1990 baseline levels, capping total emissions at 175 megatonnes for the five-year block. The CCP breaks down these targets into specific 'sectoral contributions':

- **Energy Supply Decarbonisation**: The plan targets a 93.4% reduction in electricity supply emissions by 2040, measured against the 1990 baseline levels. For onshore wind, this requires a massive acceleration in capacity, where the decommissioning and repowering of high-yield sites is prioritised over greenfield developments.
- **The Circular Mandate for Waste Management**: The CCP projects a 73.1% reduction in waste management emissions. It explicitly states that circular economy policy must pull levers relating to both territorial and consumption emissions. This provides the legal basis for the Circular Decommissioning model; by reclaiming material on-site, wind farm projects avoid the heavy carbon penalties associated with virgin material production and waste transportation.
- **Mandatory Monitoring**: Under the 2026 framework, the energy sector must evidence how it is contributing to these reductions, ensuring projects align with the Analytical Annex of the CCP which tracks sectoral resource efficiency.
- **Just Transition Duty**: The CCP mandates that every climate action must deliver a 'Just Transition'. Decommissioning activities are legally linked to Community Wealth Building, requiring projects to maximise local supply chain opportunities and ensure fair, high-value work remains within the local region.

1.6.3. National Planning Framework 4 (NPF4): Policy 11 and 12

National Planning Framework 4 (NPF4) [Ref. 14] Policy 11(a) states that "development proposals for all forms of renewable, low-carbon and zero emissions technologies will be supported", including "wind farms including repowering, extending, expanding and extending the life of existing wind farms". Policy 11(e) further requires project design and mitigation demonstrate how "proposals for decommissioning of development including ancillary infrastructure, and site restoration" and "the quality of site restoration plans including the measures in place to safeguard or guarantee availability of finances to effectively implement those plans" are addressed. Policy 12(a) states that "development proposals will seek to reduce, reuse, or recycle materials in line with the waste hierarchy." Policy 12(b) further outlines that development proposals will be supported where they "reuse existing buildings and infrastructure", "minimise demolition and salvage materials for reuse", "minimise waste, reduce pressure on virgin resources", and "use materials with the lowest forms of embodied emissions, such as recycled and natural construction materials".

1.6.4. The Scottish Biodiversity Strategy to 2045 (SBS) (2024)

The circular economy is legally linked to nature restoration through the Scottish Biodiversity Strategy to 2045 [Ref. 15]. This strategy mandates a Nature Positive approach to all national infrastructure, requiring that developments contribute to the recovery of Scotland's ecosystems. By adopting a circular decommissioning model (which utilises site-won materials and avoids the carbon-heavy extraction and transport of new mineral) projects reduce their physical footprint and minimise habitat disturbance. This integrated approach demonstrates that circular resource management is a key tool for achieving Nature Positive outcomes, fulfilling the environmental duties established in the Circular Economy (Scotland) Act 2024.

1.6.5. The Infrastructure Strategy 2027-2037 (Draft, January 2026)

The draft Infrastructure Strategy 2027–2037 [Ref.16] was published in January 2026 and sets out a ten-year framework to guide Scotland's transition to a resilient, net-zero economy. Following its public consultation phase in early 2026, the strategy introduces a mandatory investment hierarchy that prioritises the maintenance and repurposing of existing assets over new construction. This document replaces the vision of the outgoing Infrastructure Investment Plan (IIP) 2021–2026. The Strategy transitions Scotland from the project-led approach of the 2021–2026 IIP to a 10-year strategic framework focused on asset longevity and place-based investment.

For energy infrastructure, the plan specifically prioritises the re-industrialisation of port infrastructure and the creation of regional hubs to support the offshore and onshore wind supply chains. By integrating community-led energy activities and focusing on regional equity, the framework ensures that infrastructure investment acts as a catalyst for Just Transition goals, particularly in the Highlands and Islands.

The public consultation period closed on 5 May 2026. The Scottish Government is currently analysing the consultation feedback to produce the final document, which is scheduled for publication in late 2026.

1.6.6. The Energy Strategy and Just Transition Plan (ESJTP) (Draft 2023)

The draft Energy Strategy and Just Transition Plan (ESJTP) [Ref. 17] addresses the critical requirement of sustainably securing materials for Scotland's energy infrastructure by prioritising the reclamation and reuse of high-value resources from decommissioning sites. Under National Planning Framework 4 (NPF4), this objective is balanced with nature conservation, creating an enabling framework that accelerates the planning process for repowered assets. This integrated approach ensures that the energy transition is supported by dedicated circular economy material management facilities, reducing the environmental footprint of the 2030 infrastructure rollout.

1.6.7. Scotland's Circular Economy and Waste Route Map to 2030 (2024)

The Scottish Government's Circular Economy and Waste Route Map to 2030 [Ref. 18] sets out the strategic pathway to deliver national reuse and recycling targets. The actions outlined in the Route Map are designed to align with the statutory requirements of the Circular Economy (Scotland) Act 2024 to support an effective, localised approach to resource management across Scotland.

Key actions presented in the Route Map include a review and refresh of Scotland's Waste Data Strategy's action plan maintaining a program of research on waste prevention and related areas, developing public procurement opportunities to reduce environmental impact, and supporting the uptake of green skills, training, and development opportunities. These actions collectively aim to build a robust framework for a circular economy, encompassing data management, policy development, and skill enhancement.

1.6.8. The Circularity Gap Report 2024

The Circularity Gap Report Scotland [Ref. 19] is a landmark study produced by Circle Economy in collaboration with Zero Waste Scotland. It applies a globally recognised metric to measure the circular state of the Scottish economy, providing a baseline for national resource efficiency. While the Global Circularity Gap Report is an annual publication by Circle Economy that tracks the world economy, the Circularity Gap Report Scotland was a bespoke, deep-dive analysis published in August 2022 to establish a specific national baseline.

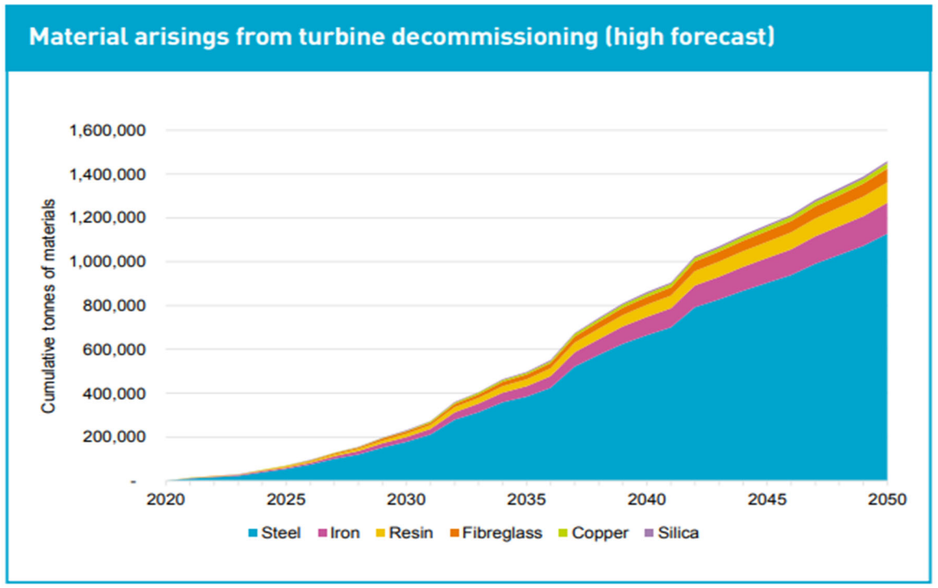
According to the 2024 Circularity Gap Report, Scotland's economy was only 1.3% circular. This means that Scotland is almost completely reliant on the use of virgin materials which is in stark comparison to the Netherlands whose economy is about 25% circular.

The 2024 report highlighted opportunities to cut resource use in Scotland to bring its circularity to 11.8% and addresses seven areas of improvement, including the circular decommissioning of Scotland's energy infrastructure.

1.6.9. Zero Waste Scotland: The Future of Onshore Wind Decommissioning in Scotland

The Zero Waste Scotland's (ZWS) [Ref. 20] research serves as the primary technical baseline for end-of-life asset management in the renewables sector. This work established the Wind Turbine Materials Forecast as presented in Figure 2, which remains a critical foundation for current project planning. While originally drafted as a future forecast, this data now serves as the validated material benchmark for the industry; it identifies the precise volumes of steel, iron, and copper that projects must return to the circular economy to meet the statutory targets set by the 2024 Circular Economy Act.

Figure 2: Wind turbine materials forecast.



Reference: Zero Waste Scotland (2023), [Ref. 20].

The foundational research highlighted the vast material opportunities for the coming decades, identifying that between 2025 and 2050, over 5,600 turbines are expected to be decommissioned in Scotland. This represents a reclamation opportunity for up to 1 million tonnes of steel. The research emphasises that the lifespan of these assets must be maximised through a strict hierarchy: prioritising the reuse and refurbishment of high-value components (such as gearboxes and generators) before considering bulk recycling. Because recycling metals like steel and copper can offset greenhouse gas emissions by approximately 35% compared to virgin material production, high-value recovery has transitioned from a recommendation to a statutory priority.

While the 2021 report initially identified a "data gap" regarding the actual disposal destination of materials, the 2024 update integrated this research with the Onshore Wind Sector Deal and the 2026 implementation of Mandatory Digital Waste Tracking. This evolution allows movement beyond the initial estimates of 2021 and provides real-time, verified data on how its decommissioned assets contribute to the £70 million in potential material value identified for the Scottish renewables sector.

By following the hierarchy established in this research, decommissioning wind farm projects transforms the "significant opportunities" identified by Zero Waste Scotland into measurable outcomes. This ensures that the decommissioning process is not merely a waste management exercise, but a strategic contribution to the Clean Power 2030 Action Plan, directly safeguarding critical raw materials and supporting the growth of green-certified skills and jobs within regions.

1.6.10. The Environmental Authorisation and Mandatory Digital Waste Tracking

The Environmental Authorisation (Scotland) Regulations 2018 (EASR) [Ref. 21] and the Digital Waste Tracking (Scotland) Regulations 2026 [Ref. 22] together form the core regulatory framework for decommissioning. Following the 2025 integration of waste management licensing into the EASR framework, wind farm decommissioning is now a regulated Waste Management Activity, requiring a transparent, digital audit trail.

EASR 2018 provides the legal mechanism to enforce the Circular Economy (Scotland) Act 2024 at the site level:

- Statutory Duty of Care (Schedule 11): Under EASR, developers must apply the Waste Hierarchy, making the reuse and recycling of turbine components a mandatory requirement for permit surrender.
- Authorised Restoration: Mandates that a site be returned to a "satisfactory state," ensuring no environmental debt remains.

The Digital Waste Tracking (Scotland) Regulations 2026 serve as the statutory instrument that mandates the use of the new UK-wide digital tracking service within Scotland.

While the UK system launches in October 2026, the Scottish Regulations formally come into force on 1 January 2027. This creates a critical transition window in late 2026 where voluntary use during the service's Public Beta phase. A live testing period where the digital system is fully operational for testing data submissions and software integrations without incurring non-compliance penalties. Participating in the Public Beta phase allows major Scottish infrastructure projects and supply chain partners to test systems and iron out data workflows ahead of the strict 2027 legal mandate.

The 2026 Regulations mandate that specified information regarding waste movements (including the unique Digital Waste Record Number) must be entered into the system by the end of the second working day after the waste is received or moved.

The Regulations grant SEPA new powers to issue compliance notices and recovery notices. For wind farm repowering, this means that every tonne of steel or composite material must have a verifiable digital handshake between the site and the reprocessor to avoid significant variable monetary penalties.

By digitising the Duty of Care, the Regulations turn the theoretical carbon savings of the Zero Waste Scotland research into verifiable facts, providing a real-time audit of how decommissioned assets contribute to Scotland's 2045 Net Zero goals.

2. Nadara's commitment to circular decommissioning

2.1. Evolving decommissioning practice

Nadara's circular decommissioning approach originated with the Beinn Ghlas Wind Farm Repowering project (Outline Circular Decommissioning Strategy, April 2025; planning ref: 25/01240/PP, August 2025). The planning application for the Beinn Ghlas Wind Farm Repowering was submitted to Argyll and Bute Council in August 2025 (planning reference 25/01240/PP) and remains pending consideration.

Building on this foundation, Novar 1 aims to continue to deliver circular value by embedding similar ambitions and demonstrating that sustainable wind farm decommissioning can scale effectively.

Nadara recognises that decommissioning strategies must not remain static for on-site practices. While Beinn Ghlas provided the initial framework and Novar 1 demonstrates its portfolio scalability, the decommissioning model will naturally continue to evolve. Future iterations across Nadara's assets will continually integrate emerging best practices, advancing processing technologies, and refined circular economy methodologies as industry capabilities mature.

2.2. Novar 1 Wind Farm Repowering

The 34 Bonus B44/600 turbines[2] of Novar 1 have a total installed capacity of 17 megawatts (MW) of electricity. The existing Novar 1 Wind Farm is located on land (the 'Site') within the Novar Estate, approximately 11 km north of Dingwall and 9 km northwest of Alness in Easter Ross. Positioned in the Highlands of northern Scotland, the Site sits on the slopes overlooking the Cromarty Firth and falls within the jurisdiction of The Highland Council. It was one of Scotland's first large-scale onshore wind farms to commence operations, beginning generation in 1997. The Site is adjoined by the operational Novar 2 Wind Farm, which comprises 16 turbines with a maximum blade tip height of 106m (this site is owned and operated by RWE).

Novar 1 continues to operate efficiently with technical analysis of the wind turbines demonstrating that they can continue to operate beyond their original design life. Novar 1 secured planning consent to operate until 2031 following a life extension planning application in 2020 to extend the original planning consent expiry date.

Two principal considerations typically influence the decommissioning of a wind farm. The advantages offered by repowering with turbines incorporating the latest technological advancements, and the diminished performance and increased maintenance requirements resulting from the degradation of existing assets.

Nadara proposes to decommission and remove the 34 existing turbines and associated infrastructure at Novar 1, replacing them (subject to planning consent) with 9 high-capacity turbines featuring a maximum tip height of 180m.

Decommissioning and construction is anticipated to take up to 36 months to complete.

Significant socioeconomic benefits will accrue from informed sustainable decommissioning, notably the utilisation of local supply chains, the creation of skilled employment opportunities within sustainable supply chains and use of local infrastructure where possible. This includes, for example, the utilisation of local accommodation, site welfare facilities, plant hire, fuel suppliers, catering, and regional trade subcontractors to support external tier one and two suppliers.

2.3. Optimising energy production prior to decommissioning

Inspection and maintenance activities at Novar 1 are overseen by Nadara's Asset Management team, working closely with their operations and maintenance service providers to ensure the safe, compliant and efficient operation of the wind farm. Through ongoing performance monitoring, regular site engagement, and structured operational and technical reviews, we maintain oversight of asset condition, maintenance delivery and operational performance.

Nadara's asset management and maintenance approach will help maximise renewable energy production from the wind farm throughout its operational life, while ensuring the asset continues to be managed safely, efficiently and in accordance with all relevant obligations until decommissioning.

2.4. Alignment with traceability & circular reporting

[2] The turbines are de-rated to 500kW.

Operating within the parameter of incoming legislation (specifically the Environmental Authorisation (Scotland) Regulations 2018 (EASR) and the Digital Waste Tracking (Scotland) Regulations 2026) Nadara will utilise its industry expertise to establish data-informed circular reporting and seek to align practices of digital waste tracking into its project planning processes.

By embedding these standards into project planning, Nadara will help contribute to the UK drive for supply chain behavioural change to eliminate destructive disposal, demonstrate EASR duty of care compliance, and accurately quantify the carbon and material outcomes of site restoration.

2.5. Planning & forecasting for circular decommissioning

In accordance with its commitment to responsible wind farm operation, Nadara will conduct a pre-decommissioning assessment of the turbines, the site infrastructure and resultant materials at Novar 1. This assessment will serve to identify the optimal circular economy options available at the time of decommissioning, which will be implemented to the extent practically feasible.

To ensure the implementation of optimal site works and circular solutions at Novar 1, a comprehensive understanding of site-specific downsizing and removal methodologies, available contractor skill sets, and suitable material solutions is required throughout both the planning and implementation of the entire decommissioning process.

Current circular decommissioning options that are proposed for Novar 1 include the following:

- Reconditioning of decommissioned wind turbines for second life use at a different site (where feasible).
- Reusing wind turbine components as spares for other wind farms.
- Reusing components and other structures for non-wind farm solutions for use in local communities and other sectors.
- Metal recycling.
- Glass Fibre Reinforced Polymer (GFRP) and Carbon Fibre Reinforced Polymer (CFRP) material processing through early-stage recycling methodologies, where practical, to advance technological readiness levels, such as shredding and grinding for use in novel mechanical, thermal and chemical recycling technologies.
- Removing, crushing and reusing aggregate from concrete bases, where practical.
- Use of existing tracks for the repowered wind farm and/or other landuse purposes where feasible.

Notwithstanding the above, Nadara's plans for the decommissioning of Novar 1 will be examined and revised on a periodic basis through the following principles and justification, including but not limited to:

2.5.1. Evolving approach

The early intentions of circular decommissioning strategies are not prescriptive. They can change as technology develops, new evidence emerges, and best practice matures. This demonstrates an ongoing commitment to up-to-date thinking.

2.5.2. Practical solutions

The emphasis on ‘practical solutions’ recognises that optimal circular economy solutions need to be weighed against what is practically achievable. Feasibility, affordability, and logistics will all be considered when deciding on the approaches taken.

2.5.3. Optimal & sustainable

The aim is to deliver the ‘optimal and sustainable’ decommissioning of Novar 1. This is to secure the best combination of environmental protection, economic sustainability, and social responsibility.

2.5.4. Stakeholder consultation

Most importantly, Nadara commits to a wider consultation with appropriate key stakeholders close to the start of decommissioning works with the focus on local consultation and making local concerns and expertise part of the final decommissioning plan.

2.6. Ensuring circular practices during site works

Nadara is committed to working with partners who share their vision and can deliver technically sound solutions while minimising environmental impact and staying within project budget.

From planning to purchasing and on-site activity management, Nadara will look to apply the following general principles (although not solely):

2.6.1. Diverse service providers

There could be multiple specialists involved in dismantling and removing wind turbines and infrastructure. This recognises the nature of work and the requirement for varied expertise.

2.6.2. Collaboration

Nadara will endeavour to engage with Reblade and other specially selected supply chain partners, with a focus on collaboration to achieve technical excellence within budget. This implies the need for cooperation and common goals.

2.6.3. Reuse of Assets

While Nadara will explore market interest for entire turbines or functional spare parts across its operating fleet, it is recognised that the Bonus B44/600 technology represents older, sub-megawatt machinery with limited resale demand. Where complete resale is unviable, components will be managed via high-value recycling and material recovery streams.

2.6.4. Steel and other metals

Steel and other metals derived from end-of-life wind turbines are easier to manage in that they hold substantial residual value as a major global commodity.

An LCA for steel material could focus on the downsizing of large steel components (electric arc or thermal methods) and transport to suitable steel recyclers.

2.6.5. Transportation methodologies

To minimise carbon emissions due to fuel consumption, smart planning for transport should be employed in the decommissioning strategy. The transport plan must consider downsizing and circular activities to effectively reduce repeat movements around site and beyond. For example, minimising the need for escorted loads can greatly reduce the number of vehicles required during component removal and this can be achieved by ensuring transport loads stay below the maximum of 2.9m wide where practical.

Materials should be assessed in detail to understand the optimal loading strategies, and this may include downsizing blades, nacelles or tower sections. Understanding the best combinations of each component to get the most amount of material off site safely is also key to reducing greenhouse gases.

Where practical, the use of local transport suppliers could be a viable methodology for minimising greenhouse gases during transportation and indeed throughout the entire scope of works.

2.7. Committing to circularity through an LCA approach

2.7.1. LCA

Nadara recognises that by taking an LCA-focused approach to decommissioning, negative environmental impacts can be minimised through reducing greenhouse gas emissions and reducing the consumption of natural resources. Life cycle analysis is a methodology that can be used to quantify the environmental impact of a product or a service throughout all or selected stages of its lifecycle. The key stages of an LCA are illustrated on Figure 3 below.

Figure 3: A typical product/service lifecycle



Reference: Composites UK/National Composites Centre (2022) [Ref. 23].

By calculating the carbon impact of each material or process used throughout the life of a product or service, it is possible to highlight areas of improvement and compare avenues for the optimal

carbon solution. LCAs take an accumulation of many environmental factors of using a material or process and quantify this with an aggregated value of the tonnes of carbon dioxide (CO2) equivalent that this represents. By using a global figure, it makes comparing the environmental impact of two items much easier. CO2 equivalent considers the cost to human health, ecotoxicity, resource depletion and carbon footprint. By quantifying these benefits through a site-specific LCA, Nadara ensures that the decommissioning phase of Novar 1 directly supports the UK's pursuit of a clean power system by 2030 while safeguarding critical raw materials for future renewable infrastructure.

2.7.2. A 'traffic lights' approach to material management

Where practical and where there are existing and/or scalable new material solutions Nadara aims to achieve 'no landfill' for all composite materials resulting from Novar 1 decommissioning. Nadara will strive to ensure that all the 102 wind turbine blades will be diverted from landfill and instead directed to reuse, repurposed, recycled or recovered material management solutions.

Nadara will seek to commit to a sustainable approach to Novar decommissioning using the following (but not limited to) principles of optimal material solutions:

- Reuse.
- Repurpose.
- Recycle.
- Recover.

To guide these outcomes, Table 1 outlines the target high-value recovery tiers and potential circular output streams for the principal material groups decommissioned from the Site.

Table 1: Optimal Circular Destinations and High-Value Recovery Tiers

Material	Recycling Output	Circular Tier
Composite (GRP)	Repurpose: Potential to be repurposed for blade architecture, public realm infrastructure, sound barriers, cladding, fencing, flooring, and decking. Recycle: Printing Filament & Polymer Pellets. Mechanical and chemical recycling can reduce composites into feedstock for the manufacturing sector.	Decommissioned blades: Can be shredded and compressed with a binding agent to create high-durability boards, retaining the structural properties of the glass fibre while diverting material from cement co-processing. Decommissioned nacelles: The unique, weather-proof casing of the nacelle offers immediate repurposing potential with minimal modification.
Steel (Tower)	New structural steel beams	Recycle
Copper (Generator)	Electrical wiring / Components	High-Value Recovery
Concrete (Base)	Certified Type 1 Aggregate	Direct Re-use

To optimise the circularity potential of Novar 1 during the decommissioning works, Nadara deems it essential to possess comprehensive knowledge of Novar's component parts, their condition, and their potential circular decommissioning options. Nadara proposes to achieve this through the utilisation of its expert in-house resources and external contractors, drawing upon the combined input from the sustainability, procurement, asset management, and operational teams. Furthermore, Nadara will engage with circular-focused decommissioning service providers and advisors to help formulate both business-wide decommissioning strategies and specific site decommissioning plans.

Prior to any on-site dismantling & material handling, Nadara will look to ensure Novar 1 is thoroughly assessed to identify where possible materials can be managed optimally. This approach will maximise the potential for handling material as a resource and not as waste. While market interest for whole wind turbine units or spare parts will be explored, components will

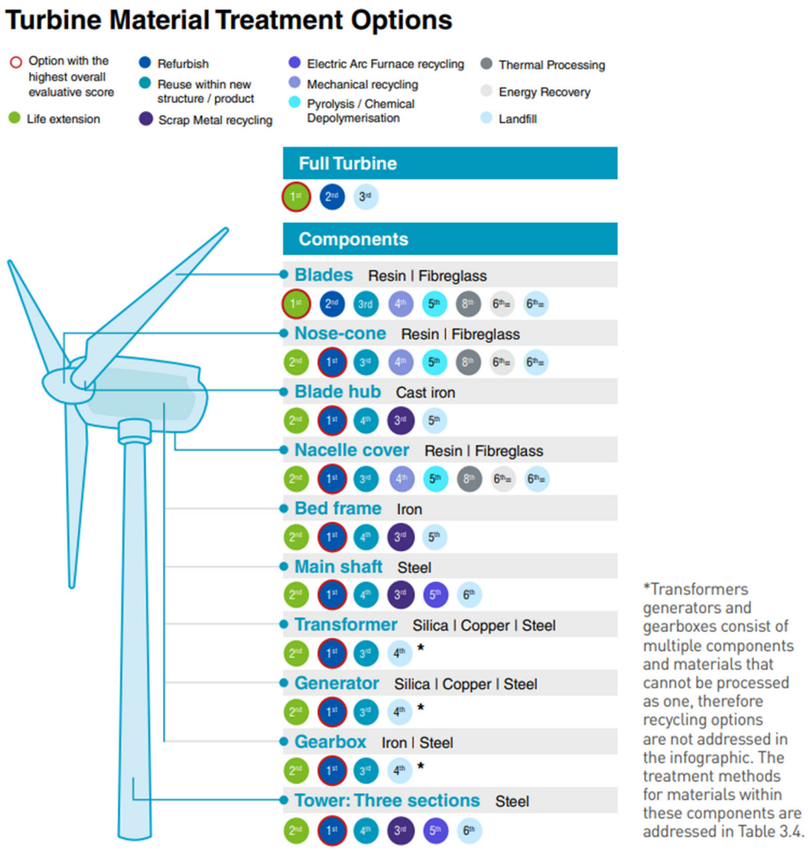
primarily be managed via high-value recycling/recovery streams where complete resale is unviable.

The turbine towers, which are made of steel, are expected to make up the maximum tonnage of materials recycled from Novar 1. Raw steel accounts for around three quarters of greenhouse gases during wind farm construction, therefore it is recognised that steel could have the most potential for carbon savings.

Novar 1 derived GFRP and CFRP will be decommissioned and managed using the most viable solutions available at the time of the decommissioning.

Due to the increasing focus on end-of-life composites, it is believed that blade-focused material solutions currently being devised such as thermal and chemical-based solutions will have been proven and technically available at the scale required. Nadara will, where practical, also look to utilise some of the blades to make useful public realm infrastructure to help accelerate and promote innovative and carbon friendly solutions for end-of-life wind farm derived materials. This approach is in alignment with the principles and guidance contained within Zero Waste Scotland's Onshore Wind Decommissioning in Scotland report that concludes, where possible, a multi-criteria analysis should be undertaken to maximise resource use, outlined below in Figure 4.

Figure 4: Turbine material treatment options



Reference: Zero Waste Scotland (2023) [20].

3. Outline Decommissioning Strategy

3.1. Overview

This Strategy acts as a preliminary baseline; it will evolve into a finalised detailed DRP submitted to the relevant Planning Authority for approval in satisfaction of a planning condition(s) prior to the commencement of decommissioning activities.

Key objectives for this phase include:

- All of the 102 wind turbine blades will be diverted from landfill through alternative material processing.
- Aggregates removed from foundations, hardstands and tracks will, where feasible, be processed on-site for direct reuse in the repowering construction phase.
- High-value components, including gearboxes and transformers, will be assessed for refurbishment and industrial reuse.
- Ferrous metals (steel) and high-value non-ferrous metals (such as copper from generator windings/cables and aluminium) are targeted for high-value recycling and return to the domestic supply chain.
- Cabling underlying tracks designated for re-use and widening will be systematically extracted and stripped to recover aluminium and steel, while cables under redundant tracks will be isolated, capped, and retained in situ.
- Substation decommissioning will mandate early de-pollution (including fluid vacuum extraction and SF6 gas capture) followed by on-site concrete crushing to provide certified sub-base material for the new repowered substation footprint.
- Hazardous hydraulic oils and lubricants will be vacuum drained into sealed containers for purification and circular re-use.
- All small electronics, control panels, and PCBs will be stripped and segregated to facilitate the recovery of gold and rare earth metals via specialised WEEE recycling streams.

The project aims to utilise a LCA approach to quantify the net-zero contribution of the decommissioning works, comparing the carbon savings of material recovery against the impact of site activities.

The decommissioning and repowering of Novar 1 is anticipated to be delivered via a three-year (36 months) decommissioning and construction programme.

3.2. Nadara's approach to Bonus B44/600 turbines and components

Nadara's primary objective for the 34 Bonus B44/600 turbines at Novar 1 is to maximise sustainability and circularity while maintaining a realistic approach to this aging technology. The largely obsolete B44/600 units may restrict the benefits of certain refurbishment and reuse options. Further, given the Bonus B44/600 turbines produce a lower output relative to modern standards, and considering the influx of larger decommissioned models (such as V80s) in the European market, the demand for whole refurbished B44/600 units within large-scale portfolios is currently restricted.

Nadara commits to reviewing potential opportunities for refurbishment and reuse options regarding turbine components. Nadara will assess all units and components (such as nacelles, gearboxes, blades and hubs) for potential reuse as spare parts within its remaining operational fleet or to third parties.

To facilitate this, decommissioning would focus on deconstruction for component reuse (where feasible) rather than 'demolition'. However, final execution would remain subject to a detailed commercial and technical viability audit, ensuring that reuse options remain aligned with current international safety and warranty standards.

Units designated for component re-use, will be carefully dismantled and loaded for offsite reuse. Components destined for metal or GFRP recycling will be transported to a central onsite area for processing and downsizing before final disposal.

3.2.1. Towers

The towers of the Bonus B44/600 weigh up to 57 metric tonnes, at a height of 42m to hub. The towers are of a conical steel tube construction with painted corrosion protection. In the absence of re-use options, the simple and effective method for sustainably dealing with the towers would be to downsize into sections (typically 2 or 3) and recycle at an oversize steel recycling plant. Metal and steel recycling is a mature industry, and this solution is typically financially viable and minimises additional greenhouse gas production.

The optimal approach for towers will involves a detailed analysis of Novar's proximity to metal scrap dealerships to select options that ensure minimal transportation times. Selection criteria for these facilities include appropriate yard capacity and the specific machinery required to

accommodate large sections of oversized steel. Consequently, Novar tower sections are expected to be downsized on-site to facilitate streamlined transportation to metal recyclers. This process minimises traffic disruption by ensuring all loads remain within acceptable transport dimensions.

3.2.2. Nacelles and internal components

Each nacelle, weighing approximately 22.5 metric tonnes, contains a high proportion of steel and copper within the bed plate and structural elements. These metals are expected to be mechanically separated and processed as high-grade recyclates, following the same methodology as the tower sections.

Specialised on-site separation can recover high-value copper from generator windings and cabling, as well as cast iron from gearbox housings.

The composite elements, including spinner covers and rear plates, are anticipated to undergo mechanical downsizing. In the absence of viable reuse options, these materials would be directed toward emerging industrial recycling routes, such as cement co-processing or mechanical recycling, to ensure they remain out of the waste stream. Available options will be explored closer to the time of decommissioning.

All internal control panels and electronics are segregated for Waste Electrical and Electronic Equipment (WEEE) recycling to recover precious and rare metals.

3.2.3. Wind turbine blades

Resins and fibreglass materials make up a significant tonnage of materials being decommissioned at Novar and are anticipated to present technical challenges when assessing options for end-of-life management.

Nadara is committed to sourcing and implementing optimal solutions that balance high circularity outcomes with commercial and technical viability for wind turbine blades and other wind farm derived glass/carbon fibre materials.

An important note is that the LM 19.1 blades used on this turbine have a stall tip construction, which will likely be comprised of steel and carbon fibre components. There may also be carbon strengthening throughout the blade which will have to be considered. During blade segmenting and downsizing, targeted separation techniques can potentially be applied to isolate carbon-strengthening elements, steel stall-tip components, and residual oils from the primary composite matrix, if recycling is required.

Figure 5 summarises the value of wind turbine blade decommissioning when undergoing various end-of-life repurposing and recycling processes. The graded traffic light scale is from worst to best. Fibres are deemed to have:

- No value in landfill or Energy-from-Waste (red).
- Low value as cement feedstock (orange)
- Mid-value when thermally or mechanically recycled, which leads to some fibre damage (yellow)
- More value in chemical recycling where fibres could be relatively undamaged but still need processing into intermediate material forms (yellow green)
- Most value when retained in the matrix for refurbishment/repurposing (green).
- The 'Energy Use' column indicates the energy intensity level required to undertake each process, with chemical recycling having the worst impact.

Figure 5: Comparison of reuse and recycling for GFRP from wind turbines

	Fibre value	Resin value	Energy use	Cost (at scale)	Commercial status
Refurbishment / repurposing				varies	
Mechanical recycling					
Thermal – pyrolysis				?	
Thermal – fluidised bed + fibre recovery				?	
Chemical recycling				?	
Cement kiln co-processing					
Energy from waste					
Landfill					

Reference: Reblade.

Some material value for resin is indicated where it is used as filler (mechanical recycling), or chemicals are recovered. The flame indicates resin is burnt and energy is recovered.

Energy use is a combination of energy for downsizing plus process energy required. Thermal processes are assumed here to be powered by recovering the resin energy, though there is still further energy needed for fibre processing into intermediates.

3.3. Auxiliary Components

It is important to be cognisant of the infrastructure components and their material role in decommissioning and repowering. In addition to the turbines, there are many additional elements that play key roles in wind farms and due care is necessary to approach the best end-of-life solutions.

Foundations, roads and crane pads and the subsequent material solutions for them will be carefully assessed based on material, reuse and carbon emissions involved with any removal works and material destinations. Liaison with landowners and statutory stakeholders will be critical to ensure any infrastructure of use to others over and above Nadara's requirement will be factored into agreed removal methodologies and material destinations.

3.3.1. Foundations

The repurposing of existing wind turbine foundations presents a significant engineering and certification challenge. The immense structural stresses endured by foundations during decades of operation, coupled with the substantially higher load demands and evolving specifications of modern, larger-scale turbine technology, almost certainly precludes the direct reuse of existing bases.

The extent and depth of foundation removal will be determined through the final DRP, taking account of planning and landowner requirements, ground conditions, environmental effects, the repowering layout and the engineering implications of retaining sub-surface concrete. Recovered concrete may be processed for suitable on-site reuse, subject to testing, specification compliance and the necessary environmental authorisations. Any rebar removed will be recycled.

3.3.2. Cables

The existing inter-array cabling network at Novar 1 is not likely to be suitable for the increased capacity of modern turbines and new cables are expected to be installed as part of any repowering works on site.

Where access tracks are designated for retention and widening to accommodate the repowered turbine layout, underlying cables are expected to be systematically excavated, recovered, and recycled for high-value aluminium and steel.

Conversely, where redundant access tracks are to be reinstated cables will be retained in situ. The cabling will be electrically isolated, capped, and proven 'dead' by a Senior Authorised Person (SAP). As-Left Asset Maps will be provided to the landowner and relevant Planning Authority for all retained cabling. The precise breakdown of cabling removed versus retained in situ will be finalised closer to decommissioning.

3.3.3. Site roads and crane pads

While the proposed repowering project is designed to utilise existing wind farm tracks to the maximum extent possible, certain track sections will require structural upgrades to accommodate the larger craneage and construction machinery required for the new turbines together with some sections of new track.

In alignment with the project's circular economy objectives, redundant tracks and crane pads will be excavated and there may be scope for the site-won aggregate to be reused on site, where practical, as part of any repowering construction works (e.g. new tracks and hardstanding; used as backfill for excavated foundation voids). Site won aggregate could also be removed from site for use in other local construction.

Redundant tracks will be excavated to an agreed depth below surface, targeting the recovery of clean, high-quality stone while leaving deeper blinding and sub-base layers in situ to maintain the structural and hydrological integrity of the underlying ground.

Recovered aggregate will be inspected and, where necessary, tested for contamination. Geotextiles and other non-mineral materials will be segregated where practicable, as their presence may affect the suitability of the recovered aggregate for reuse or recycling.

For the existing crane pads that are not required or upgraded for the repowered wind farm, the aggregate will be removed down to an agreed depth and reused on Site where feasible.

The excavated land would then be backfilled with soil and sensitively restored to an agreed method statement. The final depth of excavation for tracks and crane pads would be determined closer to decommissioning works informed by intrusive ground investigation, construction

records where available, trial pits and an approved restoration design. This will be presented in detail in the DRP to be approved by the relevant Planning Authority.

3.3.4. Substation decommissioning and footprint reuse

The existing substation at Novar 1 was built in 1997 and represents a typical utility-scale compound for a wind farm of its era. The control building houses the electrical substation infrastructure, including the wind farm's switchgear, battery systems, and control mechanisms. The control building and compound area are enclosed by a secure fence protecting an open-air yard. The ground conditions consist of an engineered hardstanding composed of concrete or compacted gravel.

The decommissioning of this 1997-era substation compound provides an opportunity to unlock the engineering and logistical advantages of the repowering project by locating the new substation upon the existing footprint of the old facility. This approach directly aligns with National Planning Framework 4 (NPF4) and SEPA's Gatecheck guidance that developers should minimise the development footprint on previously undisturbed ground. By constructing the new substation upon the location of the original asset, the approach eliminates the requirement for new civil clearings, soil stripping, and habitat disruption.

High-value switchgear and transformers are anticipated to be extracted for refurbishment or recycling.

In Scotland, the decommissioning of a substation is a statutory requirement managed under the Electricity Act 1989 [Ref. 24] (as reflected in the site's Section 36 consent) and enforced via conditions set by the decision-making authority. This process usually requires the entire substation to be fully disconnected from both the national electricity grid and the wind farm array, a highly technical operation executed in close coordination with the network operator to manage system outages safely.

Dismantling is a strictly regulated and legally controlled operation performed by a specialist team under the direct authorisation of a Senior Authorised Person (SAP). The SAP ensures that all electrical equipment is fully isolated, tested, earthed, and confirmed "dead," certifying that the environment is safe before any structural dismantling or demolition is permitted to commence. Following this formal electrical sign-off, mechanical demolition is governed by a Permit to Work (PTW) system to ensure the absolute safety of the site team.

It is anticipated that the excavated concrete rubble generated during structural demolition of the substation will be fed into a mobile on-site crushing and screening train. The resulting aggregate could be retained on-site to stabilise, grade, and level the footprint, serving immediately as the certified sub-base layer for the new repowered substation foundations.

All recovered materials, including processed dielectric oils and recovered SF6 gas, will be monitored via the Mandatory Digital Waste Tracking system to ensure statutory environmental compliance. Environmental bodies such as SEPA may inspect the site during these works to verify the safe handling of hazardous substances and review the integrity of secondary spill containment areas.

3.3.5. Oil

Old oil from turbines is no longer considered waste by EU legislation and is now considered a valuable resource that can be purified and used again. This oil is used in the turbines in hydraulics and lubricants for moving parts such as the rotor and yaw bearings. The recycled oil can be reused in turbines, and Nadara will endeavour to reuse any suitable recycled oil from the Novar 1 turbines.

3.3.6. Small electronics

The control boxes and internal electronic systems within the Bonus B44/600 turbine bases represent a specialised resource stream with significant potential for high-value component harvesting. To ensure these systems are managed in accordance with the circular management hierarchy, the following decommissioning protocols will be implemented.

Given that many electronic components within the B44/600 series are common across various industrial applications, all control boxes will be audited prior to dismantling to identify functional parts for use as spares.

Where direct reuse as a spare part is not technically viable, the equipment will be managed as Waste Electrical and Electronic Equipment (WEEE). All segregated printed circuit boards and electronic components will be sent to licensed specialist facilities for the recovery of gold, silver, and other precious or rare earth metals. This systematic stripping and segregation ensures that critical elements are returned to the manufacturing supply chain, diverting high-value electronic waste from general disposal streams.

3.4. “As-Left” Asset Mapping & Subterranean Liabilities

To ensure long-term environmental protection, transparent asset management, and clarity of future liabilities, Nadara will produce comprehensive "As-Left" Asset Maps following the completion of decommissioning activities. These mapping records are critical for documenting any infrastructure retained in situ, specifically subterranean inter-array cabling along redundant access tracks, direct-buried cable entries, and structural sub-base layers left in place to preserve site ground stability and natural hydrological pathways.

The "As-Left" Asset Mapping protocol will incorporate the following core procedures:

- **GIS & Spatial Verification**: All retained cables, cut/capped surface terminals, and buried sub-base footprints will be precisely mapped using high-accuracy Global Positioning System (GIS) land surveys prior to final backfilling and surface restoration.
- **Asset Condition & De-pollution Certification**: Maps will explicitly record the operational status of all retained assets, certifying that all cabling has been electrically isolated, tested "dead" by a Senior Authorised Person (SAP), and capped.
- **Liabilities & Duty of Care Alignment**: The finalised mapping pack will define the precise spatial extent of legacy infrastructure remaining within the site boundary, establishing a clear baseline for future land management and mitigating risk of accidental ground disturbance during subsequent repowering operations or third-party activity.
- **Statutory Submission:** Complete "As-Left" Asset Mapping packages will be formally submitted to both the landowner and the relevant Planning Authority as part of the final post-decommissioning handover documentation.

4. Responsibly sourcing circular-minded suppliers & contractors

4.1. Environmental management and internal governance

At Novar 1, Nadara is committed to the responsible sourcing of circular-minded suppliers and contractors through its continually evolving sustainable procurement practices.

Circularity and moving away from a linear economy are an environmental necessity. Scotland's highly skilled and experienced renewable energy sector is well placed to lead the way through developing new industry standards and prioritising the principle of the Waste Hierarchy through resource recovery, reuse, repair and remanufacture.

Any materials and products procured on behalf of Nadara, where practical, will be selected with LCA in mind based on optimal recyclability and reuse content, for example implementing cradle to cradle design principles.

Recycling and reuse targets will be in place and in alignment with Nadara's own company targets, with compulsory reporting to be delivered on request as and when required by Nadara.

For raw materials, packaging and embedded carbon should be minimal, and environmentally benign materials used where possible. The use of recyclates will be encouraged as well as maximising the lifespan of procured products.

4.2. Sustainable Management Plans and Waste Minimisation

A Sustainable Management Plan (formerly referred to as a Waste Management Plan) will be requested of all suppliers and contractors to identify and audit intended material and proposed waste management streams.

All construction waste will be required to be as minimal as possible through the application of the Sustainable Management Plans, and suppliers and contractors will be required to follow the principle of the Waste Hierarchy to ensure resources are managed efficiently by identifying and mitigating against unsustainable practices.

Waste prevention must be prioritised where practical, followed by reuse, recycling, and recovery, with landfill being the last option following an exhaustive review of the Waste Hierarchy process.

4.3. Tendering and Sustainable Procurement Practices

A strict tender procurement process for Novar will ask tender submissions to demonstrate clearly how construction environmental management processes can implement circular and green technologies on site designed to improve efficiencies and to reduce and remove any negative construction impacts on the environment.

All suppliers and contractors will be expected to have a Responsible Sourcing Policy, a Sustainable Procurement Policy or similar in place in alignment with current standards.

During the tender stage for the construction phase, prospective suppliers and contractors should demonstrate how they can offer lower-carbon alternatives to conventional construction and transportation methods. They will be asked to demonstrate how they can utilise and support innovative technologies to support circularity in collaboration with Nadara.

4.4. Sustainability and Health & Safety

Nadara will endeavour to ensure that suppliers and contractors make best attempts to put circular and sustainable processes in place, provided that the method statements and risk assessments and the tools and equipment all maintain the highest level of health and safety performance and strictly adhere to health and safety where appropriate.

4.5. Sustainability and supplier & contractor reporting

All suppliers and contractors should expect to be able to report on the following environmental sustainability benchmarks when requested during and after the construction phases:

- Annual reporting on Scope 1 & Scope 2 Greenhouse Gas (GHG) emissions in alignment with the UK Government's environmental reporting guidelines.
- Reductions in embodied carbon through the procurement of construction materials and assets on behalf of Nadara.
- If requested, provide externally validated carbon data by accredited third parties to recognised standards, such as ISO14064 and ISAE3000 [Ref. 25] and [Ref. 26].
- Waste management data in tonnage, including those materials prevented, reused, recycled, recovered, and sent to landfill.

5. Measuring and capturing the benefits of Novar's circular-focused decommissioning

5.1. Overview

The deployment of renewable energy infrastructure is essential to avoid the worst effects of climate change and, according to the International Renewable Energy Agency (IRENA)'s World Energy Transitions Outlook 2024 [Ref. 27], a tripling of installed renewable power capacity is required by 2030 in the pursuit of achieving a climate threshold of 1.5 degree Celsius above pre-industrial levels. This will require a substantial number of materials such as steel, concrete, aluminium and copper, as well as putting significant demands on supply chain capabilities.

A circular approach to renewables is necessary to achieve ultra-low energy generation sources and reduce greenhouse gases through minimising resource use and waste, but it also creates significant socioeconomic opportunities. Decommissioning old wind farm assets and constructing and operating new, repowered wind farms significantly contributes towards achieving net zero targets, but it can also create circular sustainable businesses and jobs and deliver new supply chains.

The economic benefits associated with circular renewables can help to reduce operational costs through delivering improved and more efficient products and services, designed to meet modern circular economy sustainable benchmarks, and will contribute towards local and community social wellbeing through new employment and business opportunities.

Demand for circular economy principles within the supply chain will increase as material demands for building new renewable energy infrastructure projects increase, creating opportunities for circular-focused businesses who can grow and adapt to help create solutions that can enhance the efficiency of material use within the Scottish Wind Energy Sector.

5.2. Novar 1 Wind Farm

The planned Novar 1 decommissioning works and required material solutions thereafter can result in substantial socioeconomic benefits, particularly in geographic locations close to and surrounding wind energy infrastructure, such as in the Highland region.

The repowering of Novar 1 presents an opportunity for the local economy and for the businesses and communities surrounding the wind farm as well as the wider Scottish and UK economies. Nadara recognises the importance of early engagement to help facilitate and achieve this level of local economic gains through circularity and decommissioning and is committed to working alongside local stakeholders to maximise the benefits arising from the decommissioning.

Nadara's plan to adopt circular decommissioning strategies at a local level has the potential to create a more resilient and sustainable renewable energy sector. By reducing reliance on critical materials and fostering the growth of new and existing supply chains, Nadara can contribute to a more secure and environmentally friendly energy future for both the communities and business surrounding Novar 1 and beyond.

5.3. Reporting on carbon emission reductions

The environmental impact of decommissioning is a growing area of interest for stakeholders and climate impact projects are increasingly important based on the benchmark LCA method. LCA explores the best options to limit negative climate impact reducing CO2 emissions and can measure health, ecotoxicity and resource depletion like rare earth elements. Nadara endeavours to commit to measuring carbon production and savings throughout the entire Novar 1 decommissioning works via an informed LCA process.

5.3.1. Stakeholder engagement & circularity

The decommissioning and repowering of Novar 1 will involve engagement with key stakeholders to investigate and implement innovative circular solutions that are carbon negative and climate positive.

Ensuring the potential community wealth building and socioeconomic benefits from onshore wind decommissioning are investigated and implemented is of great importance when planning decommissioning works.

A wide range of stakeholders and their input will be relevant in the context of the circular decommissioning of Novar 1, aiming to gather important feedback and to provide information on the various opportunities and benefits to the local area, initiating dialogue as early as possible.

Through initiating early dialogue on the sustainable circular decommissioning of Novar 1, Nadara is seeking to help raise awareness of the potential for additional local and community socioeconomic benefits, which include positive impacts such as supply chain opportunities, employment and positive impacts to local businesses.

Nadara will reach out to a wide range of stakeholders, including local residents, community councils, landowners, environmental groups, businesses and government agencies.

Further consultation engagement will be undertaken to receive valuable feedback and on how Nadara seeks to adopt best practice, as well as to measure and capture the benefits of taking a sustainable circular decommissioning approach to the repowering of Novar, including with:

- The Highland Council

- Scottish Environmental Protection Agency
- Caithness and Sutherland Chamber of Commerce
- University of Highlands and Islands
- Zero Waste Scotland
- Scottish Renewables
- Renewable UK
- CWIC

Appendix 2 provides an overview of the opportunities and benefits that could be achieved through sustainable circular wind farm decommissioning with general detail on potential job creation, skills, education and training networks.

5.4. Circular supply chain opportunities

5.4.1. Helping support a diverse & circular local supply chain to provide wind farm decommissioning services

Through working with specialist, circular-focused supply chain companies such as Reblade, Nadara is committed to engaging with small to medium-sized businesses to help maximise and strengthen Scotland's renewable energy supply chains. By engaging at a local community level, it is recognised that the decommissioning and repowering of Novar 1 could have the potential to positively impact the Highland region.

Nadara further recognises that the deployment of renewable energy infrastructure requires a wide array of skills, experience and engineering know-how. Achieving maximum reuse, recirculation and recyclability of wind farm components and materials is a key objective of optimal wind farm repowering. A movement towards securing circular practices is an important consideration when selecting companies to help make the energy transition happen sustainably.

Through decommissioning and repowering projects like that at Novar 1, companies and organisations across Scotland can benefit from the socioeconomic opportunities that a growing decarbonisation pipeline offers.

5.4.2. Circular procurement & local companies

Nadara will take an active role in helping inform existing and potential businesses how it plans to undertake the full Novar 1 scope of works and the supply chain it will need to decommission the site optimally and with a circular approach to the forefront.

Nadara recognises that a local circular economy supply chain for onshore wind offers significant economic opportunities. The Regen report estimates that the market for refurbished UK wind turbines could provide £1.6 billion in gross value added and support over 3,500 full-time equivalent jobs by 2035. By engaging local contractors early, Nadara can help avoid the supply chain bottlenecks identified by Regen and enable Novar 1 to contribute to a domestic circular wind economy that retains value in the local area.

With critical decommissioning requirements such as technical staff, transport, craneage, on-site support services, plant supply, materials solutions and ground works, to specialist and technical engineering solutions, Nadara will look to support local organisations who are or are willing to be ready to support the decommissioning and repowering of Novar 1.

Examples of local businesses that could benefit through the repowering of Novar 1 include businesses already working in the renewable energy sector, as well as those wishing to secure new work because of local supply chain opportunities.

Examples of local supply opportunities include, but are not limited to:

- Craneage
- Consumables
- Groundworks and civil contractors
- Scrap metal (steel and cables)
- Site services (construction design and management (CDM) regulations, cabins)
- Plant supply
- Storage
- Accommodation, catering and fuel services
- Technical engineering services (lifts, CDM, staff)
- Material solutions (oil, blades, concrete).
- Supporting circular innovation

It is understood that innovative companies are critical to redefining the processes and services in the future of decommissioning and recycling in the energy sector. Through sourcing a diverse and innovation-led supply chain, Nadara commits to support and encourage the vital role that suppliers make in the journey to achieving circularity and net zero emissions in the context of Novar 1.

Innovative supply chain companies have an opportunity to decommission energy assets through identifying new sustainable applications and solutions for decommissioned materials and components.

Appendix 3 details information on current circular-focused research and development innovation.

5.4.3. Brown jobs with a green twist

With a focus on measuring both carbon and socioeconomic impacts, Nadara will look to identify local service suppliers who provide services during the decommissioning works focusing on elements including but not limited to:

- Business locations within a 10, 30, 50km radius of the decommissioning boundary for all service providers on site
- Numbers, job roles and postcodes of onsite staff
- Numbers, type and postcodes of material solution providers and roles sustained
- Numbers, type and postcodes of all suppliers related to the decommissioning works
- Map all local service providers in use for the decommissioning works (accommodation, fuel supply etc.).

5.4.4. Measuring additional carbon savings

Through identifying and utilising local supply chains and services where practical, Nadara recognises that there can be a significant reduction in the carbon footprint of a wind farm project. This approach not only promotes a reduced carbon footprint through wind farm decommissioning, repowering and operational activities, it also helps pioneer new sustainable and circular solutions and helps catalyse local economic growth.

A circular economy approach through focusing on the benefits of procuring local supply chains can contribute towards a significant percentage reduction in greenhouse gases compared to securing supply chains located geographically further afield.

Furthermore, hiring a local workforce where possible can also enable local businesses to expand their operations and help further reduce carbon emissions in the future by retaining a local service provision that can be utilised during the operational lives of renewable assets.

Nadara will look to provide full LCA analysis for the material solutions phase of the decommissioning works and provide direct comparisons to more traditional solutions that have been implemented previously across the industry.

6. References

[1] Scottish Environmental Protection Agency (SEPA) (2006), Is it Waste? Understanding the Definition of Waste SEPA. Available at: https://www.sepa.org.uk/media/154077/is_it_waste.pdf. Accessed on: 20/08/2026.

[2] The European Parliament and the Council of the European Union (2008/98/EC) (2008), The Waste Framework Directive. Available at: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en. Accessed on: 20/08/2026.

[3] London Assembly (2017), London Assembly Environment Committee Waste Management: Environment Committee Waste Management Scoping Paper. Available at: https://www.london.gov.uk/sites/default/files/environment_committee_-_waste_management_-_scoping_paper.pdf. Accessed on: 20/08/2026.

[4] Scottish Environmental Protection Agency (SEPA) (2016), Life Extension and Decommissioning of Onshore Windfarms SEPA Guidance version 1. Available at: https://www.sepa.org.uk/media/219689/sepa-guidance-regarding-life-extension-and-decommissioning-of-onshore-windfarms.pdf. Accessed on: 20/08/2026.

[5] The European Union, (2023), The Critical Raw Materials Act (2023). Available at: https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en. Accessed on: 20/08/2026.

[6] The Scottish Government (Energy and Climate Change Directorate), (2023), Onshore Wind Sector Deal. Available at: https://www.gov.scot/publications/onshore-wind-sector-deal-scotland/. Accessed on: 20/08/2026.

[7] Regen (2026). A Second Wind: Unleashing the Potential of Repowering. Key challenges, opportunities and policy requirements to breathe new life into onshore wind across Great Britain. Available at: https://www.regen.co.uk/insights/a-second-wind-unleashing-the-potential-for-repowering. Accessed on: 20/08/2026.

[8] Great British Energy. https://www.gbe.gov.uk/. Accessed on: 20/08/2026.

[9] DESNZ (2024), Clean Power 2030 Action Plan: A New Era of Clean Electricity. * Policy Mandate: Published December 2024. Establishes the UK government's mission to achieve a clean power system by 2030, specifically prioritising the repowering of existing wind assets to unlock low-cost generation faster than greenfield projects. Available at: https://www.gov.uk/government/publications/clean-power-2030-action-plan. Accessed on: 20/08/2026.

[10] UK Government (2023), Energy Act 2023 (c. 52). Available at https://www.legislation.gov.uk/ukpga/2023/52. Accessed on: 20/08/2026. * Statutory Basis: Provides the primary legal framework for the licensing of carbon dioxide transport, hydrogen production, and the regulation of the energy market including decommissioning coordination under the Independent System Operator and Planner (NESO).

[11] The Scottish Government (2024), Circular Economy (Scotland) Act 2024. Available at: https://www.legislation.gov.uk/asp/2024/13. Accessed on: 20/08/2026. *Statutory Basis: Mandates that materials be managed according to the legal Waste Hierarchy and grants Scottish Ministers powers to prohibit the landfilling of valuable wind turbine components.

[12] The Scottish Parliament (2024). Net Zero, Energy and Transport Committee. Available at: https://www.parliament.scot/api/sitecore/CustomMedia/OfficialReport?meetingId=15734. Accessed on: 20/08/2026.

[13] The Scottish Government (2025). Scotland's Climate Change Plan (CCP) 2026-2040 (Draft). Available at: https://www.gov.scot/publications/scotlands-climate-change-plan-2026-2040/. Accessed on: 20/08/2026.

[14] The Scottish Government (2023). National Planning Framework 4 (NPF4). Available at: https://www.gov.scot/publications/national-planning-framework-4/. Accessed on: 20/08/2026.

[15] The Scottish Government (2024). The Scottish Biodiversity Strategy to 2045. Available at: https://www.gov.scot/publications/scottish-biodiversity-strategy-2045/. Accessed on: 20/08/2026.

[16] The Scottish Government (2026). Infrastructure Strategy 2027-2037 (Draft). Available at: https://www.gov.scot/publications/consultation-infrastructure-strategy-2027-2037/. Accessed on: 20/08/2026.

And outgoing - The Scottish Government (Public Spending Directorate) (2021), A National Mission with Local Impact: Infrastructure Investment Plan for Scotland 2021-22 to 2025-26. Available at: https://www.gov.scot/publications/national-mission-local-impact-infrastructure-investment-plan-scotland-2021-22-2025-26/. Accessed on: 20/08/2026.

[17] The Scottish Government (2023). Draft Energy Strategy and Just Transition Plan (ESJTP). Available at: https://www.gov.scot/publications/draft-energy-strategy-transition-plan/. Accessed on: 20/08/2026.

[18] The Scottish Government (Environment and Forestry Directorate), (2024), Scotland's Circular Economy and Waste Route Map to 2030. Available at: https://www.gov.scot/publications/scotlands-circular-economy-waste-route-map-2030/. Accessed on: 20/08/2026.

[19] The Circularity Gap Report (2024), Circularity Gap Report. Available at: https://www.circularity-gap.world/scotland. Accessed on: 20/08/2026.

[20] Zero Waste Scotland (2023), The Future of Onshore Wind Decommissioning in Scotland. Available at: https://www.zerowastescotland.org.uk/resources/future-onshore-wind-decommissioning-scotland. Accessed on: 20/08/2026.

[21] The Scottish Government (2018). The Environmental Authorisations (Scotland) Regulations 2018. Available at: https://www.legislation.gov.uk/sdsi/2018/9780111039014/contents. Accessed on: 20/08/2026.

[22] The Digital Waste Tracking (Scotland) Regulations 2026. * Enforcement Mechanism: Established under powers in the Environmental Protection Act 1990. Mandates that all waste producers and site operators must log material movements digitally from October 2026 (UK-wide) or 1 January 2027 (Scotland enforcement).

[23] Composites UK/National Composites Centre (2022) The Sustainability of Fibre Reinforced Polymer Composites: A Good Practice Guide. Available at: https://compositesuk.co.uk/industry-support/good-practice-guides/. Accessed on: 20/08/2026.

[24] The Scottish Government (1989). The Electricity Act 1989. Available At: https://www.legislation.gov.uk/ukpga/1989/29. Accessed on: 20/08/2026.

[25] International Organisation for Standardisation (2018), ISO 14064 Greenhouse Gases. Available at: https://www.iso.org/obp/ui/#iso:std:iso:14064:-1:en. Accessed on: 20/08/2026.

[26] International Standard on Assurance (ISAE) (2013), 3000 Revised, Assurance Engagements Other than Audits or Reviews of Historical Financial Information. https://www.iaasb.org/publications/international-standard-assurance-engagements-isae-3000-revised-assurance-engagements-other-audits-or. Available at: Accessed on: 20/08/2026.

[27] International Renewable Energy Agency (IRENA) (2024), World Energy Transitions Outlook 2024. Available at: https://www.irena.org/Publications/2024/Nov/World-Energy-Transitions-Outlook-2024. Accessed on: 20/08/2026.

[28] Chavero-Navarrete, E., Perea, M., Jauregui, J., Carrillo-Serrano, R.V. & Moreno, G.J. (2019), Expert Control Systems Implemented in a Pitch Control of Wind Turbine: A Review. Available at: https://doi.org/10.1109/ACCESS.2019.2892728. Accessed on: 20/08/2026.

[29] Bladena (2019), Wind Turbine Blades Handbook. Available at: https://www.bladena.com/uploads/8/7/3/7/87379536/cortir_handbook_2019.pdf. Accessed on: 20/08/2026.

Appendix 1: Wind turbine components and decommissioning

1. Wind turbine components and inside a wind turbine

1.1. Wind turbine rotor blades

Wind turbine rotor blades work like an aeroplane wing. When the wind blows, a pocket of low-pressure air forms on the downward side of the blade, and it is this pocket of air that pulls the blade towards it; a force called 'lift'. The lift force is much stronger than the wind's force against the front of the blade and causes the rotor to spin around it. Most turbines have two or three blades.

Wind turbine blades are made from fibre-reinforced composites such as carbon fibre, polyester and glass fibre that allow the blades to bend without breaking. They are shaped like an aircraft wing to help catch the wind.

Older blades are carbon fibre, and modern blades are typically made from fibreglass. Fibreglass is made from bundles of glass fibre woven into a cloth which is then dipped into resin. Once hardened the material is remarkably strong and lightweight. It is moulded into the aerofoil shape required for the blade to slide through the air and harness the wind.

Wind turbine blades must operate in remote regions where the environmental and weather conditions can be very harsh which is why the materials need to be tough as well as lightweight and durable. The blades are painted in a specific RAL paint to fit with the usual weather conditions, for example in Scotland where it is often cloudy, and turbines exceeding 150 metres (500 feet) require aviation lighting.

1.2. Rotor hub

The blades are joined to the rotor hub which controls the angle of blades. The rotor hub turns a slow-spinning shaft.

1.3. Stall-tip

First generation turbines such as the Bonus B44/600s blades cannot pitch at the hub. A mechanism inside the tip and section preceding it allows the tip to rotate independently of the rest of the blade when spinning at slow speeds.

1.4. Shaft

The shaft transfers the spinning energy of the rotor to the generator. The shaft is connected to a gearbox that makes another shaft (the output shaft) spin much faster.

1.5. Gearbox

The gearbox increases the speed of the shaft between the rotor and the generator.

1.6. Generator

The output shaft is connected to a generator that turns the spinning energy into electricity, using electromagnets. The generator uses the spinning energy of the shaft to generate electricity by making a big coil of wire move inside the magnet, and electricity is carried by cables to a transformer, which is then connected to either the local power network or the national grid.

1.7. Brake

The brake halts the shaft in an emergency.

1.8. Controller

The controller is an electronic monitoring system that ensures the turbine faces the optimal wind direction. It checks the position of the wind several times per second then moves the turbine, so it is in the best position to catch the wind. If the wind is too slow the blades will not turn, and if it's too fast the controller shuts down the turbine, making them safe and efficient when serviced regularly.

1.9. Nacelle

The nacelle (also sometimes known as the 'casing') is the main body of the turbine. Inside the nacelle are the generator, the gearbox and the electronics that control the turbine. Rare earth elements are important parts of a wind turbine's permanent operation and are in the nacelle.

1.10. Tower

The tower lifts the blades off the ground, supports the rotor and the nacelle and is made of steel sections. The rotor blades are mounted on tall towers as there is less turbulence off the ground. During construction, the steel sections are lifted into place by cranes before being bolted together.

2. Wind farm site infrastructure

2.1. Transformers

Step-up transformers are used on turbines to increase the voltage and ultimately decrease the power losses that occur when transmitting large amounts of current over long distances with transmission lines. Some transformers are internal to the wind turbine.

2.2. Substation and control building

Inside the substation, transformers convert high-voltage electricity into lower voltages for delivery to the distribution system. The control building takes in all operational information from the turbines such as wind speeds, power output and any faults reported and is the location from which turbines can be remotely operated.

2.3. Foundations

The primary function of a wind turbine's foundation is to distribute loads into the soil beneath. Vertical and horizontal forces exerted on the turbine foundation stem from its own weight and the force of the wind, respectively.

2.4. Cables & trenches

These include the transmission lines between wind turbines, transformers and the substation. All the turbines on a site are connected via trenched medium-voltage cables which also house the earth and optical fibre cables.

2.5. Wind farm tracks

The wind turbines, substation and site entrances are connected by access tracks formed of stone and gravel.

2.6. Crane hard standings

Areas of compacted gravel are established around the base of each turbine for use by various machinery such as cranes.

3. Wind farm decommissioning practices

Nadara prioritises reusing wind turbine components within its existing operational assets whenever possible. Decommissioned components may also be retained for spare parts. While a resale market exists for refurbished wind turbines, offering reliable and efficient technology, Nadara will carefully evaluate the cost-effectiveness and carbon impact of this option, ensuring all reused components are thoroughly tested. Refurbished or remanufactured turbines can be a viable alternative to new models, particularly for smaller wind farms facing constraints such as tip height restrictions, access challenges, or limited grid capacity. Additionally, this market provides valuable spare parts for owners of older turbines facing obsolescence issues.

Warranty guarantees are another consideration. This is especially important when considering the reuse of wind turbine blades. Over time, blades weaken due to the bending stresses they experience when rotating as they operate to generate renewable electricity.

4. Reuse & repurpose

4.1. Wind turbine blades

Wind turbine blades are mostly made of glass fibre and epoxy resin (a composite) which acts like a plastic superglue giving a very strong resilient material, lasting through all sorts of weather

conditions. Very little composite waste in the United Kingdom is recycled now, with most going to landfill or energy-from-waste. This presents a big challenge for such a sustainability-minded industry.

Reblade decommissions turbine blades without the use of landfill by pioneering innovative approaches to blade handling that enable circular end-destinations for blade waste. Reblade recognised early on the needs of the renewable energy industry to responsibly decommission in environmentally friendly ways and an increasingly urgent need to develop scalable non-landfill destinations for blade and nacelle waste within the sector. Reblade's key objective is to ensure blade materials stay out of landfill.

The reuse and repurposing of wind turbine blades into new structures and products through sustainable methodologies is a viable option assuming the structural properties of the composite are being used effectively.

4.2. Nacelles

Some wind turbine manufacturers utilise glass fibre for their nacelles which are used to house the main mechanical components of the turbine. As mentioned above, the composites are not easily recycled, and no current commercial options are available. The nacelles present a unique opportunity for easy repurposing into various items due to the inherent shape. Examples include repurposing nacelles into commercial glamping pods or offices, and as outdoor sheltered areas. Composite nacelles will be particularly challenging due to the thickness and overall weight of materials used to support heavy components.

4.3. Other composites

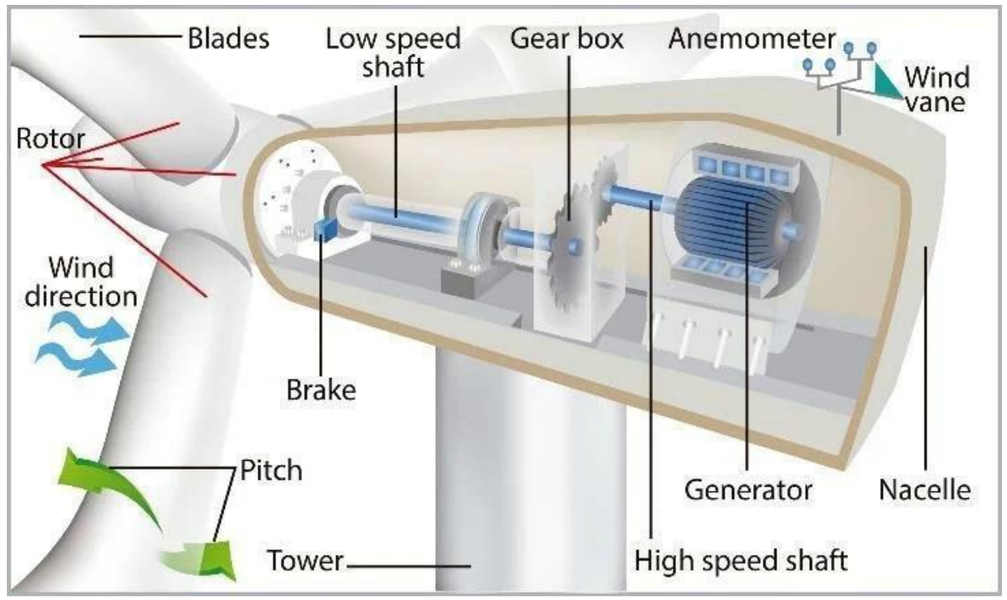
Other common GFRP and CFRP elements of wind turbines include the hubs, spinner covers and transformer housing. These present unique opportunities to devise the best end solution for the material as the transformer box roofs and walls can easily be refurbished and supplied as spares for other wind farms with compatible infrastructure, although some transformer infrastructure is located inside the base of the turbine tower.

4.4. Major components

Adoptions of recirculated parts can be achieved through increasing confidence in the product, raising awareness of the benefits of recirculated parts, establishing a dedicated supply chain and developing up to date legislation.

Research into Nadara's current portfolio in the United Kingdom and Europe for the potential of using spares should be taken forth to understand the benefit of storing and maintaining major components. Outside of Nadara there may be scope to sell refurbished parts to the wider market. Appendices Figure 1 illustrates wind turbine components.

Appendix 1 Figure 1: Wind Turbine Anatomy



Source: Chavero-Navarrete, Ernesto & Perea, Mario & Jauregui, Juan & Carrillo-Serrano, R.V. & Moreno, G.J.. (2019) [Ref. 28].

5. Recycling

5.1. Overview

Wind turbine blades, nacelles and spinner covers are predominantly manufactured from GFRP composites, though some onshore wind turbine blades (typically older first generation) can include CFRP composites. Offshore blades and some larger onshore blades also contain internal structural CFRP spars.

The recycling of GFRP and CFRP composites differs due to their carbon and glass fibre materials, and the resulting fibres from both require processing differently to that of virgin fibres. Several recycling routes have been demonstrated through research and development, with some commercialisation activities taking place and further research ongoing.

To date, the volumes of composite waste from the wind sector alone have not been available in sufficient volumes to support significantly scaled-up recycling routes for wind farm derived waste composites in the United Kingdom. Recycling solutions are being developed collaboratively within the sector, however, in anticipation of an increase in wind farm decommissioning, and there are many ongoing research projects and some beginning to show commercial readiness.

5.2. Mechanical methods

The initial first stage challenge to recycling is the mechanical breakdown of the blades. This can be challenging and energy intensive due to a very strong and highly resistant design feature called the ‘spar cap’. The spar cap is specially engineered to create strength and flexibility. It varies in thickness along the length of the entire blade, from the root, similar in principle to that of a steel girder, providing the strength and flexibility that is required for the blade to safely operate in all weather conditions, whilst absorbing loads from rotational and wind forces.

5.3. Chemical recycling

Turbine blades are hard to recycle. Some research and development companies and academic institutions are trialling the burn-off of the plastic components using strong chemicals to dissolve the resins. What remains is the fibre, which can be used to make new products, but these processes are not perfect. They all take a great deal of energy, and the recovered fibre is degraded through the very fierce technology required. This means chemical recycling is likely to remain economically challenging for the foreseeable future.

5.4. Thermal recycling

Pyrolysis is a recycling method used for wind turbine blade disposal. It involves heating the waste at high temperatures without oxygen. This process breaks down the materials into gas, liquid, and solid forms. Components like epoxy resin, thermoplastic polyurethane, carbon fibre, and glass fibre can be broken down effectively. Valuable substances such as phenol and p-isopropenylphenol can be extracted from the liquid products. Pyrolysis also removes the resin while preserving the fibre materials' integrity. However, the high temperatures can harm the fibre surfaces and lessen their strength. Typical pyrolysis processes for polymers occur between 400 and 700°C, depending on the composite's type. This temperature range breaks down the polymer matrix and retrieves the fibres.

There is no clear data on the LCA of pyrolysis. Reblade expects to find that due to the extreme heat/pressure required that the energy expenditure will far surpass that of other mechanical recycling methods. If the fibres reclaimed from this method are of a higher strength than other processes, then the potential for offsetting the production of new GFRP may make up for this energy usage. More research is required to understand the applications for the reclaimed fibres and the market for them.

5.5. Cement kilns

As an alternative to landfill and recovery options, trials are seeing smaller quantities of composites taken from wind turbine blades and other components for coprocessing in cement kilns. This is classed as a combination of recycling and recovery in the EU Waste Framework Directive and requires mixing with other materials to keep the calorific value (CV) low and manageable.

The shredding of blades to be incorporated into cement is not yet a palatable option; but in the absence of commercially available circular recycling options, it is a potential route that could be scaled up pending funding and trials, some of which are ongoing in the UK, to achieve an economical route for the processes to become commercially viable. This is something that is proving difficult to achieve currently.

Importantly, incineration in a cement kiln is not considered a recycling route for carbon fibre turbine blades (commonly associated with older first-generation wind turbines) because the carbon fibres would burn like coal. Only glass fibre materials would be applicable should a commercial route become available. It is also important to note the need for established cement kiln material handling processes to ensure materials and chemical contents are consistently

achieving strict limits for certain chemicals required to be managed. Halogens are very limited, such as chlorine and bromine where limits are around 0.8% and 0.25% respectively, which rules out glass fibre with high levels of fire retardants.

6. Recovery

6.1. Energy-from-waste

A significant amount of composite material is diverted from landfill to incineration, burning the organic parts and recovering the energy in a process known generally as energy-from-waste (EfW).

When applying waste hierarchy principles, recovery is favoured over landfill however, and importantly, it should be highlighted that the LCA when undertaken may not recommend this to be the most carbon negative option. This is because burnt fossil fuel releases greenhouse gases, so unless recovery directly replaces a more negative impact, such as directly replacing the combustion of mined fossil fuels, then the LCA for recovery compared against landfill is likely to be more carbon intensive.

Further, the high CV from burning wind turbine blades and other composite components is not ideal because the incinerators are usually limited by the CV of the burnt fuel as opposed to the actual mass of the materials. This is reflected in the fact that EfW plants typically charge a gate fee for the materials based on the tonnage of material committed to EfW recovery and not the actual energy produced.

It is also important to note that not everything is burnt in the process of recovery. Ash containing glass fibres or mineral filler is either sent to landfill or put into aggregate which does not count as recycling in accordance with the Waste Framework Directive.

In summary, wind turbine blades are not recommended for incineration, and reuse, remanufacture and recycling (where practicable, and when technologically and commercially available) are preferable.

7. Disposal

7.1. Landfill

Landfill should only be the last option following a thorough review of the Waste Hierarchy.

Appendix 2: Decommissioning skills and benefits

1. Circular jobs creation

There are significant opportunities within the renewable energy sector to create long-term sustainable green jobs related to the circular economy, all requiring a diverse range of skills.

These circular roles have already begun to emerge and will increase significantly as whole site decommissioning and repowering projects take place shortly, creating new jobs not necessarily aligned with traditional science, technology, engineering, and mathematics (STEM) subjects.

These will include roles such as industrial designers supporting sustainable and circular manufacturing and taking reused energy assets, specialists applying circular processes and solutions for decommissioned materials, and many more roles specialising in directly and indirectly supporting a sustainable and circular economy.

The table below provides examples of emerging circular roles being created through Scotland's growing decarbonisation pipeline.

Appendix 2 Table 1: Examples of new and emerging circular economy job roles

Circular Economy Job Title	New job role in creation?	Personnel sought from other 'traditional' roles, such as...
Clean-Tech Company Directors	Yes	Cross sector - business minded individuals with a central focus on environmental and climate change target driven priorities.
Sustainable Development Managers	Yes	Project management, environmental managers, civil, electrical and structural engineering, manufacturing, contract managers.
Sustainable Energy Optimisation Engineers	Yes	Blade technicians, composites engineers.
Circular Materials Resource Managers	Yes	Those with experience in extraction of raw materials and manufacturing.
Research, Development and Innovation Circular Development Managers	Yes	Cross sector (including third) and those with experience in extraction of raw materials (primary), manufacturing (secondary), or service industries.
Circular Health, Safety, Environment and Quality Managers	No	Renewables, composites, and construction.

Source: Reblade.

The decommissioning and material management of wind farms will create significant job creation opportunities as well as opportunities for business growth through the supply chain. Zero Waste Scotland's estimate of 1.2-1.4 million tonnes of materials from decommissioned wind farms by 2050 underscores the scale of the challenge and the opportunity for Scotland to lead in wind turbine recycling and a circular economy approach [Ref. 21].

With this scale of decommissioning, Scotland has the potential to become a leader in wind turbine component reuse, refurbishment, and recycling to create jobs, stimulate economic growth, and contribute to a more sustainable future.

2. Decommissioning skills & education

Decommissioning job opportunities arising from making the shift from that of a Take-Make-Dispose economic model to one that maximises value extracted from resources are significant and supported by the Scottish policy landscape. Keeping goods and materials in a loop is good for the economy, not just the environment, and requires a pipeline of skills and education to support new circular skills and jobs.

Nadara recognises that integrating sustainability and the circular economy with internal skills and training programmes and opportunities supports the promotion of a circular economy mindset within the organisation. This approach will be woven throughout the organisation's development

activities to help nurture critical thinking that supports the principles of circularity, enabling employees to make informed decisions to support a more sustainable future.

Nadara also recognises that hundreds of organisations across Scotland are working hard to collaborate, upskill, innovate, expand and develop circular skills to help make the energy transition happen. Nadara is committed to supporting companies spearheading the renewable energy revolution and will look to work with those organisations who are upskilling their workforces and growing capabilities to meet the needs of our future energy system.

3. Decommissioning-focused training networks

Deploying renewable energy infrastructure requires a vast array of skills and the potential job creation and skill demand associated with circularity across the energy supply chain from infrastructure construction to end-of-life and decommissioning is increasingly significant. The economic opportunities created in remanufacturing, reuse and refurbishment is becoming clear as assets reach end-of-life.

Greater awareness of material demands as Scotland continues to develop and construct new energy infrastructure means there is a sustainable, economic and social responsibility to embed circularity creating a demand for specialised engineering skills associated with extraction, remanufacturing and asset management services.

With a focus on decommissioning of wind assets at Novar 1, there is an opportunity to identify the emerging roles to support decommissioning through reuse, remanufacturing, and refurbishing and to engage with local community wealth building organisations to ensure the opportunities from Novar 1 are realised.

Appendix 3: Supporting circular-focused research & development

1. Wind turbine end-of-life recycling projects

There are multiple areas of research within the recycling of end-of-life wind turbines, with the aim of achieving technology readiness as well as achieving circularity.

In general, these are:

1.1. Pre-treatment methodologies

These are the pre-recycling processes required before any recycling can take place. They include:

- Handling of blades
- Cutting of blades
- Shredding of blades
- Sorting of the downsized blade materials

1.2. Fibre reclamation processes

There are currently two types of fibre reclamation processes that are in various stages of technical and commercial viability:

- Thermal-based such as thermal pyrolysis
- Chemical-based such as chemical solvolysis

1.3. Upgrading (or recycling) of recovered fibres

It is still unclear which solutions for blade recycling will prove to be the most practical, and profitable, and research continues to help develop the most circular and sustainable options. Technical, economic, environmental and social criteria will all support decision making when determining the optimal methods in place for recycling in the future to ensure robust and transparent decision making when it comes to determining the best technologies for end-of-life blade recycling systems.

1.4. Recyclable blades

Original Equipment Manufacturers (OEMs) are inventing dissolvable resins. This separates the resins from the glass fibres so they can be used for new products, such as suitcases and scaffold boards. This technology is cutting edge, however it is at an early stage and much more research is needed.

The barriers to widespread adoption are cost, availability and urgency. The key benefit of recyclable blades is not likely to be realised until end-of-life, 25-30 years in the future, meaning the roll-out of recyclable blades is still many years in the future.

1.5. Rare earth magnets

It is predicted that by 2040 there will be a significant shortfall of rare earth magnets. This will potentially slow down progress in the transition to net zero. Research and development is already underway to help find new ways of sourcing magnets, as well as looking to establish ways to reduce the associated environmental impacts and obstacles. The sector is committed to pioneering circular supply chain innovation to overcome these challenges and the first wave of large-scale wind farms now planned for decommissioning could present an opportunity to support the recycling of rare earth elements.

1.6. The recycling of composite materials

The objective of developing methods for recycling industrial composite materials such as GFRP and CFRP, has been in development for some time now through a mix of academic and industrial research and development. The sector is working hard to commercialise practical recycling solutions that can manage wind turbine blades and other composite materials to become feedstock for other second-life innovative products. However, the challenge to finding these processes is that they must fit the market demand in terms of:

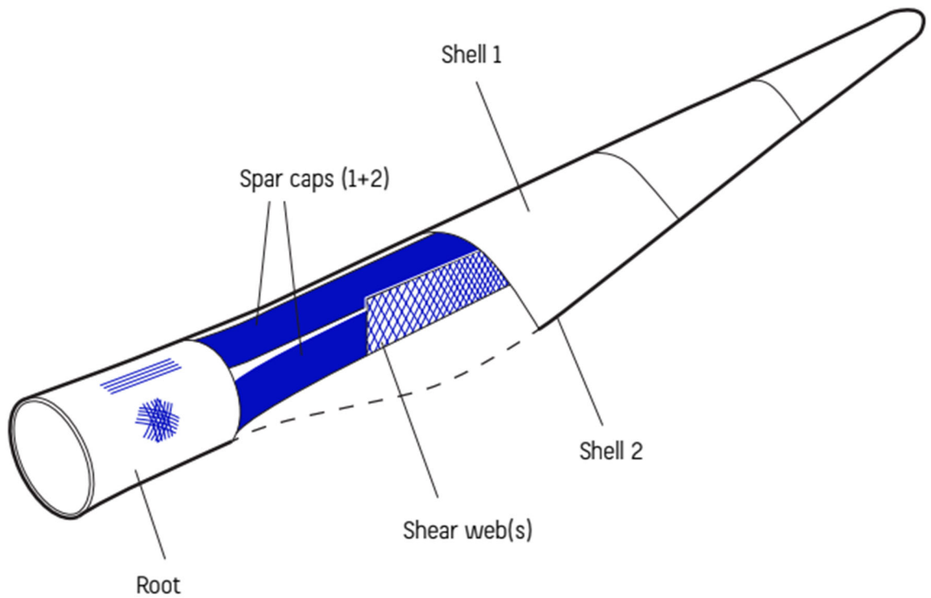
- Price competitiveness
- Quality of performance
- Positive carbon balance
- Positive environmental impact

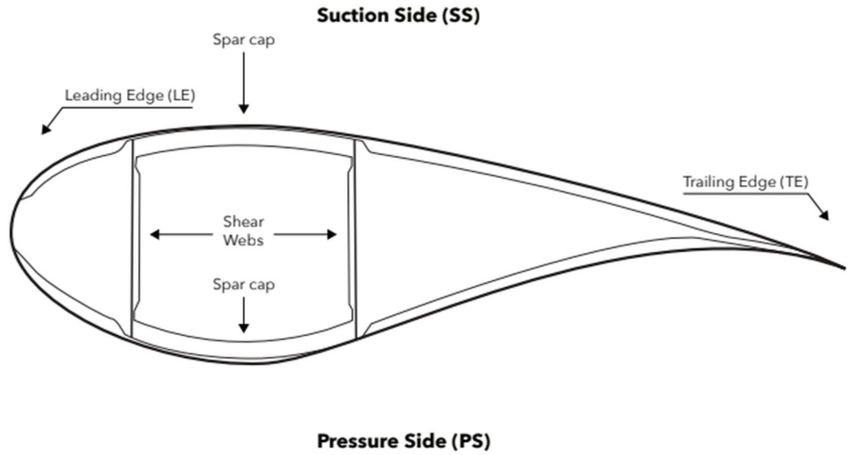
Mechanical recycling processes suit some composite materials, such as some composite waste from automotive, aviation, electrical and manufacturing sectors where materials can be shredded,

milled and then ultimately remoulded into other products or into recycled construction materials. This is also true for some composites within the renewables sector; however, end-of-life wind turbine blades present a particular difficulty. This is down to challenges in achieving the aforementioned criteria due to the inherent design nature of them. The processing of wind turbine blade materials has, and continues to be, trialled using several different recycling processes, but to date these processes are still challenged and the commercialisation yet at scale remains unclear.

To understand why this is the case for wind turbine blades it is necessary to understand a typical commercial wind turbine blade's design and physical morphology, illustrated in Figure 1.

Appendix 3 Figure 1: Wind turbine blade morphology





Reference: (2019) [Ref.29]

Blades are primarily made from GFRP sheets bonded via resin, and core material is sandwiched between layers of glass fibre. The spar caps are made from many layers of unidirectional GFRP, which essentially act as the girder down the length of the blade and provide most of the strength. As the spar caps are so strong they are also very difficult to break down and shred.

Most commercial GFRP recycling processes are fine-tuned to take in specific quantities of material so any contaminants or changes may ruin batches yield quality. This is where blades can cause problems. As the material makeup can vary massively from each blade type or blade generation, this makes building a recycling solution to facilitate all turbine blades very difficult. Reblade observed large variations in the resin used to bind the GFRP, with whatever was the cheapest option at the time of manufacture that also fit their specifications being used. First-generation blades were also often over engineered as they wanted to increase safety factors, so carbon fibre is used to strengthen the shell or spar. Core materials can differ as well from high density foam to balsa wood.

A recycling solution that can effectively manage material variation and can be supplemented with various other GFRP waste is key for commercial maturity and widespread usage across the industry.

Appendix 4: Glossary of Terms

Term	Definition
As-Left Asset Maps	A set of spatial mapping documents provided to the landowner and relevant Planning Authority upon decommissioning completion. They detail the precise location, depth, and status of all subterranean assets retained in situ (such as capped array cabling) to avoid future ground disturbance and manage long-term site liabilities.
Carbon Fibre / CFRP (Carbon Fibre Reinforced Polymer)	A high-strength, lightweight material composed of thin, strong crystalline filaments of carbon bonded together in a polymer matrix (often epoxy resin). Used in wind turbine blade manufacturing (particularly high-stress structural spar caps and root reinforcements in larger blades) to increase structural stiffness and length while reducing total weight. Due to its complex resin-composite structure, carbon fibre requires specialised end-of-life recycling pathways, such as chemical solvolysis, pyrolysis, or mechanical reprocessing into secondary non-woven mats.
Glass Fibre / GFRP (Glass Fibre Reinforced Polymer)	A high-performance composite material consisting of fine glass fibres embedded within a polymer resin matrix (such as polyester or epoxy resin). It serves as the primary structural material in wind turbine blade manufacturing (particularly in main blade shells, webs, and general aerodynamic fairings) due to its exceptional strength-to-weight ratio, durability, and cost-effectiveness. At end-of-life, it requires specialised reclamation techniques (such as mechanical grinding into filler aggregate, cement kiln co-processing, or chemical recycling) to recover mineral content and prevent landfilling.
Calorific Value	A measure of the heating power or energy content released when a material is combusted. Composite materials (like blade resins) have a very high CV, which can cause incinerators and cement kilns to overheat if not carefully blended with lower-energy materials.
Circularity	A holistic economic model and operational approach designed to minimise waste, cut carbon emissions, and reduce reliance on finite natural resources by creating closed-loop systems. It replaces traditional linear disposal pathways (take-make-dispose) by keeping products, components, and materials in continuous high-value use for as long as possible through strategies at the highest tiers of the Waste Hierarchy (specifically asset prevention, component re-use, refurbishment, remanufacturing, and high-value recycling).
Circular Economy Roadmap	A strategic, policy-driven framework (anchored in Scotland primarily by the Circular Economy (Scotland) Act 2024 and supported by UK powers under the Environment Act 2021) that sets out binding targets, regulatory measures, and industrial pathways to transition sectors (such as onshore wind) from linear waste streams to closed-loop material cycles, enforcing resource tracking, remanufacturing, and high-value material recovery.
Circular Economy Job	Jobs in repair, reuse, resource recovery and recycling. These jobs can extend the life of products and close raw material cycles meaning waste products of one process become the raw material for other processes.
Community Wealth Building	A practical approach to local economic development that aims to restructure local economies so that wealth is created, held, and reinvested locally. In wind energy decommissioning and repowering, Community Wealth Building is delivered by prioritising regional supply chains, supporting local enterprise or community co-ownership, enforcing fair work standards, and ensuring that material recovery and site works directly generate local jobs and training opportunities.
Critical National Priority (CNP)	A formal designation for projects, that are considered essential to achieving national energy security and net-zero targets.
Decommissioning and Restoration Plan	A comprehensive document submitted by the developer / applicant for formal approval by the relevant Planning Authority prior to the commencement of site works. Evolving from the Outline Circular Decommissioning Strategy, the final DRP establishes the definitive operational schedule, environmental risk mitigations, contractor compliance standards, and reverse-construction methodologies for safely dismantling site infrastructure. It details the precise material pathways, circular recovery targets, and progressive land reinstatement protocols required to satisfy planning consent conditions and return the site to an agreed, environmentally stable state.
Digital Product Passport	A digital tool used to track the composition, origin, and maintenance history of major components to facilitate informed circular decision-making at end-of-life.

Ecological Clerk of Works	An appointed environmental specialist responsible for monitoring on-site ecological compliance, silt mitigation, and verifying habitat restoration throughout decommissioning and construction.
Energy-from-Waste	A thermal recovery process where non-recyclable waste materials are combusted at high temperatures to generate electricity, steam, or hot water for district heating networks. Classified under the Waste Hierarchy as Recovery (rather than Recycling), Energy-from-Waste (EfW) diverts organic materials and resins away from landfill but releases greenhouse gases during combustion. In the wind sector, burning composite blades via EfW is generally discouraged due to their high calorific value (which restricts plant capacity) and the remaining non-combustible glass ash, which must still be landfilled or downcycled.
Environmental and Social Governance	A formal framework and set of operational standards used to measure an organisation's sustainability, ethical footprint, and long-term societal impact. Core Components: Environmental: Assesses resource stewardship, greenhouse gas mitigation, biodiversity protection, and circular lifecycle management (e.g., zero-landfill commitments, site-won aggregate crushing, and net-zero decarbonisation). Social: Evaluates community wealth building, public health and safety, supply chain equity, and Just Transition commitments within local host communities (e.g., local supply chain hiring and stakeholder consultation). Governance: Covers internal corporate accountability, transparent ESG benchmarking, digital material tracking, and adherence to statutory waste duties and environmental permitting.
High-value recycling	Refers to the extent to which, through the recycling chain, the distinct characteristics of a material (the polymer, the glass or the paper fibre, for example) are preserved or recovered to maximise their potential to be reused in a circular economy.
Inter-Fleet Harvesting	A circular resource-recovery methodology where functional, high-value components (such as gearboxes, generators, transformers, and electronic control units) are non-destructively removed from decommissioned wind turbines and refurbished to serve as certified secondary spare parts across an operator's wider operational fleet.
	This practice keeps complex assemblies at their highest utility value, mitigates supply chain risks for legacy parts, and avoids destructive scrap metal processing.
Just Transition	A framework ensuring the shift to a net-zero economy is socially and economically fair, specifically by creating local jobs and community wealth in the Highlands.
Life Cycle Analysis / Assessment	An objective, data-driven methodology (governed by ISO 14040/14044 standards) used to measure and evaluate the total environmental impact of a product, asset, or process across all or selected stages of its lifecycle (from raw material extraction, manufacturing, and transport, through to operation, reuse, recycling, or final end-of-life). In the wind sector, it quantifies net carbon savings, human health impacts, ecotoxicity, and resource depletion to guide optimal circular decision-making.
Life Extension	An asset-management and operational strategy that involves inspecting, monitoring, repairing, and re-certifying existing wind turbine components to allow a wind farm to continue generating clean energy safely and efficiently beyond its original 20–25 year design lifespan. It delays full site decommissioning, maximises the return on initial embodied carbon, and defers the need for virgin raw materials.
Mandatory Digital Waste Tracking	A statutory regulatory framework (governed in Scotland under the Digital Waste Tracking (Scotland) Regulations 2026) that mandates the use of a centralised UK-wide digital tracking service to log all waste and material movements leaving a site. It replaces paper-based duty of care records by requiring developers, site operators, and licensed reprocessors to enter specific shipment information (including a unique Digital Waste Record Number) into a digital database within two working days. In wind farm decommissioning, it provides a real-time, verifiable digital audit trail that enforces compliance with the Waste Hierarchy, validates carbon saving estimates, and ensures zero-landfill commitments are met.
Materials	Substances or compounds are used as inputs to production or manufacturing because of their properties. A material can be defined at different stages of its lifecycle: unprocessed (or raw) materials, intermediate materials and finished materials. For example, iron ore is mined and processed into crude iron, which in turn is refined and processed into steel. Each of these can be referred to as materials.
Mobile Waste Plant Licence	A statutory environmental authorisation issued by the Scottish Environment Protection Agency (SEPA) under the Environmental Authorisation (Scotland) Regulations 2018 (EASR) that permits the

	operation of temporary, moveable waste-processing machinery on site. In wind farm decommissioning, it provides the legal compliance framework required to deploy mobile crushing and screening trains for processing concrete foundations and track aggregates into certified sub-base engineering material, as well as equipment for segmenting composite blades and processing metals.
Nature-Positive	An approach prioritising environmental enhancement and carbon stability, such as retaining certain infrastructure in-situ to prevent soil oxidation in deep peat areas.
Original Equipment Manufacturer	The company that originally designed and manufactured the wind turbine units, major mechanical assemblies, or specialised components. In the context of wind farm decommissioning and repowering, OEMs (such as Bonus Energy or Siemens Gamesa) dictate component specifications and original material compositions. OEM supply chains and technical documentation are key reference points when assessing whether legacy components can be refurbished, repurposed, or supplied as second-life spare parts.
Permit to Work	A formal safety management system that controls high-risk mechanical demolition and structural dismantling activities following electrical isolation.
Public Beta (Phase)	A live testing window for the UK Digital Waste Tracking service allowing developers to test digital waste tracking workflows ahead of statutory enforcement without incurring non-compliance penalties.
Polluter Pays Principle	An established statutory rule dictating that those who produce pollution or generate waste must bear the full financial responsibility for managing it safely, mitigating its environmental impacts, and restoring the affected environment. In wind farm decommissioning, this ensures developers and operators retain ultimate financial and operational liability for asset removal, hazardous material handling, and site reinstatement, preventing environmental or financial liabilities from falling upon taxpayers or landowners.
Polychlorinated Biphenyls (PCBs)	Hazardous legacy chemical fluids historical to older electrical transformers and substations requiring targeted subgrade screening prior to new site development.
Producer Responsibility	A regulatory and environmental policy approach (formalised under mechanisms such as the Environment Act 2021) that holds manufacturers, developers, and asset owners legally and financially accountable for the entire lifecycle of their products, mandating the design, reuse, redistribution, and high-value recovery of materials at end-of-life to minimise environmental impact and landfill reliance.
RAL Paint / RAL Colour Standard	A standardised European colour matching system originally created in 1927 by the German Reichs-Ausschuß für Lieferbedingungen (Reich Committee for Delivery Terms). In wind turbine manufacturing and decommissioning, specific RAL codes (e.g., RAL 7035 Light Grey or RAL 9010 Pure White) are strictly specified for towers, nacelles, and blades to ensure colour uniformity, compliance with visual landscape planning consents, and standardised anti-corrosion protective coatings across infrastructure assets.
Rare Earth Elements	A group of 17 heavy metallic elements. In wind turbine manufacturing, key Rare Earth Elements (REEs) such as Neodymium (Nd), Dysprosium (Dy), Praseodymium (Pr), and Terbium (Tb) are utilised to manufacture high-performance Neodymium-Iron-Boron (NdFeB) permanent magnets housed within the nacelle's generator. Due to their status as critical raw materials with volatile supply chains, recovering REEs during decommissioning is a major target for high-value circular resource recovery.
Recycling	The process of breaking down waste materials and reforming them into new products and materials.
Refurbishment	This is when a component is completely broken down into its constituent parts, inspected, with broken or worn parts replaced and then reassembled and repainted. Refurbished parts should all come with a warranty that is as good as their new equivalent.
Remanufacturing	Remanufacture is the most comprehensive of the circular economy with each component being broken down and inspected, approved, repaired, or replaced. Each remanufactured component will come with a lifespan that is as good as its equivalent in new as well as the same warranty period.
Repair	The restoration of a product or material.
Resource Recovery	This entails the collection of waste materials.
Senior-Authorised Person	A certified high-voltage electrical engineer who holds formal legal authority to perform circuit isolation, testing, earthing, and safety sign-offs prior to structural demolition.

6F5 Engineering Material / Certified 6F5 Aggregate	A granular structural sub-base material specification produced by on-site crushing and screening of concrete rubble for immediate structural re-use.
Site-won	Refers to raw construction materials or structural elements (such as stone, gravel, topsoil, peat, or concrete) that are excavated, reclaimed, or processed directly from within the project development boundary. In circular decommissioning, site-won concrete and track aggregates are crushed and screened on-site to be reused for backfilling or civil works, eliminating the need to haul in virgin materials from external quarries.
Special Waste Consignment Note	A statutory legal tracking document required for the movement and disposal of hazardous site waste streams (e.g., drained synthetic oils, contaminated soils, SF_6 gas).
Sulphur Hexafluorise (SF6)	A greenhouse gas used as an insulating medium in high-voltage switchgear requiring specialised vacuum capture during substation de-pollution.
Sustainable Management Plan	A comprehensive operational strategy (formerly referred to as a Waste Management Plan) required from all suppliers and contractors prior to the commencement of site activities to audit, manage, and minimise environmental impacts. It mandates the strict application of the Waste Hierarchy to prioritise resource recovery, waste prevention, component re-use, and on-site material recycling (such as aggregate crushing) while systematically eliminating unsustainable practices and diverting waste from landfill.
Take-Make-Dispose Model	The traditional, unidirectional system of resource consumption where finite raw materials are extracted from the earth ("take"), transformed into components or infrastructure ("make"), consumed during an operational lifespan, and finally thrown away into landfill or incinerators ("dispose") once their primary use ends. This approach contrasts directly with a circular economy, which keeps materials in continuous high-value use through re-use, refurbishment, and recycling to eliminate waste and prevent resource depletion.
Track Recovery Protocol	A structured decision hierarchy governing whether underground cables are extracted (along widened track alignments) or retained in situ (along redundant tracks) to balance resource recovery with ecological protection.
Type 1 Aggregate	A specific crushed stone material specification commonly used for constructing and upgrading site access tracks and crane hardstandings
Waste	Any substance, material, or object that the holder discards, intends to discard, or is required to discard, as defined under the Waste Framework Directive and managed under SEPA regulations. In pollution control, it encompasses any material requiring lifecycle regulation to prevent environmental risk, harm, or the permanent loss of valuable resources from the circular economy.
Waste Hierarchy	A core legal framework and regulatory principle (established under the Waste Framework Directive and UK/Scottish Waste Regulations) that ranks waste management options in order of environmental priority: Prevention, Preparing for Reuse, Recycling, Other Recovery (e.g., energy recovery), and Disposal (landfill) as a last resort. It imposes a statutory duty on waste producers to keep materials at their highest value and utility for as long as possible.
Waste Transfer Note	A mandatory legal document providing a Duty of Care record for every non-hazardous material load leaving the site.

Appendix 5: Key Acronyms/Abbreviations

Word / Abbreviation	Definition
CCP	Climate Change Plan
CDM	Construction Design and Management
CV	Calorific Value
CFRP / CFRC	Carbon Fibre Reinforced Polymer/Carbon Fibre Reinforced Composite
CNP	Critical National Priority
CO2 / CO2e	Carbon Dioxide/Carbon Dioxide Equivalent
CRM	Critical Raw Materials
CRMA	Critical Raw Materials Act (EU)
CWIC	Coalition for Wind Industry Circularity
DEMP	Decommissioning Environment Management Plan
DESNZ	Department for Energy Security and Net Zero
DRP	Decommissioning and Restoration Plan
DPP	Digital Product Passport
EASR	Environmental Authorisations (Scotland) Regulations 2018
ECoW	Ecological Clerk of Works
EfW	Energy-From-Waste
EGDIP	European Green Deal Investment Plan
ESJTP	Energy Strategy and Just Transition Plan
ESG	Environmental and Social Governance
FTE	Full Time Equivalent
GBE / GB Energy	Great British Energy
GFRP / GFRC	Glass-Fibre Reinforced Polymer/Glass Fibre Reinforced Composite
GHG	Greenhouse Gas
GIS	Global Information System
GVA	Gross Value Added
GW	Gigawatt
IBC	Intermediate Bulk Container
IIP	Infrastructure Investment Plan
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
ISO	International Organisation for Standardisation
KW	Kilowatt
LCA	Life Cycle Analysis/Assessment
MW	Megawatt
MoU	Memorandum of Understanding
MV	Medium Voltage
NESO	National Energy System Operator
NMIA	National Manufacturing Institute of Scotland
NPF4	National Planning Framework 4
OEM	Original Equipment Manufacturer
ORE	Offshore Renewable Energy (Catapult)
PCB	Polychlorinated Biphenyl (environmental hazard)
PE	Polythene
PPP	Polluter Pays Principle

PTW	Permit to Work
PVC	Polyvinyl Chloride
RAL	German Colour Standard System (Reichs-Ausschuß für Lieferbedingungen)
REE	Rare Earth Elements
RESCUE	Regulations to Ensure Sustainable Use at End-of-life for Wind
RME	Raw Material Equivalent
RMC	Raw Material Consumption
RO	Renewables Obligation
SAP	Senior-Authorised Person
SBS	Scottish Biodiversity Strategy
SEIP	Sustainable Europe Investment Plan
SEPA	Scottish Environmental Protection Agency
SF6	Sulphur Hexafluoride
SCADA	Supervisory Control and Data Acquisition
SSEN	Scottish and Southern Energy Networks
STEM	Science, Technology, Engineering and Mathematics
SWA	Steel Wire Armour
SWCN	Specialist Waste Consignment Note
UPS	Uninterruptible Power Supply
WEEE	Waste Electrical and Electronic Equipment
WTN	Waste Transfer Note
XLPE	Cross-Linked Polyethylene
ZWS	Zero Waste Scotland