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# Scotland's net zero sectors – An investment readiness methodology and assessment

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# 1 Executive summary

The Scottish Government has committed to a just transition to net zero by 2045. However, the cost of this transition cannot be met by public sector funding alone, so sectors must attract private capital investment to fill investment gaps.

This study aims to develop an approach for assessing the investment readiness of net zero sectors, and to test this approach in relation to onshore wind, offshore wind and hydrogen as a proof of concept. The report also includes key interdependencies, barriers, and opportunities for priority action by the Scottish Government or its partners.

## 1.1 Key findings

We define investment readiness as: "a position where investors can understand the investment opportunity and develop projects with sound understanding of financial fundamentals and risks based on reasonable projections." This definition is based on a literature review, stakeholder engagement, and our own expertise.

This definition of investment readiness can be viewed as both:

- A minimum standard of attractiveness at which an investor would consider an opportunity.
- A way of assessing how risky an investment is, which will affect the return that investors demand and, therefore, the cost of capital for the proposition.

The definition is based on the perspective of an investor looking to generate risk-adjusted returns. Where government can improve the investment readiness of a given energy transition sector, this would encourage capital investment from a wider range of investors, and, likely, at a lower cost of capital.

We developed a bespoke investment assessment framework that uses a scorecard approach. Under this approach, sectors are scored against the following criteria:

- market growth potential
- profitability
- policy support
- market accessibility
- supporting infrastructure
- demand

The key qualitative findings we identified from the individual sector assessments are:

- The hydrogen sector scores lower with regards to **overall investment readiness** compared to the wind sectors, since it is still developing. This is reflected in domestic regulation and incentives which are still in progress. Developing supply chains are vulnerable to external shocks and demand uncertainty. These challenges offer a chance for policy makers to make informed decisions on hydrogen market design, ensuring maximum benefits from the evolving market.
- **Market growth potential** is strong for both onshore and offshore wind sectors over the forecasted horizon of 5 to 10 years, backed by policy support. Based on the evidence collected and presented in this report, we anticipate growth for hydrogen. However, this growth is expected to be modest compared to the wind sectors due to uncertainties surrounding factors such as end-use scenarios and availability of buyers, as well as the ongoing development of export plans.
- There is a low industry **profitability** level for both wind sectors in the short-term and long-term. Maturing global supply chains, increased competition levels and interest rates all reduce future profitability. There is below average ability to control costs due to reliance on imports of key components. This presents an opportunity to decrease exposure to global supply chains, and mitigate potential profitability erosion risks from proposed changes to network charges, such as those discussed as part of the electricity market reform processes.
- Onshore and offshore wind sectors scored highly in terms of level of **policy support**. There are well-established regulatory pathways supporting project development and the industry enjoys broad political support across the major political parties in Scotland. Green hydrogen is generally well perceived in political discussions, but potential challenges with its adoption limits policy support. Domestic regulations and incentives are still being developed for green hydrogen.
- Onshore and offshore wind are mature technologies and are crucial for decarbonising the power sector, resulting in above average scores for the **market accessibility** – for selected technologies only – reflecting the ability of a company to enter a sector.

- **Supporting infrastructure** scored poorly relative to each sector's overall scores. This presents an opportunity to improve investment readiness as sectors continue growing. Existing electricity grids require significant upgrades to compensate for increasing wind capacity. Grid reinforcements progress has been slow despite plans in place according to stakeholder interviews, leading to delays in connecting wind projects. Additionally, stakeholders noted that planning applications for wind developments are tedious and may delay progress. For hydrogen, where supply chains are developing, stakeholders highlighted potential funding gaps for skills and development.
- Stakeholders noted that whilst the ambition to increase supply of wind is a good indicator of a supportive investment climate, investors would need to consider the offtake of that renewable power. At present, there are well publicised network constraints on transmitting Scottish wind power to England where **demand** is greater. This has led to times when that power is curtailed / turned down and may act as a concern for future investment in wind power. Stakeholder discussions pointed to the importance of ensuring that there is offtake for that power; either through transmission to England, export to third countries, or greater demand from Scottish industry, such as hydrogen electrolysis.

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# 2 Glossary / Abbreviations table

| | |
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| AEM | Anion Exchange Membrane, is a type of hydrogen electrolyser technology that uses a special anion exchange membrane and is currently still being researched. |
| ALK | Alkaline electrolyser, is a type of hydrogen electrolyser technology that uses alkaline substance as electrolytes. |
| AR | Allocation Rounds are periods during which CfDs are awarded to low-carbon eligible projects. The allocation process is a competitive auction where eligible projects bid for CfDs. The rules and eligibility requirements for each allocation round are set in the Allocation Framework |
| Asset class | An asset class is a grouping of investments that have similar characteristics. The most traditional asset classes are equity and bonds. Alternative asset classes include infrastructure, property, commodities, and currencies, amongst others. |
| ASP | The Administrative strike price (ASP) sets the maximum support, on a £/MWh basis, that the government is willing to offer developers for each technology in a given delivery year. ASPs set a cap on clearing prices in an auction as generators cannot receive a strike price value higher than their technology ASP. |
| Brownfield projects | A brownfield project is a project of expansion or reuse of land that has been previously used for commercial or industrial purposes. Brownfield projects typically have a key advantage during the planning process when compared to greenfield projects. |
| BtM | Behind-the-Meter, refers to energy assets such as solar panels, storage, or other systems installed on-site. BtM systems provide power that can be used on-site without passing through a utility meter, whereas power provided by front-of-meter (FtM) system must pass through an electric meter before reaching the end user. |
| Capital | Wealth in the form of money or other assets with financial value, owned by a person or organisation. |
| CfD | Contract for Difference, is a government mechanism that guarantees a fixed price for electricity generated by |

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| | renewable energy projects. It provides stability for investors by ensuring a steady income, even if market prices fluctuate. |
| Core infrastructure | A sub-category within infrastructure equity investment, which focusses on low-risk assets with limited asset management required to generate returns. Core infrastructure assets should provide consistent performance throughout all stages of the economic cycle. |
| EPC | Engineering, Procurement, and Construction contractors |
| Equity | Ownership stake in a company or an investment. Equity holders often have voting rights attached to their holdings and can have entitlements to dividends. On sale of the company or business, equity investors participate in any uplift in value of the company. In the event of a liquidation, equity represents the value that would be returned to shareholders after all the company’s assets were liquidated and all of the company's debts were paid off. |
| ESJTP | Energy Strategy and Just Transition Plan |
| EV | Electric vehicle |
| Debt | Debt is a collective term for money owed to creditors of the business. Debt often takes the form of loans or bonds that entitle investors to a stream of interest payments. Typically, loans and bonds have a maturity date on which the money loaned to the company is repaid |
| Fixed bottom | Or ‘fixed offshore wind’, is a type of wind energy technology where wind turbines are installed in the seabed or ocean floor and are not floating. These turbines are typically designed for shallower waters where the turbine foundation can be securely attached to the ocean floor. |
| Floating bottom | Or ‘floating offshore wind’, is a type of wind energy technology where turbines are not anchored to the seabed but instead float on the water’s surface. These turbines are typically designed to operate in deeper waters where fixed structures are impractical. |
| Greenfield projects | A greenfield project typically involves development on a completely vacant site where no notable prior construction has taken place. |
| HAR | Hydrogen Allocation Round, is a competition where hydrogen projects bid for contracts to obtain a certain strike price. |

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| Hydrogen Business Model | A mechanism for supporting hydrogen production in the UK by offering investors a guaranteed price for produced hydrogen, similar to the renewables CfD. |
| Inflation linkage | An agreement where income received is indexed against a given inflation measure (such as the Consumer Price Index). An increase in inflation would result in higher income. |
| INTOG | Innovation and Targeted Oil and Gas, is a leasing round for offshore wind projects with focus to directly reduce emissions from oil and gas production and boost further innovation. This program is managed by Crown Estate Scotland. |
| Investment manager | A person or company responsible for managing investments on behalf of a financial institution or clients. |
| Investor | A person or organization that provides money to financial schemes, investment funds or companies with the expectation of achieving an income or a profit. |
| LCOE | Levelized Cost of Electricity, is a metric used to reflect the average costs of generating one unit of electricity over the entire lifespan of a power plant. LCOE is useful to compare the costs of different energy technologies. |
| LMP | Locational Marginal Pricing, is a mechanism that operates on the principle that the price paid by demand and received by generation represents the marginal cost of electricity at a specific location. This cost varies due to network limits and fluctuating electrical losses (based on the injection or withdrawal of power across the network). |
| PEM | Proton Exchange Membrane, is a type of hydrogen electrolyser technology that is the most common in the industry due to their efficiency and relatively low operating temperature. |
| PPA | Power Purchase Agreement is a contract where a company agrees to buy electricity directly from a renewable energy project, ensuring a stable and often cost-effective supply. Corporate PPAs involve businesses directly supporting renewable projects while also meeting their energy needs sustainably. |
| RAG rating | A rating scale of red, amber and green, where green is the most positive rating. |

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| REMA | Review of Electricity Market Arrangement, is the UK Government’s review to reform the current electricity system to suit the UK’s targets to decarbonise the power system, lower energy bills, improve energy security, and reduce exposure to the volatility of the global fossil fuel markets. |
| SOEC | Solid Oxide Electrolyser Cells, is a type of hydrogen electrolyser technology that uses solid oxide materials as the electrolytes. |
| SME | Small to medium sized enterprise |
| Strike Price | The strike price is the agreed upon price a renewable energy generator will receive for the energy it generates. This strike price is set through an auction process (capped by the ASP). Generators are paid a variable top-up between the market price and the strike price. Generators will pay back when the market price goes above the strike price. This mechanism helps to provide certainty of income for investors which encourages the development of renewable energy. |
| Technology Readiness Levels | Technology Readiness Levels (TRLs) are a method for estimating the maturity of technologies. They enable consistent and uniform discussions of technical maturity across different types of technology. TRL scale is from 1 (least mature) to 9 (most mature). We provide a breakdown of each level in Appendix C. |
| TNUoS | Transmission Network Use of System charges, refers to the charges that electricity generators and suppliers have to pay for using the transmission network to transport electricity from where it's generated to where it's needed. This network includes the high-voltage power lines and substations that transmit electricity over long distances. TNuOS charges help cover the costs of maintaining and operating this transmission infrastructure. |
| Value add infrastructure | Value add infrastructure refers to assets that may have similar or the same qualities to core assets but offer the opportunity for additional value creation through further development, new contracts, or increased capacity, for example. |
| Venture capital | A form of private equity investment which finances start-up companies with the potential for significant growth. |

# 3 Introduction

This report provides a methodology to assess the investment readiness of Net Zero sectors in Scotland. The methodology is applied to three test sectors: offshore wind; onshore wind, and hydrogen.

## 3.1 Policy context

The Scottish Government has committed to a just transition to net zero by 2045. The cost of this transition cannot be met by public sector funding alone. It must therefore include substantial private capital investments into net zero sectors, such as energy.

The findings of the study will be used to feed into future policy development such as Scotland's forthcoming Just Transition Plans, the delivery of the Policy Prospectus, and the National Strategy for Economic Transformation. The methodology designed as part of this study is intended to be used by the Scottish Government in any net zero sectors in the future. This will provide a basis for future measurement and evaluation of these sectors, thereby supporting the Scottish Government's efforts to improve investment readiness of net zero sectors to reach net zero by 2045.

## 3.2 Research aims

The aims of this research project were to:

- develop a clear definition of 'investment readiness'
- develop a repeatable methodology to assess the investment readiness of net zero sectors in Scotland
- test this methodology by providing an initial high-level assessment for three of the net zero energy production sectors: onshore wind, offshore wind, and hydrogen
- validate the methodology and assessments with stakeholders, including the Scottish Government, investment managers, and asset owners in the three net zero energy production sectors
- provide a narrative explaining the outcomes of the investment readiness assessment for three net zero energy production sectors
- identify key interdependencies, barriers, and opportunities for priority action by the Scottish Government or its partners.

# 4 Defining investment readiness

Investment readiness is a relatively broad concept, and its application varies depending on the wider context. In providing a definition in this project, we aimed to strike a balance of broad applicability (i.e., the definition is broad enough to apply effectively to a variety of sectors) whilst also meeting the needs for the energy transition. The definition is supported by LCP's experience, a literature review[1], and our stakeholder engagement.

We define investment readiness as follows: **a position where investors can understand the investment opportunity and develop projects with sound understanding of financial fundamentals and risks based on reasonable projections.**

Understanding the opportunity is crucial for investors. Investors should be able to identify the scale of the opportunity and how it is likely to evolve over the coming years. This is particularly appropriate to energy transition investments, where investors are looking to profit from a rapidly evolving market with high levels for potential growth, widely expected to last for over 30 years (as supported by stakeholders that were engaged for this project).

Having a sound understanding of financial fundamentals and risks is key to energy transition investments. These investments tend to be large scale projects with high volumes of capital committed upfront. Therefore, based on LCP's experience, investors look to establish detailed, credible financial projections before investing. Further, we note that a large proportion of these investments are in core infrastructure assets – where the investor looks to minimise uncertainty, and therefore risk, in the income produced by these assets. This is often achieved through the use of contractual income schemes such as Contracts for Difference (CfDs) or power purchase agreements (PPAs) for generating assets. We explore risk management for core infrastructure investors further in Appendix B.

"Reasonable" projections depend on the sector that is being analysed. However, for projections to be deemed reasonable, other investors who analyse the same set of information should broadly agree with the projections used.

Ultimately, an environment where risks can be understood and reasonably quantified is a pre-requisite to attracting capital, both equity and debt. The definition of investment readiness provided above can be viewed as both:

- A minimum standard of attractiveness at which an investor would consider the opportunity. If a proposition does not reach that minimum standard, it is not investment-ready.
- A way of assessing how risky an investment is, which will affect the return that investors demand and therefore the cost of capital for the proposition.

[1] See overview of literature reviewed with regards to investment readiness in Appendix A.

The methodology for assessing investment readiness in Section 6 details the factors that investors consider when analysing an investment further[2]. Of course, a sector that is not "investment ready" would be expected to receive a low score on this assessment.

We carried out a literature review to gather broad definitions of investment readiness to test whether our working internal definition was applicable or needed refinements.[3]

We broadly found that other definitions of investment readiness aligned with our definition. Common themes included in definitions include a requirement for sufficient publicly available information to assess and understand an opportunity. Furthermore, there is a requirement for projects to meet investment parameters for investors (i.e., the criteria or factors that investors consider when evaluating potential investment opportunities).

Our investment readiness definition is based on the perspective of an investor looking to generate risk-adjusted returns. Investors will look at projects on a case-by-case basis and determine their attractiveness. Critically, where the government can improve the investment readiness of a given energy transition sector, this would encourage capital investment from a wider range of investors, and, likely, at a lower cost of capital.

## 4.1 How investors take decisions

The section below is based on LCP Delta's insight into investor decision making. This is was gathered from LCP's 25 years' experience in providing investment advice in over £250 billion of invested assets.

When determining whether to invest in a particular sector, investors typically follow a two-stage decision making process, referred to by the investment industry as 'top-down meets bottom-up'. This can be explained as follows:

1. **Top-down: Sector level opportunities are screened against the investor's investment parameters at the macro level.** For example, an investor may be looking to invest in certain regions and sectors, and to invest in projects at different stages of development (e.g., greenfield vs brownfield projects). These decisions might be influenced by the history and expertise of the firm as well as its geographical location.
2. **Bottom-up: Individual deal opportunities are assessed in detail to determine an expected return on investment, and the level of risk associated with the project.** At this stage, financial models are developed and, importantly, investors look to establish a credible revenue and cost models, and determine the level of competitive advantage. To perform this level of analysis, investors require sector information to be readily available.

[2] The process by which factors for the methodology were selected and validated is provided through Section 5 and Appendix B.

[3] Further details on the literature review used to gather definitions of investment readiness are outlined further in Appendix A.

The precise weighting that each investment manager places on each stage varies from investor to investor. We have found that in the energy transition space, sector allocation (i.e., the proportion of the portfolio invested in each region and sector) is often determined by the expertise/area of focus of a specific investment manager rather than a global assessment of the opportunity set.

We have observed many investment managers adopting a bottom-up process when making investment decisions. There is a minimum level below which investors will not invest. Above this minimum level, the more attractive the investor perceives the opportunity to be, the less return they will demand for taking the risk, lowering the cost of capital.

We note that investments in the energy transition will typically be in infrastructure-like projects. These projects can be categorised in terms of their risk and expected return characteristics. We list the key categories as follows, from low risk and return expectations to high:

- Core: a sub-category within infrastructure equity investment, which focusses on low-risk assets with limited asset management required to generate returns. Core infrastructure assets should provide consistent performance throughout all stages of the economic cycle. Examples of core infrastructure would be ports, rail, or roads.
- Value add infrastructure refers to assets that may have similar or the same qualities to core assets but offer the opportunity for additional value creation through further development, new contracts, or increased capacity, for example. An example of a value add infrastructure asset would be a solar farm where most of the asset is operational but the investment manager is developing a significant expansion to the size and capacity of the solar farm, requiring material capital investment.
- Venture capital - a form of private equity investment which finances start-up companies with the potential for significant growth.

Where investors deploy capital into value-add and venture capital opportunities, additional risks might include:

- Additional construction and development activities. The costs for these activities may be greater than the investment manager's budget, or the activities may take longer than initially expected, introducing additional uncertainty over profits to be received in the short term.
- The use of less mature technologies. The investment manager may invest in newer technologies that have not been used at scale. The potential upside may be higher for the investment manager if the technology becomes widely adopted, however this is balanced with the risk that the technology is less profitable than expected.
- Investing in projects or companies at an earlier stage, where there may be high profit opportunities but higher levels of uncertainty.

Investors often access energy transition investments via closed ended funds – these are funds that have a finite life (usually around 10 years). Investors commit capital at the inception of the fund, and the investment manager invests this capital as opportunities arise. At the end of the fund’s life (in its “wind down” period), the manager disinvests from assets and returns capital (and any gains) to investors. In contrast, open ended funds have a perpetual life, with regular (perhaps quarterly or semi-annual) dealing dates in which investors can invest or disinvest from the fund.

Investment into the energy transition is open to all asset owners, but due to the type of arrangements being offered by investment managers, typically larger institutional investors have dominated as the minimum investment sizes are typically USD10 million per fund. We expect that large asset owners (e.g., those with at least £400 million in assets) are likely to be important investors in the energy transition space.

These observations are backed by the stakeholder engagement we completed with investment managers. These investment managers first screen out opportunities that are not applicable to the specific mandate of a given fund. This screening may take place as follows:

- At the broadest level, the asset class, e.g., equity, bonds, commodities, currencies, etc., and geography is considered - some investors only take equity positions, as opposed to debt positions and only invest in Europe rather than globally, for example.
- Some investment managers screen out certain countries where the investment manager has a lack of knowledge or expertise in that country, despite being within the allowable regions of the fund. One investment manager noted that they will only invest where they believe they have a competitive advantage compared to other investors. Therefore, they would not invest in certain countries where they lack experience.
- Sub-divisions of asset classes are also considered – infrastructure equity investors may have a mandate for core (lower risk) infrastructure assets only, whilst some may invest in higher risk areas such as venture capital. This distinction may be set explicitly in the fund’s terms, or indirectly as indicated by the range of returns that the fund targets.
- Screening may take place based upon a variety of other objectives for the fund. For example, one investment manager’s fund includes an explicit objective of delivering a measurable decarbonization impact. Alternatively, one investment manager has a variety of objectives including extending equality of opportunity, net zero, and innovation. The investment manager also aims to invest where private market funding is lacking. A fund’s explicit objectives will naturally lead to the screening out of certain opportunities.

# 5 Frameworks for assessing investment readiness

A wide variety of frameworks have been developed for the assessment of sector attractiveness with regards to investment. Several have gained more traction with frequent use within industry and support in academic literature. We discuss three of the most prominent and relevant frameworks to the energy transition below: Porter's Five Forces, PEST, and SWOT[4].

## 5.1 Porter's Five forces

Porter's Five Forces is used to understand both the attractiveness of an industry, and the levels of competition within it. The framework is very popular in both the academic environment and industry.

The framework focusses on evaluating the factors that determine the level of profit that can be achieved in a particular industry, driven by the level of sustainable competitive advantage. We describe each element of the traditional Porter's Five Forces model as follows:

1. **Supplier power.** An assessment of suppliers' ability to set prices. This is driven by factors such as the number of suppliers, how unique each product or service is, relative size and strength of the supplier, and cost of switching from one supplier to another. Where suppliers have power, a sector might face cost pressures which increase the cost.
2. **Buyer power.** An assessment of how effectively buyers can negotiate prices downward. This is driven by factors such as the number of buyers in the market, the importance of each individual buyer to the organisation, and cost to the buyer of switching from one supplier to another. Strong buyer power can reduce profitability.
3. **Competitive rivalry.** The main components of this force are the number of competitors in the market and their similarity to the organisation. If there are many competitors offering very similar products and services, this would lead to downward price pressure and therefore would reduce attractiveness of the sector.
4. **Threat of substitution.** Where close substitute products exist in a market, it increases the likelihood of customers switching to alternatives (especially in response to price increases).
5. **Threat of new entry.** Profitable markets attract new entrants, which erodes profitability. Unless the existing organisations have strong barriers to entry (e.g., patents or high capital requirements) and economies of scale, then new entrants will emerge.

Aside from the application of Porter's Five Forces in academic literature, literature exists which directly evaluates the effectiveness of the model. Generally, we believe the model is well supported, albeit with certain criticisms that are highlighted in a short sample of this literature in Appendix A. We address these criticisms of the model directly in Appendix B.

[4] Literature review for the models is provided throughout Appendix A and B.

## 5.2 Political, economic, social, and technological analysis (PEST)

PEST analysis focusses on the external factors affecting an industry and how these factors will impact the performance and activity of the sector in the long term. PEST is used in academic literature to assess the attractiveness of a wide variety of industries.

The external environment considered by PEST is an important factor to consider for industry analysis. The political and regulatory environment is very important to energy transition investments. LCP's opinion is that whilst Porter's Five Forces is generally a more effective model for evaluating the ability to generate strong profits in a particular industry, it is important to ensure that the external factors in PEST are incorporated.

We consider that a key drawback of the PEST framework is that its focus is purely external. Internal factors such as competitive rivalry and barriers to entry are not included, and are fundamental to the attractiveness of an industry – therefore, PEST should not be relied upon alone.

The PESTEL framework expands upon PEST by adding two factors: Environmental and Legal. Energy transition investments are inherently positive for the environment category by their nature and therefore this is generally not a differentiating factor between energy transition sectors. Also, we believe that legal considerations can be captured within the same category as political and regulatory factors.

## 5.3 SWOT

SWOT, or strengths, weaknesses, opportunities, and threats analysis is used to assess both the internal and external forces that may create opportunities or risks for an organisation. The framework is broad and relatively generic, such that it can be applied to a variety of contexts and situations. However, a key drawback of it is that it is much less descriptive than other models such as Porter's Five Forces and PEST – the factors are less specific, making it more difficult to apply on a consistent basis.

Overall, we believe that the four elements of the SWOT framework are already incorporated within Porter's and PEST frameworks in a structure that is more relevant to energy transition sectors.

# 6 Investment readiness methodology

Our framework to assess investment readiness is based on stakeholder engagement with investors, relevant academic literature as described in the section above and the author's expertise of the nature of energy transition sectors. On basis of these considerations, we have modified Porter's approach to include time elements, policy support, supporting infrastructure, and technology readiness. See Appendix B for further detail.

The resulting investment readiness framework is in the form of a scorecard approach composed of six factors:

- market growth potential
- profitability
- policy support
- market accessibility
- supporting infrastructure
- demand.

For ease of visualisation, we have plotted the factors on a 'radar' chart, as illustrated in Figure 2. In general, the larger the area bounded by the scores, the more investable a sector is. Where factor scores dip toward the centre, this should indicate that further investigation as to how the score might be improved is warranted.

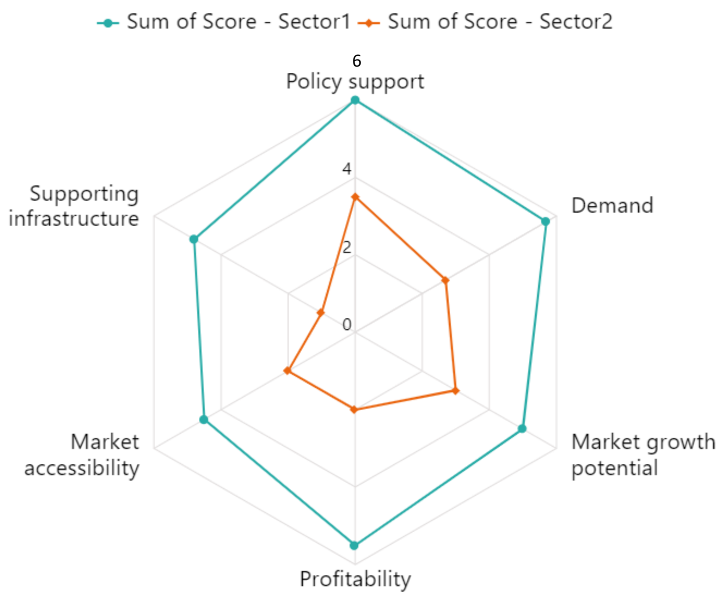


Figure 1. Example 'radar' output.

The factors and the types of aspects underlying their analysis are presented below.

## 6.1 Market growth potential

This factor covers how much the markets are expected to grow in a five-to-ten-year horizon for that technology. Some sectors may expect to see periods of decline or near zero growth whilst others experience growth significantly greater than the rest of the economy. This metric helps capture what phase a technology is at in the lifecycle model - whether the market is emerging, in growth, under maturity, or in saturation and decline. We note that a time horizon of 5-10 years is in line with the time horizon for entering and exiting an investment for managers that we met with as part of the stakeholder engagement.

## 6.2 Profitability

Profitability encompasses a range of factors aimed at capturing security of income. This includes short term factors that indicate whether the sector can make viable profits either now or in the foreseeable future. Examples of these considerations may be current revenue trends and an examination of variable costs (e.g., raw materials, labour) to determine the margin of profit. We also measure how vulnerable the industry is to variable costs and who holds more market power in costing decisions. We also look at longer-term factors to indicate how secure pricing/revenue will be for a certain technology. Some technologies are backed by long term pricing contracts, such as CfD's, that provide long term pricing security. Other examples that may be considered is the market stability and the impact of technological advancements, such as improvements in efficiency or cost reduction from economies of scale.

## 6.3 Policy support

Policy support measures the extent to which the government (both the Scottish and UK Government) has put in place a policy or regulatory environment designed to support, de-risk and/or aid the growth of the sector. Examples of considerations that can be made are renewable energy targets, subsidies and incentives to encourage investment in the sector, as well as the permitting processes, grid connection regulations, and environmental standards, to determine if they facilitate sector growth. The regulatory environment is combined with an analysis of wider political support which considers whether other political parties are similarly disposed to the sector. These factors help gauge the extent to which current or future governments are providing a supportive, and therefore a de-risked, environment for investing.

## 6.4 Market accessibility

Market accessibility measures the competitive environment and other market factors. This helps to determine the extent to which the sector is exposed to growth, competition, and barriers to entry. Firstly, we look at a range of subfactors encompassing how competitive the market is for a technology or sector. This includes companies that supply similar products that may provide a similar service both in the short and long term. In addition to competition, the maturity of the market is also measured to understand the level of risks for the adoption of a sector or technology. Other aspects that may be considered are competitors' strategies, including pricing, marketing, and product differentiation, to understand competitive dynamics. Regulatory, technological and capital barriers to entry can be considered. These factors help to understand whether a market for a technology or sector is ripe for new entrants as well as for growth.

## 6.5 Supporting infrastructure

Supporting infrastructure determines the capability of a country to support the growth of a sector or technology. The availability and capability of the domestic installation and maintenance workforce determines the ability to meet demand for the technology or sector. We also measure for the state of domestic infrastructure to see if it would be able to support these technologies or sectors. Further, this factor assesses the development and efficiency of supply chains. A sector with strong supporting infrastructure sends a strong signal to investors that growth will not be constrained by this factor. The factor may include the consideration of physical infrastructure such as roads, bridges, utilities, and telecommunications networks, digital infrastructure to facilitate technology adoption and connectivity, as well as energy specific infrastructure, including power generation, transmission, and distribution systems, to meet the sector's energy needs.

## 6.6 Demand

Demand measures price competitiveness compared to alternative sources for the product or service against other technologies or sectors. We assess this by looking at two different time horizons: short term (up to 3-years) and long term (5-10 years). Furthermore, the demand for the asset's product or service is considered over the forecast horizon of five to ten years. A sector or technology with strong demand for its product or service will send strong signals to investors that there will be sufficient levels of demand to satisfy the expected level of supply.

## 6.7 How to use and interpret quantitative results

A detailed scorecard, including specific sub-factors has been provided to the Scottish Government for further development and use. Applying the scorecard to a sector requires the user to assign a 1-6 score to a list of sub-factors that fall under each factor described above. For example, profitability may include sub-factors around current revenue trends, industry vulnerability to variable costs and security of pricing / revenue. The sub-factor scores are averaged to create a factor score. The six factor scores are aggregated using equal weight averaging to create a total score.

It is important **not** to take either the total score or factor scores as absolutes in terms of whether a sector is investment ready or not. As the sub-factors included in different factors may interact with each other, it is not recommended that total scores are used in the context of sector filtering or ranking. This would require additional analysis.

The scores allow a high-level assessment of relative strengths and weaknesses of sectors and to drill down to the factors and sub-factors that are driving the score. The objective is to identify where scores are lower and to use that as a basis of discussion as to how the score or scores can be improved, or if a score is particularly low that it may in itself be restricting investment despite high scores elsewhere. In general, taking action to improve scores should lead to improved levels of investability and a lower cost of capital[5].

[5] Improving investment readiness scores (reflected by a higher ranking in the scorecard methodology) addresses the key risks and uncertainties associated with the sector, technology, or asset. As these perceived risks decrease, the sector, technology, or asset becomes more likely to meet the maximum risk appetite for a greater number of investors. Therefore, a wider array of investors will be more willing to commit capital to the sector. Similarly, as the perceived risk decreases, the cost of debt reduces as the level of interest that investors require on debt instruments, while the minimum return shareholders may require on their equity investment will also be reduced. Combining these factors leads to a decrease in the cost of capital, making it cheaper for the company to raise funds for its operations and investment projects.

# 7 Investment readiness of selected energy sectors

This section presents results from the three example net zero sectors to which our investment ready methodology was applied and tested. The purpose of this analysis is to test the methodology and to provide an initial high-level assessment of the test sectors. The analysis relies on the authors' internal industry expertise; however, the level of stakeholder engagement was limited by the scope of the project to three industry experts / asset owners and the relevant sector leads at the Scottish Government. Furthermore, the analysis is representative of the authors' understanding of the sector at the time it was completed, in November 2023 - January 2024.

Figure 3 shows the investment readiness scores for Scotland's offshore wind, onshore wind, and hydrogen sectors (a score of 1 is lowest, while a 6 is best). Quantitative results are illustrative only due to the limitations explained above.

Offshore wind has the highest overall score, whereas hydrogen has the lowest overall score. Hydrogen receives low scores for several factors mainly because the sector is still in the early stages of development.

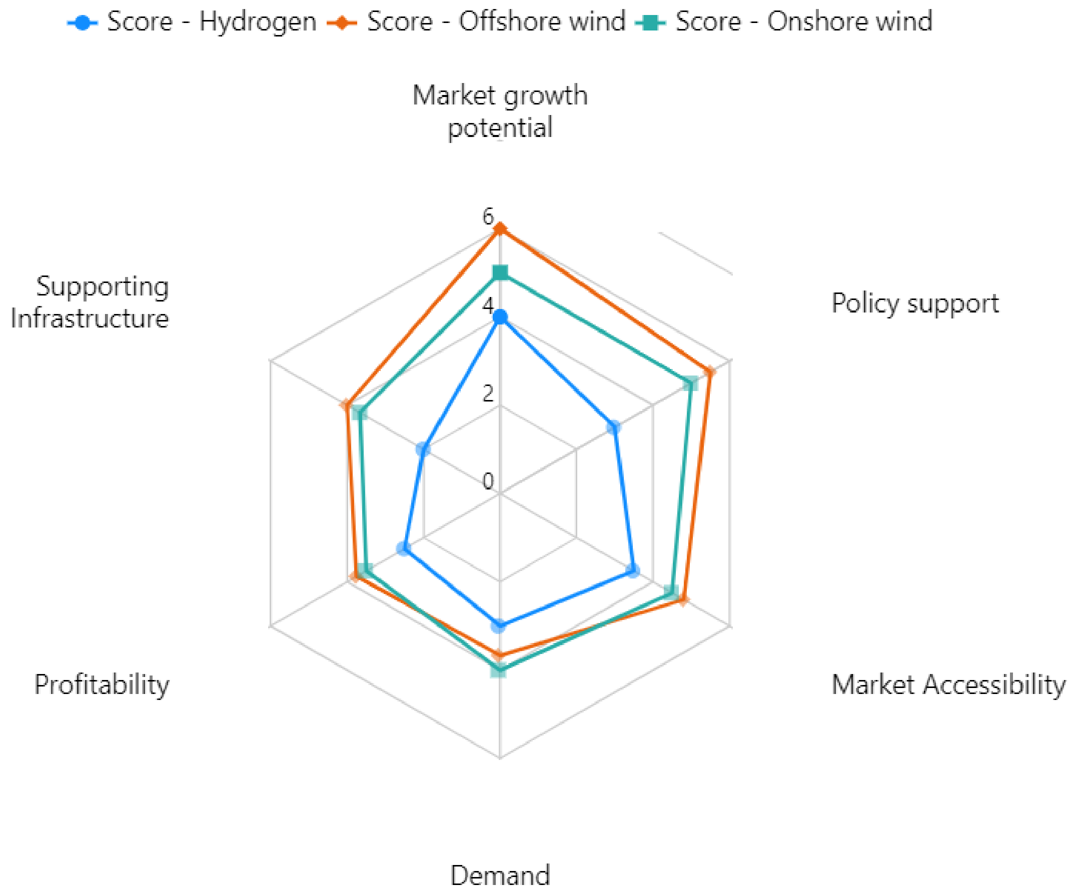


Figure 2. Investment readiness scores for offshore wind, onshore wind, and hydrogen

Table 1. Investment readiness scores for the example net zero sectors

| Factor | Offshore wind | Onshore wind | Hydrogen |
|---|---|---|---|
| Market growth potential | 6.0 | 5.0 | 4.0 |
| Profitability | 3.3 | 3.5 | 2.5 |
| Policy support | 5.5 | 5.0 | 3.0 |
| Market accessibility | 5.0 | 4.5 | 3.4 |
| Supporting infrastructure | 4.0 | 3.7 | 2.0 |
| Demand | 3.7 | 4.0 | 3.0 |
| **Overall average** | **4.6** | **4.3** | **3.0** |

*Illustrative results only. See limitations in section 6.7.

## 7.1 Offshore wind

Offshore wind technology involves the installation of wind turbines in ocean waters, where winds are stronger and more consistent than on land. In this assessment, both fixed and floating offshore wind technologies are collectively considered as part of the offshore wind sector as a whole. Overall, this sector receives a strong overall score of 4.4 out of 6.0, surpassing other sectors included in this study. The market growth potential factor scored a maximum 6.0 points, while profitability scored the lowest, at 3.5. The scores assigned are supported by high-level narratives, drawing on a range of data sources and having undergone a validation process. These narratives are discussed below.

Table 2. Detailed investment readiness scores for offshore wind

| Overall average | Market growth potential | Profitability | Policy support | Market accessibility | Supporting infrastructure | Demand |
|---|---|---|---|---|---|---|
| **4.6** | 6.0 | 3.3 | 5.5 | 5.0 | 4.0 | 3.7 |

*Illustrative results only. See limitations in section 6.7.

**Market growth potential**

We scored the market growth potential for Scottish offshore wind at the highest possible score of 6.0 out of 6.0. The Scottish Government has been clear that wind power is one of the lowest cost forms of electricity and where it is focussing efforts. We expect strong market growth for Scottish offshore wind given Scotland's commitment to reach 8-11GW offshore wind capacity by 2030 (Scottish Government, 2023). This is also supported by the Scottish Government's commitment to invest up to £500 million over five years towards Scotland's offshore wind supply chain through the Strategic Investment Model, with £67 million committed towards the 2024/25 financial year (Offshore Wind Scotland, 2024). Additionally, there is potential for significant additional capacity beyond current ambitions and Scotwind alone could deliver up to 28GW offshore wind by early 2030s (Munro, 2022).

**Profitability**

We assigned a relatively modest profitability score to offshore wind of 3.3 out of 6.0. We are expecting the aggregated profitability to remain close to breakeven level both in the short-term and within the next 5-10 years due to a number of reasons. The offshore wind sector demonstrates a below-average ability to control costs due to surging supply chain and interest rate costs. Additionally, the Scottish offshore wind sector still relies on imports for key components such as turbine blades (Almqvist, et al., 2023). This could expose projects to risk of supply chain bottlenecks as there is an increasing global trend for offshore wind developments (Global Wind Energy Council, 2023). There is a high certainty for the pricing/revenue mechanism as the sector mainly relies on CfDs. However, Scottish wind projects face additional costs compared to other locations in the UK due to transmission losses and Transmission Network Use of System (TNUoS) charges, making price points to be more expensive by 20-30% compared to rest of the UK (based on stakeholder interviews)[6]. Future policy change will bring risks, such as the potential move to Locational Marginal Pricing (LMP) under the ongoing Review of Electricity Market Arrangements (REMA) (Tam & Walker, 2023). This could be a significant change for the sector and is outside the direct control of the Scottish Government as it is not a devolved matter.

**Policy support**

The sector scored highly in terms of level of policy support at 5.5 out of 6.0. There is a well-established regulatory pathway supporting the development of projects from the Crown Estate Scotland leasing rights, through to requirements for CfD eligibility (UK Department for Business and Trade, 2020). The industry enjoys broad political support in Scotland, with major parties (including the current governing party) endorsing its expansion. The Scottish Government's commitment to achieving net-zero emissions by 2045 further solidifies this support (Scottish Government, 2023). The Scottish Government recognizes wind as essential for decarbonising the power sector and the wider economy.

**Market accessibility**

The overall score for market accessibility is relatively high at 5.0 out of 6.0 mainly due to the sector's maturity. Fixed-bottom offshore wind technology has been proven in industry at scale in Scotland, and there is a substantial potential pipeline for floating wind capacity (24.7GW) which could be delivered by 2035 (Offshore Wind Scotland, n.d.). Additionally, this industry is vital for both the power sector and the overall economy. It has a great opportunity for growth in the coming years without becoming oversaturated. Currently, the Scottish offshore wind market has around 16 players comprising of a mix between major players (typically large international companies), consortiums, and local companies (Crown Estate Scotland, 2023).

**Supporting infrastructure**

We assessed the supporting infrastructure for the Scottish offshore wind sector at 4.0 out of 6.0. Scotland has a strong history of producing highly skilled workers for oil and gas, shaped by legacy offshore activities, that supports the capability of wind installation and maintenance workforce (Almqvist, et al., 2023). The Scottish grid infrastructure supports the

[6] TNUoS charges recover the costs of the transmission system. As a result, generators located close to demand centres face lower charges than those located further away, e.g. generators in the north of Scotland located far from large demand centres in the south of England.

integration of offshore wind given the availability of power stations and transmission lines across Scotland. However, challenges related to the grid (such as decreasing headroom availability) and connection delays may emerge with the growing capacity of offshore wind installations. Mitigation plans to upgrade the grid are in place (NGESO, 2022), however, the pace of grid delivery compared to planning applications remains underwhelming. This is evident from the long queue of nearly 400 GW energy projects across the UK as of late 2023 (Ofgem, 2023).

The offshore wind supply chain is relatively well-established, yet risks exist with importing key turbine components and availability of supporting facilities like ports and hubs (Almqvist, et al., 2023). However, we have seen efforts underway to upgrade port facilities to support offshore wind deployment, led by both the Scottish Government (Scottish Renewables, 2023) and private equity (Jones, 2023).

**Demand**

We scored the demand factor for Scottish offshore wind at 3.7 out of 6.0. The power system is changing as we decarbonise. Thermal generation units (such as gas or coal fired power stations) are retiring and being replaced with low-carbon solutions, such as wind or solar which is driving demand for these assets.

Stakeholders noted that whilst the ambition to increase supply of offshore wind is a good indicator of a supportive investment climate, investors would need to consider the offtake of that renewable power. At present, there are well publicised network constraints on transmitting Scottish wind power to England where demand is greater. This has led to times when that power is curtailed / turned down and may act as a concern for future investment in wind power. There is further network investment planned which should alleviate some of these concerns (for example, the B6 boundary - the boundary between Scotland and England – is due to double in capacity).

In the future, hydrogen is expected to be an offtaker for wind-generated electricity instead of curtailment, but this remains uncertain as the hydrogen sector is still developing. Moreover, hydrogen electrolysis will compete with other technology options for using curtailed energy, such as interconnection, battery storage, demand-side response and new pumped hydroelectricity capacity (Hawker & Oakley, 2022).

In stakeholder discussions, investors pointed to the importance of ensuring that there is offtake for that power; whether through transmission lines to England, export to third countries, or greater demand from Scottish industry (such as hydrogen electrolysis).

## 7.2 Onshore wind

Onshore wind technology involves the installation of wind turbines that harnesses wind energy through turbines located on land. This sector receives a strong overall score of 4.3 out of 6.0, sitting marginally behind offshore wind, but ahead of green hydrogen. Market growth potential and policy support scored highly, each scoring a 5.0, while profitability and supporting infrastructure scored the lowest at 3.5 and 3.7, respectively.

Table 3. Detailed investment readiness scores for onshore wind

| Overall average | Market growth potential | Profitability | Policy support | Market accessibility | Supporting infrastructure | Demand |
|---|---|---|---|---|---|---|
| **4.3** | 5.0 | 3.5 | 5.0 | 4.5 | 3.7 | 4.0 |

*Illustrative results only. See limitations in section 6.7.

**Market growth potential**

We scored the market growth potential for Scottish onshore wind at 5.0 out of 6.0. Growth for the Scottish onshore wind sector is supported by national ambitions (Scottish Government, 2023) to increase onshore wind capacity to 20 GW by 2030. This is a positive ambition, but delivery will be impacted by several factors. Stakeholder interviews highlighted that actual growth will depend on the pace of the consenting process by the Scottish Government. Whilst there are various routes to market for onshore wind, including PPAs, the CfD scheme operated by the UK Government will be important.

**Profitability**

Profitability is the lowest scoring factor for onshore wind at 3.5 out of 6.0. Levels of profitability are expected to decrease as the sector becomes even more mature. As domestic competition increases, Scotland's first mover advantage becomes less significant, given less opportunity for greater innovation or learning-by-doing. Onshore wind benefits from consistent global cost reductions due to technological advancement and supply chain maturity. However, the sector may be exposed to supply chain bottlenecks as Scotland is still relying on import for key wind turbine components (Almqvist, et al., 2023). As with offshore wind, there are uncertainties for costs and pricing going forward. While CfD ensures stability for revenue stream and costs for onshore wind, the introduction of LMP (Tam & Walker, 2023) may affect this in the future. Additionally, the existing TNUoS charges will continue to impact the profitability of the onshore wind sector.

**Policy support**

We scored the policy support factor for Scottish onshore wind at 5.0 out of 6.0. There is strong policy support and regulations favouring the onshore wind sector (Scottish Government, 2023). This support is a contrast to the UK Government where onshore wind has had much less favourable support – this has been to the benefit of Scotland as developers look to Scotland as the only viable GB market. Similarly to offshore wind, the onshore wind sector also enjoys broad support from major parties (including the current ruling party) and the public. The Scottish Government's commitment to achieving net zero emissions by 2045 further solidifies this support. However, there is a potential risk stemming from REMA that could significantly impact the market arrangements, for example LMP or other reforms to the CfD mechanism.

**Market accessibility**

We scored the market accessibility factor for Scottish onshore wind at 4.5 out of 6.0. Onshore wind is a mature technology that has been used at scale in Scotland. There is currently 8.8 GW installed onshore wind capacity in Scotland, equal to 60% of the overall UK onshore wind capacity (Kerr, 2023). The technology is considered important to support the power sector and achieving net zero by 2045. There is significant capacity in the pipeline, mostly delivered by several key players (Scottish Renewables, n.d.). This shows that there is competition within the market, but not so much that it is oversaturated. This is a result of market entrance being relatively expensive and requiring long lead times.

**Supporting infrastructure**

We scored the supporting infrastructure factor for Scottish onshore wind at 3.7 out of 6.0. Scotland has a strong record in producing highly skilled workers for the energy sector, albeit within oil and gas. The level of skilled personnel and access to training in the onshore wind sector are slightly limited, which could impact operation going forward. On top of existing connection issues, there are potential risks on grid stability as more onshore wind turbines are installed (NGESO, 2021). As with offshore wind, plans are in place to mitigate these issues (NGESO, 2022), although the pace of progress is still deemed to be a limiting factor. The sector also faces supply chain challenges. Most turbine components are imported and therefore exposed to supply chain bottlenecks (Almqvist, et al., 2023). Some manufacturers have shown their interest in building a turbine manufacturing facility in Scotland; however, no further details have been announced for investment (Emanuel, 2023).

**Demand**

We scored the demand factor for Scottish onshore wind at 4.0 out of 6.0. The levelized cost of electricity using onshore wind is relatively low and provides a competitive advantage over other low-carbon power generation sources such as nuclear or CCGT with carbon capture. Furthermore, over the next 5-10 years, it is expected that prices will decrease as the sector matures further and competition increases (UK Department for Business, Energy and Industrial Strategy, 2020).

Scotland's first mover advantage in onshore wind could result in a new revenue stream from end-of-life services given by the end of the forecast period. End-of-life services include activities such as repowering, decommissioning, or recycling the production capacity after a project's technical or commercial end of life (Almqvist, et al., 2023).

Currently, and as highlighted for offshore wind, generation output is already surplus to demand in Scotland (Scottish Government, 2024), and the sector is potentially exposed to the effects of oversupply as more projects are completed (LCP, 2022). As discussed in the Offshore Wind section, stakeholder discussions identified the importance of ensuring there are offtakers for this low-carbon power, through transmission to England, export opportunities to third countries, or increased demand in Scotland through electrification and potential hydrogen electrolysis.

## 7.3 Hydrogen

For hydrogen, the focus was on the production of green hydrogen through the deployment of electrolyser technology. This sector receives the lowest overall score of 3.0 when compared to the other sectors assessed in this study. Market growth potential scored the highest with 4.0 out of 6.0, supported by potential export opportunities while supporting infrastructure scored the lowest at 2.0.

Table 4. Detailed investment readiness scores for onshore wind

| Overall average | Market growth potential | Profitability | Policy support | Market accessibility | Supporting infrastructure | Demand |
|---|---|---|---|---|---|---|
| **3.0** | 4.0 | 2.5 | 3.0 | 3.4 | 2.0 | 3.0 |

*Illustrative results only. See limitations in section 6.7.

**Market growth potential**

We scored the market growth potential for Scottish green hydrogen production at 4.0 out of 6.0. Green hydrogen is expected to grow in Scotland due to ambitious production capacity targets (Scottish Government, 2022) and recently announced large-scale hydrogen production projects (LCP Delta, n.d.). However, we expect slow market growth within the next 5-10 years as currently there isn't a clear case for large-scale hydrogen use in Scotland. Furthermore, despite Scotland's ambitious hydrogen export target, no exclusive agreements have been made for hydrogen exports with international markets which would provide a demand for the product.

**Profitability**

Profitability for Scottish green hydrogen production scored relatively low at 2.5 out of 6.0. At present, green hydrogen projects rely heavily on government subsidies, meaning that the industry is currently not profitable. However, the aggregate industry level profitability is expected to increase as projects scale up and electrolyser costs decrease (IRENA, 2021). We expect the sector to have poor ability to control costs. This is due to a relatively high supplier power for electrolyser supply and raw materials (for domestic electrolyser production). There is a reasonable level of certainty on the revenue model following the CfDs for hydrogen (Hydrogen Allocation Round 1 [HAR1]) under the Hydrogen Business Model scheme (UK Department for Energy Security and Net Zero, 2023).

**Policy support**

We scored the policy support factor for Scottish green hydrogen production at 3.0 out of 6.0. Green hydrogen is generally well viewed in political discussions given it is potentially a low-carbon solution for multiple sectors. However, there is debate regarding how big a role it will play in a low-carbon economy, given the uncertainties. The Scottish Government has established national targets, action plans and funding to support its development (Scottish Government, 2022). However, some stakeholders may not show their full support due to the potential challenges with hydrogen adoption. For example, facilitating hydrogen use requires significant costs for repurposing existing gas grids and building new infrastructure (LCP Delta, 2023). Furthermore, domestic regulations and incentives are still being developed for green hydrogen in Scotland since the sector is still developing. Currently, the revenue support mechanism for hydrogen is regulated by the UK Government and Scottish

Government has little to no ability to influence this. Additionally, there is a slight shift in the current focus of hydrogen consumption: the UK is focused predominately on domestic consumption, whereas there is a greater focus in Scotland on potential export opportunities. We are expecting further policy and regulatory developments as the sector matures.

**Market accessibility**

We scored the market accessibility factor for Scottish green hydrogen production at 3.4 out of 6.0. There are various types of electrolyser technology with varying TRLs (IRENA, 2021). Green hydrogen will likely be a dominant technology for hydrogen production over the forecast horizon. However, the market is relatively new and risks remain. There are some barriers to entering the market, including scaling up the technology and availability of Engineering, Procurement, and Construction (EPC) contractors. We expect competition to exist in the medium term as these barriers are relatively manageable.

**Supporting infrastructure**

Supporting infrastructure received the lowest score among all factors for Scottish green hydrogen production, with 2.0 out of 6.0. There is currently a limited skills base given the immaturity of the sector (RGU Energy Transition Institute, 2021); however, there is a strong potential for transferable skills from the large oil and gas workforce base in Scotland. A large amount of training is being dedicated to this area but the sector will not benefit greatly in the short term. On the infrastructure side, Scotland will need to upgrade the existing gas grids and build more hydrogen storage to facilitate hydrogen transport. Green hydrogen supply chains are still being developed and may be exposed to external shocks, such as certain countries controlling the supply chain or other geopolitical events (Baringa, 2023). Additionally, there are potential issues from the availability of water sources, as the electrolysis process would need a significant amount of water.

**Demand**

We scored the demand factor for Scottish green hydrogen production at 3.0 out of 6.0. For the short term, green hydrogen may be more expensive compared to other forms of energy. Production costs are expected to decrease over the next five to ten years due to learning and economies of scale. This will bring down Scottish green hydrogen prices to be aligned with European green hydrogen prices (Kerle, Herborn, Prickett, & Ltd, 2024). However, demand for hydrogen in Scotland is expected to be relatively low over the forecast horizon, placing further emphasis on export markets. Ongoing trials for hydrogen use in heating and transport have not progressed to commercialisation. Additionally, Scotland's early-stage plans to export hydrogen into the wider European market may face challenges, including the requirement for new transmission lines and finding an international buyer.

# 8 Conclusions

This report developed a clear definition of 'investment readiness' which we define as: "the position where investors can understand the investment opportunity and develop projects with sound understanding of financial fundamentals and risks based on reasonable projections." This definition has been formed from a literature review, stakeholder engagement, and our own expertise.

When determining whether to invest in a particular sector, investors typically follow a two-stage decision making process, referred to as 'top-down meets bottom-up'. This can be explained as follows:

1. Top-down: Sector level opportunities are screened against the investor's criteria at the macro level.
2. Bottom-up: Individual deal opportunities are assessed in detail to determine an expected return on investment, and the level of risk associated with the project.

To assess investment readiness a wide variety of frameworks have been developed but each has its own limitations. We carefully considered the limitation of key frameworks (Porter's Five Forces, SWOT, and PEST), and when combined with stakeholder validation and LCP's expertise of energy transition sectors and experience working with investors, we developed a framework that uses a scorecard approach. This approach entails assigning numerical scores against selected factors.

Our investment readiness definition is based on the perspective of an investor looking to generate risk-adjusted returns. Investors will look at projects on a case-by-case basis and determine their attractiveness. Where the government can improve the investment readiness of a given energy transition sector, this would encourage capital investment from a wider range of investors, and, likely, at a lower cost of capital.

The Scottish Government will be able to apply this methodology to other sectors to assess the investment readiness of net zero sectors in Scotland. This methodology can be applied to the same sectors periodically to track the progress of net zero sectors as the Scottish Government aims to reach its net zero goals by 2045 from a just transition.

## 8.1 Key findings of the investment readiness of net zero sectors

Market growth potential is strong for the onshore and offshore wind sectors over the forecast horizon, backed by strong policy support. Growth is present for hydrogen, although relatively modest compared to the wind sectors.

The Scottish Government is setting ambitious targets for both offshore and onshore wind with substantial capacity in the pipeline. Actual market growth will depend on both the Scottish and UK Government's support. Green hydrogen has market growth potential supported by production and export targets, and the Hydrogen Business Model (a UK Government revenue support scheme to hydrogen producers to overcome the operating cost gap between low-carbon hydrogen and high-carbon fuels). However, we expect this growth to be lower relative to both wind sectors due to uncertainties around demand.

**Both onshore and offshore wind are mature technologies, resulting in above average score for market accessibility.**

Wind technology is mature and has been proven commercially at scale in Scotland. Going forward, offshore and onshore wind will be crucial for decarbonising the power sector and the broader economy. This forms the basis for the maximum scores in technology readiness and sets it as a dominant technology to deliver electricity to the wider economy. Onshore wind has fewer barriers to entry and more competition than offshore wind due to the sector's maturity, thus slightly lowering its overall market accessibility score relative to offshore wind.

**Green hydrogen is assessed lower than wind since the hydrogen sector is still developing. This brings uncertainties across the various factors, prompting the lower score.**

Scores for policy support, supporting infrastructure, and market growth potential are significantly lower for green hydrogen than wind. Hydrogen is generally well-received, with good political support across the political spectrum although domestic regulation and incentives are still being developed. On supporting infrastructure, the supply chain for hydrogen is still being developed and may be vulnerable to external shocks. There are also risks related to water source availability and how the sector somewhat depends on wind electricity (as green hydrogen is envisioned as a potential offtaker for surplus wind electricity). However, these challenges offer a chance to make informed decisions on the hydrogen market design, including realising potential to export production volumes to mainland Europe, to ensure maximum benefits from the evolving market.

**The profitability levels of the industry for both onshore and offshore wind are relatively low in the short and long term.**

Maturing global supply chains, increased levels of competition and interest rates in the sectors is reducing future profitability. Furthermore, there is a below-average ability to control costs with the sectors relying on imports of key components of turbines. This level of uncertainty directly impacts investment confidence in the sectors. However, it also presents an opportunity to develop the attractiveness of the sectors from decreasing exposure to global supply chains, and by mitigating risks to the erosion of profitability from LMP-REMA and TNUoS charges.

**Uncertainty on LMP-REMA could be a significant barrier to investment in offshore wind, onshore wind and green hydrogen.**

Various stakeholders highlighted this point for all sectors. However, the exact effect remains uncertain, particularly given the delay in the REMA process (Paul, 2024). The Scottish Government has published key plans and strategy for upscaling all three sectors, but long-term uncertainty remains from the UK Government on the future policy landscape.

**Supporting infrastructure scored poorly relative to each sectors' overall scores. This presents an opportunity to largely improve investment readiness in the three sectors analysed as sectors continue to scale.**

Scotland has a large base of skilled workforce and potential to upskill existing oil and gas workers. However, stakeholders highlighted potential funding gaps for skills and development across all sectors (particularly for hydrogen). Furthermore, engagement highlighted that existing electricity grids require significant upgrades to integrate increased wind capacity going forward. Plans are in place for grid reinforcements but progress to resolve this has been slow. Additionally, stakeholders noted that planning applications for wind developments are long-winded and may delay progress.

For green hydrogen, where supply chains are developing, there is an opportunity to significantly upgrade infrastructure (existing gas grids, new transmission lines and storage facilities) to support increasing green hydrogen production capacity for domestic use, as well as exports.

Supply chain issues exist for all sectors due to reliance on import, as faced by the rest of the economy. Yet, when combined with the evident market growth potential, this provides an opportunity to expand domestic manufacturing, which could turn into a new revenue stream.

**Stakeholders noted that whilst the ambition to increase supply of wind is a good indicator of a supportive investment climate, investors would need to consider the offtake of that renewable power.**

The future power system is changing as we decarbonise. Thermal generation units (such as gas or coal fired power stations) are retiring and being replaced with low-carbon solutions, such as wind or solar, which is driving demand for these assets. At present, there are well publicised network constraints on transmitting Scottish wind power to England where demand is greater. This has led to times when that power is curtailed / turned down and may act as a concern for future investment in wind power(Scottish Government, 2024). Stakeholder discussions pointed to the importance of ensuring that there is offtake for low-carbon wind power; whether through transmission lines to England, export to third countries, or greater demand from Scottish industry, such as hydrogen electrolysis (Hedley, 2024; Hunter, 2024).

# 9 References


Almqvist, M., Parker, R., O'Gorman, S., Pritchard, A., Jones, A., Nyström, S., & Ltd, R. U. (2023). *Assessment of the structure, conduct and.* Edinburgh: Climate XChange.

Baburaj, Y., & Narayanan, V. K. (2016). *Five Forces Framework.*

Baringa. (2023, September). *The geopolitics of hydrogen - navigating the new world order.* Retrieved from https://www.baringa.com/globalassets/insights/low-carbon-futures/the-geopolitics-of-hydrogen/geopolitics_of_hydrogen_part_2.pdf

Capital Dynamics. (2023, October 31). *Sainsbury's signs PPA with Capital Dynamics' Longhill Burn Wind Farm in Scotland*. Retrieved from Press Releases: https://www.capdyn.com/news/sainsburys-signs-ppa-with-capital-dynamics-longhill-burn-wind-farm-in-scotland/

Crown Estate Scotland. (2023, July 13). *ScotWind Leasing Supply Chain Development*. Retrieved from Crown Estate Scotland: https://www.crownestatescotland.com/news/scotwind-leasing-supply-chain-development-statements-updated

Crown Estate Scotland. (n.d.). *Our role in offshore wind*. Retrieved from https://www.crownestatescotland.com/scotlands-property/offshore-wind/our-role-in-offshore-wind

Crown Estate Scotland. (n.d.). *ScotWind leasing round*. Retrieved from https://www.crownestatescotland.com/scotlands-property/offshore-wind/scotwind-leasing-round

Dälken, F. (2014). *Are Porter's Five Competitive Forces still Applicable? A Critical Examination concerning the Relevance for Today's Business.* Retrieved from University of Twente - Student Theses: https://essay.utwente.nl/65339/

Dulčić, Ž., Gnjidić, V., & Alfirević, N. (2012). From Five Competitive Forces to Five Collaborative Forces: Revised View on Industry Structure-firm Interrelationship. *Procedia - Social and Behavioral Sciences*, 1077-1084.

Emanuel, C. (2023, November 17). *Vestas plans Scottish turbine factory*. Retrieved from TGS 4C Offshore: https://www.4coffshore.com/news/vestas-plans-scottish-turbine-factory-nid28268.html

Fellnhofer, K. (2016). Literature Review: Investment Readiness Level of Small and Medium Sized Companies. *International Journal of Managerial and Financial Accounting*.

Global Wind Energy Council. (2023). *GLOBAL OFFSHORE WIND REPORT 2023.* Brussels: Global Wind Energy Council.

Goyal, A. (2021). A Critical Analysis of Porter's 5 Forces Model of Competitive Advantage. SSRN.

Gregory, D., Hill, K., & Keen, S. (2012, July). *Investment Readiness in the UK.* Retrieved from TNL Community Fund: https://www.tnlcommunityfund.org.uk/media/research-documents/social-investment/er_invest_ready.pdf?mtime=20190215124536

Hawker, G., & Oakley, G. (2022, November). *The potential for hydrogen to reduce curtailment of renewable energy in Scotland.* Retrieved from CXC: https://www.climatexchange.org.uk/media/5627/the-potential-for-hydrogen-to-reduce-curtailment-of-renewable-energy-in-scotland-jan-23.pdf

Huppé, G. A. (2014, July 24). *Building Impact Investment Readiness.* Retrieved from Stanford Social Innovation Review: https://ssir.org/articles/entry/building_impact_investment_readiness#

IRENA. (2021, March 23). *Hydrogen series – Part 2: Scaling up Electrolysers.* Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Events/2020/Jun/IRENA-Insights/Part-2-Green-Hydrogen-Cost-Reduction/IRENA-Insights---Electrolyzer-report-webinar.pdf?la=en&hash=DAA78A2CD061F4894EA5F62E43FC209996308F21

IRENA. (2021). *Making the breakthrough: Green hydrogen policies and technology costs.* Abu Dhabi: IRENA.

Jones, F. (2023, April 24). *Scottish port acquires $374m in private equity for wind power development.* Retrieved from Power Technology: https://www.power-technology.com/news/scottish-port-acquires-374m-for-wind-power-development/?cf-view

Kerle, F., Herborn, M., Prickett, S., & Ltd, O. A. (2024, January). *Cost reduction pathways of green hydrogen production in Scotland - total costs and international comparisons.* Retrieved from https://www.climatexchange.org.uk/research/projects/green-hydrogen-production-and-international-competitiveness/

Kerr, N. (2023, April 26). *Wind energy in Scotland: current position and future plans.* Retrieved from The Scottish Parliament - SPICe Spotlight | Solas air SPICe: https://spice-spotlight.scot/2023/04/26/wind-energy-in-scotland-current-position-and-future-plans/#:~:text=Currently%2C%20Scotland%20has%208.8GW,capacity%20was%2077GW%20in%202021.https://spice-spotlight.scot/2023/04/26/wind-energy-in-scotland-current-posi

LCP. (2022, May). *Renewable curtailment and the role of long duration storage.* Retrieved from Drax: https://www.drax.com/wp-content/uploads/2022/06/Drax-LCP-Renewable-curtailment-report-1.pdf

LCP Delta. (2023, August 22). *Heating homes in different regions of Great Britain.* Retrieved from Citizens Advice: https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/Locational%20costs%20of%20heat%20technologies%20in%20Great%20Britain%20-%20FINAL%20REPORT.pdf

LCP Delta. (n.d.). *HYbase-Hydrogen Intelligence Service*. Retrieved from https://delta.lcp.com/research-services/hydrogen-intelligence-service/

Mason, C., & Kwok, J. (2014). *Discussion Paper on Investment Readiness Programmes.* Retrieved from OECD: https://www.oecd.org/global-relations/45324336.pdf

Mooney, A. (2023, June 11). *Gridlock: how a lack of power lines will delay the age of renewables*. Retrieved from Financial Times: https://www.ft.com/content/a3be0c1a-15df-4970-810a-8b958608ca0f

Moray West Offshore Wind Farm. (n.d.). *Developing the Moray West wind farm*. Retrieved from Moray West Offshore Wind Farm: https://www.moraywest.com/about-us/project

Munro, M. (2022, November). *The Bank and ScotWind: Working with Developers to Maximise Scottish Impact & Embed the Energy Transition.* Retrieved from The Scottish National Investment Bank: https://www.thebank.scot/sites/default/files/2022-11/scotwind-blog-2.pdf

Net Zero Technology Centre. (n.d.). *Hydrogen Backbone Link: Connecting Scotland to Europe.* Retrieved from https://www.netzerotc.com/reports/hydrogen-backbone-link-report/

NGESO. (2021). *How do we balance the grid?* Retrieved from ESO: https://www.nationalgrideso.com/electricity-explained/how-do-we-balance-grid/what-inertia

NGESO. (2022, July). *The Pathway to 2030 Holistic Network Design.* Retrieved from Future energy: https://www.nationalgrideso.com/document/262676/download

NGESO. (2023, July). *Future Energy Scenarios.* Retrieved from https://www.nationalgrideso.com/document/283101/download

Offshore Wind Scotland. (2024, February 20). *Strategic Investment Model Stage 2 projects announced*. Retrieved from https://www.offshorewindscotland.org.uk/news/2024/february/20/sim-projects-published-highlighting-offshore-wind-sector-priorities-for-supply-chain-and-infrastructure/

Offshore Wind Scotland. (n.d.). *Offshore Wind Scotland - What's happening and where?* Retrieved from https://www.offshorewindscotland.org.uk/#:~:text=All%20of%20the%20above%20puts,all%20potentially%20deliverable%20before%202035.

Ofgem. (2023, November 13). *Ofgem announces tough new policy to clear 'zombie projects' and cut waiting time for energy grid connection*. Retrieved from Ofgem - Press release: https://www.ofgem.gov.uk/publications/ofgem-announces-tough-new-policy-clear-zombie-projects-and-cut-waiting-time-energy-grid-connection

Paul, K. (2024, January 8). *Looming election delays UK power market reform - analysts*. Retrieved from Montel: https://www.montelnews.com/news/1534725/looming-election-delays-uk-power-market-reform--analysts

RenewableUK. (2022, February 22). *New poll shows majority of Scottish voters support building more onshore wind*. Retrieved from News & Publications: Press Releases: https://www.renewableuk.com/news/596321/New-poll-shows-majority-of-Scottish-voters-support-building-more-onshore-wind.htm

RGU Energy Transition Institute. (2021, May). *Robert Gordon University.* Retrieved from UK Offshore Energy Workforce Transferability Review: https://www.rgueti.com/wp-content/uploads/2021/05/workforce-transferability-report.pdf

Scottish Development International. (2023, July 5). *Green hydrogen: assessing the fuel economics and Scotland's advantages.* Retrieved from https://www.sdi.co.uk/news/green-hydrogen-assessing-the-fuel-economics-and-scotlands-advantages

Scottish Government. (2022, September 2023). *Assessment of Electrolysers - Final Report.* Retrieved from https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2022/10/assessment-electrolysers-report/documents/assessment-electrolysers-final-report/assessment-electrolysers-final-report/govscot%3Adocument/assessment-electrol

Scottish Government. (2022, October 13). *Assessment of electrolysers: report*. Retrieved from https://www.gov.scot/publications/assessment-electrolysers-report/pages/4/

Scottish Government. (2022, December). *Hydrogen Action Plan.* Retrieved from Hydrogen Action Plan: https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2022/12/hydrogen-action-plan/documents/hydrogen-action-plan/hydrogen-action-plan/govscot%3Adocument/hydrogen-action-plan.pdf

Scottish Government. (2022, December 21). *Onshore wind policy statement 2022*. Retrieved from https://www.gov.scot/publications/onshore-wind-policy-statement-2022/pages/6/

Scottish Government. (2022, February 22). *Sectoral Marine Plan - Offshore wind for innovation and targeted oil and gas decarbonisation: initial plan framework.* Retrieved from https://www.gov.scot/publications/initial-plan-framework-sectoral-marine-plan-offshore-wind-innovation-targeted-oil-gas-decarbonisation-intog/

Scottish Government. (2023, January). *Draft Energy Strategy and Just Transition Plan.* Retrieved from https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2023/01/draft-energy-strategy-transition-plan/documents/draft-energy-strategy-transition-plan/draft-energy-strategy-transition-plan/govscot%3Adocument/draft-energy-strategy

Scottish Government. (2023, February 13). *National Planning Framework 4.* Retrieved from https://www.gov.scot/publications/national-planning-framework-4/documents/

Scottish Government. (2023, September 21). *Onshore wind sector deal.* Retrieved from https://www.gov.scot/publications/onshore-wind-sector-deal-scotland/

Scottish Government. (2023, January 10). Scotland's Energy Strategy and Just Transition Plan: Ministerial statement. Edinburgh, Scotland.

Scottish Government. (2023, December). *Sectoral Marine Plan for Offshore Wind - EIR.* Retrieved from https://www.gov.scot/binaries/content/documents/govscot/publications/foi-eir-release/2023/12/sectoral-marine-plan-for-offshore-wind-energy-eir-release/documents/eir---202200331120---information-release-part-2/eir---202200331120---information-release-part-

Scottish Government. (2023, November 14). *Update on Scotland’s renewables and wind power potential*. Retrieved from https://www.gov.scot/publications/renewables-and-wind-power-update-to-scottish-affairs-committee/#:~:text=For%20offshore%20wind%20specifically%2C%20capacity,total%20installed%20offshore%20wind%20capacity

Scottish Renewables. (2023, December 18). *Letter to the Scottish Parliament - Just Transition for the North East and Moray Inquiry - Planning and Consenting.* Retrieved from Members of Economy and Fair Work Committee - The Scottish Parliament: https://www.parliament.scot/-/media/files/committees/economy-and-fair-work-committee/annex/scottish-renewables.pdf

Scottish Renewables. (n.d.). *Statistics*. Retrieved from Scottish Renewables: https://www.scottishrenewables.com/our-industry/statistics

SGN. (n.d.). *H100 Fife*. Retrieved from https://www.h100fife.co.uk/

Tam, B., & Walker, A. (2023, May 2). *POSTnote 694 - Electricity Market Reform.* Retrieved from UK Parliament POST: https://researchbriefings.files.parliament.uk/documents/POST-PN-0694/POST-PN-0694.pdf

Thomas-Peter, H. (2023, April 5). *'Damning' report calls for major National Grid changes to prevent UK missing key wind power targets*. Retrieved from Sky News - UK: https://news.sky.com/story/damning-report-calls-for-major-national-grid-changes-to-prevent-uk-missing-key-wind-power-targets-12850663

Twidale, S. (2023, November 16). *Britain to boost offshore wind auction power price guarantees by 66%*. Retrieved from Reuters:

https://www.reuters.com/sustainability/climate-energy/britain-boost-offshore-wind-auction-power-price-guarantees-by-66-2023-11-16/

UK Department for Business and Trade. (2020, March 4). *Policy paper - Offshore wind Sector Deal.* Retrieved from GOV.UK: https://www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal

UK Department for Business, Energy and Industrial Strategy. (2021, August). *Hydrogen Production Costs.* Retrieved from https://assets.publishing.service.gov.uk/media/611b710e8fa8f53dc994e59d/Hydrogen_Production_Costs_2021.pdf

UK Department for Energy and Climate Change. (2014, November). *Urban Community Energy Fund – Getting your project 'investment ready'.* Retrieved from https://assets.publishing.service.gov.uk/media/5a7de55de5274a2e87dae369/intro_to_investment.pdf

UK Department for Energy Security and Net Zero. (2023, December 14). Retrieved from Hydrogen Production Business Model / Net Zero Hydrogen Fund: HAR1 successful projects (published December 2023): https://www.gov.uk/government/publications/hydrogen-production-business-model-net-zero-hydrogen-fund-shortlisted-projects/hydrogen-production-business-model-net-zero-hydrogen-fund-har1-successful-projects

UK Department for Energy Security and Net Zero. (2023, September). *Government Response to the Call for Evidence on introducing non-price factorsinto the Contracts for Difference Scheme.* Retrieved from https://assets.publishing.service.gov.uk/media/64f9c596a78c5f00142657f9/cfd-scheme-non-price-factors-cfe-government-response.pdf

UK Department for Energy Security and Net Zero. (2024, January 22). *Hydrogen Allocation Round 2*. Retrieved from https://www.gov.uk/government/publications/hydrogen-allocation-round-2

UK Department for Energy Security and Net Zero. (2024, March 12). *Review of electricity market arrangements (REMA): second consultation*. Retrieved from https://www.gov.uk/government/consultations/review-of-electricity-market-arrangements-rema-second-consultation

# 10 Appendices

## Appendix A – Investment readiness definition literature

We carried out a literature review to gather broad definitions of investment readiness to test whether our working internal definition was applicable or needed refinements.

We broadly found that other definitions of investment readiness aligned with our definition. Common themes included in definitions include a requirement for sufficient publicly available information to assess and understand an opportunity. Furthermore, there is a requirement for projects to meet investment parameters for investors (i.e., the criteria or factors that investors consider when evaluating potential investment opportunities).

Table 5. Literature supporting the investment readiness definition

| Paper | Context | Definition/explanation |
|---|---|---|
| **High relevance to study** | | |
| OECD discussion paper on investment readiness programmes<br><br>(Mason & Kwok, 2014) | This paper discusses the case for Small and Medium Enterprises (SMEs) attracting finance. | Key aspects of the OECD's definition of investment readiness include the need for a credible business plan, reasonable financial projections, and a strong management team. |
| Building Impact Investment Readiness<br><br>(Huppé, 2014) | This paper discusses the scaling up of institutional investment in impact strategies. | The concept of investment readiness is defined here as the capacity of an enterprise to understand and meet the specific needs and expectations of investors. At the national or regional level, the definition is expanded to consider the size of the pipeline of investment-ready enterprises. |
| Urban Community Energy Fund – Getting your project 'investment ready'<br><br>(UK Department for Energy and Climate Change, 2014) | This is applicable for energy infrastructure. | One of the definitions for investment readiness is "when a project is at the right stage to secure a bank loan or other investment such as shares that will cover the costs of constructing the project." |
| **Lower relevance to study** | | |
| Literature Review: Investment Readiness Level of Small and Medium Sized Companies | Literature review of investment readiness for SMEs | Multiple definitions are provided, such as "the capability of entrepreneurs or SME's managers to be aware of the precise needs of investors and to be able to reply through adequate information and preparation." |

| Paper | Context | Definition/explanation |
|---|---|---|
| (Fellnhofer, 2016) | | |
| Investment Readiness in the UK<br><br>(Gregory, Hill, & Keen, 2012) | Investment readiness of the Voluntary, Community and Social Enterprise (VCSE) sector in the UK | Investment readiness is defined as "an investee being perceived to possess the attributes, which makes them an investible proposition by an appropriate investor for the finance they are seeking". |
| Investment Guide: Investment Readiness<br><br>(Energy Catalyst, 2020) | Report providing guidance for businesses looking to raise external funding | Investment readiness is defined as "the capacity of an enterprise to understand and meet the specific needs and expectations of investors". |

With regards to the specifics of definitions, it is important to consider the context and purposes of each one. For example, in the papers listed in the table above, whilst investment readiness for SMEs provides useful information regarding the ability to generate reasonable financial projections (which also applies at the sector level), the strength of a management team is less applicable when analysing a sector as a whole.

Regarding *Urban Community Energy Fund – Getting your project 'investment ready'*, we note that securing a bank loan (or other investment) generally would require the presentation of detailed financial fundamentals and the development of reasonable projections. Given that energy transition sectors are relatively new, a key challenge is to build confidence in these fundamentals and projections. It is important that investors have enough available data to be able to assess these points.

**Literature review of Porter's Five Forces**

Table 6. Literature review of Porter's Five Forces

| Paper | Key findings |
|---|---|
| A Critical Analysis of Porter's 5 Forces Model of Competitive Advantage<br><br>(Goyal, 2021) | The author notes that Porter's Five Forces is an "incredible model". It is very inter-linkable with other models such as PEST (outlined in Section 5.1.2). The model correctly emphasizes the importance of searching for imperfect markets which create opportunities for supernormal profits.<br><br>The author notes that governments can have major consequences on the profitability of businesses and that this is not currently reflected in the model. Another criticism noted is that the model is static – capturing an industry at a single point in time, whilst markets are highly dynamic. |
| Are Porter's Five Competitive Forces still | The author introduces Porter's Five Forces as a powerful tool with much support but notes that it has also been criticized as being outdated due to |

| Paper | Key findings |
| --- | --- |
| Applicable? A Critical Examination concerning the Relevance for Today's Business.<br><br>(Dälken, 2014) | new market dynamics such as digitalization, globalization, and deregulation.<br><br>After examining the relevance of the model in today's business environment, the author concludes that the framework still has relevance and that it cannot be considered as wholly outdated. However, the author notes that including additional external forces such as digitalization, globalization, and deregulation does indeed help to enhance the model. |
| From Five Competitive Forces to Five Collaborative Forces: Revised View on Industry Structure-firm Interrelationship<br><br>(Dulčić, Gnjidić, & Alfirević, 2012) | The author notes that there is no doubt that Porter's framework is a helpful tool to better understand an industry. However, the author notes that the model is static and proposes the addition of time dynamics (i.e., timescales). The author notes that that initial empirical evidence from its study suggest that adding time dynamics is indeed useful. |
| Five Forces Framework<br><br>(Baburaj & Narayanan, 2016) | The authors explain that the five forces framework has been highly influential in strategy literature. However, there are two key limitations: an assumption of stability in the structural characteristics in markets (i.e., a lack of a time dimension), and that the framework is best suited for industry analysis in developed economies (rather than developing economies). |

## Appendix B – approach to developing a framework

Our own framework to assess investment readiness is based on:

- our expertise of the nature of energy transition sectors,
- many years' experience working in these sectors,
- stakeholder engagement with investors (discussed further in this section), and
- relevant academic literature (as above).

On basis of these considerations, we developed an investment readiness framework in the form of a scorecard approach. This is composed of a series of factors and sub-factors that are most important to investors in an energy transition sector scored from 1 (lowest) to 6 (highest). Sub-factor scores are aggregated to the factor level using equal weighting. Factors are aggregated to the overall sector level using equal weighting.

There are four key considerations when developing this framework, these are described below.

**Factors for inclusion**

We set out the factors to be included in the scorecard in Section 6. Below, we provide a mapping of Porter's Five Forces and other components (such as elements of PEST) to the final scorecard factors in the table below.

Table 7. Mapping Porter's Five Forces to our scorecard

| Factor | Relationship to Porter's Five Forces |
|---|---|
| Market growth potential | Literature critique of Porter's Five Forces noting that a time dimension should be included. |
| Profitability | Derivations of powers of suppliers and competitive rivalry. |
| Policy support | Literature critique of Porter's Five Forces noting that relevant external forces should be considered, and that elements of PEST can be combined with the model. |
| Market accessibility | Derivations of threat of new entry and competitive rivalry. |
| Supporting infrastructure | It is crucial for infrastructure investments to be highly connected with other areas of the economy to be profitable. |
| Demand | Derivations of power of buyers and threat of substitutes |

Academic literature provides strong validation for the factors provided, which are based on Porter's Five Forces and PEST, with further enhancements where literature and stakeholder engagement indicate limitations. Our solutions to overcoming such limitations are outlined in Table 8.

Table 8. Addressing model limitations

| **Limitation** | **Solution** |
|---|---|
| Literature notes that Porter's Five Forces is static in nature - representing an industry at a particular point in time. | Given the considerable growth required in the energy transition space, we address this limitation by adding the "Market Growth Potential" factor. Further, we note that many of the sub-factors are to be assessed over a 5-10 year horizon, rather than a single point in time. |
| Literature notes that Porter's Five Forces does not directly account for external forces such as those in PEST Analysis. | Whilst some PEST factors indirectly affect the Porter's Five Forces, we introduce an additional "Policy Support" factor, given the heavy reliance of the energy transition on a favourable policy environment. |
| Infrastructure investments typically require large scale development and to be profitable must be highly connected with other areas of the economy. Porter's Five Forces does not directly account for this. | To account for this feature of infrastructure investing, we have added a "Supporting Infrastructure" factor. |
| Many energy transition sectors are relatively new. As highlighted in our stakeholder engagement, many core infrastructure investment managers will only invest in energy transition technologies that are well proven and ready to be scaled at a commercial level. | We add a "Technology Readiness" sub-factor within the "Market Accessibility" factor to allow for the assessment of technological maturity. |

The factors in the investment readiness scorecard, outlined in Section 6, were very well supported by discussions with investment managers. Each factor had been referred to either directly or indirectly across the meetings.

Of the investors we spoke to, a number accessed energy transition assets through a core infrastructure style of investing. In this approach, there is a strong emphasis on risk management by accessing stable, contracted revenues. Investment managers generally favour long term contracts of 10 to 15 years that include explicit inflation linkage, with counterparties that are financially sound (whether they are private or public institutions). Contracted revenues such as these are more often accessed in electricity generation sectors (as opposed to energy storage or network sectors, for example).

Infrastructure style investors also note technology maturity as a consideration. Some investment managers only invest in proven technologies that are ready for wider commercial adoption, rather than investing in early stage or unproven technologies. One investment manager noted that one of their funds would generally not invest in any technology lower than level 8 on the Technology Readiness Levels (TRL) scale. The maturity of technology was also referenced through our engagement with key stakeholders from the Scottish Government, with specific reference linking this to the TRL scale.

More generally, stakeholder engagement identified the need to consider the demand for the product or service the sector produces in relation to the market potential. This considers the potential imbalance of supply and demand for the product or service which ultimately can challenge potential market growth. Therefore, despite strong market growth potential, a lack of demand may pose a challenge to market expansion and operability of existing assets.

**Qualitative versus quantitative scoring**

There are merits of both quantitative and qualitative scoring systems, but for reasons outlined here we decided to use a qualitative system. The scoring framework needs to work for a variety of energy sectors, which would make quantification challenging. For example, the scale applied to the market size of EV adoption would be very different to that of onshore wind and there will be different units of measurements between sectors. This is a key reason for the approach taken to use a qualitative scale scoring system (see Section 6).

Further, in order to take a quantitative approach to setting scores for each factor, a prerequisite is the existence of frequent, up to date, and reliable data upon which to base the scoring. This data would be used in a quantitative model that incorporates back testing and statistical proof to ensure that a given factor is appropriate for the model. However, energy transition sectors are relatively new and largely consist of private assets, which have lower data reporting requirements than publicly listed companies. Therefore, there is a generally a lack of high frequency, high quality data in the energy transition space. As a result, qualitative scoring is the only viable and appropriate method that can be used. Where quantitative data is available, we provide guidance on how this can be used to generate consistent outcomes.[7]

**Factor weighting versus unweighted**

Based on LCP's extensive experience and stakeholder engagement, weightings for models may appear to be an intuitively attractive element as people, by nature, often have a high-level innate sense of what is more important in a decision. However, as factors become more granular, this sense is less reliable, making a weighting system fraught. In a high data frequency environment, weightings can be derived statistically, but these must be kept under constant review as to their continued effectiveness. Given that we do not have

[7] The qualitative information that was used in the assessment of the three example sectors was evaluated using LCP Delta's expertise in energy markets.

quantitative data, or any method of empirically testing the appropriateness of weightings, we decided to leave the factors and sub factors unweighted.

Further, we note that the weight placed on any given factor would depend on the opportunity or sector being assessed, as opposed to a sector level assessment. This is supported by the stakeholder engagement we completed. We aim to provide a framework that is broad such that it can be applied to various sectors, and as such we believe that not applying a weighting is most prudent for the framework.

**Numerical scoring versus Red Amber Green (RAG) rating**

This is generally a lower order decision and one of preference. RAG ratings can be intuitively and visually attractive but are limited by the effective three colour ‘score’. Conversely, scoring using a high number for a maximum rating can lead to too much debate and time spent on nuances that do not affect real-world outcomes.

We decided to use a numerical scoring from 1 (worst) to 6 (best) for each factor, which allows sufficient distinction to be made between the attractiveness of energy transition sectors, whilst avoiding unnecessary complexity.

## Appendix C – Technology Readiness Levels

Technology Readiness Levels (TRLs) are a method for estimating the maturity of technologies. They enable consistent and uniform discussions of technical maturity across different types of technology. TRLs are used in our methodology for assessing net zero sectors to distinguish between sectors that are reliant on well-established technologies, compared to technologies which are newly emerging and less proven, which therefore may introduce more risk[8]. The TRLs can be defined as:

Table 9. Technology readiness level categorisation

| Technology Readiness Level | Description |
|---|---|
| TRL 9 | Actual system proven in its operational environment (competitive manufacturing in the case of key enabling technologies). |
| TRL 8 | Active Commissioning: The technology has been proven to work in its final form and under expected conditions. Qualified for full-scale manufacturing but may require minor changes or improvements to the manufacturing process. |
| TRL 7 | Inactive Commissioning: The technology has been proven to work in its final form and under expected conditions. However, it has not been qualified for routine use. |
| TRL 6 | Large Scale: The technology is proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. |
| TRL 5 | Pilot Scale: The basic components of the technology are integrated with reasonably realistic supporting elements. This is high-level technology readiness. |
| TRL 4 | Bench Scale: Basic components of the technology are integrated to establish that they will work together. This is relatively low-level technology readiness. |
| TRL 3 | Proof of Concept: Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. |

[8]More information on TRLs can be found here: Guide to Technology Readiness Levels for the NDA Estate and its Supply Chain (publishing.service.gov.uk)

| Technology Readiness Level | Description |
|---|---|
| TRL 2 | Invention and Research: Applied research begins to be translated into practical application. Theoretical applications are developed and applied through analytical and laboratory studies. |
| TRL 1 | Basic principles: Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties. |

# Appendix D – Stakeholder engagement methodology

A key consideration for this project was to validate the methodology and sector assessments with stakeholders. This included engaging key stakeholders for the Scottish Government, investment managers, as well as asset owners and industry experts in the three net zero energy production sectors. We completed this by splitting stakeholder engagement into three groups based on the stakeholder type. The objective of the engagement with each stakeholder group differed depending on their expertise. The split of stakeholders engagement by type and objectives are:

1. **Gaining feedback on the objectives and approach taken to complete the research.** This involved the Scottish Futures Trust, and the three Scottish enterprise agencies who were engaged in a single round table. The meeting objective was to inform them of the research and ultimately gain feedback on the approach, methodology, and the key considerations for each sector that was assessed. Follow-up meetings were arranged with Scottish Enterprise to discuss the project in more detail.
2. **Investment process discussions.** This included the Scottish National Investment Bank (two meetings) and two investment managers we identified. Each stakeholder was engaged individually to discuss their investment process, the key factors considered for investments, and any emphasis on individual factors or sub-factors.
3. **Key factors that are considered for investments.** All remaining stakeholder groups: Scottish asset owners, industry experts and the Scottish Government energy sector teams were engaged to discuss the key factors considered for investments in each area. All stakeholders were engaged individually, with exception to the Scottish Government policy teams. The policy teams were engaged in a single roundtable to discuss their respective sectors. These interactions helped validate the methodology presented in this report. Additionally, the sector assessments and key challenges in each of the sectors was discussed with the stakeholders.

The below table summarises the stakeholder engagement we completed:

Table 10. Stakeholder engagement overview

| Aim of engagement | Stakeholder(s) engaged | Status of engagement |
|---|---|---|
| 1. Feedback on objectives and approach | Scottish Futures Trust, Scottish Enterprise, South of Scotland Enterprise, Highlands and Islands Enterprise | Round table completed 09/01/2024.<br>Follow-up meeting completed with Scottish Enterprise 30/01/2024. |
| 2. Investment process discussions | SNIB (Scottish National Investment Bank), and two other investment managers selected by us | SNIB meetings completed 20/12/2023 and 16/01/2024. Investment manager calls |

| Aim of engagement | Stakeholder(s) engaged | Status of engagement |
|---|---|---|
| | | completed during December 2023. |
| 3. Key factors considered for investment | Scottish Government energy policy teams for hydrogen, onshore wind and, offshore wind, three industry experts / asset owners in the three energy sectors | Round table for Scottish Government policy teams completed 09/01/2024.<br>3 separate calls completed for industry experts / asset owners during December 2023 and January 2024. |

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