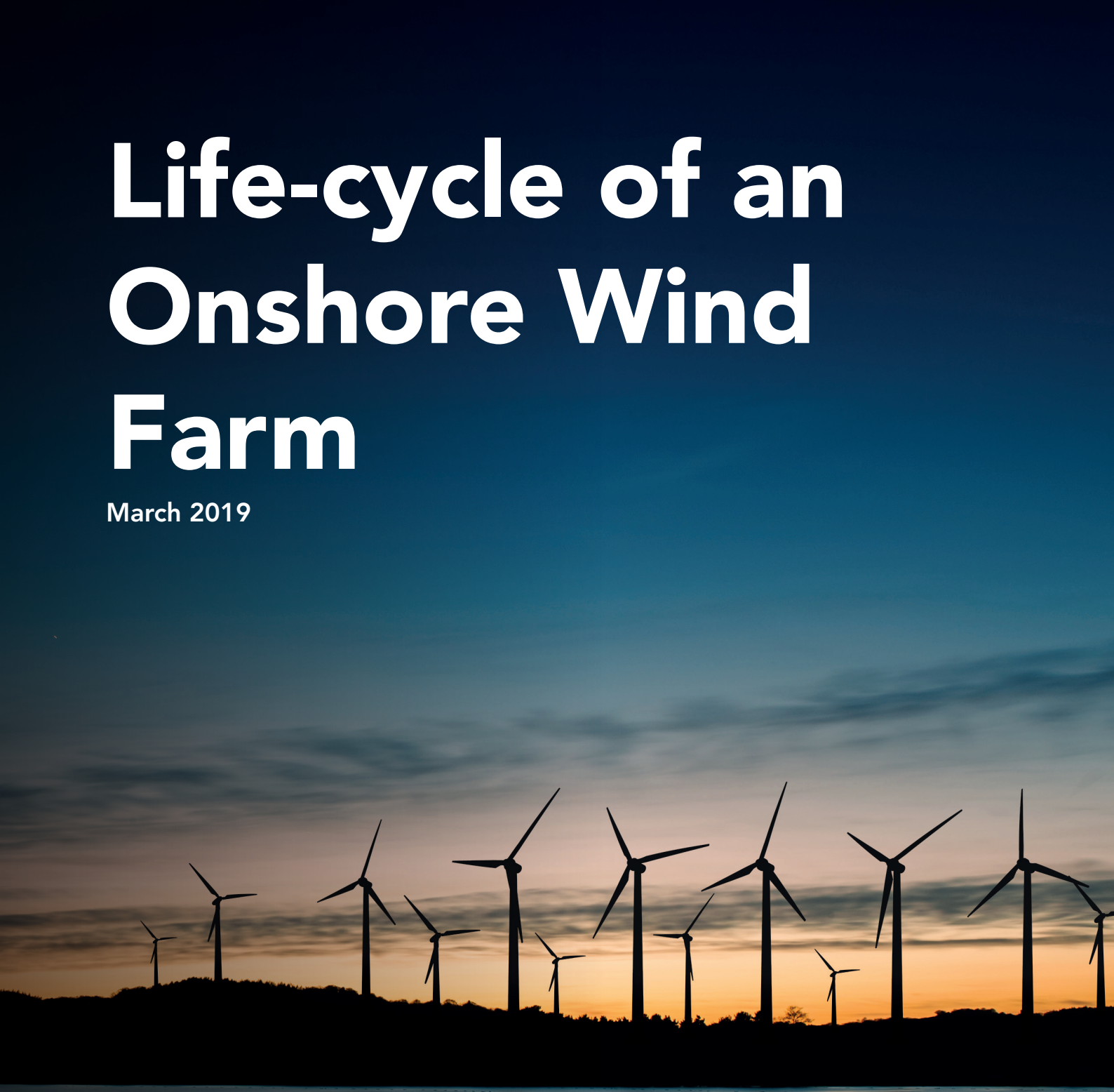
Life-cycle of an Onshore Wind Farm

March 2019



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Glossary

AER	Alternative Energy Requirement scheme; the original auction-based support scheme for renewable energy projects in the Republic of Ireland
CRU	Commission for Regulation of Utilities (formerly Commission for Energy Regulation)
ECP 1	Enduring Connection Policy (1); a revised process for applying for and processing applications to connect to the electricity system introduced in 2018
EirGrid	Electrical Transmission System Operator (TSO)
ESBN	ESB Networks; electrical Distribution System Operator (DSO)
PPA	Power Purchase Agreement; an agreement with a company who supplies electricity to consumers (domestic, commercial) to purchase the electricity produced by the wind farm
REFIT 2	The second scheme under the Renewable Energy Feed in Tariff regime – a mechanism for providing a fixed energy price to support renewable energy projects
RESS	Renewable Electricity Support Scheme; auction-based support scheme expected to be introduced in late 2019 to support renewable energy projects through a series of auctions to be held over the next 10 years
SCADA	Supervisory Control and Data Acquisition; computerised monitoring system used for monitoring a wind farm and individual wind turbines

1. Introduction

This report briefly describes the life-cycle of an onshore wind farm from conception through to end of life decommissioning. It separates the wind farm's life-cycle into various stages and broadly describes the main activities and parties involved in each stage. It is intended only as an approximate guideline to give a basic understanding of the life-cycle and the process will vary because every project is unique.

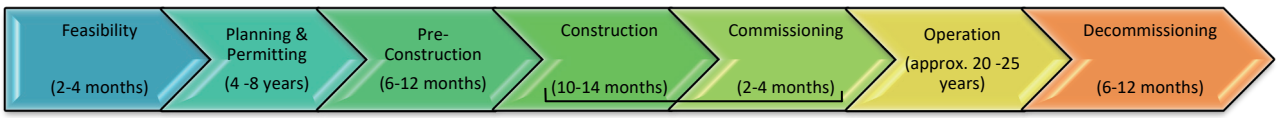
1.1 Structure of report

The report has a section on each significant stage of a wind farm's life-cycle. In practice these stages overlap and interact, and vary over time, and a project can be at more than one stage at any given point in time, but the majority of wind farms proceed in a logical fashion through each stage. Each section describes the activities typically involved at that stage, and who could carry out these activities.

1.2 Wind Farm life-cycle stages

The life-cycle of a wind farm project is described in the following stages with each corresponding to a chapter in this report:

- Feasibility
- Planning and Permitting
- Pre-Construction
- Construction
- Commissioning
- Operation
- Decommissioning



2. Feasibility

2.1 Overview of Feasibility Stage

A project feasibility review is generally the starting point for a wind farm project or indeed any type of infrastructure project. The purpose of this review is to identify sites that are broadly suitable for wind farms, and those that not. Typically, a project is conceived either by a wind farm developer seeking suitable sites, or in some cases interested landowner(s) or a community contacting or being referred to a person in the wind industry.

The first step is to assess the site to see if it has potential to become a commercially viable wind farm. The feasibility of a potential site would typically be assessed under a number of criteria including;

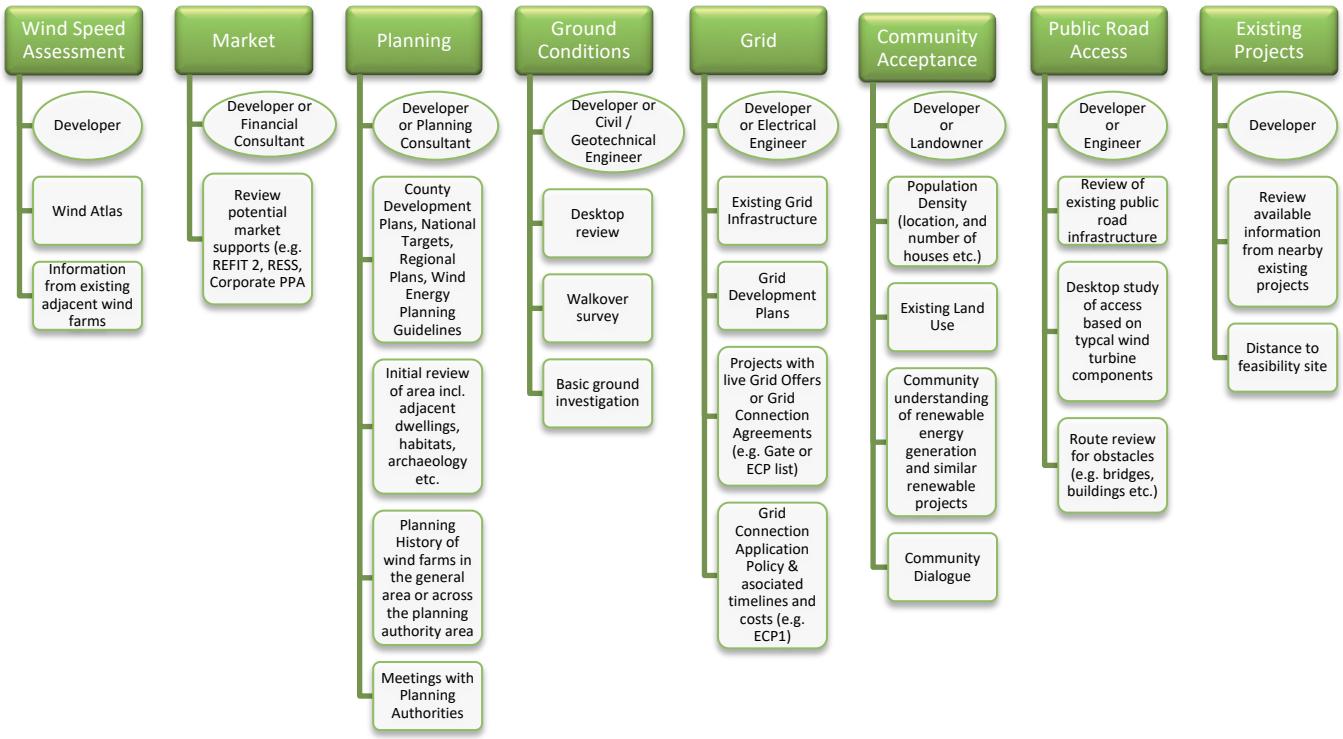
- Average wind speed at the site
- Area of available land and land ownership
- Setback distance from houses
- Planning environment including proximity to protected sites (e.g. Special Areas of Conservaiton) and consideration of local development plans
- Ground conditions and land-use of proposed site and adjacent land
- Existing and future grid infrastructure
- Community acceptance
- Construction access to the area via public roads
- Existing wind farms in the area and wind farm or other electricity generation projects in development nearby

Many of these criteria are interrelated and more could be applied depending on the individual project. The feasibility screening stage is used to predict how likely it is that a wind farm would succeed at this location. It helps a developer to decide what projects to focus on, and what projects are unlikely to progress.

Feasibility reviews have a short duration and would typically be carried out over a short number of weeks using a combination of site visits and desktop assessments and analysis.

2.2 Parties & Tasks at Feasibility Stage

A number of tasks are required to carry out a wind farm feasibility study, and each task involves a range of knowledge that can involve numerous parties and information sources. The following table outlines some key tasks, parties and information resources that come together to perform a wind farm feasibility study.



3. Planning & Permitting

3.1 Overview of Planning & Permitting Stage

Once a project passes its feasibility screening it proceeds to a planning and permitting stage. The project will begin to require an increased level of investment of both time and money at this stage.

Planning and permitting is a broad heading and includes the actual permits, and some associated tasks that are required to bring a project through from feasibility to pre-construction including;

- Land Lease Options for the site and access to the site
- Community Engagement
- Planning Application and associated environmental surveys and studies
- Grid Connection Application
- On-site wind speed monitoring

As with other parts of the process many of these tasks are inter-related. Decisions or results in one part of the project can have knock-on effects for other parts. For example, after engaging with the local community a developer might move the location of a number of turbines. This might have an effect on the land and access requirements.

The nature of the grid connection can determine both the voltage level and method a project connects to the grid, both of which will influence the design and scale of the substation and the type of underground cable or overhead line that needs to be submitted for planning approval. Recent court rulings require the grid connection route to form part of the planning and appropriate assessment process.

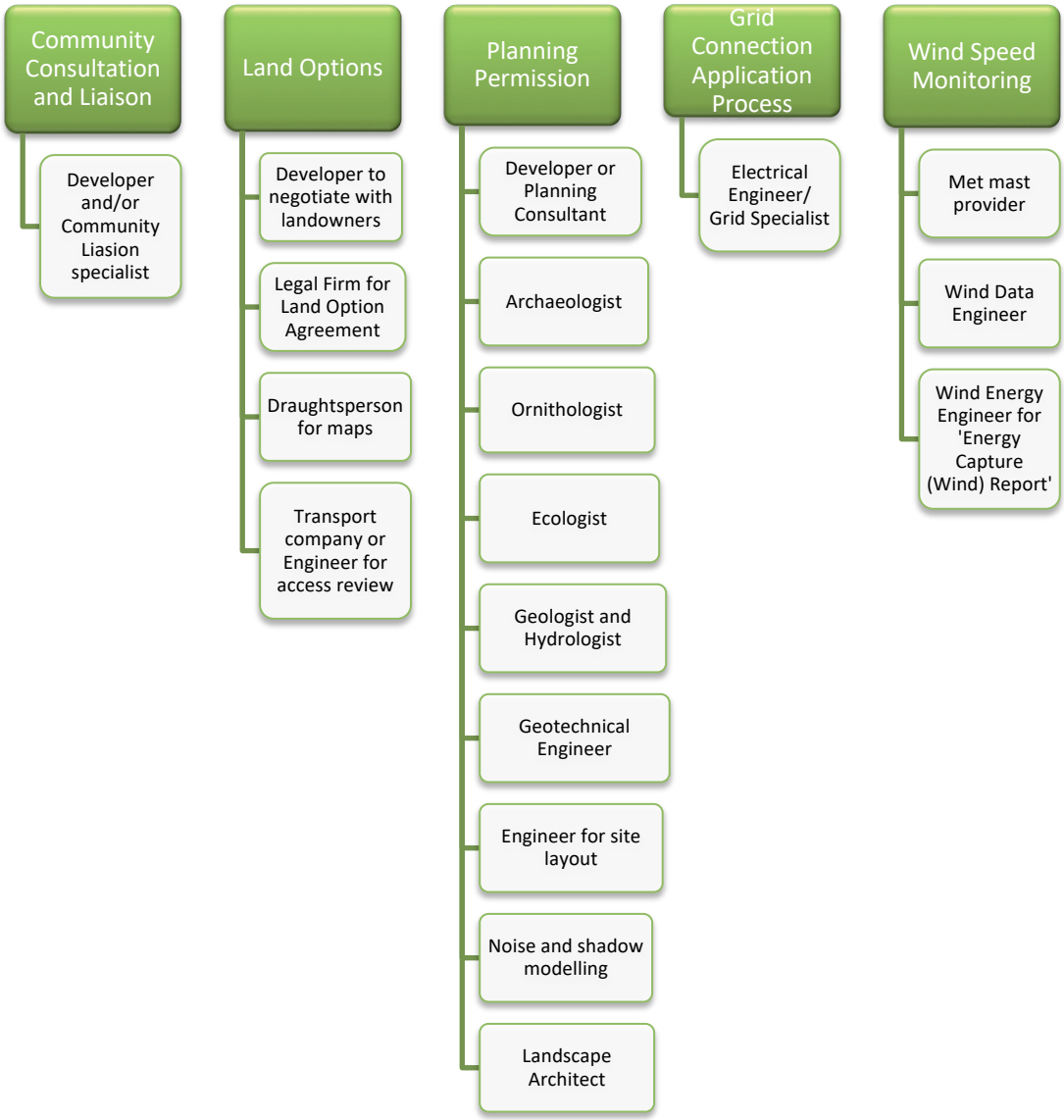
It should be noted that more recently, planning permission has become a requirement for making a Grid Connection Application (under the new Enduring Connection Process 1 (ECP 1) application process).

The Planning and Permitting stage typically takes several years. This is partly due to the length of time to go through the various stages of the planning process (often including appeals), and also due to the timeframe between submitting a grid connection application and receiving a grid connection offer. The often lengthy period to obtain planning permission is not unique to wind farm development as a number of recent infrastructure and development projects have highlighted.

Until recently four to eight years was typical of the duration required for the planning and permitting stage of a wind farm, partly due to long delays in processing grid connection applications. It remains to be seen how much this timeline will change under new ECP grid connection application processes, which may result in the processing of grid applications more quickly. Under the new ECP system a project must have planning permission before applying for a grid connection. Both planning permission and a grid connection offer are likely to be needed before a project can apply for the new Renewable Electricity Support Scheme (RESS), when it comes into force. While there are benefits to the new process it is still unlikely that most renewable energy projects will be able to proceed through the planning and permitting stage in less than four to five years.

3.2 Parties and Tasks at Planning and Permitting Stage

For each of the above tasks several professions and disciplines are involved. Typically, this process is managed by a project developer. The developer may use a range of in-house or contract staff for this stage depending on their resources.



4. Pre-Construction

4.1 Overview of Pre-Construction Stage

When a project has all the required land options secured, successfully achieves planning permission, receives a grid connection offer and a suitable commercial offer to sell the renewable electricity it will produce, it typically proceeds into a pre-construction stage.

The project also needs to secure finance for the Construction Stage. Projects can be funded by the project developer, known as balance sheet or equity funding, or from a mix of developer equity and loans. These loans are typically sourced from banks.

Generally, the lender requires the loan to be paid back before the REFIT/RESS support ends. This is because while the wind farm has REFIT/RESS support the price the wind farm will get for the electricity it produces can be easily predicted. This means there is less risk for lenders, and it reduces the cost of borrowing.

Before a lender agrees to provide a loan to the project they will engage advisers to carry out a review of the project and contracts, known as project due diligence. On successful conclusion of the project due diligence, and completion of loan agreement negotiations the project reaches financial close/financial investment decision and the developer enters a loan agreement (Facility Agreement) with the lenders. This process is somewhat similar to getting mortgage approval and buying a house. Pre-construction can typically take six to twelve months to complete.

Because the planning and permitting stage can take a number of years, during this pre-construction stage the planning permission is reviewed to ensure it matches the grid connection methodology and the physical characteristics of wind turbines available in the market at this time. Because a developer has to get planning permission before getting a grid connection, and the grid connection process is a slow process it can happen that when they do get the grid connection offer the requirements of connecting to the grid or the available wind turbine models might require them to make small changes to the planning permission.

Planning compliance submissions are also prepared to discharge the pre-commencement and construction related planning permission conditions and are submitted to the planning authority for approval.

The grid connection can be built on a contestable or a non-contestable basis. Contestable grid connections are grid connections built by the developer to the utility's engineering designs and standards. Non-contestable grid connections are built by the utility (ESB Networks or EirGrid). The developer can choose between a contestable or a non-contestable connection. Regardless of who builds the grid connection, once it is complete, it belongs to the utility and is the property of ESB Networks (ESBN).

Construction contracts are negotiated in this stage too. These construction contracts are normally prepared by consultant engineers and lawyers hired by the developer unless the developer has suitable in-house resources themselves. Typically, projects are either constructed under one 'turnkey' construction contract, where a single company is responsible for the wind turbine, electrical and civil works associated with the project, or as separate contracts for wind turbines, electrical works, and civil works. Where 'turnkey' contracts are undertaken the wind turbine supplier is generally the turnkey contractor, and then subcontracts the civil and electrical works. Contestable grid connection works may also be included in the contracts for some projects. Normally a maintenance contract is also agreed with the turbine supplier at this stage, to cover maintenance of the turbines during wind farm operation (this could be a fifteen or even twenty-year contract).

At this stage the project also applies to the Commission for Regulation of Utilities (CRU) for its licence to construct the project and its licence to generate electricity – both of which are required for any entity to construct and operate an electricity generating facility. The CRU can take a number of months to process these applications. The project will also negotiate a Power Purchase Agreement (PPA) with a

company who will buy the electricity from the wind farm and sell it on to domestic and/or commercial customers.

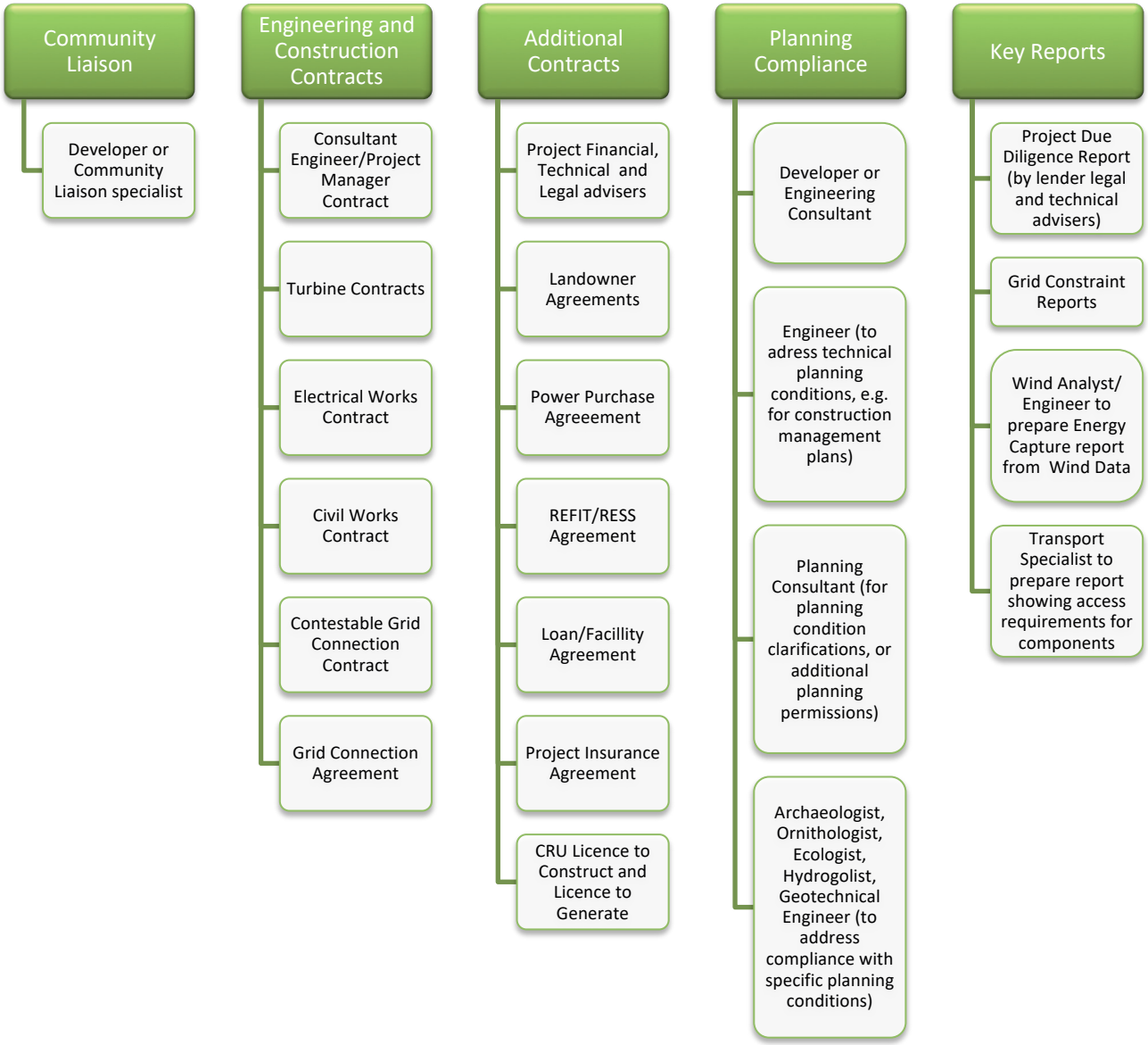
The project may also apply for inclusion in a government support scheme for renewable energy generation at this point. Over the past two decades have been a number of government support schemes for renewable energy including the Alternative Energy Requirement (AER) and the Renewable Energy Feed in Tarif (REFIT). They can broadly be thought of as a government approved and sponsored scheme which secures a minimum price for each unit of electricity supplied by the wind farm. REFIT support lasts up to 15 years and the next scheme the government are proposing, the Renewable Electricity Support Scheme (RESS) is expected to be similar, with wind farms having a typical production life of approximately 20 to 25 years. Once the wind farm's REFIT/RESS support ends there is no guaranteed price for each unit of electricity supplied by the wind farm, and the electricity will be traded at 'market' price. The market price may ultimately be higher or lower than the REFIT/RESS price depending on supply and demand and fossil fuel prices at that point in time.

The current REFIT 2 scheme offers the same fixed price to all qualifying projects. However, RESS will be auction based, where projects bid in the estimated price they need to charge for electricity in order to construct and operate their project, with the lowest prices winning the auction. The details of this auction have yet to be designed. A recent report by Baringa, a respected international consultant, showed that between 2000 and 2020 support schemes for wind energy in Ireland will have cost €1.00 per person per year when all the supports and savings have been considered[1]. This clearly shows that wind energy has already provided very good value to electricity users.

[1] https://iwea.com/images/files/baringa-wind-for-a-euro-report-january-2019.pdf

4.2 Parties and Tasks at Pre-Construction Stage

For each of the above tasks several professions, disciplines, and companies are involved. Typically, this process is overseen by a project developer, who may engage an external consultant to assist in project managing the process. The developer may use a range of in-house or consultant and contract staff to deliver specific tasks during this stage.



5. Construction

5.1 Overview of Construction Stage

Construction typically follows pre-construction, though in some instances the two can overlap with construction beginning before pre-construction is complete. During the construction stage contractors move onto the site, and the civil works, electrical infrastructure and wind turbines are brought to site and installed. This is the most capital-intensive stage of the project. Typically, the civil contractor moves onto the site initially and constructs the site roads, upgrades the public roads as required, constructs the wind turbine foundations and areas for the cranes used in turbine assembly (hardstands), and the electrical substation.

As the civil works advance the electrical contractor also starts work on site, installing the electrical cables with the civil contractor. Within the wind farm underground electrical cables are typically used to bring the electricity from each wind turbine to the wind farm electrical substation. The electrical contractor also begins installing the electrical equipment in the electrical substation once the civil contractor has finished building it.

When the project is completed the electricity can then flow from the substation built on the wind farm to an ESBN or EirGrid electrical substation via underground cable or overhead wires.

Off-site grid connection works are generally constructed at the same time as the on-site wind farm works. These can typically include upgrades to existing ESBN or EirGrid substations, or even the construction of a new substation. The electricity then flows from the ESBN or EirGrid substation along the existing electricity network to domestic and commercial electricity customers.

The grid connection works normally take the most time (primarily due to how long it takes to manufacture some of the large and complex electrical equipment), and all the other works (civil, wind farm electrical works and turbines) are scheduled to be completed at the same time the grid connection works are complete and ready to be energised.

During this period the wind turbines are also being manufactured and shipped to a port in Ireland. Once the civil works are largely complete and the electrical and grid connection works are well advanced the wind turbines are brought from the port to the wind farm site and assembled at the wind farm.

Due to their size, the wind turbines are shipped and transported to site in several separate sections. Typically, it takes one week to assemble the sections and erect a wind turbine at a wind farm site, though if weather conditions are suitable it can be completed in two days. The turbines are assembled and erected using large cranes and a team of engineers and technicians who specialise in this work.

Throughout the construction stage the project is monitored by various specialists to ensure it is constructed safely, correctly and in compliance with the planning conditions. This can include community liaison officers, ecologists, archaeologists, ornithologists, hydrologists etc. alongside construction monitoring by various engineers to ensure the project is constructed in accordance with the designs and contracts. Wind farm developers typically use either in-house or consultant project managers to tie the whole process together and ensure the project is delivered safely, in accordance with the permits, permissions and contracts, and within the agreed time frames and budgets. Lenders can also retain their own technical adviser from the pre-construction stage to carry out occasional site visits and project monitoring on their behalf.

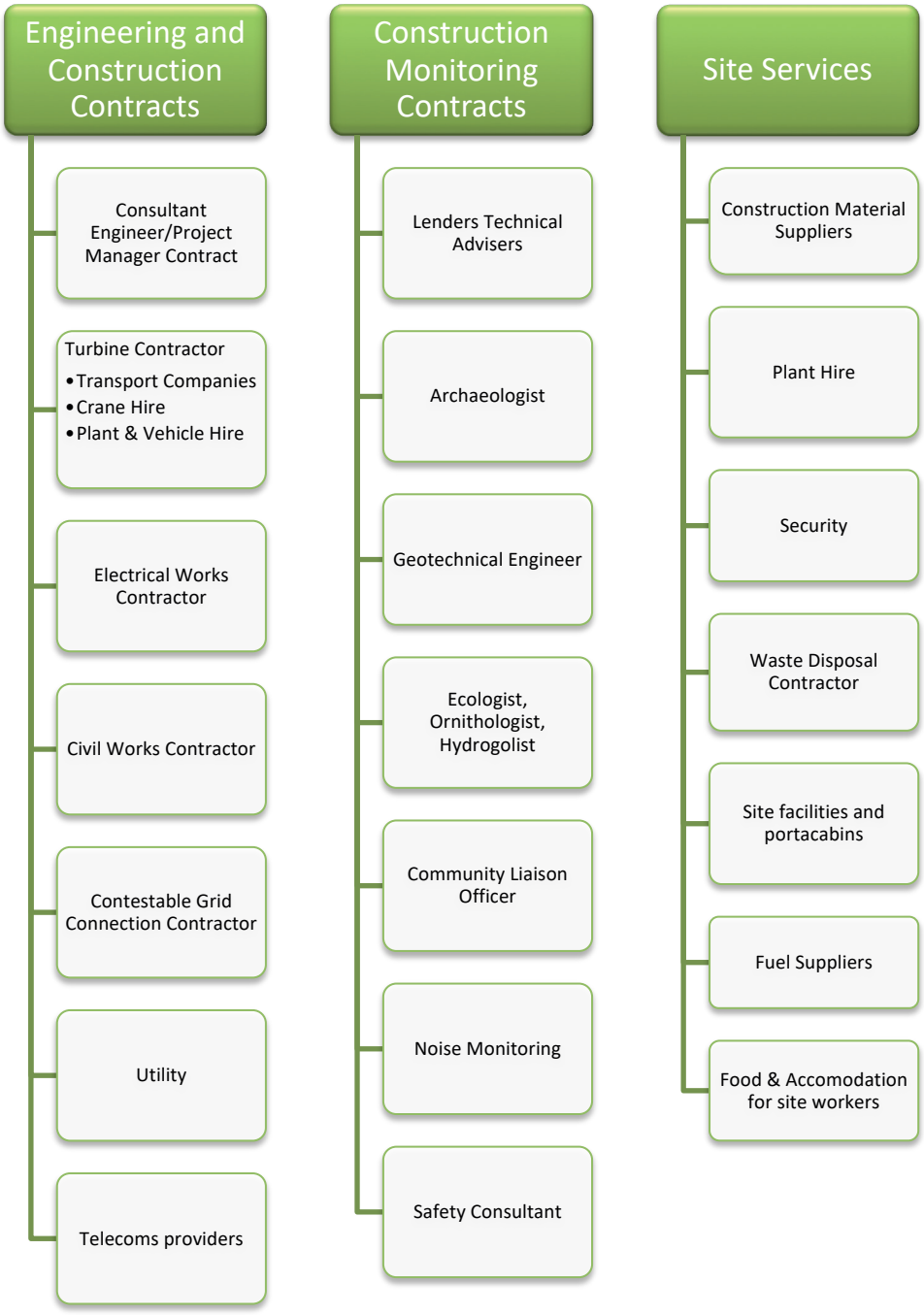
The construction stage can provide a large boost to local communities near the windfarm. Materials for the civil works are normally sourced locally, and many local sub-contractors and suppliers can also have an opportunity to supply and work on the projects. Local accommodation providers, hardware shops, service stations, grocery shops, garages etc. also benefit from this stage of the project. One recent 169MW windfarm project estimated that €20 million was spent with local suppliers and contractors within 30 kilometres of the site during construction.

Once the grid, electrical and turbine works are sufficiently advanced the project is ready to enter the Commissioning Stage, when the wind farm starts to generate renewable.

Construction and Commissioning timeframes depend on the size and complexity of a project, but in general, combined they take approximately twelve to eighteen months to complete. The wind farm could be constructed and commissioned more quickly, but as the grid connection typically takes so long to be designed and constructed the wind farm works are timed to coincide with the completion of grid connection. These grid connection timelines will also be similar for other renewable energy projects.

5.2 Parties involved in the Construction Stage

For each of the above tasks several professions, disciplines, and companies are involved. Typically, this process is overseen by a project manager, either employed directly by the project developer, or as an external consultant working on behalf of the project developer. The following table sets out some of the professions typically involved in wind farm construction



6. Commissioning

6.1 Overview of Commissioning and Testing Stage

As the grid, electrical works and turbines near the end of construction/installation the commissioning and testing stage begins. The commissioning work is included in the same contract as the construction, but often involves different staff.

This stage involves specialist commissioning engineers and technicians who check, test and adjust the equipment until it is ready to operate safely and reliably. Commissioning timeframes vary depending on the scale and complexity of a project.

A newly constructed ESBN or EirGrid electrical substation can take between three and four months to commission before it is fully energised. A new wind farm or any renewable energy project substation could take between one and two months to commission (including time for ESBN to commission their equipment at the renewable energy project substation). Once the grid connection and wind farm substation have been commissioned and energised, each wind turbine typically takes one week to commission and often a number of wind turbines are commissioned simultaneously.

At this stage, the wind farm (similar to any electrical generation facility) also carries out what is called grid code compliance testing with the grid system operator (either ESBN or EirGrid depending on the scale of the project). This ensures that the project meets the rules the grid system operator sets out to maintain the continued smooth, secure and reliable operation of the electrical transmission and distribution systems.

At the end of commissioning, the wind turbines undergo an extended test phase, sometimes called a reliability run before being finally handed over at the end of the commissioning stage. The project manager and specialist engineers monitor the commissioning and testing to ensure everything performs safely and reliably in accordance with the various contracts.

After this, during the Operational Stage the wind farm continues to undergo further grid code compliance tests for a period of time until all the requirements of the system operators (ESBN or EirGrid) have been checked and certified.

6.2 Parties involved in the Commissioning and Testing Stage

In general commissioning and testing are carried out under the same contracts as the construction works, but often by different people. After the civil works have been completed and the grid equipment, electrical equipment and wind turbines have been installed most of the construction staff normally move to the next construction site and the number of people on site generally decreases. Commissioning staff from the same companies come to the site to bring the project through its commissioning and testing stage.

7. Operation

7.1 Overview of Operation Stage

Once the project is commissioned and tested it is handed over to the wind farm developer/owner to begin life as an operating wind farm. The wind farm generates electricity which feeds into the electrical network and provides clean renewable electricity to domestic and commercial electricity users.

The wind farm owner can either use in-house staff or specialist asset management consultants to co-ordinate the wind farm operation. During the operations stage of a wind farm the operation and reliability, maintenance, finance, ongoing compliance with permissions and permits, safety, security, community relations and benefits, land-owner agreements etc. must be continually managed.

During operation the wind turbines and other key wind farm equipment are continually monitored remotely via a computer system (SCADA). Using this system, the wind farm owner, operations supervisor or turbine maintenance contractor can monitor the wind farm production and performance to ensure it is working efficiently. Where a fault occurs the computer system will identify it and inform the supervisor who will send a maintenance crew to the site.

Typically, each wind turbine undergoes routine maintenance between two and four times a year depending on the turbine type. Each routine maintenance can take number of days and involves at least two service technicians. The maintenance technicians also carry out unscheduled maintenance in response to faults or to replace components.

Civil works are routinely maintained as necessary, typically twice a year for routine maintenance, but this depends on the specific project. The electrical infrastructure typically undergoes routine maintenance and testing at least once per year. Monitoring of the civil and electrical works can also result in additional unscheduled maintenance.

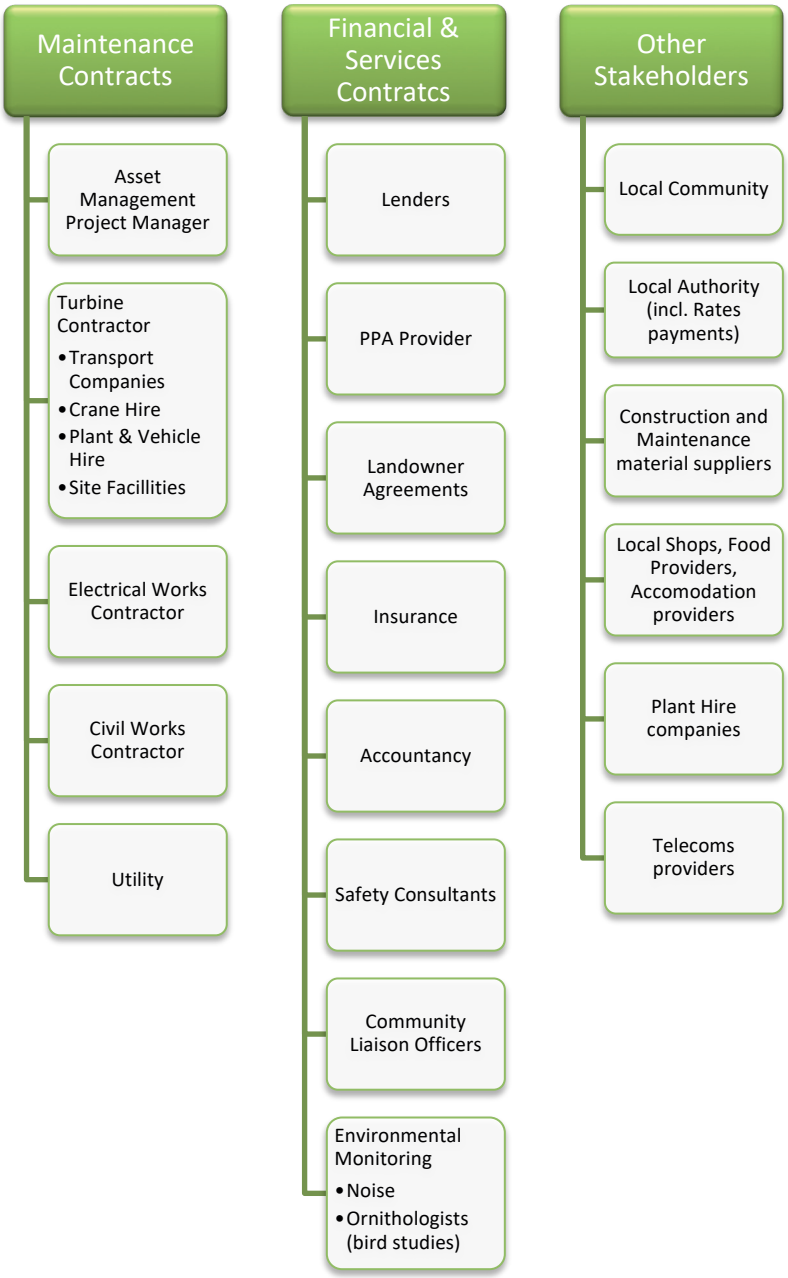
As a general rule of thumb approximately two wind turbine operation and maintenance jobs are created for every ten wind turbines, though with larger more complex turbines this may change to two jobs per six to eight turbines. The turbine technicians tend to live in the areas near the wind farms and are thus located throughout rural Ireland.

The electricity produced by the wind farm is sold to customers and the income is used to pay back the loans taken out at the pre-construction stage to construct the project (typically up to fifteen-year loans), pay the maintenance contractors, wind farm operators, utility charges, landowners rent, local authority rates, project insurances etc.

In addition, windfarms can provide community benefit funds to local communities during their operational stage. One modern wind turbine could contribute up to €250,000 to a local community over its lifetime, making a significant positive contribution to the rural community adjacent to the wind farm.

7.2 Parties involved during the Wind Farm Operation Stage

Various parties are involved in the successful operation of a wind farm, some of whom are outlined above and as follows;



8. Decommissioning

8.1 Overview of Decommissioning Stage

When a wind farm reaches the end of its useful life it will be taken apart and removed from the site. This is known as decommissioning. Because wind farms have a typical lifespan of approximately twenty to twenty-five years and the first commercial wind farm in Ireland only began operation in 1992 wind farms in Ireland have yet to reach the decommissioning stage. It may be possible to extend the wind farms lifespan beyond twenty to twenty-five years in some cases.

The decommissioning process is the reverse of the construction process and involves dismantling and removing the wind turbines and the electrical and civil infrastructure. Many wind turbine components still have a commercial value at this stage in addition to their recycling potential. For example, the steel towers, and aluminium and copper cables can create additional revenue when they are sent for recycling.

At the same time a wind farm is decommissioned, and where suitable planning permission can be obtained and landowner leases are agreed, an additional option is to repower the project. This involves removing the old turbines and at the same time installing newer more efficient turbines at the same site. This allows some of the existing civil and electrical infrastructure to be retained and reused, with associated environmental and economic benefits. Generally, it would involve construction of new turbine foundations as the type of turbine will probably change, and it may also involve the replacement of some or all of the electrical equipment if the wind farm electrical output is increased.

Repowering a wind farm with new turbines brings the project back to the start of the life-cycle process, with new feasibility studies, planning and permitting, pre-construction, construction and ultimately operation.

9. Summary

This is a broad overview of the various stages of a wind farm's life-cycle, which can vary from project to project, and over time. It doesn't try to capture every element of the project or those involved at each stage but may be a useful guide to better understand how a wind energy project progresses through its life-cycle.

With almost 30% of Ireland's electricity coming from wind farms in 2018, at a net cost above fossil fuel electricity prices of just €1 per person per year between 2000 and 2020[2], and the possibility of generating 70% of our electricity from renewable energy by 2030[3], wind energy will continue to form an integral part of our electricity system for decades to come. Wind energy cuts the CO_2 emissions from our electricity system, reduces Irelands over-reliance on imported fuel, provides jobs and benefits in rural communities throughout Ireland, and also helps us do our part in helping the world to minimise the potentially catastrophic effects of man-made climate change.

[2] https://iwea.com/images/files/baringa-wind-for-a-euro-report-january-2019.pdf
[3] https://iwea.com/images/files/70by30-report-final.pdf