Wind power: from conception to reality – an overview

In the first of a special Renewable Energy Focus series looking at the key stages and processes involved in taking a wind project from A to Z, Gail Rajgor gives some rules of thumb that are vital from the offset, and takes a closer look at the all important issue of choosing the right site for your wind farm.
So you want to build a wind farm. Good for you. With the global drive towards a low carbon economy, it is surely the right way to go for many individuals, companies and, indeed, Governments around the world. As information from the Canadian Wind Energy Association (CanWEA) points out, “from large energy companies to individuals looking to supplement their own energy needs, there’s a great future in wind energy.”

But while wind energy can make good economic sense for many, planning and developing a wind farm is, CanWEA adds, “a big ask”.

It’s not for the faint-hearted, nor for those in any particular hurry. And in many cases it’s not necessarily the right option at all.

In fact, when it comes to developing a wind project from A to Z, there is a minefield of potential obstacles, risks to be factored in, and almost certainly some controversy to be faced. Get it right though and, in the words of the Canadian association, the rewards make it all worthwhile.

Key ingredients for success

Successful wind project development needs proper assessment, the right market conditions in place to make it economically feasible, and a great deal of careful preparation and handling. It’s the same whether you are talking about one turbine or a thousand, wanting to go onshore or offshore, or are dealing with a private development or a community-owned scheme.

In most countries too, there are a multitude of different approval processes (often at local, regional and central Government level) to go through.

And that’s before you even begin to face the practical matters of actually building the thing. Then there’s the sticky issue of securing the finance you need (not trivial during a global credit crunch); due diligence issues (technical and non-technical alike); equipment selection; project engineering; construction and grid connection; along with a host of other things to tick off the list. And then when it has been built, the wind farm needs to be run as efficiently as possible to maximise the returns available.

Every country has its own specific characteristics, rules and conditions that come with developing any energy project, and with them come different risks to be aware of. Some of these will of course affect how a project is developed, and whether or not it can be done cost-effectively. Working with people that have good local knowledge is always a sensible approach to take.

But while there are country-specific hurdles and obstacles to overcome, there are also certain universal steps that any (and all) prospective developers or project owners need to take. And similarly, there are certain words of cautionary advice they would be wise to heed, which will be discussed throughout this series.

So to kick off, just as a local working knowledge of how business is done in any specific country is important, the wisest course of action for any prospective wind farm owner is to turn to the multitude of experts in the field, to ensure the whole thing goes smoothly and effectively.

Even the biggest companies in power generation do not necessarily have all the expertise they need in-house. Like everybody else, they sometimes need to turn elsewhere for the expertise they require.

New methods for measuring the wind

Although computer models of wind flow over terrain have improved dramatically in the past few years, there is still no substitute for data recorded at the site, according to wind resource assessment professionals SecondWind.

The most widely accepted method of measuring the wind at a site has been to use wind sensors mounted on a met mast/tower, recorded by a wind data logger. For best results, the tower should be at least as tall as the hub of a likely wind turbine, says the firm. “This can create a challenge as wind turbines can be 80 metres or above at hub height, while the most popular style of meteorological towers used for prospecting – tilt-up temporary masts – are 50 or 60 metres in height.”

The solution in such instances, says SecondWind, is to use remote sensing technologies, such as its Triton Sonic Wind Profiler, which can measure wind at higher heights. More and more companies are now providing these technologies. “In addition to complete wind resource assessment, remote sensing systems can be used for wind prospecting,” the company adds. “The advantage of remote sensing is the substitution of measured wind data for modelled wind data.”

GL Garrad Hassan agrees. “Remote sensing measurement techniques enable measurements to hub height and beyond.” The company says it makes significant use of “value-adding alternative technologies” and this includes resource measurement using sodar and lidar. Its experts, it adds, have been involved in the testing of remote sensors since their market inception and “are therefore well placed to advise on their use as part of a wind monitoring programme”.

In fact, it is fast becoming standard industry practice to use measured data from validated remote sensing technologies in combination with met tower measurements, something viewed as particularly useful when trying to secure financing for wind farms. In November, for example, developer Continental Wind Partners (CWP) made use of the Triton Sonic Wind Profiler as part of its standard wind resource assessment practice. With a fleet of 8 Tritons, CWP is using the technology to expedite wind farm development, reduce project uncertainty and streamline project financing at sites in five Eastern European countries.

In addition to Eastern Europe, CWP is an investment partner in several projects in Australia with Wind Prospect and also plans to use the technology there. “Although met tower data remains a key part, remote sensing is becoming more and more necessary to reduce uncertainty by measuring hub height wind conditions,” says Konrad Gorkowski, wind & site engineer at CWP.

The company has already accumulated nearly 100,000 hours of Triton data in Central and Eastern Europe. At the earliest phase of the development cycle, Tritons are deployed for wind prospecting – taking an initial measurement of a site’s resources to determine whether the site qualifies for a lengthier study with meteorological towers.

On sites with existing met towers, CWP has deployed the system at several locations around the site to better map the available wind resources, an approach known as micro-siting. “Triton always correlates well to the met tower measurements and provides valuable information on each site’s profile,” says Maciej Baginski, wind measurement and GIS specialist at PS Wind Management, CWP’s Poland-based development group.
A dedicated wind or renewable energy association is likely to be many people’s first port of call when seeking advice, but to make sure you are turning to the right people when it comes down to the nitty gritty, you need to know exactly why you need them, and when.

This series of articles aims to help you know just that, and be aware of the issues you need to address.

Patience will be a virtue

Taking a wind project through from initial conception to full operation and beyond is then an extensive process that can take years. According to Australian firm AGL Energy, there is a 6-phase process involved in any wind project:

Kicking off is the pre-feasibility and feasibility phase (or project conception stage as some refer to it).

This is then followed by the development phase, design and planning, construction, handover and close out, and finally maintenance and performance.

Just the main development phase before construction can even begin is a “timely process and requires extensive research, technical reporting and consultation with relevant planning authorities, organisations and members of the local community”, AGL notes.

The initial steps for any project, involve investigating whether it is even feasible to run with the idea and develop it further. As with anything, just deciding that you want to develop wind power – and it actually making sense to take the idea to a stage where some serious time and money need to be committed – are poles apart.

A preliminary assessment as to whether or not there is scope for a project, and where/what the least-cost, most efficient and profitable opportunity lies, may need to be conducted first:

“Designing a wind farm is often a complex and iterative process,” explains international wind and renewable energy consultancy GL Garrad Hassan. “In the early stages the focus is on identifying the approximate size of the project and spotting any show stopping issues before too much expense is incurred.” As the development process progresses, the company adds, “the focus changes to identifying in detail all the issues which may influence the final size and layout of the project, and to optimise development within those constraints”.

So the twin goal is to minimise risk while maximising the return on investment.

Generally, the pre-feasibility stage involves conducting a low cost analysis of various potential sites. This stage often involves pre-selecting sites, preparing a simplified design for the best sites, choosing potential turbine models, preparing preliminary cost estimates and financial summaries and then drafting a pre-feasibility report.

If the pre-feasibility analysis shows a project to be viable, more detailed assessments then take place to draw up a full feasibility and costing report, after which the main project development stage can begin.

Consultation with local authorities and nearby communities likely to be affected by a project is vital from the outset, and so should be seen as a part of the preliminary feasibility assessment. And it should continue throughout the development process.

“It is extremely important to contact the municipality before undertaking any steps,” suggests CanWEA. “The consultations with municipalities will
Case study: Wind data collection in the UK – plan to succeed

In planning any wind energy project, whether it's a full-scale wind farm or a micro generation site, accurate and up to date data is essential to predict future energy production. But what are the key factors involved in planning an effective wind measurement and analysis strategy?

Although Government wind speed data exists in the form of wind maps, this data is too general to make precise forecasts of energy production from a proposed site. Accurate measurement is carried out using a range of sophisticated instruments combined with technical expertise and knowledge.

The use of met towers equipped with anemometers and wind vanes to assess wind speed, direction, and shear, as well as sensors to measure temperature, pressure and relative humidity are essential to build up a complete picture of the wind environment on the site. Sensors on the met mast must be carefully positioned by technically – qualified experts. A well established method is used by Wind Measurement International in order to determine the wind vane north offset.

This process is continuously being improved, and currently allows the wind vane setting to be presented to the nearest degree. There is evidence to show that if the separation of the anemometers from the met mast, booms and other sensors is not sufficient then the wind speed recorded by the sensors will be inaccurate.

There are known standards which state the recommended minimum separation and orientation of particular sensors. Full-scale tests and computational simulations should be carried out for each type of mast, in order to minimise the sheltering effects on these sensors.

Increasingly, LIDAR technology (Light Detection and Ranging) is also employed to measure the wind profile from 10m up to 200m according to the proposed turbine configuration. This system is very accurate at measuring wind speed and turbulence. It is therefore a useful tool, when combined with met towers, for predicting the long term energy yield for a particular site.

Incomplete or inaccurate data can have a huge impact on the anticipated energy yields from a proposed development. For example, a site which has an annual average wind speed of just 10% higher than another will produce over 20% more energy. A change of just 1% on the final energy yield can be the difference between a site being viable or not. This shows how critical it is to choose the correct sensors, have sound installation procedures and site reporting for the met masts and LIDAR, and have the knowledge and expertise to produce an accurate final energy yield analysis.

Most planning authorities and banks will require developers to provide at least one year's full data and in some cases up to three years to verify the feasibility of a site. It is vital therefore that data collection and analysis is carried out in the most efficient way possible if project delays are to be avoided.

The first thing to bear in mind is the type of mast required. The height of the met mast should be as close to the proposed turbine hub height as possible in order to reduce the uncertainty of the energy yield calculations. If the height of the top anemometer is below the proposed turbine hub height then extrapolation techniques should be applied. The total uncertainty will increase as a result of this extrapolation.

The level of uncertainty will depend on the accuracy of the extrapolation model. Wind Measurement International has an in-house peer reviewed software package called ShelterMap which minimises the uncertainty associated with this extrapolation process by including the surrounding shelters into the analysis.

Anemometers vary with price and accuracy. Some have known problems which cause errors in their readings. Therefore the trade-off between price and accuracy has to be considered when choosing suitable anemometers for use on a met mast. The calibration of the anemometers also varies with manufacturer. It is important to check with the banks what criteria they are using to assess the data and ensure compliance with this. Most banks will ask for a specific calibration, which will add a significant cost to a met mast installation.

It makes sense to involve wind measurement professionals from the beginning of the project. Using inexperienced operators can lead to problems further down the line and there could be health and safety issues with an inexperienced crew. An amateur installation can lead to under estimating or over estimating wind resources, which is bad news as it could fail banking due diligence.

At the site survey stage a professional wind measurement company should be employed to carry out desk research to screen the proposed site for potential pitfalls such as proximity to public spaces, paths, power lines and microwave links. In addition, electromagnetic interference with respect to mobile phone, radar and TV transmission needs to be measured. The location, height and characteristics of all significant wind obstacles on the site need to be accurately assessed to optimise wind measurement location and maximise the certainty of the wind speed measurements.

On a large windfarm site a number of met masts must be strategically placed to give accurate data. However, as wind is highly variable year to year this data needs to be correlated with longer term weather stations (such as those based at airports) and necessary adjustments made. Wind speeds can vary enormously according to the type of terrain, vegetation and buildings on the site, so sophisticated wind modelling software is used to calculate the impact these factors will have on future energy forecasts.

You should expect monthly reports from your wind measurement company. This should include correlation with the nearest available meteorological data and detailed analysis of the turbulence intensity and average wind speed. Any site issues should also be highlighted on this report – including high wind shear, low mean wind speed or high turbulence levels. This is a good opportunity to check that all the sensors are in good working order, and the battery is healthy.

Data is captured using loggers attached to the met mast. These loggers must be robust and reliable to function in all types of weather conditions. They should be programmed to send an SMS message in the event of any malfunction or drop in battery voltage, have photovoltaic charging systems and be capable of transmitting data remotely using a GSM modem back to base.

Erection of the met masts should be carried out accurately within the strictest health and safety guidelines. There are a number of proven anchoring systems, which ensure the mast will stay up even in hurricane winds. However, regular inspection and maintenance of the met mast is essential to ensure it is functioning properly. On completion of the wind measurement phase the masts need to be decommissioned.

Once the data is amassed and analysed the last part of the equation is the final resource assessment, which can be used for bank due diligence purposes or to quantify individual investment risks for smaller turbine installations. It should present the calculated energy yield in conjunction with an in-depth uncertainty analysis. This report can also include complex terrain flow analysis, wake analysis, optimisation and noise assessment plus shelter analysis and height extrapolation.

In conclusion, the key to a successful wind measurement campaign is proper planning, choice of the right equipment and employing high level technical expertise.

By Dr Steve Ritchie, director, and Mr Lee Rowberry, wind energy analyst, Wind Measurement International
really help in making a project successful. Take the time to talk to your municipality and the people in the community who may be impacted directly, and also indirectly. Engage them early in the planning process, answer any questions and/or concerns that they might have, and keep an open dialogue with them throughout the whole development."

British industry association, RenewableUK agrees: “Community support and involvement is essential to planning for wind energy. For a relatively new technology to proceed through the planning system, it is important that the local community understands both the need for wind power and the way in which it coexists with other aspects of their local environment."

Where to build – testing the wind regime

“Location, location, location.” The mantra of many a real estate agent and broker. And so it should be too for anyone looking to invest in wind power. After all, if there is no wind, then there is no wind power. But for a potential project to succeed, just having some wind is not enough.

It has to be sufficient to generate enough electricity, regularly, to bring the required return you are looking for, so wind resource and potential energy field assessments are essential. And this involves much more than just monitoring wind speeds.

“Wind energy success is all about location, and selecting the right site is critical to cost-effective wind generation,” according to SecondWind, an American company established in 1980 which now provides wind resource assessment equipment and services to wind farm owners, developers, and consultants in over 50 countries (see ‘a higher height data wakeup call’ on page 18).

The key question, when it comes to assessing a site’s specific wind power generation potential, says CanWea, is simply this: “Is there a strong and consistent wind?”

But sticking your finger in the air for an hour or so will not give the answer. “Several factors are required for a utility-scale wind project to be sited, but the most important of these is good wind resource,” agrees SecondWind: “Site selection typically begins with wind prospecting, or the search for a good general location for a wind energy facility. Wind data in this early stage may come from maps and publicly available databases of historical climate data. Wind maps provide a rough estimate of the average annual wind at a proposed site.”

The terrain also needs to be suitable for turbine(s) and any related infrastructure. How easy it is to access the chosen site and transform it into a power generation facility – and at a later point maintain it on a regular basis – will also have overall project cost implications. “Wind turbine towers and blades are huge components, and transportation to site needs to be fully considered,” explains RenewableUK. “You need to ensure there are suitable access roads, or take into account the cost of building them.”

The potential impacts of turbines on nearby communications installations such as RADAR; microwave; wireless & cell networks, as well as possible environmental impacts on wildlife, habitats and local communities all need to be assessed also. All of these issues need to be considered and assessed in the early stages.

Environmental impact assessments (EIAs) have grown in particular importance, according to RenewableUK. An EIA is a detailed assessment of all the local environmental data, taking into account issues such as species types, movements and numbers; distance to the nearest dwelling/road; and impacts on local nature or land conservation areas.

“Professional advice should be sought from a consultant to ensure a comprehensive EIA is undertaken that can stand up to scrutiny,” the organisation warns. In other words if an EIA does not come up to scratch, the project won’t get far out of the planning process starting blocks.

Meantime, another vital factor in determining the success of a proposal is proximity to the electricity grid, states CanWEA and others. ‘Many questions must be answered at the pre-planning stage: Does the energy carrier have space for the electricity? Will your site need upgrading? How will it connect to the grid and who will pay for that connection? The answers to these questions vary by Province in Canada for example.’ And the same is true in other countries of course.

...Whether you are talking about one turbine or a thousand, onshore or offshore, a private development or a community-owned scheme, wind projects needs proper assessment, the right market conditions, and careful preparation and handling

Site selection is obviously then one of the first considerations, and once you have decided on potential locations for your project, the first thing to do, assuming you are not the landowner, is actually try to secure access to the land via negotiations with the landowner, so that you can assess the wind at those sites itself. This may involve negotiating an option on the land – should the project proceed and gain all necessary approvals (firm land lease agreements with the owner are generally negotiated once approval has been granted).

More detailed wind resource assessments, using specialist equipment such as anemometers, met masts and specially-developed software, are typically then used to evaluate the quality of wind on a given site for a period of at least one year (see case study on page 15). Wind speeds, direction, variability, and a host of other factors all need to be monitored and assessed scientifically. And it is at this point that in most countries the first major application for planning approval has to be made, in this instance, for the met mast if there is not one in the area already.
“It is standard practice to utilise meteorological masts to measure meteorological data at a potential wind farm site,” continues GL Garrad Hassan, which has been providing measurement solutions for nearly three decades, from management of mast installation and ongoing maintenance to an online data management service. “The installation and maintenance of meteorological masts is a significant cost during the development process of a wind farm,” it says:

“High quality meteorological data from a site is a key requirement for optimising the design of the wind farm, predicting the future energy production, and also as an input to selecting appropriate turbine technology for the site.”

However, the wind speeds required for cost-effective wind generation will vary depending on several factors, adds SecondWind. These include the eventual land, equipment, and infrastructure costs, the price that is paid for the electricity generated from the wind farm, and the actual cost of money secured via loans and credit finance arrangements to construct the project. “When considering wind generation, one important thing to consider is that the power in the wind increases dramatically as the wind speed increases (power is proportional to the cube of the wind speed).

Thus, a 10 percent increase in the wind speed, from, say 7 to 7.7 meters per second, translates to 33 percent in energy potential,” says the company.

Of course, conducting such resource and energy yield site assessments is meaningless unless there will be a buyer for the power generated from a project. Indeed, in some countries developers must have power purchase agreements (PPAs) in place before planning permission can be granted. This is so in many provinces throughout Canada, for example, although not all. In some, there is no need for a PPA prior to submitting a planning application. Instead, electricity is bought and sold based on the daily market price.

Next comes the process of trying to obtain all the necessary consents from the local regulatory authorities, before you can actually contemplate the realities of actually building the project (dealing with the planning process will be discussed in the next part of this series).

Along with securing all the necessary planning consents, these initial stages are arguably the most critical in a project’s lifespan. Alone they can take years, and require not just a great deal of patience, but skilled implementation to avoid losing the time and money invested.

Even then, the final outcome of the planning process is never guaranteed. And it’s the same whether you’re looking to build a project in an established market like Europe or the US, or in a young, up-and-coming market like Mexico, Bulgaria or South Korea.

However, there are ways to significantly minimise the risks of a project failing to get the green light for construction. Using the vast array of industry experts and consultants out there will help you to that end.