Enabling wind farm projects

Contributors: Hesam Marzooghi, Stephen Bex, Amir Mehrtash, Luke Livermore

PSC
Specialist Consultants
to the Electricity Industry
pscconsulting.com

Introduction

The global imperative to reach net zero and the current geopolitical climate amplifies the need for energy alternatives. As volatility in international markets drives up oil and gas prices, green energy becomes more important to our energy security. For countries aiming to reduce their reliance on fossil fuels, renewables are no longer 'want-to-haves.' Instead, wind power, solar and hybrid technologies have become 'must-haves' essential to eliminating GHG emissions and stabilizing energy supplies now and in the future.

Renewable challenges

With renewables come challenges, among them the variability inherent in intermittent energy sources and their impact on power system stability and security.

"The introduction of wind and solar power into a network adds new complexities," said Andrew Robbie, Principal Power Systems Engineer, PSC APAC. "The energy they introduce may instigate an undesirable response, or a network may not be able to absorb all of the power available from wind and solar."

While renewables may be intermittent, their generation can be predictable, especially when considering solar. We can also answer the variable nature of renewables with technology like energy storage and by co-locating solar and wind assets to exploit their complementary generation profiles.

There is a growing "NIMBY" (not in my backyard) sentiment from residents opposed to large renewable energy plants being proposed near them. Moving wind farms offshore satisfies the need for emissions-free energy to the grid while being located out of sight and sound of major populations.

Offshore wind also alleviates competition for land that might be used in more highly valued ways than electricity generation like farming, for example.

"Achieving energy stability with renewables is a continuous process of test, trial, refine and try again. We are working on solutions to make green energy projects more viable for the market."

~ Hesam Marzooghi, Team Leader, Power System Studies, PSC APAC

Energy mix diversification

"Wind is not replacing solar on renewable farms. Instead, it is increasing energy capacity and diversifying the energy mix," said Marzooghi. Capacity factors for solar farms tend to be lower than wind farms - about 20-25% compared to up to 60% for optimally located wind farms. Their generation is often complementary to solar, providing energy production before the sun rises and after it sets.

In some areas, wind power could reduce reliance on hydro and minimize water storage issues. For example, most of New Zealand's hydropower is in the South Island's mountainous region, connected by an extended network to the top of the North Island, where most of the load is located. There are inherent transmission problems getting power out of the South Island, with increased risk during dry years when lakes run low.

Countries with more mature wind power capabilities are moving towards energy interdependence and power hybridization to maximize the effectiveness of alternative energies and minimize reliance on fossil fuels. For example, in Europe, the UK sends excess wind energy to Norway to reduce hydro usage during high wind periods. Conversely, Norway generates hydro and transmits it to the UK when the wind resource is low.

Tipping point

According to McKinsey research[1], global installed offshore wind capacity is expected to reach 630 gigawatts (GW) by 2050. The UK had more than 24 GW of installed wind power capacity in March 2022, [2]making it challenging to connect to the grid.

The majority of existing wind farms are radially connected. As such, the closest available connection point for an offshore wind farm may be further onshore, making the distance to connect a wind farm much longer.

Wind farms have grown from a few hundred megawatts (MW) to the order of gigawatts (GW), especially for offshore farms. This is a consequence of capturing the more consistent and powerful wind energy found further offshore using larger machines, providing more favorable economics for offshore wind farms. Consequently, wind farms are generally further offshore than in previous generations.

As electricity is transmitted over long distances – from an offshore wind farm to onshore transmission grid infrastructure – there are inherent energy losses along the way. High voltage transmission minimizes the amount of losses.

AC transmission voltage has increased to 245 kV AC and inter-array voltage levels are increasing to 132 kV. But at these extended connection lengths and with increased wind farm capacities, high voltage direct current (HVDC) is becoming a more viable connection method than high voltage alternating current (HVAC). Thus, the need for more robust HVDC connections accelerate as wind farms move further offshore.

1 How to succeed in the expanding offshore wind market, April 2022, McKinsey
2 Renewable UK Wind Energy Statistics, visited 9 June 2002 - https://www.renewableuk.com/page/UKWEDhome

Bias for solutions

Our work on more than 40 HVDC projects worldwide often involves identifying and creating proper models representing actual sites.

“We analyze a variety of technologies from numerous original equipment manufacturers (OEMs). As a result, optimal performance of a model in one scenario may not generate the same performance on another system,’ said Amir Mehrtash, Team Leader, Power System Studies, PSC APAC.

During initial conversations, experts on all sides share knowledge from direct experience and research. From this collaboration, modeling takes many forms, including black-box modeling to troubleshoot existing technologies, new model development and multiple OEM model integration.

Inverter-based technologies may be patent-based and change from one OEM to another, so we test each for all scenarios and conditions. Some OEMs are not willing to share details of their models. For example, in black-box modeling, we cannot see what is inside the controller and the different elements.

“We troubleshoot an existing model to determine which response to anticipate in various conditions. Then, from experience gained on similar projects, we know what the expected response should be. If we witness a response that does not make sense, we raise it with an OEM,”.

~ Amir Mehrtash, Team Leader, Power System Studies, PSC APAC

International experience with deep expertise

PSC helps OEMs unfamiliar with modeling requirements in Australia by developing their inverter models from scratch. PSC may not know the detailed control system an OEM uses, but we can model based on renderings considering a country's standards they want to meet. We conduct rigorous testing on models sent from OEMs in Europe and the US, as an example, and suggest how a particular model could be modified to meet Australian standards.

In a hybrid system, equipment from two or more OEMs may need to integrate while maintaining optimal performance. OEMs, however, tend to know only their own models. As a third party, we integrate models from multiple OEMs to meet local requirements.

"We make sure models are communicating with each other and functioning under expected conditions," said Mehrtash.

PSC currently provides onsite technical direction for establishing and upgrading HVDC interconnectors in Scotland, allowing the integration of swathes of offshore wind farms currently under construction in the North Sea. The goal is to connect vast areas of plentiful renewable generation in Scotland with major load centers in England and throughout the UK. These projects employ the latest technology and control systems to integrate multiple HVDC converters in very close proximity. PSC's role, among others, is to ensure efficient and cost-effective solutions are employed.

On the US Eastern Seaboard, PSC is currently supporting a project to build 1 GW of energy from offshore wind turbines. We are working with the developer to determine how best to transport this energy back to land. We are helping the developer go to OEMs with the right specifications, then analysing the OEM's responses and cost proposals. For example, do the OEMs understand the developer's remit? Are technical challenges 'de-risked'? We consider these and other issues as we identify and assess the best locations onshore to import power.

In Australia, PSC provides consultancy services for AEMO Victorian Connections for Marinus Link, the proposed 1500 MW capacity undersea and underground electricity connection between Tasmania and Australia's National Electricity Market (NEM). The Marinus Link will carry clean energy from the island state to the mainland.

> *"Utilizing one state's natural wind and water resources, we are able to provide increased access to more secure, affordable, renewable energy to an entire country,".*
>
> *~ Stephen Bex, Principal Power Systems Engineer and Technical Director for Marinus Link, PSC APAC*

Our collective experience informs our thinking about the opportunities and challenges of energy alternatives in today's environment. Entities less familiar with wind, solar and hybrid technologies benefit from the best practices of organizations and governments in mature markets. We apply these learnings from our work on five continents to support our clients' efforts to integrate renewables into their energy-stabilizing strategies.

Lets talk!

If your organization is keen to explore options for connecting renewables, or optimizing their renewable projects, please reach out to us at apac-clients@pscconsulting.com.

About the contributors

Hesam Marzooghi, Ph.D.

Hesam has 9+ years of experience in various industrial and research projects. The projects that he has been managing and delivering include: Generator Technical Performance Standard (GTPS) and National Electricity Rule (NER) compliance studies (connection and R1 studies), commissioning, hold point and model validation studies (R2) for renewable energy resources in the Australian National Electricity Market (NEM); planning and development of microgrids including rooftop Photovoltaics (PV) and battery energy storage in Australia.

Stephen Bex

Stephen Bex is a Principal Engineer and Technical Director with over 30 years' experience in the high voltage electricity industry. His areas of expertise include a strong focus on power system modeling and analysis, renewable energy systems and HVDC.

Amir Mehrtash, Ph.D.

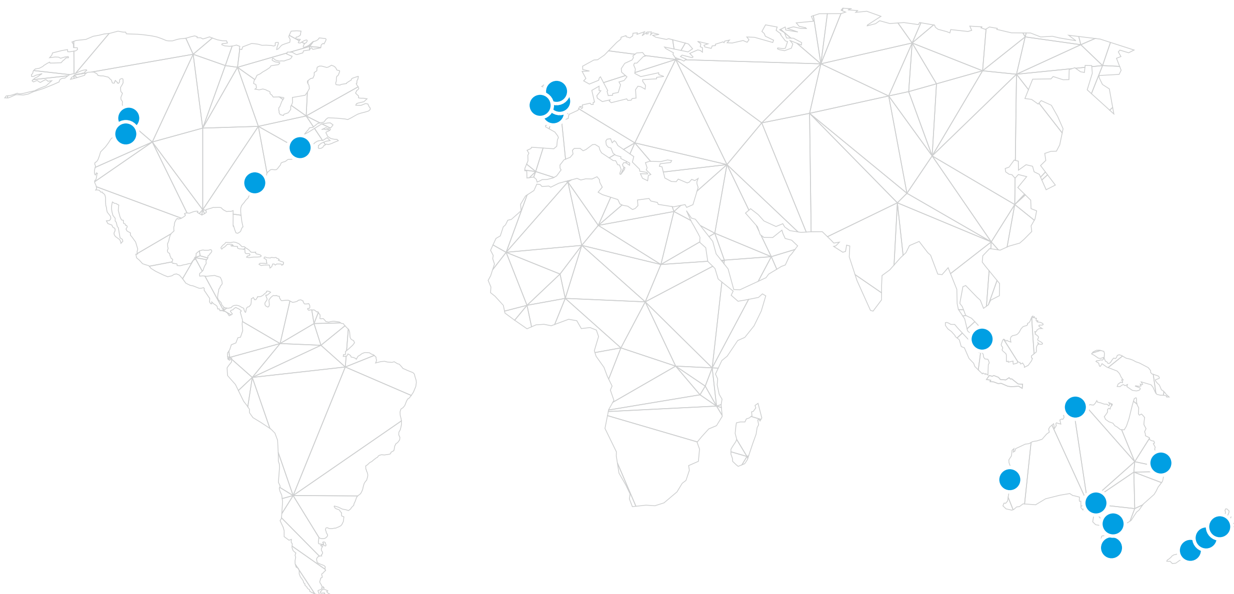
Amir is a Principal Power Systems Engineer with over 15 years of experience in the analysis, planning, research, and design of power systems. His experience in industrial projects as well as research works has ranged from power system modeling and analysis to transmission line and substation design.

Luke Livermore, Ph.D.

Luke is an electrical engineer with extensive experience in HVDC interconnector projects through tender to contract stage with expertise in technology capability, costs and programme. He has developed technical specifications for interconnector projects, specifically converter station equipment design, system studies, control and protection, spares and maintenance.

At PSC, we're helping power a more sustainable world

Our global team of electricity experts has been tackling the thorniest problems for some of the most prominent industry players for over 25 years. By empowering people to make a difference and do the right thing, we help our clients and employees innovate and thrive in a rapidly changing industry.



Specialist Consultants to the Electricity Industry

pscconsulting.com

New Zealand
Wellington
+64 4 232 7680

Australia
Fortitude Valley, QLD
+61 1300 933 632

North America
Kirkland, WA
+1 425 822 8489

Europe
Warwick, UK
+44 1926 675 851

Asia
Singapore
+65 9823 1912