AECOM

Shannon Technology and Energy Park (STEP) Power Plant

Appendix A3.1: Baringa Report

Shannon LNG Limited

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The Baringa Shannon Wholesale & Ancillary Revenue Report

In order to run the grid in a secure manner EirGrid must procure services from dispatchable generators (e.g. thermal power plants) to account for the intermittent nature of renewable sources (e.g. wind). These services include the provision of reserves of power, inertia and management of the rate of change of frequency. As the penetration of renewables increases out to the predicted 2030 and 2050 levels, the need for these services to manage running the system with higher percentages of output from variable sources (e.g. wind, solar) will increase.

For example, as the level of renewable generation on the system at any one time increases, thermal power plants have their dispatch quantities decreased by EirGrid to facilitate the output of the renewable power plants. However, a certain number of dispatchable plants must remain on the system to provide the services mentioned above. "Positioning" is when the grid operator keeps a power plant running so as to be on standby to provide these services to the grid operators in real time. This is a vital process for grid stability; however, with inflexible power plants it can lead to larger than necessary power plants being positioned. This causes increased emissions, increased curtailment of renewables (to make room for the positioned power plant) and increased costs.

Eirgrid has advised the Applicant in pre-application consultations that to ensure grid stability in the context of increased contribution to the grid from renewable sources, the future grid requires flexible gas-fired power plants with high inertia[1], low minimum stable generation and fast response capability. Ireland's National Energy and Climate Plan 2021-2030 supports this advice noting in section 2.4.2 that:

> *In addition, as Ireland transitions itself to a low carbon economy, the gas and electricity networks must be planned and developed to make the transition as smooth as possible. As we make the transition the energy networks in Ireland will face many challenges. For example, as the penetration of electricity generated from wind increases the electricity network must be flexible to handle the unpredictability of wind while still operating in a secure manner. The increased penetration of wind energy also places an increased reliance on Ireland's gas network*

The Commission for Regulation of Utilities in their Draft Opening Statement for the Joint Oireachtas Committee on Climate - Sector by sector analysis towards a 51% reduction in emissions by 2030 over 2018 levels, July 6th, 2021 noted

> *The twin challenges of replacing a large part of our existing generation fleet, while meeting rapidly growing demand, means that a minimum of 2GW of new gas-fired plant will be needed in the next few years. This **flexible** capacity is required to support increased renewables, enable us to retire older carbon intensive plant (coal, peat and oil) and ensure security of supply.* **[emphasis added]**

[1] One of the challenges with increased renewable (wind) generation on the system is a potential for an increased rate at which the grid frequency falls. This is known as the rate of change of frequency (RoCoF). Events that result in high RoCoF levels can potentially lead to instability in the power system. All power systems, including the Irish power system, have inertia. Inertia is a resistance to change in motion. The inertia on the power system resists the RoCoF and helps maintain system stability.

Captured Carbon

Given the above, the applicant commissioned a detailed market analysis (*the Baringa Shannon Wholesale & Ancillary Revenue Report*) report to consider these issues and model the future operation of the power plant from 2023 to 2050. Other power plant configurations were also modelled. The model assumes the government's 70% renewable by 2030 target is met. The Baringa Shannon Wholesale & Ancillary Revenue Report is a forecast for the possible future operation of the power plant.

The study makes reasonable assumptions on the many factors that influence power plant dispatch and operation from now to 2050. Such factors, for example include the rate at which renewable generation is built out from now to 2050, future commodity prices, technology costs, generator bidding behaviour, and governmental and regulatory policy. It also incorporates the key system constraints which are imposed by EirGrid in its operation of the grid. These include the system non-synchronous penetration (SNSP) limit, and system stability ('min gen') constraints.

For commercial confidentiality reasons, and intellectual property rights, elements of the report have been redacted. However, the main summary point of the report are as follows;

- The multi-shaft configuration rather than a single shaft, and incorporation of a battery energy storage system BESS, has the effect of lowering the minimum stable generation level (i.e. the minimum output of electrical power the plant can be lowered to by EirGrid before being shut off) allowing the Power Plant to provide the necessary services at lower output levels, and hence lower emissions, than other Power Plants while providing fast frequency response and high inertia.
- If the Power Plant were not designed in such a way, the same need for services would sit with EirGrid and they would be forced to get these services from another plant which would be more carbon intensive. Accordingly, the flexibility designed into the plant is better able to accommodate the needs of EirGrid in facilitating a higher penetration of renewables.
- Where EirGrid cannot secure the grid to its safety standards via the procured services it becomes necessary to curtail the production of renewable power; the design of the plant to include additional flexibility in its output better allows for EirGrid to use this flexibility to avoid curtailment of renewable power and increase the overall production of renewable power plants each year.

In conclusion, analysis confirmed that the flexibility of the Power plant, including the BESS, is ideally aligned with a high-renewable market from now to 2050. In particular, the power plant offers the market high inertia, very low minimum stable generation and fast response capability.

Attachment 1 *Baringa Shannon Wholesale & Ancillary Revenue Report* (redacted)

Baringa
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Irish CCGT gross margin projections

Asset report

Shannon LNG
November 2020

Introduction to wholesale market modelling

Baringa

We have modelled two configurations of CCGT plant in the I-SEM market

- Baringa has been mandated to support Shannon LNG Ltd in appraising the development of the main value drivers and revenue streams for a flexible thermal asset in Ireland.
- We have modelled two different types of flexible CCGT assets against Baringa Reference Case projections. The asset types analysed are:
  - 1 unit – single shaft CCGT (600 MW [redacted]
  - 3 units – multi shaft CCGT (200 MW [redacted]
- We modelled the asset configurations using our price-taker asset model to project their economic operation in the unconstrained wholesale electricity market (day-ahead market).
- We first projected the gross margins and dispatch of the assets in our Reference Case market scenario.
  - This is our independent in-house 'central' scenario for the Irish power market. It uses central views on commodity prices, technology costs, generator bidding behaviour, and governmental and regulatory policy.
- [redacted]
  - [redacted]
  - [redacted]
- We then used our 'constrained' model of the Irish power market to determine how the physical operation of the CCGT could change, taking account of constraint actions taken by EirGrid.
  - Our constrained model incorporates the key system constraints which are imposed by EirGrid in its operation of the grid. These include the system non-synchronous penetration (SNSP) limit, and system stability ('min gen') constraints.
- Finally, we used our integrated DS3 model to project the potential ancillary services revenues for the CCGT under the Reference Case.
- [redacted]
  - [redacted]
  - [redacted]

Key assumptions: Technical parameters

We used the following client technical parameters in our modelling of the two CCGT configurations

Technical Plant Parameters

Variable	Unit, real 2020	Single shaft	Multi shaft
Number of units	MW	1	3
Maximum capacity @ station gate	MW	600	200
Maximum capacity – unifired	MW	n/a	164
Intermediate load point	MW	450	123
Minimum stable level (MSL)	MW	176	41
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Wholesale market dispatch: Reference Case

[redacted]

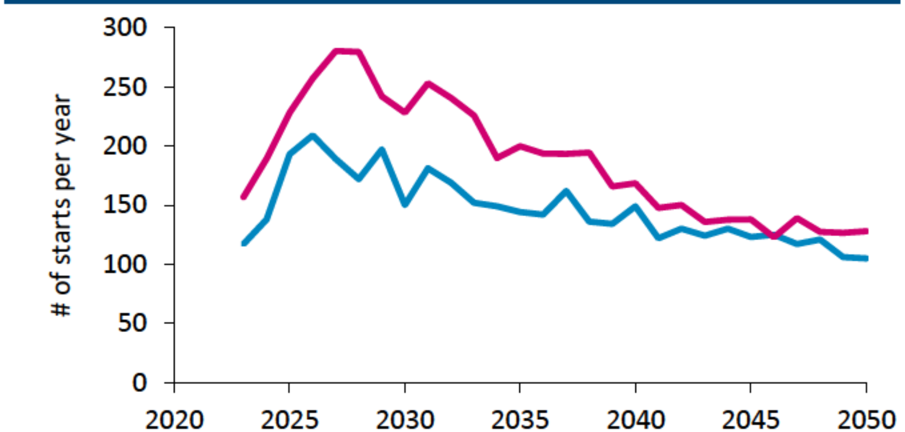
Overview

- [redacted]
  - [redacted]
  - [redacted]
- The number of running hours is quite similar between the two configuration suggesting that the multi shaft configuration on average runs at a lower generation level relative to maximum capacity.
- The number of starts per year is higher for the multi shaft setup reflecting the higher degree of flexibility for that configuration.

[redacted]

[redacted]

Number of starts per year



Introduction to constraint payments

Baringa

In addition to revenues from the wholesale energy market, thermal plant are exposed to system constraint actions in Ireland

- EirGrid, the transmission system operator (TSO) of SEM takes actions to adjust the output of plant in order to maintain the stability of the grid. Plant can be turned up or turned down from its nominated / traded position. These actions can include turning on a plant when it would be economical to run based on market prices, as well as curtailing a plant completely that otherwise be 'in the money' based on market prices.
- [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
  - [redacted]
- [redacted]

[redacted]

- [redacted]
- [redacted]
  - [redacted]
  - [redacted]
- We assume that the asset can be constrained on / off to meet each of the following key system-wide constraints. The asset is also assumed to be able to meet the local 'Moneypoint' constraint:
  - SNSP (System Non-Synchronous Penetration) limit;
  - Minimum inertia on the system;
  - RoCoF (Rate of Change of Frequency) limit;
  - Minimum units on-load required for dynamic system stability;
  - At least one local unit (currently MP1, MP3, TYC) must be on-load at all times to support the 400kV network in the area.

Future system constraint assumptions

Our assumptions of future evolution of system constraints in SEM is based on latest announcements from EirGrid, including 2019 TES scenarios

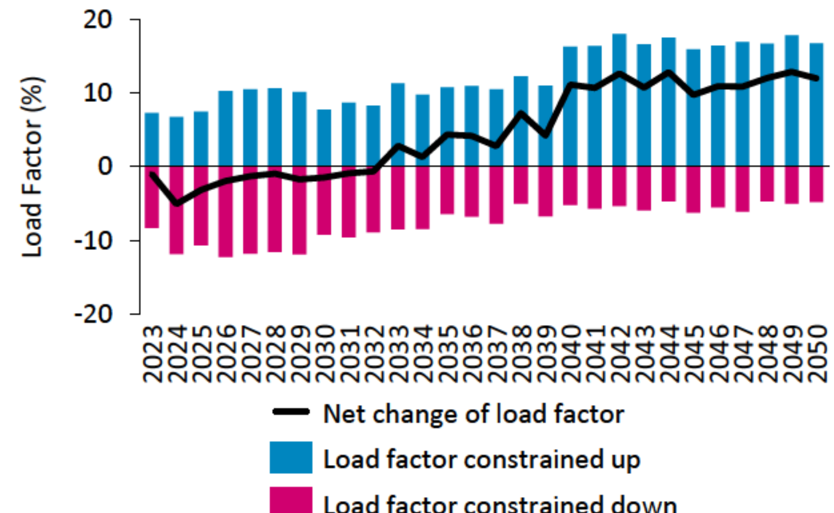
Parameter	2020 - 2024	2025 - 2029	2030 +
SNSP limit	65% 70% from Oct. 2020 75% from Apr 2021	80%	90%
Minimum inertia (MWs)	23000 20000 from Jul. 2020 17500 from Jan. 2021	15000	n/a
RoCoF limit (Hz/s)	0.5 1 from Oct. 2020	1	1
System stability minimum units	5 ROI 3 NI 2 NI from Jan. 2021	5	4 3 from 2035

System constraint actions: Dispatch results

[redacted]

- [redacted]
  - [redacted]
  - [redacted]
- The net result of these actions is to reduce the unconstrained load factor of the asset until 2033, with the largest reduction of 5% seen in 2024.
- The remaining years of the horizon see the plant dispatch increased overall, with an increase in load factor of 12% seen in 2050.
- [redacted]
  - [redacted]
  - [redacted]

Change in load factor (%)



[redacted]

Hours constrain [redacted]

Hours constrain [redacted]

The flexibility of the asset allows it to capture significant margins from several DS3 services

[redacted]

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