Question 3.2.2:

Worldwide the economic impact of new power lines has to be weighed between environmental impact, economic consideration as well as technical capability. With this in mind, what is the general methodology followed when designing new power lines or refurbishment of existing lines both underground and overhead?

Response:

Ireland and Northern Ireland have one of the highest levels of variable renewable generation in a single synchronous power system anywhere in the world. The power system on the island is now accommodating up to 75% System Non Synchronous Penetration (SNSP – the ratio of non-synchronous generation and net interconnector imports to demand and net interconnector exports, see paper ID 11016 in C4 Power System Technical Performance and C4 poster session Wednesday afternoon)

Accommodating these levels of renewable generation requires transmission network reinforcement through new-build transmission circuits, both overhead and underground, as well as upgrades to the existing grid.
The success of these network reinforcement projects is crucial to assisting Ireland meet its ambitious decarbonisation targets which includes up to 80% of electrical energy from renewable sources by 2030.
To meet these targets the connection of at least 7GW of new offshore wind generation, up to 8GW of onshore wind generation, approx. 5.5GW of solar PV generation to the grid, and operation at levels up to 95% SNSP.
In 2014, EirGrid developed our Six Step Framework for Grid Development[1]. This ensures we engage openly, transparently, consistently and participatively when developing major new network reinforcement projects in Ireland. The steps of the framework are described at a high level in Figure 1.
The Six Step Framework for Grid Development aims to ensure that all relevant stakeholders are engaged throughout the lifetime of a project and that this is supported with the appropriate level of detail and information.

[1] https://www.eirgridgroup.com/__uuid/7d658280-91a2-4dbb-b438-ef005a857761/EirGrid-Have-Your-Say_May-2017.pdf

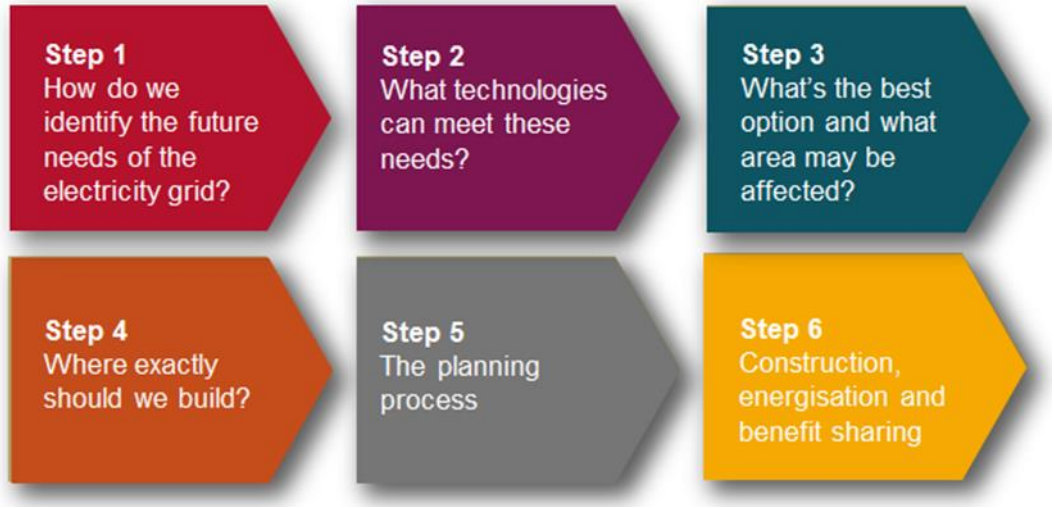

Figure 1 – High level description of the EirGrid Six Step Framework for Grid Development

Step 1 of the process involves identifying future network needs on the transmission system. To achieve this a robust system of scenario analysis is undertaken. This relies on input from a wide range of stakeholders across the power industry and from government and policy makers. These inputs are used to generate a range of potential futures describing differing levels of optimism and ambition when looking to the future of electricity use. By applying these inputs in transmission system modelling tools in a system needs assessment the needs of the power system in the future can be identified. The system needs assessment is supplemented by analysis related to the connection of new generation and large-scale demand at specific locations. Most recently, EirGrid completed its largest consultation and engagement process to date, Shaping Our Electricity Future[2], which took a whole of society approach to identifying how to prepare the grid to meet 2030 renewable energy targets. This, coupled with regional energy roadshows, has provided a more meaningful role for community stakeholders in Step 1 of this framework.

Steps 2 and 3 of the process relate to the design of options to meet the needs involved and the reduction of a long list of options toward an emerging best performing option. Step 4 relates to selection of circuit routes or substation locations.

The analysis in Steps 2, 3 and 4 is underpinned by EirGrids Decision Making Framework which relies on Multi-Criteria Assessment to ensure all relevant inputs to the selection of the best performing option are considered. For network reinforcement projects five main criteria are used. These are:

- Technical Performance,
- Economic Performance.
- Environmental,
- Socio-Economic, and
- Deliverability.

Sub-criteria of the main criteria can be selected as appropriate.
Each option at each step of the process is compared against the others in terms of the five main criteria and the selected sub-criteria. A colour coded scale is used to grade the significance, difficult, or risk associated with the evaluation of each criterion. Figure 2 shows the colour scale used and the range of application.

[2] https://www.eirgridgroup.com/the-grid/shaping-our-electricity-f/

Figure 2 – Scale used to assess each criterion

This scale is clarified by text, as follows:

- High: dark blue;
- Moderate-high: blue;
- Moderate: dark green;
- Low-moderate: green; and
- Low: cream.

In Step 2 a technology review is undertaken to identify appropriate technologies to use to meet the identified need. The technology review focusses on making best use of the existing grid before developing new circuits. Therefore, the technology review initially focusses on circuit uprates, network reconfiguration, power flow controlling devices, etc. Where these are insufficient to meet the need overhead line and underground cable technologies are considered for new circuits at the appropriate operating voltage levels, new transformers where appropriate or required, as well as Air Insulated, and Gas Insulated Switchgear substations where required. The results of the technology review leads to the development of a long list of options to meet the need. Analysis is carried out to refine the long list and begin the process of determining the best performing option. As the process of refining the long list proceeds, and the list becomes shorter, the level of detail in the analysis is increased.

In Step 3 the remaining short list of options is compared in detail. It is in this step that detailed analysis is undertaken to understand aspects of the technical performance of the options. For new circuits, especially underground cable circuits, analysis of reactive compensation requirements, harmonic amplification, temporary overvoltage, voltage and transient analysis, short circuit analysis, among others, are undertaken. Similarly, detailed analysis is undertaken across the economic, environmental, socio-economic, and deliverability criteria.

Step 4 relates to route selection for new circuits, or site selection for new substation. Again, multi-criteria assessment across the relevant criteria is carried out to select the best performing route or site. The technical analysis carried out in Step 3 is re-visited and refined as circuit route lengths are finalised and the final conductor selection is made.

Step 5 relates to the consenting process, and Step 6 then relates to the construction and energisation of the reinforcement. Generally, these steps do not require multi-criteria assessments.

An example of a completed Step 3 multi-criteria assessment using the comparative colour scale is shown in Figure 3.

	Option 1	Option 2	Option 3	Option 4
Technical Performance				
Economic Performance				
Deliverability				
Environmental				
Socio-Economic				
Combined Performance				

Figure 3 – Sample Step 3 Multi – Criteria Assessment for a project with 4 options.