National Grid's Future Energy Scenarios:

Decarbonisation Based on Import and New Nukes

National Grid (NG) publishes every year the Future Energy Scenarios (FES)[1]. The report is describes as *"a range of plausible and credible pathways for the future of energy from today out to 2050"*.

Other NG publications are based on the FES. The 2017 edition mentions for instance:

- Electricity Capacity Report
- Electricity Ten Year Statement
- Gas Ten Year Statement
- System Operability Framework
- Future Operability Planning
- Network Options Assessment
- System Needs and Product Strategy

The four 2017 Future Energy Scenarios are:

- Two Degrees: A world where environmental sustainability is top priority
- Slow Progression: A world focused on long-term environmental strategy
- Steady State: A world focused on security of supply and short-term thinking
- Consumer Power: A world which is relatively wealthy and market driven

The four scenarios are arranged in a matrix (fig. 1): less or more focus on green ambition and less or more money available. The extremes are Steady State and Two Degrees.

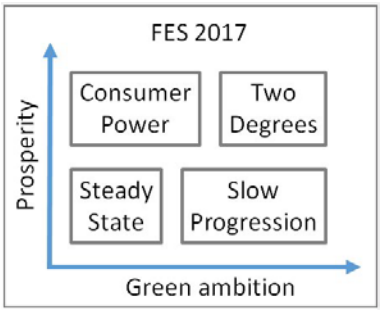

Fig. 1 - The scenario matrix

Future prosperity will depend on economic conditions, which are difficult to predict. A sustained green ambition depends on political determination. Both high green ambitions and high prosperity are necessary conditions for meeting the reduction targets for future British carbon emissions[2].

FES 2017 is well written and published in an inviting layout.
All details are available in a separate Charts Workbook. NG's documents are recommended for further studies of the British ideas of the future energy supply.

This introduction will have special focus on the most ambitious scenario, *Two Degrees*.

Two Degrees – Green ambitions boosted by high prosperity

NG introduces *Two Degrees* with this text: *"Two Degrees has the highest level of prosperity. Increased investment ensures the delivery of high levels of low carbon energy. Consumers make conscious choices to be greener and can afford technology to support it. With highly effective policy interventions in place, this is the only scenario where all UK carbon reduction targets are achieved."*

[1] http://fes.nationalgrid.com/
[2] The first section of the UK Climate Change Act 2008: *"It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline."*

The future demand for electricity and gas is discussed in chapter 3 of FES 2017 together with new related technologies. It is supposed that electrification of heating and transport will increase demand for electricity and reduce demand for gas.

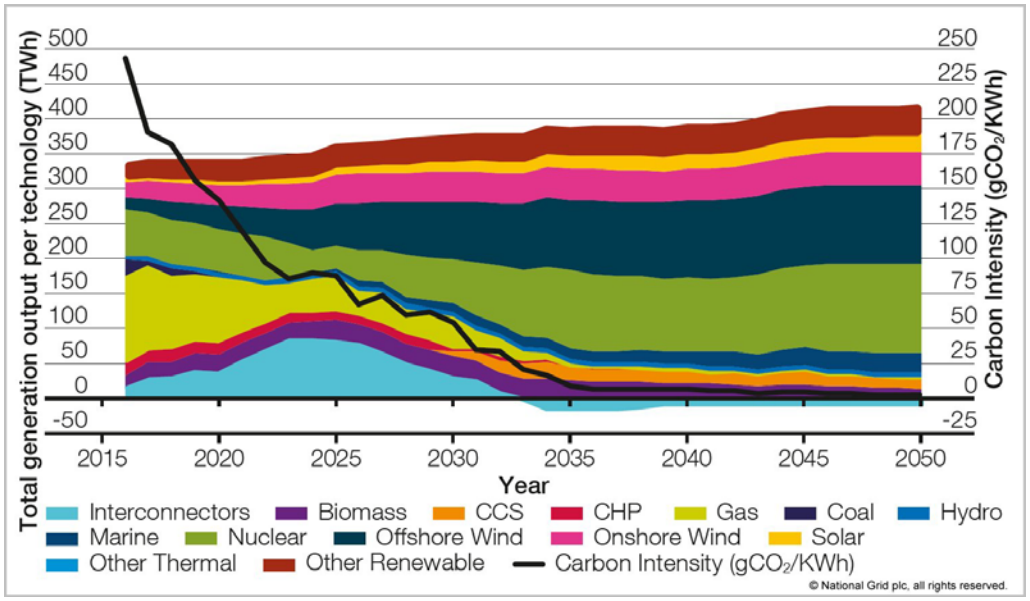

Fig. 2 - Two Degrees - Generation output and carbon intensity

The carbon intensity from electricity production in *Two Degrees* falls from 242.6 gCO_2/kWh in 2016 to 2.3 gCO_2/kWh in 2050 (fig. 2). The rapidly decreasing carbon emission has been achieved by *electricity import* (up to 82 TWh in 2024) and after 2025 by an increasing share of *nuclear energy*. The main electricity sources in *Two Degrees* by 2050 are:

- Wind: 39%
- Solar: 7%
- Other renewable: 8%
- Nuclear: 31%
- Marine: 7% (tidal and lagoon power plants)

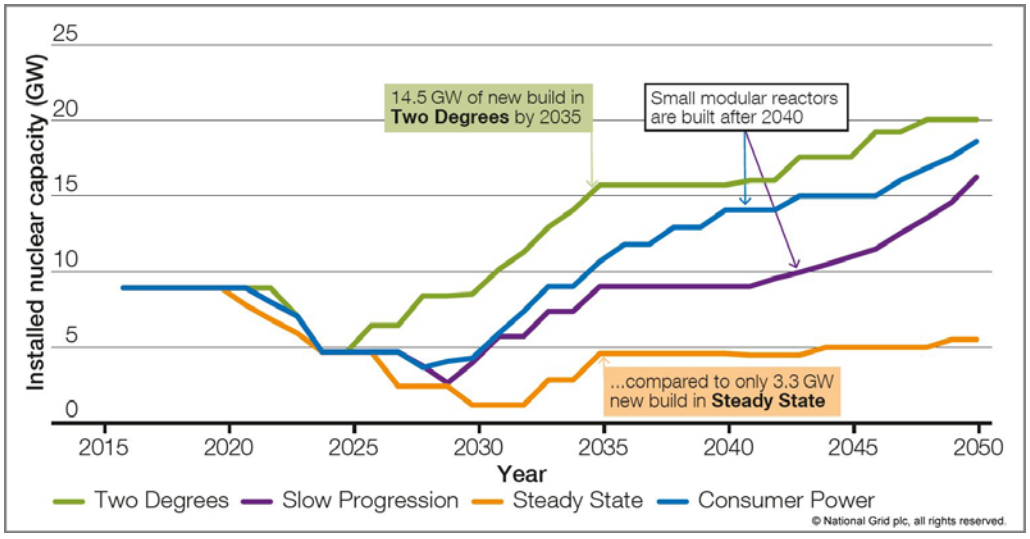

Fig. 3 - Nuclear Capacity in the four scenarios

14.5 GW new nuclear capacity is supposed to be commissioned between 2014 and 2050 in *Two Degrees*. It is obvious that investments in this programme will depend on the future availability of money.

It is striking that the reliance on import and new nuclear capacity are so decisive in the most ambitious green scenario.

System Operability – Future Challenges

The control of a power system is a complex matter. Supply and demand must continuously be balanced, and the balance must be resistant to unforeseen disturbances. Loss of control can result in power cuts or system blackout.

The increasing share of non-dispatchable power sources will cause new challenges for the safe and reliable operation of the power system. NG analyses the new challenges and discusses the findings in the regular publication *System Operability Framework* (SOF)[3]. The 2017 edition has not yet been published.

The slides from the launch of SOF 2016 discuss and explain in detail important issues, e.g.:

- Balancing
- Frequency management
- Voltage management
- Whole system coordination

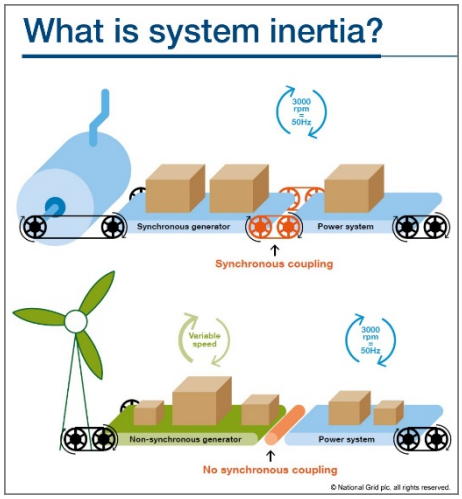

Fig. 4 - Difficult matters explained

These issues are intangible to most people. Most countries have had a committed energy debate for many years, but the operational problems have been practically absent in the debates. It is doubtful if political decision makers understand the scale of the new operational challenges.

NG makes a laudable effort to explain and illustrate the problems (example in fig. 4). A broader understanding may lead to the implementation of necessary new measures in due time.

New Interconnectors

The total British interconnector capacity increases from 4 GW to between 10 GW (*Steady State*) and 20 GW (*Two Degrees*) until 2035 in the four scenarios (fig. 5).

The import level in the mid-twenties is about 80 TWh in *Two Degrees*. Increasing renewable generation is assumed to lead to

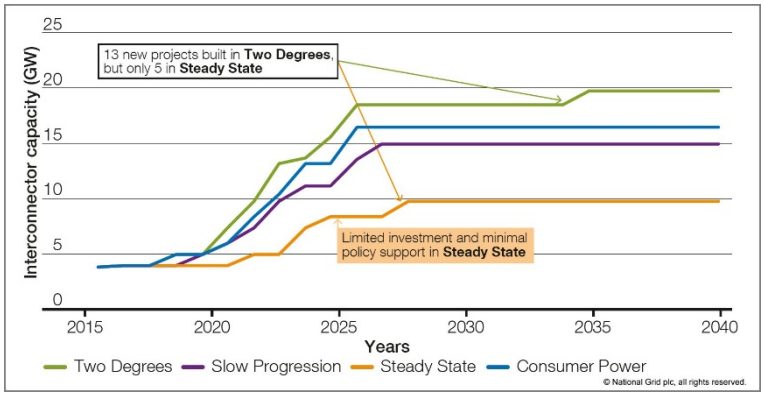

Fig. 5 - Total interconnector capacity in the four scenarios

[3] http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/

lower GB market prices and low net exchanges after 2030 (fig. 2).

FES 2017 emphasizes that UK's decision to leave the European Union (EU) has brought uncertainty to the future of energy trading arrangements between the UK and EU member states.

Uncertainty about exchanges and future trading arrangements suggests caution with the planning of expensive interconnectors, for instance across the North Sea.

Decreasing Demand for Gas

FES 2017 also includes demand and supply for natural gas. Several sectors are assumed to demand gas in 2050: industrial, commercial, residential, hydrogen conversion, transport and export to Ireland. The total demand for gas in *Two Degrees* in 2050 is 45 billion cubic metres (bcm) (fig. 6), which is lower than for the other three scenarios. The corresponding CO_2 emission is 83 million tons (after subtraction of six bcm of green gas).

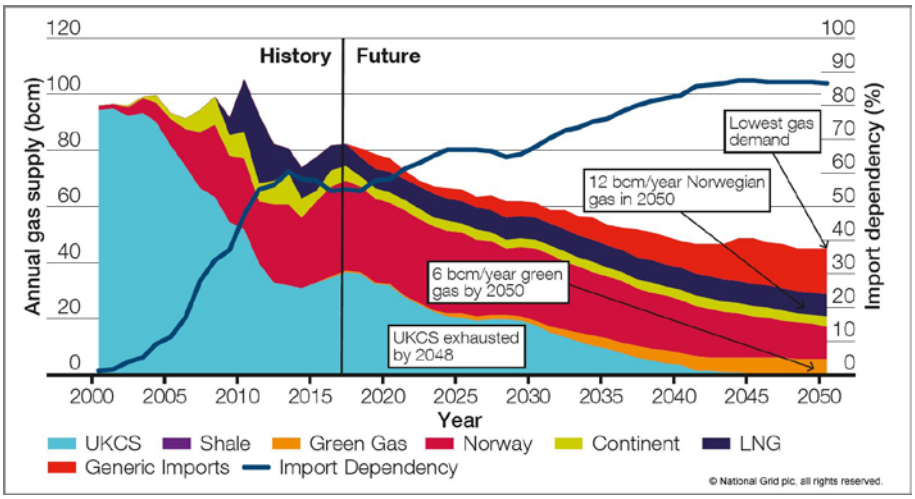

Fig. 6 - Annual gas supply pattern in Two Degrees

Generic imports could be LNG or continental gas or a mixture.

Imported gas will remain a necessary element of British energy supply long time after 2050. The import dependency makes the question of security of supply topical. FES 2017 states: *"There is sufficient gas available worldwide to meet GB demand throughout the scenario period."*

Besides wind and solar energy, imported gas and new nuclear power stations seem to be decisive to the transition into a more green future. The transition will be expensive. Political determination and availability of money are necessary conditions. Therefore, I consider the scenario matrix (fig. 1) to be well chosen.