Unlocking Large Volumes of Renewable Generation while Keeping Network Costs Low

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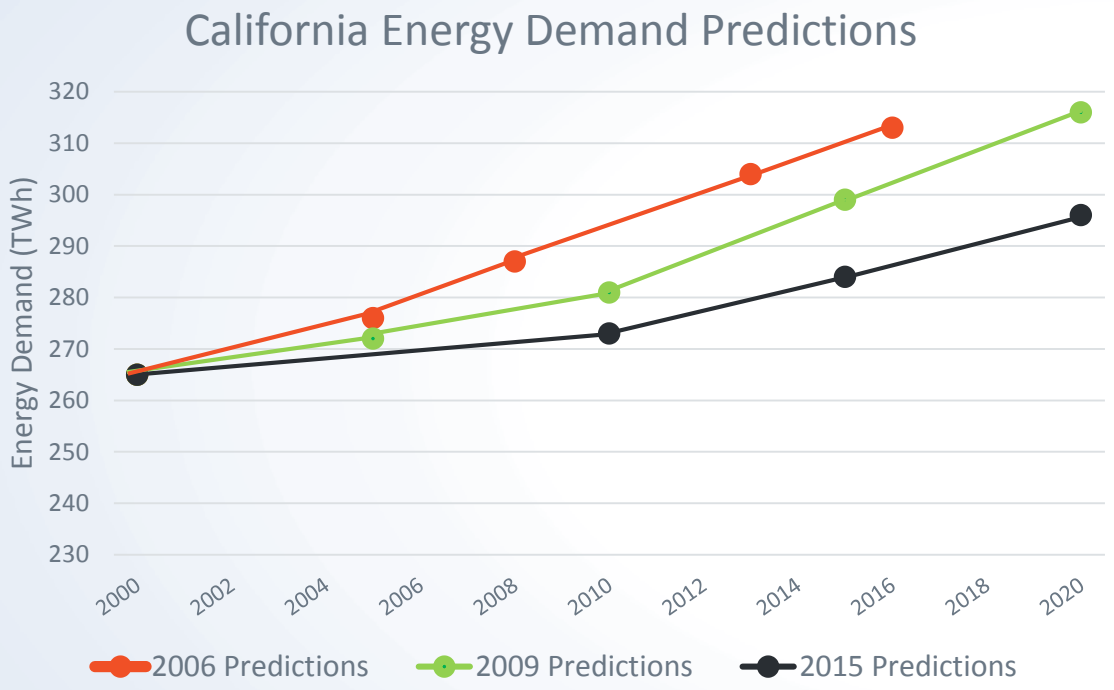
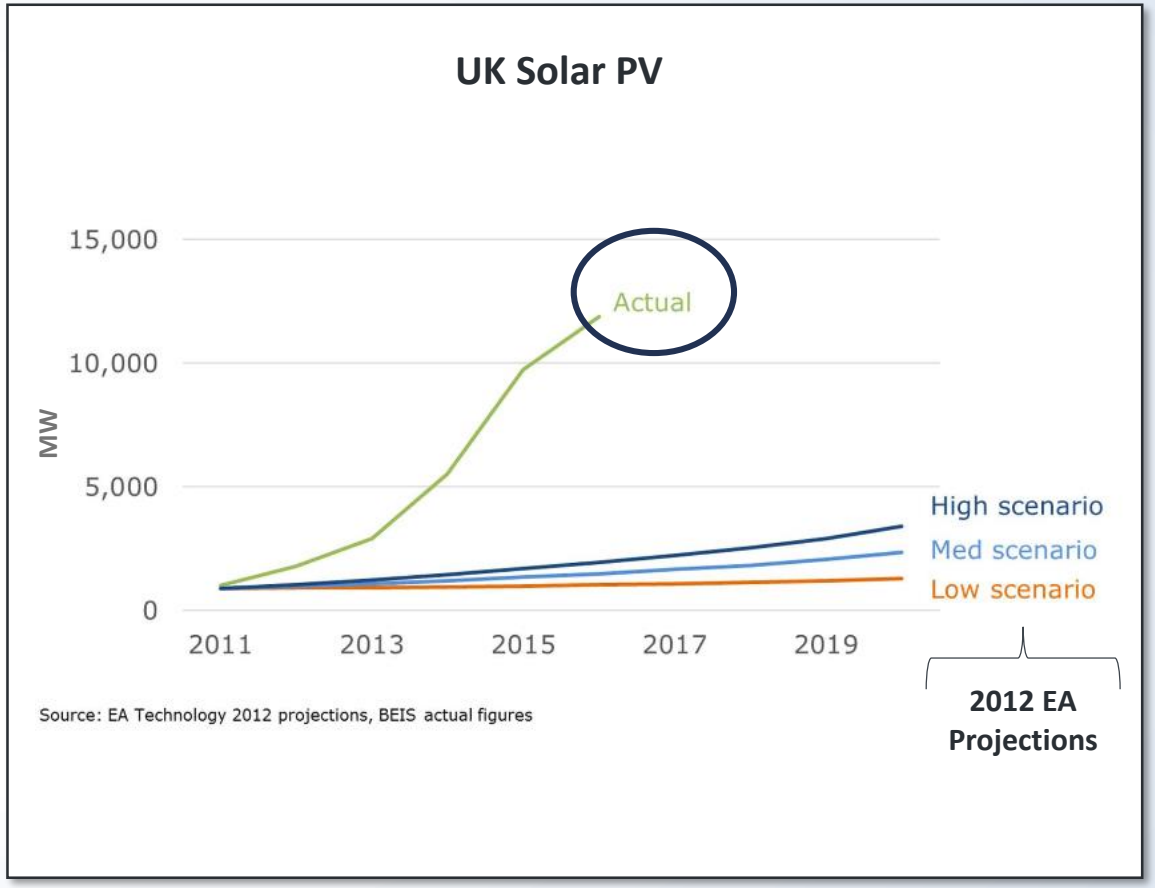
SMART WIRES
REIMAGINE THE GRID

Uncertainty & Change

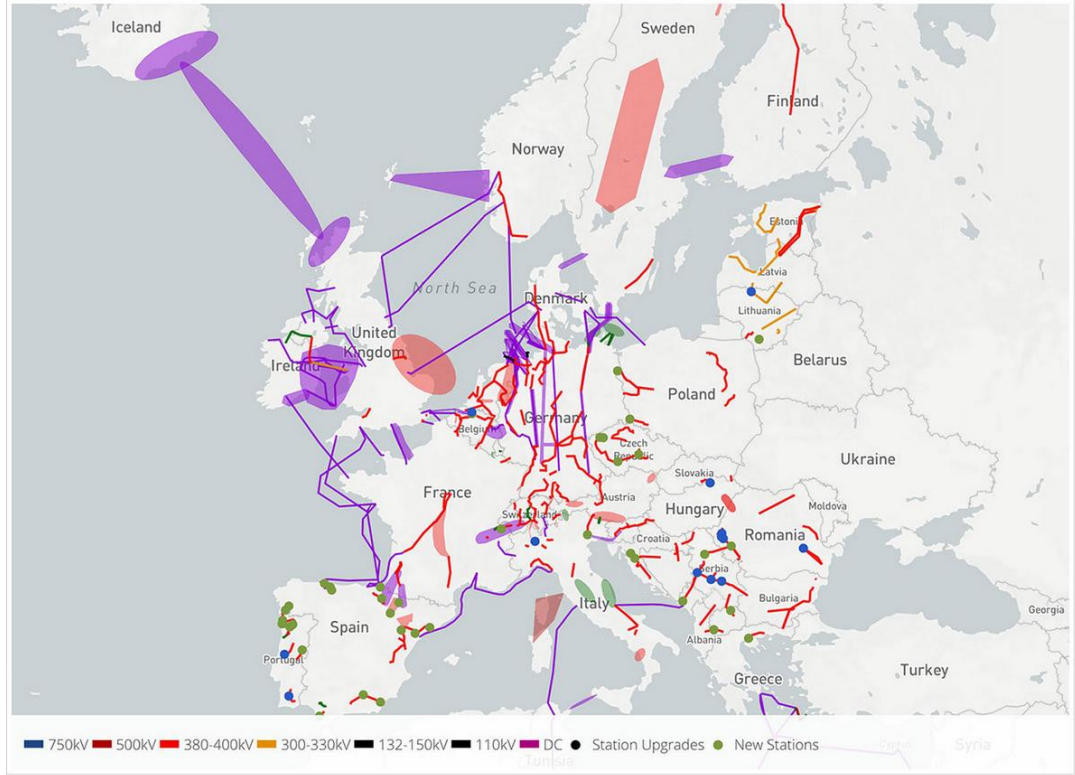




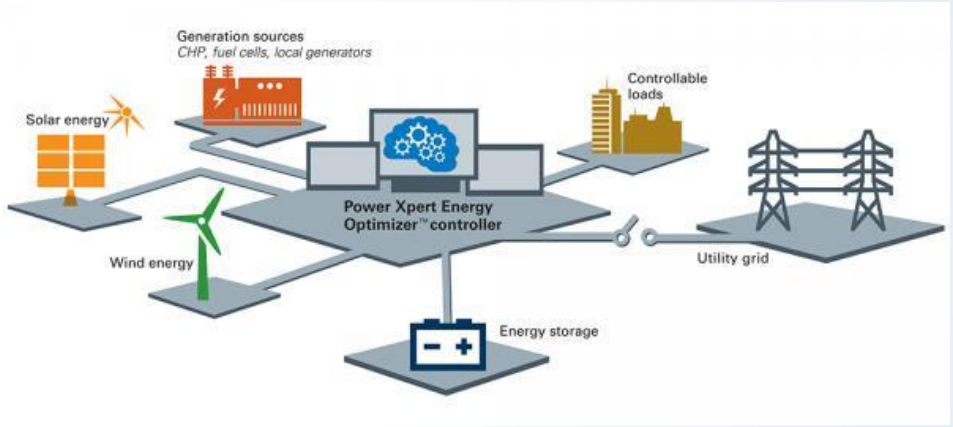
Future grid conditions are increasingly difficult to accurately predict.

Two Competing Visions to Unlock Largescale RES

Optimised Energy System over Large Area



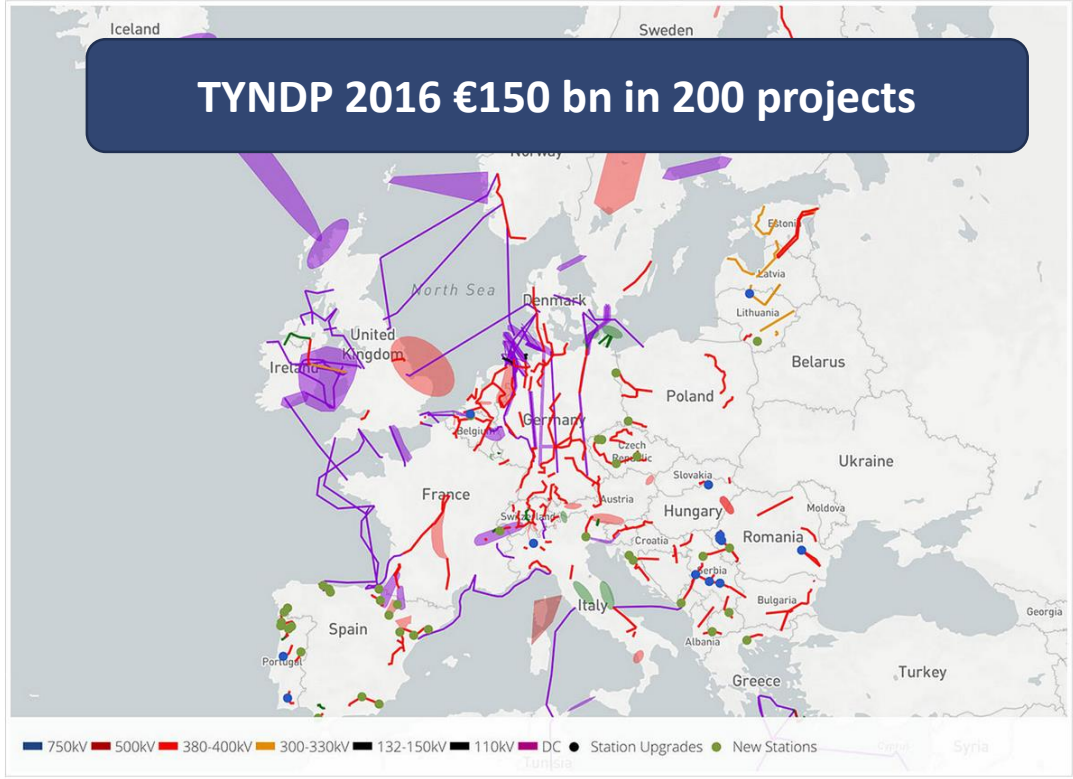
Community Microgrids



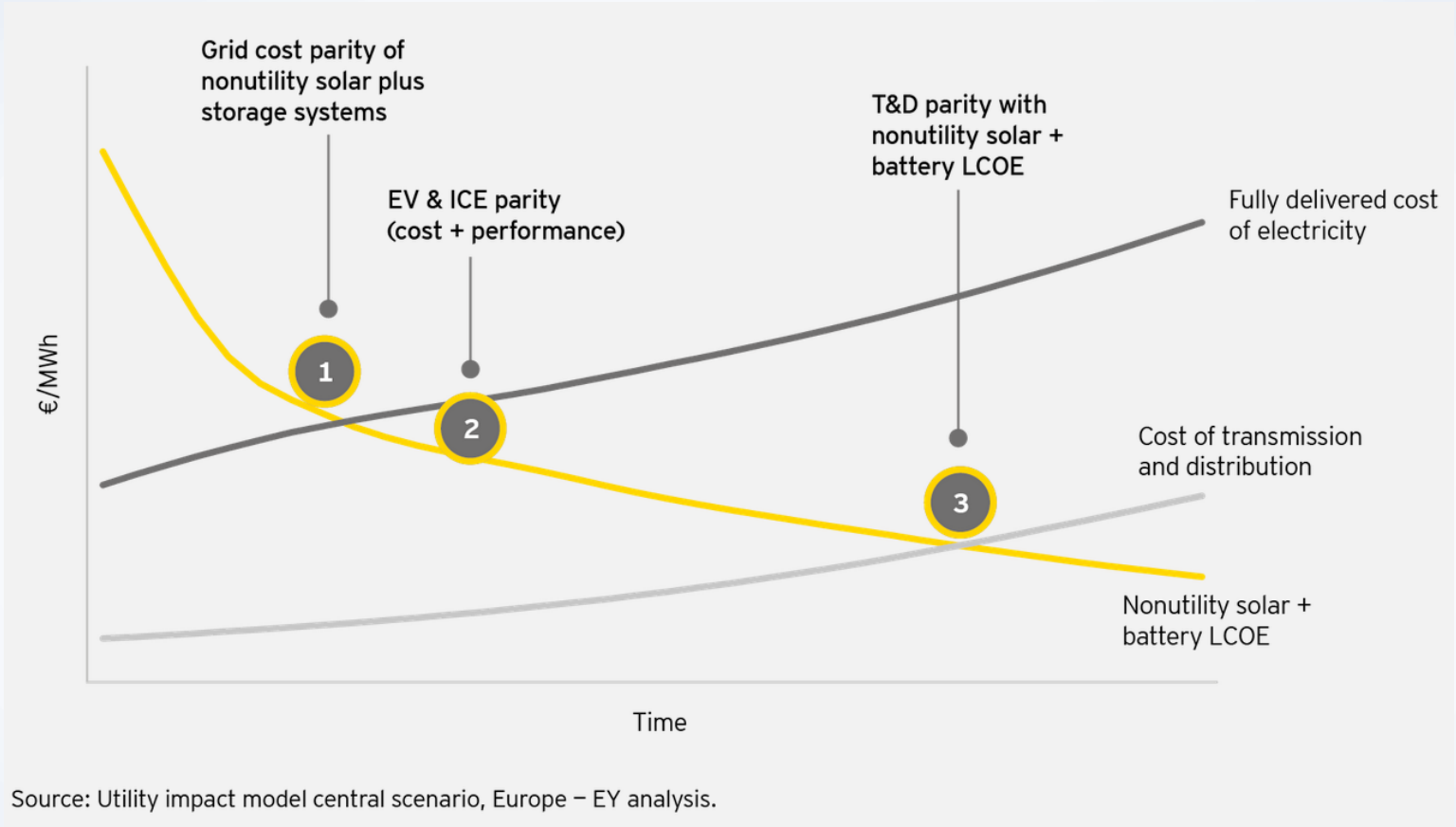
http://ieee.electricenergyonline.com/show_news.php?ID=3738

It is uncertain which vision or what combination of the visions will unfold to achieve a 100% renewable Europe.

Hundreds of Billions of Investment Planned



Tipping Points for Electric Utilities and the Electric Grid



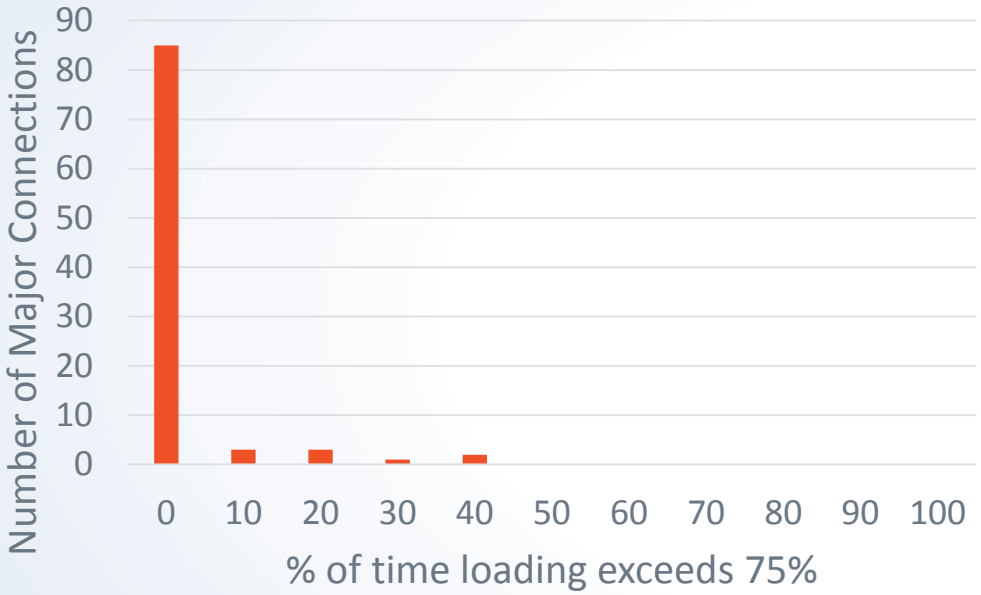
Source: Utility impact model central scenario, Europe – EY analysis.

Dates for tipping points vary across the globe based on regional trends and drivers, however Tipping Point 1 will arrive as early as 2021 in Oceania.

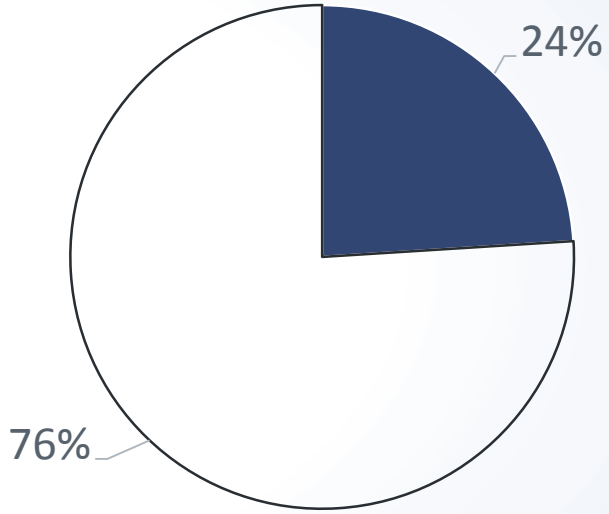
http://www.ey.com/gl/en/industries/power---utilities/ey-evolution-of-european-power-sector-likely-to-prompt-more-impairment
https://betterworkingworld.ey.com/digital/energycountdownclock

Low Network Utilization

US Eastern Interconnect



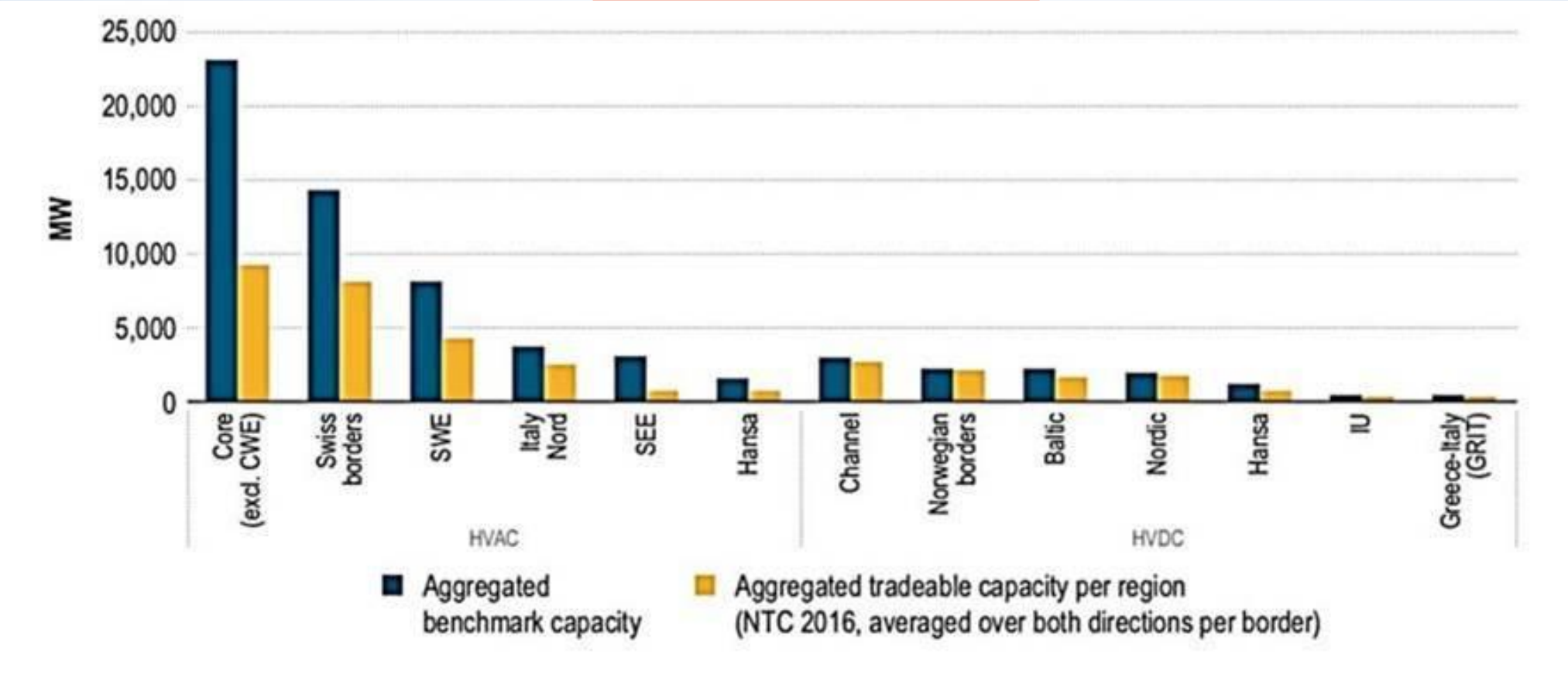
European HVAC Interconnections



Significant capacity exists on our networks today.

https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202015%20-%20ELECTRICITY.pdf

Europe Grid Utilisation



Germany limits imports from the Netherlands to some 12 percent of available interconnector capacity, while the Netherlands manages to allow 83 percent for flows in the opposite direction.

Ideas?

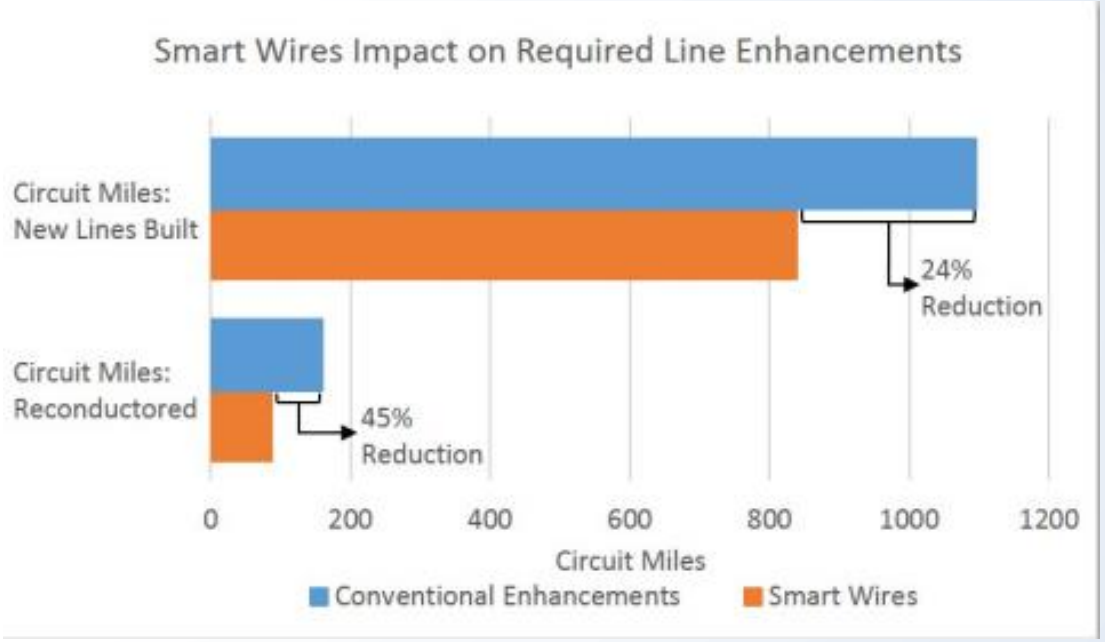
Defer Investments until needs emerge – Develop real options

Increase Flexibility – Use solutions that can adapt to changing need

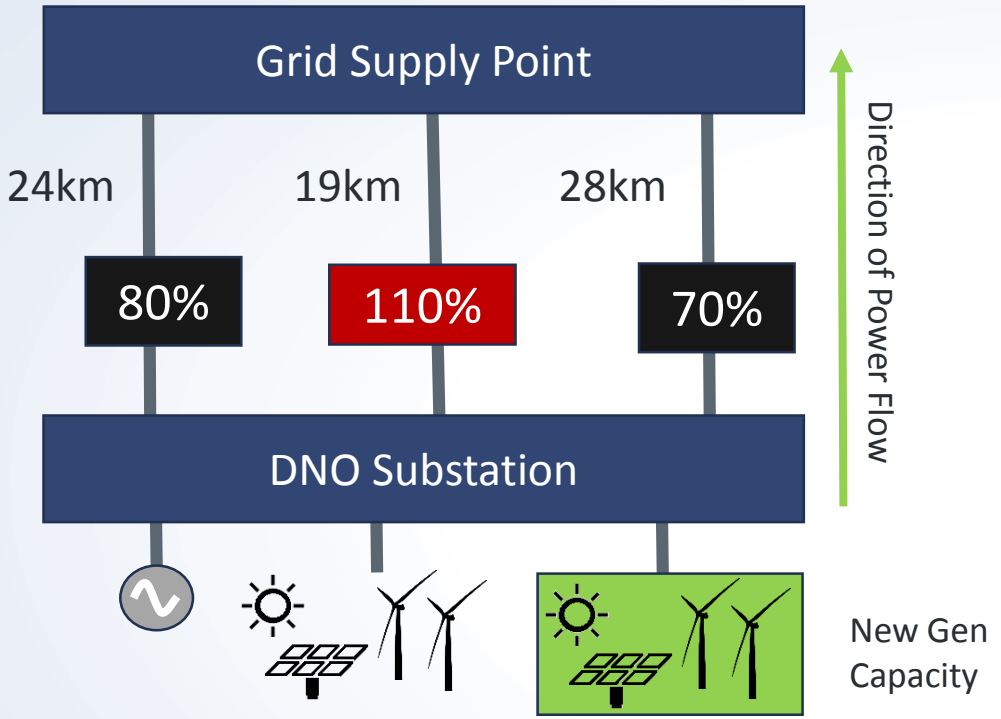
Maximise use of existing assets

Potential for Power Flow Control
DNVGL Study on PJM Footprint

- **Enable nearly 220,000 GWh of additional renewable generation,**
- **Reduce total CAPEX investment from $4 B to $2.2 B between 2020 and 2026**
- **Eliminate the need to build or reconductor nearly 300 circuit miles of transmission**
- **Deliver annual production cost savings of nearly $630 M**



Increase Renewable Penetration



Smart Wires **can balance line loading on parallel circuits**

Smart Wires **can relieve generation constraints or release additional generation capacity**

Capacity can be better utilized without building new infrastructure.

Overview:

- Distribution Network constrained by uneven loading on three parallel lines.

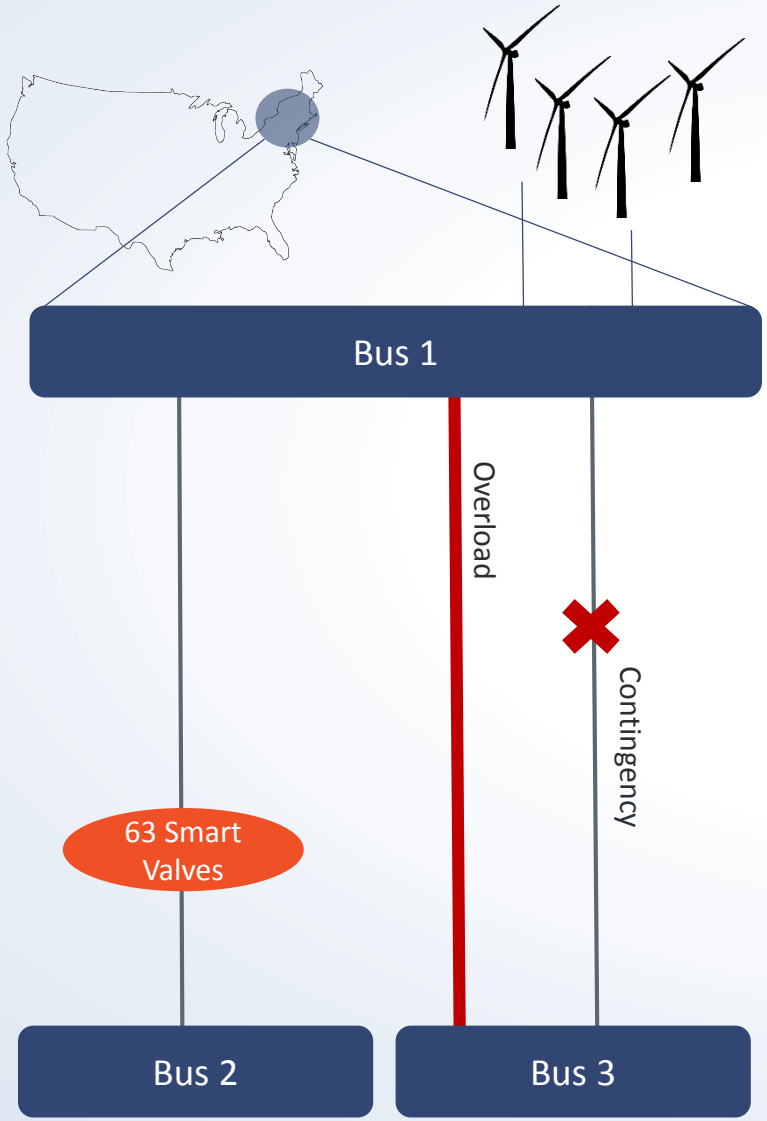
Solution:

- A hybrid power flow control solution involving 21 Power Guardians and 147 PowerLine Guardians was designed to meet granular control requirements and specific environmental constraints.
- The solution can be scaled up or down as required. Solution size and location may change depending on the level of new generation that connects

Impact:

- Active Management/Balancing loading between the three circuits delivers nearly **200 MW** in new generation capacity.
- The connection of these resources is expected to produce over GBP 3.5m in annual savings for consumers and avoid 90,000 tonnes of CO_2 per year.

Providing Renewable Generation Capacity



Objective:

- Determine how much series compensation is required to release 158 MW of renewable generation connection capacity.

Solution:

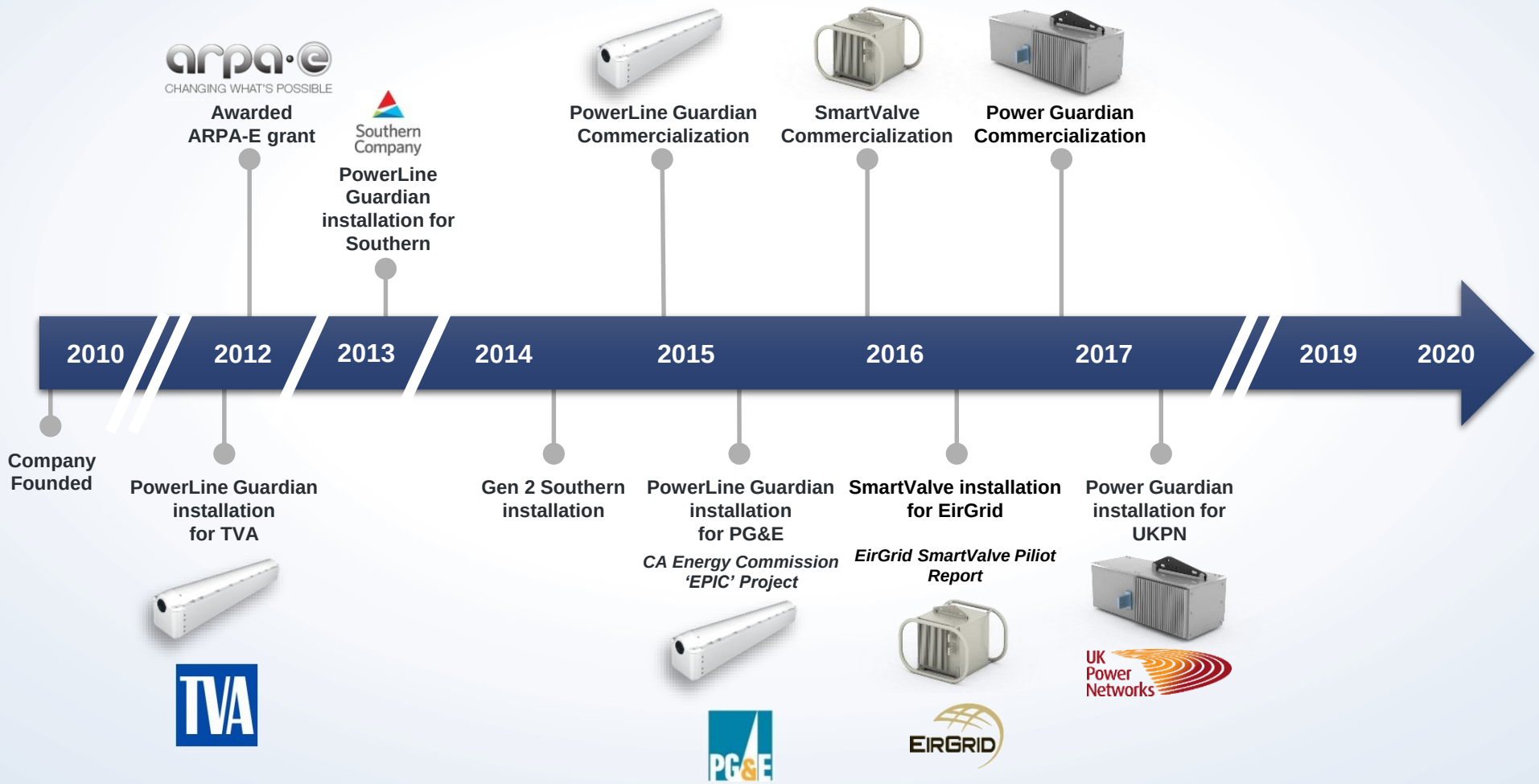
- Add 63 **SmartValves** on Bus 1 – Bus 2

Impact:

- 3.5 Ohms Power flow control can unlock an incremental **160 MW** of *existing* network capacity on this 345kV corridor
- The circuit was rated to 3400A and the Smart Wires solution provided a change in flow of 368A.

SMART WIRES
REIMAGINE THE GRID

A New Paradigm of Power Flow Control



Global Adoption

Customers include over 20 of the world's largest grid operators

Thank you

For your Attention