Offshore Transmission Planning – Lessons Learned

New Jersey Offshore Wind Transmission Stakeholder Meeting

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SAFER, SMARTER, GREENER

Leveraging our experience to support the offshore wind industry

85 YRS

Power grid &
Electrical
engineering

45 YRS

Offshore
Oil and Gas

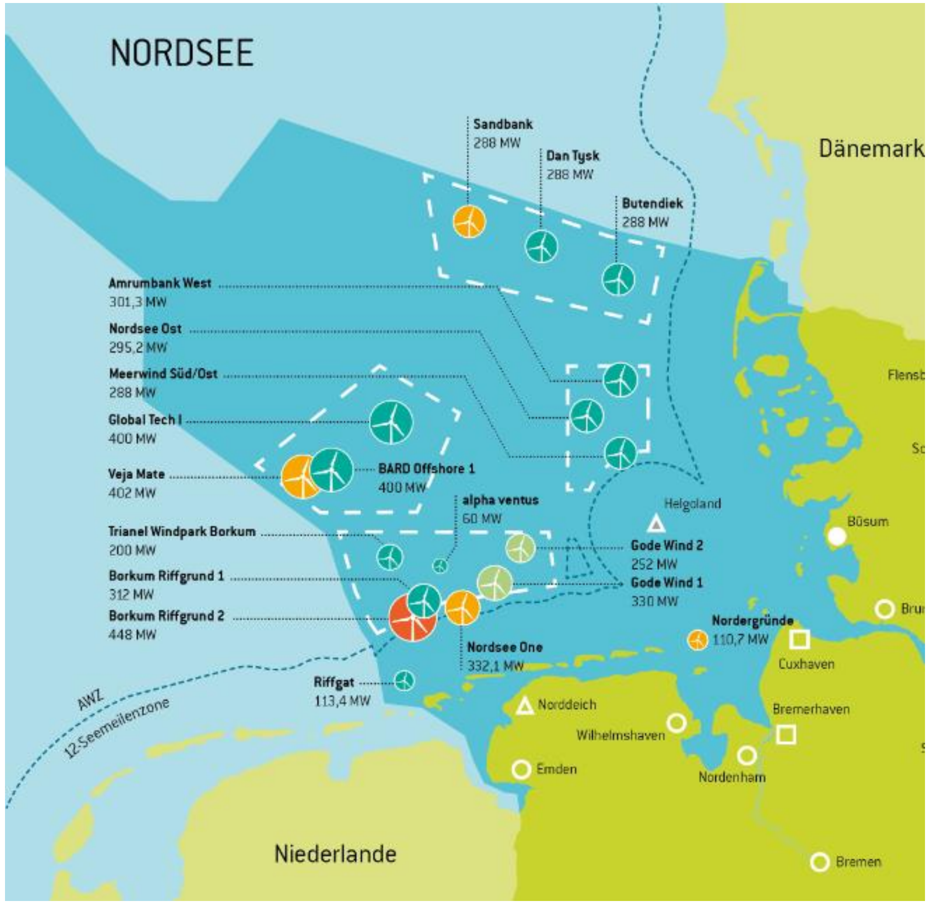
150 YRS

Shipping & Ports

30+ YRS

Wind Energy

DNV GL's Select European OSW Experience

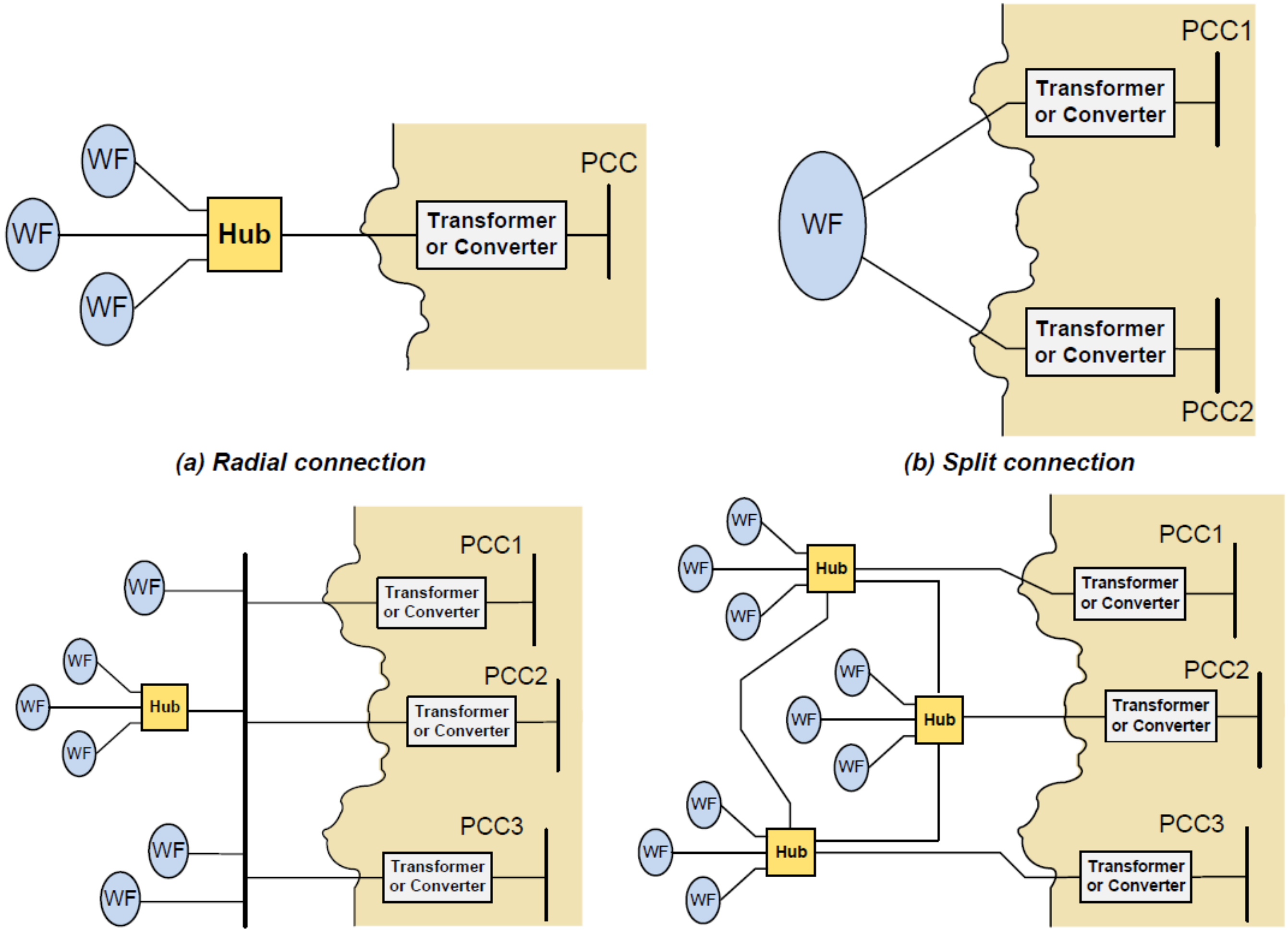


North Sea (TenneT) ~ 5GW
2016-2019

Baltic Sea (50Hertz) ~2.4GW
2015-2019

Source: German O-GDP

DNV GL’s Select European OSW Experience (Cont’d)



(a) *Radial connection*

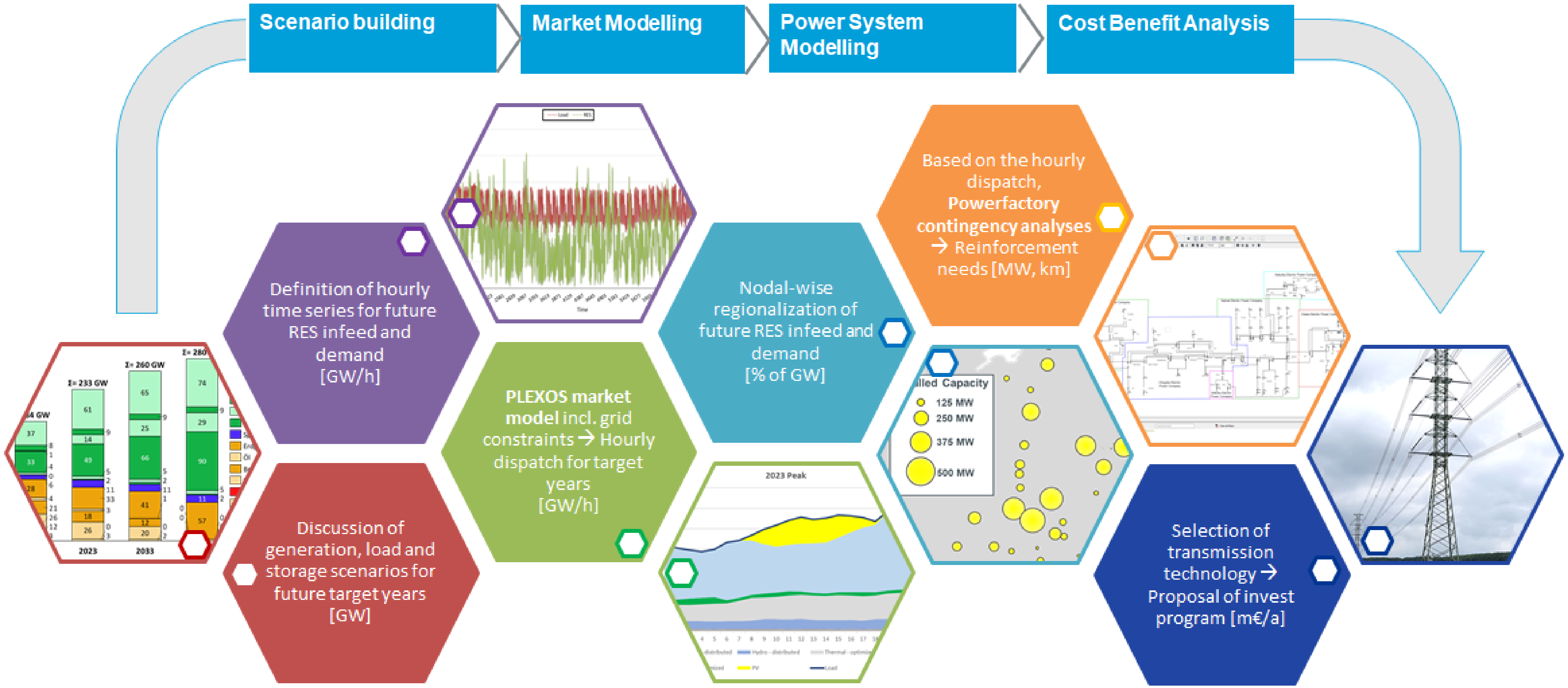
(b) *Split connection*

(c) *Backbone connection*

(d) *Grid connection*

Source: National Offshore Wind Energy Grid Interconnection Study

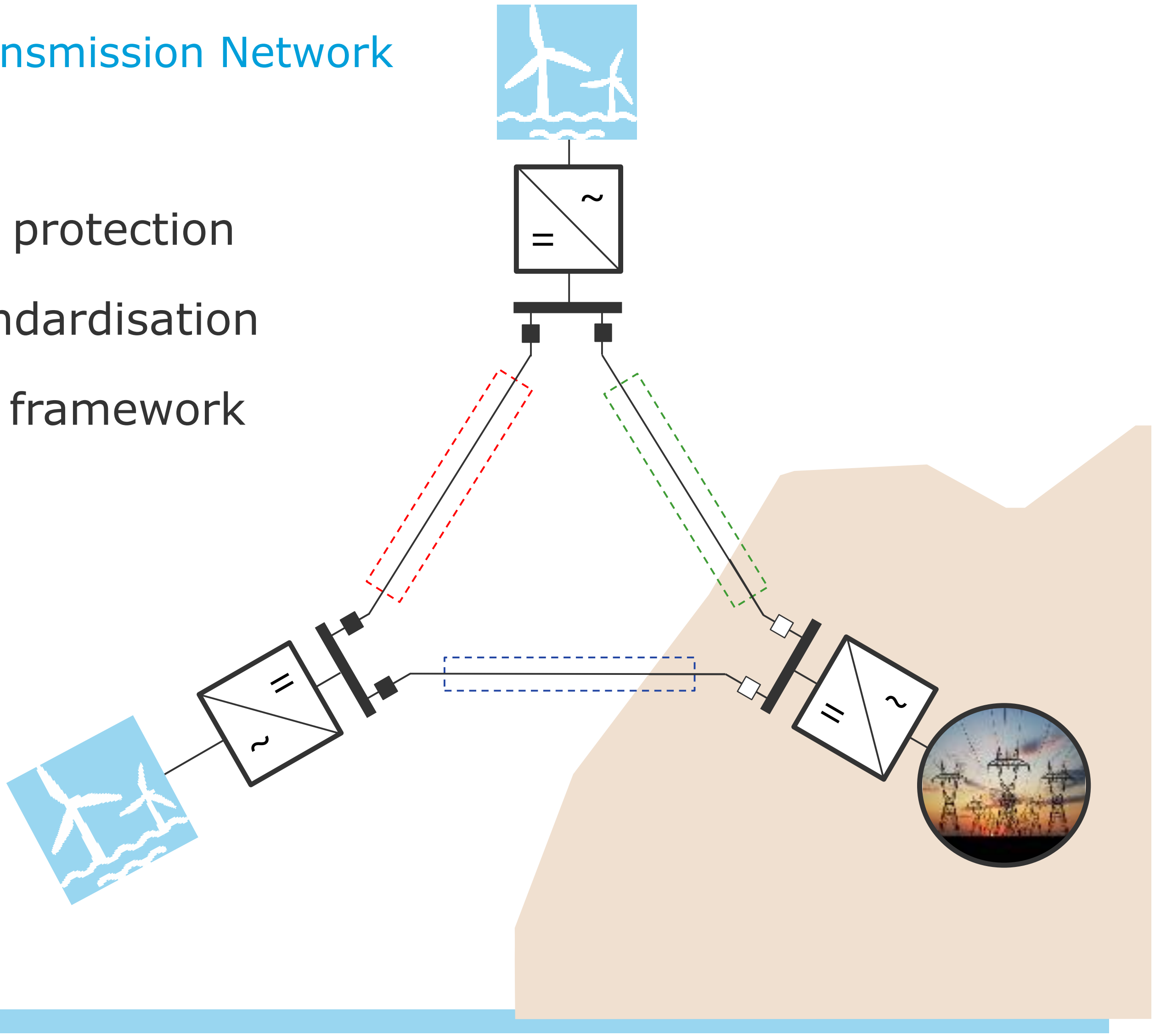
Type of analyses performed



DNV GL’s Select European OSW Experience (Cont’d)

PROMOTioN: Progress on Meshed Offshore HVDC Transmission Network

- Develop cost effective & reliable HVDC network protection
- Work towards technology interoperability & standardisation
- Recommendations for EU regulatory & financial framework
- Deployment plan for implementation by 2050
- Full scale technology demonstrations



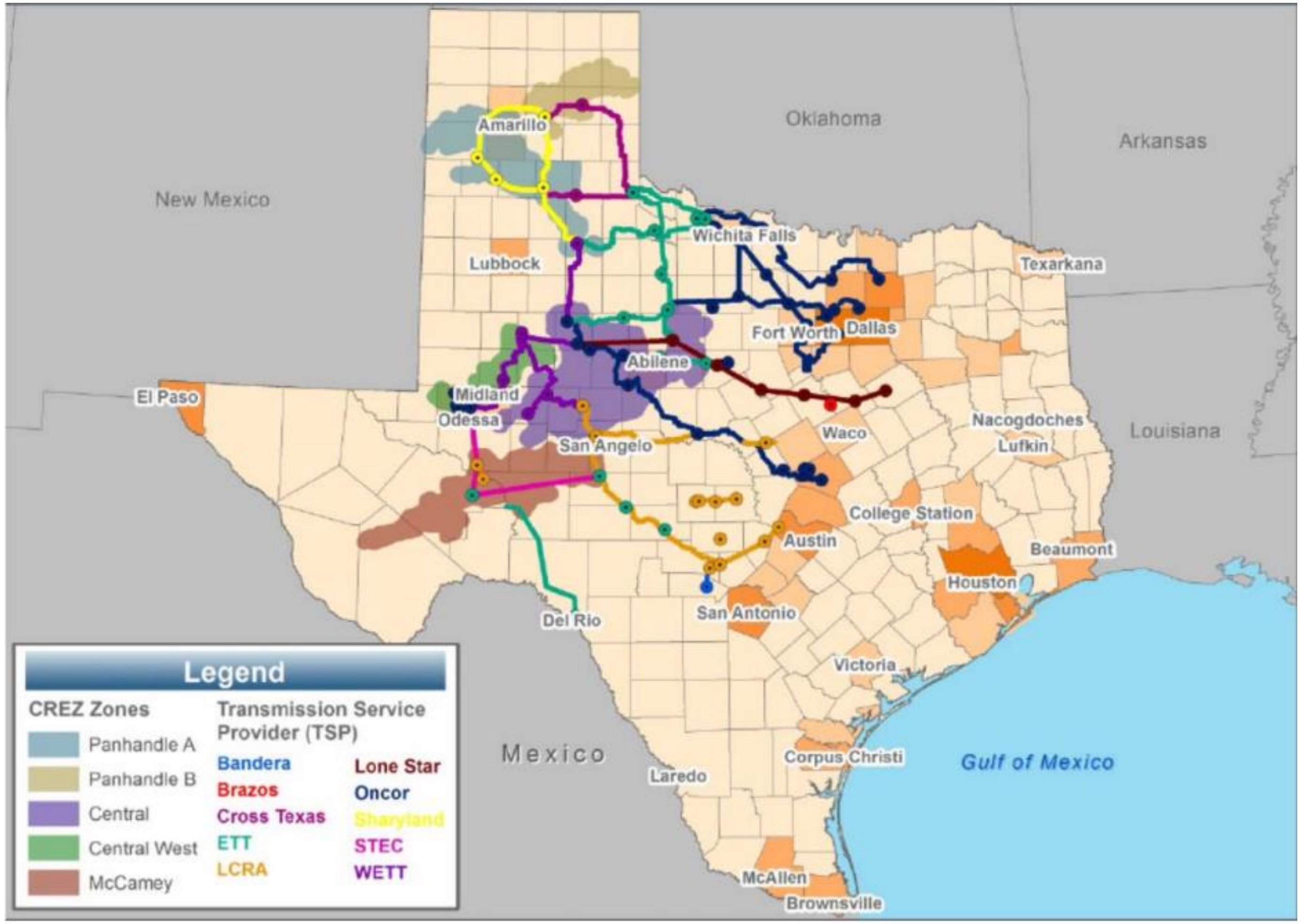
...Lessons Learned...

- Holistic approach is the key in both macro and micro levels
- Need analyses for grid connection decisions (AC vs. DC, single connection vs. offshore hub vs. offshore meshes, etc)
  - Detailed cost-benefit analyses needed
- Component standardization in offshore grid technology key to lower inventory & maintenance costs.
- Ask about interoperability between offshore grid technology vendors, especially for HVDC.
- Consider peak shaving using storage systems in analysis of onshore grid reinforcements.
  - Storage system can be potentially used with dual applications:
    - maximizing the benefit of renewable energy by making the energy available when customer needs it.
    - As transmission deferral application (transmission asset)

DNV G's select Onshore Experience

- **2005: Public Utility Regulatory Act**
- **2006: ERCOT Study published**
- **2008: PUCT Endorsement**
- **2013: CREZ became operational**
- **2018: Installed wind ↑ from 8.9GW to 21.5GW**
- **How about wind deliverability and curtailment?**

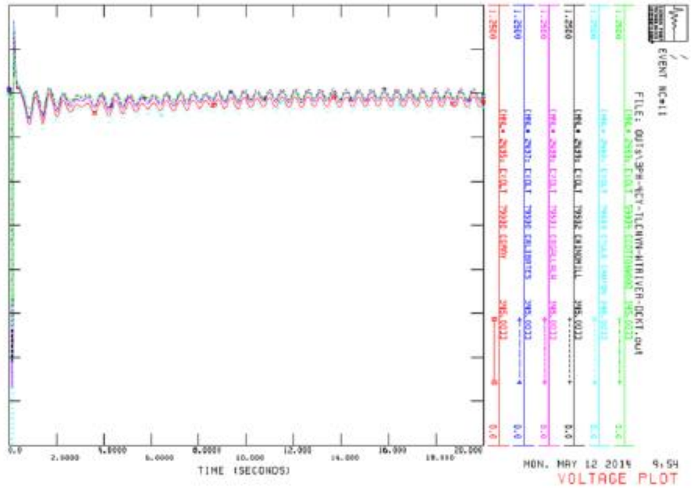
While CREZ project was a relatively successful and well-planned initiative, however many wind and solar developers are experiencing significant curtailments and many investors are not able to justify new investments as the curtailment risk remains high in few areas due to unforeseen reliability challenges that were unique to CREZ project.

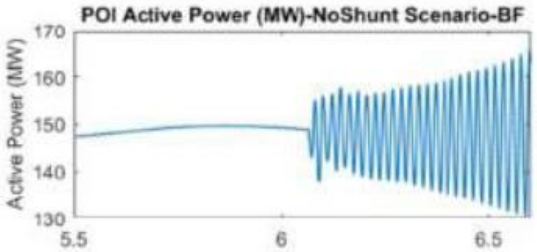


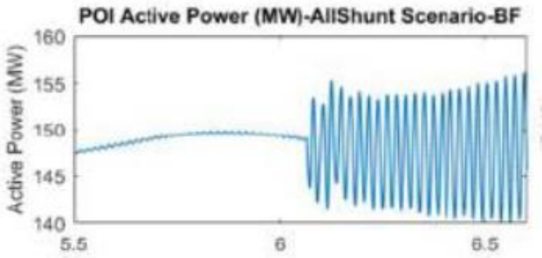
Texas CREZ: ~2400 HV line for 18.5 GW RES

...Lessons Learned...

- **Change in Grid strength** (replacing fossil based units with renewable generation will result in a weaker grid)
- **Risk of control interactions** (between inverter-based wind resources, storage systems, HVDC, etc.)
- **Risk of grid stability** due to transfer of large amount of power from remote locations to a weak grid
- **Change in reserve requirements & resiliency** due to large penetration of intermittent energy resources
- **Transmission congestion & curtailment** of free renewable energy
- **Need for grid equipment upgrades** due to change in the flow pattern of supply and demand







Conclusion and way forward

- Traditional planning strategies, especially the ones related to PJM grid interconnection process, are not sufficient in meeting the grid long-term goals in a cost effective and reliable manner.
- Need for long-term strategic planning for accommodating the aggressive targets of offshore wind
  - High penetration of inverter-based resources could introduce many challenges outside of those foreseen in existing regional planning practices.
- Need for detailed and comprehensive cost-benefit analysis as part of this long-term planning for **both** offshore and onshore networks
- Need for a long-term strategy for both offshore and onshore that can be implemented in phases to meet the evolving states targets associated with offshore wind resources
  - Resulting in more reliable and more cost-effective solution for rate-payers in long-term
- Need for optimizing the grid strategies using storage to maximize the benefit of renewables and/or reduce the CapEX.

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