CREZ Voltage Stability Issues – Causes and Solutions

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ERCOT System Planning

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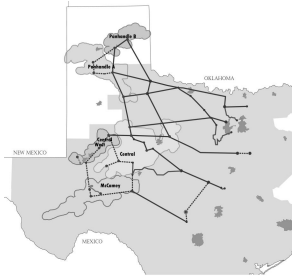
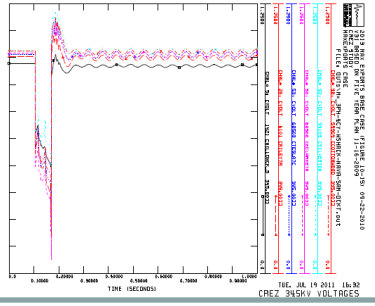
ERCOT Regional Planning Group Meeting

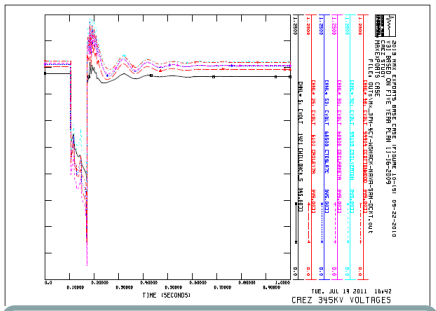
Study process…



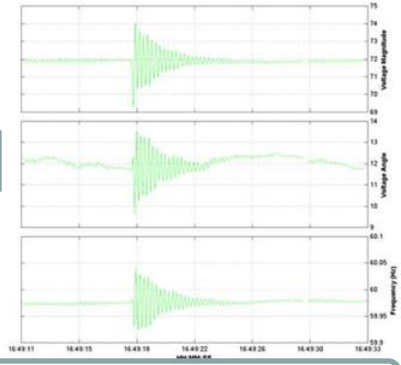
CREZ



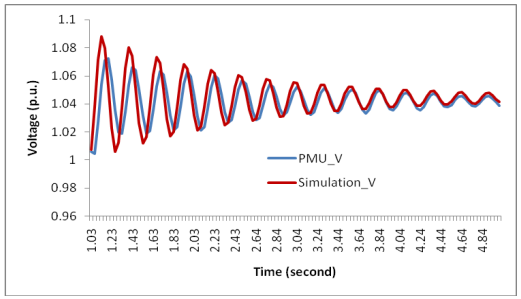
CREZ Reactive Study



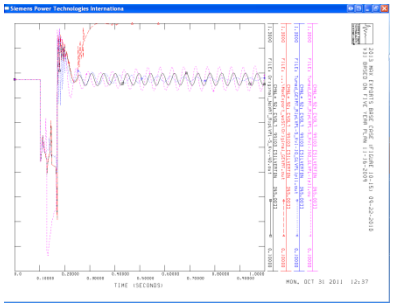
SVC Tuning



Operation Events



Post Event Analysis

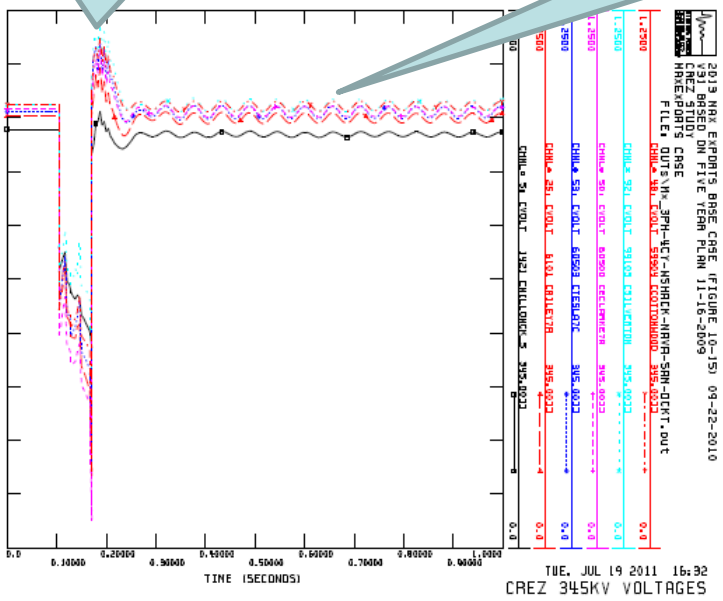


Findings and Solutions

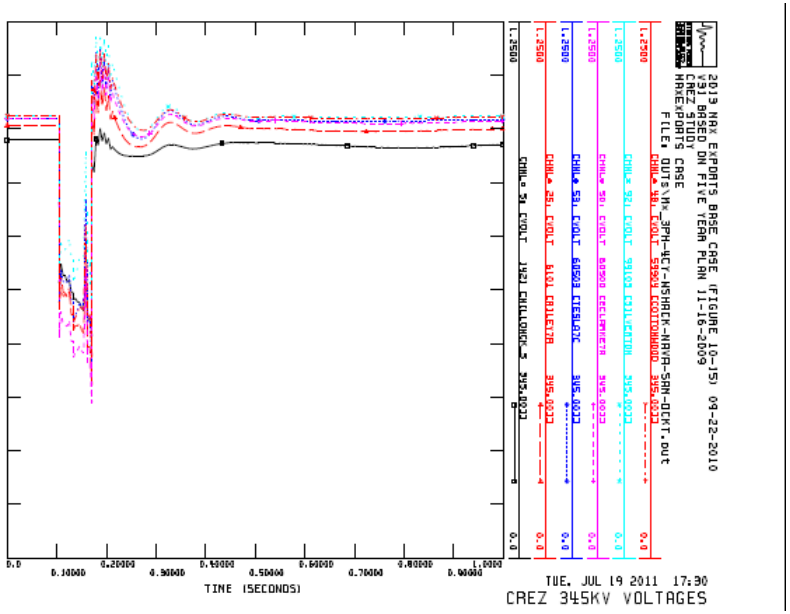
CREZ Reactive Compensation Study: High Wind Scenario

Cause and solution for temporary overvoltage?

Cause and solution for high frequency oscillations?



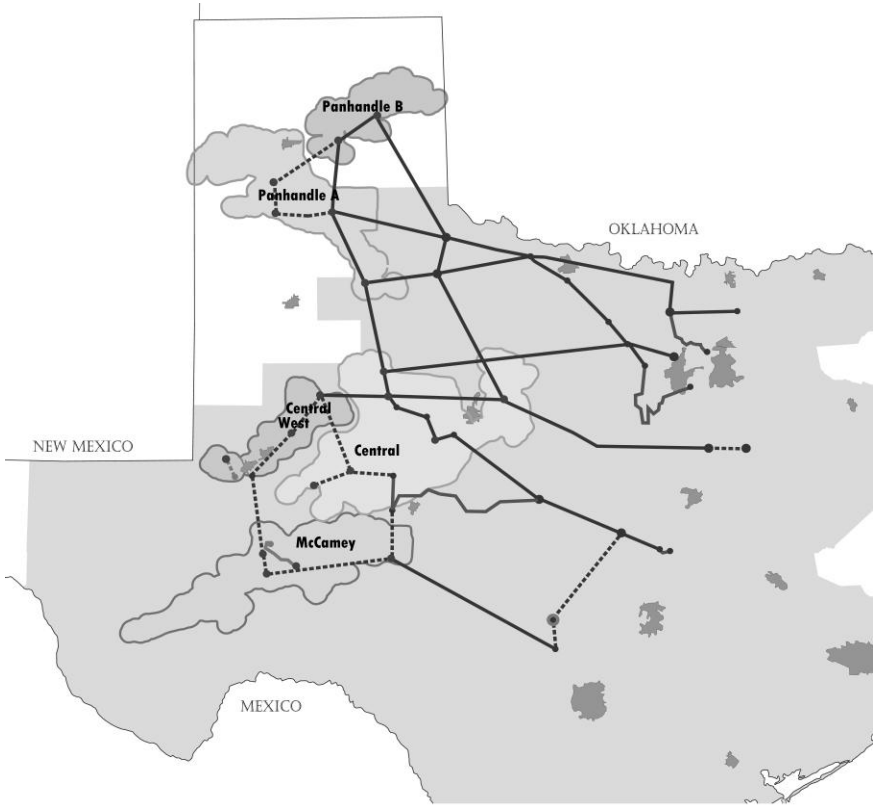
Without Synchronous Condenser



With Synchronous Condenser

CREZ System Characteristics

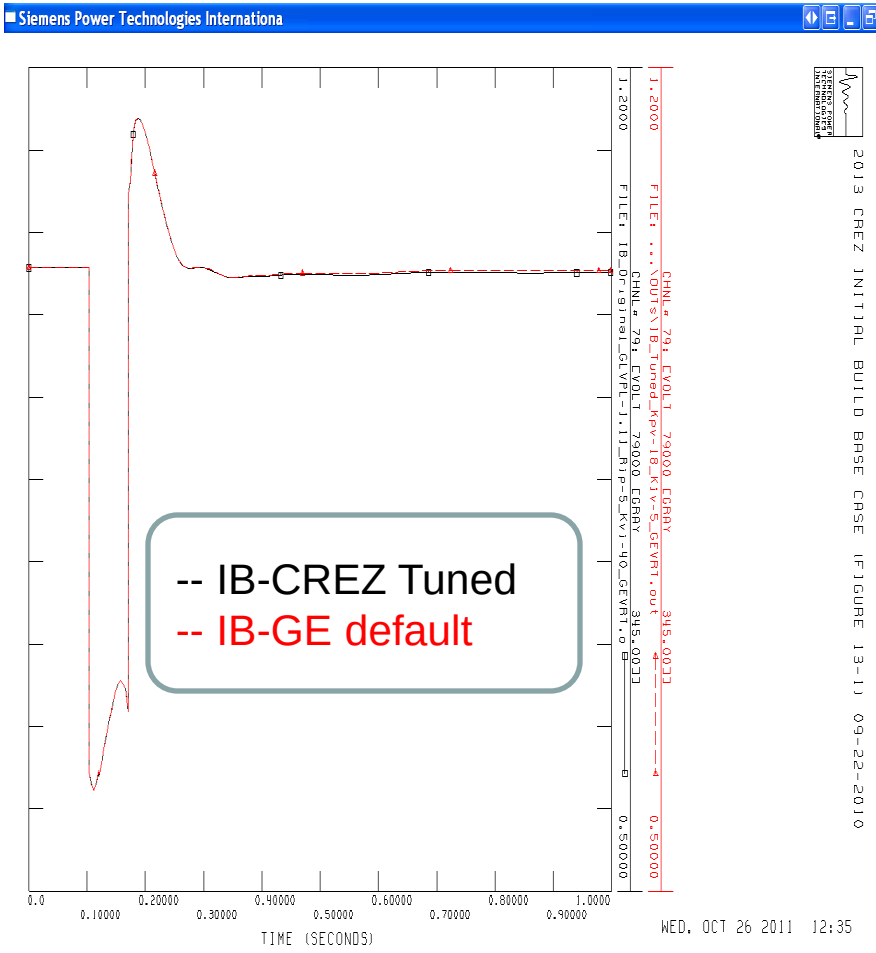
- **Deliver wind power from remote region to the load centers through long extra high voltage transmission lines.**
- **Located at remote region, far away from synchronized generators and load.**
- **Significant power electronic devices to provide system support.**
- **Weak Grid**
  - Low short circuit ratio (SCR)
  - Voltage will not be stiff, challenge for voltage control (steady state and dynamic)
  - System performance is dominated by high wind/low wind, not summer peak/winter off-peak

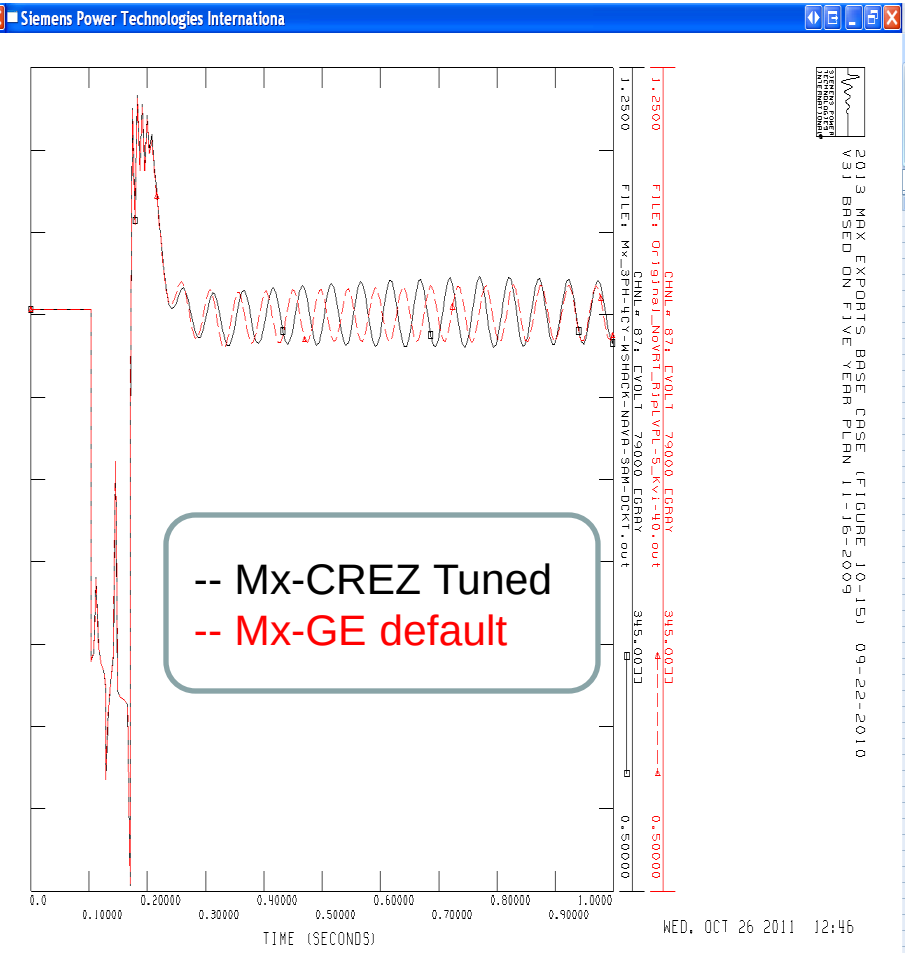


Summary of the major findings

- **Wind generation voltage support is provided through two controls, plant level control and turbine level control.**
  - Turbine control provides a initial response to address severe disturbance.
  - Plant control provides a slower response for voltage refinement.
- **Low Voltage Power Logic (LVPL) control the MW contribution during and immediately after the fault. The ramp rate limit is the key to the post fault power recovery, which is also the key to the post fault voltage recovery.**
  - In normal system, high SCR with load, it is desirable to have slower/smooth post fault power recovery to have a stable voltage response.
  - However, slower power recovery may not be desirable due to the fact that CREZ is a region with low SCR and no load dynamic response during disturbance.

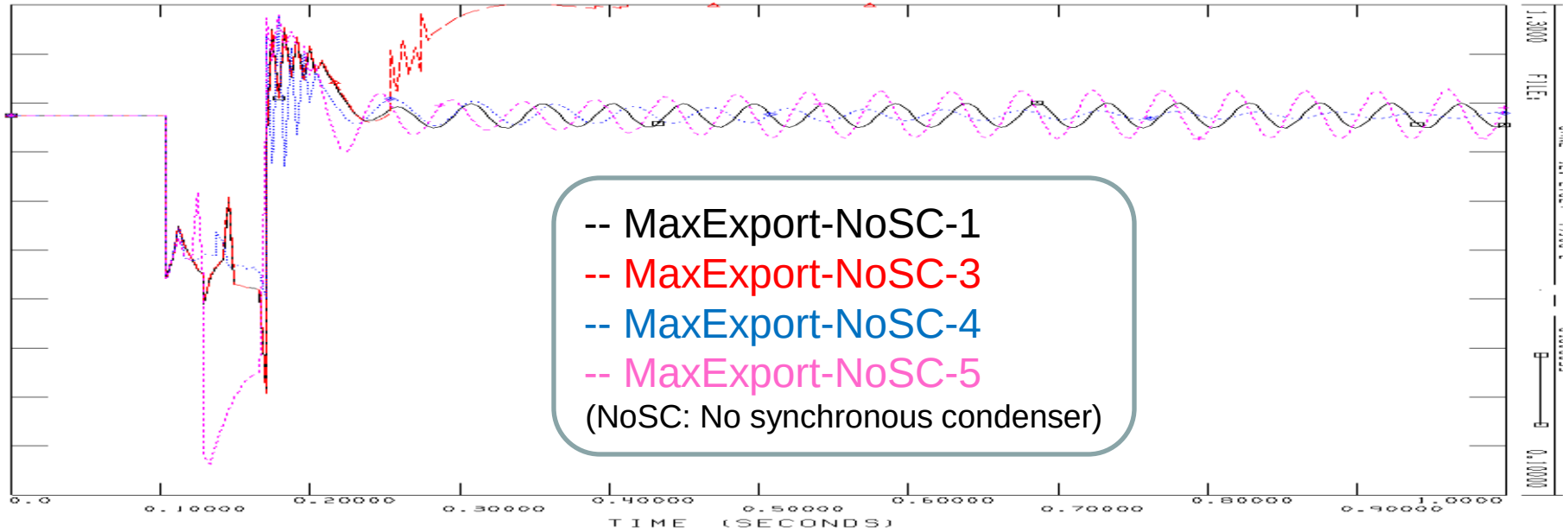
CREZ Case: Impact of Plant Level Control



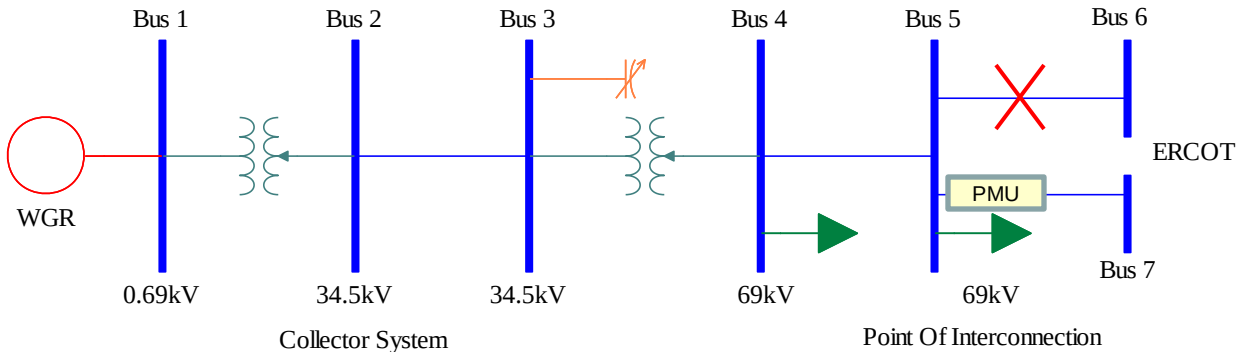


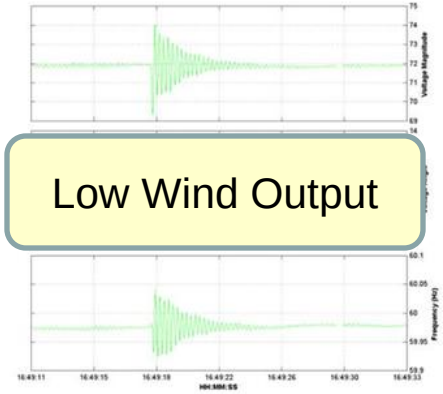
Revised Run for CREZ Initial Build and Maximum Export

Scenario	CREZ Protection	Wind Dynamic Model	Oscillation	VRT Trip (MW)	HVRT/LVRT	Trip Units
IB-1	NoVRT	CREZ	Na	0	Na	Na
IB-2	CREZ-VRT	CREZ	Na	1130	HVRT	Panhandle
IB-3	GE-VRT	CREZ	Na	0	Na	Na
IB-4	CREZ-VRT	Tuned	Na	0	Na	Na
MaxExport-NoSC-1	NoVRT	CREZ	Yes	36	LVRT	Sweetwater
MaxExport-NoSC-2	CREZ-VRT	CREZ	Yes	9124	High Voltage Collapse	Panhandle+Others
MaxExport-NoSC-3	GE-VRT	CREZ	Yes	6995	High Voltage Collapse	Panhandle+Others
MaxExport-NoSC-4	GE-VRT	Tuned-Slower	Improved	0	Na	Na
MaxExport-NoSC-5	GE-VRT	Tuned-Faster	Worse	0	Na	Na

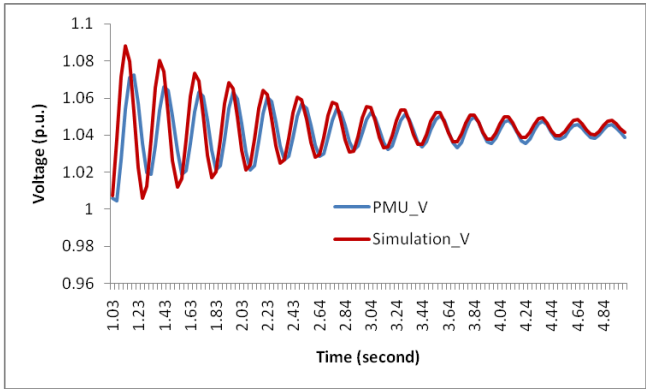


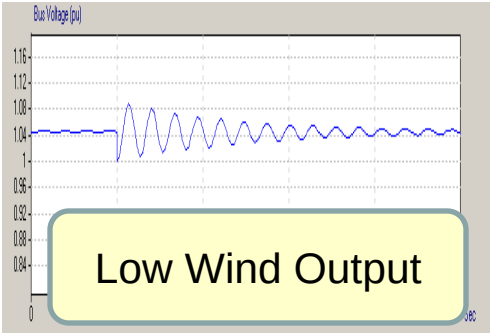
Operation Events Validation: Oscillatory Response

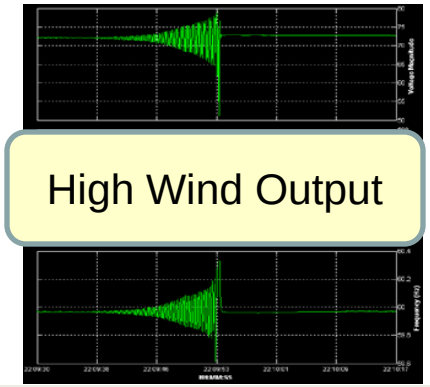




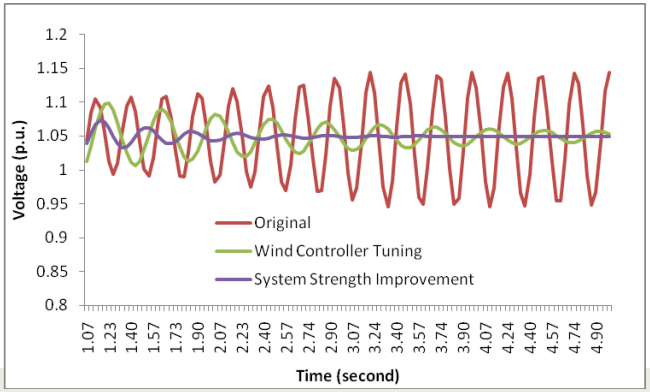
Low Wind Output

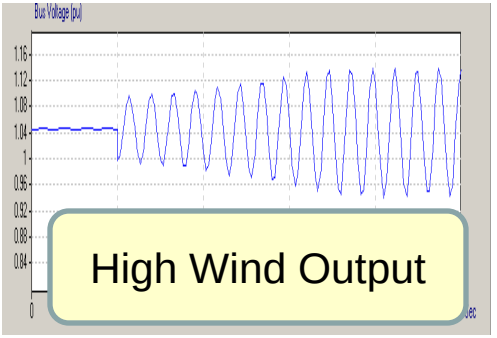






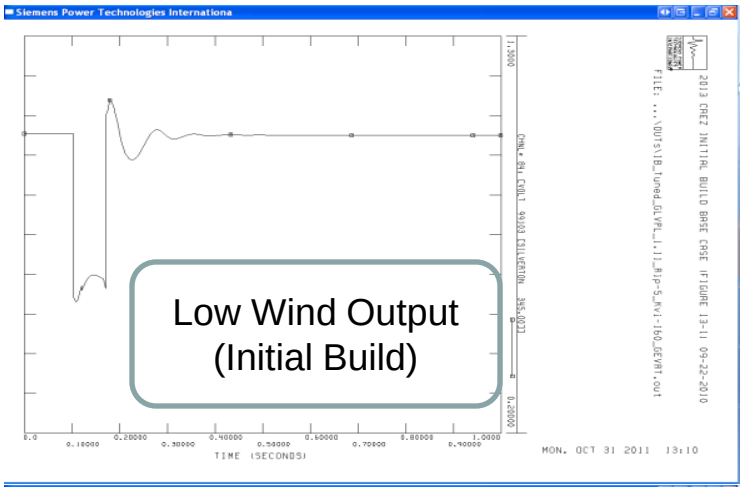
High Wind Output

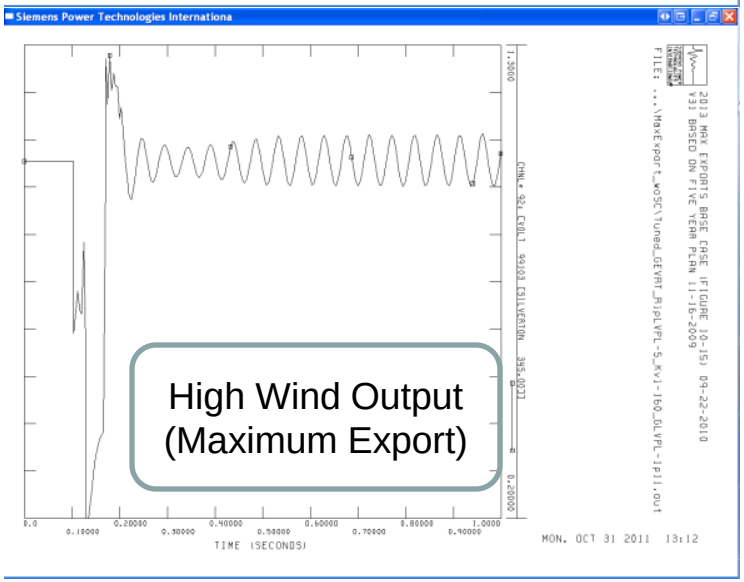




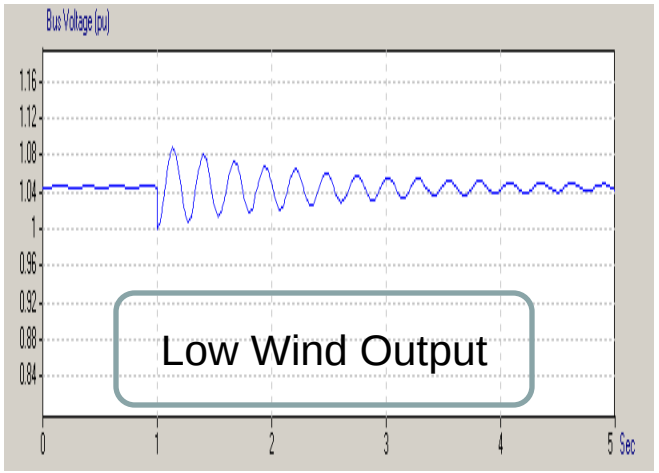
CREZ Simulation Validation: Oscillatory Response

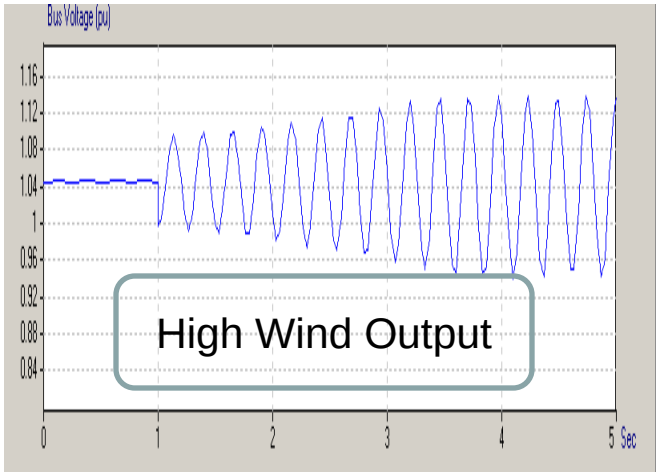
CREZ (Planning)





PMU (Operations)

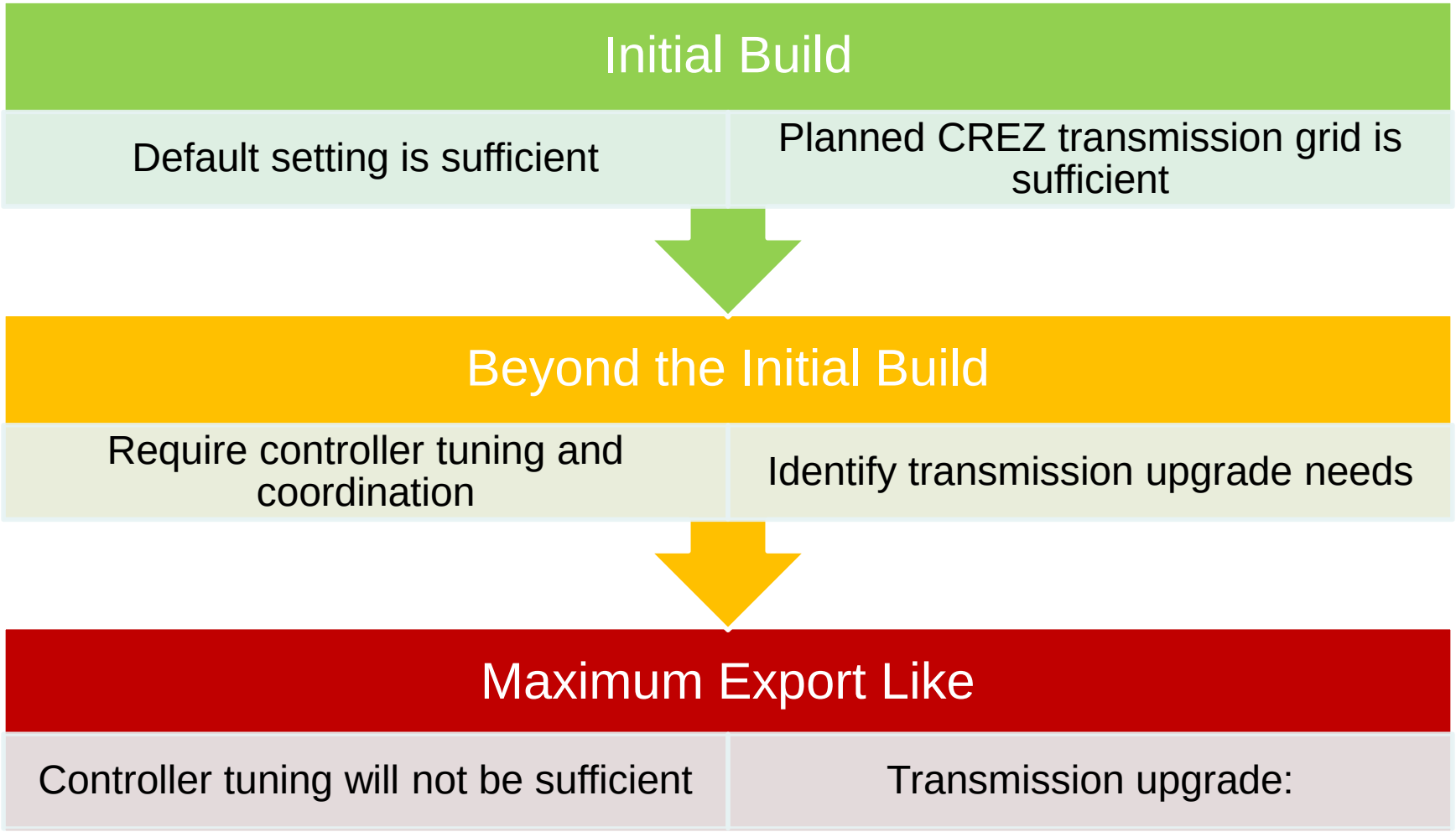




Conclusion

- **Unique CREZ system characteristics**
  - Low short circuit ratio, voltage is not stiff, no load, no synchronous generators, dynamic performance is mainly driven by generators…
- **Overvoltage: post fault active power recovery control**
  - Tune faster -> quicker MW restoration -> lower overvoltage -> slower voltage recovery
- **Oscillation: WTG voltage control**
  - Tune faster -> faster reactive support -> faster voltage recovery -> potential to lead to oscillatory/unstable response
- **The tuning of plant level control doesn't have much impact on the first second during/after the disturbance.**
- **Operation events and PMU data support the findings of the CREZ analysis.**

Solutions:


Initial Build
Default setting is sufficient
Planned CREZ transmission grid is sufficient
Beyond the Initial Build
Require controller tuning and coordination
Identify transmission upgrade needs
Maximum Export Like
Controller tuning will not be sufficient
Transmission upgrade:

Discussion and Follow Up

- **Improvement of FIS Short Circuit Study.**
  - Provide a range of short circuit current (ratio) instead of maximum short circuit current can help developer to better understand the potential system condition and properly set up the wind farm control system.
- **Need to revise HVRT**
  - To prevent the potential high voltage collapse
  - 1.1 pu should be treated as expected post fault steady state response, not suitable for dynamic response criteria.
  - Static cap banks to compensate reactive support may not be acceptable. Dynamic Var capable devices are needed. (Protocol 3.15.(3), NPRR423)
- **TSPs also start to observe similar stability issues through the FIS studies.**

Discussion and Follow Up

- **Wind dynamic model**
  - Proper wind dynamic model for low short ratio condition is needed.
  - Accurate control setting (dynamic model parameters) is important.
  - Technical document (control block diagram and functionality description) is important.
  - Wind developer may also need to revise the robustness of the control system at low short circuit ratio condition.
- **PMU data**
  - Provide more transparent system dynamic response that is not available in the EMS/SCADA.
  - Provide good benchmark reference for post event analysis. (Model Validation)

Thanks for your time!

Questions?

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