

Bulk Wind Transmission

Oct. 8, 2007
ERCOT CREZ



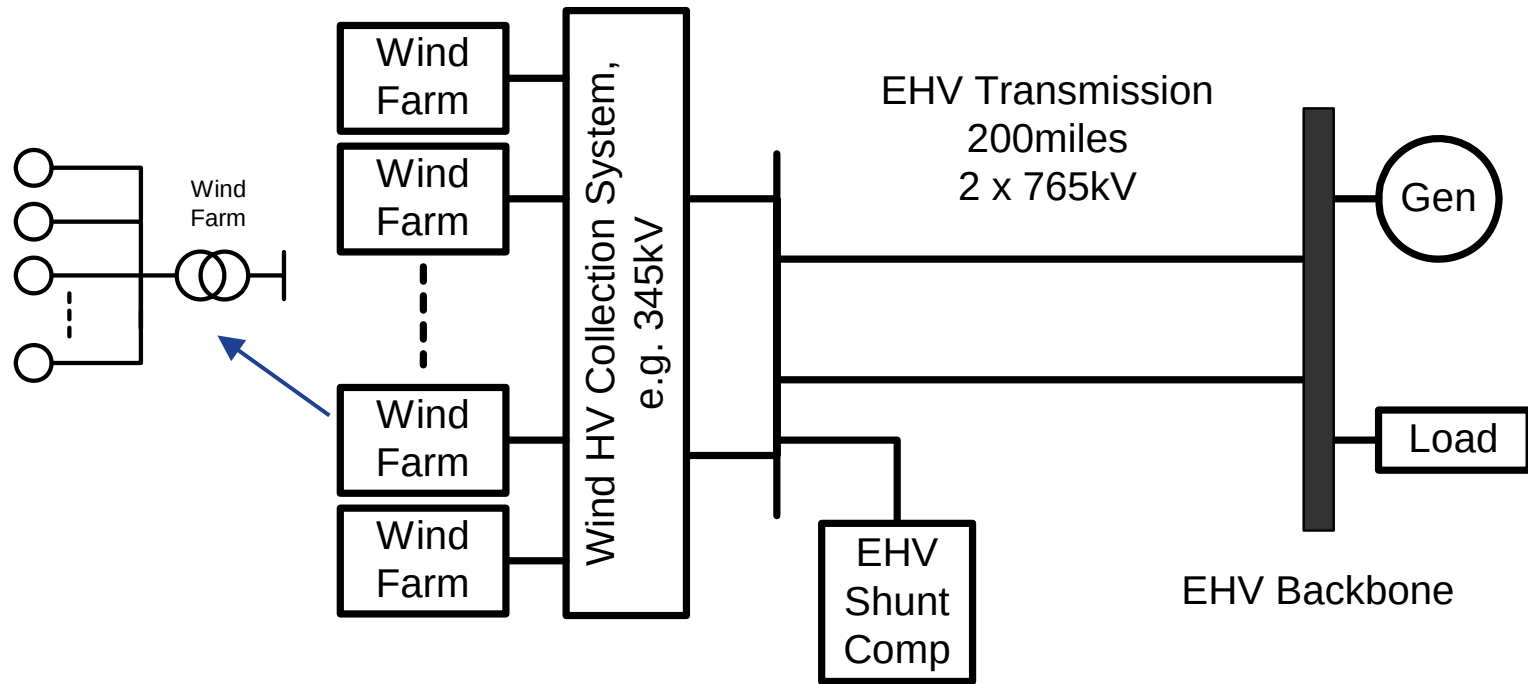
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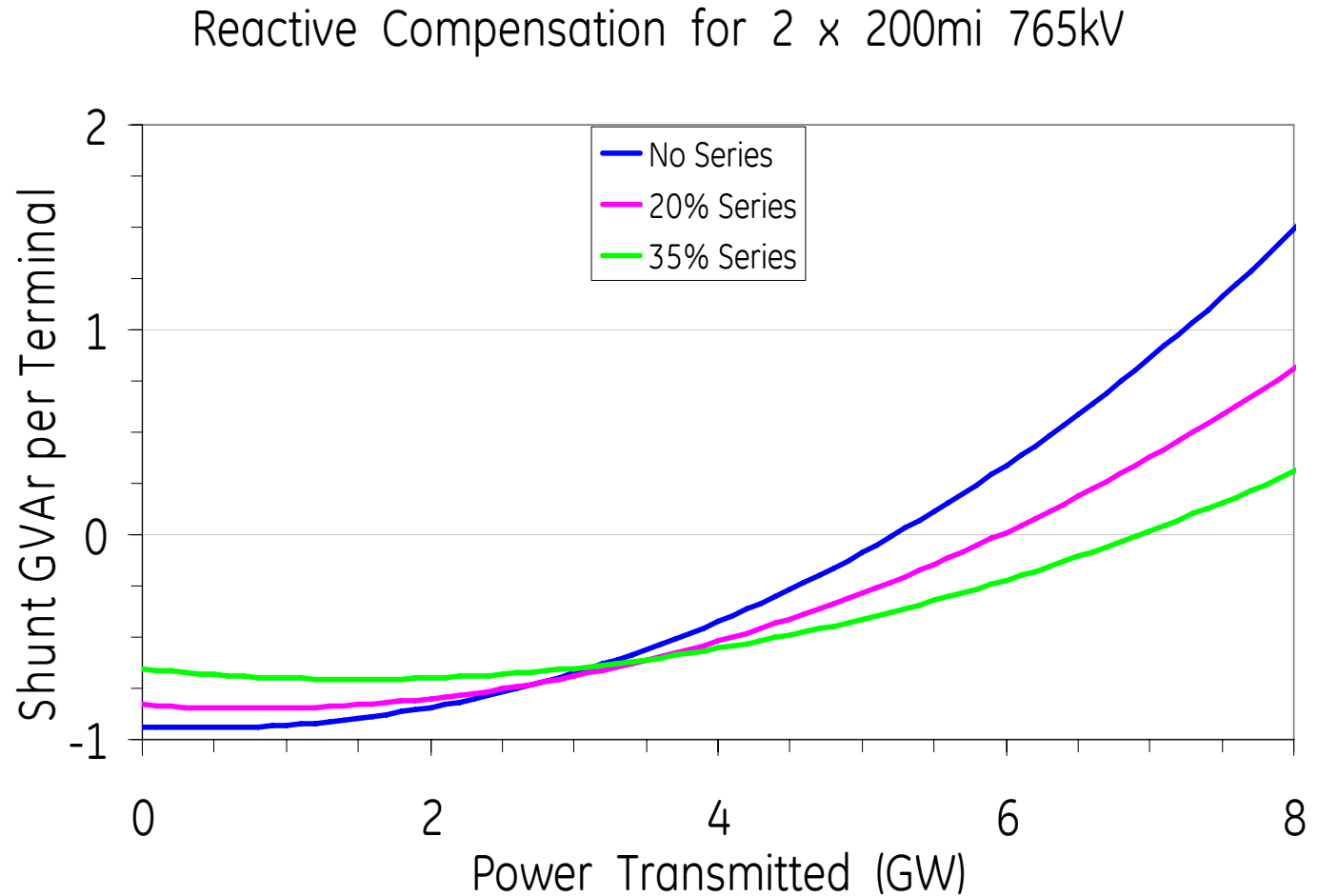
imagination at work

Bulk Transmission Scenario



Desire >5 GW Wind

EHV Steady-State Reactive Compensation for 2 x 765kV , 200miles



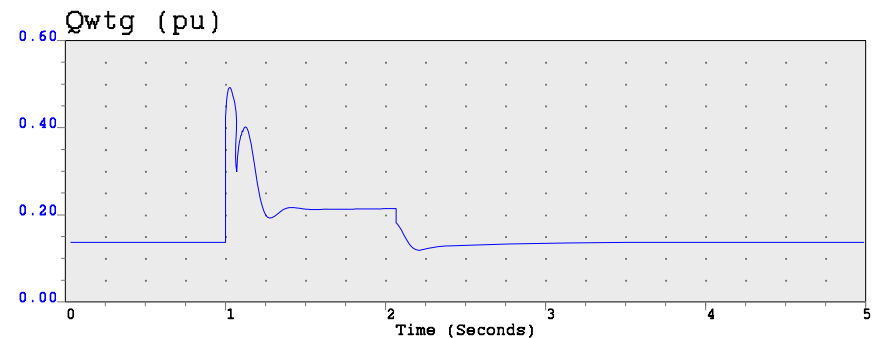
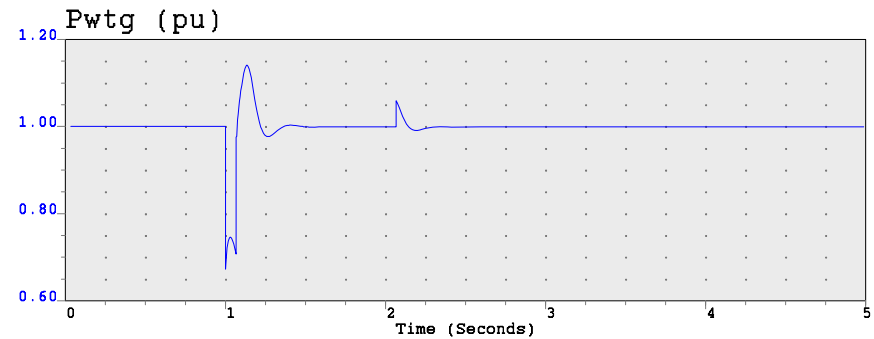
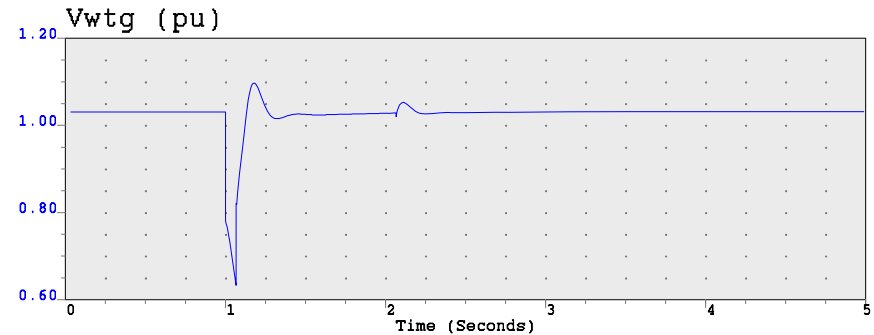
Transient Stability Criteria

No generation tripping or load shedding for:

Single line-ground fault, single-phase open for 1 sec.

Transient Stability – 5GW wind with GE WTG's

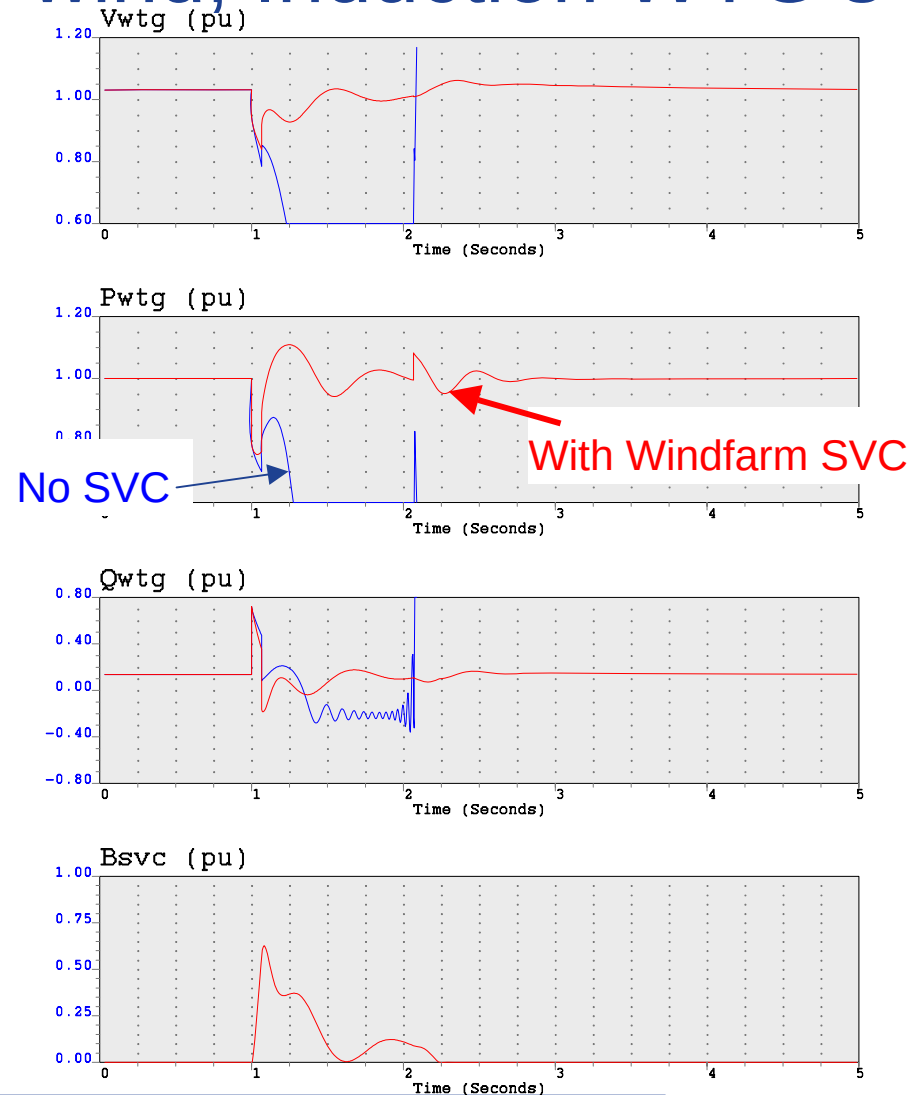
- No EHV shunt comp.
- No EHV series comp.



Stable Response, Well Mannered

Transient Stability – 5GW wind, Induction WTG's

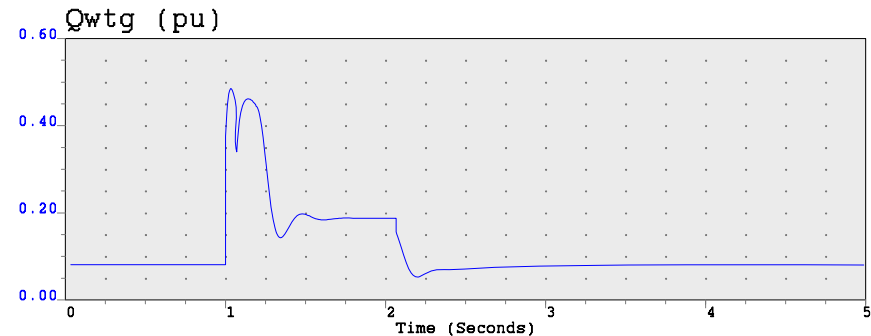
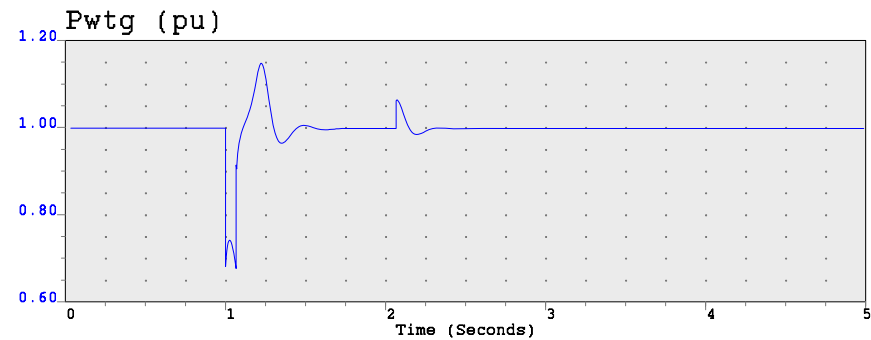
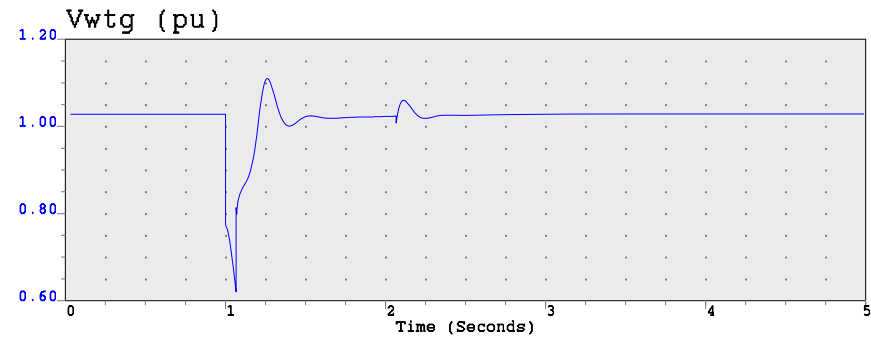
- No EHV shunt comp.
- No EHV series comp.
- SVC in each windfarm,
rated 60% of MW capacity



***Requires SVC within Windfarm
Significant Transient***

Transient Stability – 6.3GW wind

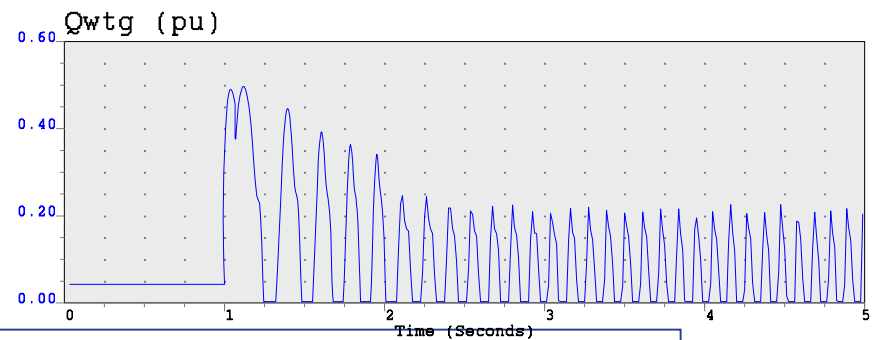
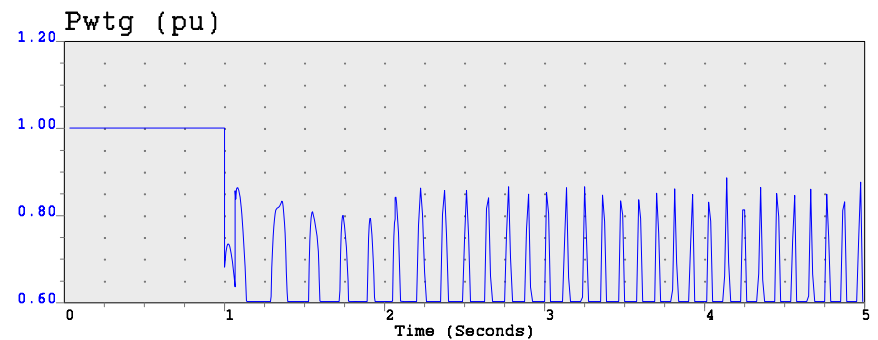
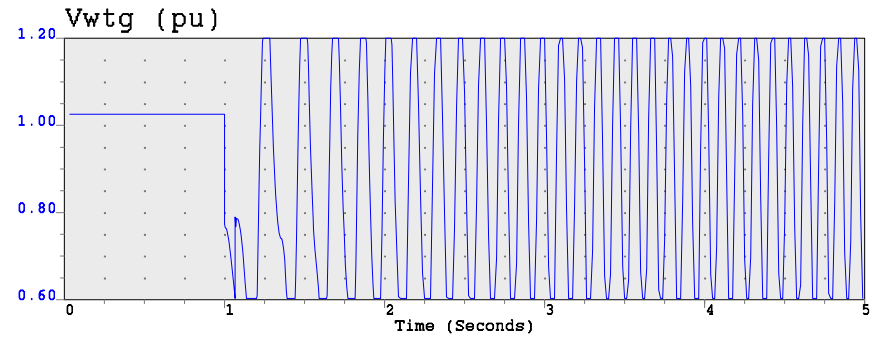
- GE WTG's
- 500MVAR EHV fixed shunt comp.
- No EHV series comp.



Stable Response, Approaching Limit

Transient Stability – 7GW wind

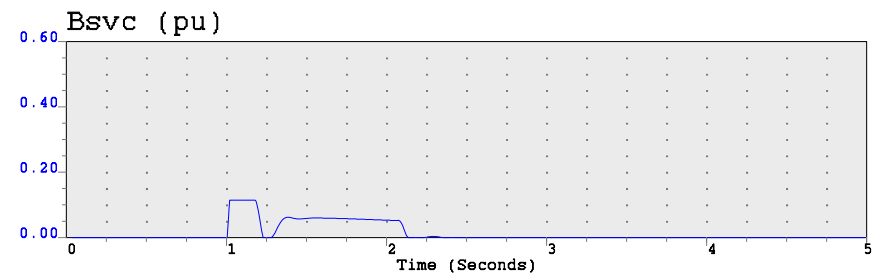
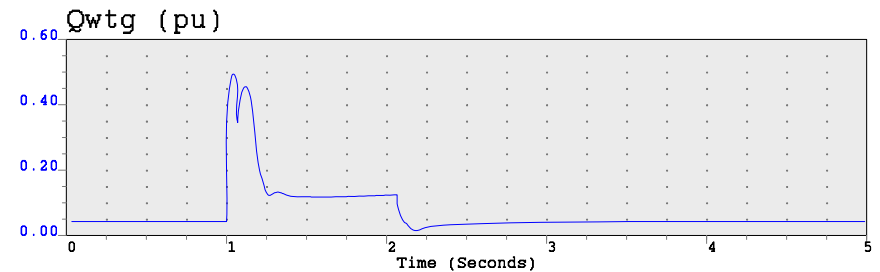
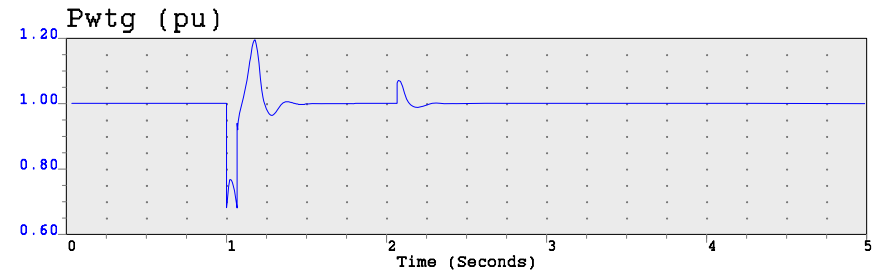
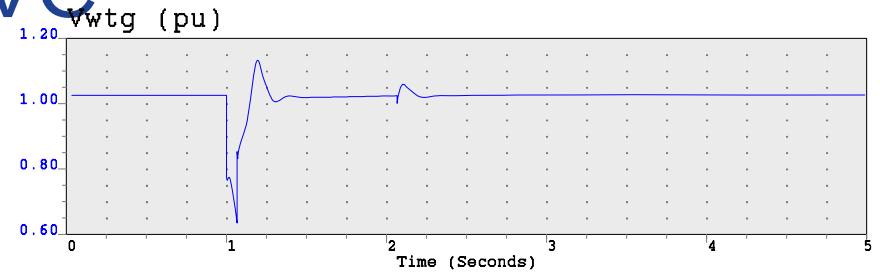
- GE WTG's
- 860MVAR EHV fixed shunt comp.
- No EHV series comp.



Unstable

7GW wind with EHV SVC

- GE WTG's
- 860MVA EHV fixed shunt comp.
- 800 MVar SVC at EHV
- No EHV series comp.

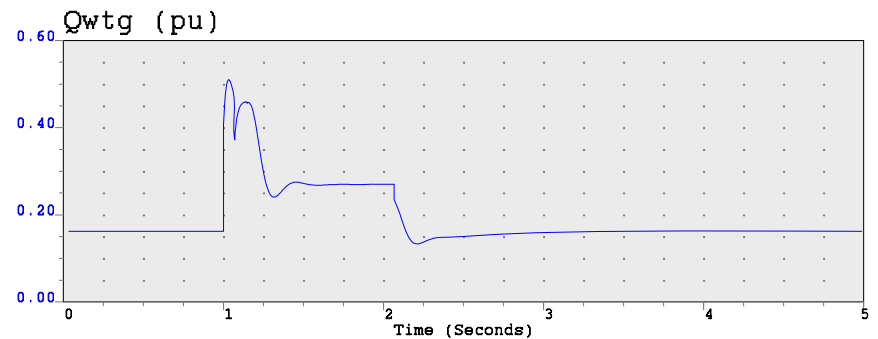
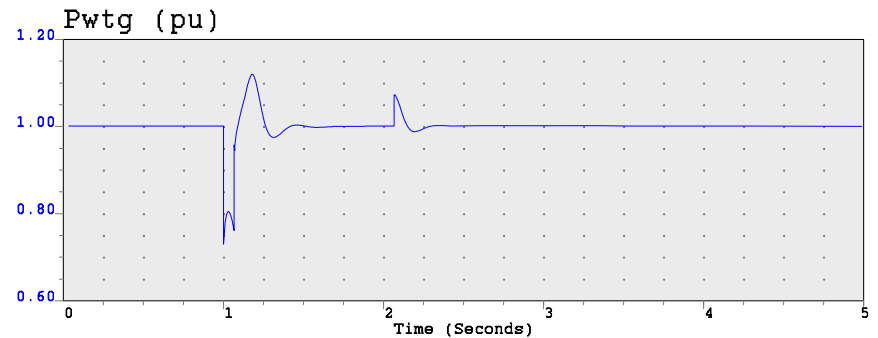
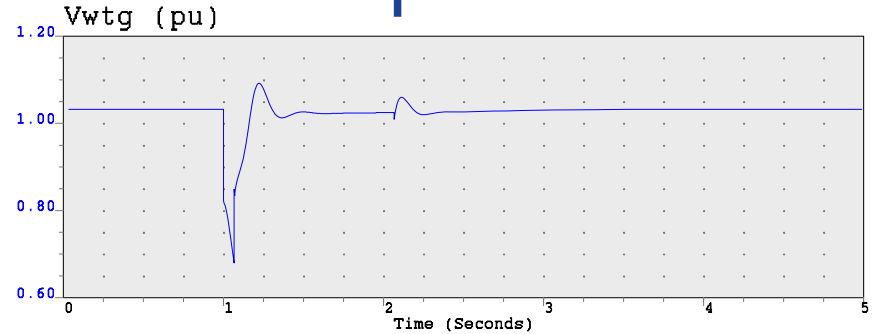


Stable

7GW wind with EHV Series Compensation

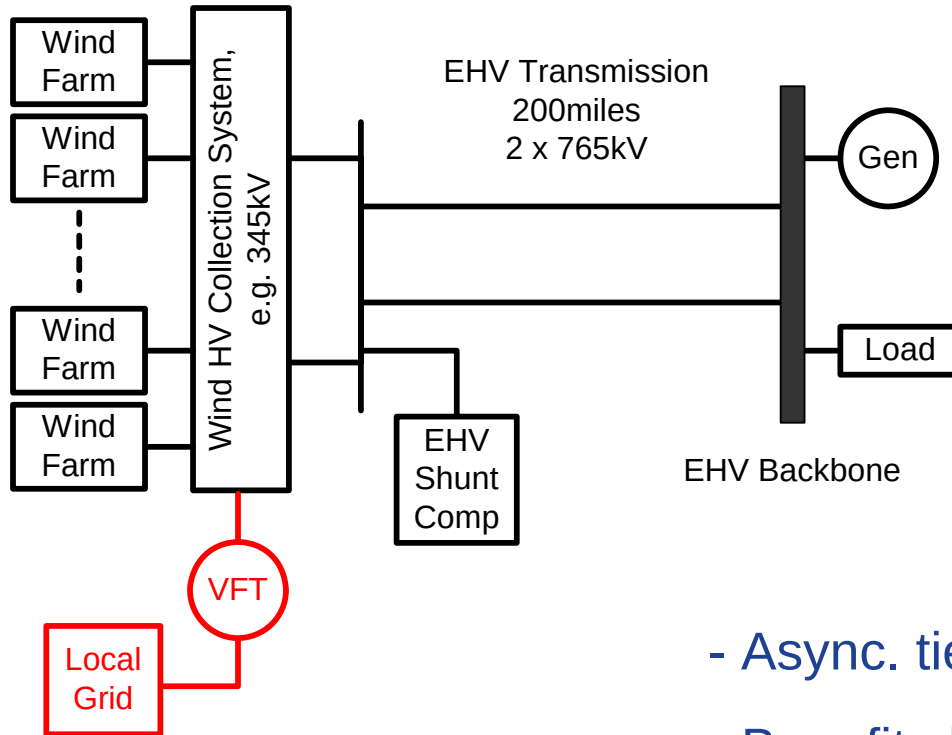
- GE WTG's
- 400MVAR EHV fixed shunt comp.
- 20% EHV series comp.

(670MVAR total for 2 lines)



Stable

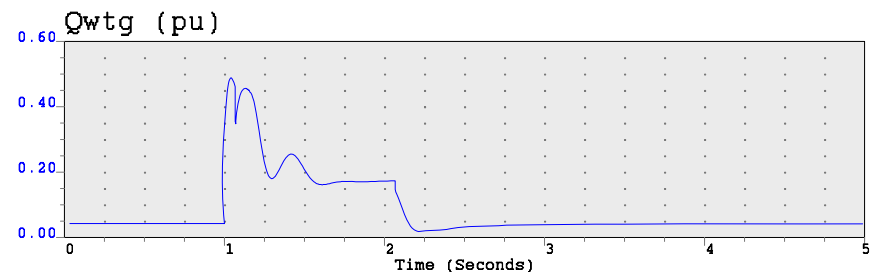
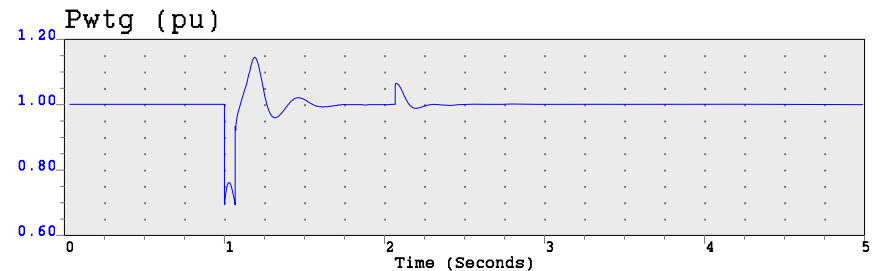
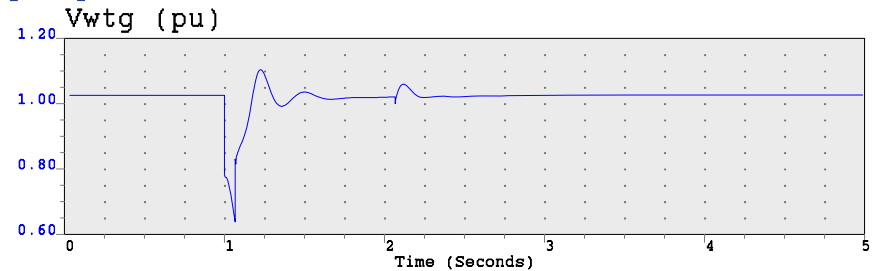
New concept – add small VFT ties



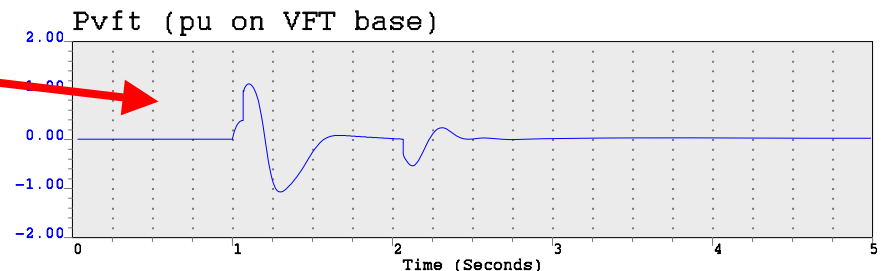
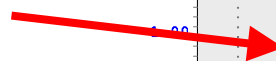
- Async. tie to grids near windfarms
- Benefits both grids
 - Stability improvement
 - Power exchange opportunity

7GW wind with Local VFT

- GE WTG's
- 860MVar EHV fixed shunt comp.
- No EHV series comp.
- No EHV SVC
- 300MW VFT tie to local grid



VFT “shock-absorber” action

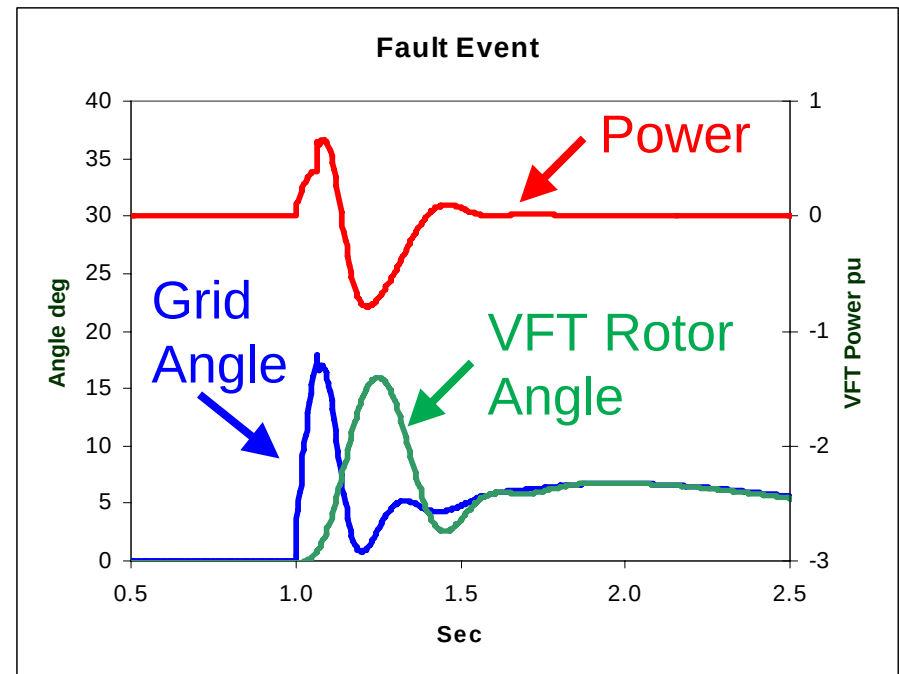
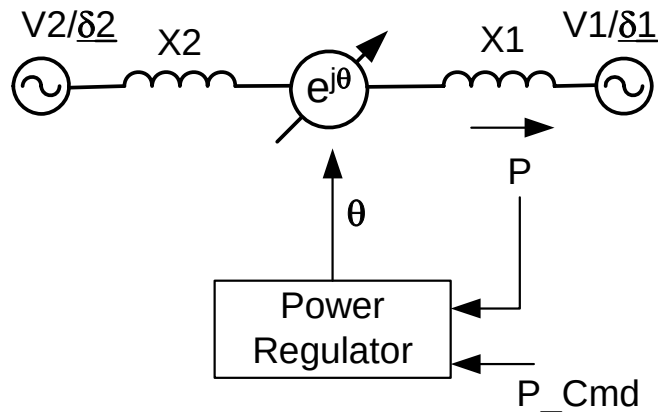


Stable

Insight to VFT “Shock Absorber” Effect

VFT is continuously-variable phase shifting transformer

- Large inertia
- Steady-state power regulator



Natural Reaction is Strong Stabilizing Influence

Options for 7GW

	Series Only	SVC Only	VFT Only
EHV Fixed MVar per terminal	400	860	860
EHV Series Comp MVar (%)	670 (20%)	-	-
EHV SVC MVar	-	800	-
VFT MW	-	-	300

Combinations can work also

Conclusions

- Large Remote Wind Feasible via EHV ac
- 5GW on 2 x 200 mile 765kV is “natural fit”
 - GE-type WTG control up to 6.3GW
 - Induction Gen + Windfarm SVC ok at 5GW
- More possible with added equipment
 - EHV Series compensation
 - EHV SVC's
 - Small VFT ties to local grid