DEVELOPING GRID MODEL FOR THE STATE

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Agenda

- Background & Capabilities
- Notable Work
- Case Study – Gen & Trans Planning
- Grid Model – Need
- Appendices

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- **Background & Capabilities**
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Background & Capabilities

- Over 100 generation & transmission planning projects with ~23 clients in US
- Selected optimum Points of Interconnection (POIs) for generation development avoiding congested spots
- Studied over 15 GW of renewable projects and 5 GW of natural gas projects
- Electrical system studies – Load Flow, Short Circuit & Relay Coordination for distribution systems
- Software: PowerWorld and PSSE for transmission network and ETAP for distribution network

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Notable Work

- ***Provided the due diligence analysis reports*** for generation assets acquisition for Alcoa Hydro Power Plants in Tennessee in 2011 and Renewable Portfolio enhancements for Sumitomo Corporation in 2013
- Identified ***solutions to eliminate over $M 200*** network upgrades for 850 MW Natural Gas plant in Pennsylvania (In-service since 2016) and $M 100 for 675 MW Natural Gas plant in New Jersey (In-service since 2015)
- ***Automated daily generation curtailment data capture in Python***
- ***Notable Clients:*** E.On, Panda Funds, Pioneer Green Energy, Moxie Energy, Sun Edison, BP Alternative Energy, Orion Renewables

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Notable Research & Publication Work

- Authored ***whitepaper on US Electrical Market*** in 2008 – Overview and Trend in generation, load, transmission expansion, congestion and environmental aspects of the states comprising of SOx, NOx and COx emissions
- Presented at the International RE Grid Integration conference 2017 on "Grid Integration Challenges in Offshore Wind in Tamil Nadu & Gujarat"
- Paper at the 7th International Conference on Power Systems by IEEE on "Challenges for Policy Makers & Transmission Planners in Offshore Wind Integration in Tamil Nadu & Gujarat"

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Notable Work – Summary

- Summary of Renewable Energy Projects

#	Client	Project - Location	Fuel	Studied MW	Type of study	Year Studied	Final Project size <= 20 MW or > 20 MW
1	Safe Harbor	SH	Hydro	420	NERC Compliance study	2009	> 20 MW
2	Orion Renewables	NJ	Solar	1000	Site screening & GI studies & file application	2011 - 2012	7* <= 20 MW
3	Orion Renewables	GA	Solar	1000	Site screening & GI studies	2012 - 2013	5* <= 20 MW
4	Orion Renewables	TN	Wind	1000		2011 - 2012	5* <= 20 MW
5	Brookfield Renewables	Alcoa - TN	Hydro	352	Transmission consultant as a part of due diligence for acquisition of few generation projects	2011	
6	Volkswind	GEN-2010-44 - NE	Wind	100	Validate & Redo SPP's study to minimize network upgrade cost	2012	> 20 MW initially & then made <=20 MW finally
7	Sempra	Prairie Hills / Callaway - NE	Wind	200		2016	> 20 MW
8	EON	SC	Wind	1000	Site screening & GI studies	2017	> 20 MW
9	EON	OH	Wind	1000		2017	> 20 MW
10	OCI Solar	GA	Solar	20	Site screening & GI studies & file application	2012	<= 20 MW
11	FOWIND	Tamil Nadu, Gujarat	Offshore wind	1000	Grid integration study - preliminary validating STU's reports	2016 - 2017	> 20 MW

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Notable Work – Summary

- Summary of Non-Renewable Energy and Mix of RE & Non-RE Projects

#	Client	Project - Location	Fuel	Studied MW	Type of study	Year Studied	Final Project size <= 20 MW or > 20 MW
1	Hess Corp	T107 - NJ	Natural Gas	650	Validation of PJM's studies to minimize network upgrade cost	2009 - 2010	> 20 MW
2	Moxie Energy	Liberty - PA	Natural Gas	850		2011 - 2012	> 20 MW
3	Moxie Energy	Patriot - PA	Natural Gas	850		2011 - 2012	> 20 MW
4	Panda Funds	TX	Natural Gas	1700	Site screening & GI studies & file application & Validate ISO's studies	2010	> 20 MW
5	Panda Funds	MD	Natural Gas	850		2012	> 20 MW
6	PBMR	Span US			US energy market research	2009	
7	EON	TX			Automated module tracking client generation curtailment	2008	> 20 MW
8	Sumitomo	Span US & Canada			Transmission consultant as a part of due diligence for acquisition of generation projects	2013	> 20 MW

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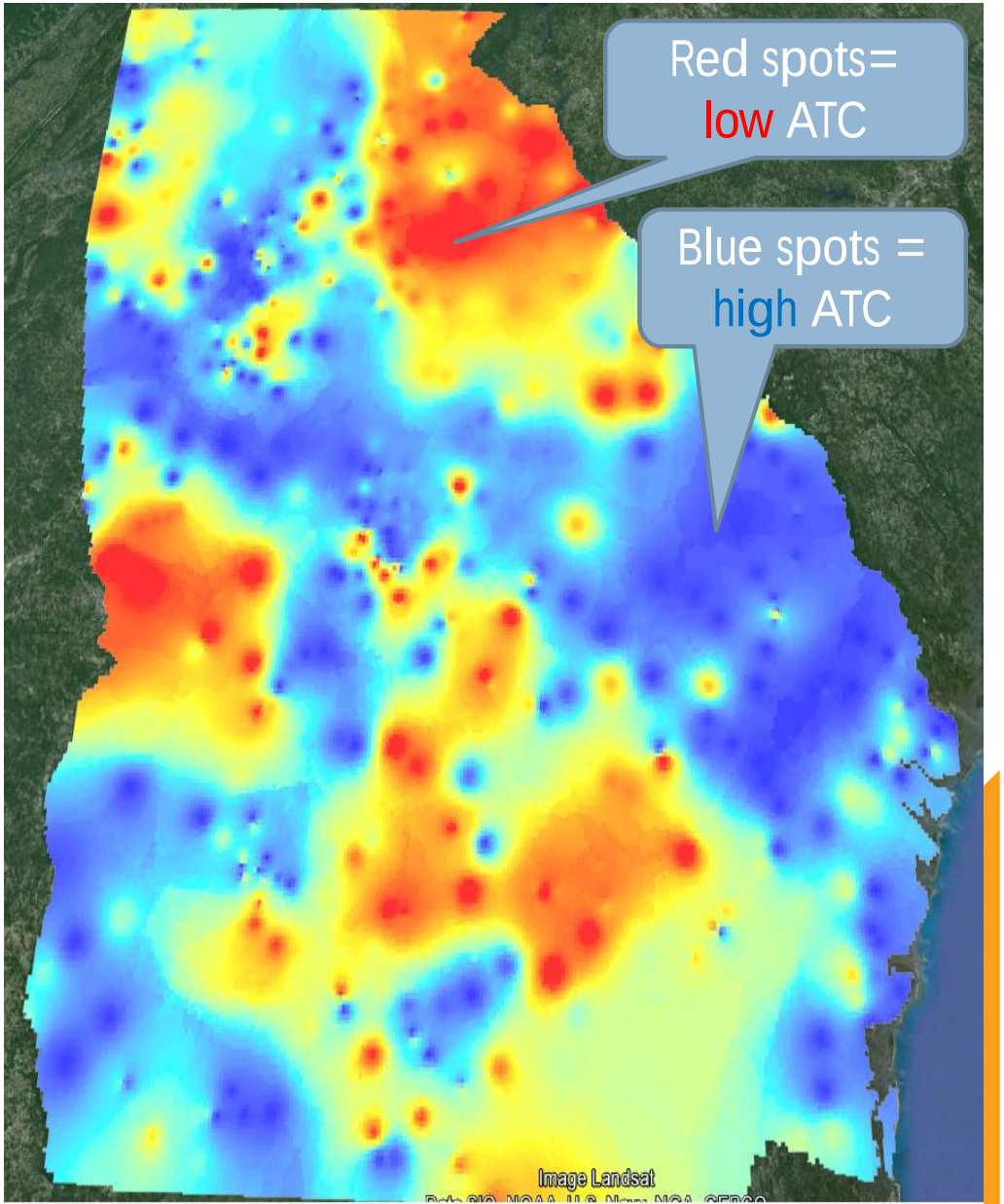
Case Study – Georgia

- The study was carried out for **Georgia Transmission Company** (GTC) to identify
  - **Optimum solar injection points**
  - **Possible congested spots for effective transmission planning**
- The contouring is based on the Available Transmission Capacity (ATC) at each studied node – 69 to 345 kV
  - The bluer spots have relatively higher ATC & Redder spots are more congested



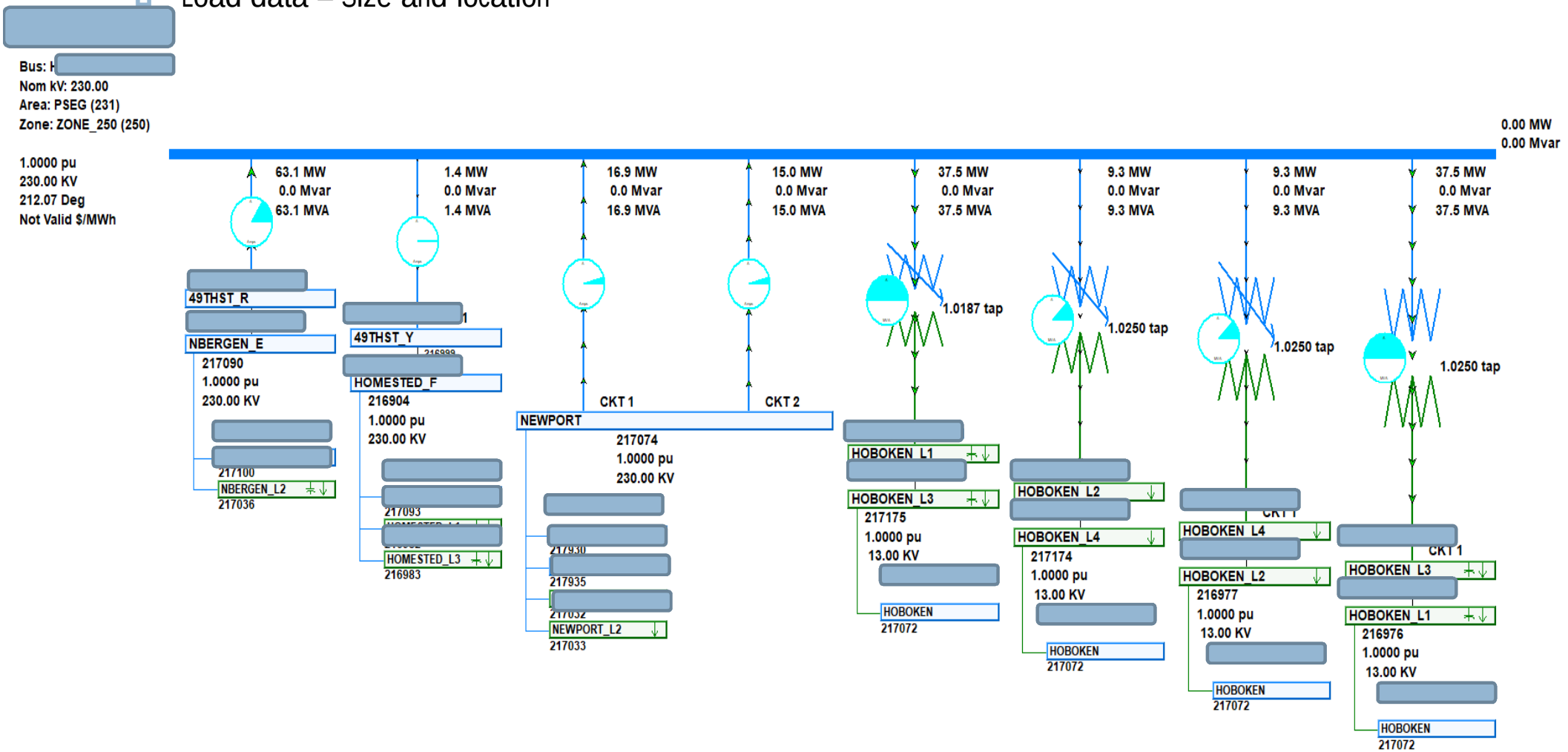
Case Study – Georgia

- Factors considered in ranking of the studied nodes are:
  - Project size (MW)
  - Interconnection cost w.r.t. reliability upgrades
  - Impact of prior queues
  - Previously existing known congestion issues
  - Planned transmission projects

- Takeaways for GTC:
  - Issued Request for Proposal to bidders at the blue spots
  - Annual Transmission Planning included the flowgates at the red spots
  - Advanced planning for balancing intermittency due to RE during specific generation & transmission outages

Case Study – Georgia

- Basic Grid Model is the underlying foundation for such studies:
  - Transmission data – Lines and Transformers
  - Generation data – Size and location
  - Load data – Size and location



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Need for Grid Model

- Application of generation and transmission planning in India
  1. **GIS contouring** merging solar radiance and transmission flowgate maps
  2. Knowledge of **optimal locations for RE additions** based on grid accessibility and evacuation
  3. Knowledge of **mitigation options** and the involved cost at specific locations
  4. With 2. huge **investors base can be invited** generating revenue
  5. With 3. **grid can be enhanced** to accommodate investors and to attract more
  6. Achieve **175 GW green energy vision** of the nation by 2022

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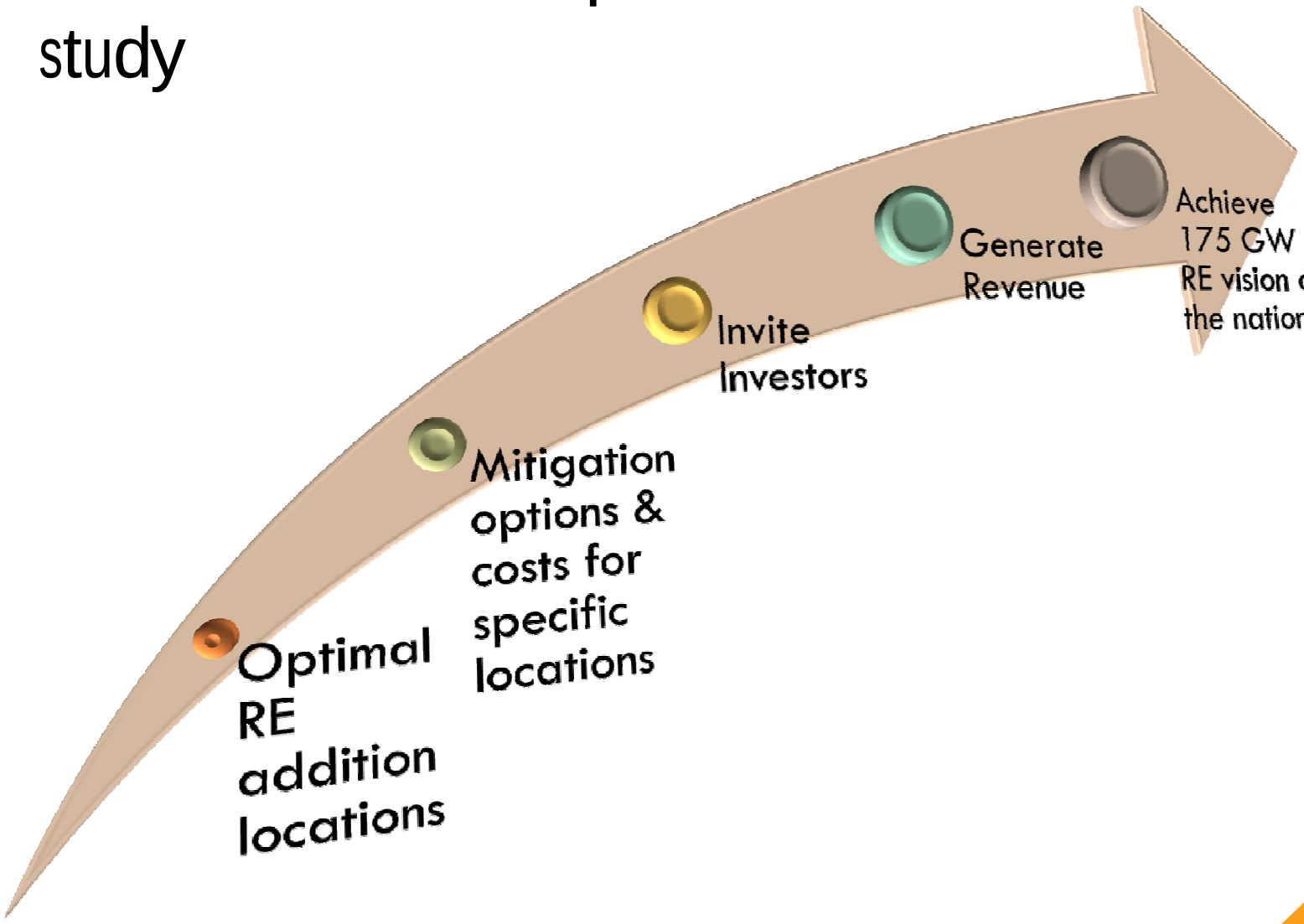
Need for Grid Model

- Here is the roadmap of benefits of the model & the study



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Need for Grid Model

- To conduct comprehensive studies on the current, planned and conceptual scenarios, relevant ***data is the key***
  - With cluttered data as the input, credibility of the resulting output decreases
- For 'Digital India' to become real, vital aspects of the economy need to be digitalized
  - Enormous intelligence can be drawn from the archived and real time data
  - Any updates to the system will be reflected in hours for experts to analyze
  - Policy makers can assess and validate the impact of many scenarios using such digital models

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A typical LV system with high solar penetration

- A typical LV system from 34.5 kV level with 0.5 GW of solar at two random substations serving load at a distant random substation in a hypothetical region is represented here
- Power Flow solution is applied (Newton Raphson) on the system & two snapshots are presented here:
  - List of top buses with voltage issues
  - Power flow snapshot around 250 MW generation

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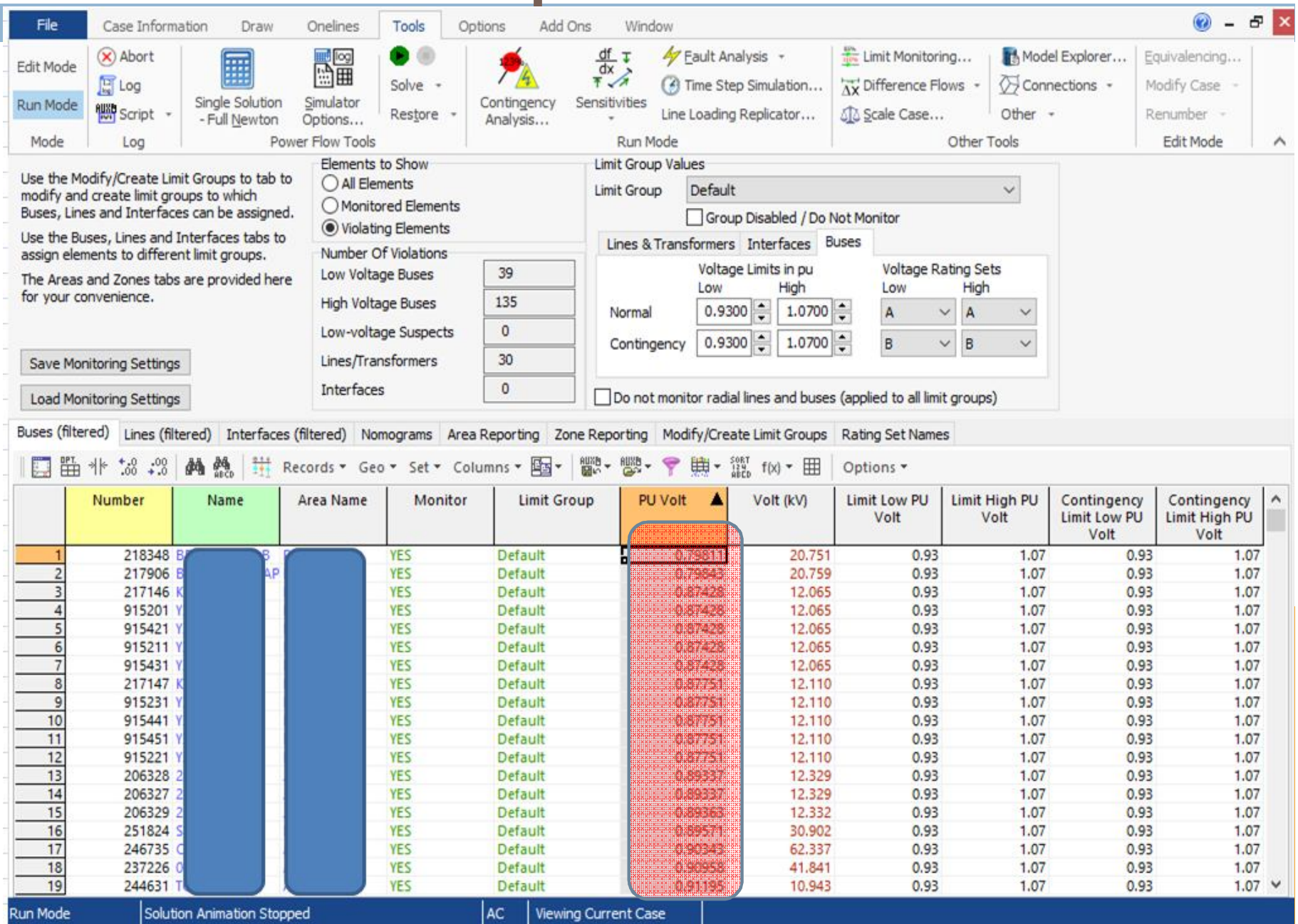
A typical LV system with high solar penetration

List of buses with voltage issues in descending order with 250 MW



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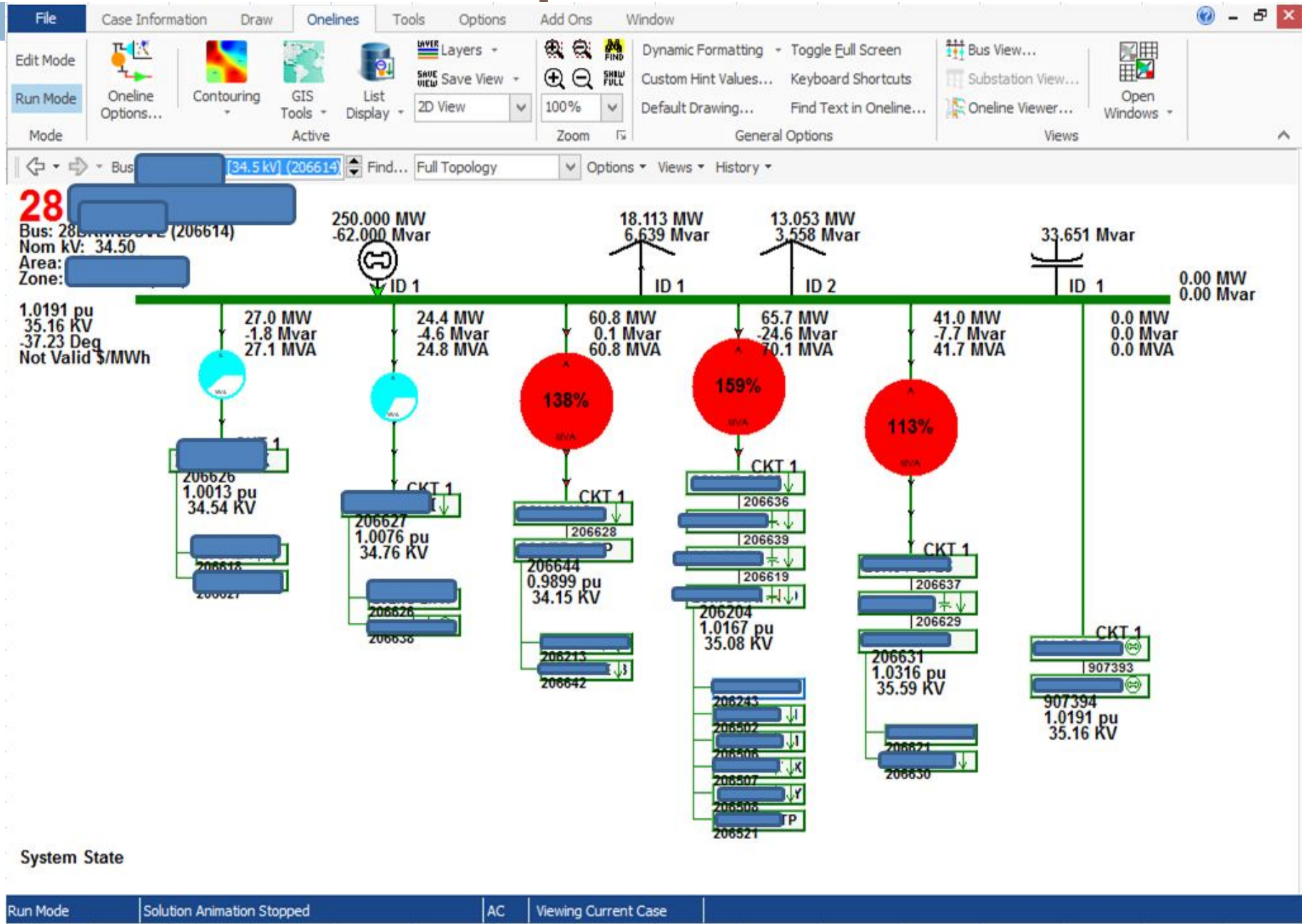
A typical LV system with high solar penetration

Power flow snapshot around 500 MW generation



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Current Course of Action

- State Load Dispatch Center and Prism are working closely in developing the model for the state
- Work is in progress

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Thank you!

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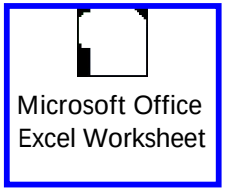
Appendix

- Technical details of load flow studies can be discussed at interest
- Transmission Planning Impact in US
- Current work on developing the state grid model



Transmission Planning Impact in US

- PJM Queue Status

Status	MW
Active	47,158
IS / ISP	35,628
Suspended	4,016
UC	14,647

- MISO Off Peak Transmission Capacity