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Challenges in Research on Discreet & Continuous Mathematics, Statistics and related for Smart (Power) Grids
Subjective Point of View of a Physicist

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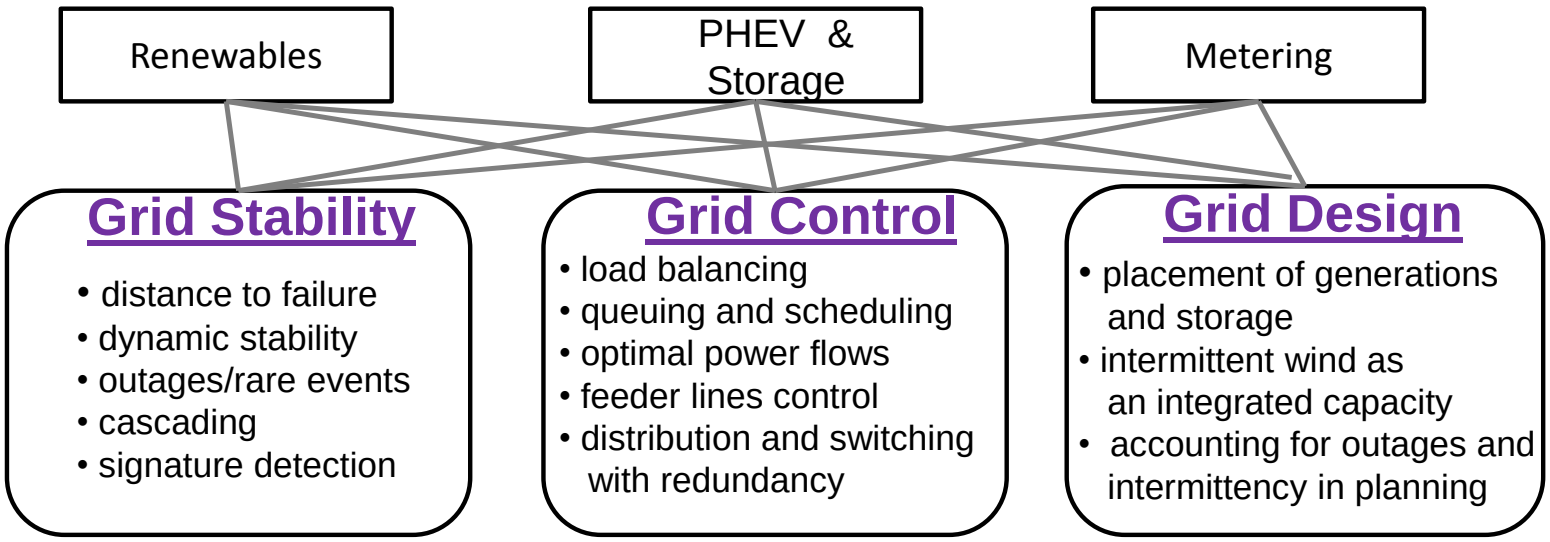
Our (LANL) *Road Map* for Smart Grids

New Systems



New Challenges

All of the above also requires scientific advances in

- Analysis & Control
- Stability/Reliability Metrics
- State Estimation
- Data Aggregation & Assimilation
- Middleware for the Grid
- Modeling Consumer Response

General Remarks

- 90% of time should be spent on formulating problems, which will normally be ill posed.
- The theory setting may be "toyish" (abstracting out "insignificant" effects) but needs to be based on power grid reality (e.g. power flows constraints should be accounted for in cyber, communication research)
- We (theorists) should be fishing for "universality" general principles (an example: scalings in cascades)
- Should have a good understanding of diverse temporal and spatial scales
- Make data, possibly sanitated and/or synthetic but realistic, available as benchmarks for researchers (different scales networks and power flow solutions - not necessarily algorithms)

More Technical (but still general) Remarks

- Distribution & Transmission Systems should not necessarily be considered separately
- Power Engineering should benefit from some unification (example: transient stability & voltage collapse are not so distant research areas)
- Statistical Power Flow (fluctuations, disorder, Master Equations, Fokker-Planck) bringing more of stochastic dynamics into power engineering
- Coarse-graining is not trivial (example from from fluid mechanics - large eddy simulations)
- Intermittency of new (renewable) sources is a separate important field/direction (need significant input from physics/atmosperic sciences)

Algorithms & Theory for Smart Grids

Design

- (re)formulating as optimization (possibly multi-objective)
- find an exact (optimal) or approximate (efficient) solutions
- worrying about probabilistic guarantees

Control

- clearly state the objective for control
- dynamics vs static
- markets (account for or not)
- learning in games (distributed control)

Stability

- different metrics for distance to failure (example - voltage collapse)
- cascades
- extreme events (of various kind)
- $\Leftarrow$ control and design of all the above