Appropriate Realism in Simulation Testbeds and Models for Power Systems

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Samuel Cody's tree
RAE Farnborough England 1908
Used to measure biplane thrust

Let’s consider models and testbeds for power grid as a **system**
(the discussion for components and devices can differ)

Experimenting with the grid is usually illegal,
…. hence the importance of
validating models and testbeds with observed data
and consistency with physical laws
for specified purposes

There is no such thing as a single grid model

All models cut corners.
Which corners to cut for given purpose?

We need new, validated cyberphysical grid models

Can we drive part of model from observed data?
… new possibilities for combining models and data
to get actionable information

Types of models and testbeds

High-level models for understanding, analysis, metrics

Detailed digital simulation models/testbeds
of an aspect of some of the cyberphysical grid

arrows show validations

GRID DATA AND OBSERVATIONS

Objectives for models/testbeds

- Test ideas in more realistic and controlled context which allows experiment… often more detailed representation of an aspect of the grid.
- Model incorporates appropriate physics and engineering
- Make operating and planning decisions with confidence
- Validate simplified models
- Enable practical simulation
- Enable analysis and calculations
- Provide understanding
- Educate the modelers

Process for getting models

- Communities discuss for years deciding which aspects to model for particular problems and in what detail, and validating them for a particular engineering use.
- Models for new phenomena or new engineering, which must start off with initial and simpler choices, are controversial
- In engineering, do not have the highly restricted context used to test scientific theories, and have great complexity, but judiciously approximated models often work well
- Models are at the heart of understanding, analysis, computation, data processing and actionable information.

Technical Problems

- There is no such thing as a single power system model;
  each useful model is tailored to only a few particular
  phenomena and particular aspects of the engineering problem.
  (Modifying these requires re-evaluating or modifying the model)

- All models compromise and negotiate between
  detail AND neglecting or approximating parts of the problem,
  availability of data, computational or analytic feasibility

- Even models well-established for particular phenomena
  omit important effects, especially when repurposed.

Cultural Problems

- Both modeling and validation are hard and can take years of work by a community (eg IEEE working groups);
  start with simpler models that are subject to criticism;
  long-term view and patience is needed.
- Engineers and analysts get very attached to models they are familiar with. This conservatism is both useful and a curse.
  … sometimes need to follow, sometimes oppose expert opinion
- Some engineers do not distinguish between the real grid and models
- There is a notion (sometimes correct) that more detail is better
- Some analysts do not recognize the existence of the real grid.
- Easier to write proposals for more detail or speed or algorithms;
  harder to write proposals for developing or validating models.
  But modeling is the heart of the grid engineering and science

Checklist questions for models/testbeds

- What are the phenomena and aspects of the engineering problem? That is, what will do with the model?
- How well is phenomenon/engineering problem understood?
- Does model engage with realistic physical and engineering constraints? Is there a science basis for model?
- What are timescale, subsystems of interest, voltage levels, etc?
- Is good data available to obtain model parameters?
- Is computation or analysis feasible?
- What aspects are modeled in what detail?
- What accuracy is needed for the engineering?
- Is model already validated for the intended purpose and what further validation is required?
- What type of comparison is adequate for validation?
- Is the model wrong in significant ways?
- Does model move us towards solution of engineering problem?