NREL
Transforming ENERGY

Sienna

Integrated Systems Planning: A Software Perspective

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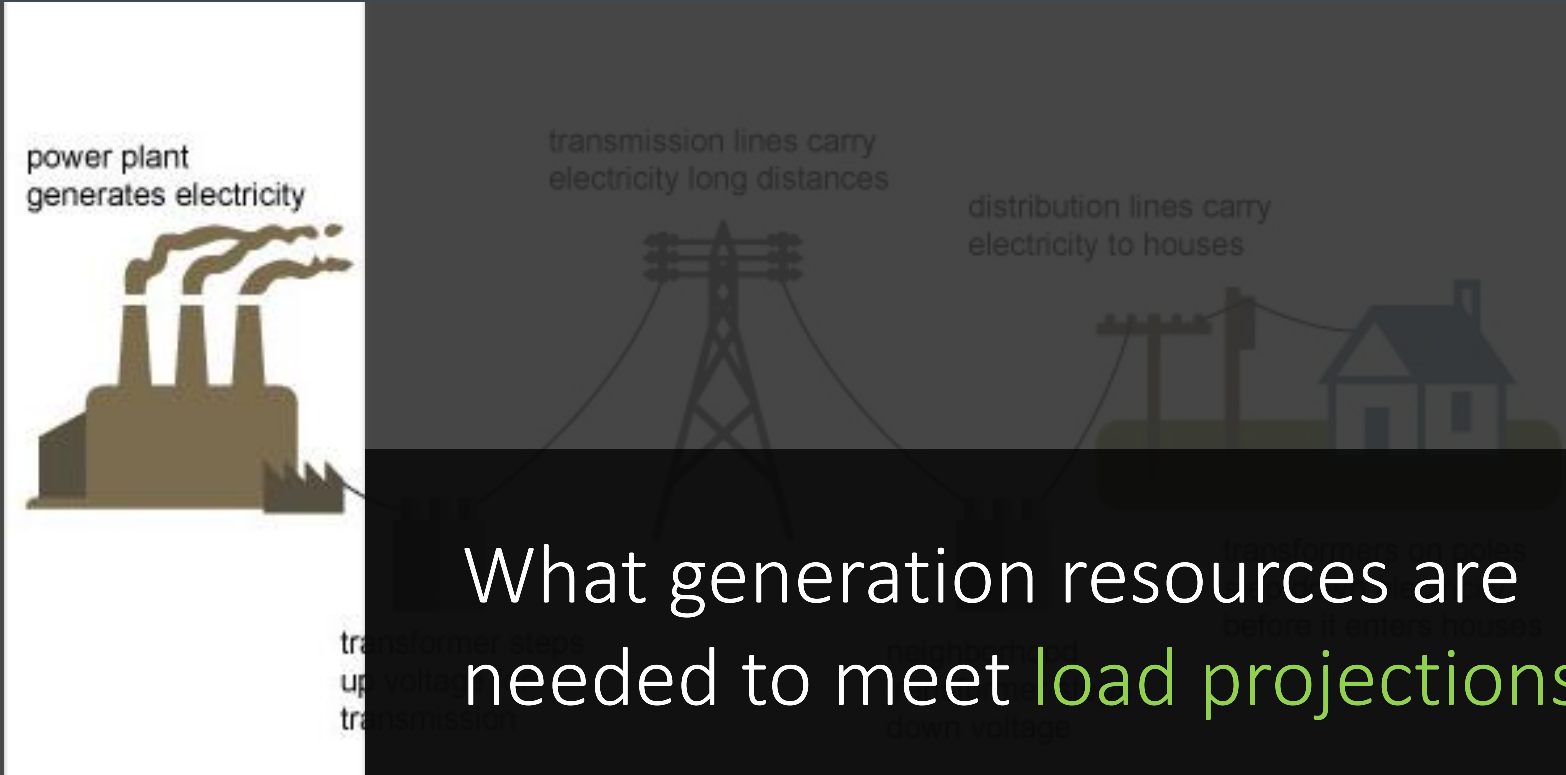
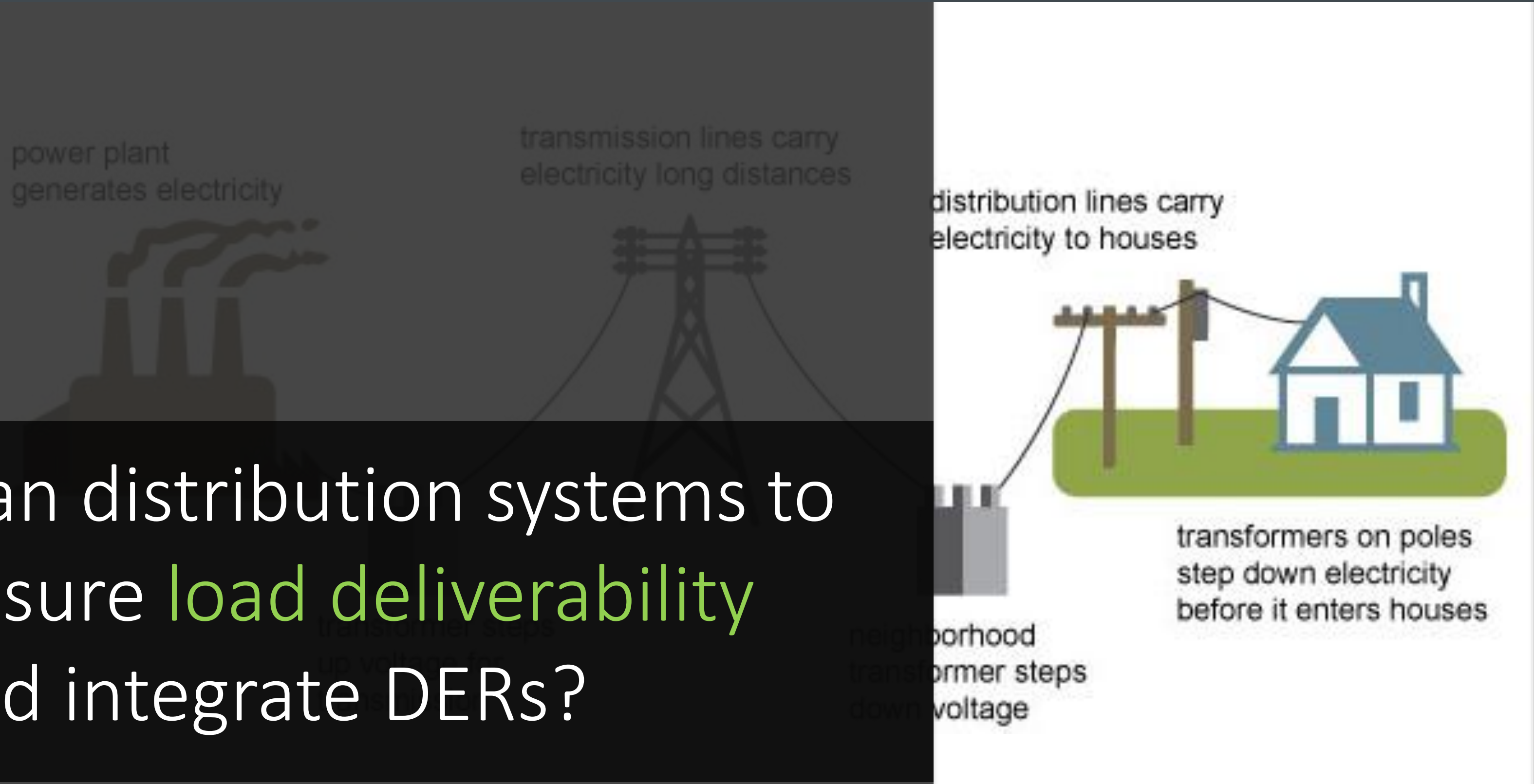
Where we've been: IRP



What generation resources are needed to meet load projections?

Source: https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php

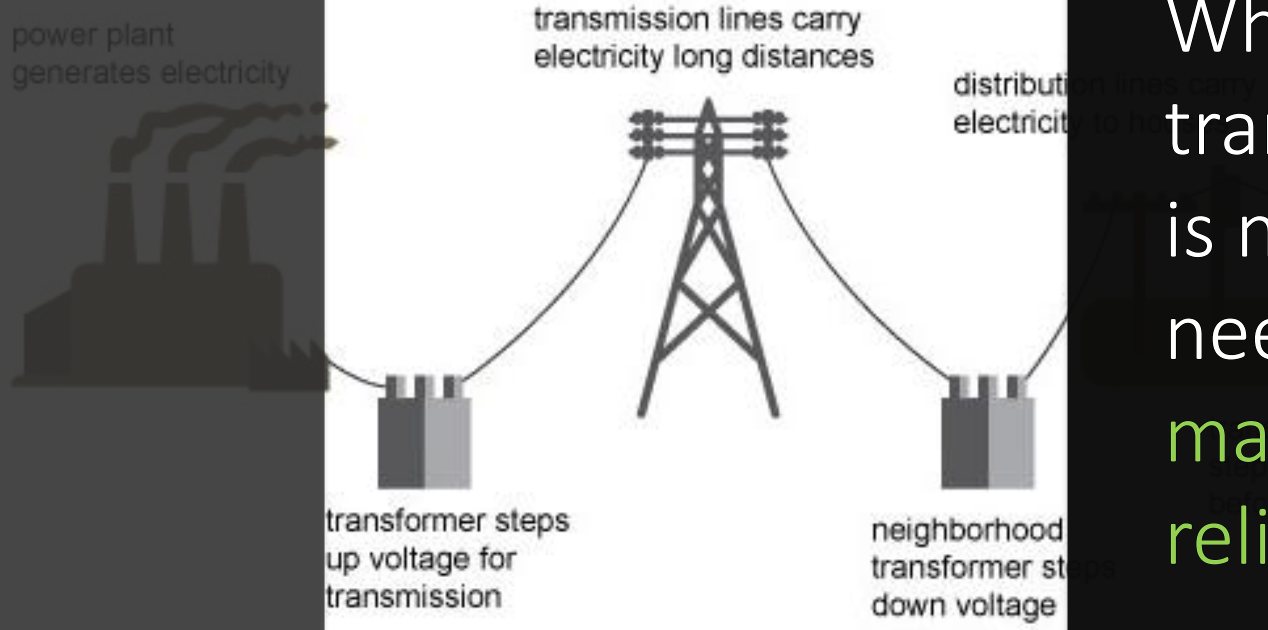
Where we've been: Distribution Planning



Plan distribution systems to ensure load deliverability and integrate DERs?

Source: https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php

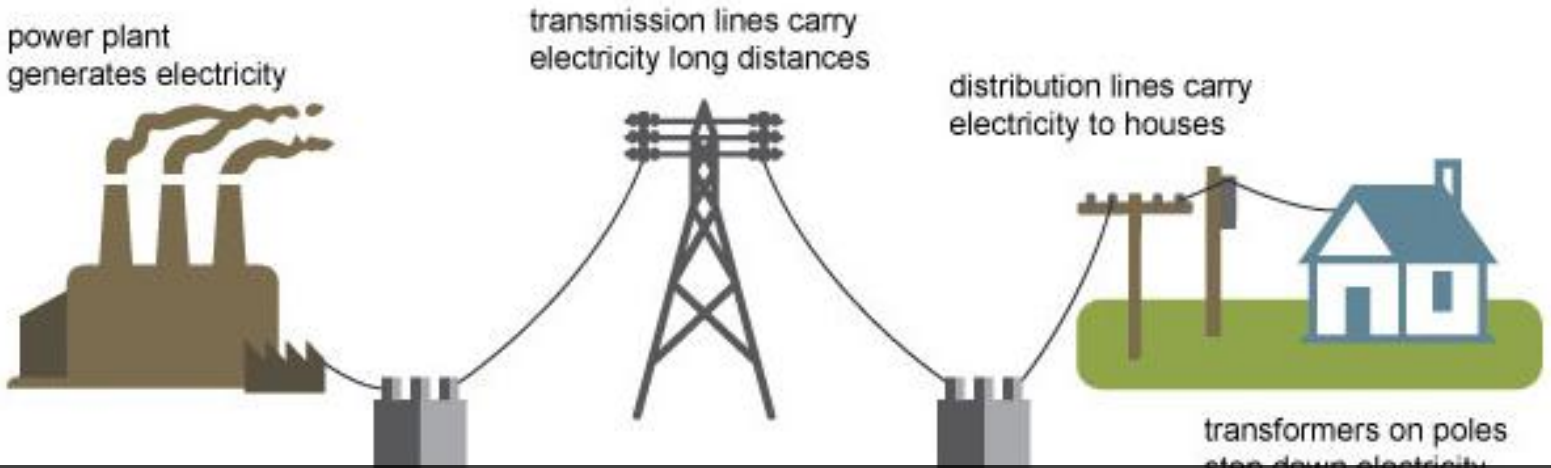
Where we've been: Transmission Planning



What transmission is needed needed to maintain reliability?

Source: https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php

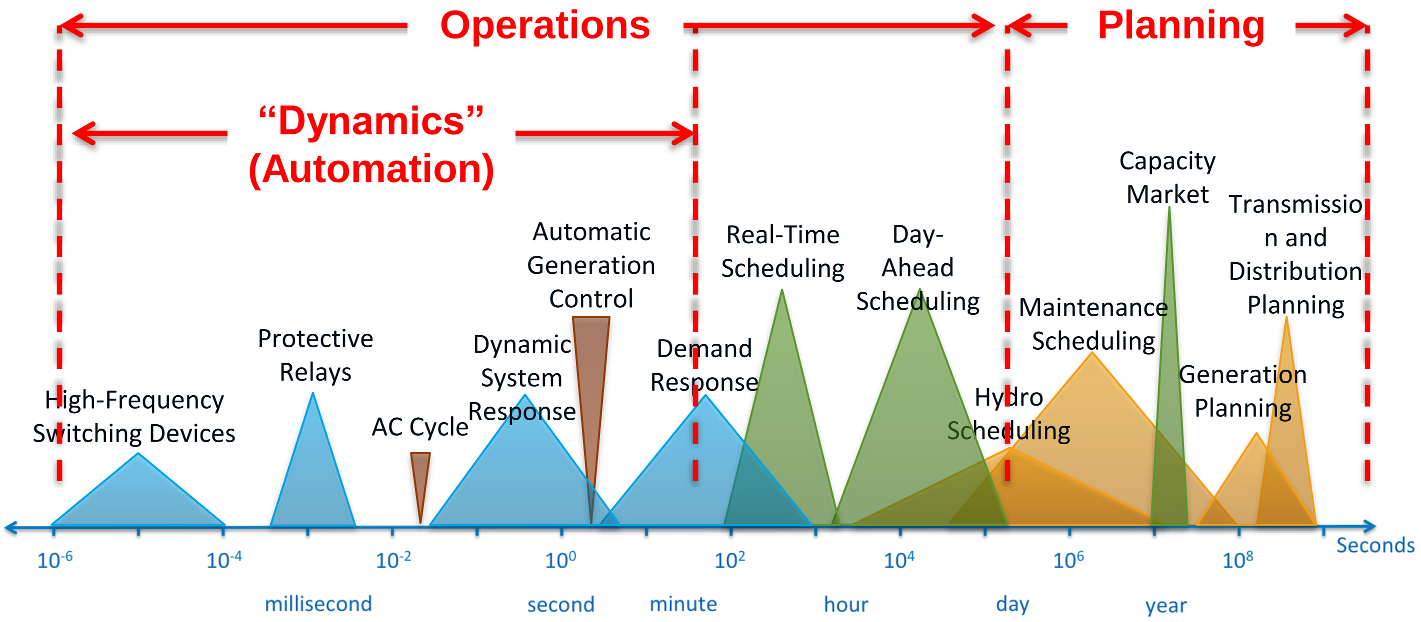
Where we're going: ISP



Which generation, transmission, and distribution projects achieve desired outcomes?

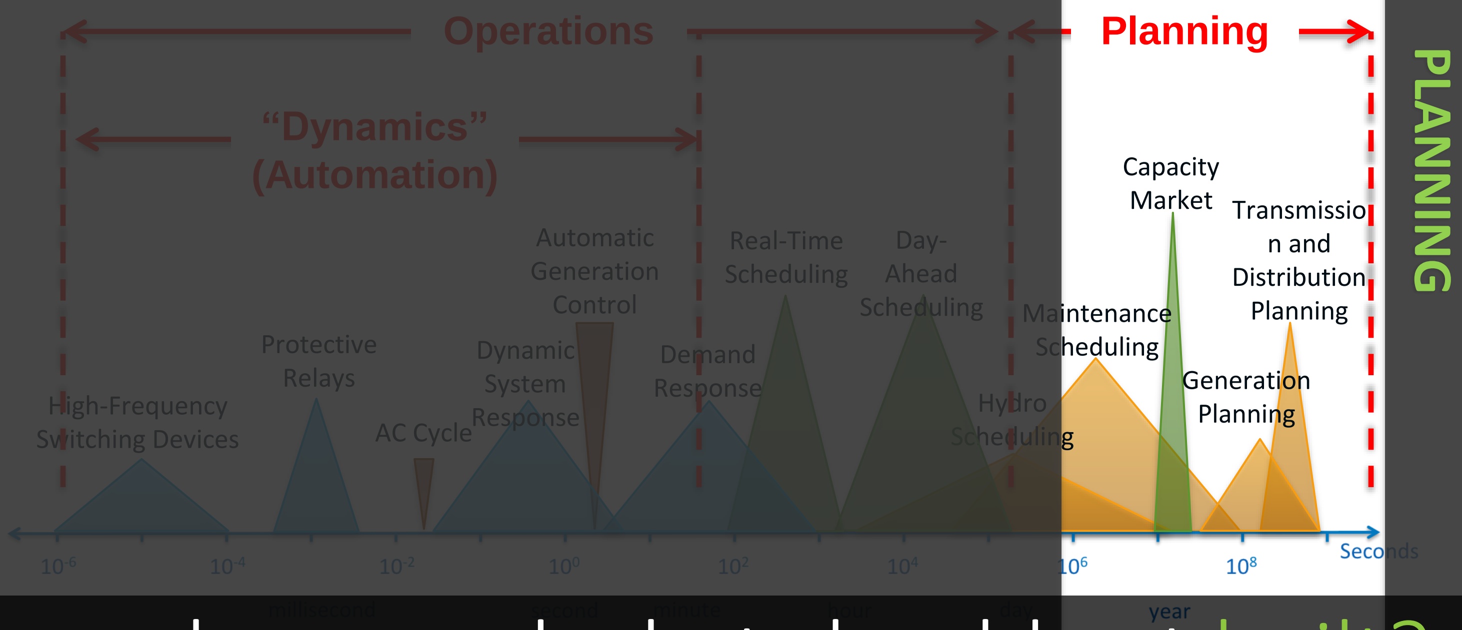
Source: https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php

Relevant grid decision timescales span 15 orders of magnitude



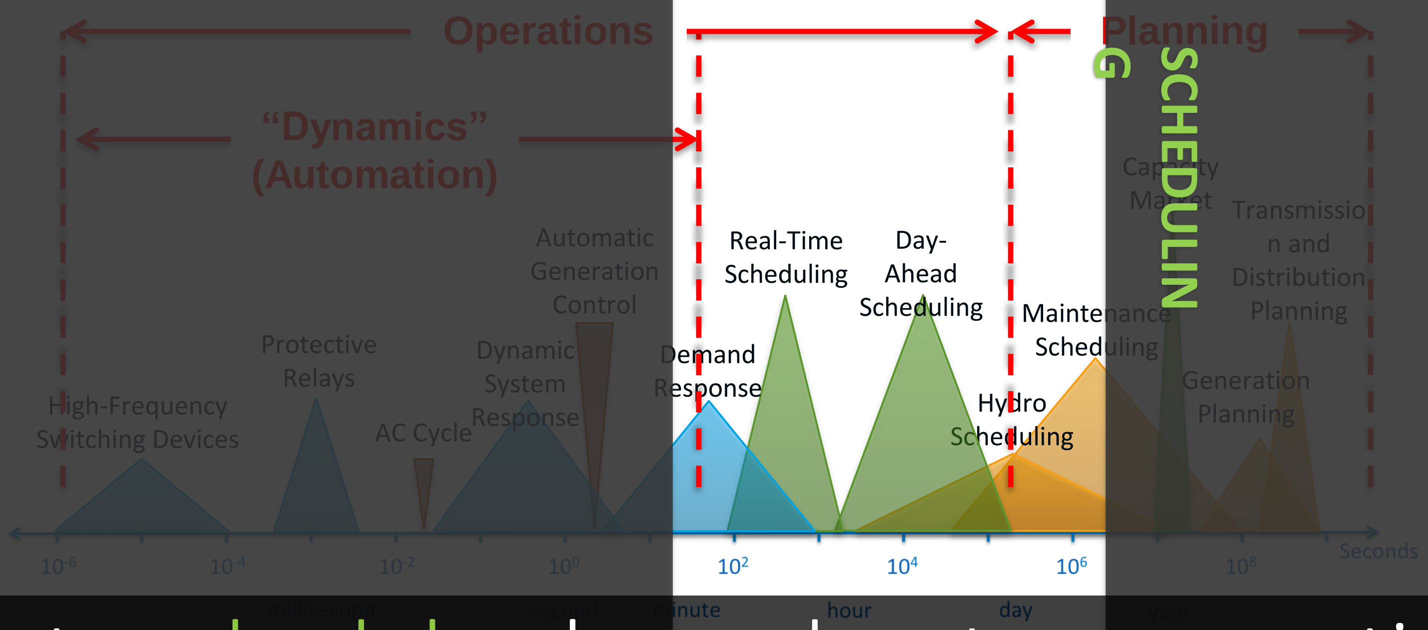
Adapted from A. Von Meier

Relevant grid decision timescales span 15 orders of magnitude



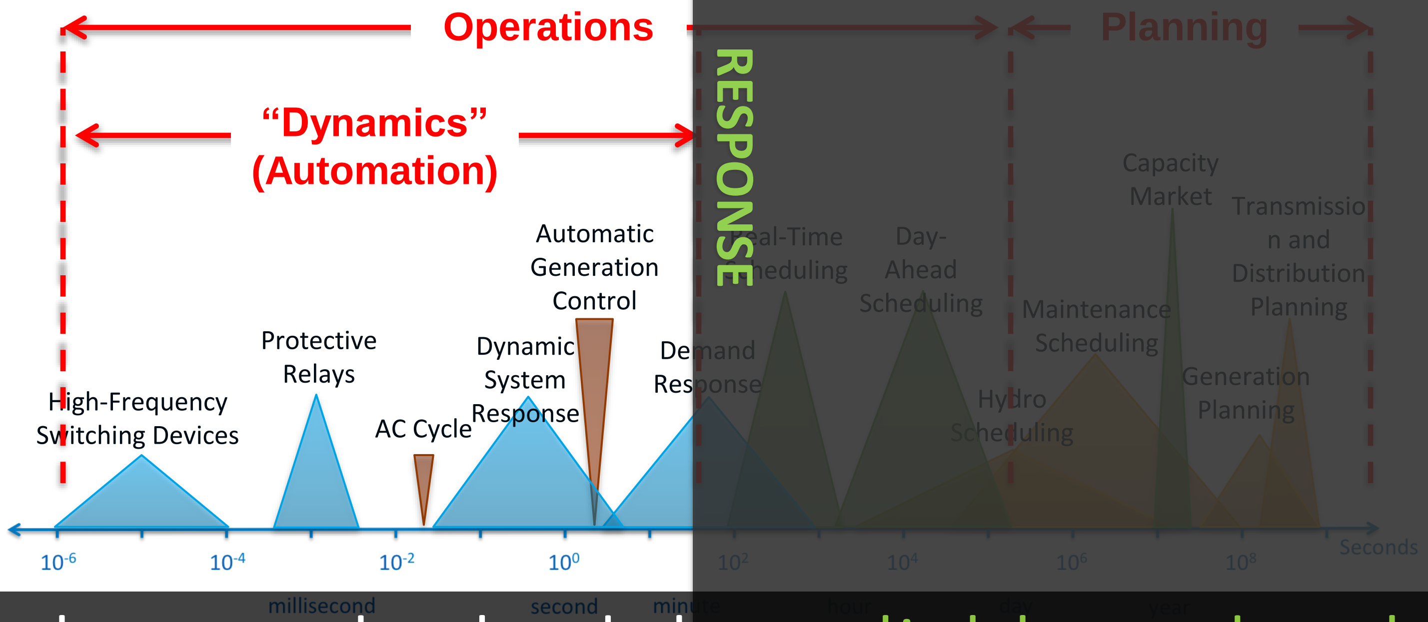
When, where, and what should get built?

Relevant grid decision timescales span 15 orders of magnitude



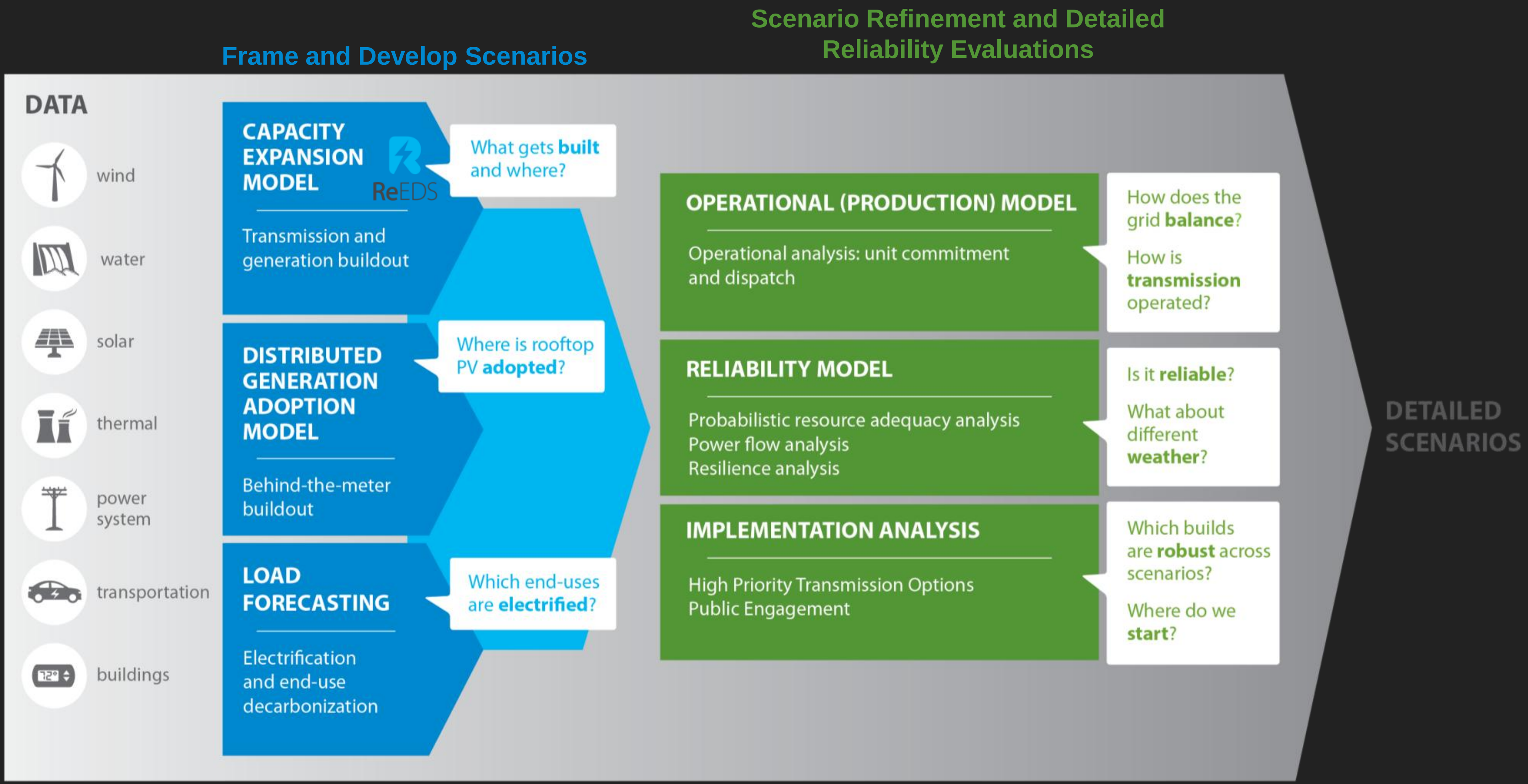
How to schedule planned system operations?

Relevant grid decision timescales span 15 orders of magnitude

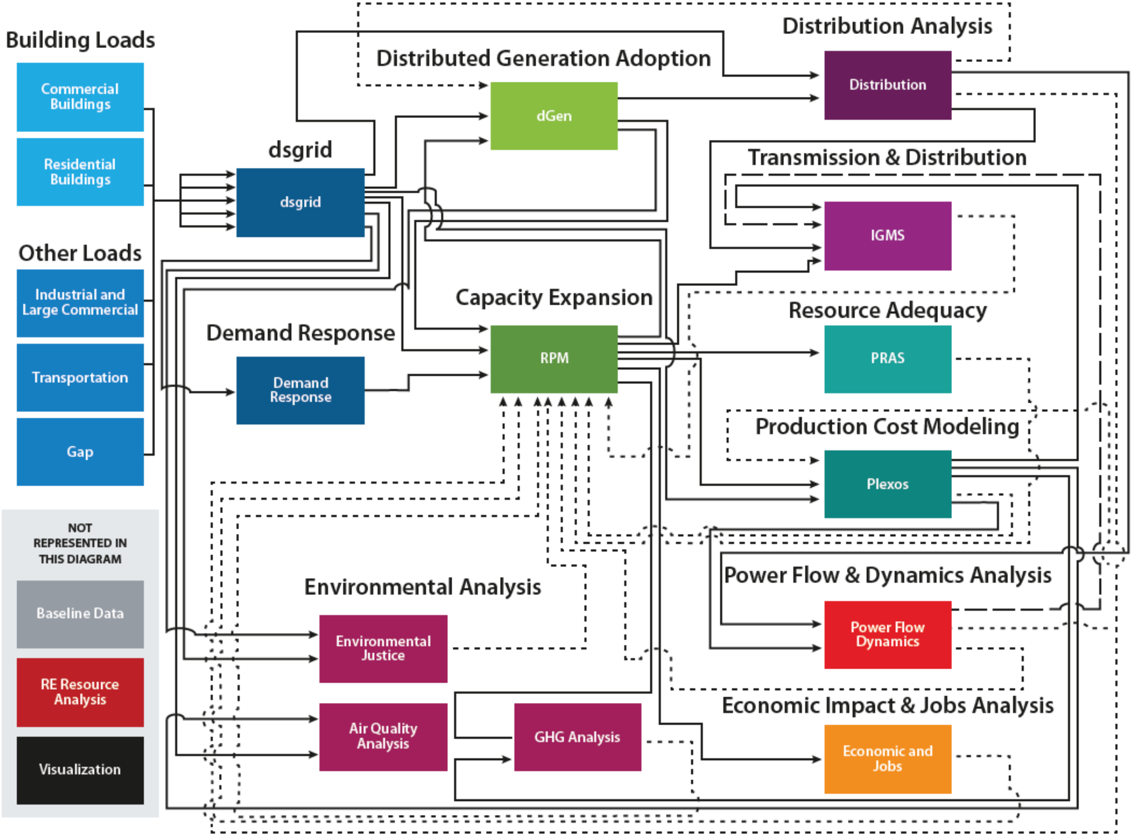


Are plans and schedules reliable and stable?

GPAC integration studies rely on multiple linked modeling exercises



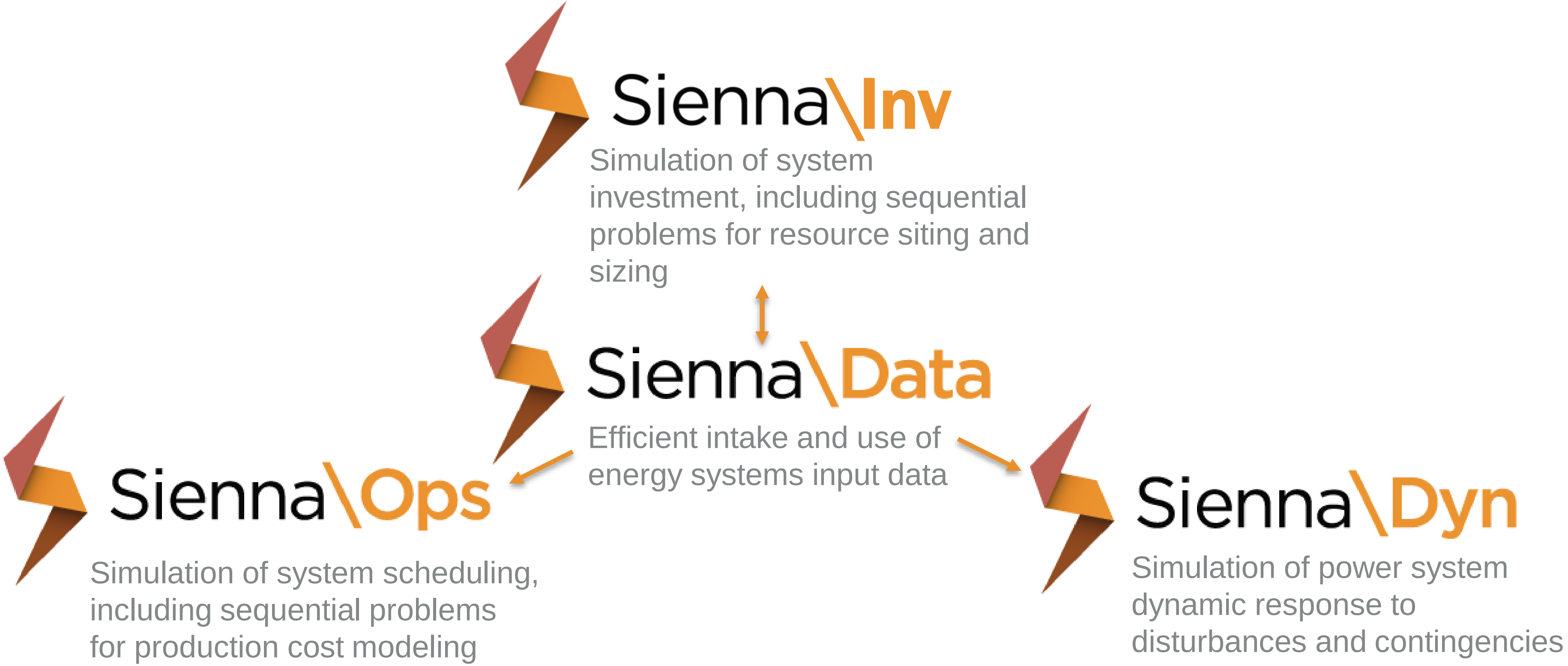
Problem Description from the software perspective



Each one of these arrows is doing A LOT OF WORK.

In most cases the software requirements for these arrows is not understood correctly and leads to using **"Heuristic Ad-hoc Code" (HAC)** that isn't reproducible or re-usable

Open-Source Ecosystem for Power System Modeling, Simulation, and Optimization



https://github.com/NREL-Sienna

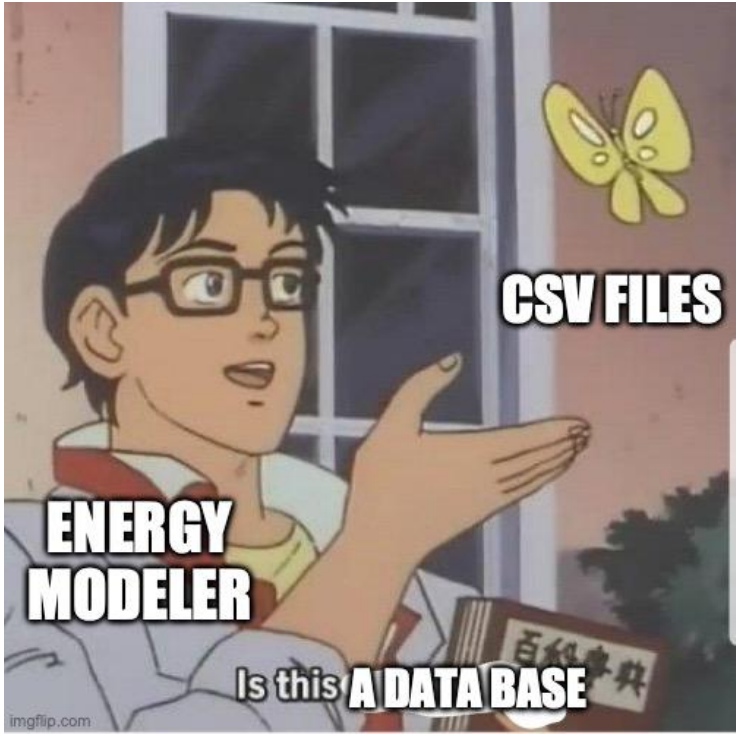
What we think integrated planning is…

- Integrated planning is a sort of catch all term that comprises multiple aspects.
  - Many subsectors of study: Generation, Transmission, Distribution
  - Many tools that need to be used for the study: PowerFlow Solver, Production Cost, Resource Adequacy, Capacity Expansion
  - Many stakeholders involved: utilities, ISO's, consumer advocacy groups and government agencies

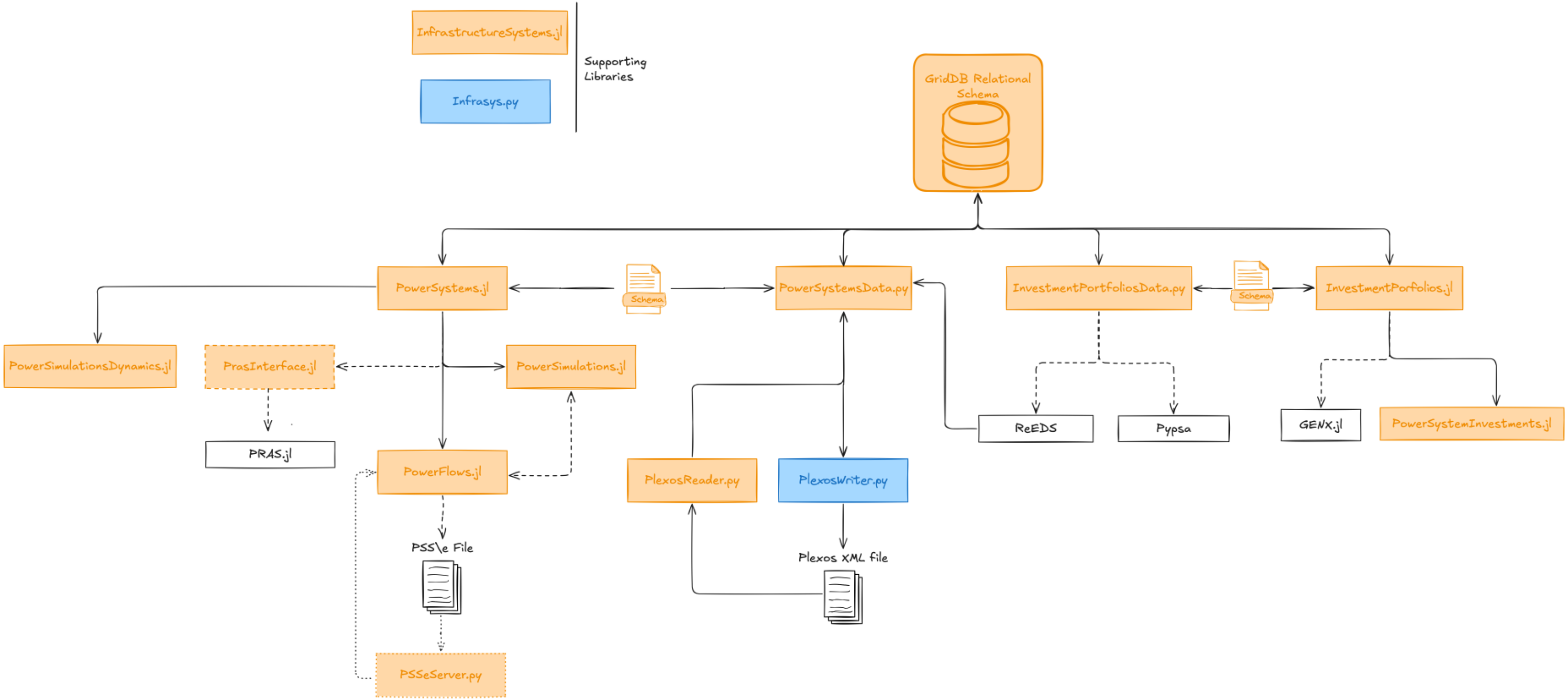
Lessons learned in Sienna

Current Issues with data handling for modeling

- **Motivation**
  - Diverse representation, file formats and file transformation across different tools. Makes the process inconsistent.
  - Addressing the challenges posed by CSV files as input data, including potential data inconsistencies and limitations in data validation. The process is not always repeatable.
  - Every analyst manipulates a different version of the data.



Unified Data Model For Analysis Applications



OpenSource Conversion Libraries

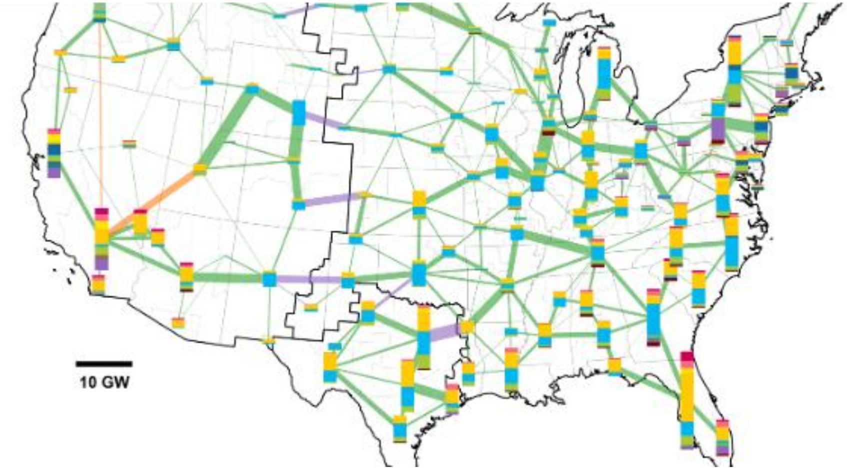
R2X

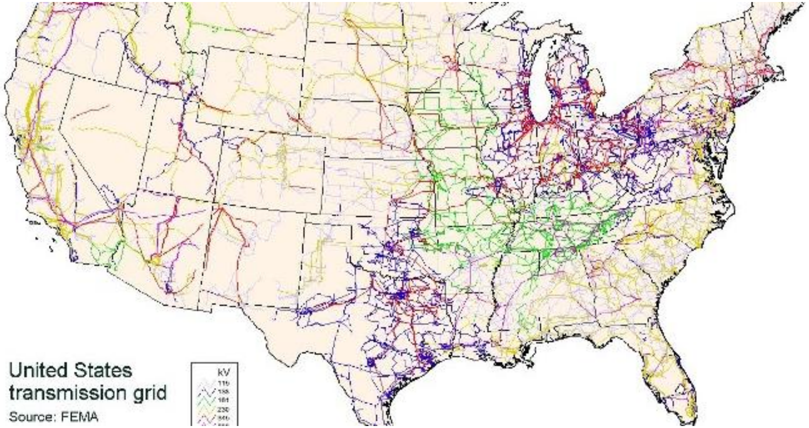
- WHAT IT IS?
  - Application for converting inputs/outputs of power system model to an “X” model(s).
  - Modular code-base to customize requirements for any model.
- WHY WE BUILT IT?
  - Originally to translate results from ReEDS to production cost models.
  - Reproducible CEM -> PCM workflows

- plexosdb.py
- Infrasys.py
- chronify.py
- powersystemsdata.py

CEM to PCM

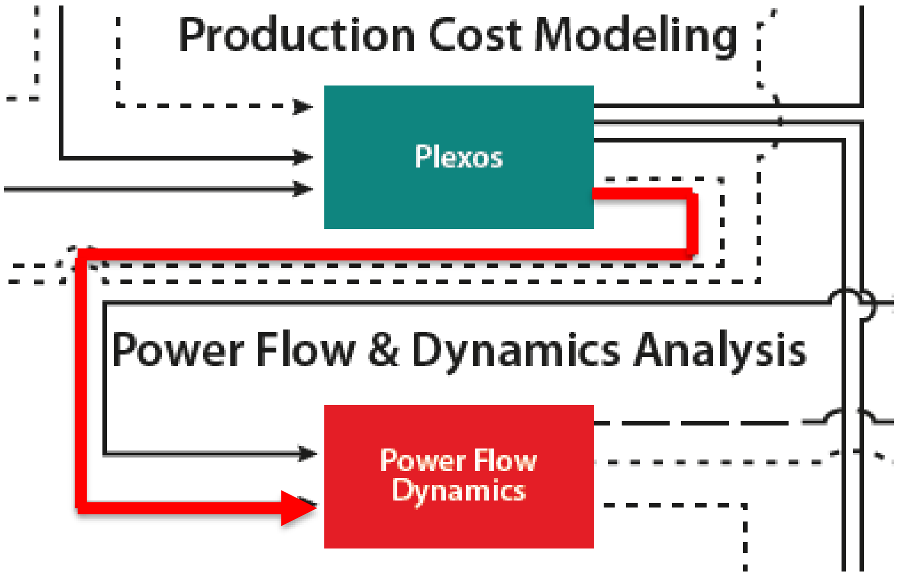
- Model interoperability requires translation
- Translations are models





- CEM simplifications are difficult to undo

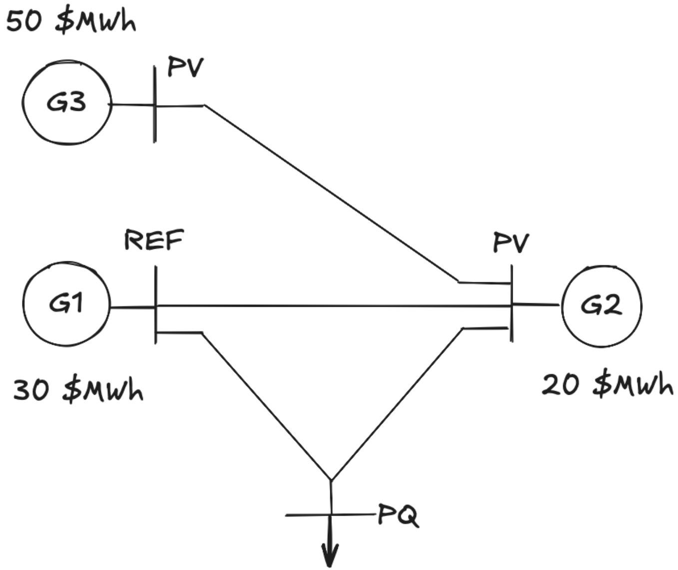
A deeper look into one single arrow in the diagram: PCM to PF

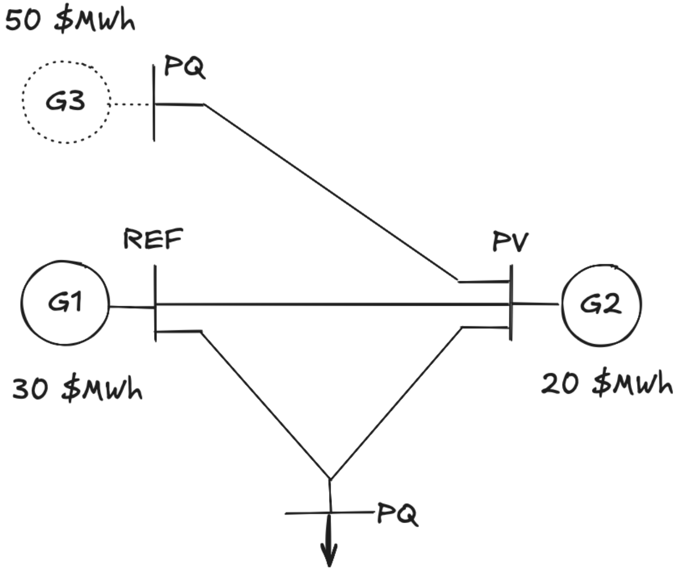


Consistency of the data between the applications

- The data has to start from the power flow files.
- Which units are on/off for the case file?
- Power flow cases have MANY pass-through nodes (degree 2 nodes) with no injections

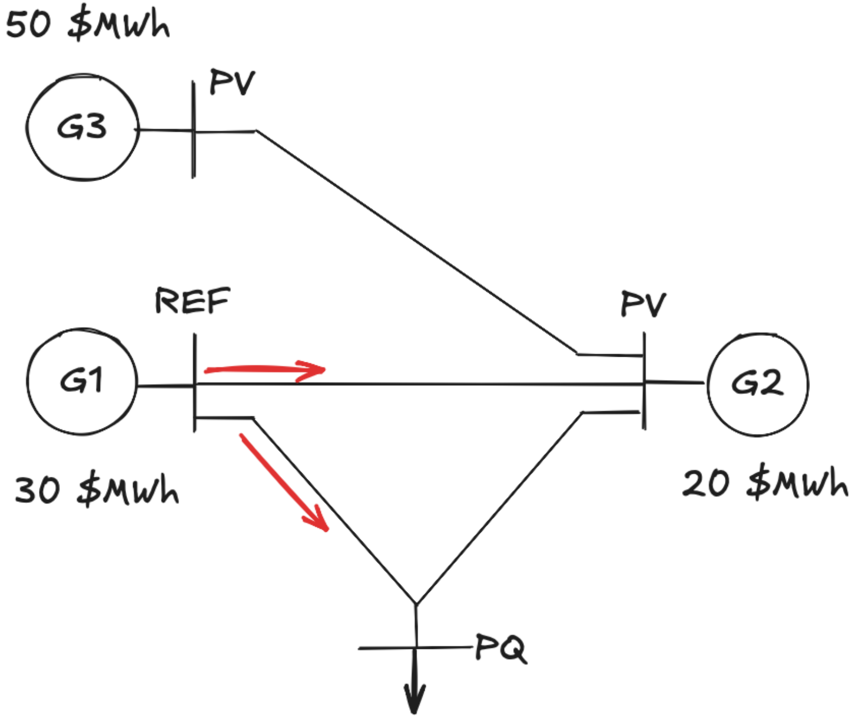
Unit Commitment + Power Flows



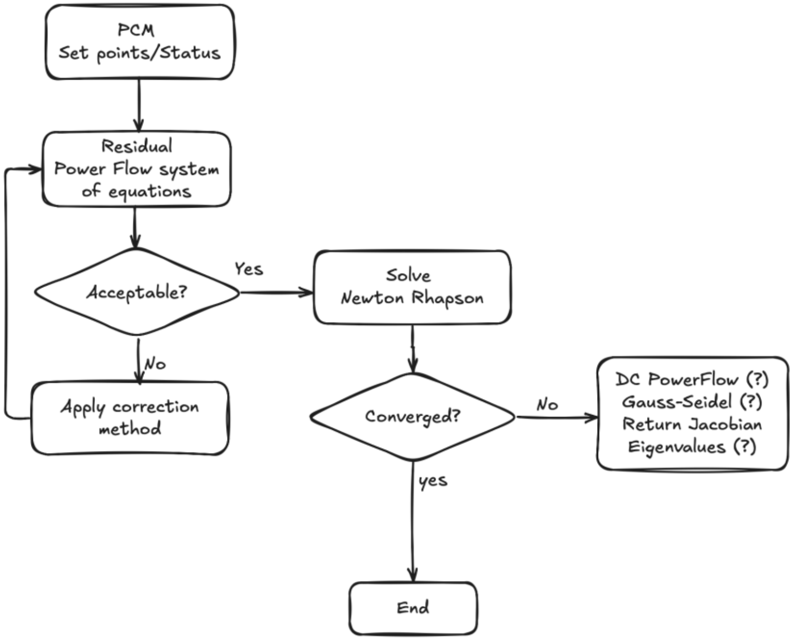


The PCM can decommit a unit and the bus type needs to change in the

What about losses?

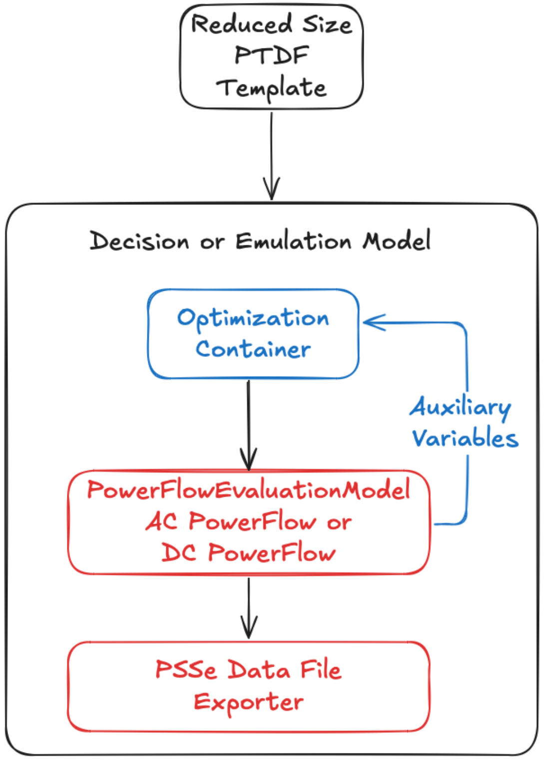


Convergence Failures



How to handle HVDC?

Interoperable Power Flow evaluation for reduced order operation problems



- PowerFlowEvaluationModel is multiperiod object by default that can take the details of the optimization model and populate the correct power flow model for that time-step.
- For each time in the horizon, it is possible to evaluate the power flow and if required export a PSSe file correctly specified for the specific formulation in the template.
- Integrate Loss Factors as auxiliary variables from Power Flow
- Yes, you can export 8760 power flow cases for a PCM simulation of any size grid.

Conclusions

- Workflow requires huge amount of effort for connecting tools simply for feedforward information.
- In many cases feedback between tools is not known
- You can't really make up data, you need to start from a detailed model (today data) and augment it. It's a fool's errand to start from capacity data and make up operational pcm data.