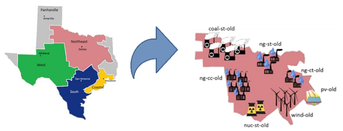
Flexible Modular Formulations for Grid Infrastructure Expansion Planning

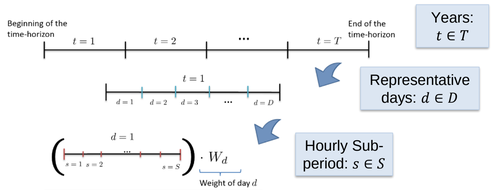
Kyle Skolfield, John Siirola
Sandia National Laboratories

IDAES® Institute for the Design of Advanced Energy Systems

Motivation

Current Expansion Planning Models are Restrictively Specialized





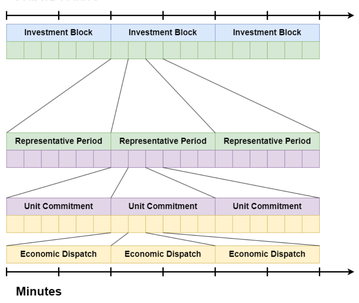
Existing models are tailor-made to a single case study with fixed time periods

How can we formulate expansion planning to **flexibly** adapt to new systems, technologies, timelines, & requirements?

Modular Generalized Dynamic Programming GTEP

Optimization

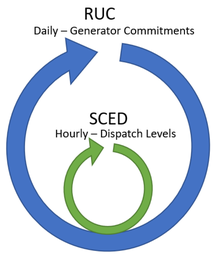
PYOMO PYOMO GDP



Integrate Standard Models for Power Flow and Data Handling

Prescient

EGRET



MILP:

$$\underline{P_g} \leq P_{gt} U^{ON}_{g\tau} Y_{gT} \leq \overline{P}_g$$

$$0 \leq P_{gt}\left(U^{SU}_{g\tau} + U^{SD}_{g\tau}\right) Y_{gT} \leq \underline{P_g}$$

GDP:

$$Y_{gT} \left(\left(U^{ON}_{g\tau} \right) \left(\underline{P_g} \leq P_{gt} \leq \overline{P}_g \right) \vee \left(U^{SU}_{g\tau} \right) \left(0 \leq P_{gt} \leq \underline{P_g} \right) \vee \left(U^{SD}_{g\tau} \right) \left(0 \leq P_{gt} \leq \underline{P_g} \right) \right)$$

Assumptions

Case Study and Model are Independent

- Generation decisions (technologies, locations, sizes, etc.)
- Transmission decisions
- Storage decisions
- Regional requirements
- Time periods

Prior Static Assumptions

- Annual Investment Periods
- Representative Days
- Hourly Commitment
- Hourly Dispatch
- Transport Power Flow Model
- Single Case Study per Model

Updated Modular Assumptions

Investment Periods
- Decadal
- Annual
- Monthly
- Other

Representative Periods
- Daily
- 72-hourly
- Weekly
- Other

Commitment Periods
- Hourly
- Sub-hourly
- Other

Dispatch Periods
- Hourly
- 15-minutely
- 5-minutely
- Other

Power Flow Model
- Transport
- DCPF
- ACPF
- LPAC

Extensive Use of Disjunctive Programming
- Unit Commitment
- Investment
- Storage

Contact: Kyle Skolfield, jkskolf@sandia.gov

User Adaptability

Input Formats

Because EGRET and Prescient are used to process input data, any standard format supported by those tools is supported in IDEAS GTEP. This allows for flexibility and reliability in data that is independent of modeling tools.

Standard data formats supported include:

- Matpower
- RTS-GMLC
- json, json-ed, json.gz
- csv
- pglib-uc
- Prescient *.dat

Flexibility

Minimize hard-coded parameters while still providing default values matching the most common decisions

- Investment Length
- Representative Period Number and Length
- Commitment Length
- Dispatch Length

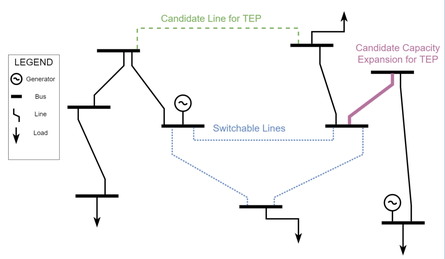
Modularity

Add/remove modeling components easily – especially those with major consequences or computational burdens:

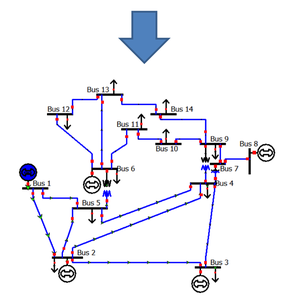
- Power Flow Model
- Unit Commitment
- Redispatch
- Contingency Flags
- Storage
- Generation Classes
- Transmission Expansion

Ongoing Work

Additional Expansion and Operational Decisions



Generalized Modeling Framework Enables Scalable Methodology Research



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