SWITCH-WECC

http://rael.berkeley.edu/switch

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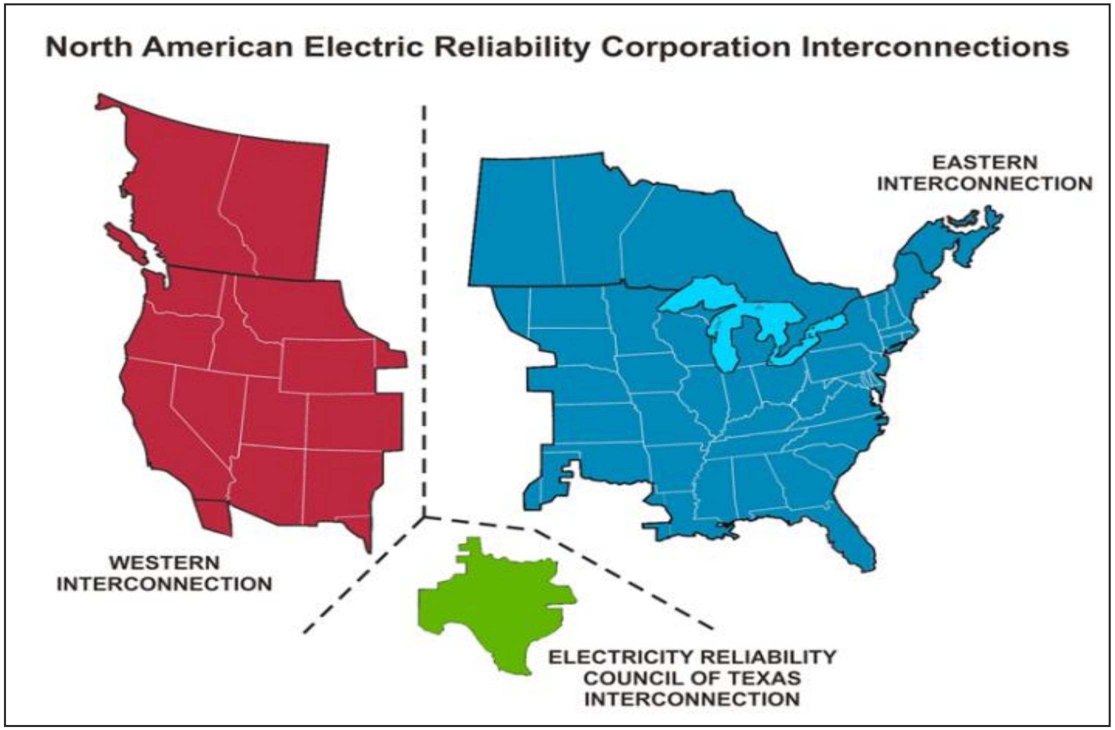
The SWITCH Model

- Model created to study the cost of achieving high renewable energy targets in California
  - Fripp, M., 2008. Optimal investment in wind and solar power in California. Ph.D. Dissertation, University of California, Berkeley, Energy and Resources Group, 2008.
  - Fripp, M., 2012. Switch: a planning tool for power systems with large shares of intermittent renewable energy. *Environmental Science and Technology* 46 (11), 6371-6378.
- Model expanded to the Western Electricity Coordinating Council (WECC)
  - Nelson, J., Johnston, J., Mileva, A., Fripp, M., Hoffman, I., Petros-Good, A., Blanco, C., Kammen, D., 2012. High-resolution modeling of western North American power system demonstrates low-cost and low-GHG futures. *Energy Policy* 43, 436-447.
  - Wei, M., Nelson, J., Greenblatt, J., Mileva, A., Johnston, J., Ting, M., Yang, C., Jones, C., McMahon, J., Kammen, D., 2013. Deep carbon reductions in California requires electrification and integration across economic sectors. *Environmental Research Letters* 8 (1), 014038.
- SWITCH-WECC enhanced to better capture impacts of intermittency and system flexibility options
  - Mileva, A., Nelson, J., Johnston, J., Kammen, D., 2013. SunShot solar power reduces costs and uncertainty in future low-carbon electricity systems. *Environmental Science and Technology* 47 (16), 9053–9060.

SWITCH-WECC

- Capacity planning for large geographic region over several decades
- SWITCH can be applied to other regions

- **Geographic extent**
  - Western North American power system (the WECC)
  - Plant-level existing generators
  - Existing high-voltage transmission
  - Thousands of possible new wind and solar projects
- **Time-synchronized hourly profiles for load and renewable output**
  - Goal is to capture the temporal relationship between load and renewable power



SWITCH-WECC

- Formulated as a linear program
- **Objective function**: minimize the total cost of the power system between present day and a future date
- **Main constraints**: demand, reliability, and policy
  - Meet projected electricity demand in every hour
  - Maintain a planning reserve margin in every hour
  - Maintain operating reserves (spinning and quickstart) in every hour
  - Meet renewable portfolio standard (RPS) goals
  - Meet carbon emission cap goals and/or optimize with a price on carbon emissions
- **Main variables**: investment and unit commitment
  - Capacity installation decisions in each "investment period"
    - Operate or retire existing generation capacity
    - Invest in new generation, transmission, and storage capacity in each investment period
    - All investment periods are optimized simultaneously
  - Linearized unit commitment for representative timepoints
    - Seven categories of generators with different levels of flexibility (baseload, flexible baseload, intermediate, peaker, intermittent, hydropower, and storage)

SWITCH-WECC

- **Temporal resolution**
  - Investment
    - Usually 4 investment periods in an optimization
  - Unit commitment
    - Peak and median load day from every month are sampled every 4 hours
    - 144 hours per investment period (12 months x 2 days/month x 6 hours/day)
    - 576 dispatch periods per model run (4 investment periods x 144 hours/investment period)
  - All investment and unit commitment decisions are optimized concurrently
  - Subject to computational constraints

- **Post-optimization verification**
  - Checks that the power system designed by the main optimization can meet load during hours that were not optimized for
  - 1 or 2 years of hourly time-synchronized demand, wind output, and solar output data per investment period
  - Linearized unit-commitment