Overview of renewable technologies in the National Energy Modeling System (NEMS)

For

Workshop:

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By

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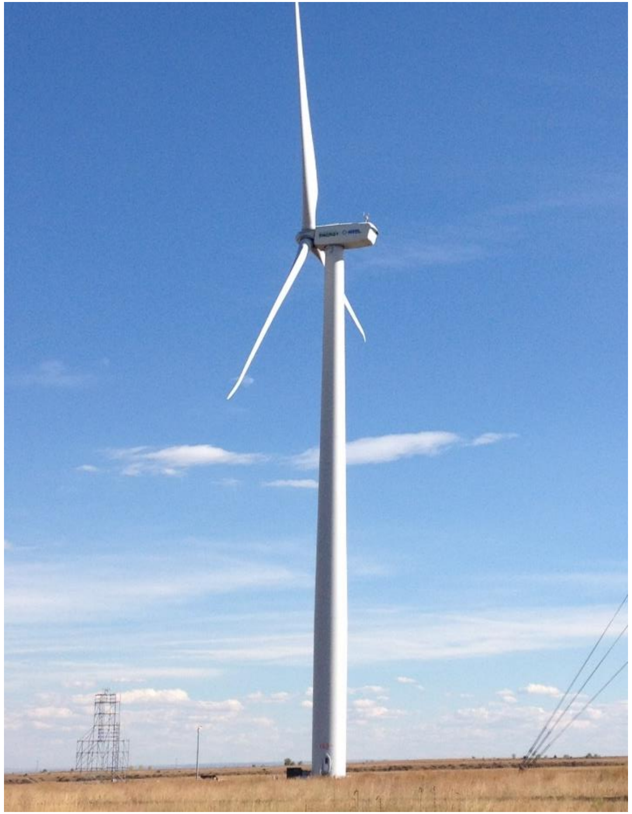
Eight different utility-scale renewable electricity technologies are represented in the model

- Renewable electricity technologies represented in NEMS include:
  - Biomass-Wood
  - Biomass-Municipal solid waste/ Landfill gas
  - Geothermal
  - Conventional hydropower — seasonal/ energy limited
  - Solar-thermal
  - Solar-photovoltaic
  - Wind-onshore
  - Wind-offshore

  (Solar-thermal, Solar-photovoltaic, Wind-onshore, Wind-offshore:) non-dispatchable, e.g. intermittent or variable



Biomass

- Can be used in dedicated, direct-fired biomass plants or cofired with coal
  - Much biomass generation comes from the pulp/paper industry
  - This cogeneration is accounted for in the industrial sector
- Previous AEOs saw a lot of cofiring, but several factors make this less attractive now, including lower cost alternatives and pressure on existing coal plants
- Fuel derived from urban wood waste, forestry residues, agricultural residues, and energy crops
  - Urban wastes and forestry are the lowest-cost resources
- MSW/LFG model is dated and currently under revision

Conventional Hydropower

- Provides available supply of new conventional hydroelectric generating capacity that can be built at known and well-characterized sites
  - ≥ 1 MW, < $0.10/kWh
  - Based on list of known conventional hydro sites – 1299 sites, 22 GW potential
  - 3-step supply function – by year, region
    - Average cost
    - Performance characteristics
    - Aggregate capacity
- Hydro is dispatched on an energy-constrained basis
  - Dispatches at full capacity into the highest-value period within a season
  - Dispatches into the next highest-value period until seasonal energy is exhausted

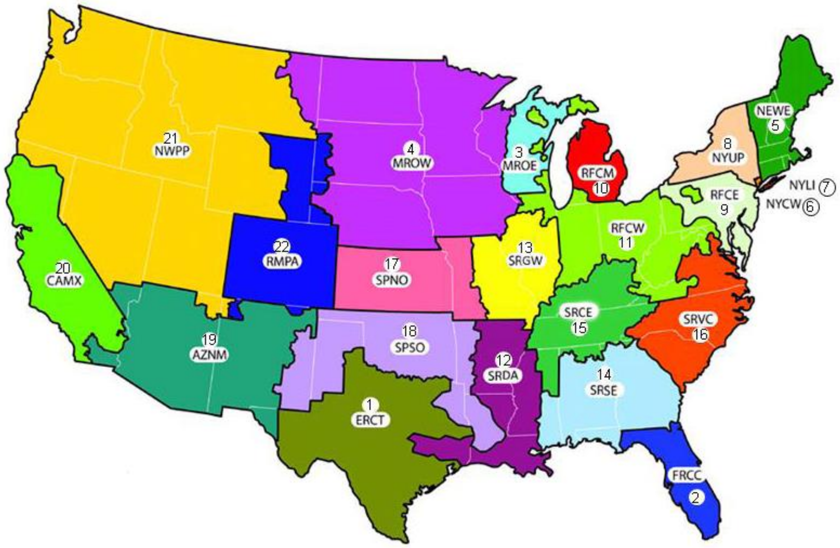
Geothermal

- Like hydro, geothermal supply is described by a list of specific, known sites
  - Least-cost sites are high-quality hydrothermal resources using dual flash or binary turbines
  - “Near-field” sites are extensions of existing resource areas that may require engineering of rock to stimulate flow (such as through hydraulic fracturing)
- Based on historic experience, the build-out of any given site is limited to 25 MW per year
  - Helps developers better manage the resource
  - Results in slow build-out, despite sometimes favorable economics
- With high availability and low variable cost, geothermal is dispatched as baseload

Wind and Solar

- Wind and solar technologies are **non-dispatchable** and therefore are dependent on the availability of the resource by:
  - location
  - time

- However the model's representation of regions and time for capacity planning decisions is limited
  - 22 regions
  - 9 time slices

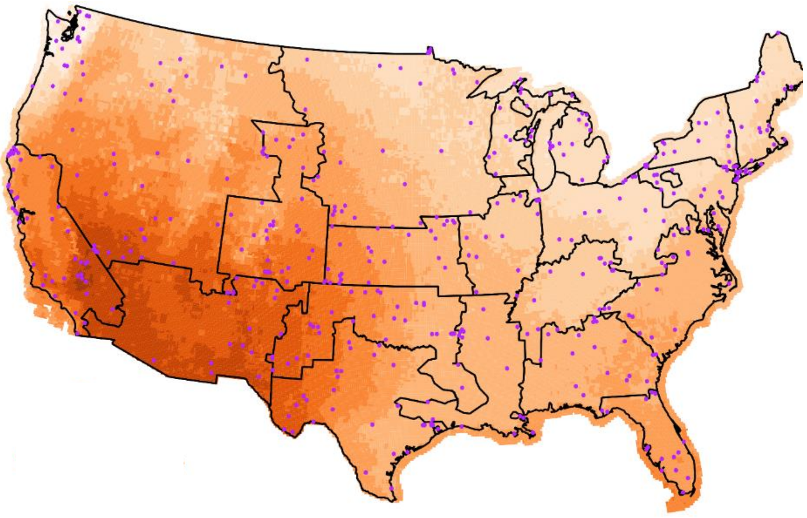


Site specific solar resource data was averaged to develop capacity factors for each of the 22 regions in NEMS

- NREL supplied EIA with 335 locations, 5 randomly selected for each ½ kWh class in each NEMS region

- EIA used SAM to calculate the hourly capacity factor for each location

- The locational 8760 capacity factors were averaged by NEMS region and the hourly values were aggregated into a 12X24 (month/hour) matrix



Similar for wind, but the 22 regions contains a supply curve that breaks out the wind resource into 4 representative wind classes

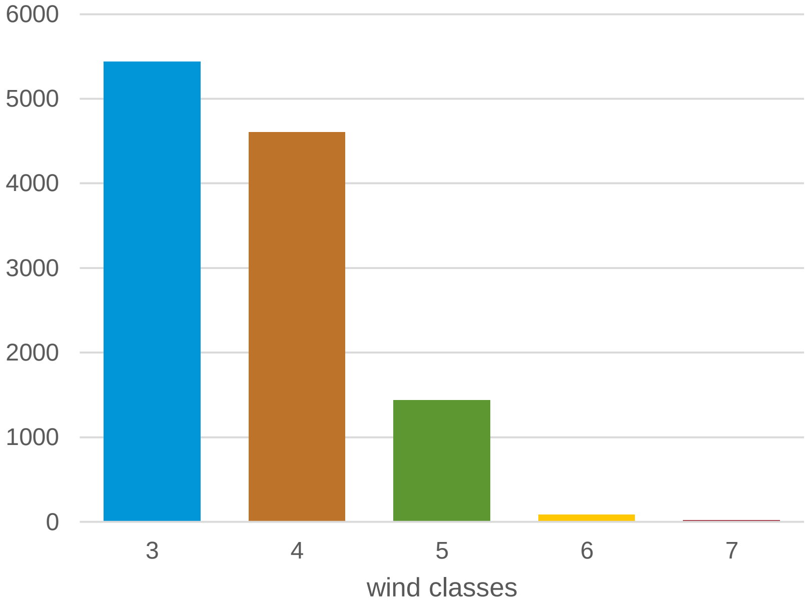
- Each NEMS region represents 4 wind resource classes (6&7 are combined):

Wind Class	Average Annual Wind Speed (mph)
7	19.6 +
6	17.9 – 19.6
5	16.8 – 17.9
4	15.7 – 16.8
3	14.3 – 15.7

- Each sub-category (NEMS region / wind resource class) contains 5 cost multipliers, ranging from 1 to 2, representing the cost integration challenges, e.g. dist. to transmission

U.S. available wind capacity by resource class

gigawatts (GW)

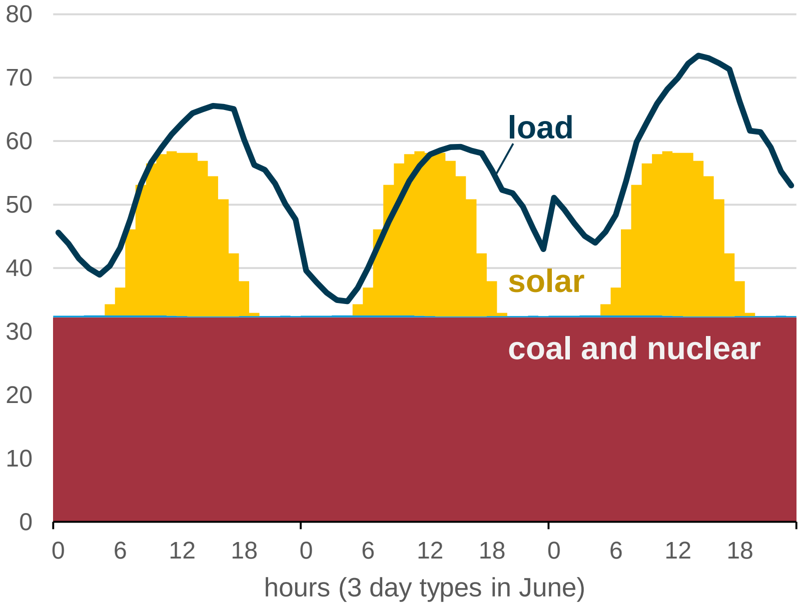


Curtailments are estimated based on hourly load, non-dispatchable generation, and minimum generation levels from coal and nuclear

- Loads is computed for 864 time slices (24 hours X 12 months X 3 day types)
- PV and wind capacity factors are provided by 24 hours X 12 months
- A minimum level of generation from nuclear and coal is established
- Excess solar generation is evaluated counts against future planning decisions

generation profile for estimated curtailments, example

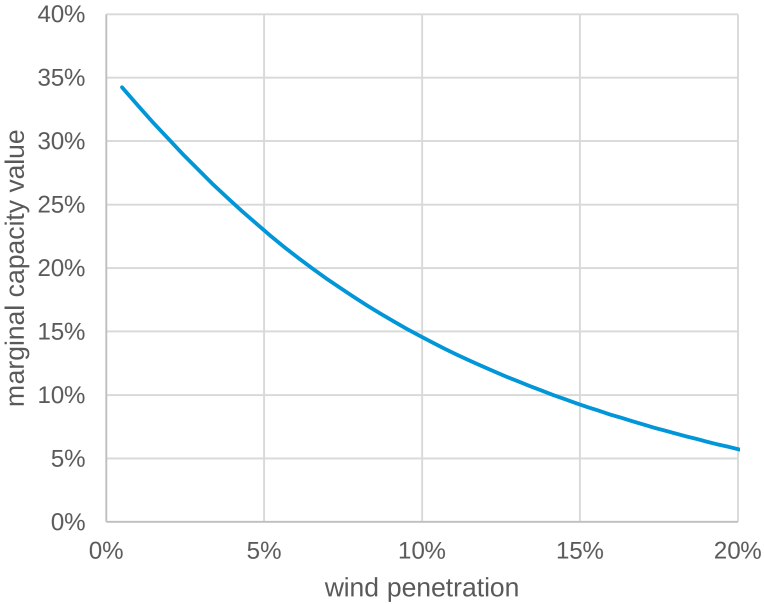
gigawatthours (GWh)



Declining marginal capacity value for intermittent generation accounts for inherent intermittency affects

Decline in wind's marginal capacity value, example

percent



- For conventional technologies, the amount of capacity available at peak is a function of their forced outage rates
- Even though wind and solar technologies are intermittent, they still contribute to regional effective load carrying capacity
- However as the penetration of intermittent technologies increase, their marginal contribution towards regional reliability reserves declines

Looking forward

- Other enhancements for the model that address intermittency of renewable technologies include:
  - Developing curtailment using 864 time slides for wind
  - Integrating energy storage
  - Estimating the marginal capacity value using 864 time slices

For more information

Assumptions Document	|	*http://www.eia.gov/forecasts/aeo/assumptions/*
Model Documentation	|	*http://www.eia.gov/outlooks/aeo/nems/documentation/*
Annual Energy Outlook	|	*www.eia.gov/aeo*

Wind (or solar) increases the average availability, but reliability is determined at the lower tail of the distribution

- Because the variance of wind is larger than the variance of conventional generation, it increases the “spread” of the availability distribution

- The tails increase in height, so the critical “Z” value doesn’t increase proportionate to the average