

3 Simplified Model Description

This section describes—in simplified form—the variables, constraints, and other attributes in the linear program formulation of ReEDS. It outlines, in order:

1. Subscripts (variables and constraints)
2. Major decision variables
3. The objective function
4. Constraints

A fully detailed listing of the variables and constraints is contained in Appendix A.

3.1 Subscripts

Variables, parameters, and constraints are all subscripted to describe the space over which they apply. The various sets are listed below.

3.1.1 Geographical Sets:

- i, j —356 supply/demand regions track where wind and solar power are generated and to where they are transmitted. Source regions are generally noted ‘ i ’ and destinations, ‘ j .’
- n, p —134 balancing authorities (abbreviated PCA, for Power Control Authority), each of which contains one or more supply/demand regions, track dispatchable generation. Source regions are generally noted ‘ n ’ and destinations, ‘ p .’
- $states$ —There are 48 states (no Alaska or Hawaii).
- rto —32 regional transmission organizations, each of which contains one or more balancing authorities. In the base case, reserve margin requirements, operating reserve requirements, and wind curtailments are monitored at the RTO level, though there is an option in the code to use balancing areas, NERC regions, or interconnects instead of RTOs.
- r —There are 13 NERC regions/subregions.
- in —There are 3 interconnects that are electrically isolated from each other.

3.1.2 Temporal Sets:

- $year$ —2006 to 2050
- $period$ —There are 23 2-year periods
- s —4 annual seasons
- m —16 time-slices during each year, with four seasons and four daily time-slices in each season plus one superpeak time-slice. (Spring has only 3 slices.)

3.1.3 Other Sets:

- $c-5$ wind classes
- $l-3$ wind locations (*onshore, shallow offshore, deep offshore*)
- $cCSP-5$ Concentrated Solar Power (CSP) classes
- $pol-4$ pollutants (SO_2 , NO_x , Hg , CO_2)
- q —Conventional generating technologies:
 - hydropower
 - natural gas
 - combustion turbine
 - combined cycle
 - combined cycle with carbon capture and sequestration (CCS)
 - coal
 - traditional pulverized coal, unscrubbed, scrubbed, or cofiring
 - modern pulverized, with or without cofiring
 - integrated gasification combined cycle (IGCC) with or without CCS
 - oil-gas-steam
 - nuclear
 - dedicated biomass
 - geothermal
 - landfill gas/municipal solid waste
 - others (distributed PV)
- st —There are 4 storage technologies:
 - pumped hydropower (PHS)
 - batteries
 - compressed air energy storage (CAES)
 - ice-storage

3.2 Major Decision Variables

The major decision variables include capacity of conventionals, renewables, and storage along with transmission; and dispatch of conventional capacity and storage. Unless otherwise noted, capacity variables are expressed in megawatts and energy variables are expressed in megawatt-hours.

- $W_{tur_{c,i,l}}$ — new wind capacity
- $WN_{c,i,j,l}$ — new wind transmission capacity between regions
- $WSurplus_{n,m}$ — wind curtailments (surplus)
- $CSPTur_{cCSP,i}$ — new CSP capacity
- $CSPN_{cCSP,i,j}$ — new CSP transmission capacity
- $ReT_{n,p}$ — new transmission capacity for wind and CSP (renewables) between balancing areas