Reinventing Transmission and Resource Planning

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Key Ideas:

- Production costing and CO_2 reduction is a study of the maximum production of variable energy resources.
- Reliability adequacy is a study of installed equipment capacity and the minimum production of variable energy resources.
- The first step in planning a system is to make it reliable, and then the second step is to calculate the overall plan's cost.
- Transmission lines connecting an area to the larger grid look just like a type of power plant that serves the local area.

RTS - Reliability Test System – RTS1 Single Area Features

1) Six digit precision reliability indices LOLE, LOLH, and EUE,

2) Calculates ‘exact’ reliability indices for any sized system,

3) Executes at lightning speeds not possible with Monte Carlo,

4) Variable energy resources use actual sequential historical hourly data to avoid introducing modeling errors, and

5) Automatically finds a peak demand MW for a desired LOLE.

RTS - Reliability Test System – RTS2 Two Area Features

1) Identical to RTS1 except hourly LOLPs of two areas is found,

2) Area 1 is a total system (like ERCOT or WECC),

3) Area 2 is a sub area (like Austin or CAISO),

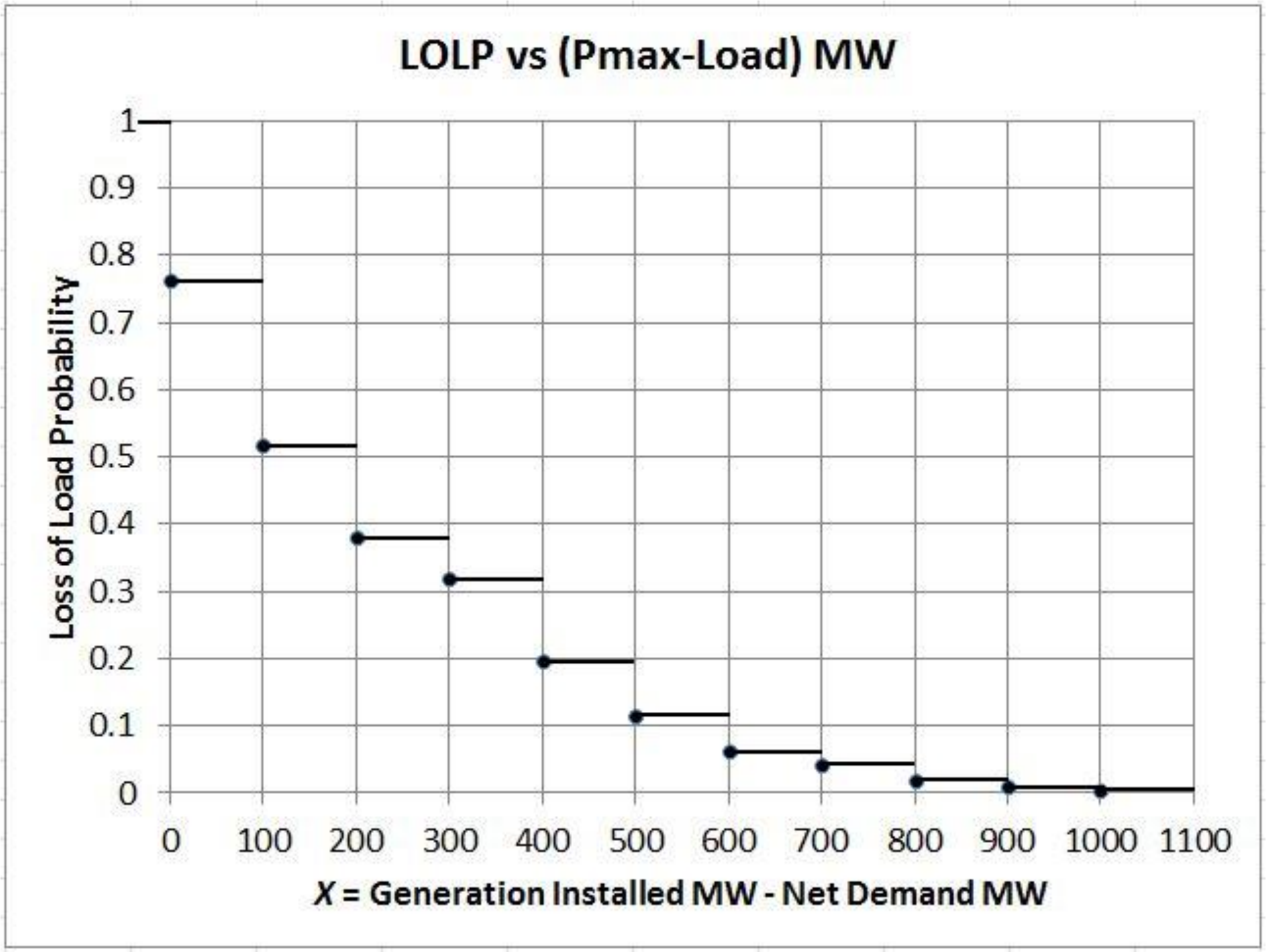
4) ATCs for importing power into area 2 are calculated external to RTS2 using ATC computer programs already widely in use,

5) Import ATC MWs are assigned probabilities and allow the creation of an 11 state equivalent generator for area 2,

6) <u>A MW peak demand for area 2 is automatically calculated for the unique generation and transmission plan being studied.</u>

<u>Single Area LOLP (loss of load probability) Analysis in RTS1:</u>

1) Create a Capacity Outage Probability Table that looks like this:



2) 100 MW steps are shown, but RTS1 and RTS2 use 1 MW steps,

3) If a larger step 100 MW grid is interpolated, then the LOLP calculation is very much slower than a simple 1 MW 'lookup',

4) The LOLP is 'looked up' for an *X* MW installed generation minus the Net Demand MW, *X* real is set to the next lower integer,

5) Example: when peak demand = generation, LOLP = ~ 0.76,

6) If peak demand slightly > generation, LOLP jumps to 1,

7) Net Demand = Load MW – (Wind+Water+Solar+Storage) MW,

8) The process of scaling, shifting, and adding these cumulative distributions was invented by Baleriaux in France in the late 1960s as an approximate way to capture hydro energy dispatch under load duration curves,

9) Booth (Australia) showed in 1972 this is an ‘exact’ calculation,

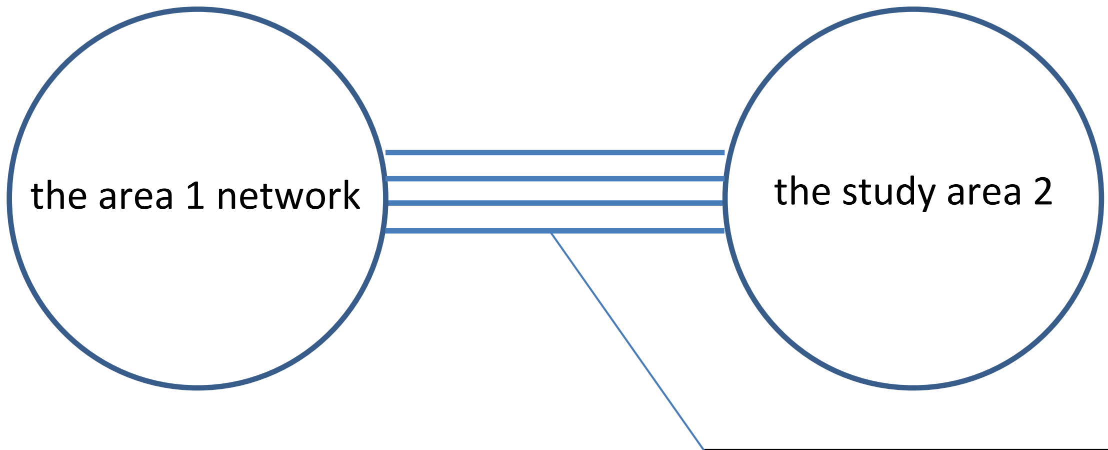
10) In 1997 Preston’s PhD also shows Booth-Baleriaux is an ‘exact’ calculation process using a binary tree expansion example,

11) In 2016 RTS1 and RTS2 programs give the ‘exact’ IEEE RTS single area indices that are published in a 1986 IEEE paper.

12) The RTS1 and RTS2 programs have two major internal steps, first they create the COPT table(s) from dispatcable and independently outage generators, then they sweep through all hours of many historical years scaled to a single future study year to find the LOLPs of all historical patterns, and from this the annual indices, which are then averaged over several years; LOLE, LOLH, and EUE are calculated from hourly LOLPs.

Two Area LOLP Hourly Load, Variable Resource, and COPT in RTS2:

In RTS2 the probabilistic model interpretation shows area 2 can view the transmission lines bringing power into area 2 as an equivalent generator.



A set of multiple paths connecting the two areas with multiple line outage states and MW probabilities of those line outages.

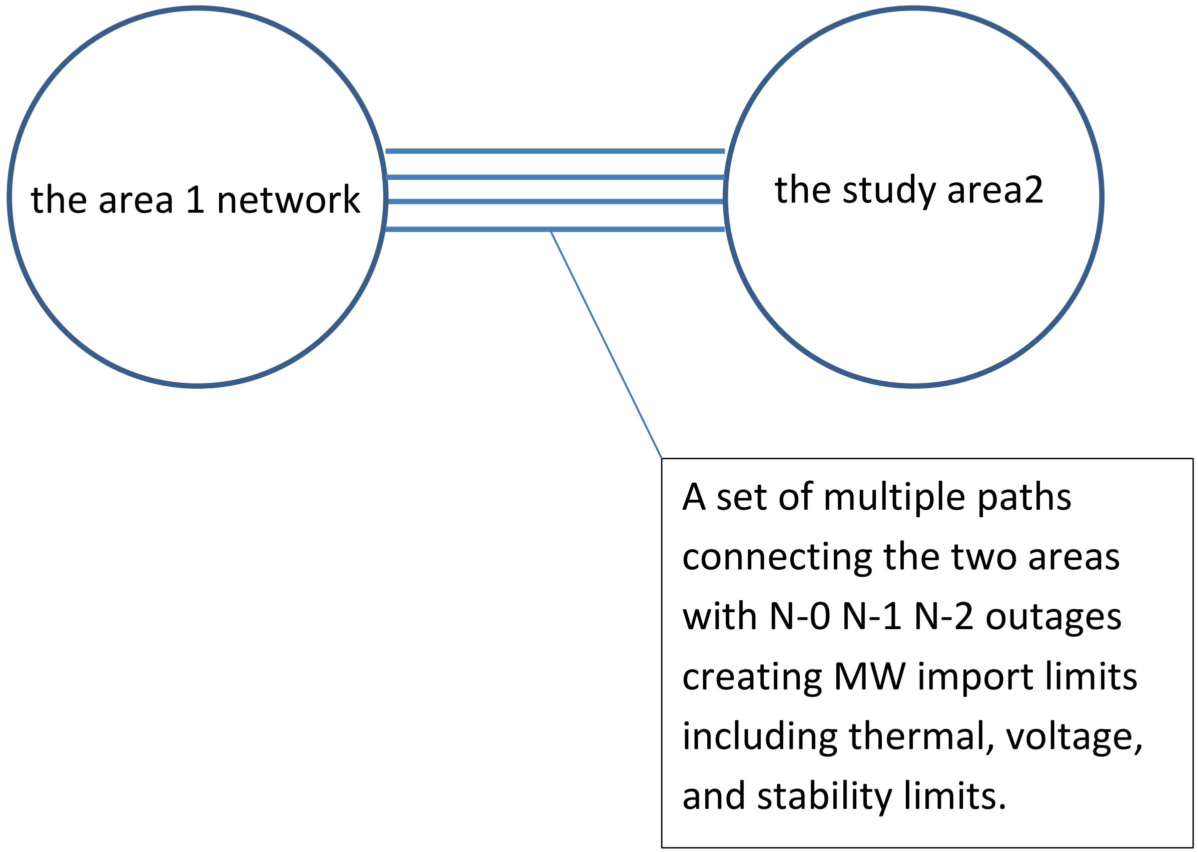
LOLP = loss of load probability

COPT = capacity outage probability table

VR = variable resources such as wind and solar

Note that area 1 includes everything in area 2 in the area 1 data.

An Available Transfer Capability (ATC) detailed electrical analysis can be used to find all the significant transmission constraints:



We take advantage of the reliability and electrical model's similarities.

Two Area RTS2 Input Data Requirements:

1. Gdata file generator data (MW’s, FOR’s) for conventional power plants for the larger grid, such as ERCOT.
2. Hdata file hourly historical demand and variable energy resources such as wind and solar in different locations.
3. Run the above files through RTS1 to get single area indices.
4. Gdata file generator data (MW’s, FOR’s) for conventional power plants inside the study area, such as Austin Energy.
5. Hdata file hourly historical demand and variable energy resources such as solar power inside the study area.
6. An extra line in the Gdata study area file describes the transmission tie lines importing power limits and probabilities.
7. RTS2 calculates a maximum peak demand that can be served.