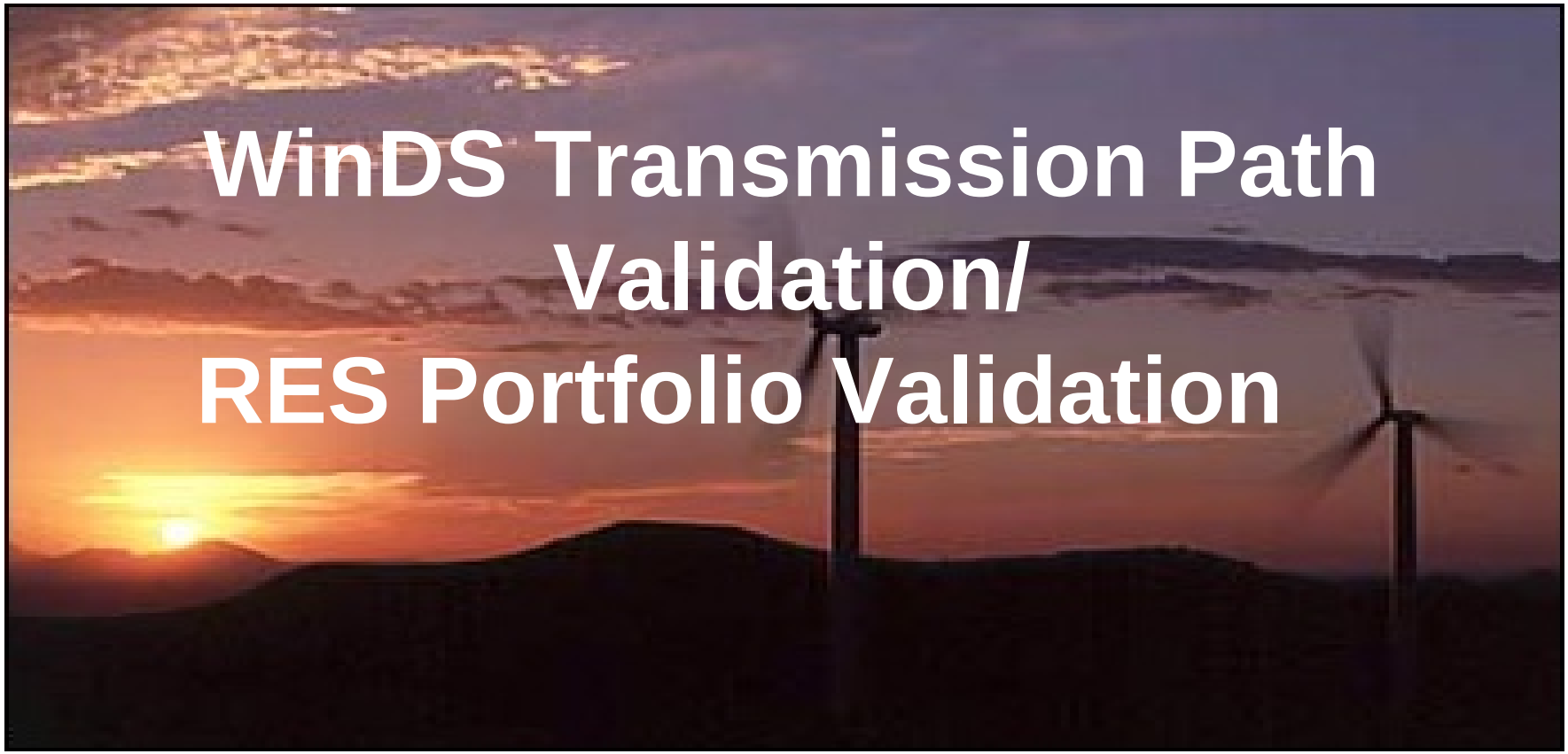

WinDS Transmission Path Validation/ RES Portfolio Validation

Presented to: FERC Conference on Planning Models and Software, Session E

LA-UR-09-3164

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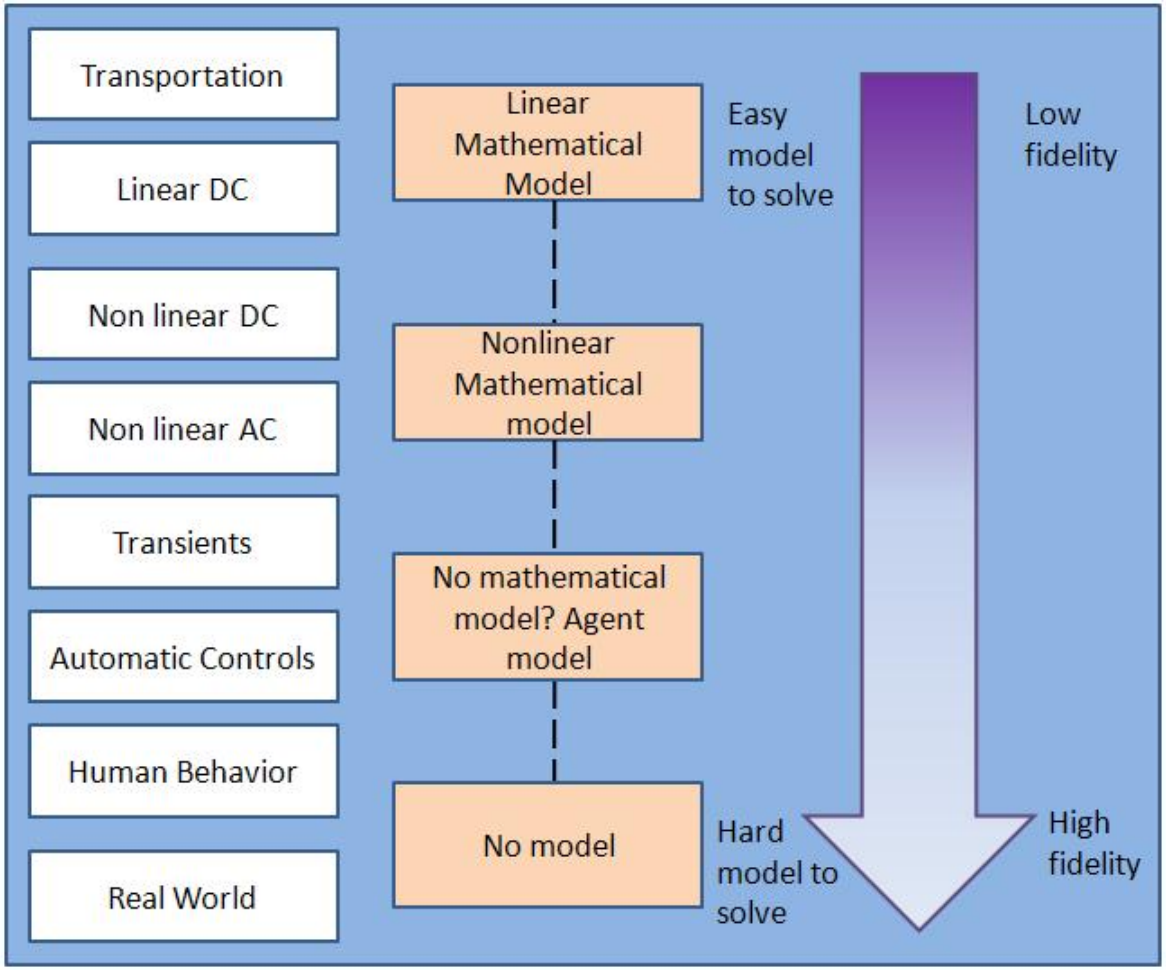
June 10, 2010

UNCLASSIFIED

The Universe of Transmission Planning Tools

Application of differing scales (temporal and spatial), varied data fidelity, physics-based power flow and multiple plan objectives is ***analytically feasible***



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Statement of Problem

- Develop an independent assessment of transmission path features of the future western grid, based on "20% Wind Energy by 2030"

Technical challenges addressed by this project:
Construct a feasible transmission power flow model (including cost of grid upgrades, validating operational features) given 20% wind penetration; communicate results to utilities and other industry players

Ref. "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to the U.S. Electricity Supply," DOE/GO-102008-2567, May 2008

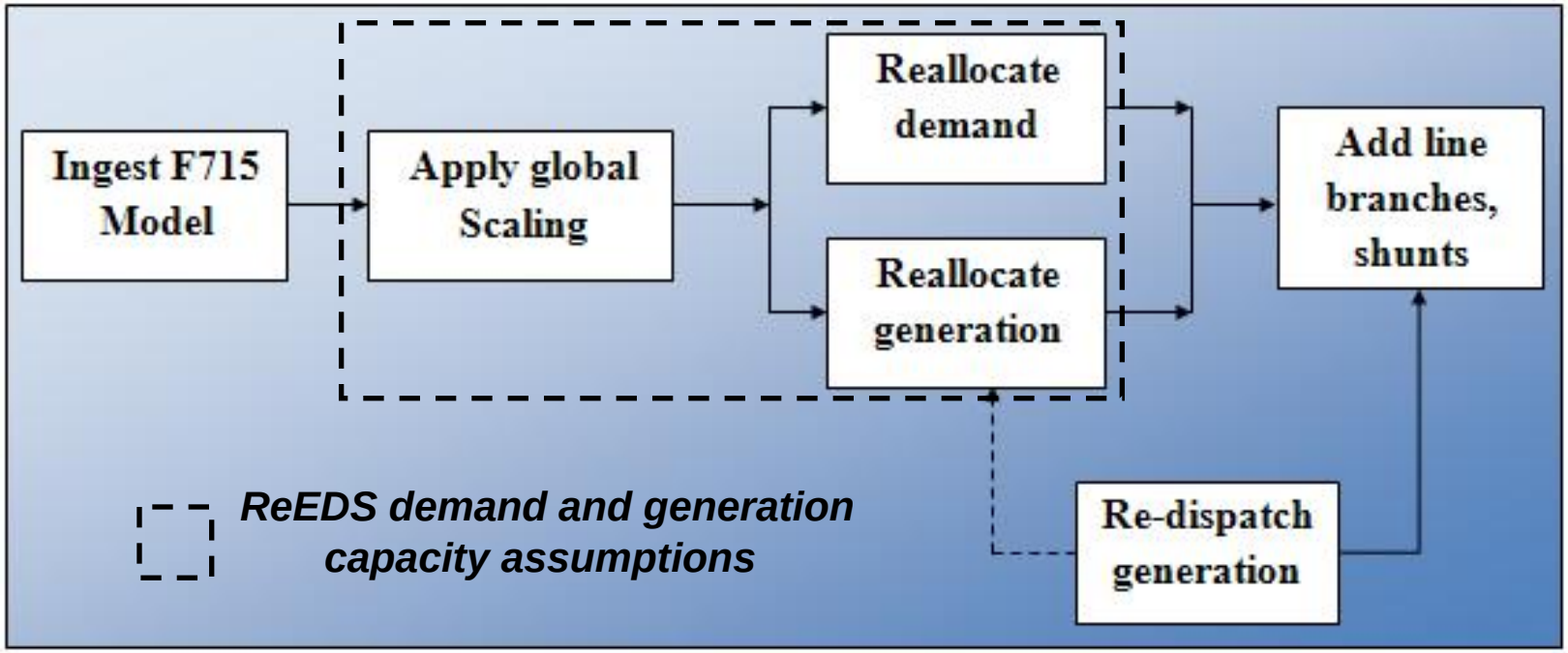
Grid Modeling Process

- In this project, new analytic methods were developed and tested to address a broad class of scenarios incorporating AC power flow over a 20-year horizon, LSE/Interconnection modeling scale, and dispersed renewable technology insertion

- All transmission solutions that met ***heuristic criteria with multiple constraints*** (cost, capacity, etc) were explored

- ***PFLOW-CED*** (CAI Constrained Economic Dispatch), ***PSLF*** (GE Positive Sequence Load Flow) were applied

Grid Modeling Process



Manual/automated modeling steps required for assembly of a feasible (solvable) transmission model incorporating ***ReEDS*** assumptions

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Grid Modeling Process

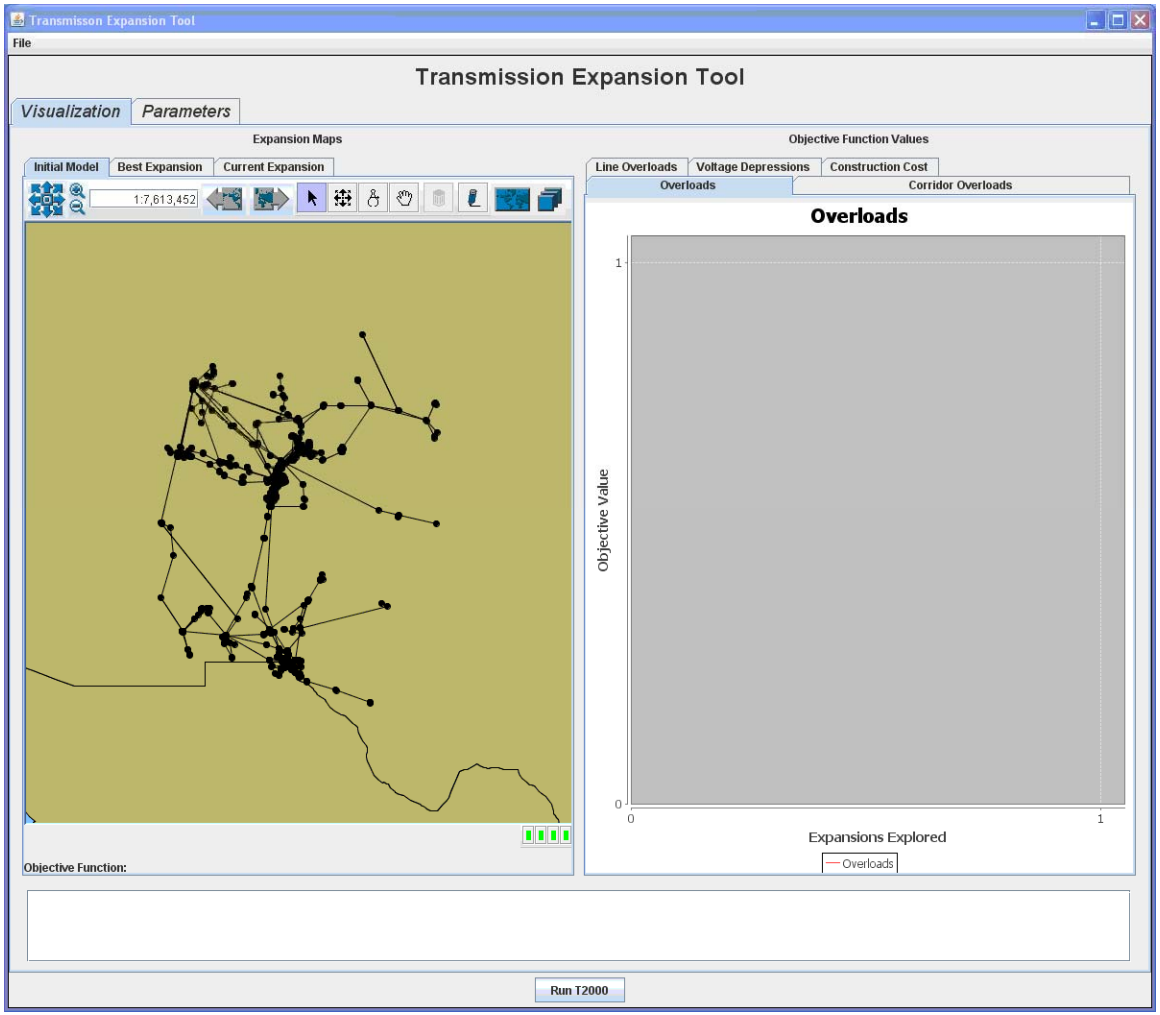
- To address this problem more generally, ***Limited Discrepancy Search LDS*** was utilized; LDS is a generalization of heuristic (rule-based) and exhaustive search approaches

- An automated software tool ***TRANS-EX*** incorporating LDS methods was coded, tested and validated to address a broad class of wind energy scenarios

Ref: W.D. Harvey and M.L. Ginsberg. *Limited Discrepancy Search*. In Proceedings of the 14th International Joint Conference on Artificial Intelligence, Montreal, Canada, August 1995

TRANS-EX User Interface with Parameter Selection

Example: Search of feasible AC expansion alternatives within New Mexico's transmission grid



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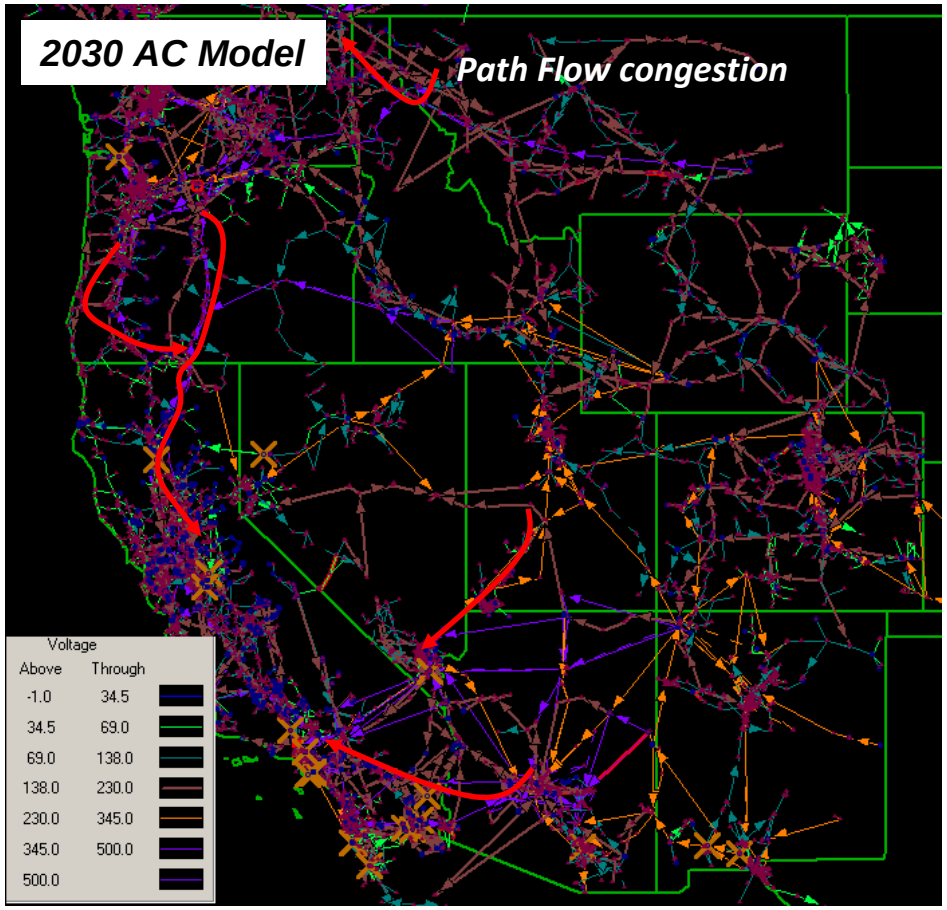
Modeling Accomplishments

- Construction of solvable 2030 Western grid model completed, based on ***ReEDS*** projections (20% wind energy capture at summer peak H3 conditions

- To achieve stable and robust flow conditions ***3,365 new transmission elements were added;*** N-1 failures needing mitigation were identified near major load centers

- The estimated cost of transmission upgrades for the WECC grid exceeds ***$10.5 billion through 2030*** (exclusive of costs incurred prior to 2017)

Modeling Accomplishments



Scenario Factsheet: 2030 High Summer (NREL H3)		
Metric	**Value**	**Unit**
Added branch capacity	550 (incl. 125 pri. Transformer)	GVA
Added shunt capacity	69	GVAR
End-point L/R	Load 209; Resource 244	GW
Generation capacity	167 Conv.; 77 Nonconv (wind)	GW
Highest HV line loading	59 (NE California), 53 (SE Oregon)	%
Highest inflow	24 (Seattle), 17 (Phoenix)	GW
Highest outflow	13 (Seattle), 12 (San Francisco)	GW
Highest N-1 load shed	25 (Phoenix), 8 (SW New Mexico)	GW
New/Upgraded corridors	8,118	Miles
Primary voltage upgrades	100 to 230	kV
Transmission upgrade cost	10,544 M +/- 150	2009$

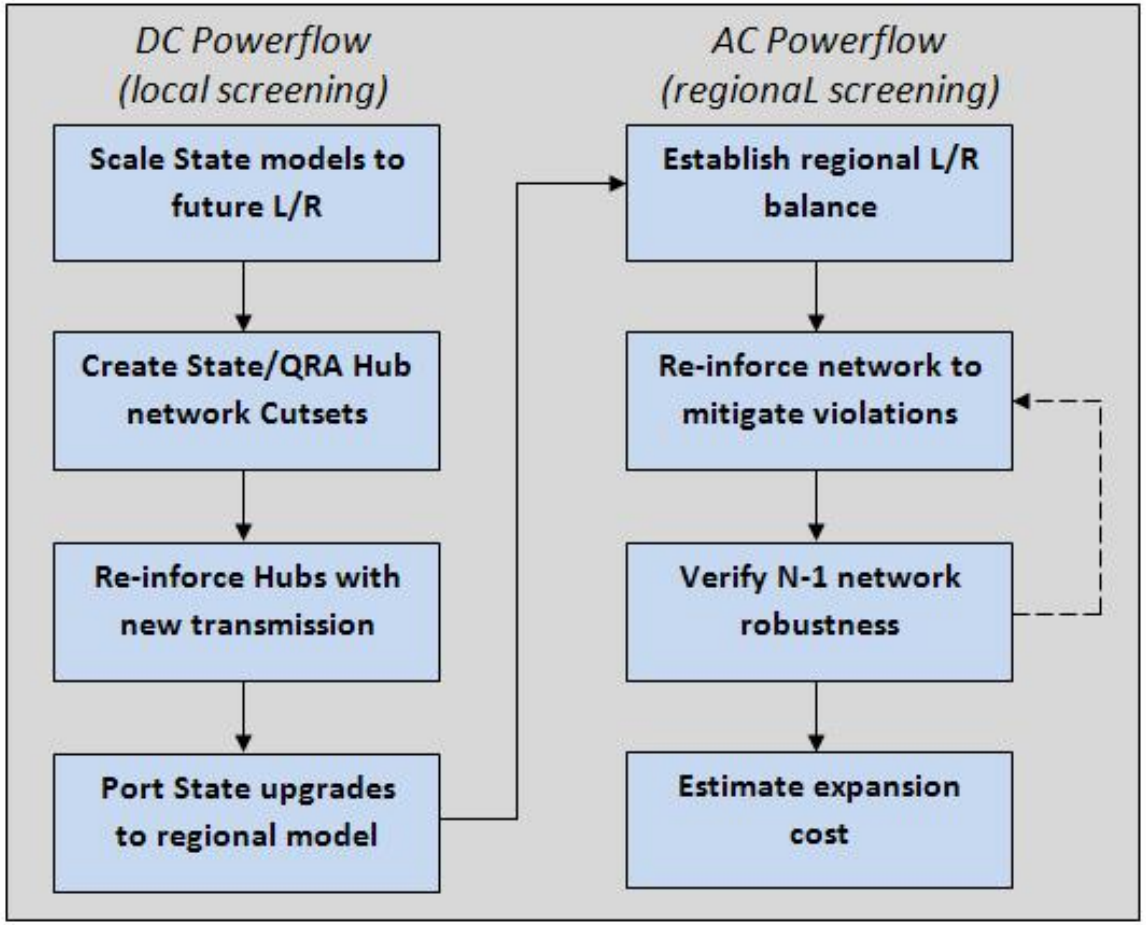
Western Region Transmission Model Incorporating 20% Wind Injection

Renewable Portfolio Validation

- Evaluate the ***type, size, and timing*** of renewable transmission capacity additions in the WECC Interconnection; identify feasible expansion plans for 5-10 Phase I Qualifying Resource Areas, QRAs
  - Input QRA specification (location, capacity, time) with WECC planning constraints
  - Code and test TRANS-EX scenario generator
  - Issue white paper outlining TRANS-EX applications to future planning scenarios: **October, 2010**

QRA Transmission Analysis

TRANS-EX screening analysis process to be validated with State QRA planning drivers



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Credit for this work…

http://www1.eere.energy.gov/windandhydro/

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Wind & Water Power Program

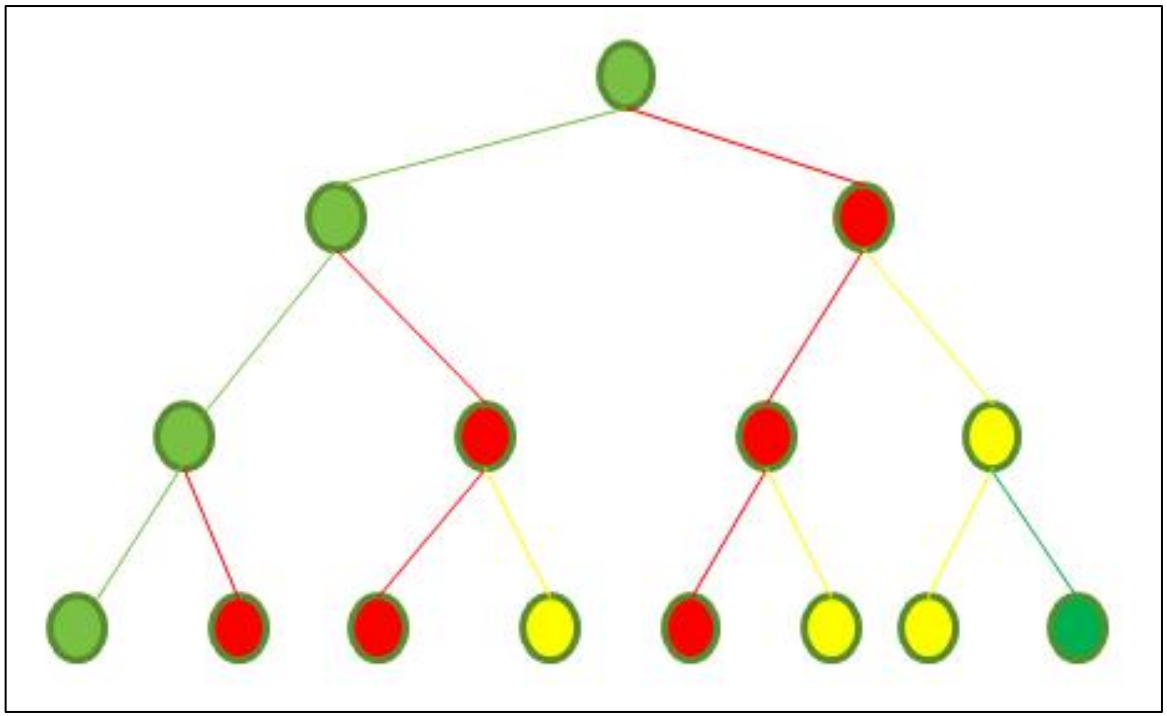
<u>Research to Address Grid Integration Barriers</u>

- Address grid access constraints through ***improved planning support for high wind energy scenarios***

LDS Algorithm

- Explore all network solutions that “violate” the heuristic up to “x” times i.e. ***discrepancies***

- Lines branching to the left of a node indicate heuristic “best” choice



- Decision variables, i.e. how many transmission lines to add to corridor “x”, how much shunt to add to bus “x”, the voltage level for bus “x”, etc.

Backup

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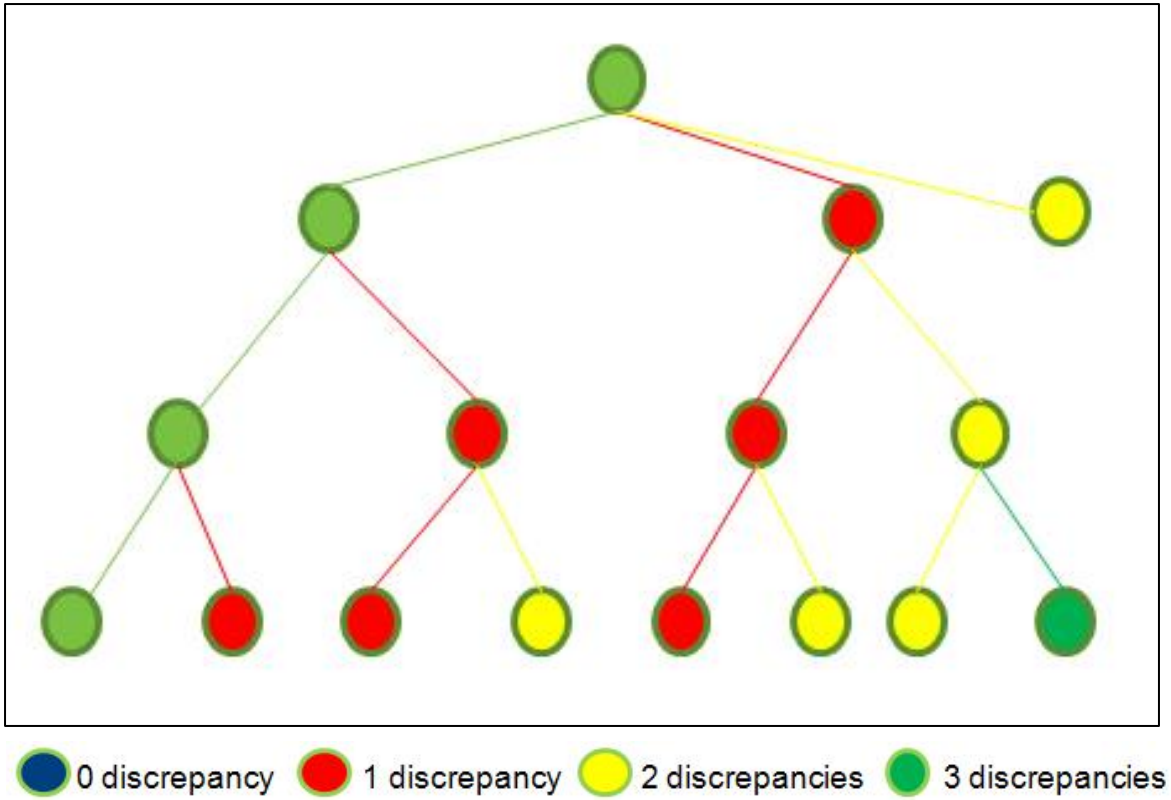
LDS Algorithm

- Branches to the right represent violations of the heuristic
- The number of discrepancies at any node is the "amount" each expansion path moved to the right



Backup

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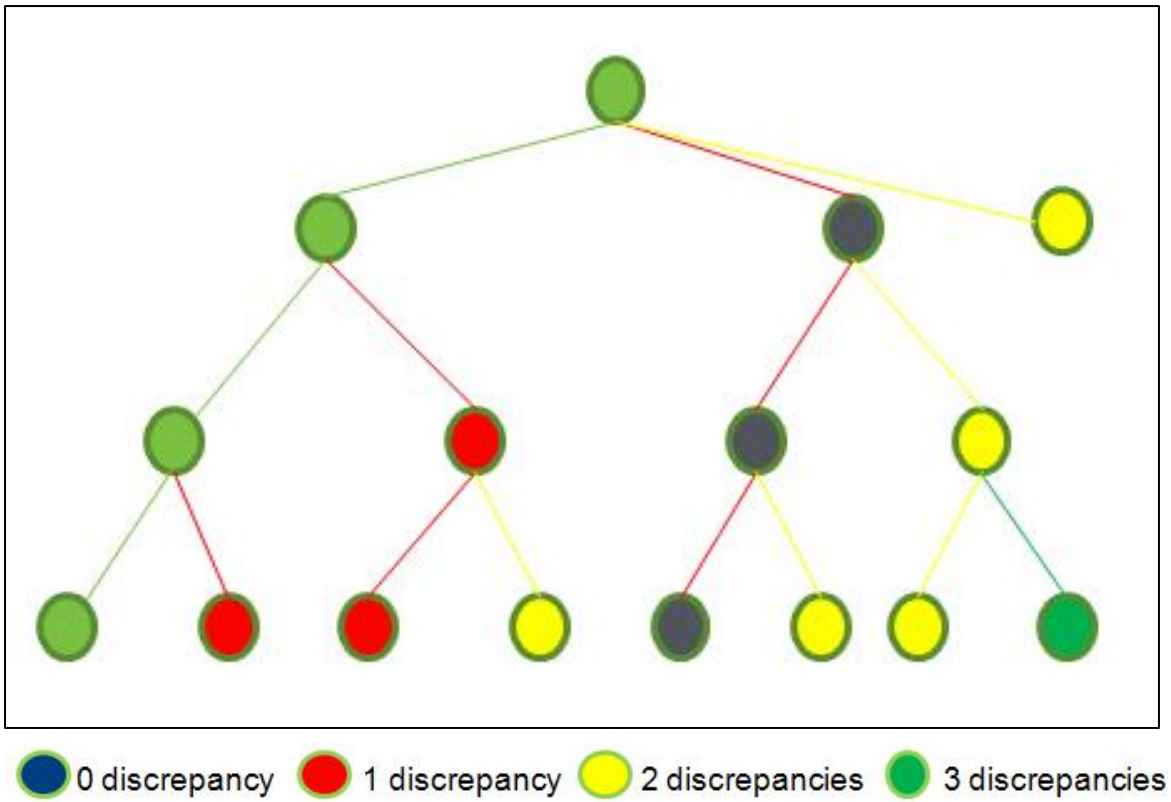
LDS Algorithm

- If a choice degrades the objective function, there is ***no benefit to explore*** that part of the search tree

- Add a parameter to explore paths that degrade the solution <“y” times



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LDS Algorithm

- LDS can incorporate ***arbitrary constraints and objective functions***

- ***Example:*** choose the transmission corridor with the largest overload, then choose the bus with lowest per-unit voltage; globally apply these constraints:
  - Minimize total MW overload
  - Minimize number of overloaded lines
  - Minimize number of buses in low voltage state
  - Minimize total cost of expansion

Backup

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