Flexible Transmission Modeling

March 20, 2012

CRA Charles River Associates

Agenda

1. **Current State of Modeling**
2. Where the World is Heading
3. Next Generation of Transmission Modeling
4. Discussion

Current Status of Modeling

Fixed Transmission Topology

Simulation Models

History

Prehistoric Days
-DC/AC Calculating Boards (*and sliding rulers*).

1930s -1960s
-AC Network Analyzers.

1960s - 1970s and later
-Computer Simulations.

Current Day Simulations

-Based on mathematical models that searches for analytical solutions.

-The analytical solutions start from a set of parameters and initial conditions.

-As a result, initial conditions are rarely changed within the simulation.

-Transmission topology is often considered as a constant (initial) condition.

Topology Definition:

- Characteristics of Individual Elements
- Connectivity of the Elements

1949 Iowa State University
AC Network Analyzer

Gap between Operation and Planning
-EMS vs Market Engine / Planning Models
-Unscheduled Outages

1955 Cornell Power
Network Calculator

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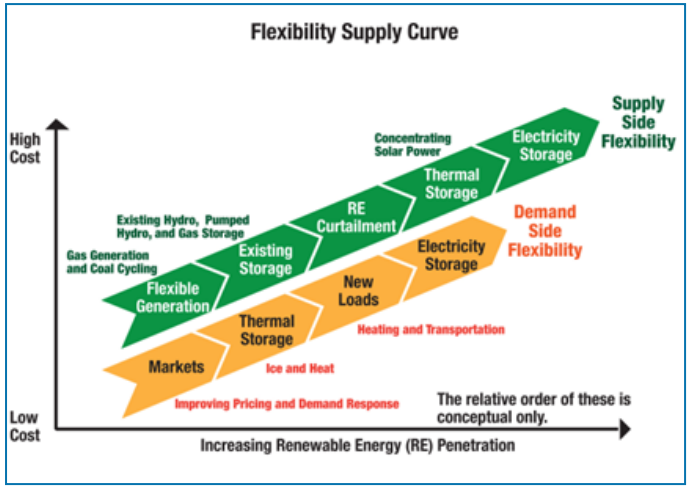
Where the World is Heading

The Grid is No Longer Considered Static

Increase in Flexibility Needs

Generation/Load



Transmission

Connectivity

-Line Opening/Topology Control

- ARPA-e

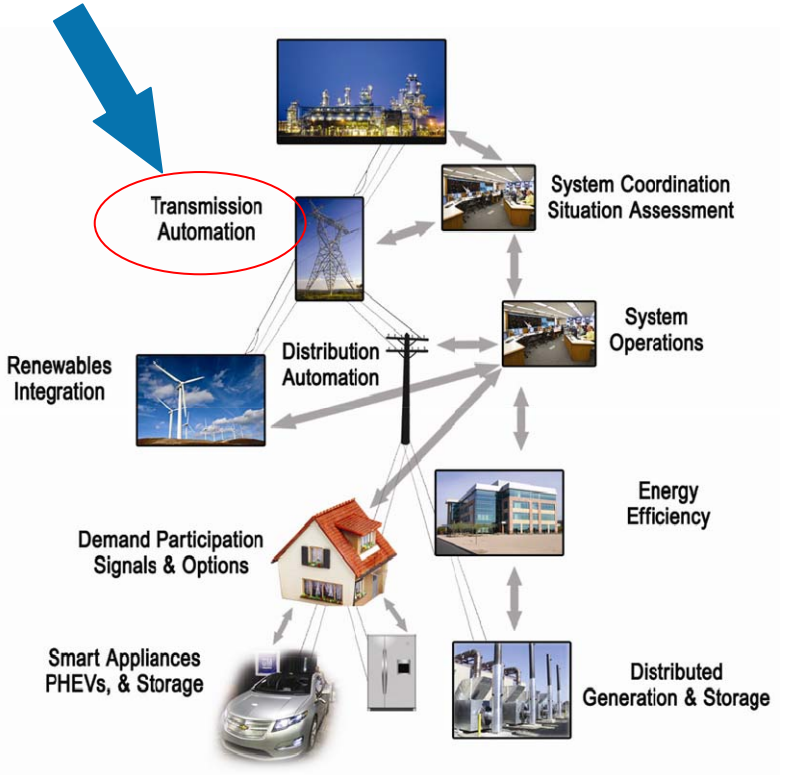
Characteristics:

-Dynamic Line Rating

- ERCOT
- NYISO
- CA-ISO
- ISO-NE

Smart Grid

The U.S. Department of Energy has designated Dynamic Line Rating technology as a key Smart Grid T&D Infrastructure Metric in its Smart Grid System Report.



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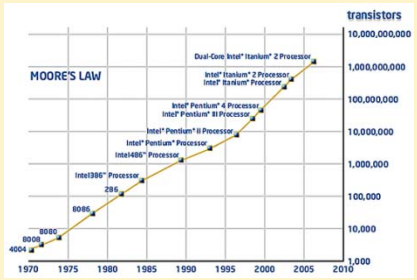
Needs Going Forward

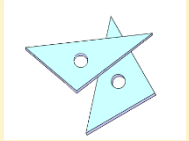
Conclusion

- ✓ Modeling transmission flexibility is a must in the future.
  - Industry is moving towards flexible operation.
  - Gap between planning and operations can not become larger.
  - New equipment types.
  - New market/products.

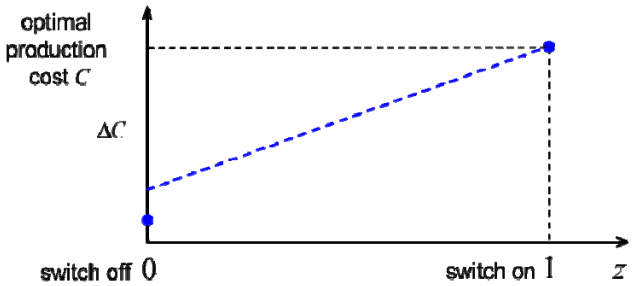
- ✓ Computational speed is important.
  - Required increments are getting smaller.
  - Moore's Law.



- ✓ Approximate results are sufficient for planning.
  - Dynamic stability calculation is not needed for long term planning.
  - All forecasts are wrong…..



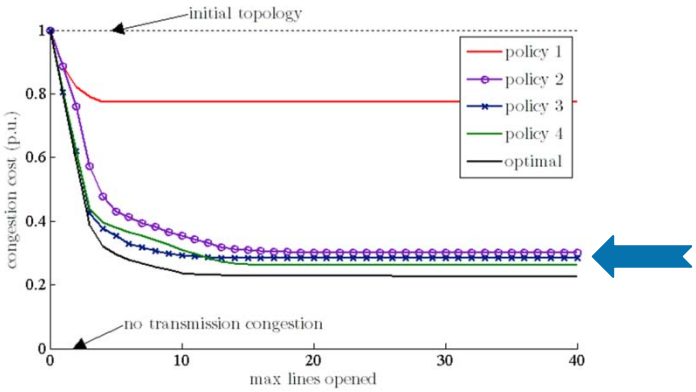
Approximation Example



- ✓ Select the line k with the most negative first order approximation of the cost change, if any

$$\Delta C \approx -f_k \frac{\partial C}{\partial f_k} = f_k \left(\pi_{n_k} - \pi_{m_k} \right)$$

- ✓ Economic interpretation: *most unprofitable line.*



Source: P. Ruiz et al, Tractable Transmission Topology Control using Sensitivity Analysis

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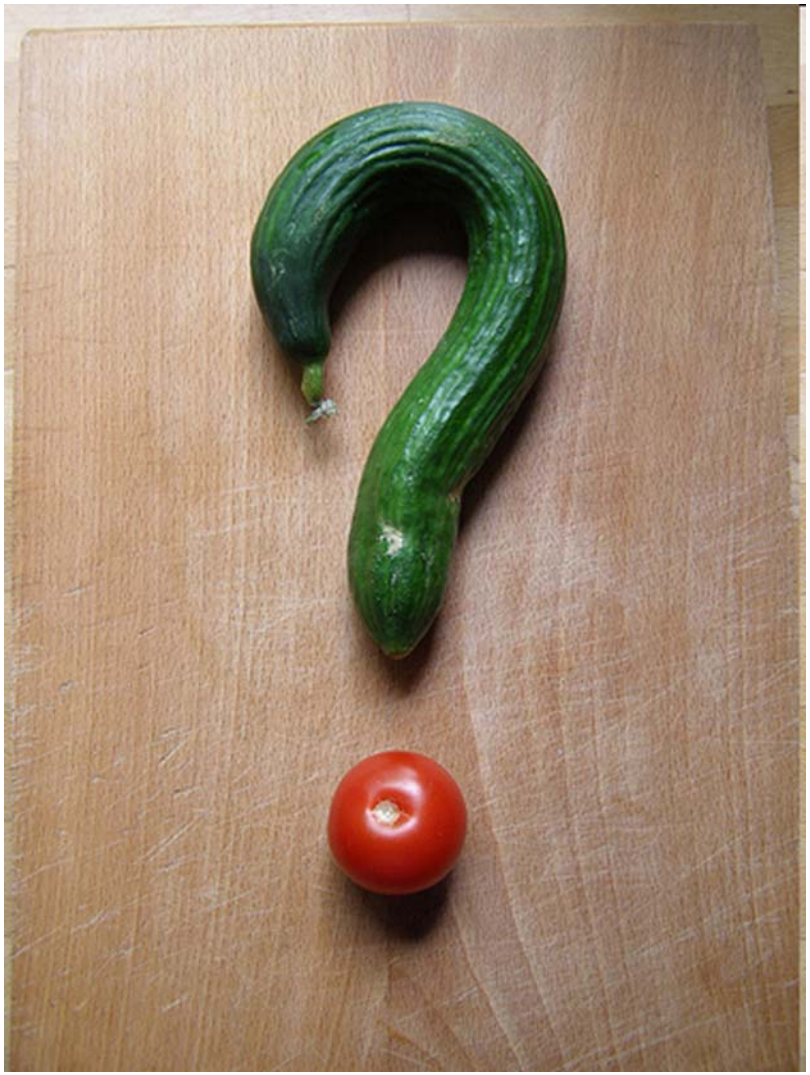
Questions?



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