Grid Limitations

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Ross Baldick

Department of Electrical and Computer Engineering

The University of Texas at Austin
Outline

• Overview of the generation, transmission, and distribution system,

• Evolving roles of electric transmission,

• Planning of the electricity system,

• Merchant generation,

• Grid limitations,

• Increasing capacity of transmission,

• Implications for distributed generation:
  – Concentrate on “on-grid” applications,

• National energy policy.
Overview of Generation, Transmission, and Distribution.

"Central" Power stations

Transmission system

Distribution substations

Distributed Generation (DG)

Load

Load

Load

Distribution system

Distribution System DG

Load
Transmission.

• Provides for “long-distance,” “bulk” transport of energy,
• Accounts for about 10% to 20% of total cost of electric power system,
• Inter-connects almost all electric generation and demand in North American into four huge systems:
  – potential for trade over large geographical area.
Inter-connections in North America

WECC

ERCOT

Quebec

Eastern Inter-connection
Evolving roles of transmission.

• Bringing power from remote generators:
  – Historical trend to ever larger generators,

• Inter-connecting utilities to allow sharing of generation “reserves:”
  – Provide reliability more cheaply,

• Enabling trade:
  – Opportunities to buy and sell,

• Mitigating market power:
  – In restructured electricity markets.
Planning of the electricity system.

• Historically, utilities planned generation and transmission jointly to meet growing demand:
  – large central generation projects had long lead times allowing for transmission to be built,

• Restructured electricity markets leave generation planning (mostly) to the market:
  – “merchant generation” building smaller generation projects with shorter lead times.
Merchant generation.

- Largely unregulated (economically) owners of generation capacity:
  - still face environmental regulations,
- Sell energy at market rates,
- Assume (most) risk of business decisions,
- Harness competition to drive costs down and develop technology,
- Considerable merchant development in Texas,
- Can be central or distributed generation or even “dispersed” resources such as wind power.
Transmission.

• Transmission mostly remains regulated:
  – “rate of return” paid on investments,
  – incentives for developing technology and upgrading capacity tend to be weak,

• Difficult to plan and build new transmission,

• Limitations on moving electric power are prevalent in North America, particularly into urban areas.
Grid limitations.

• Limit trade opportunities,
• Limit opportunities for development of merchant generation,
• Create local market power:
  – particularly in “import limited” areas,
• Cost of grid limitations on trade and market power may be large compared to the construction cost of transmission.
Grid limitations and new merchant generation.

- Existing system.
- New generation planned by merchant.
Technology to increase capacity of existing transmission system.

• Existing technologies with potential for further development and deployment:
  – “Reactive compensation,” “phase angle regulators,” “Flexible AC transmission,” (FACTS), “high-voltage DC light” (HVDC light),
  – Range of costs and characteristics,
  – Several of these are already heavily deployed.

• Rebuilding lines to increase capacity:
  – “Re-conductor” lines,
  – Continuing improvements in metallurgy are providing better conductors.
Technology to increase capacity of existing transmission system.

- Development of technology to allow temporary upgrades and re-locatable equipment:
  - Fast response to announced need,
  - Re-locatable resources reduce risks of “build it but they do not come,”
  - Used extensively in United Kingdom, similar proposals by affiliated company in United States,

- New technologies:
  - Super-conducting cables,
  - Super-conducting magnetic energy storage (SMES), a distributed energy resource,
  - Test applications, potential for large improvements.
Alternatives to increasing transmission capacity.

• Given a growing demand:
  – build new transmission (or increase capacity of existing transmission) and build new (or access existing) central generation, or
  – build new distributed generation near demand center (and avoid need for transmission).
Distributed generation resources.

- Distributed generation reduces needs for imports and reduces “transmission losses,”
- Helps to mitigate market power in import limited areas,
- Geographically well-positioned generation can provide “voltage support” that enhances the capability of the transmission system:
  - conversely, “dispersed” DG such as wind power typically requires additional transmission.
Distributed generation resources.

Central power station

100 MW capacity
Transmission system
100 MW demand

20 MW distributed generation

105 MW capacity

125 MW demand
Distributed generation resources, continued.

• May not be economically viable on basis of selling “base-load” energy alone:
  – Energy conversion efficiency may not be as high as that of a large, central power station,
  – “Peaking” opportunities viable if there is an energy market that differentiates prices over time:
    • “Time of use” meters to reflect variation in prices,
  – How to set up transmission prices that “credit” these resources for the enhancement to transmission that they provide?
Distributed generation resources, continued.

- Transmission expansion, pricing, and interconnection policy have significant effects on distributed energy,

- Generation and transmission are partial substitutes for supplying electricity:
  - difficult to have effective competition in one sector while the other is regulated.
Demand center versus Distribution system DG.

• Locating close to demand center potentially avoids need for new transmission and can even enhance transmission capability and reliability,

• However, distribution system DG may not provide these benefits without additional distribution system infrastructure:
  – Integration of distribution system DG requires new or modified distribution system infrastructure in addition to time-of-use meters,
  – Increasing the reliability of end-use customers typically also requires “ride-through” capability using uninterruptible power supply with energy storage.
National energy policy considerations.

• Difficult to appropriately regulate transmission because of its partial substitutability with generation:
  – competition (merchant generation) versus
  – regulation of transmission,

• How to price scarce transmission capability and “credit” distributed resources?
  – much of United States still uses property rights for transmission that explicitly violate physics,
  – recent FERC decision will change this.
National energy policy considerations, continued.

• How to plan expansion of the transmission system?
  – want incentives that encourage development of the “right” portfolio of new generation resources,
  – encourage entrepreneurial activity and technological development in generation and transmission,
  – accommodate growing demand.
National energy policy considerations, continued.

- Should “merchant transmission” be encouraged, or the regulated status quo maintained, or alternative regulatory approaches taken?
  - Who will be motivated to invest in technologies such as re-locatable equipment and motivated to develop new technology,

- Should distribution system infrastructure be upgraded to accommodate distribution system DG?
  - Including integration of information technology into distribution system to enable control and monitoring.
Conclusion.

- Transmission expansion is limited in most urban areas in the US,
- Demand center located generation offers (competing) alternative for meeting demand,
- Policy considerations on regulation of transmission, pricing of transmission capacity, planning and construction of new transmission capacity, implications for distributed generation.