Creating Incentives for New Technologies in the Transmission System of the Future

Fernando L. Alvarado
Professor, the University of Wisconsin
Senior Consultant, Christensen Associates

Infocast Transmission Summit 2002
Washington DC, January 31 2002
Why expand transmission?

• Improve system reliability
• Increase trade opportunities
• Improve market performance
  – (e.g., reduce market power)
Why use new technologies?

• Better use of existing system
• More flexible future system
• Improve system resiliency
• (More cost effective)
Primary system limitations

• Voltage and reactive power limits
  – Localized problems due to insufficient reactive power

• Thermal limits
  – These occur on individual lines

• Stability limits
  – Dynamic response of generators coupled with transmission system characteristics and relaying system behavior
Improving transmission: options

• Direct reinforcements
  – Expand the grid
    ➢ Improve ability to control of flows in the grid

• Indirect reinforcements
  ➢ Optimize performance by better locational price signals
  ➢ Improve metering and monitoring
  ➢ Improve system stability

➤ denotes new technology opportunities
New technology opportunities

- Broader coordination of grid management
- Knowing the limits of safe operation
- Extending the controllability of flows
- Dealing with operational uncertainty
- A grid that heals itself
- More power in less space
- “Intelligent” systems
The dilemma

• If investors improve the grid, they have no way to collect on their investment*
  – Any benefits also end up benefiting others
    • “The tragedy of the commons” (free riders)
  – Economies of scale make expansion difficult
  – There can be large risk and uncertainty

• If the “government” expands the grid, we may end up with inefficient investments
  – A solution: rely on performance-regulated Transmission Organizations

(*) Because there is zero marginal cost!
Technology category #1: Better locational pricing

- It is always a surprise to see how effective some locations can be to relieve problems
- All markets must be based on true real time prices
- A well designed system can lead to better use of distributed resources and demand management
Technology category #2: PARs and FACTS devices

• Control the flow on congested corridors
• Greater loading of the grid
• Thermal problems are never on an interface, they are on individual flows
Technology category #3: Better wide area measurements

• Better system-wide state estimators
• Better dissemination of state estimation information
• Reduction of uncertainty
Technology category #4: New hardware options

- More compact line designs
- Better converters and electronic devices
- Better stabilizers and controls
Why so few investments?

• (Environmental concerns and externalities)
• (It does not make economic sense)
  – High prices, spikes and problems are not always a reason to build
• The “tragedy of the commons”
  – I spend the $$$ but everyone benefits
• Economies of scale and lumpiness
  – Bigger is better, but…
  – once you build it, congestion goes away
Incentivizing expansion

• Design a transmission tariff that makes it possible to expand transmission and
  – is economically efficient
  – recovers fixed costs
  – does not adversely affect system security
• We discuss seven models…
#1: Simple tariffs

• The tariff to send X MW from A to B is Y
  – This type of tariff is not economically efficient
    • It prevents transactions when $\Delta S < Y$
    • It creates gaming incentives when $\Delta S > Y$
      – It requires administrative congestion relief protocols (TLR)
  – It ignores externalities
    • Systems C and D may be adversely affected
  – This type of tariff can over- or under-recover costs
#2: MW-Mile Tariffs

• Based on load flow analysis
  – Often a “DC” load flow is preferred
    • It avoids “transaction order” problems

• It gives the *impression* of fairness
  – You pay for what you use
  – It may not recover reserve costs

• It is not efficient
  – It can over- or under-recover fixed costs
  – It can prevent efficient transactions
  – It can create incentives for inefficient transactions
#3: Access charges

- Payments are based on the size of what is being connected
  - You can charge suppliers, consumers or both
  - It can be designed to recover fixed costs
  - It can provide disincentives to connect
  - It does not distort efficient interchanges
    - Unless there is congestion
#4: Spot prices

• Efficient spot prices are determined
  – The tariff is the difference between spot prices
  – Generally spot prices are centrally determined
  – It can be zonal or nodal
    • Zonal works ok for radial systems
Spot price characteristics

• They are economically efficient
  – It can over- or under-recover fixed costs

• It results in a unique price for every location
  – The underlying price mechanism is simple

• It creates an incentive to congest for the transmission system provider
  – if its income depends on congestion revenues
#5: Modified spot prices

- The capacity of lines is artificially reduced to assure cost recovery
  - The tariff remains “linear”
  - It creates distortions
  - It can be used to increase system security

- Aumann-Shapley pricing work well
  - Allocate based on randomized entry order
  - It is short-run efficient
#6: Performance-based tariffs

- Difficult to design and implement them
  - How to measure “performance”?
    - It can be measured by monitoring the “uplift” cost
- Central coordination required
  - Essential when there are economies of scale
- When combined with spot pricing it can be most efficient
#7: Combinations

- Two-part tariffs
  - One part takes care of economic efficiency
  - The other part takes care of investment cost recovery
    - This is an “individualized tax”
Allocation criteria for expansion

• Allocate expansion costs by adjusting marginal prices
  – Aumann-Shapley seems works well
• Allocate expansion costs according to use
• Allocate expansion costs according to benefit

Allocate, nonetheless, and allocate you must
What happens when system A expands

Surplus Loss (A)

There is an investment cost to reducing congestion

System A net surplus

Surplus loss

Cost/benefit

Quantity Traded
Surplus loss (B)

Relieving congestion in system A can increase congestion in system B.

This is the norm, not the exception.
Proposed system expansion

Congestion revenue: $0

No congestion rents are collected

Proposed new line
After system expansion

Congestion revenue: $2000

The new spot prices
Designing the expansion incentive

- Expansion must be based on estimates of surplus improvement
  - Efficient expansion requires removing incentive to congest
- Expansion incentives must exceed fixed costs
  - But it must be smaller than the surplus gain
  - New views of “useful life” may be needed
- Transmission expansion affects spot prices
  - Investors need to consider locational issues when deciding where to invest
Do not forget…

• The impact of expansion on the protection system
  – Expansion can increase short circuit duty
    • It is worrisome that so few are even aware of it
• Expansion somewhere almost invariably “moves” the critical problem elsewhere
• There are dynamic interactions between markets and the physical system