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

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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 $\Delta\$ < Y$
    - It creates gaming incentives when $\Delta\$ > Y$
      - 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”

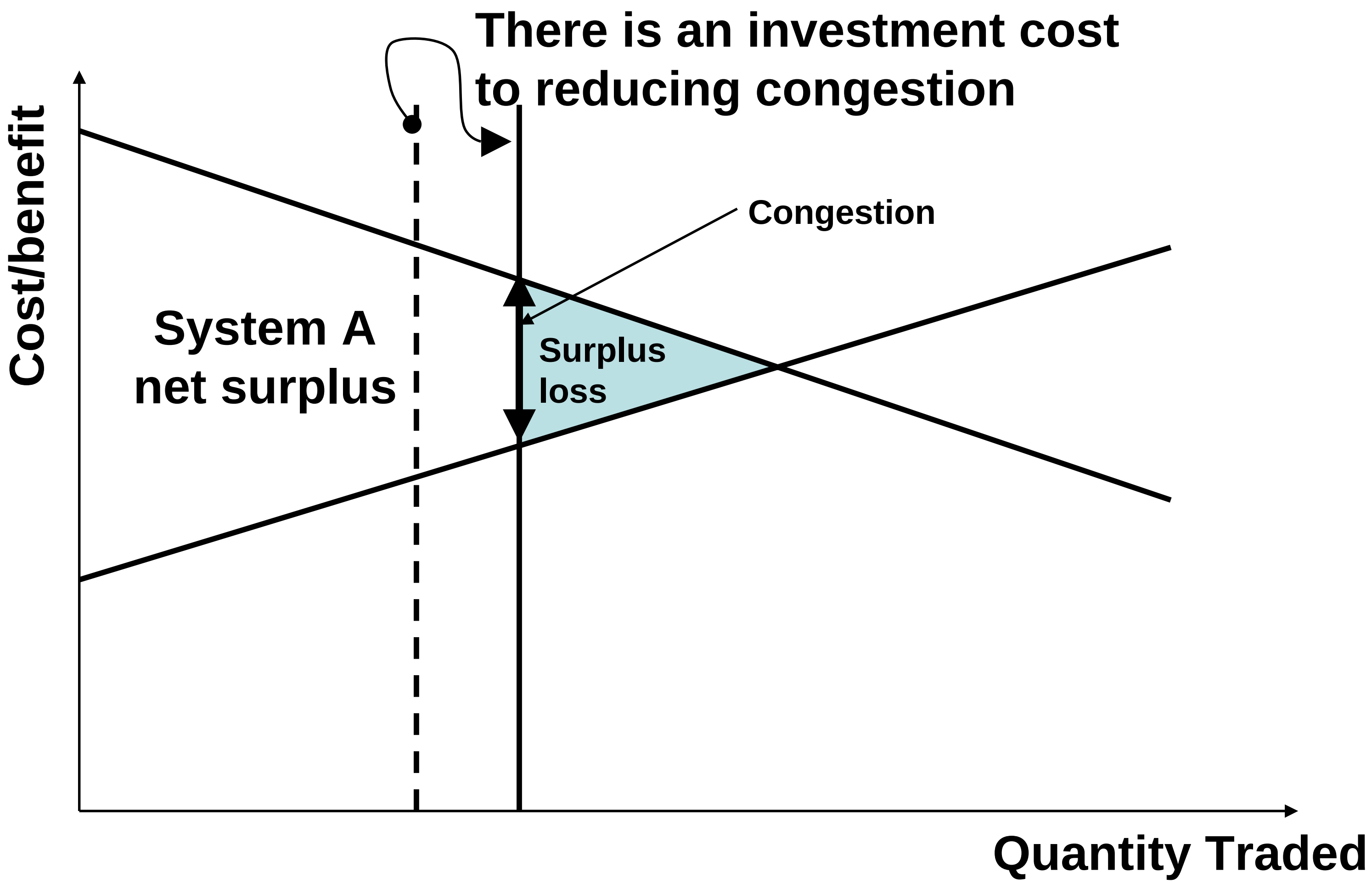
Allocation criteria for expansion

- 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

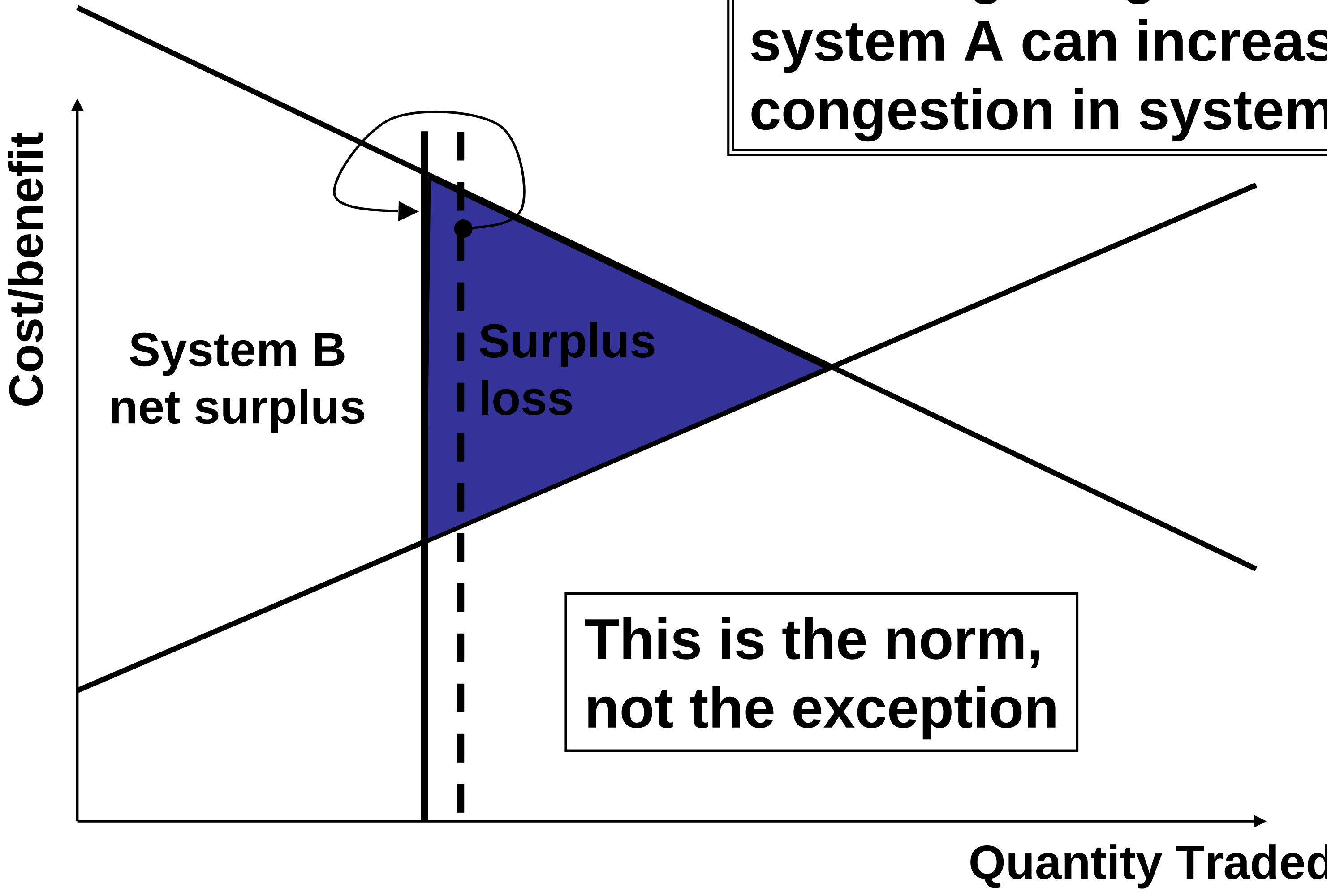
Surplus Loss (A)

What happens when system A expands



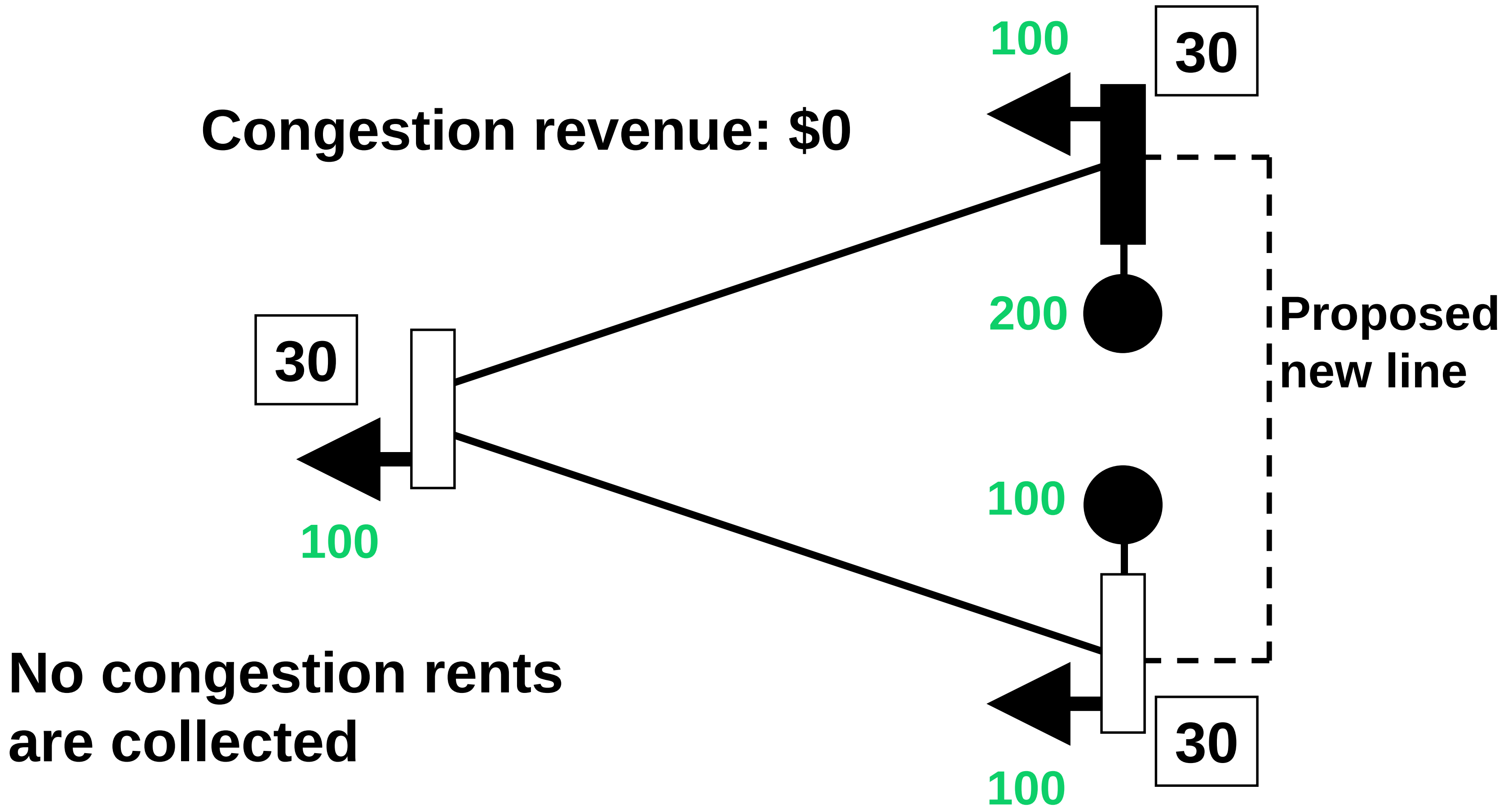
Surplus loss (B)

Relieving congestion in system A can increase congestion in system B

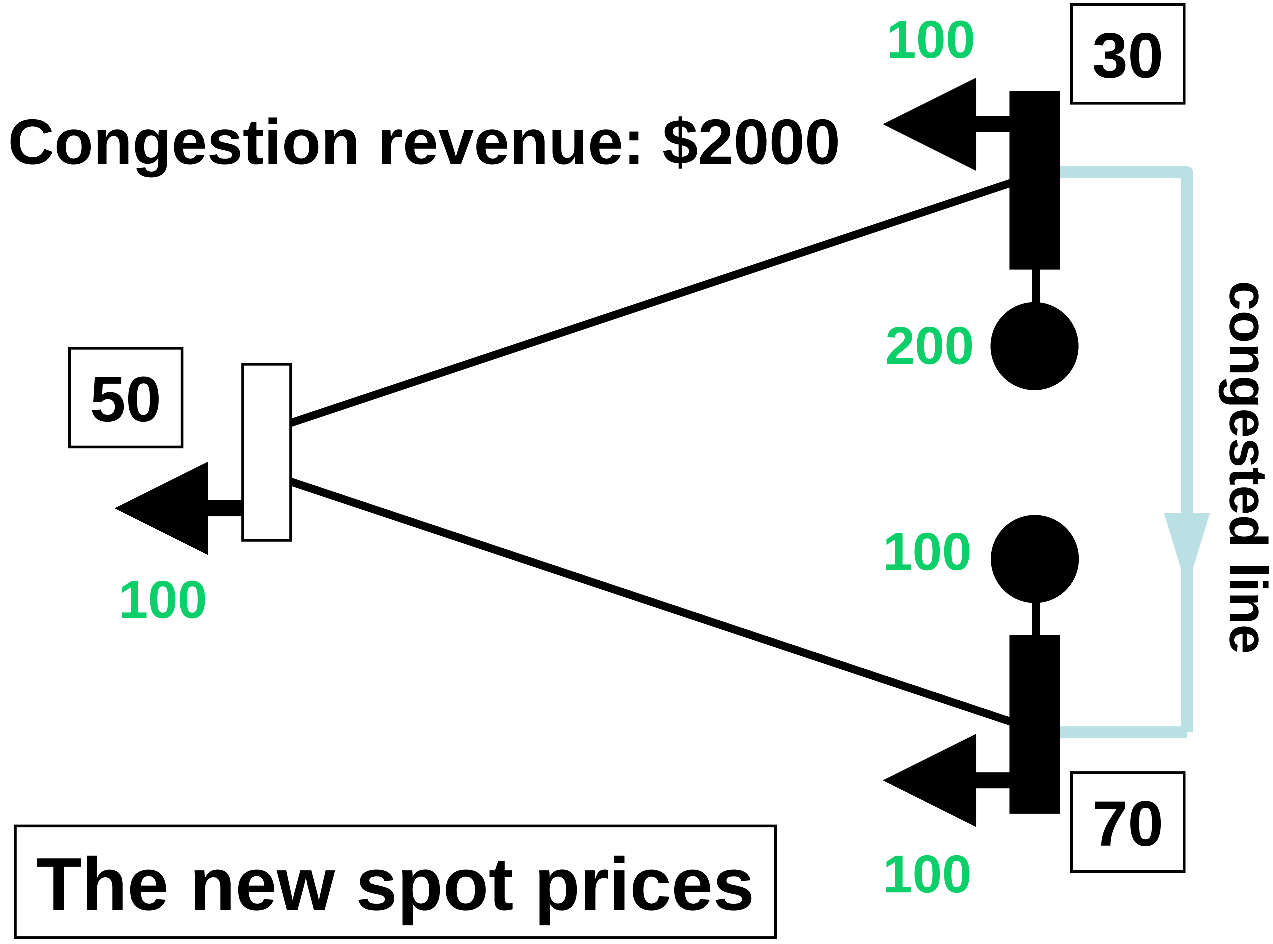


This is the norm, not the exception

Proposed system expansion



After system expansion



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