Transmission Planning in a Market Environment

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The Three Big Markets

- The Market for Energy (save a little soon)
- The Market for Generators (save a lot later)
- The Market for Transmission Lines (lose a little later)

"Deregulation," if it works, will save a lot of money by building better generators in better places with better operation. (This takes decades.)

It will save a little money on better dispatch and more efficient end use.

It will waste a little money building extra wires to make the other two markets work better.

Transmission (Tx) Investment is Difficult

- Generation has most of the qualities needed for a competitive market.   Transmission does not.
- Integrated generation and transmission is relatively easy to regulate.
- The output of an integrated system is "delivered electricity." We can measure that very accurately.
- The output of a transmission system is   . . . ????
- Transmission investment:
  1. Is very "lumpy."   (Efficient projects are huge.)
  2. Has strong externalities.   (Interactions.)

Three Approaches

- A Non-Profit Transmission Administrator (TA)
  Pro: No complex new regulatory problems.
  Con: Planning Tx is difficult without planning generation.

- A For-Profit Transmission Company (Transco)
  Pro: Might be able to harness profit motive.
  Con: Requires a new form of monopoly regulation.

- A Transmission Market
  Pro: Can utilize knowledge and motivation of generators.
  Con: Tx does not have the cost structure required for perfect competition. So far, such markets have not worked well.

Theory of Optimal Transmission

- Build Tx to save generation costs.
- If a Tx upgrade saves more than it costs,
  Build it.
- If it saves less, Don’t build it.
- One exception: It may be needed to reduce market power.

The Units of Cost

- Say a transmission line costs

  $100,000,000 + $500,000 T

  where T is the line capacity in MW.

- With a 10% cost of capital, the carrying cost is

  ($10,000,000 + $50,000 T) per year

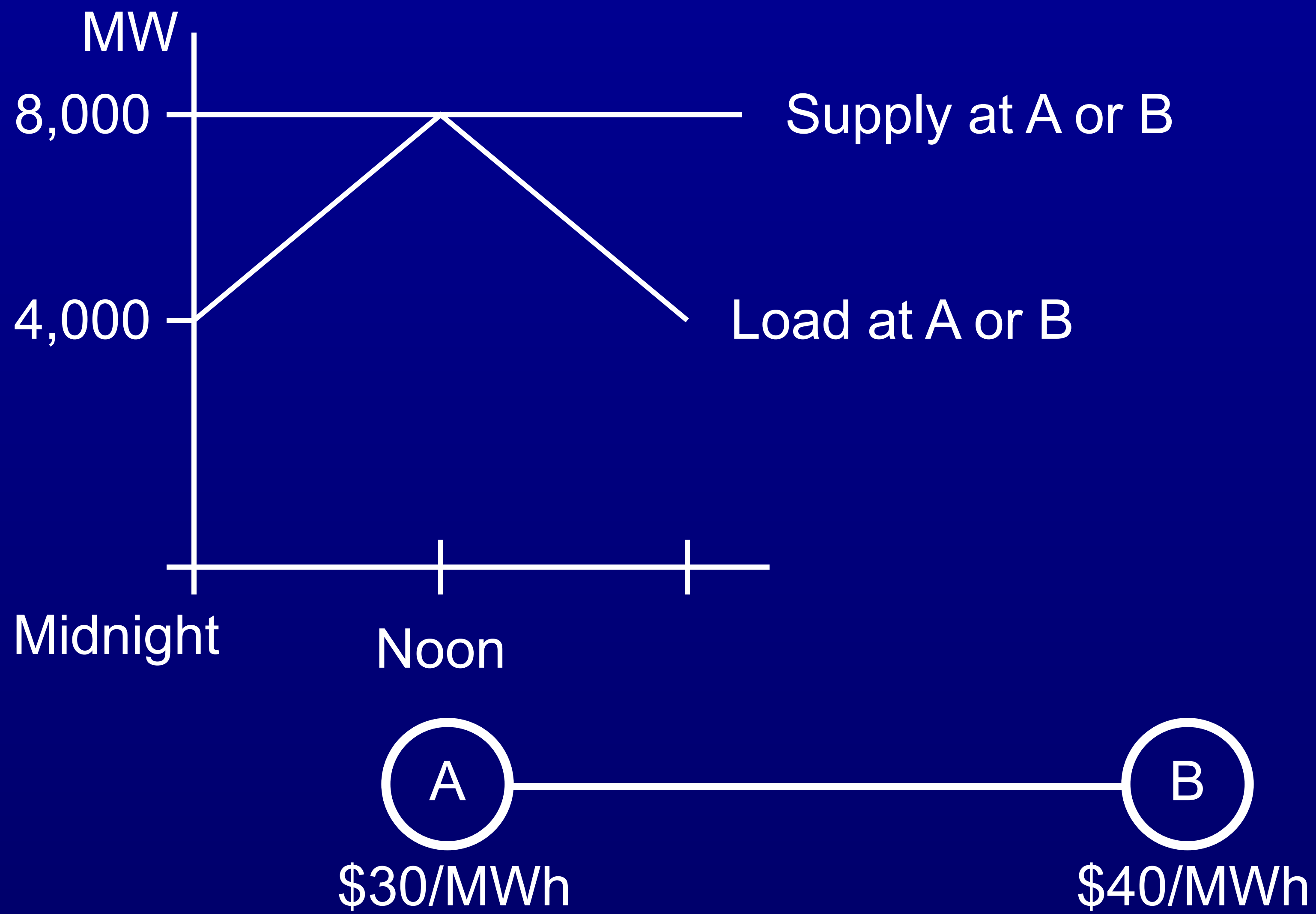
- Assuming (roughly) 10,000 hours / year, the carrying cost is

  ($1000 + $5 T) per hour

  = $1000/h + $5/MWh

- To understand the cost of a power line, think of renting one by the hour. To rent a 100 MW line there is a fixed cost of $1000/h and a variable charge of $5/MWh × 100 MW. (When planning, the line capacity is variable.)

An Example


MW
8,000
4,000
Supply at A or B
Load at A or B
Midnight
Noon
A
B
$30/MWh
$40/MWh

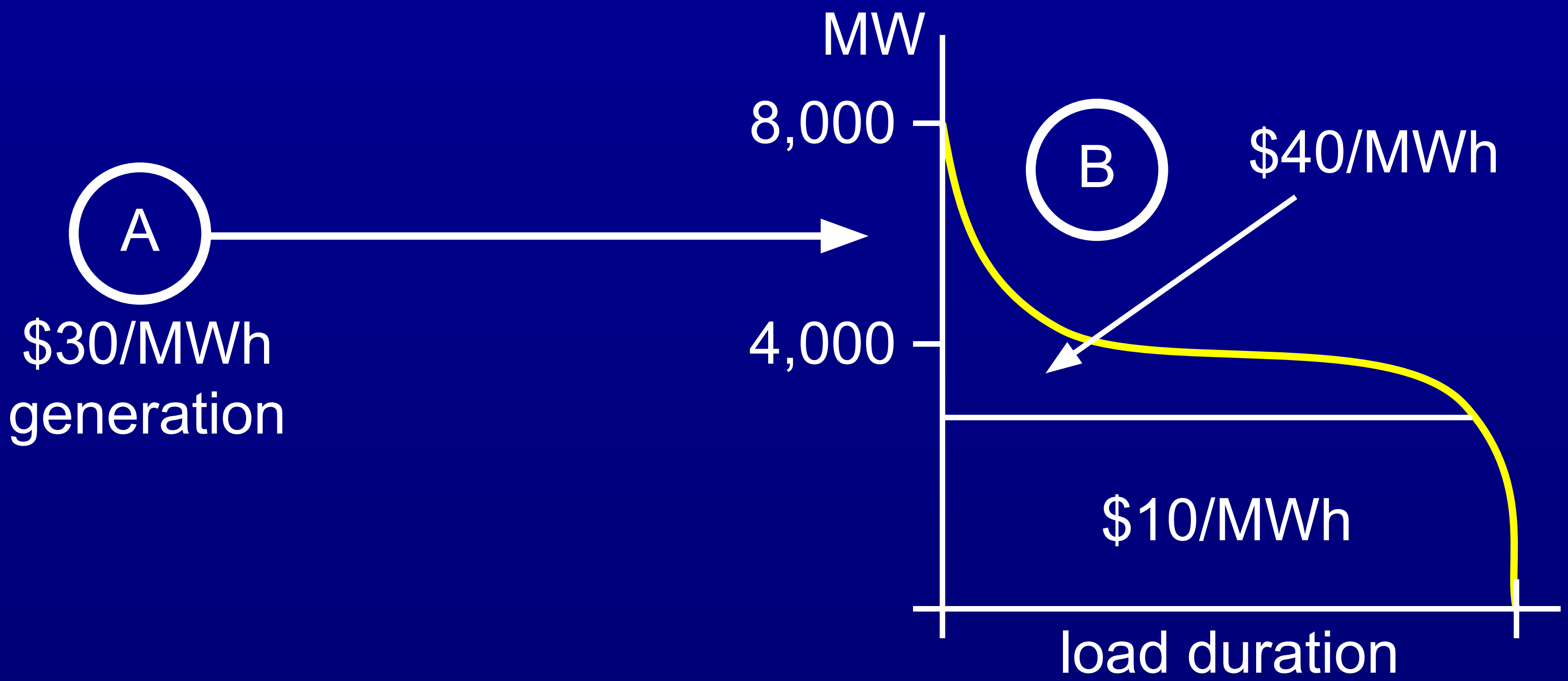
Peak Load vs. Peak Use of Lines

- At midnight the total load is only 4,000 MW.
- There is 8,000 MW of cheap ($30) generation at A.
- At maximum load, there is no extra capacity at A or B and so no possibility of trade.
- Maximum line use occurs at minimum load.
- In the first year of PJM's market, there was never any congestion when the price was $1000/MWh.

Congestion

- If the line is smaller than 4,000 MW, then some cheap A-generators would like to sell to B at midnight, but cannot because the line is too small. This is congestion.
- Congestion means: More trade is desired than can be supported by the lines.
- Congestion does not mean: (1) a reliability problem, or (2) the lines are overloaded.
- If the line is 3,000 MW and the system operator tells 1,000 MW of A-generators not to run, this does not mean congestion has been eliminated ! ! ! There is still 1,000 MW of congestion.

An Simpler Example

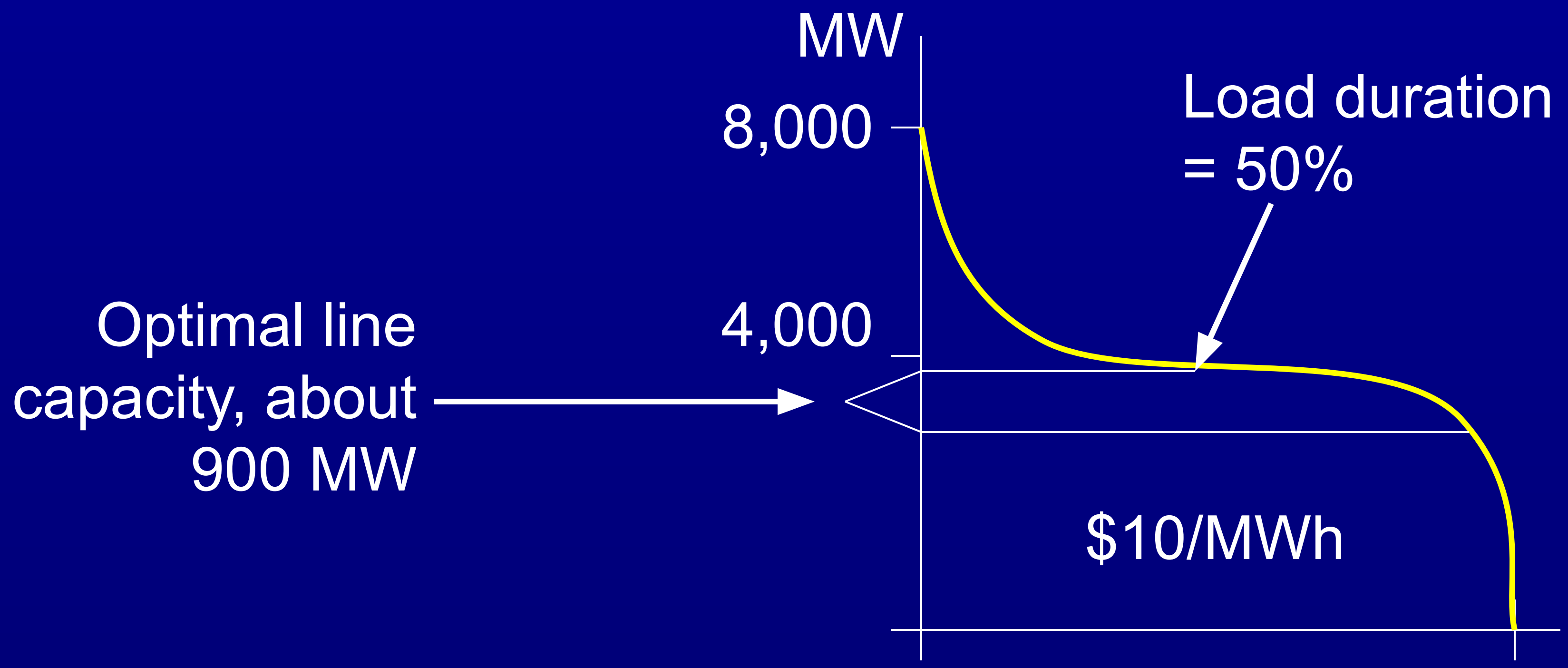


B has cheap base-load generation, but A is cheaper for mid and peak load.

Optimal Line Capacity

- The marginal cost (rent) of the line is still $5/MWh.
- The savings from using the line is $10/MWh.
- If the last MW of line capacity is used half the time, the savings is $5/MWh. This is the break-even point.
- If the line is used less, its cost is greater than its savings and it should not be built.
- Generation at B should only serve load with a duration of 50% or more.

Optimal Line Capacity (#2)



- **Serving peak load over an expensive line wastes money because the line is used very little.**
- **To eliminate congestion, build another 4,100 MW of line.**

The Zero Congestion Approach

- Alberta has a One-Price Pool.
- To help support this approach the for-profit Transco has proposed to build enough lines to eliminate all congestion.
- It has said it would build a $500,000,000 line even if the price difference were just one penny !
- It estimates that this could double the cost of wires in Alberta.
- The Transco has just learned its contract will not be renewed.

Politics

- But NOT because of its bad economics.
- The Alberta government actually wants these wires built and is going to install a non-profit TA appointed by the government.
- They want to sell power from Northern Alberta to Los Angeles and make lots of money.
- Unfortunately, California already spent all of its money and bought very expensive power for the next 10 years. (It paid about $13 billion too much.)

Approach 1: (A Non-Profit TA)

The Objective:

- **Build the lines for a minimum-cost power system.**
  Minimize cost of   Wires + Generators + Fuel
- **Congestion pricing (competitive locational pricing) will induce generators to locate efficiently.**
- **Building the right wires + competitive locational pricing is enough.**

Approach 1: Paying for Lines

- **Since competitive locational prices are optimal, demand charges and peak-use charges <u>reduce</u> efficiency.**
- **The lines should be paid for with**
  1. Congestion charges, plus
  2. A flat per-MWh charge to loads.
- **Congestion charges are not enough. The remaining cost of wires must be paid for with a "tax."**
- **A flat per-MWh charge is the "tax" that causes the least distortion.**
- **Loads must pay all costs anyway.**

Approach 1: When to Build a New Line

- Lines save different amounts at different times of the year.
- Compute the carrying cost of the new line for 1 year.
- Compute the energy-cost savings from having the line in place for each year.
- The line should go into service the first year it saves more than its carrying cost.

Approach 1: How Big a Line to Build

- This is the difficult planning problem.
- It requires predicting what generation the market will build.
- It requires comparing different possible lines over a long time horizon.

Approach 2: A For-Profit Transco

- A Transco is a monopoly and must be regulated.
- This approach has great potential.
- Some of the best economists are trying to solve the problem of how to regulate a Transco: Joskow, Tirole, Vogelsang, Wilson.
- So far they have not solved the problem, although they have many good (and complicated) ideas.
- When they do, it will take 30 years to explain it to FERC.
- Don’t rush into this.

Approach 2: A For-Profit Transco

- If you want to try this approach, . . .
- If the Transco keeps the congestion rent, it will deliberately cause congestion.
- The congestion rent should be subtracted from the Transco's profit.
- One method of regulation is to pay a large annual sum (determined for many years at a time) and subtract from it the cost of losses and congestion.
- Wilson has some good ideas about reliability insurance and charging the transco for blackouts.

Approach 3: A Market For Wires

- A generator that wishes to locate 100 km from the transmission grid should pay for its radial connection.
- That line is just like an extension of its power plant.
- Similarly, a generator that wishes to locate on a line that is fully utilized, should pay for the non-radial upgrade.
- This is not different from the radial-line case as long as this generator, and only this generator, gets to use the line.
- Transmission rights help turn non-radial upgrades into private property without causing market power.

Two Main Problems with a Market for Wires

1. A generator may need only a 100 MW upgrade, when a 300 MW upgrade would be much cheaper per MW and useful to others. (Lumpiness)
2. If a generator builds a line the power of other generators may flow on it. (Externalities / Interactions)

- These are basic problems with the cost-structure of the market.
- Economics predicts a market with this cost structure will NOT be efficient.
- Designing a successful transmission market requires fixing these structural problems.

Solving the Cost-Structure Problems

- **A transmission market needs a non-profit TA to solve these problems.**
- **The non-profit TA should**
  1. Smooth out the lumpiness of costs.
  2. Provide a system of transmission rights.

"Solving" the Lumpiness Problem

- **Say a new generator needs a 100 MW upgrade to a shared radial line.**
- **Say a 100 MW upgrade costs $50,000,000.**
- **Say a 200 MW upgrade costs $60,000,000.**
- **Say the extra 100 MW will probably be needed soon.**
- **The non-profit TA should**
  1. Build the 200 MW upgrade.
  2. Charge the generator $30 million.
  3. Give that generator 100 MW of transmission rights.
  4. Withhold the extra 100 MW of line capacity until it can sell it for $30 million to the next generator.

Transmission Rights Help with Externalities

- Physical transmission rights are very complicated.
- Financial transmission rights are simpler and are well defined.
- A typical financial transmission right (FTR) from A to B, pays the congestion charge from A to B.
- If the price is $10 at A and $25 at B, a 100 MW FTR from A to B pays $1500/h.
- It pays this whether or not you send any power.
- This gives you the right to transmit at no cost, or you can sell it and make money when you do not need it.

Rewarding Investment with FTRs

- There is a well-known rule: The Feasibility Rule.
- Think of FTRs as power flows.
- The set of all FTRs must be feasible (a safe flow of power).
- A transmission upgrade allows more power to flow, so more FTRs are feasible.
- Someone who pays for a Tx upgrade should be given FTRs for the increase in feasible flows.
- This guarantees they can use their own upgrade at no cost.

Approach 1: A Non-Profit TA

- **The TA works beside the ISO. The ISO handles the short run, and the TA handles the long run.**
- **Goals:**
  1. Minimize cost of Wires + generators + fuel.
  2. Collect cost of wires and avoid distorting the dispatch.
  3. Maximize competition.
- **Do Not attempt to reduce the average retail price except by 1 & 2 above.**

  (Any other method is an exercise of monopsony power and will cause inefficiency and higher prices in the long run.)

Approach 1: A Non-Profit TA (#2)

- Build extra lines for competition (How many ??).
- A "load pocket" is a where all incoming lines become congested.
- Generation in the load pocket has no competition from the outside.
- Transmission is a very effective way to reduce market power in a load pocket, but . . .
- A little extra transmission is cheap because it saves energy costs. A lot extra can be very expensive.

Approach 3: A Transmission Market

- An Non-Profit TA is still needed just as in Approach 1.
- The TA would still handle reliability upgrades.
- The TA would
  1. approve commercial upgrades.
  2. give out transmission rights.
  3. solve the lumpiness problem.
- The goals would be the same as Approach 1, but instead of always computing the least-cost lines, the TA would often let the market choose them.

Recommendations

- Start with Approach 1 (non-profit TA)
- Slowly add Approach 3 (include more of a market).

  (If you have a One-Price Pool, you need Approach 3 and physical rights. So don't use a One-Price Pool).
- Wait until the wholesale power market is working well before experimenting with Approach 3.
- The NY-ISO has been trying Approach 3 but without solving the lumpiness problem. In three years, one transformer has been added and one DC line has been started. We do not know if this market will work.

The End

Reliability Upgrades

- In the perfect world of economics, there are no reliability upgrades.
- In the real world these are needed.
- In Southern Alberta, Canada, they were near voltage collapse because generators were locating in the North and the North-South line as congested.
- Economics says this will not happen, generators will locate in the South because they will expect high prices when the system has reliability problems.
- But it did happen. Alberta’s power market is not perfect.
- Most power markets are far from perfect.
- Reliability can become a problem.

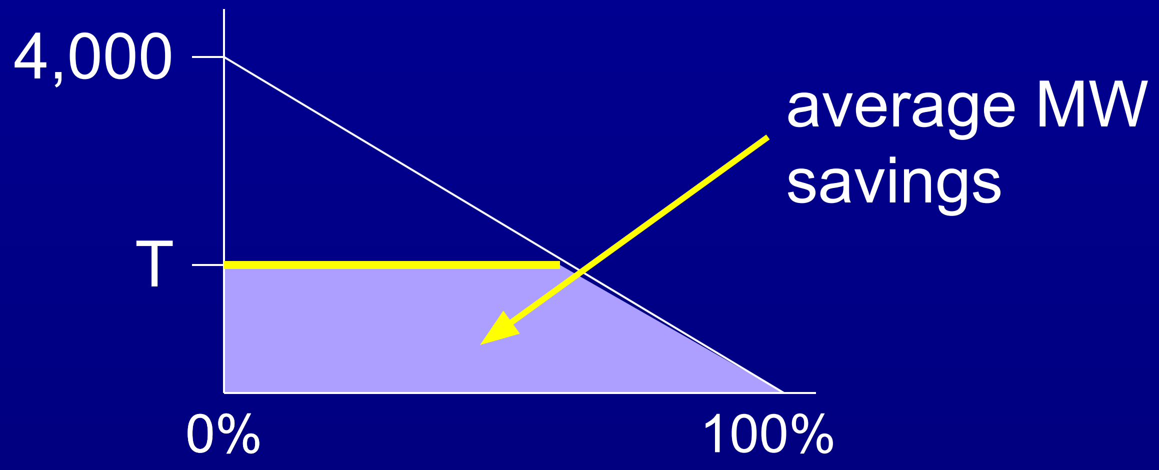
Non-Wires Solution to Transmission

- In Southern Alberta there was not enough time (6 years) to upgrade the North-South transmission.
- Instead they paid some investors to build generation plants in Southern Alberta.
- This was fast and cheap.
- They held an auction to see who would build for the least subsidy payment.
- A non-wires subsidy
  1. Should be used only for Reliability.
  2. Only when it is clearly cheaper than wires.

"Solving" the Lumpiness Problem (2)

- "X" is not well defined, but is intended as insurance for the TA in case it finds it difficult to sell the second 100 MW.
- When the TA withholds the second 100 MW until someone buys it, this can cause congestion and inefficiency.
- (Economics tells us that a transmission market will not be completely efficient.)
- Withholding of the extra transmission is necessary to prevent "free riders"--- to get someone to buy it.

What is the Short-Run Optimal Line?



Savings – Cost = \$10 (T – T^2 / 8000) /h – (\$100/h + \$5 T /h)

calculus to maximize net savings

10 – T / 4000 – 5 = 0

T = 2,000 MW.

The line is half the maximum required for all savings.

The "Marginal" View

- The last MW of line built is used one half of the time.
- The savings is $10 per MWh.
- Savings from the last MW built averages $5/h.
- The cost of the last MW built is $5/h.
- Marginal savings = Marginal cost.
- Total cost of lines + energy is minimized.
- The line is "optimal."

What Is the Long-Run Optimal Line?

- To find the optimum, assume generator fixed costs are the same at A and B.
- All of B's base load should be served from A because this saves $10/h of generation costs for a line cost of only $5/h.
- B's peak load up to a duration of 50% should be served by generation at A.
- For durations less than 50%, the energy savings is less than the line cost.
- The long-run optimal line is 6,000 MW.
- But it takes a long time for generators to retire at B and for new replacements to be built at A.

What If Congestion Is Eliminated?

- **This requires another 2,000 MW of line.**
- **The first MW is break-even. It saves what it costs.**
- **The last MW serves only the peak hour of load. It saves almost nothing and still costs $5/h.**
- **On average Cost minus Savings is $2.50/h for a total net cost of $5,000 / hour.**