FINANCIAL TRANSMISSION RIGHT INCENTIVES: Applications Beyond Hedging

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Merchant transmission investment relies on market incentives. The investor pays for the transmission expansion. Incremental financial transmission rights provide a vehicle for unregulated, market-based transmission pricing. However, network interactions and economies-of scale have always supported an assumption in favor of central planning for transmission expansion. Consider a few key issues:

- **Inefficient Transmission Investment.** In theory, inefficient investment in the transmission grid could be used to reduce capacity and enhance market power.

- **Economies of Scale and Free Riders.** With large economies of scale in major transmission upgrades, there could be a significant free-rider problem. It is often asserted that there would be no way for the merchant investor to make money.

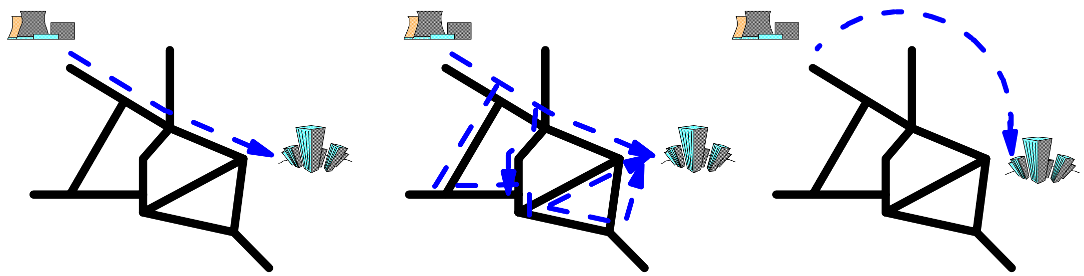
- **Incentives for Grid Owners.** There need to be incentives for maintenance and equipment replacement to preserve the existing capacity, and to cooperate with merchant transmission investments.

- **Planning Role and Incentives for ISO.** Analysis if grid expansion opportunities will at some stage involve the independent system operator.

Defining and managing transmission usage is a principal challenge in electricity markets.

Transmission Capacity Definitions

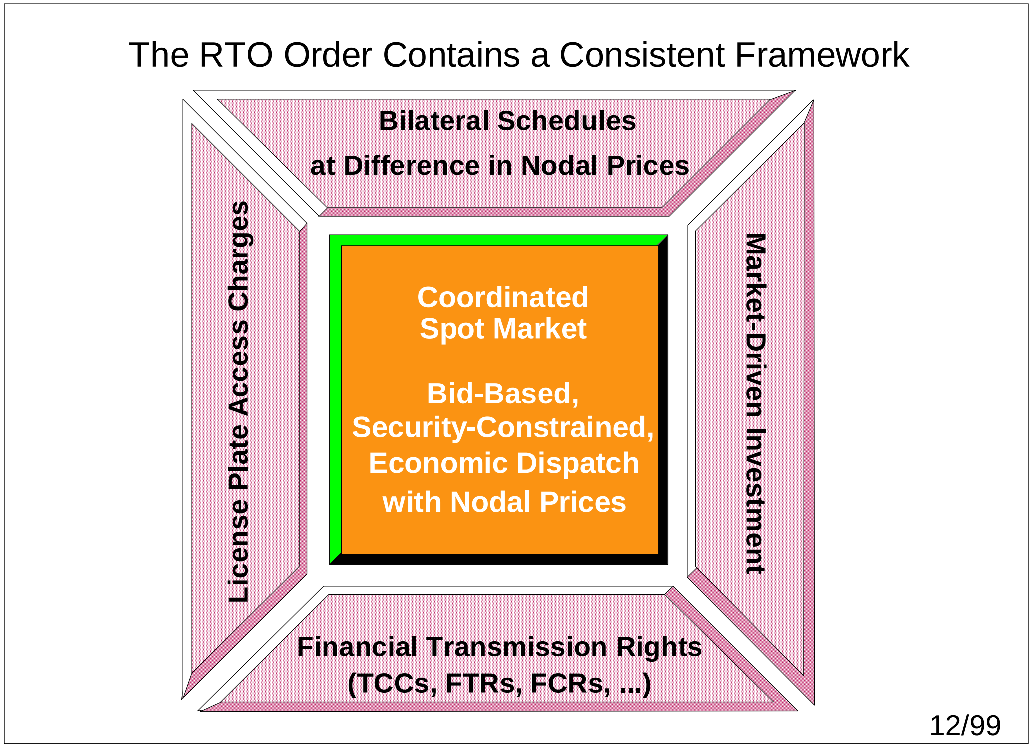
Contract Path → Flow-Based Paths → Point-to-Point



Contract Path Fiction	Parallel Flows	Flows Implicit
OASIS Schedules and TLR	~~*Physical*~~ Flowgate Rights FGs *Financial* FG-FTRs	Financial Transmission Rights PTP-FTRs

Obligations and Options

The Regional Transmission Organization (RTO) Millennium Order (Order 2000) contains a workable market framework that is working in places like New York and the PJM Interconnection in the Mid-Atlantic Region.



A spot market with locational pricing gives rise to financial transmission rights.

Revenue adequacy is the financial counterpart to the physical notion of "available transmission capacity." The physical ATC has no precise definition, and it is not possible to guarantee physical delivery even when the full grid is available. By contrast, it is possible to define the requirement for revenue adequacy.[1]

- **Revenue Adequacy**: The revenue collected with locational prices in the spot market dispatch is at least equal to the payment obligations for the FTRs in that same spot period.

- **Simultaneous Feasibility**: If the FTRs would be simultaneously feasible under conditions available for the system operator, then the FTRs would be revenue adequate.

We say that the set of FTRs is simultaneously feasible if there is a $u \in U$, the set of system controls, such that net loads *y* satisfy the balance and transmission constraints:

$$y = \sum_k \tau_k^f - \sum_k \overline{g}_k^f ,$$

$$L(y,u) + \iota^t y = 0,$$

$$K(y,u) \le 0.$$

There is one loss balance and the security constraints. With thousands of monitored lines and hundreds of contingencies, there would be hundreds of thousands of constraints.

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[1] For details, see William W. Hogan, "Financial Transmission Right Formulations," Center for Business and Government, Harvard University, March 31, 2002.

Avoiding sustained locational cost differences defines the economic rationale for investing in transmission. With prices set equal to locational marginal costs, market participants have an incentive to initiate and pay for transmission investments.

- **Transmission Benefits Along with Transmission Costs**. Financial transmission rights provide a mechanism to award the transmission benefits along with the transmission investment costs. The contracts protect the holders from future changes in congestion costs.

- **Imperfect Markets versus Imperfect Regulation**. The perfect can be the enemy of the good. Most markets have only imperfect incentives, and we should set a reasonable goal for transmission investment. Under what circumstances would tradable point-to-point rights and locational pricing provide the right incentives for investment?

- **Free Riders May Force a Residual Role for Monopoly Investment**. Due to economies of scale and network effects, there may be situations where many would benefit from a transmission expansion but no coalition is prepared to make the investment. In this case, a regulatory decision to approve the investment and allocate the costs may be required.

Without well-defined property rights, the alternative would be to rely solely on the monopoly grid owner to expand the grid and send everyone the bills.

Investment in the transmission grid should create new economic capacity. The allocation of FTRs under a feasibility rule mitigates incentives for inefficient transmission investment.

Feasibility Test: The aggregate of all financial transmission rights defines a set of net power injections in the grid. The set of contracts is feasible if these injections and their associated power flows satisfy all the system constraints.

Feasibility Rule: The grid expansion investor selects a set of new financial transmission rights with the restriction that both the new and the old FTRs will be simultaneously feasible after the system expansion.

- If the set of FTRs is feasible then the future payments required for the FTRs will never exceed the congestion revenues collected through the spot market dispatch.
- Future investments in the grid cannot reduce the welfare of aggregate use according to the existing FTRs. Hence, exposure to rent transfers is limited to the spot market.
- (Bushnell and Stoft, 1997). If PTP-FTR obligations initially match dispatch in the aggregate and new FTRs are allocated under the feasibility rule, then the increase in social welfare will be at least as large as the ex post value of new contracts.
- (Bushnell and Stoft, 1996). If PTP-FTR obligations match dispatch individually, then the allocation of FTRs under the feasibility rule ensures that no one can benefit from a network investment that reduces social welfare.

Investment would require long-term rights. If the existing grid were not fully allocated, the protocol for awarding incremental FTRs would be more complicated. Consider a few criteria.

- **Feasibility Rule.** If T is the current partial allocation of long-term rights, then by assumption it is feasible, $K(T) \leq 0$. Any incremental FTR award δ should preserve feasibility in the modified grid, hence we should have $K^{+}(T+\delta) \leq 0$.

- **Proxy Awards.** Certain currently unallocated rights $\hat{T}$ in the existing grid should be preserved. Combined with T, let $\hat{y} = T + \hat{T}$. Then we should have $K(\hat{y}) \leq 0$ and $K^{+}(\hat{y}+\delta) \leq 0$.

- **Maximum Value.** Investors should receive the incremental rights that maximize value according to their announced preferences.

- **Symmetry.** The expansion protocol should apply to both increases and decreases in grid capacity.

- **Other?** …

An investment protocol that best meets these criteria is not obvious. The hard part is defining the proxy awards.

An obvious rule that doesn't work: Every use of the current grid would be a proxy award.

Under this rule, a non-zero incremental award of FTRs could require adding capacity to every link on every path in the meshed network. This would virtually preclude investment on anything other than radial lines.

A not-as-obvious rule that might work: *The best* use of the current grid *along the same direction* would be *the* proxy award.

Motivated by the symmetry objective, treat "along" the same direction as allowing positive or negative increment, as opposed to being "in" the same direction.

The problem now is to define "best" for the proxy awards. Consider two possibilities:

Preset Proxy Preferences (p)	**Investor Preferences ($\beta(a\delta)$)**
$\hat{y} = T + \hat{t}\delta,$ $\hat{t} \in \arg\max_{t} \left\{ tp\delta \,\middle|\, K(T + t\delta) \le 0 \right\}.$	$\hat{y} = T + \hat{t}\delta,$ $\hat{t} \in \arg\min_{\substack{t \\ K(T+t\delta)\le 0}} \left\{ \max_{\theta \ge 0} \left\{ \beta(\theta\delta) \,\middle|\, K^{+}(T + t\delta + \theta\delta) \le 0 \right\} \right\}.$

Investment according to the preset proxy rule with preferences defined by prices "*p*" would be formulated as a type of auction model to maximize the investor preference in $\beta\left(a\delta\right)$ for award of "*a*" MWs of FTRs in direction δ. A similar formulation would apply for the alternative proposal using the investor preferences to define the best proxy award.

An FTR Expansion Model

$$\underset{a\geq 0,\delta,\hat{t},\hat{y},\|\delta\|=1,\iota^t\delta=0}{Max} \quad \beta\left(a\delta\right)$$

$$s.t.$$

$$K^{+}\left(T+a\delta\right)\leq 0,$$

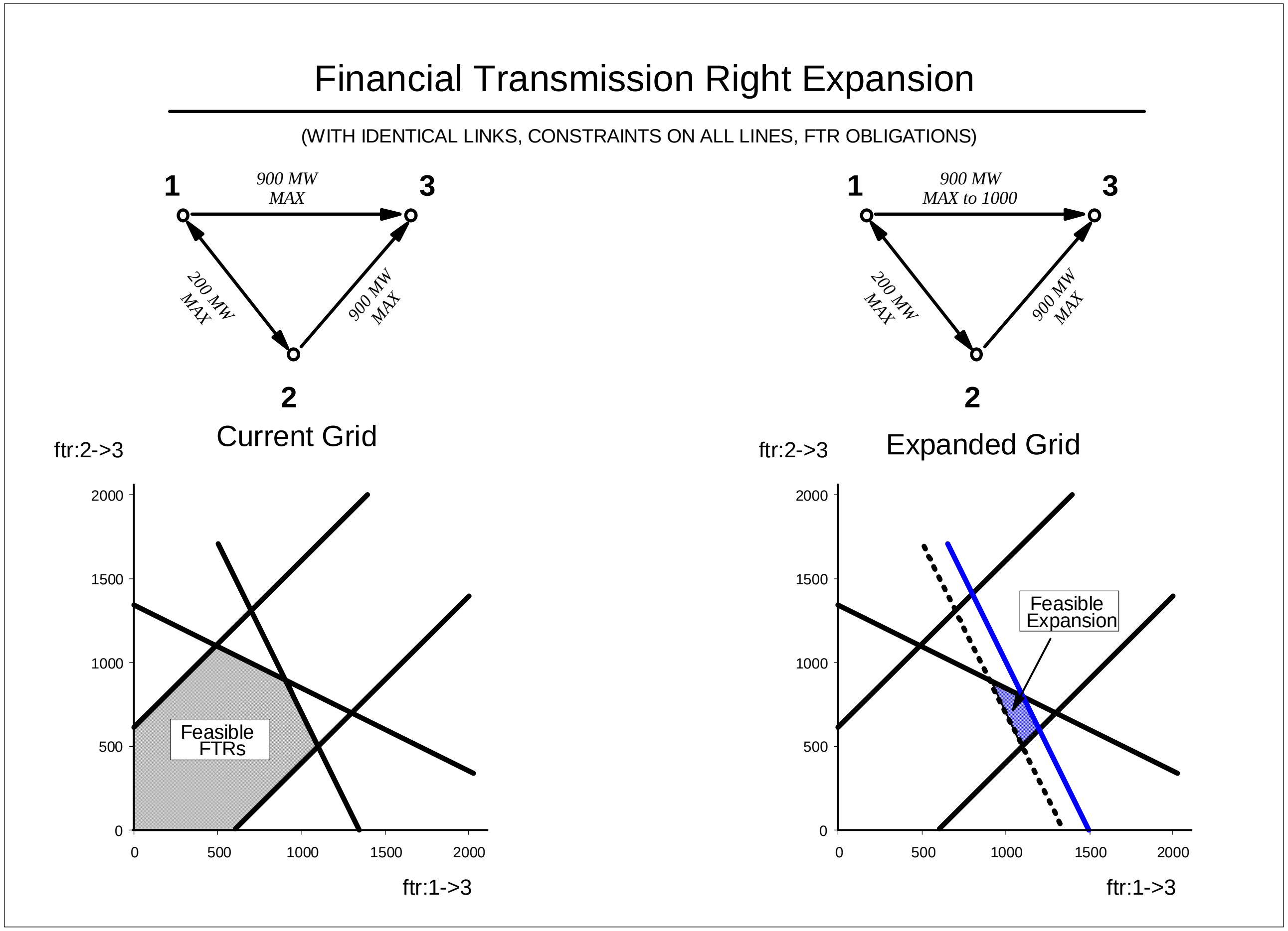
$$K^{+}\left(\hat{y}+a\delta\right)\leq 0,$$

$$\hat{y}=T+\hat{t}\delta,$$

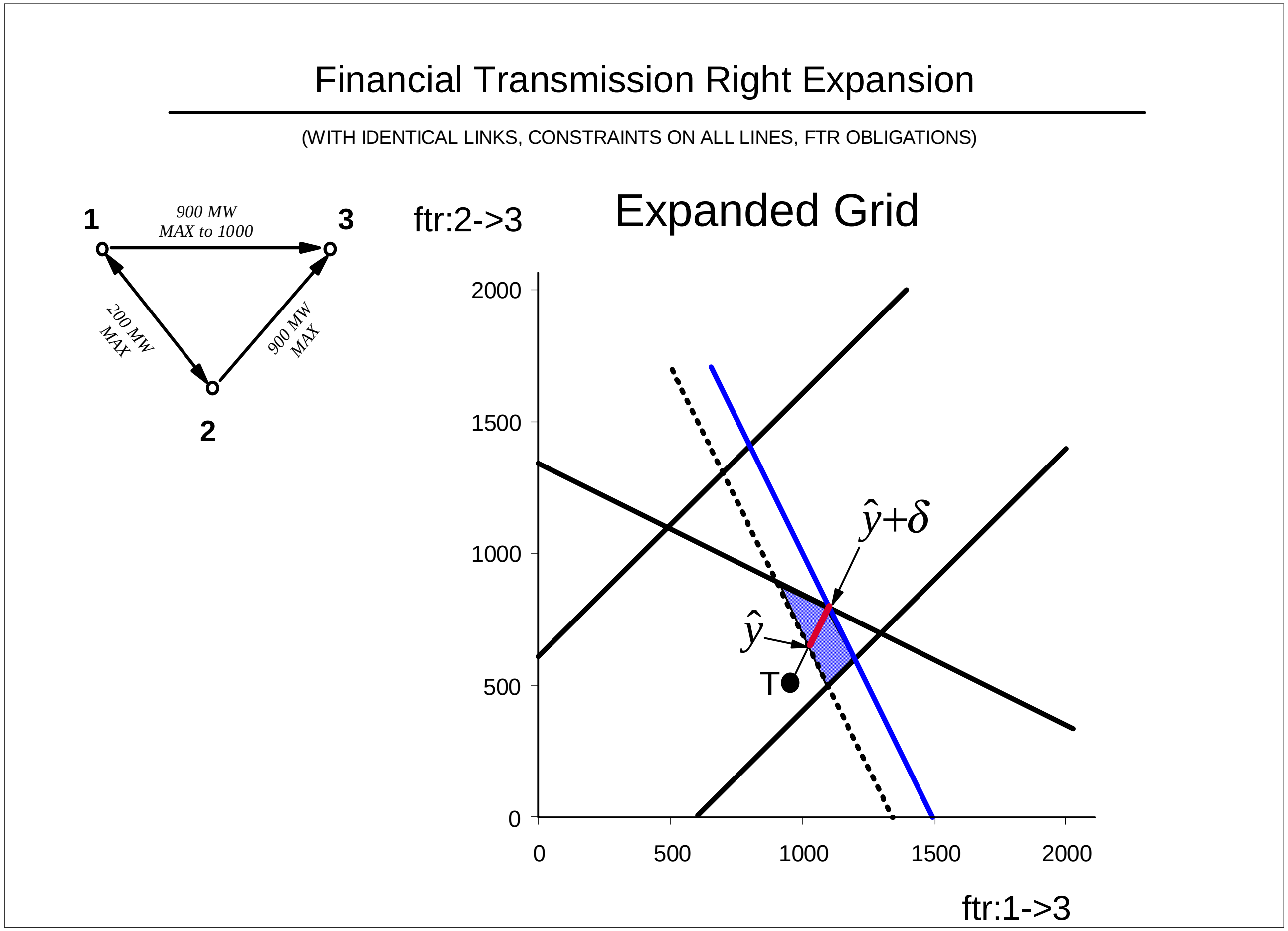
$$\hat{t}\in \arg\max_{t}\left\{tp\delta \,\middle|\, K\left(T+t\delta\right)\leq 0\right\}.$$

- **Incentives.** What incentives does this provide for merchant transmission investment? How could it be gamed?
- **Solution.** How could we modify FTR auction software to solve such a problem?
- **FTR Awards.** Does this produce acceptable proxy awards and acceptable incremental FTR awards?

Suppose the proxy preference is to maximize the sum of the FTRs. In this example, there is a simple grid expansion. Following an example of Bushnell and Stoft, the assumptions ignore losses and include the DC-load approximations.



The investor also wants to maximize the sum of the incremental awards. For this example, the existing long-term rights *T* do not use the full capacity of the grid. The proxy award uses the "rest" of the capacity in the existing grid.



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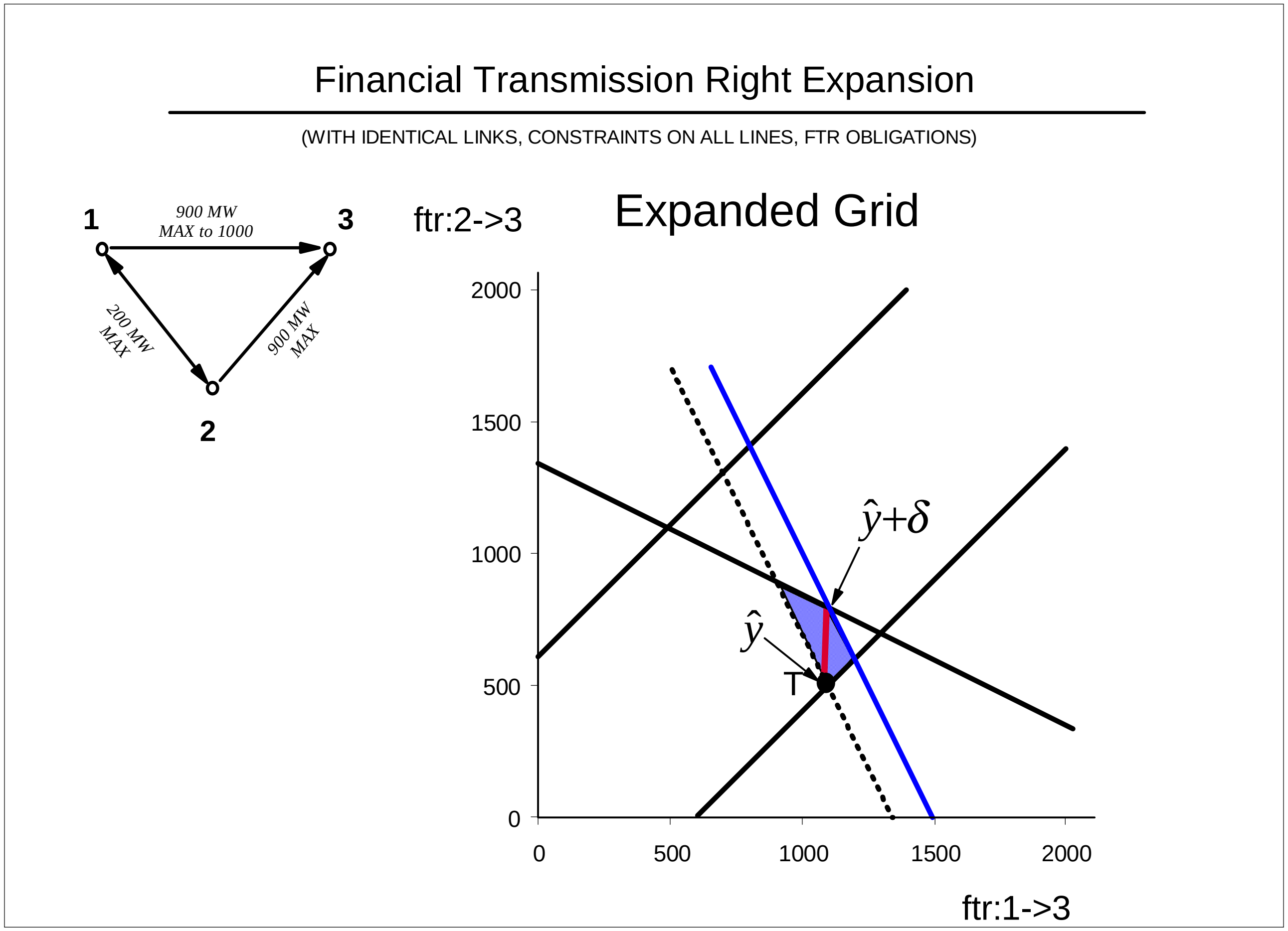
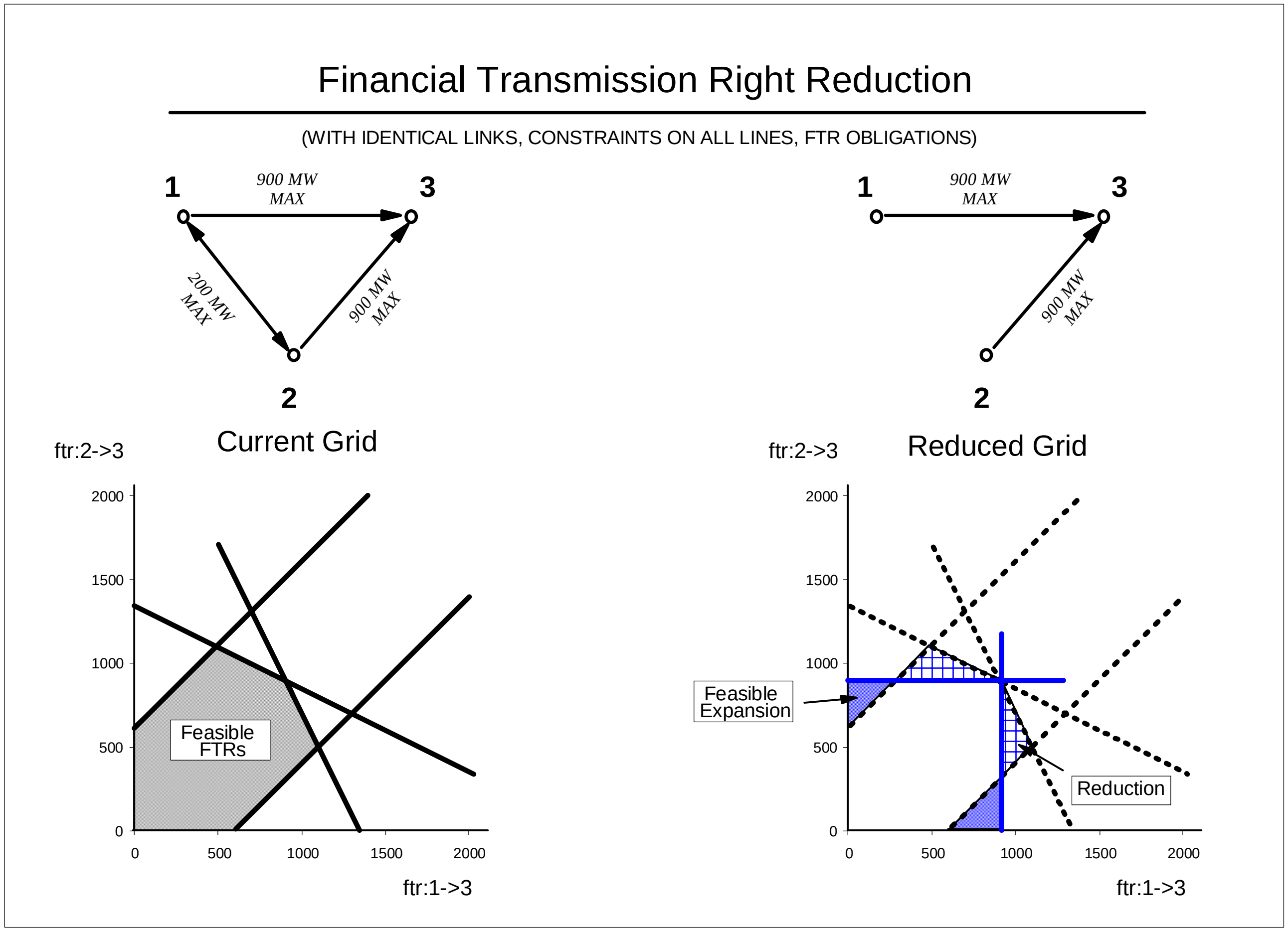
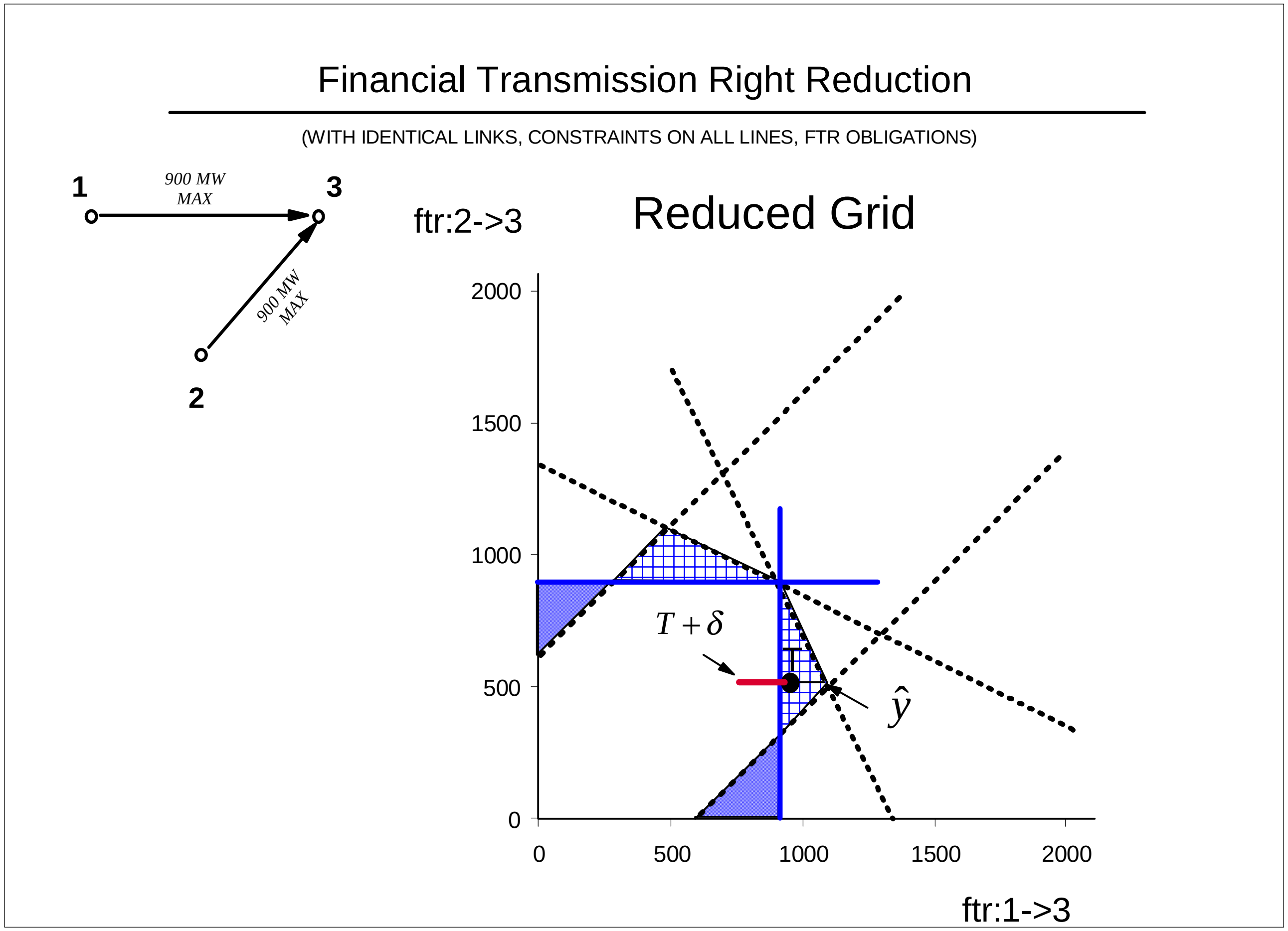


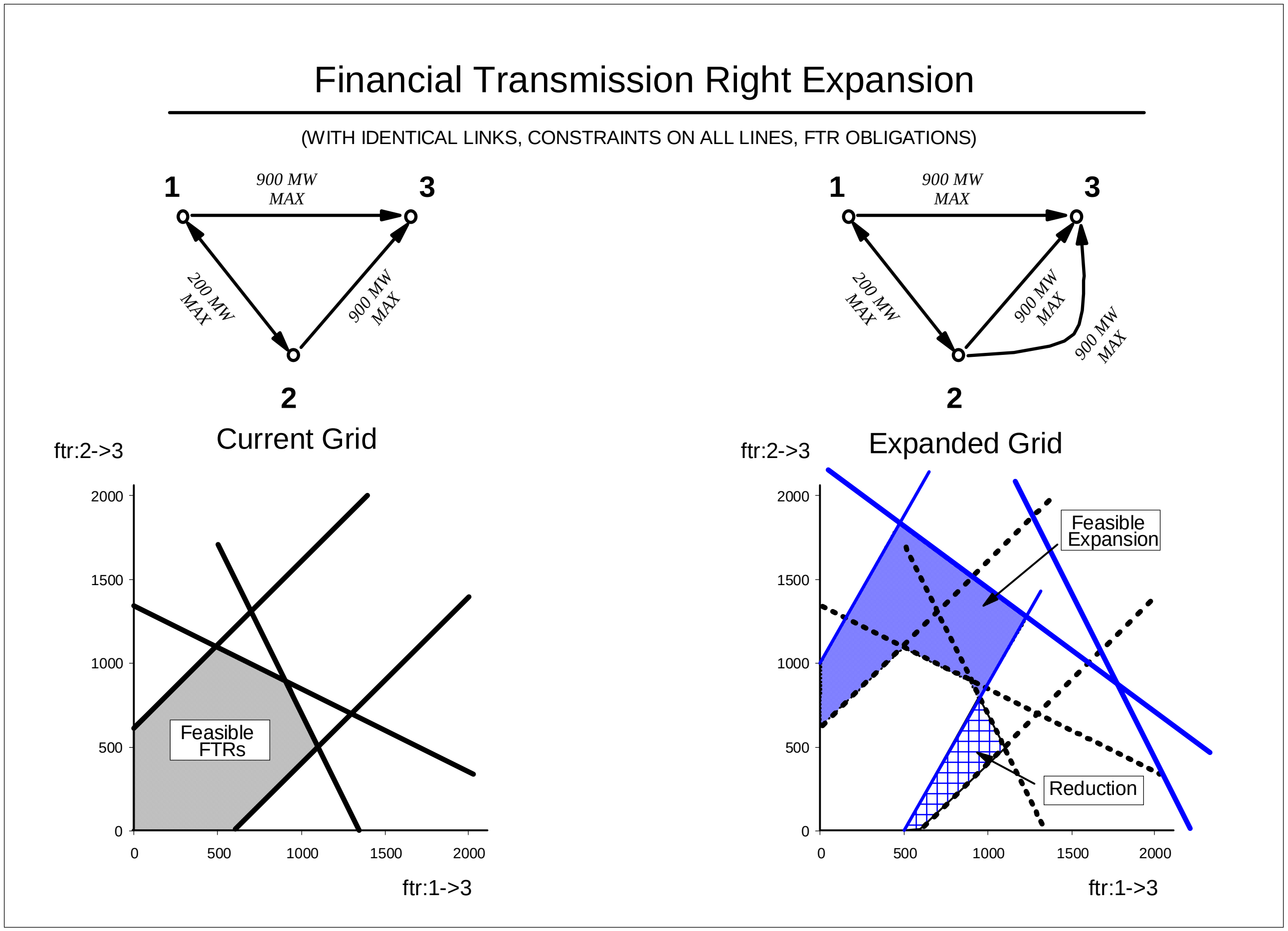
In this example, there is a grid "reduction" by removal of a line. Note that this both contracts and expands the set of feasible FTRs.



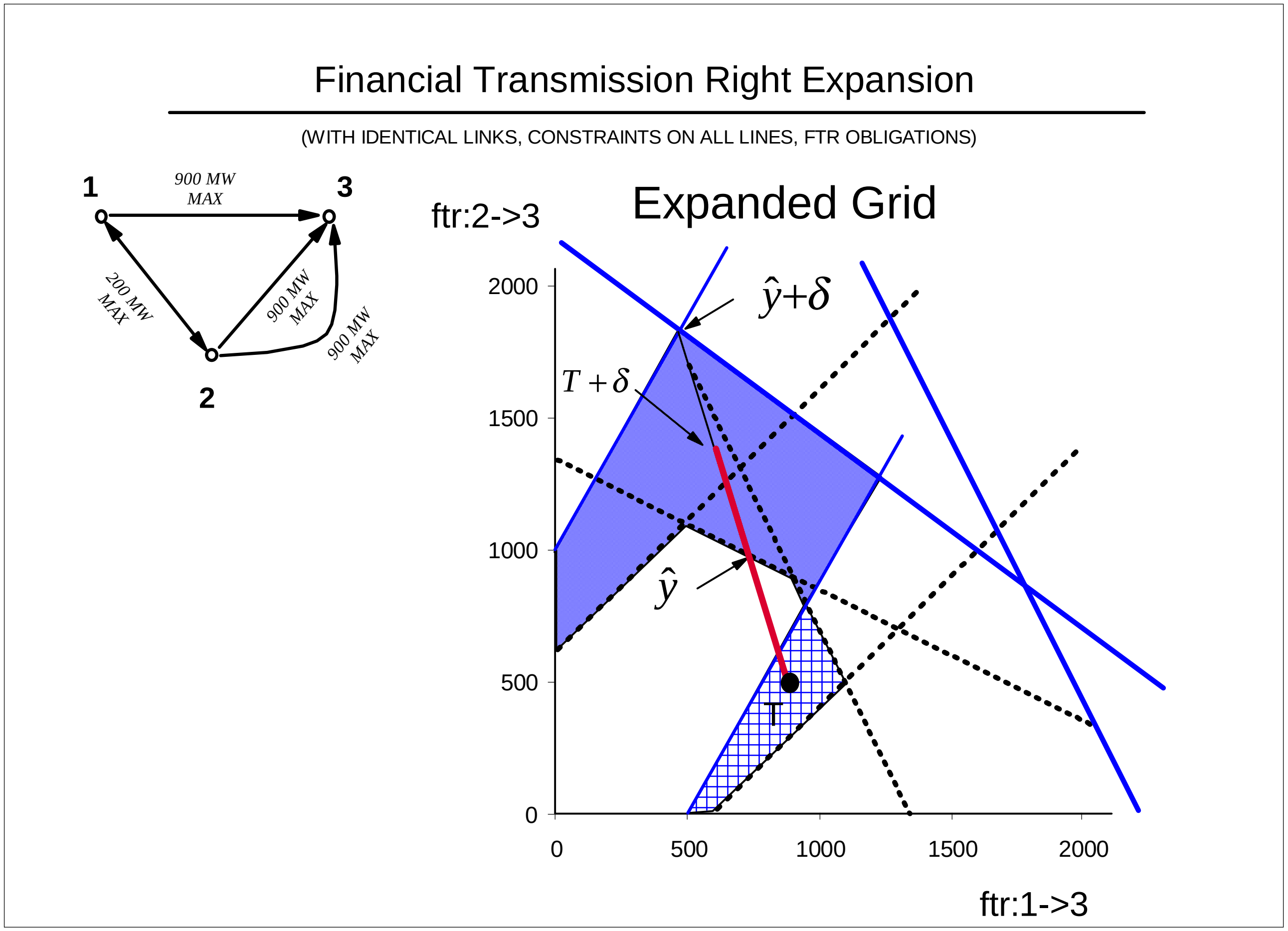
The investor wants to minimize the incremental awards needed to restore feasibility. For this example, the existing long-term rights *T* do not use the full capacity of the grid. The proxy award uses the "rest" of the capacity in the existing grid. The investor is responsible for more counterflow.



Investment that introduces a different link will change the impedances and the flow throughout the network. This would both expand and contract the set of feasible FTRs.



The investor has preferences for more rights from bus 2. For this example, the existing long-term rights *T* do not use the full capacity of the grid. The proxy award uses the "rest" of the capacity in the existing grid.



Merchant transmission investors need to be able to make money. This is not such a radical idea.

- **Modular Investments.** If the transmission investments can be made in small increments, they should have a minimal effect on market prices. In this case, acquisition of the financial transmission rights provides the right market incentive.

- **Large, Lumpy Investments.** With large economies of scale in major transmission upgrades, there could be a significant change in prices. However, there would still be ways to make money:

  Long-Term Contracts: Merchant investors could arrange for long-term power contracts at favorable prices, before making the transmission investment.

  Controllable Increments: We could accept the same tradeoff in other industries to allow for limited use of the incremental investment, perhaps for a period of time. There would be an analogy to patents. It would make lumpy investments look modular. The existing grid, paid for under regulated rate base, would not be restricted. The "Direct Link" project between Queensland and New South Wales in Australia is an example of such a merchant investment. The principle could apply to lines that are literally controllable, or through constraints used in the security-constrained economic dispatch.

Reliance on merchant investments may not cover all cases, but it could provide an efficiency improving complement to regulated, rate-based transmission expansion.

Transmission companies could perform a number of business functions related to provision of transmission capacity. Financial transmission rights such as FTRs would serve as an important tool for defining and rewarding performance through market incentives.

- **Merchant Investments.** Gridcos, like anyone else, could be in the business of making merchant transmission investments. This would be possible in any open access market, not just its own regional service territory. The Gridco would acquire and sell the FTRs.

- **Regulated Investments.** Gridcos could have primary responsibility for making regulated transmission investments when there is a market failure and insufficient merchant expansion. The FTRs could be auctioned to reduce the fixed charges.

- **Options and Forward Obligations.** Transmission rights defined as forward obligations for the existing capacity are easier to analyze for revenue adequacy, but options and longer term obligations have great appeal. Transmission rights defined as obligations could be offered over longer periods and without perfect connection to the physical capacity of the grid. The tradeoff between partial analysis of the feasibility of options and the market value of transmission rights defined as options could be evaluated by a Gridco that was prepared to take the business risk in exchange for an appropriate return. The Gridco could make a business judgement about the risks and rewards.

- **Performance Incentives.** Revenue deficits between FTRs would imply a degradation in the capacity of the grid. Sharing responsibility for any revenue deficit would provide a market-based incentive for efficient maintenance of the capacity of the grid.

Dealing with competitive markets in the face of substantial economies of scale and scope presents numerous challenges. These arise with both merchant investments in transmission and more traditional regulation of the monopoly:

- **Market Power.** Inefficient investment in the transmission grid could be used to create market power in generation by imposing new bottlenecks. In theory, FTRs mitigate but do not eliminate this form of market power. And ownership of FTRs can exacerbate market power in generation.

- **Section 211.** This section of the Energy Policy Act of 1992 requires grid owners to connect new users and expand the grid as necessary. Enforcement for true open access will not be easy.

- **Residual Investment and Free Riders.** The economies of scale and scope of grid investment can create free-rider incentives whenever the investment significantly changes prices. Need to define workable rules for authorizing regulatory investments

- **Incentives for Transmission Owners.** The incentives for maintenance and equipment replacement to preserve the existing capacity of the grid can be connected to FTRs, but the baseline and degree of exposure need further study.

- **Planning Role and Incentives for ISO.** Analysis if grid expansion opportunities will at some stage involve the independent system operator. The timing, degree of participation, and incentives for the ISO are subjects of controversy.

Supporting papers and additional detail can be obtained from the author. William W. Hogan is the Lucius N. Littauer Professor of Public Policy and Administration, John F. Kennedy School of Government, Harvard University and a Director of LECG, LLC. This paper draws on work for the Harvard Electricity Policy Group and the Harvard-Japan Project on Energy and the Environment. Conrad Edwards, Scott Harvey, and Susan Pope provided any good ideas described here. The author is or has been a consultant on electric market reform and transmission issues for American National Power, Brazil Power Exchange Administrator (ASMAE), British National Grid Company, Calpine Corporation, Comision Reguladora De Energia (CRE, Mexico), Commonwealth Edison Company, Conectiv, Detroit Edison Company, Duquesne Light Company, Dynegy, Edison Electric Institute, Electricity Corporation of New Zealand, Electric Power Supply Association, GPU Inc. (and the Supporting Companies of PJM), GPU PowerNet Pty Ltd., ISO New England, Mirant Corporation, National Independent Energy Producers, New England Power Company, New York Independent System Operator, New York Power Pool, New York Utilities Collaborative, Niagara Mohawk Corporation, Pepco, PJM Office of Interconnection, Public Service Electric & Gas Company, San Diego Gas & Electric Corporation, Sempra Energy, TransÉnergie, Transpower of New Zealand, Westbrook Power, Williams Energy Group, and Wisconsin Electric Power Company. The views presented here are not necessarily attributable to any of those mentioned, and any remaining errors are solely the responsibility of the author. (Related papers can be found on the web at http://www.ksg.harvard.edu/whogan).