Flow-Based Congestion Management: An Intellectual & Practical Dead-End

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Infocast Conference on Congestion Pricing & Forecasting
Washington, DC
February 21, 2001
Agenda

Historical and Logical Overview
Initial Claims and Hard Realities
The Search for a “Hybrid”
Current Status and Likely Outcome
Definitions and Abbreviations

FG = Flowgate (Flow-Limited Network Element)
CSF = Commercially Significant Flowgate
FGR = (Physical?) Flow Gate Right
PTDF = Power Transfer Distribution Factor
LMP = Locational (Nodal) Marginal Price
FTR = Financial Transmission Right with LMPs
RT(M) = Real-Time (Market)
RTO = Regional Trans. Org, ISO, or similar entity
Initial electricity trading used “contract paths”
• Power flow is “scheduled” on a single path
• Traders must buy rights on this single path
• BUT: Totally inconsistent with physical reality

LMP/FTR approach ignores flows for trading
• Power “ins/outs” are sold/bought at points
• Traders buy point-to-point FTRs
• RTO worries about network complexities

Flow-based trading returns to contract paths, but with traders responsible for flows on many paths
The Simple Idea Behind Flowgates

NOTE: All Lines Have the Same Impedance
Power Transfer Distribution Factors

NOTE: All Lines Have the Same Impedance
The Simple Idea Extended

PTDFs (Hub = E)

<table>
<thead>
<tr>
<th>Node</th>
<th>A→B</th>
<th>C→D</th>
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<tbody>
<tr>
<td>A</td>
<td>+0.52</td>
<td>−0.12</td>
</tr>
<tr>
<td>B</td>
<td>−0.31</td>
<td>+0.03</td>
</tr>
<tr>
<td>C</td>
<td>+0.07</td>
<td>+0.43</td>
</tr>
<tr>
<td>D</td>
<td>+0.02</td>
<td>−0.62</td>
</tr>
</tbody>
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100 A-C Needs: (52-7) A→B and (−12-43) C→D FGRs

100 B-D Needs: (−31-2) A→B and (3+62) C→D FGRs
The Initial Claims for Flowgates

There are only a “few” CSFs/FGRs that:

• Capture all “significant” congestion
• Are easy to identify and physically intuitive
• Have constant PTDFs and CSF capacities
• Can be 1-way options, not 2-way obligations
• Can be physical, not financial, rights

If this were true, flow-gate trading might be easy, liquid, transparent, with no need for LMPs/FTRs.

Unfortunately, it just ain’t so!
Reality: There Are Very Many CSFs

System operations are constrained by:

- Hundreds/Thousands of physical constraints
- Many non-flow (e.g., voltage) constraints
- Many contingency constraints

The “fact” that current congestion costs are “small” does not mean they can be ignored.

Socializing even “small” congestion costs leads to:

- Distorted operational and location incentives
- Destructive gaming (the “dec” game)
- Large congestion costs eventually
Are CSFs/FGRs Few and Intuitive?

3 potentially constrained lines “obviously” imply “only” 3 CSFs/FGRs & 9 (6 independent) PTDFs

Unfortunately, it just ain’t so!
There Are Many Contingencies

(Assumes surge limits = 120% of steady-state limits)

Contingencies constrain operations even when they do not occur
Contingency Constrained Dispatch

Contingency “0”

Contingency A

Contingency B

Contingency C

3 Lines with 4 Contingencies Imply Up To 12 Flow Constraints and 36 (24 Ind.) PTDFs
Reality: CSFs/FGRs Are Many and Abstract

All contingency constraints are the same in dispatch
• “100 MW on Line A when all lines are in”
• “120 MW on Line B when Line A is out”
• Even highly unlikely contingencies can affect dispatch and pricing in any/all hours

CSFs and FGRs must be defined accordingly
• They will NOT be “intuitive” physical things/places
• Bizarre combinations can bind at the same time

PJM has had ~100 contingent CSFs, with more/different ones appearing all the time
The Problem of Nomograms

Nomogram for A-B and C-D Flowgates

Most valuable set of FGRs if FGR Prices = $P_1$

(line of equal FGR value given FGR prices $P_1$)

But if FGR Prices = $P_2$ …

Which combination of FGRs does “the market” want?

The RTO must know the market outcome before setting the market parameters!
The Problem of Non-Flow Constraints

Flow limits depend on the entire dispatch/market outcome, which is not known even hours, much less days/months, in advance
The Problem of Controllable Lines

Controllable lines (phase shifters/DC lines):
• Are becoming more economical and common
• Have no purpose EXCEPT to change PTDFs

Flow-based “theory”:
• Has no way to deal with controllable flows
• Essentially ignores/denies them

In an LMP/FTR system, controllable lines are dispatched and affect prices like anything else; dispatch is efficient and FTRs are good hedges.
The Problem of “Physical” Rights

FGRs were initially regarded as “physical” rights
• Needed to schedule physical transactions
• “Use-or-lose,” w. penalties for exceeding FGRs
• Physical operations determined by FGRs

FGR proposals have now given up on most of this.
• FGRs not needed to schedule or operate
• Physical operations determined in RTM w. LMPs
• FGRs purely financial (w. TLR priority, use/lose?)

FGR “theory” is now scrambling for a “hybrid”
The Problem of Options vs. Obligations

Supposedly, FGRs (but not FTRs) are options that:

• Pay the holder if congestion is in expected direction
• Do not obligate the holder to provide “counterflow”

This is simply not true, logical or an FGR “advantage”

• FTRs can be options just as well as FGR can
• Counterflow obligations can be operationally useful and commercially valuable

Either there is no difference here, or FGRs are clearly inferior to FTRs
The Search for a “Hybrid” Model

A pure FGR market is now seen to be impossible.
• FGRs cannot capture complexities of a grid
• FGR trading will not be fast or efficient enough

So the search is on for a hybrid market in which:
• Forward trading would be based on CSFs/FTRs
• Real-time operations and pricing would use LMPs
• The RTO would socialize some/all of the costs of closing the gap between the two markets

*Even the hybrid will eventually prove impractical.*
Some of the Issues in a Hybrid Market

Who defines the CSFs/FGRs/PTDFs, and how, when:
• There are far too many CSFs (>100 in Alliance?)
• Capacities (FGRs) and PTDFs change constantly

Do LMPs in RTM reflect all actual constraints/PTDFs?
• If so, how is RTM congestion hedged, how are FGRs settled – and what good are they?
• If not, how is real-time congestion managed and its costs allocated?

Such issues are still unresolved, even unaddressed.
Example: Settling FGRs at LMPs

Suppose I buy FGRs that “almost” hedge a transaction
• Based on the preannounced CSFs and PTDFs
• But RT LMPs reflect different constraints/PTDFs

What am I charged/paid for congestion in the RTM?
1. The RT value of my FGRs less RT LMP charges?
2. Some “small” amount because I was “almost” fully hedged in the forward market, and if so, what?

Answer 1 is OK, but → FGRs are poor hedges;
Ans. 2 → Logical problems, last costs socialized
Example: Grandfathering Existing Rights

Existing long-term transmission rights are:
- Either point-to-point or “network” rights
- Relatively easy to convert to point-to-point FTRs

Converting existing rights to equivalent FGRs requires:
- A new set of FGRs whenever CSFs/PTDFs change, i.e., every month, day or hour
- Somebody (RTO?) to pay for each reconfiguration

This is a complex, inefficient, risky way to do what FTRs do easily and automatically!
(How) Will FGR Trading Really Work?

The claim that FTR trading will be easy, liquid, etc.
• Has no basis beyond repeated assertion
• Is implausible on its face, given that there are millions of potentially interesting FGR portfolios

Competitive selling of individual FGRs is unlikely
• Traders will want point-to-point bundles of FGRs
• Centralized, “monopoly” exchanges will be needed

Even then, FGR trading will require the RTO to guarantee an artificially simplified market
The Real Issue: Socialization of Costs

A flow-based market that reflects reality would have:

- Hundreds of abstract, contingent potential CSFs
- Ever-shifting CSF capacities (FGRs) and PTDFs
- No way to hedge more than a few hours in advance

Commercially useful FGR trading requires the RTO to:

- Select a few CSFs with fixed FGRs/PTDFs
- Somehow manage physical reality in real time
- Protect FGR holders from the real-time costs.

FGRs “work” only if the RTO socializes large costs.
Summary and Conclusions

“Everybody” now accepts the need for:
- Financial, not physical FGRs (ex. TLRs, use/lose?)
- LMP-based real-time operations and pricing

FGR/Hybrid advocates are still searching for ways to:
- Define stable CSFs, FGRs, PTDFs
- Settle FGRs against real-time LMPs
- Convince others to pick up large, socialized costs

*A flow-based market is a logical/practical dead-end – which is not to say that nobody will try it, of course!*