

WOLF

Wide Open Load Following

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NERC Market Interface Committee

2002 September 4-5

Houston, Texas

Mark B. Lively

- Utility Economic Engineers (1992 to date)
- Ernst & Ernst (1976-1991)
- AEP (1971-1976)
- Kentucky Power (1969)
- MIT
 - S.B. EE 1969
 - S.M. Mgt 1971
- Sigma Xi
- IEEE
 - Power Engineering Society
 - Reliability Society
 - USA Energy Policy Committee
- Professional Engineer

WOLF

Wide Open Load Following
A Location Marginal Pricing Mechanism for
Unscheduled Flows of Electricity

- Inadvertent interchange
- Loop flow
- Reactive power
- Unified basis

WOLF

- Sets universal price
- Geographical differentiates
- Prices reactive power

WOLF

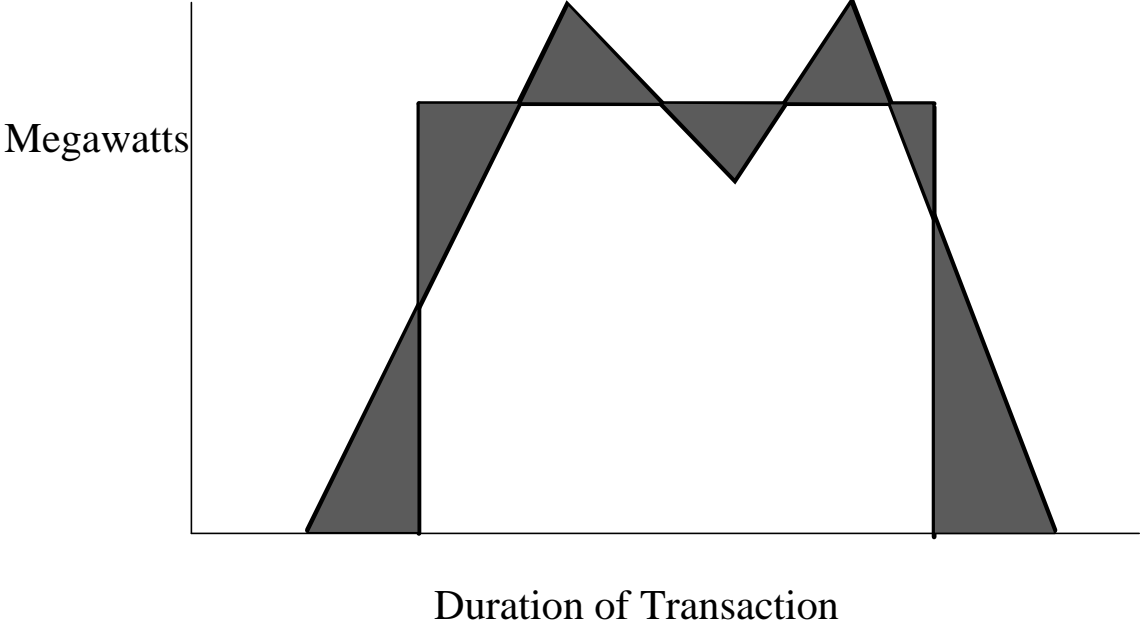
- Sets universal price
 - Frequency (ACE), time error, cumulative time error
- Geographical Differentiates
 - Marginal line losses, constraints
- Prices reactive power
 - Voltage, active power price

System Dispatch

Command and Control With INCs and DECes

- Generation reliability
 - All INCs or All DECes
- Transmission reliability
 - Mix of INCs and DECes
 - Reactive power
- Economics
 - Mix of INCs and DECes
 - Reactive Power

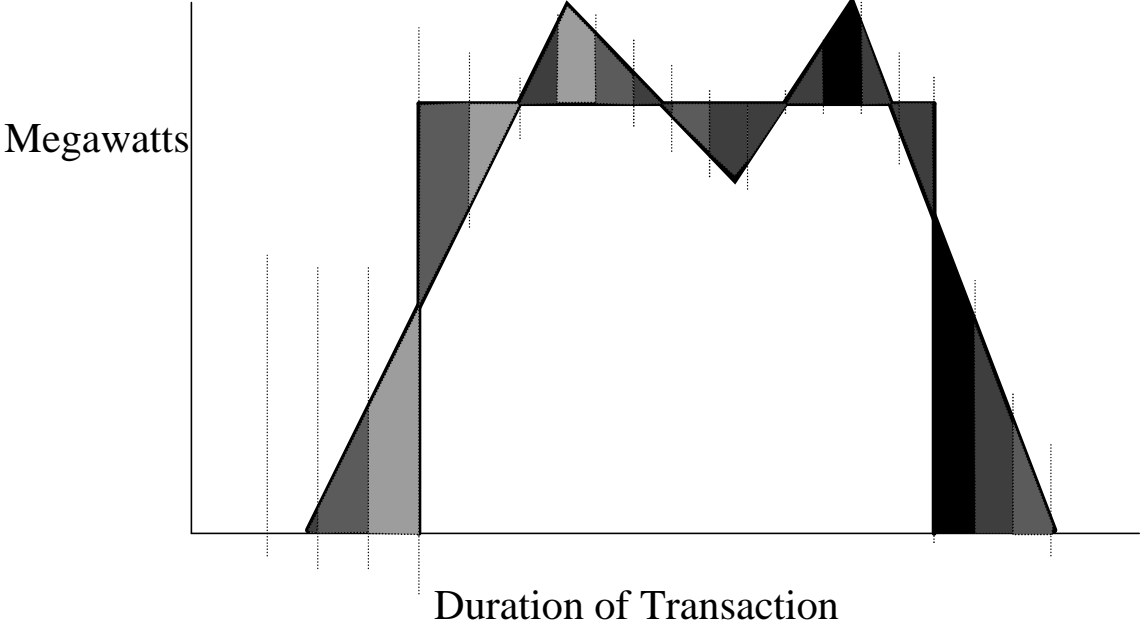
Delivering Active Power



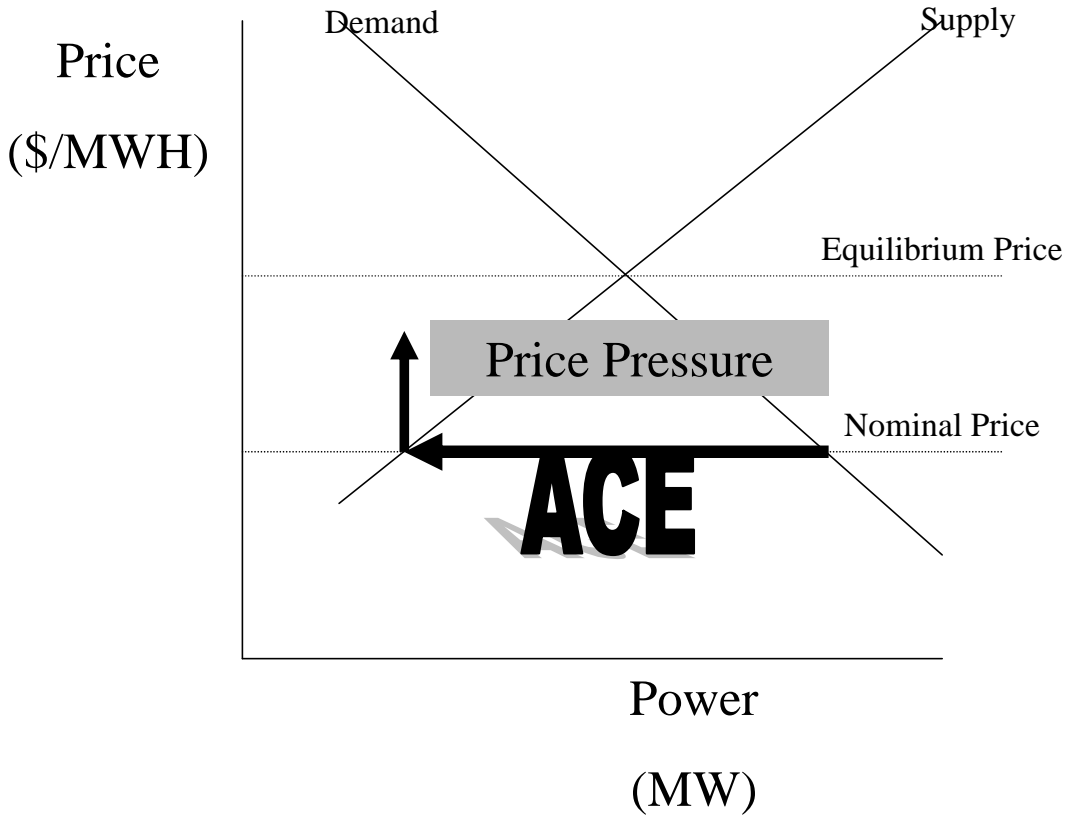
Delivering Active Power



Delivering Active Power



Economic Theory
Dynamic Pricing

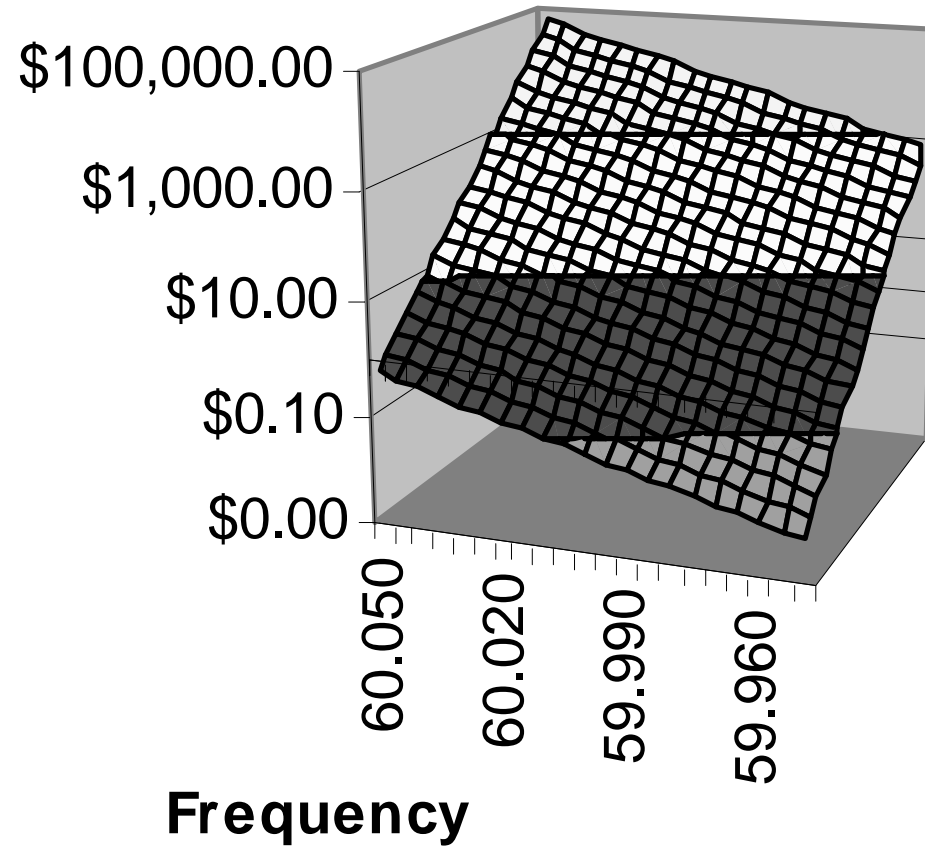


WOLF Pricing

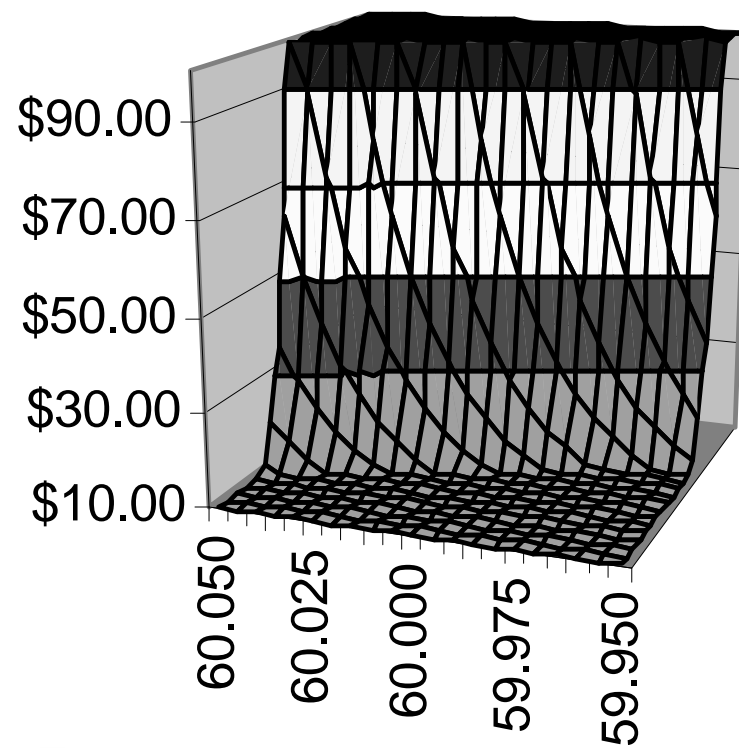
Inadvertent Interchange

- Base Price
 - Initial Seed
- Frequency Response
 - $10^{-(\text{Frequency Error})/(\text{Frequency Factor})}$
- Time Response
 - $10^{-(\text{Time Error})/(\text{Time Factor})}$
- Cumulative Time Error
 - Adjusts Seed

WOLF Prices



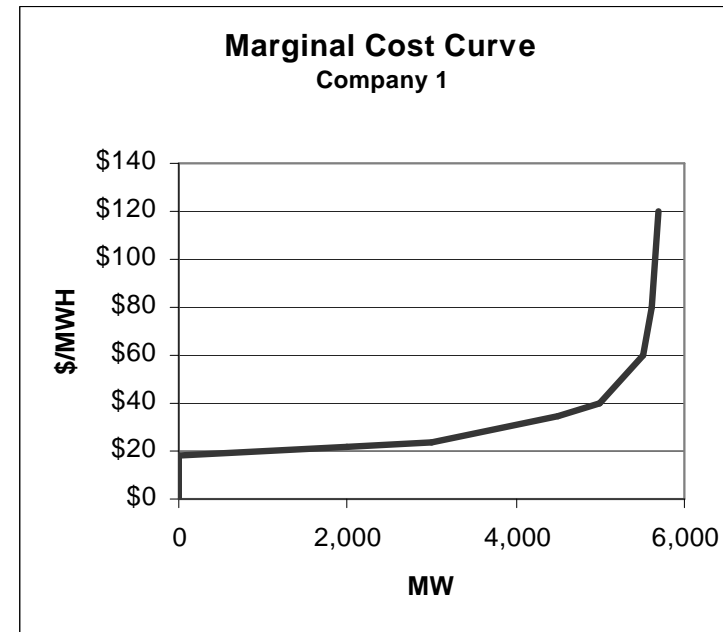
WOLF Prices



Frequency

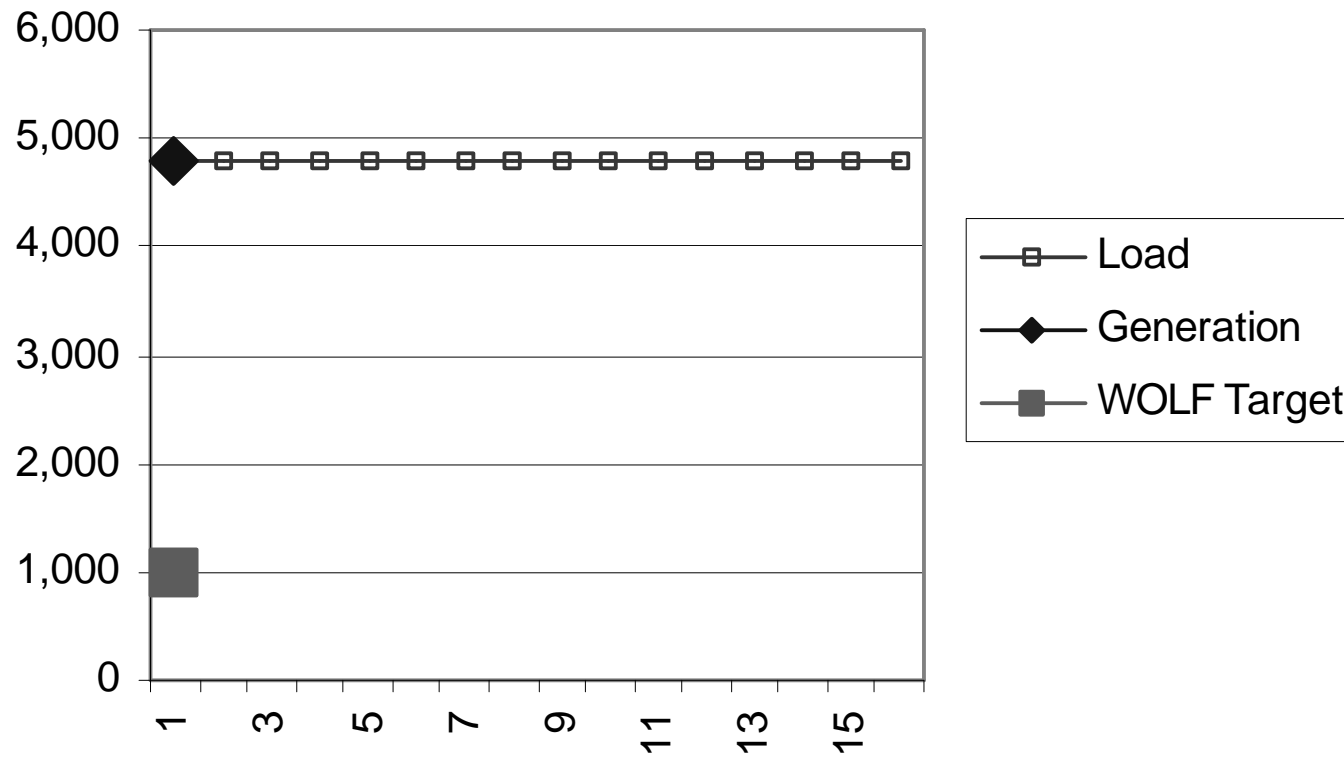
Single Control Area

- Marginal Cost Graph
- 4800 MW Load
- 50 MW/.001 Hertz
- WOLF Parameter
 - \$20/MWH Seed
 - 0.02 Hertz/Decade
 - Time Error
 - Cumulative Time Error



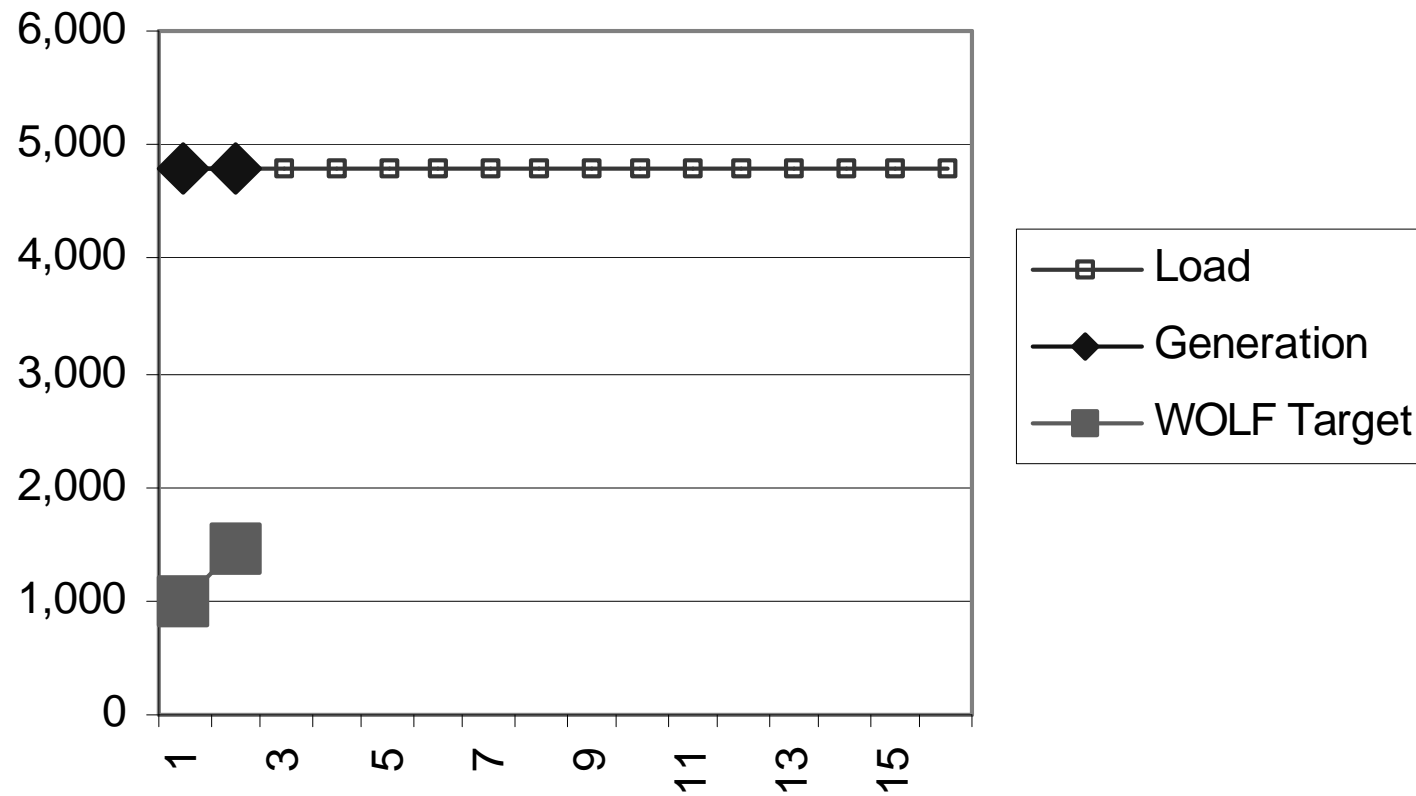
Dynamic Response

Single Control Area



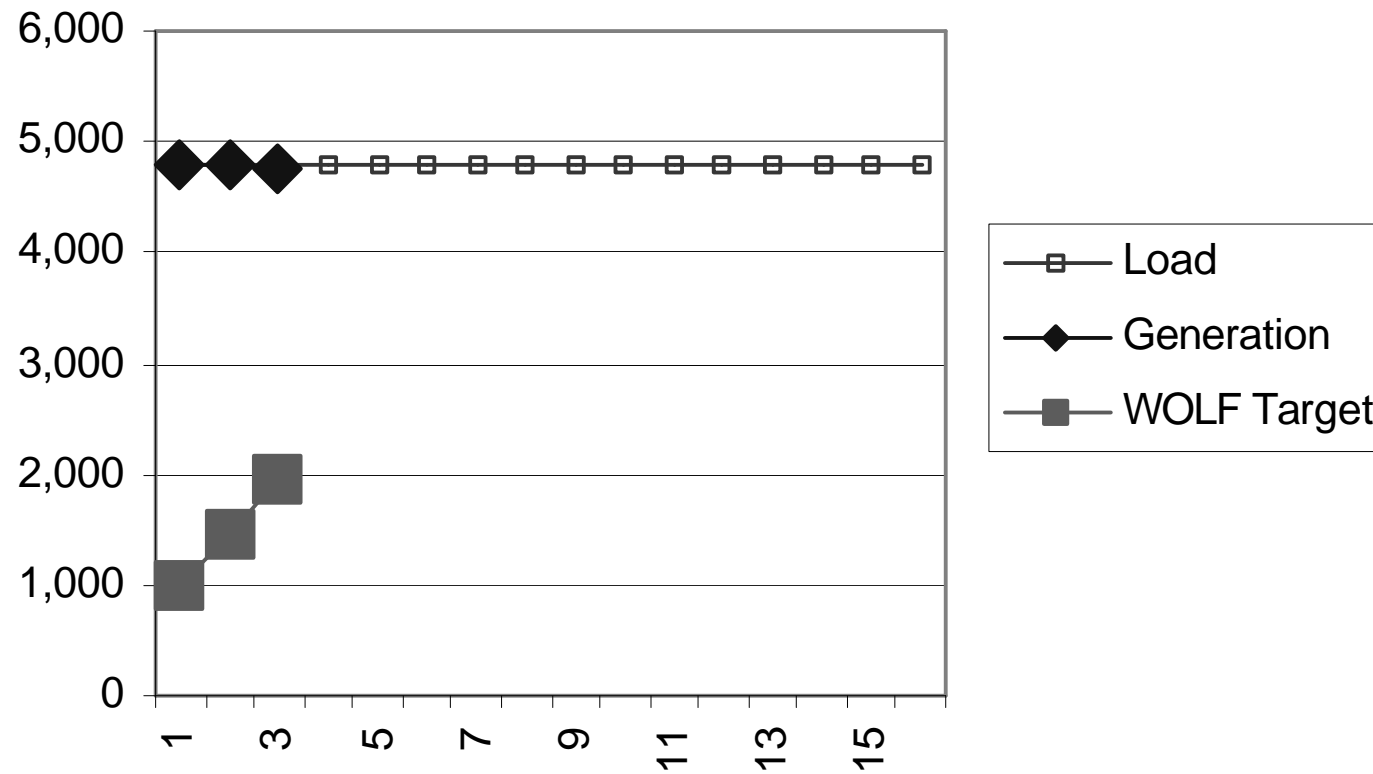
Dynamic Response

Single Control Area



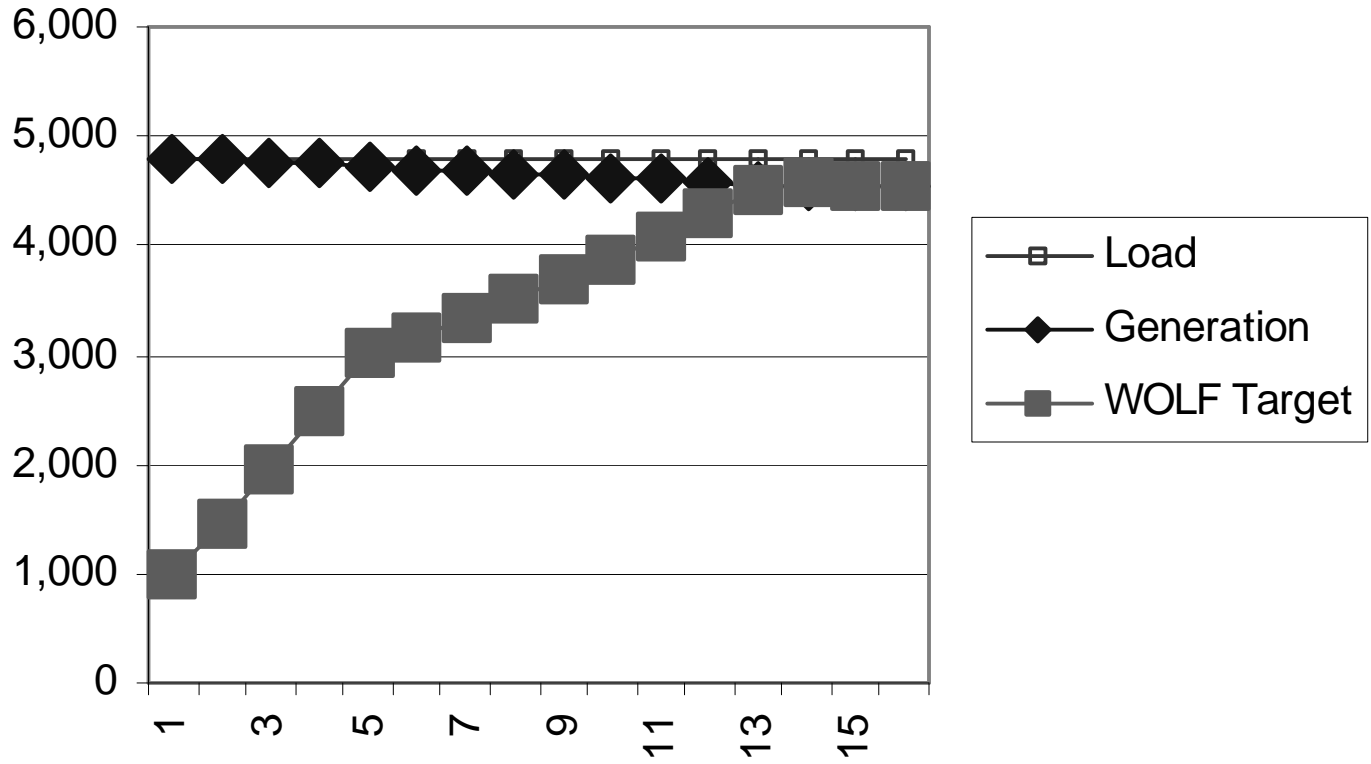
Dynamic Response

Single Control Area

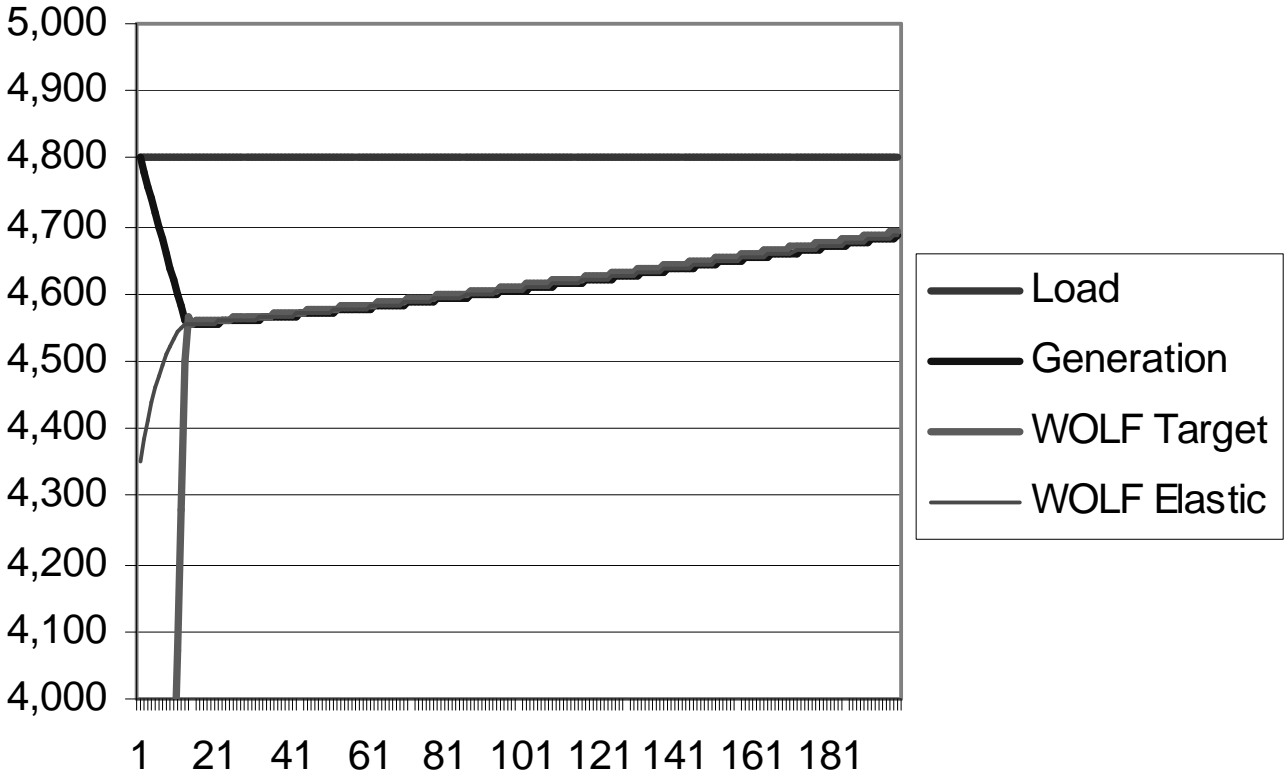


Dynamic Response

Single Control Area



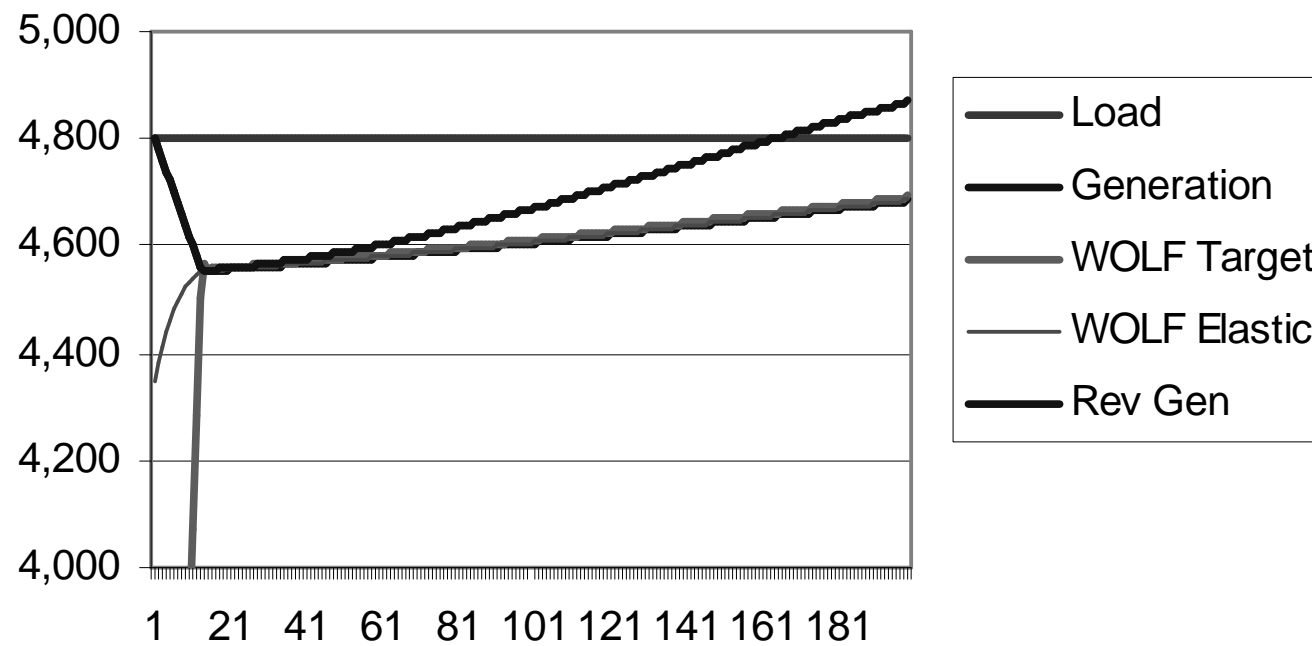
Dynamic Response Single Control Area



Dynamic Response

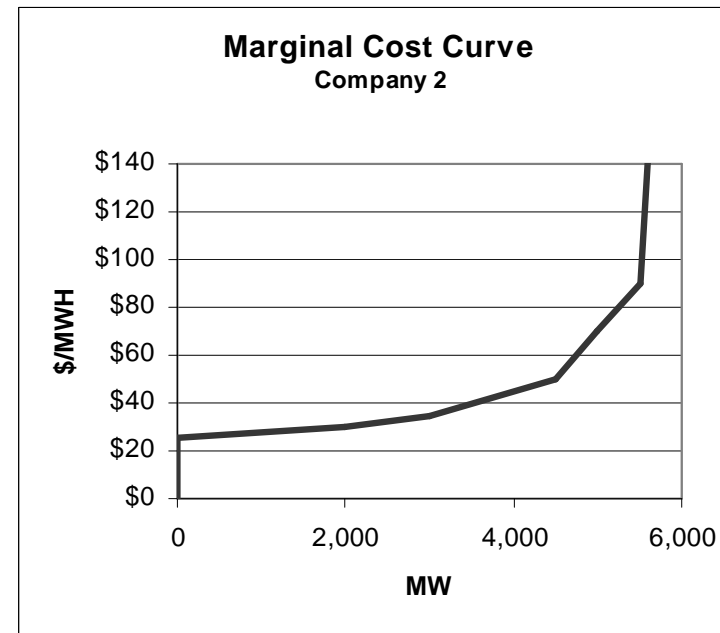
Single Control Area

With Cumulative Time Error Factor Divided by 5



Second Control Area

- Marginal Cost Graph
- 4800 MW Load
- 100 MW/.001 Hertz
- WOLF Parameter
 - \$20/MWH Seed
 - 0.02 Hertz/Decade
 - Time Error
 - Cumulative Time Error



Transmission Company

Electrical Losses

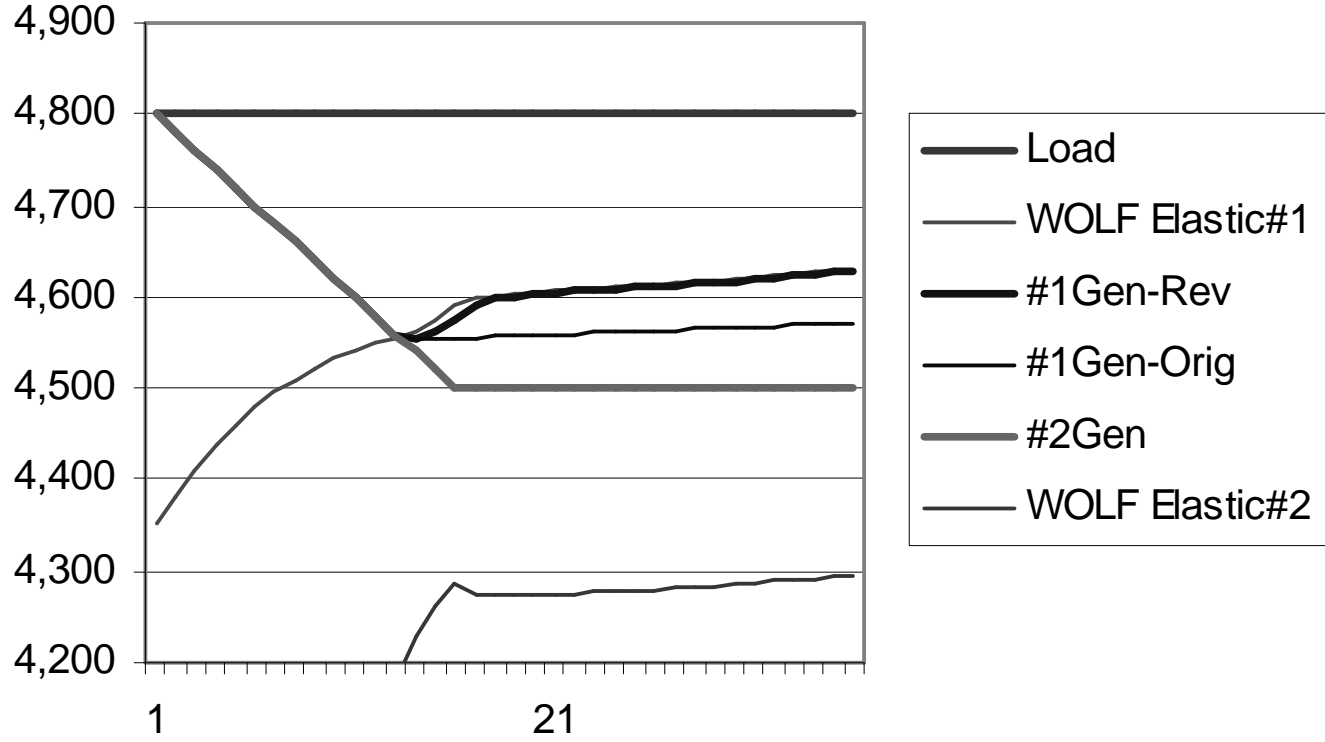
- 5 MW Losses at 100 MW Flow
- Price Differential
 - 1% at 10 MW
 - 5% at 50 MW
 - 10% at 100 MW
 - 15% at 150 MW

Transmission Company Constraints

- 100 MW Contingency Limit
- Price Multiplier
 - No price effect under 100 MW (i.e. x 1.0000)
 - 50 MW per price decade
 - 1.0000 at 100 MW
 - 10.0000 at 150 MW
 - 100.0000 at 200 MW

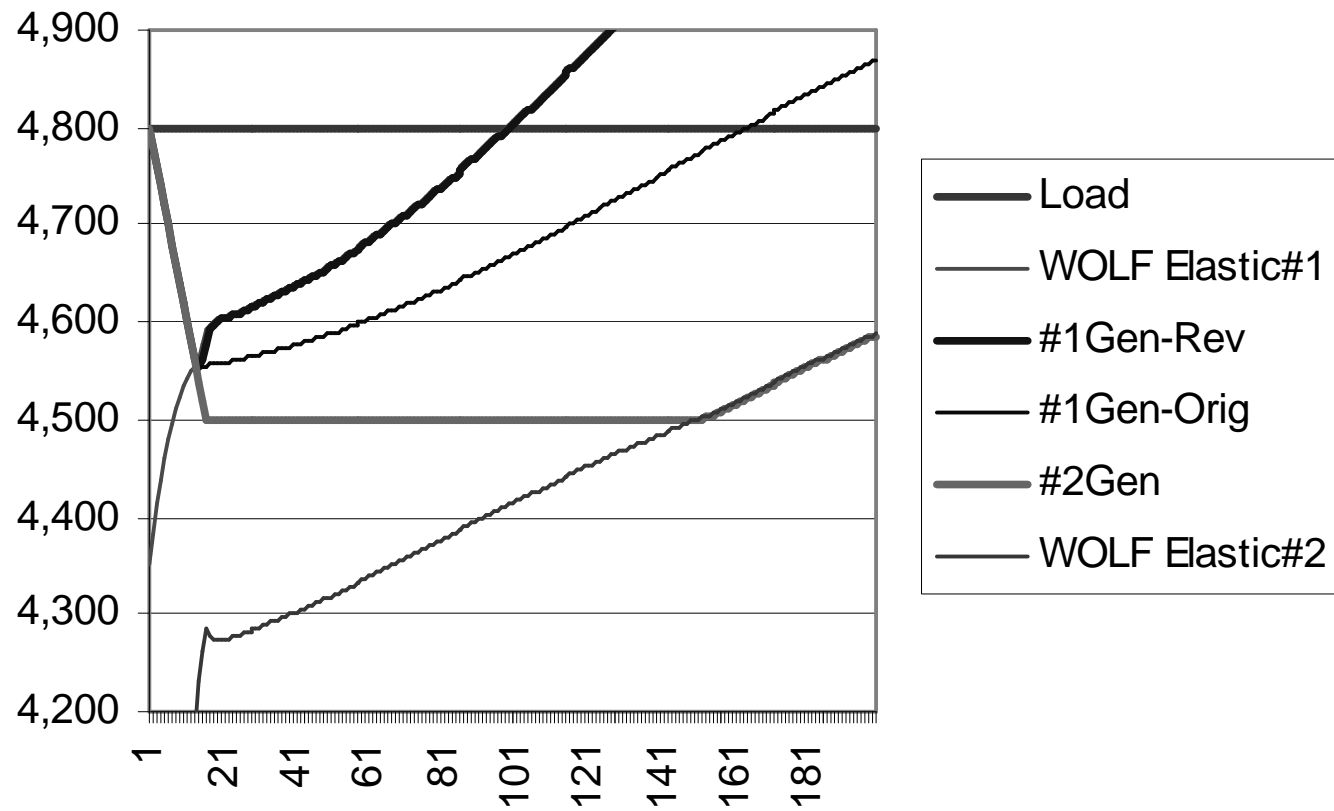
Dynamic Response

Both Control Areas

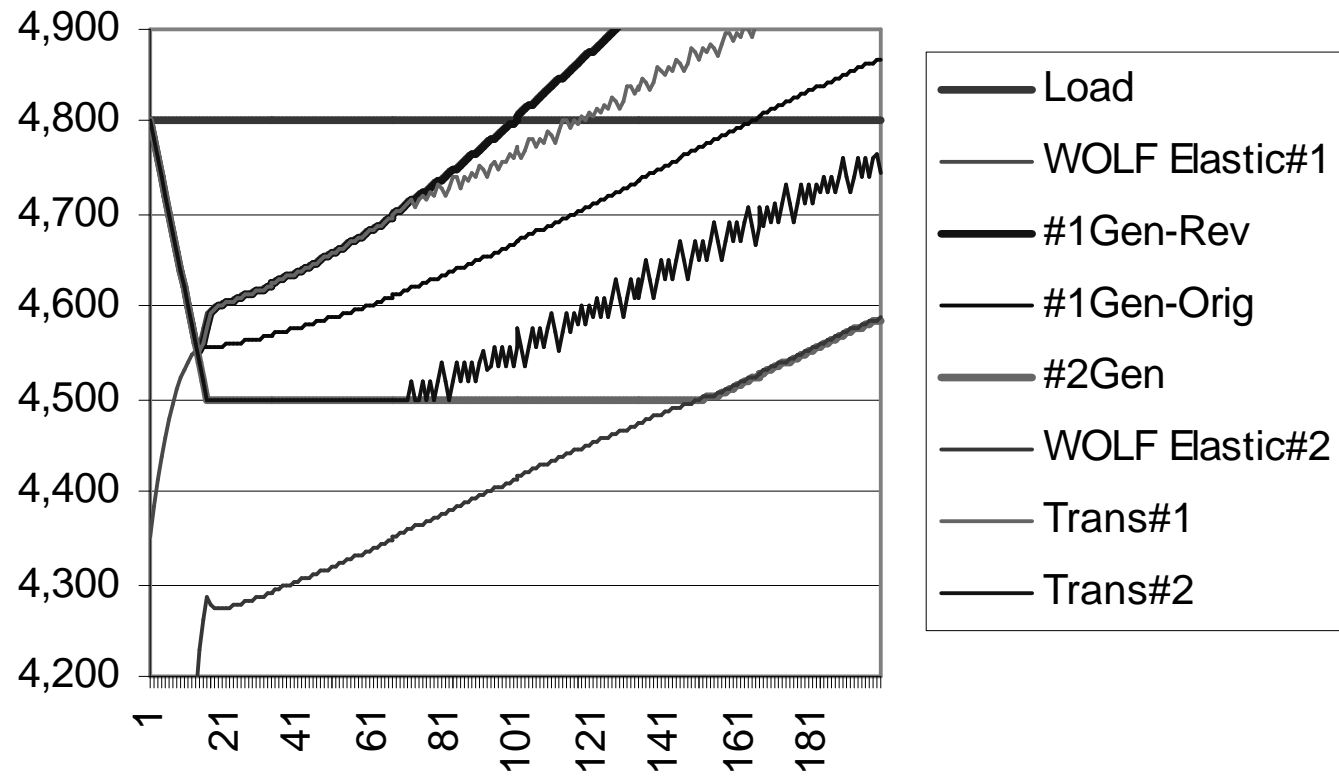


Dynamic Response

Both Control Areas



Dynamic Response Both Control Areas With Transmission Limits



WOLF Pricing Summary

- Cash Out Unscheduled Flows of Electricity
 - Loop Flow
 - Inadvertent Interchange
 - Reactive Power
- Get Finances to Mesh with Physics
 - INC prices when INCing generation
 - DEC prices when DECing generation