WOLF Pricing

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North American Energy Standards Board
Inadvertent Interchange Payback Task Force
Houston, Texas
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WOLF Pricing

WOLF -- A dynamic approach to pricing unscheduled flows of electricity including

- Inadvertent Interchange
- Loop Flow (Including parallel path flow)
- Reactive Power
- Reserves (Indirectly)

WOLF Pricing

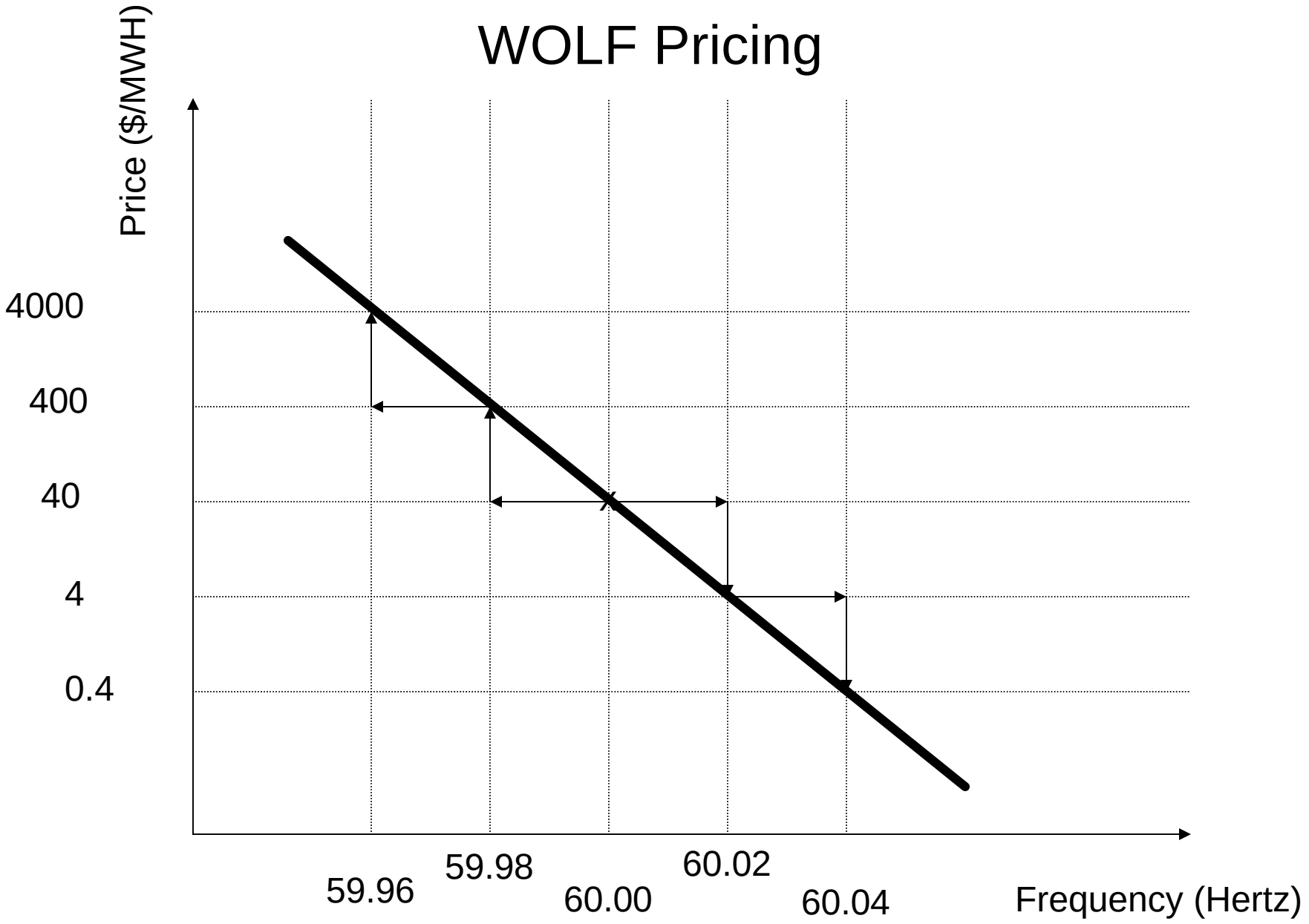
- Wide
- Open
- Load
- Following

WOLF Pricing

WOLF -- A dynamic approach to pricing unscheduled flows of electricity using measurements of

- System Frequency
- Transmission Loading
- Voltage Deviations

WOLF Pricing



WOLF Pricing

$$\text{Price} = \text{Seed} \times 10^{-\text{freq.error}/\text{Constant}}$$

- Seed
- Constant
- Precision
- Example

WOLF Pricing

- NERC AIE Survey Report for August 14
- 4 Control Areas
- Hourly average frequencies

1. August 14, 2003	Hr. Ending (CDT) 10:00	Control Area:
		Region:

AREA INTERCHANGE DETAILS (All values in MWH)

2.	Control Area(s) (Who) (Adjacent Control Areas Only)	B1	B2	B3								Total
3.	Actual Interchange (Including After-The-Fact Pseudo-	-507	-133	613								-27
4.	Scheduled Interchange (Including After-The-Fact Dynamic	-118	30	27								-61
5.	Scheduled Inadvertent Payback											
6.	Inadvertent Interchange (Line 3 - Line 4	-389	-163	586								34

AREA INTERCHANGE CALCULATION

7.	Computed Frequency Error (Ave. Freq. - Scheduled Freq.)	-0.0097	Hz (Provided by Time Monitor)
8.	Frequency Bias Setting	236.8206	MW/0.1 Hz (negative value)
9.	Frequency Bias Obligation	-23	MWh Line 7 x Line 8 x 10.0
10.	Unilateral Inadvertent Payback	-9	MWh
11.	Adjusted Area Interchange Error	66	MWh Line 6 Total - Line 9 - Line 10

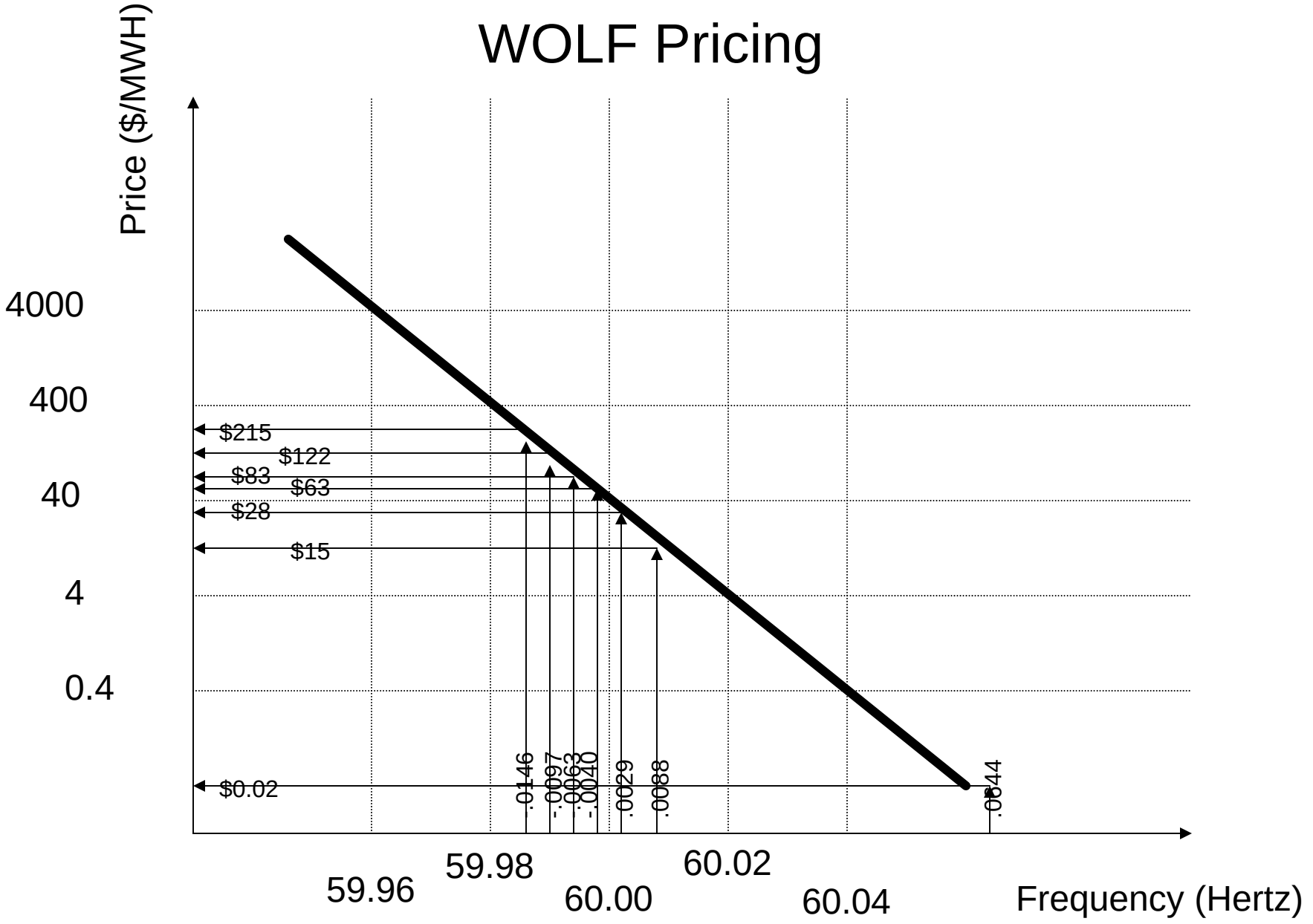
		1	2	3	4	5	6	Total	Avg
12.	Integrated ACE for the 6 consecutive periods of the CSP2 compliance (or estimate or average ACE for each 10 minute period).	:00-:10	:10-:20	:20-:30	:30-:40	:40-:50	:50-:60		Total/6
		31.0682	-3.58033	-39.2461	-41.321	-23.4991	-17.8066	-94.385	-15.7308

Notes: List remarks on separate sheet of paper, including conditions causing regulating errors. Net power delivered out of a control area (overgeneration) is positive (-
Net power received into a control area (undergeneration) is negativ

7: Computed Frequency Deviation

Hour Ending	Utility/Control Area A	B	C	D
1000	-0.0097	-0.0097	-0.0097	-0.0097
1100	-0.0146	-0.0097	-0.0146	-0.0146
1200	-0.0063	-0.0097	-0.0063	-0.0063
1300	-0.0040	-0.0097	-0.0040	-0.0040
1400	0.0088	-0.0097	0.0088	0.0088
1500	0.0029	-0.0097	0.0029	0.0029
1600	0.0644	-0.0097	0.0644	0.0644

WOLF Pricing



WOLF Pricing
August 14 Frequencies

Hour Ending	Frequency Deviation	WOLF Price
1000	-0.0097	$122.20
1100	-0.0146	$215.31
1200	-0.0063	$82.62
1300	-0.0040	$63.25
1400	0.0088	$14.61
1500	0.0029	$28.65
1600	0.0644	$0.02

Decade Constant (Hertz)
0.0200

Seed ($/MWH)
40

Accumulated Inadvertent Error (MWH)

Utility/Control Area

Hour Ending	A	B	C	D
1000	-4	42	34	87.259
1100	2	53	3	200.744
1200	2	14	17	143.213
1300	12	8	14	51.102
1400	-13	-69	-52	-16.635
1500	1	-50	-41	-7.061
1600	-2	-73	-269	-519.190
Total	-2	-75	-294	-60.568

Fixed Price ($40/MWH)

Utility/Control Area

Hour Ending	A	B	C	D
1000	$ (160)	$ 1,680	$ 1,360	$ 3,490
1100	$ 80	$ 2,120	$ 120	$ 8,030
1200	$ 80	$ 560	$ 680	$ 5,729
1300	$ 480	$ 320	$ 560	$ 2,044
1400	$ (520)	$ (2,760)	$ (2,080)	$ (665)
1500	$ 40	$ (2,000)	$ (1,640)	$ (282)
1600	$ (80)	$ (2,920)	$ (10,760)	$ (20,768)
Total	$ (80)	$ (3,000)	$ (11,760)	$ (2,423)

WOLF Price ($40/MWH Base)

Utility/Control Area

Hour Ending	A	B	C	D
1000	$ (489)	$ 5,132	$ 4,155	$ 10,663
1100	$ 431	$ 11,411	$ 646	$ 43,222
1200	$ 165	$ 1,157	$ 1,404	$ 11,832
1300	$ 759	$ 506	$ 885	$ 3,232
1400	$ (190)	$ (1,008)	$ (760)	$ (243)
1500	$ 29	$ (1,433)	$ (1,175)	$ (202)
1600	$ (0)	$ (2)	$ (6)	$ (12)
Total	$ 705	$ 15,764	$ 5,150	$ 68,491

WOLF Pricing

$$\text{Price} = \text{Seed} \times 10^{-\text{freq.error}/\mathbf{Constant}}$$

- Selected as 20 Millihertz
- Offset for time error correction
- Consistent with 1999 conditions

WOLF Pricing

Price = **Seed** x 10 $^{-\text{freq.error/Constant}}$

- Selected as $40/MWH
- Automatically changes with
  - Time error
  - Cumulative time error

WOLF Pricing
Changing the Seed for Time Error

Hour Ending	Frequency Deviation (Hertz)	Time Change (Seconds)	Time Error (Seconds)	Seed	WOLF Price
1000	-0.0097	-0.5820	0.0000	$40.00	$122.20
1100	-0.0146	-0.8772	-0.5820	$45.74	$246.18
1200	-0.0063	-0.3780	-1.4592	$55.97	$115.61
1300	-0.0040	-0.2388	-1.8372	$61.06	$96.56
1400	0.0088	0.5250	-2.0760	$64.51	$23.56
1500	0.0029	0.1739	-1.5510	$57.17	$40.95
1600	0.0644	3.8652	-1.3771	$54.93	$0.03

Decade Constants (Hertz)
0.0200
(Seconds)
10

Seed ($/MWH)
40

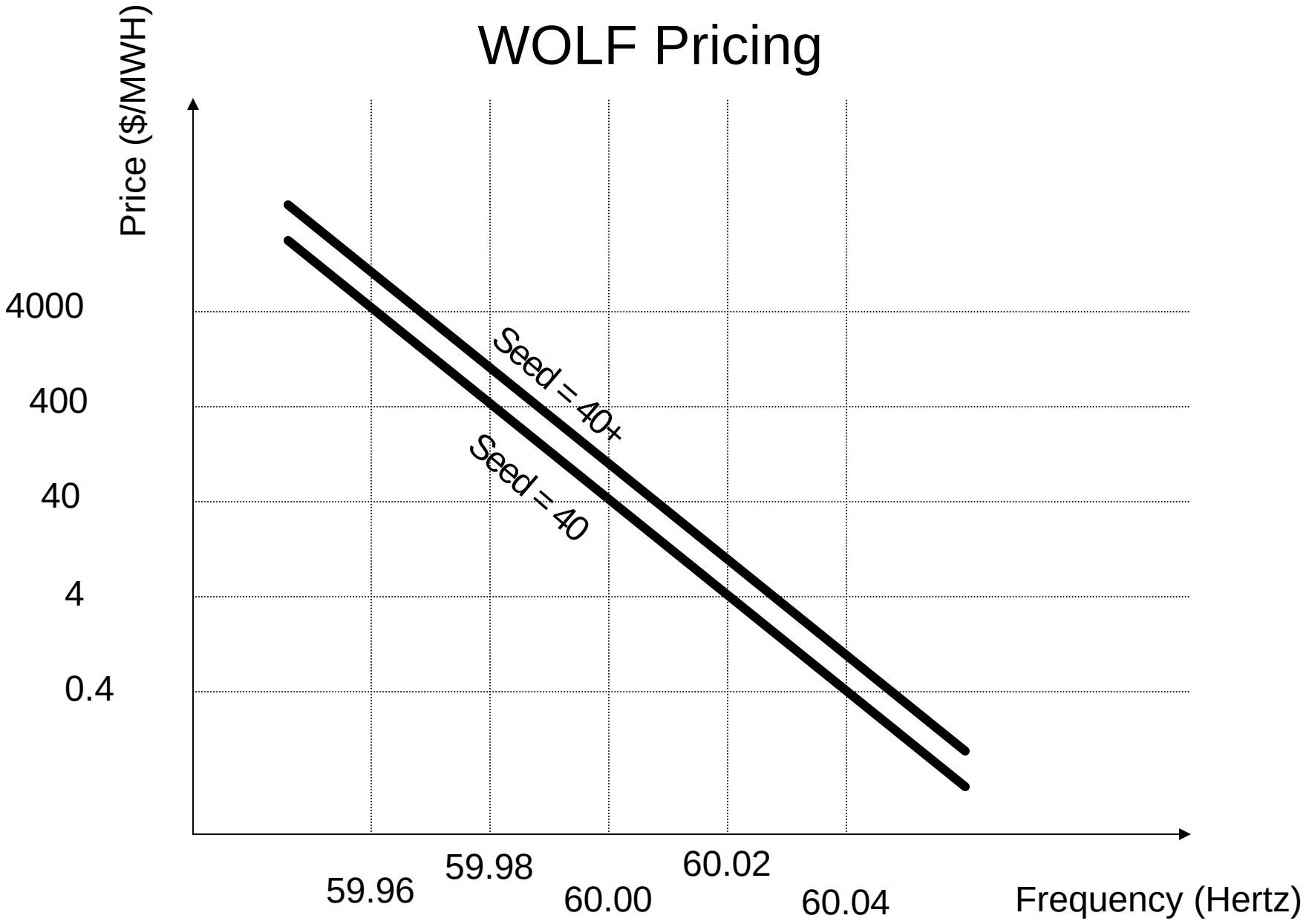
WOLF Pricing
Changing the Seed for Time Error and Cumulative Time Error

Hour Ending	Frequency Deviation (Hertz)	Time Change (Seconds)	Time Error (Seconds)	Cumulative Time Error (Sec.Sec)	Seed	WOLF Price
1000	-0.0097	-0.5820	0.0000	0.0000	$40.00	$122.20
1100	-0.0146	-0.8772	-0.5820	-0.5820	$46.35	$249.51
1200	-0.0063	-0.3780	-1.4592	-2.0412	$58.67	$121.17
1300	-0.0040	-0.2388	-1.8372	-3.8784	$66.77	$105.58
1400	0.0088	0.5250	-2.0760	-5.9544	$74.00	$27.02
1500	0.0029	0.1739	-1.5510	-7.5054	$67.95	$48.68
1600	0.0644	3.8652	-1.3771	-8.8825	$67.39	$0.04

Decade Constants (Hertz)
0.0200
(Seconds)
10

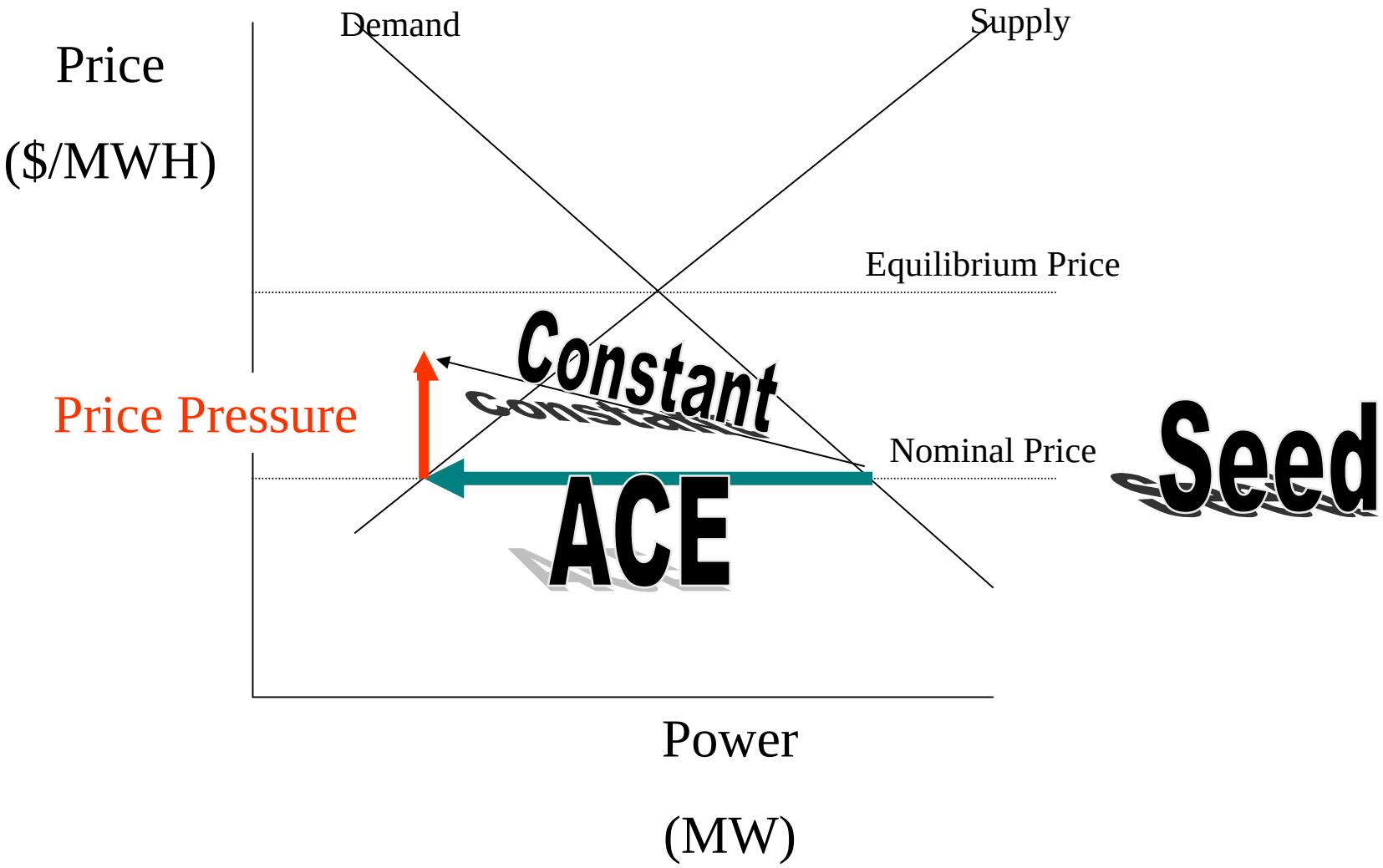
Seed ($/MWH)
40

WOLF Pricing

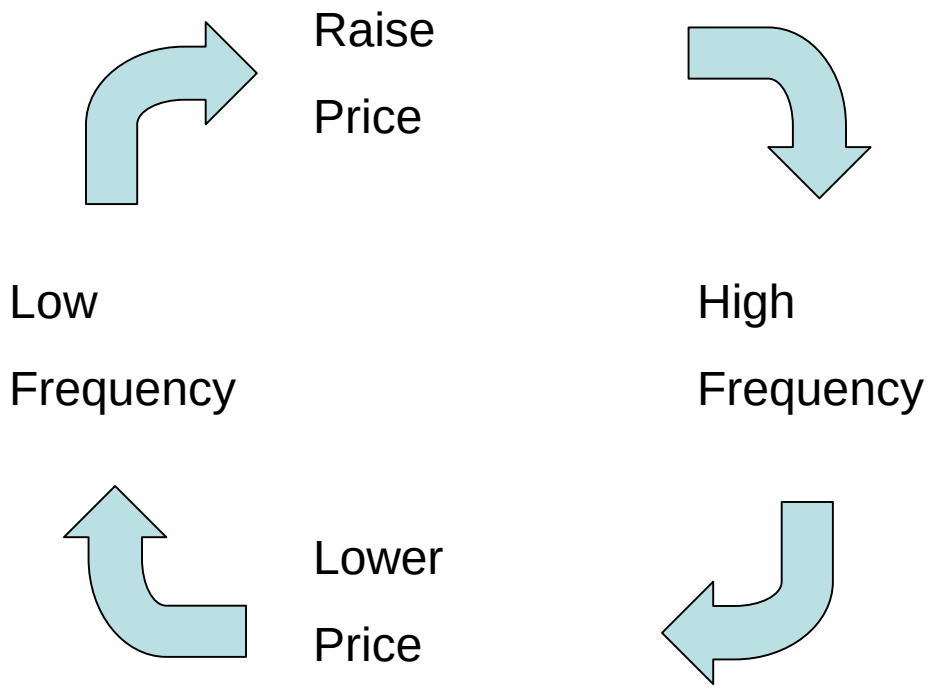


WOLF Pricing

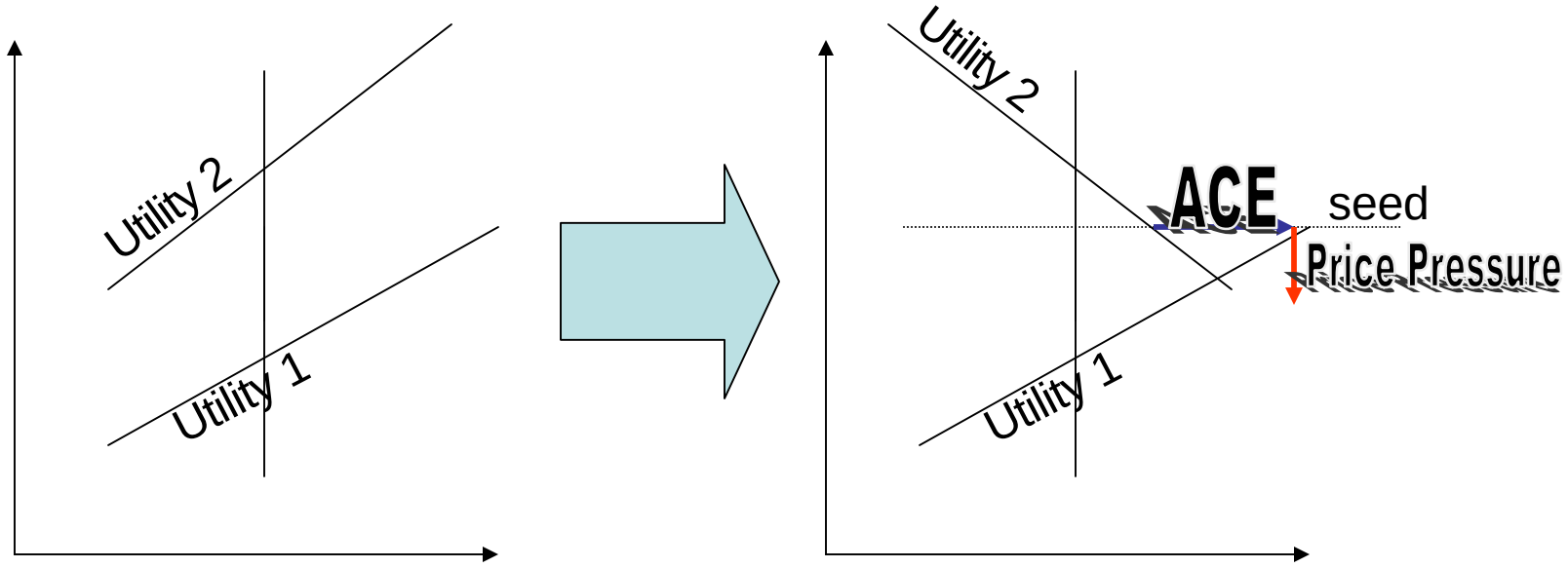
Economic Theory



WOLF Pricing
Control Theory



WOLF Pricing
Competitive Economics



WOLF Pricing
Geographic Differentiation

- Locational Marginal Price
- Marginal Line Losses
- Transmission Constraints

Geographic Differentiation Example

	A1	A2	A3	A4
Even	$40.0000	$40.0000	$40.0000	$40.0000
1%	$40.0000	$40.4000	$40.8040	$41.2120
2%	$40.0000	$40.8000	$41.6160	$42.4483
2%/100%	$40.0000	$40.8000	$41.6160	$83.2320

Geographic Differentiation Example

		A1	A2	A3	A4	Total
MWH		**-797**	**-697**	**186**	**1306**	**-2**
Even		($31,880.00)	($27,880.00)	$7,440.00	$52,240.00	($80.00)
	1%	($31,880.00)	($28,158.80)	$7,589.54	$53,822.92	$1,373.67
	2%	($31,880.00)	($28,437.60)	$7,740.58	$55,437.51	$2,860.48
2%/100%		($31,880.00)	($28,437.60)	$7,740.58	$108,700.99	$56,123.97

Termporal and Geographic Differentiation
Example

	A1	A2	A3	A4	Total
MWH	**-797**	**-697**	**186**	**1306**	**-2**
Even	-$97,206.83	-$52,989.13	$4,932.82	$145,967.92	$704.77
1%	-$97,206.83	-$53,519.02	$5,031.97	$150,390.89	$4,697.00
2%	-$97,206.83	-$54,048.91	$5,132.10	$154,902.32	$8,778.68
2%/100%	-$97,206.83	-$54,048.91	$5,132.10	$303,730.04	$157,606.40

WOLF Pricing
Reactive Power

- Voltage responsive
- Low voltage
  - Pay for leading power
  - Charge for lagging power
- High voltage
  - Pay for lagging power
  - Charge for leading power

WOLF Pricing
Treating Reserves as Insurance

Properties of Insurance Products

- Regular premiums
- Initiating event
- Liquidated damages

WOLF Pricing
Treating Reserves as Insurance

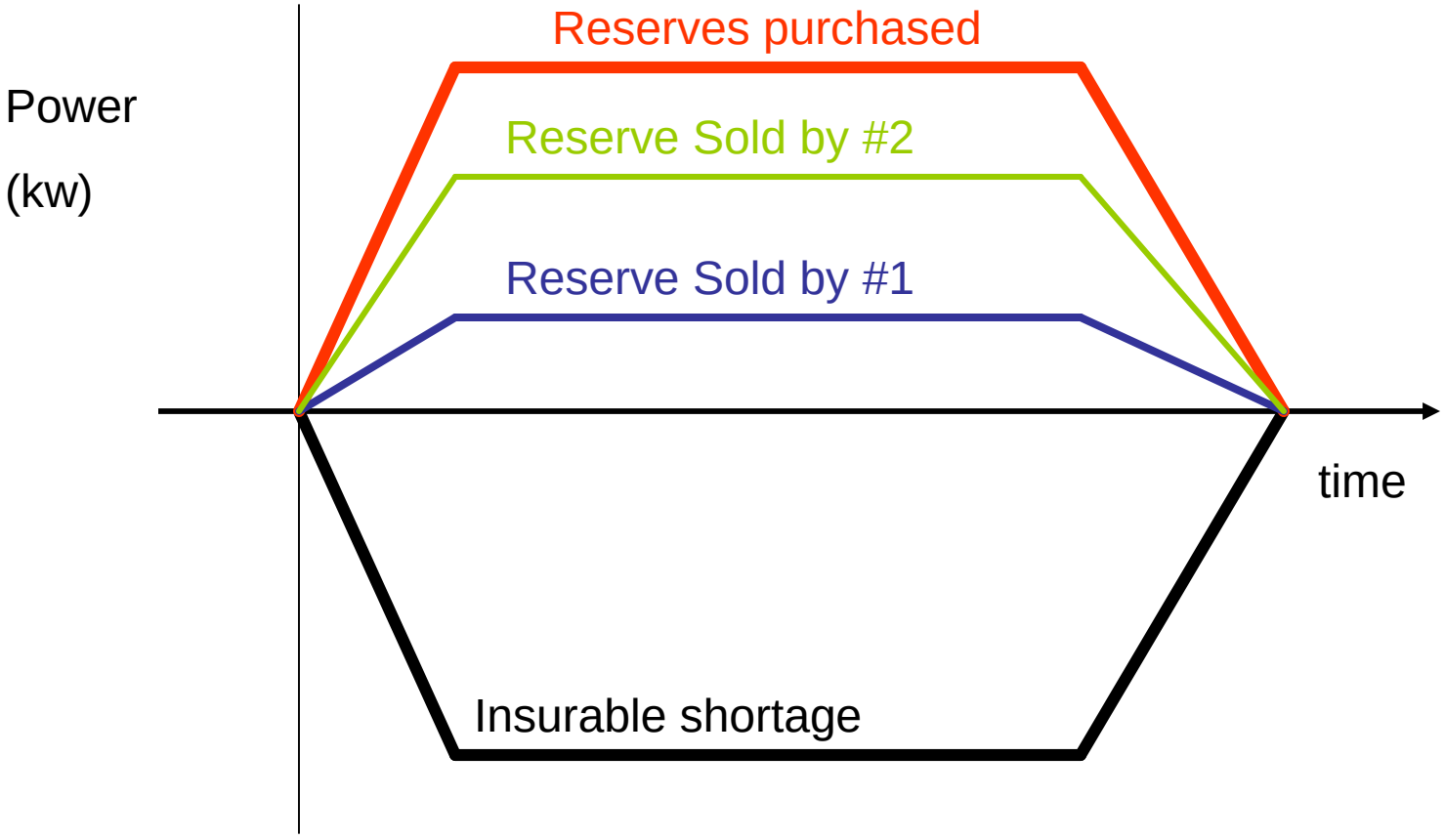
Property of reserve sharing

- Cost of maintaining reserves
- Outage
- Provide power to short utility

WOLF Pricing
Treating Reserves as Insurance

- Well define initiating event, such as the loss of a generator included in the reserve pool
- Well define the inadvertent interchange due the utility that had the initiating event, i.e., a trapezoidal power curve
- Agree to way to share the obligation to deliver inadvertent interchange by others

WOLF Pricing
Treating Reserves as Insurance



WOLF Pricing Reference

- “Profit-Enhancing Seam Management: A White Paper on Pricing The Unscheduled Flows of Electricity Across the Seams Between Utilities Using A Geographically Differentiated Auction of Inadvertent Interchange”, released 2001 March 25, www.LivelyUtility.com.

WOLF Pricing Reference

- “Metrics for Operating Reserves,” *The National Regulatory Research Institute Quarterly Bulletin*, Spring 1998. This paper was the prepared remarks at the Secretary of Energy Advisory Board Task Force on Electric System Reliability meeting of 1998 January 13.