

The Smart Grid

NCAC/USAEE

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Total Numbers of Domestic Gensets

Distributions by State

| Range (KW) State | 50-70 | 71-150 | 151-300 | 301-700 | 701- 1200 | 1201- 2000 | 2001+ | Total |
|---------------------|--------|--|---------|---------|--------------|---------------|-------|---------|
| California | 22,405 | 23,558 | 14,373 | 7,062 | 5,259 | 5,257 | 1,968 | 79,882 |
| Washington | 3,699 | 3,553 | 4,060 | 1,400 | 916 | 812 | 304 | 14,744 |
| Arizona | 2,961 | 1,421 | 2,708 | 1,120 | 220 | 650 | 230 | 9,310 |
| Oregon | 2,143 | Huge number of small generators in California | | | 530 | 470 | 176 | 8,148 |
| Nevada | 1,072 | | | | 266 | 236 | 83 | 4,072 |
| Colorado | 2,556 | 2,700 | 3,273 | 967 | 506 | 561 | 201 | 10,764 |
| Utah | 1,337 | 1,284 | 978 | 506 | 332 | 294 | 110 | 4,841 |
| New Mexico | 1,145 | 1,100 | 1,047 | 433 | 283 | 251 | 94 | 4,353 |
| Montana | 547 | 621 | 538 | 222 | 146 | 129 | 48 | 2,251 |
| Wyoming | 321 | 494 | 323 | 122 | 80 | 71 | 27 | 1,438 |
| Total | 38,186 | 37,818 | 30,240 | 13,049 | 8,538 | 8,731 | 3,241 | 139,803 |

Total Capacity (MW) of Domestic Gensets

Distributions by State

| Range (KW) | 50-70 | 71-150 | 151-300 | 301-700 | 701-1200 | 1201-2000 | 2001+ | Total |
|--------------|-------|--------|---------|---------|----------|-----------|-------|--------|
| Nominal (KW) | 60 | 110 | 220 | 500 | 950 | 1600 | 3000 | |
| State | | | | | | | | |
| California | 1,344 | 2,591 | 3,162 | 3,531 | 4,996 | 8,411 | 5,904 | 29,940 |
| Washington | 222 | 391 | 893 | 700 | 870 | 1,299 | 912 | 5,287 |
| Arizona | 178 | 156 | 596 | 560 | 209 | 1,040 | 690 | 3,429 |
| Oregon | 129 | | | | | 752 | 528 | 2,975 |
| Nevada | 64 | | | | | 378 | 249 | 1,475 |
| Colorado | 153 | | | | | 898 | 603 | 3,635 |
| Utah | 80 | | | | | 470 | 330 | 1,805 |
| New Mexico | 69 | 121 | 230 | 217 | 269 | 402 | 282 | 1,589 |
| Montana | 33 | 68 | 118 | 111 | 139 | 206 | 144 | 820 |
| Wyoming | 19 | 54 | 71 | 61 | 76 | 114 | 81 | 476 |
| Total | 2,291 | 4,160 | 6,653 | 6,525 | 8,111 | 13,970 | 9,723 | 51,432 |

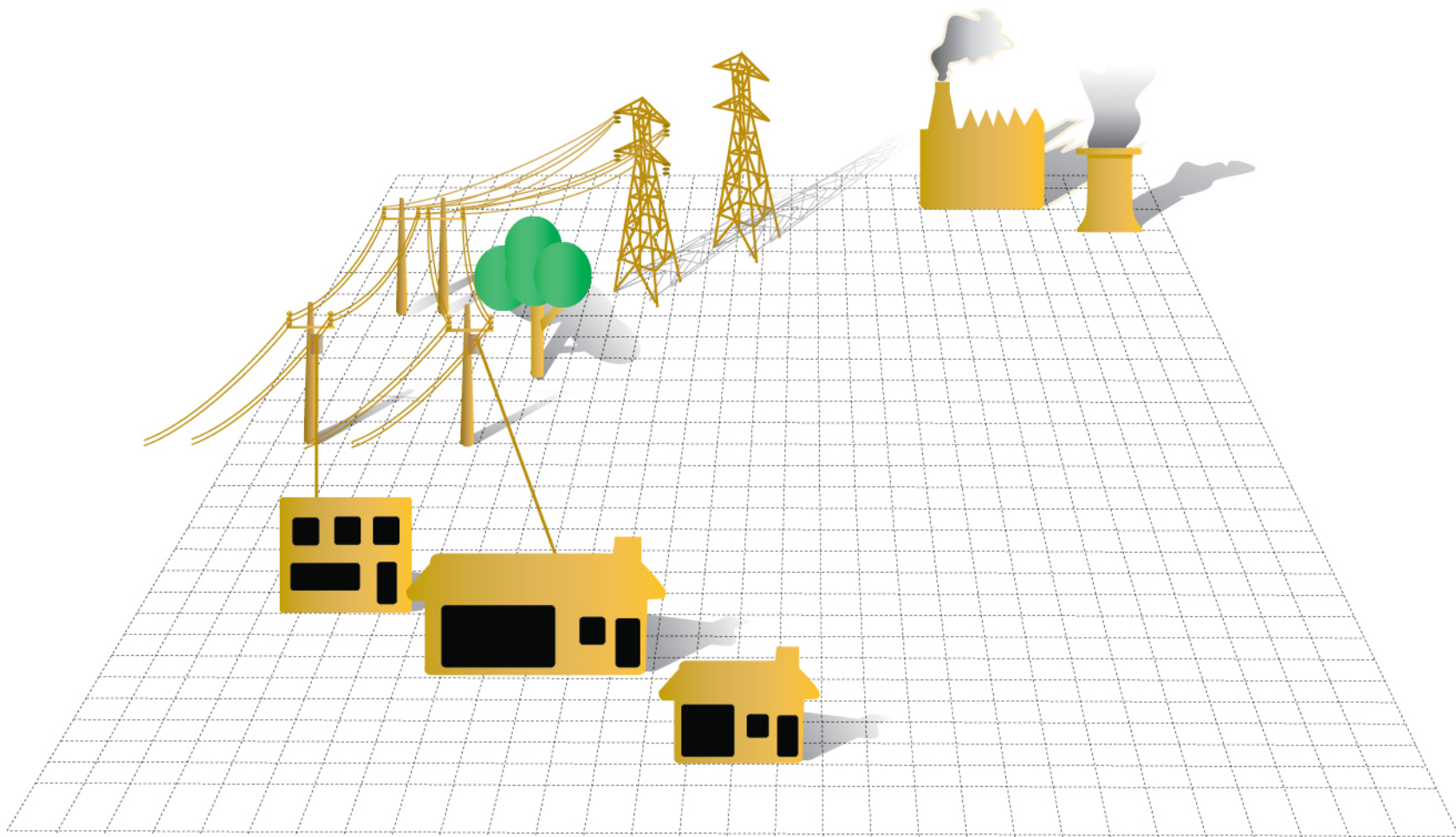
Small gen sets have capacity comparable to central station plants



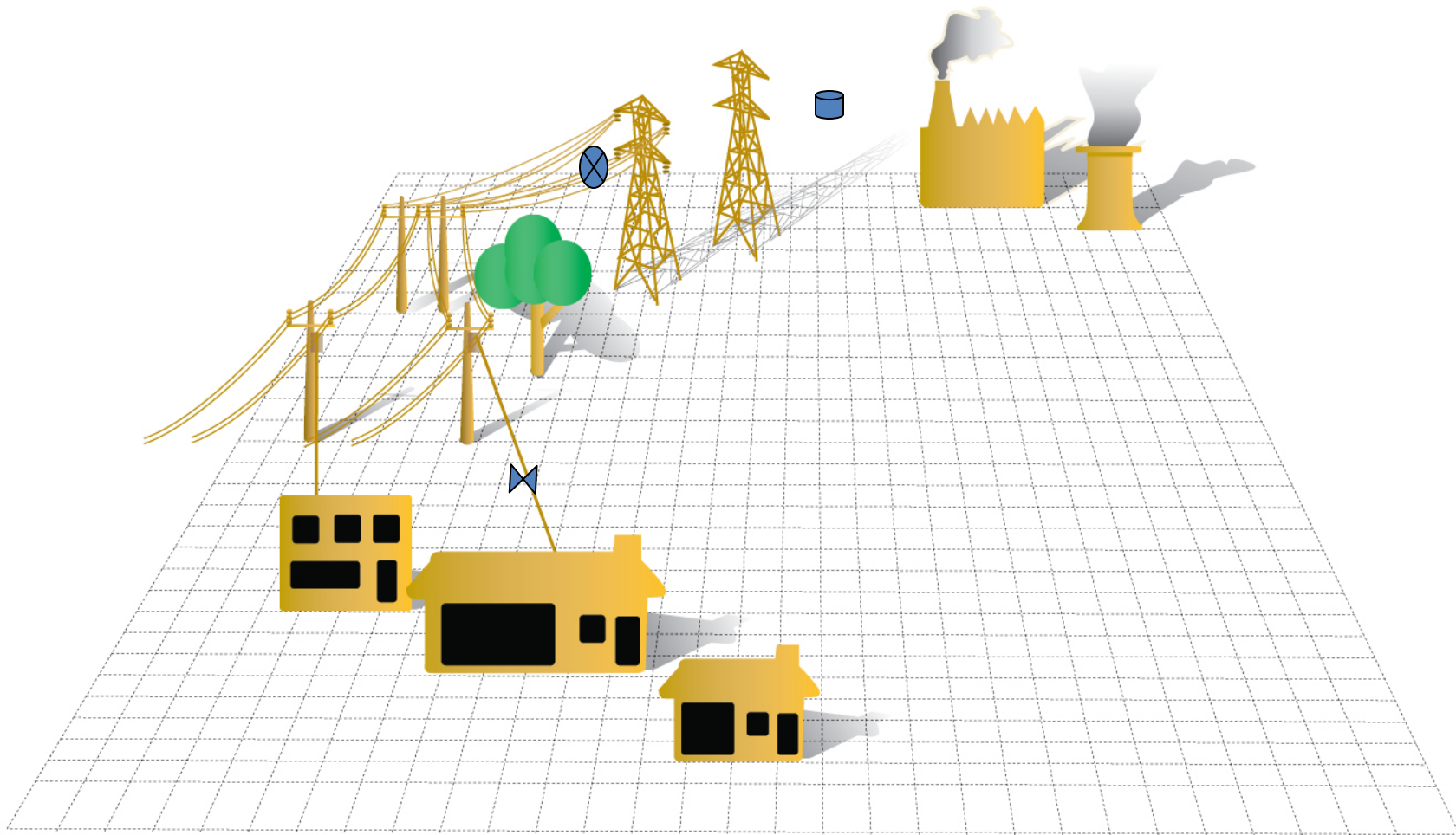
The Smart Grid

- What the Smart Grid means
- How the Smart Grid can pay for itself
- Implications for pricing electricity

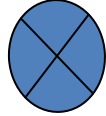

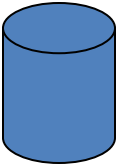
Traditional Electric Utility



Electric Utility w/ Smart Grid



A Smart Grid Has More Telecommunication

- Meters 
- Control devices 
- Computers 
- But not much more power lines
- SCADA on steroids

SCADA

- **S**upervisory **C**ontrol—Means flipping switches from a remote location using telecommunication
- **D**ata **A**cquisition—Means reading a meter from a remote location using telecommunication
- Computers do the analysis faster
- Smart Grid is SCADA on Steroids

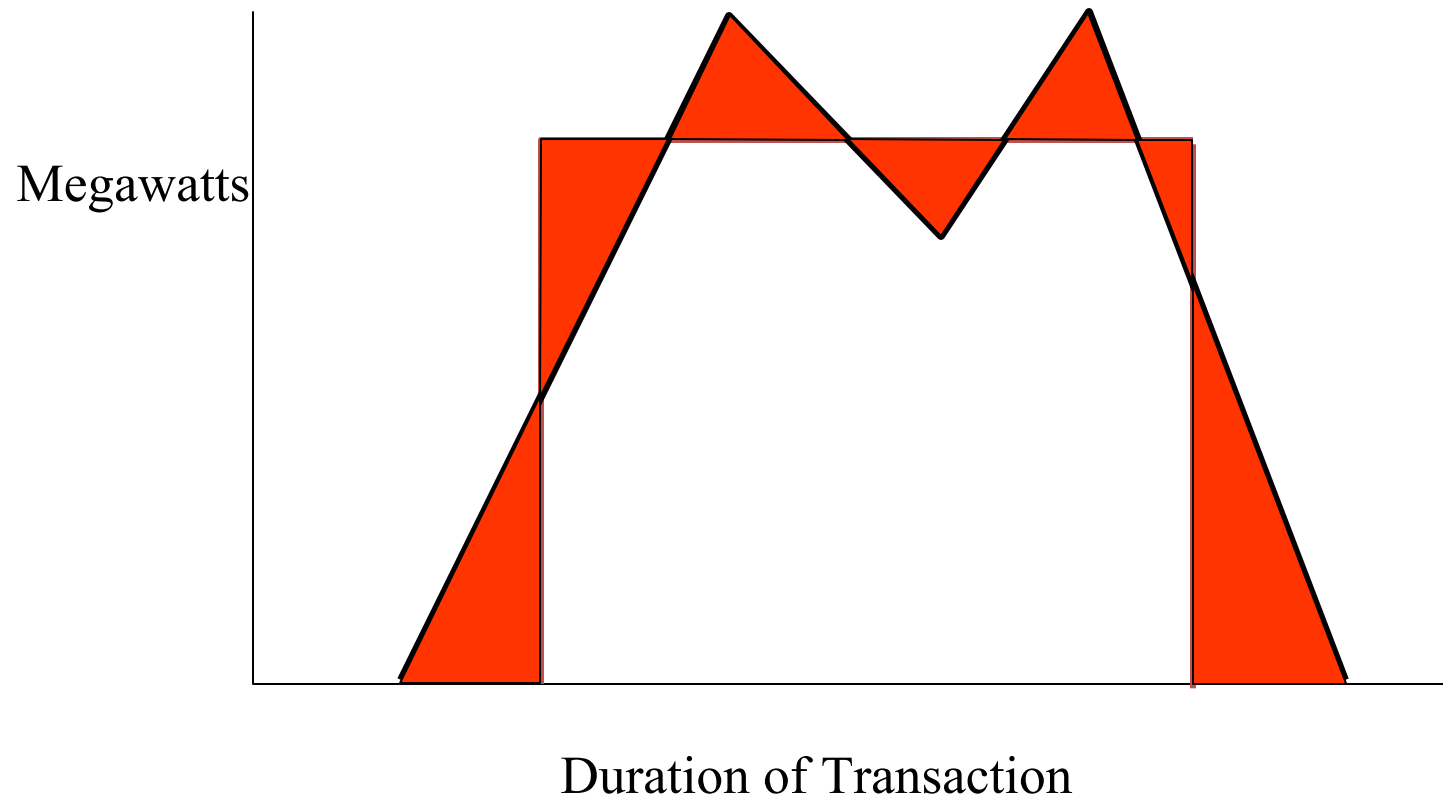
Paying for the Smart Grid

- Fewer people
 - No more manned substations
 - Flip a switch remotely instead of sending someone
- Lower reserve margins/higher load factor
- Lower average fuel costs
- Faster reconnection time

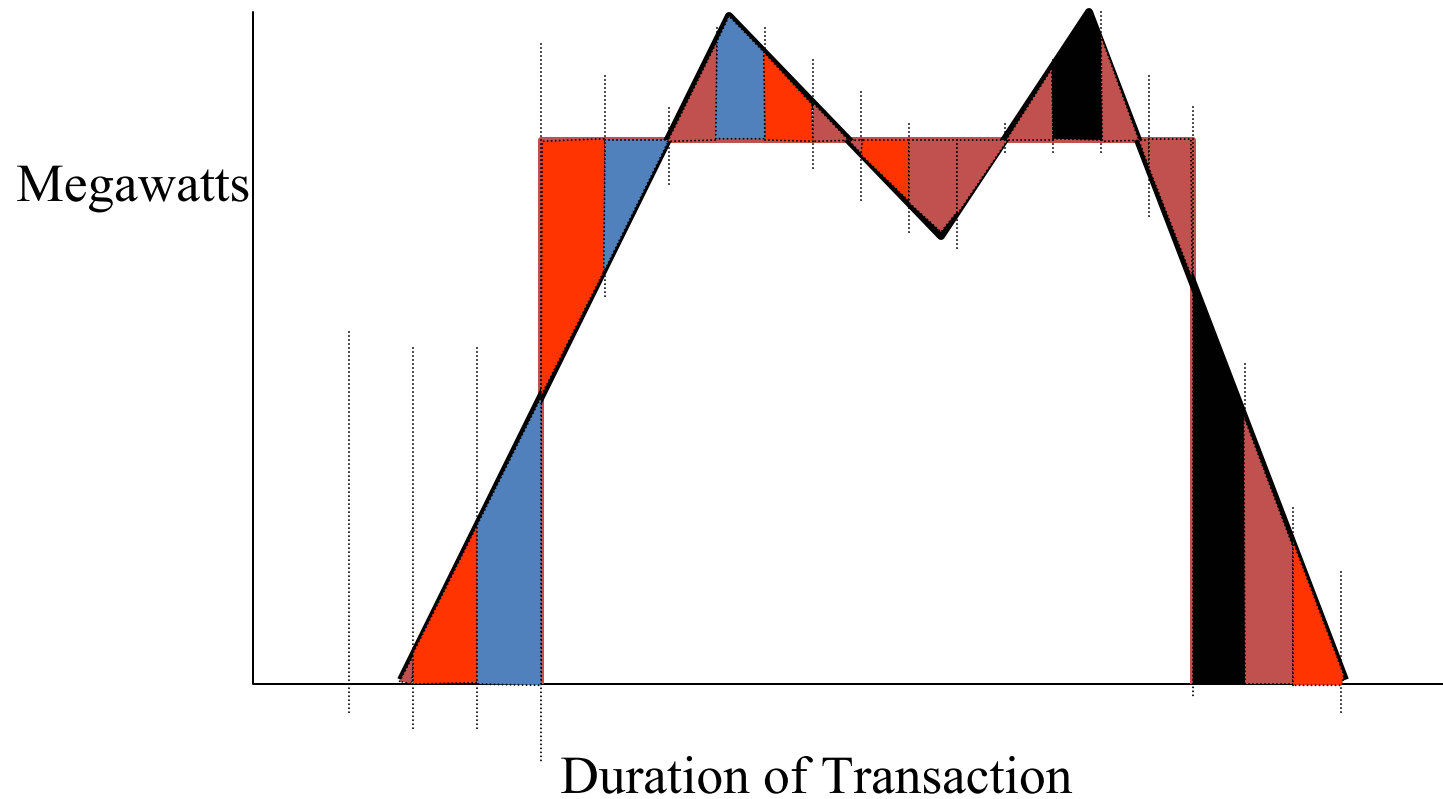
Paying for the Smart Grid

- \$/year
 - Substation automation
 - Outage identification and restoration
- \$/KW
 - Peak shaving
 - Emergency response
- \$/MWH
 - Fuel shifting

Delivering Active Power

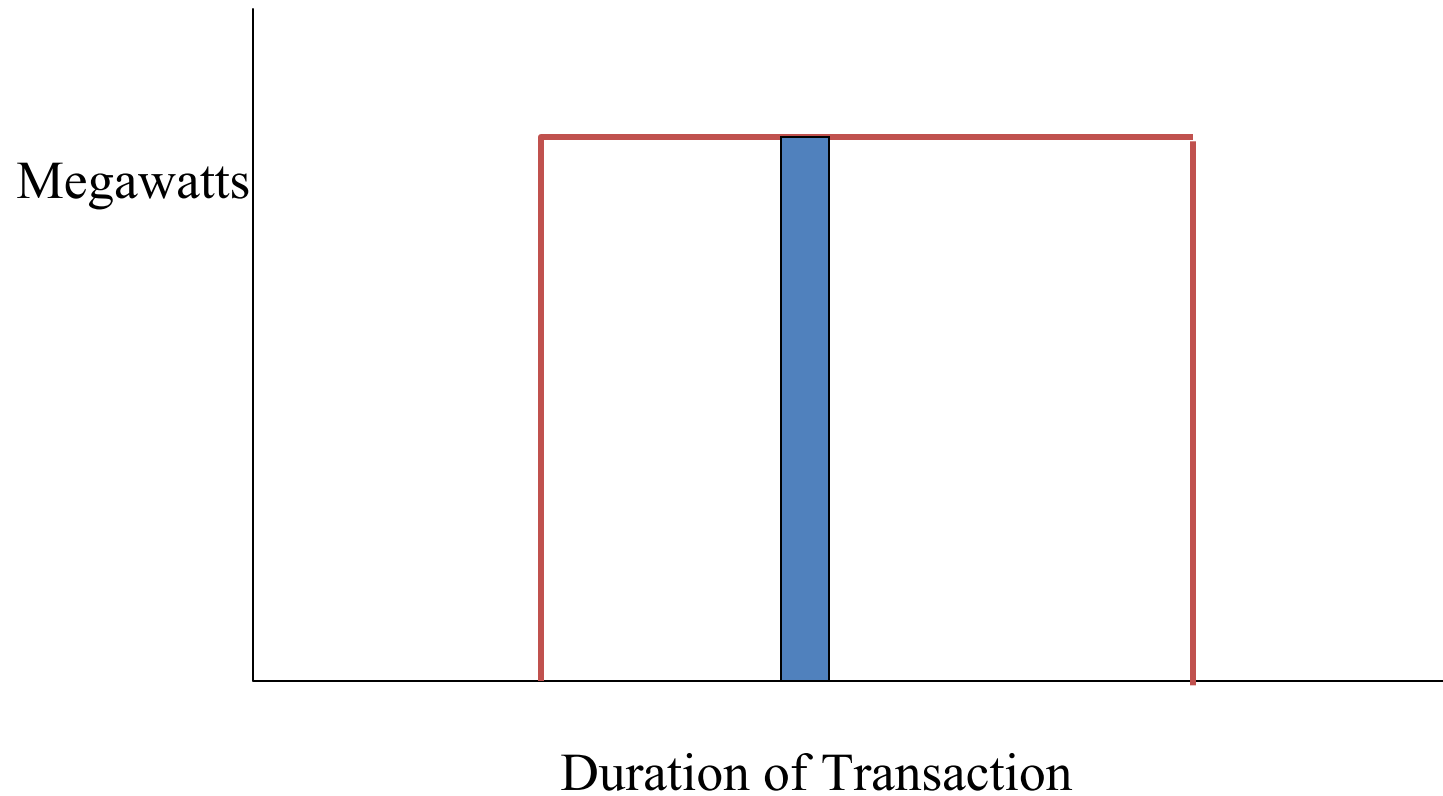


Delivering Active Power



Delivering Active Power

Load Management



Pricing Load Voluntary Interruptions

- 100 MW
- \$50/MWH
- \$5,000/hour
- 1 minute hiccup
- 1 second hiccup

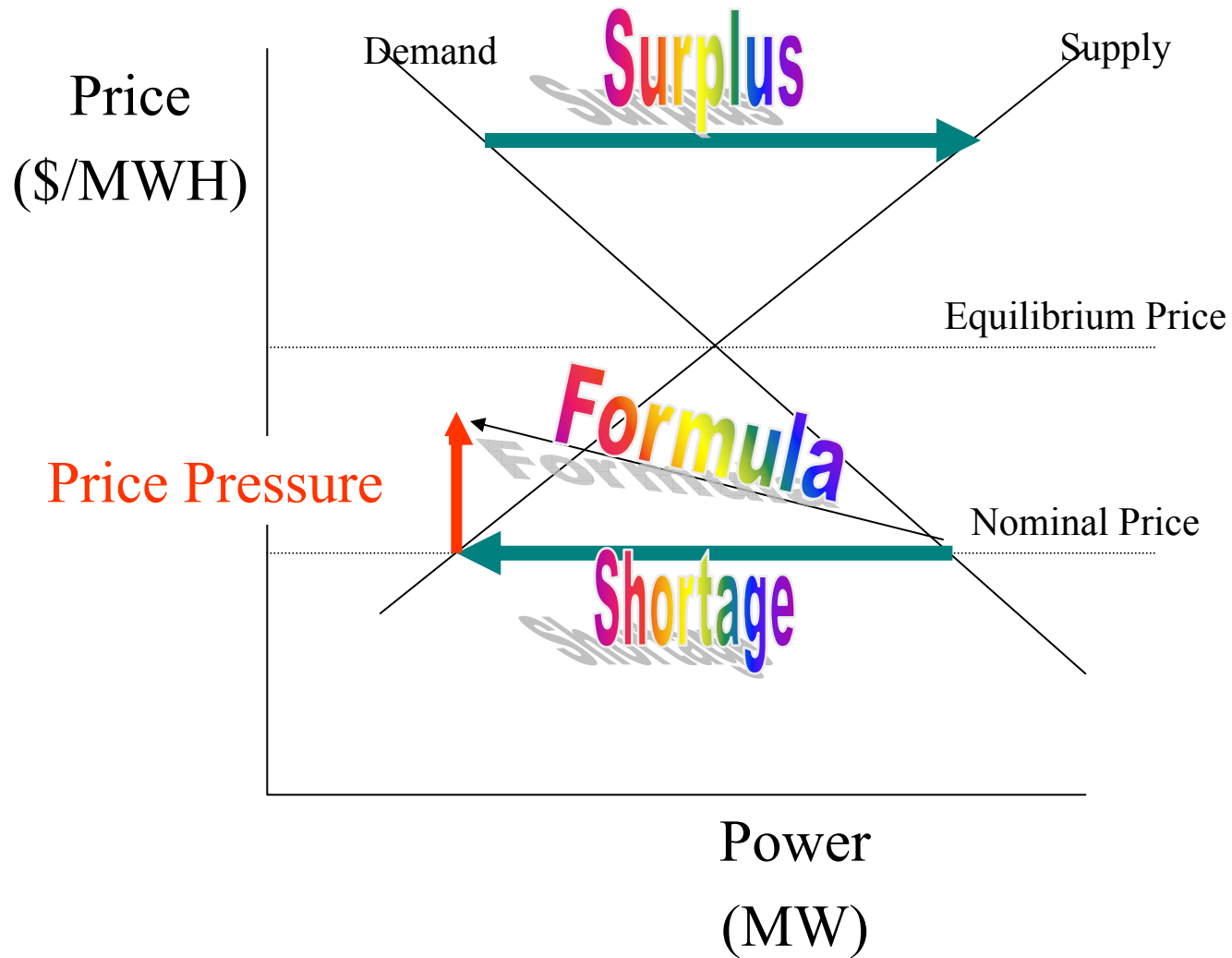
Pricing Load Voluntary Interruptions

| Price (\$/MWH) | \$50 | \$500 | \$5,000 | \$50,000 | \$500,000 |
|-----------------|-------------|-------------|---------------|----------------|-----------------|
| | | | Minute | | |
| Interruption | \$ 83.33 | \$ 833.33 | \$ 8,333.33 | \$ 83,333.33 | \$ 833,333.33 |
| Net Hourly Bill | \$ 4,916.67 | \$ 4,166.67 | \$ (3,333.33) | \$ (78,333.33) | \$ (828,333.33) |
| | | | Second | | |
| Interruption | \$ 1.39 | \$ 13.89 | \$ 138.89 | \$ 1,388.89 | \$ 13,888.89 |
| Net Hourly Bill | \$ 4,998.61 | \$ 4,986.11 | \$ 4,861.11 | \$ 3,611.11 | \$ (8,888.89) |

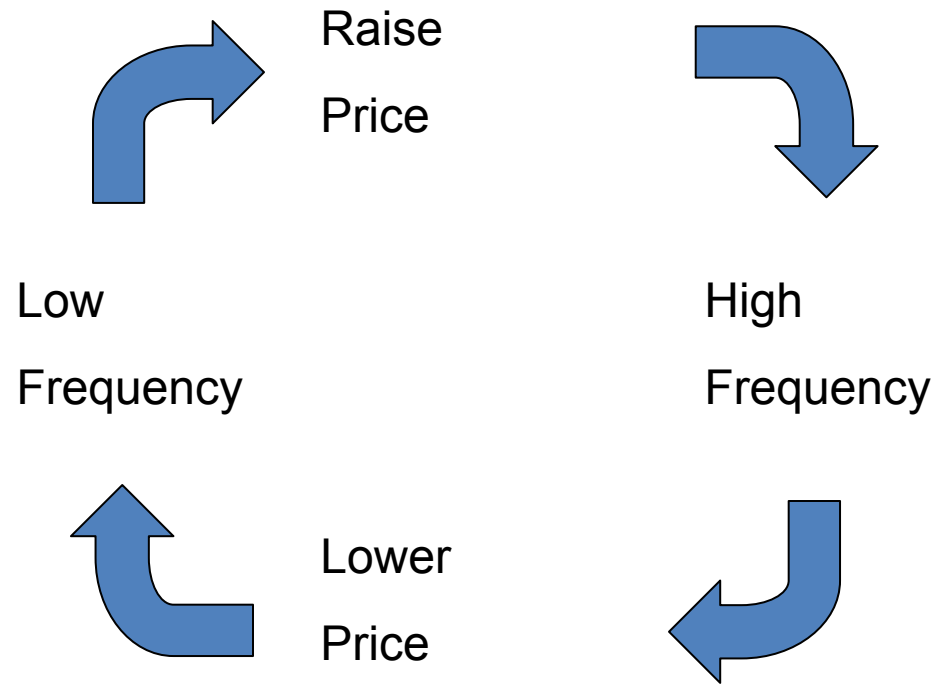
WOLF pricing is a dynamic dance

What we do in response to the
anticipated price changes the price
on us

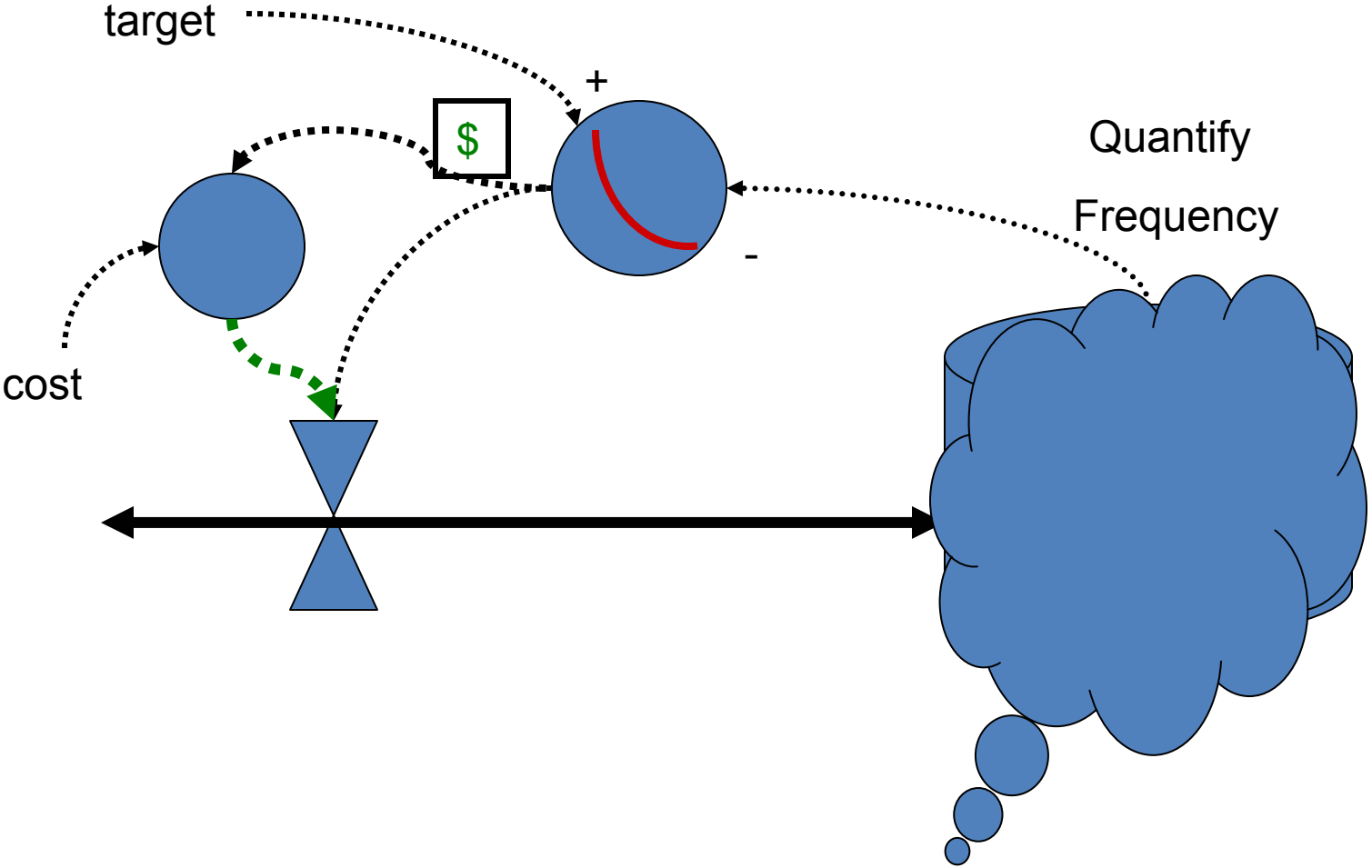
Wide Open Load Following Dynamic Economic Theory



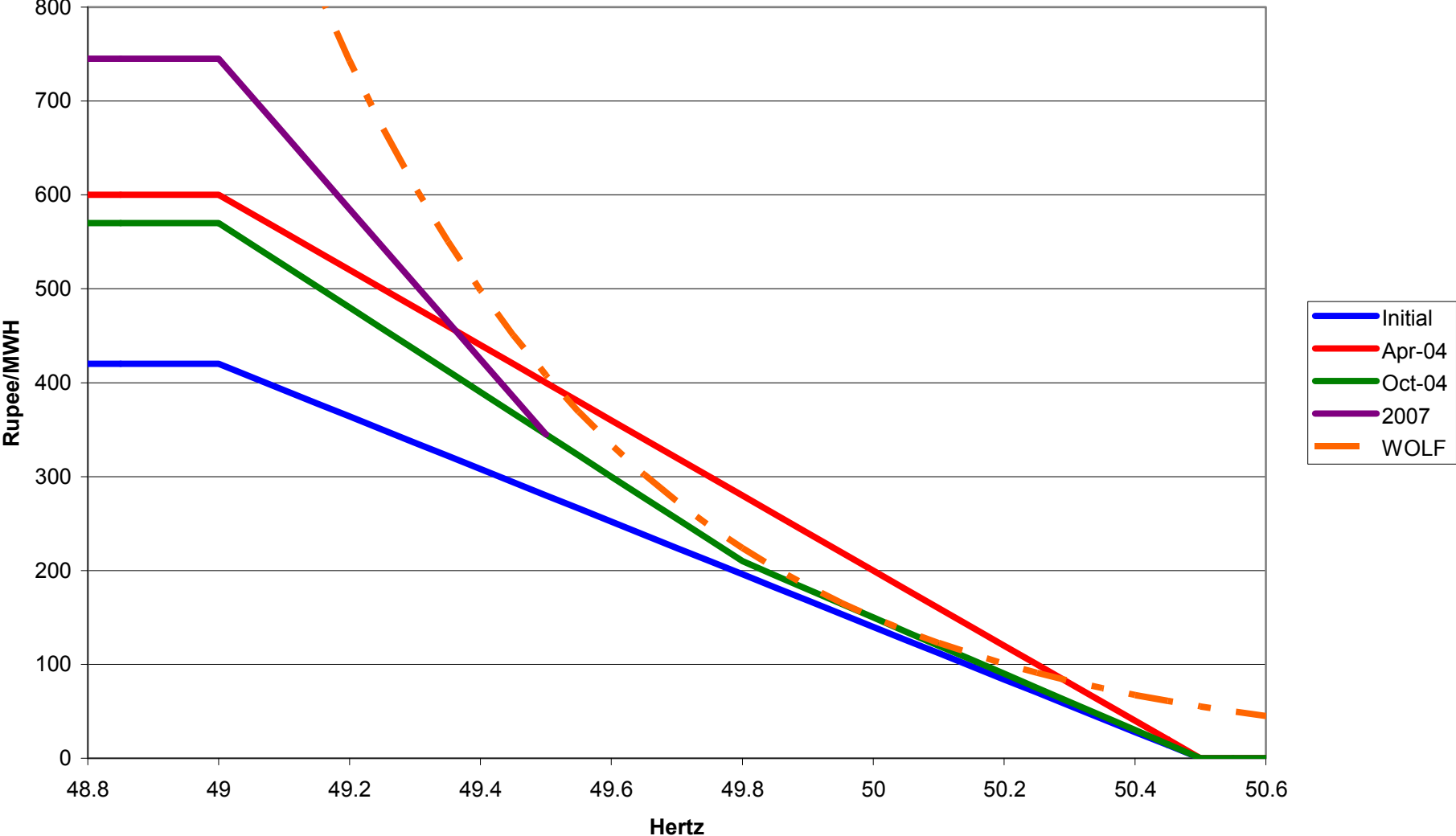
WOLF Pricing Control Theory



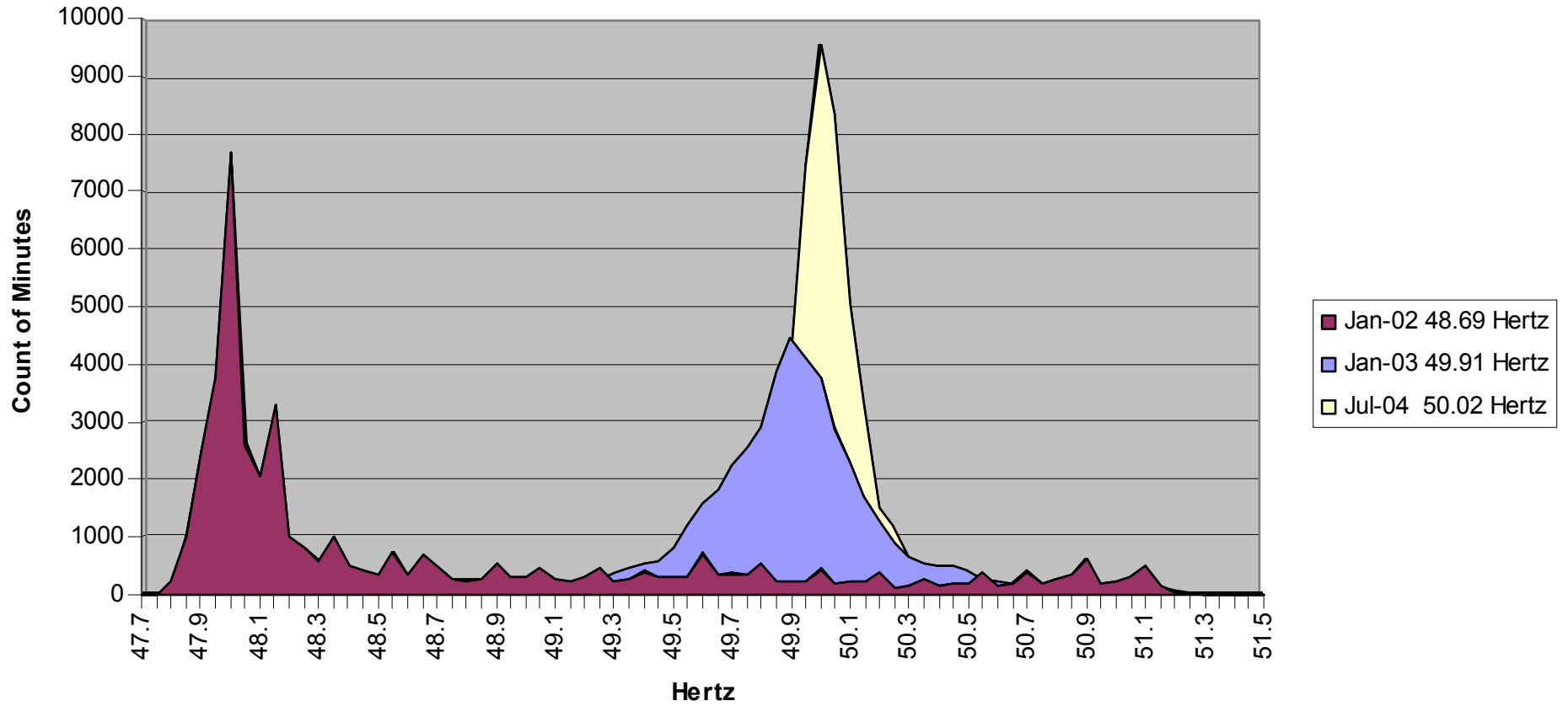
Wide Open Load Following Control Theory



ABT UI Pricing Chart
Figure 7



Monthly Distribution of Minute by Minute Frequencies



Smart Grid Pricing Niceties

- Geographic differentiation
 - Line losses
 - Constraints, e.g., N-1 or N-2
- Reactive power driven by local voltage
- Annual customer charges to pay for Smart Grid elements