Completing The Market Design

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December 16, 2004

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Frame of Reference

- Former System Operator
- Reliability – NERC Definition
  - Adequacy
  - Security
- Ancillary Services = Reliability Services

Is Price Volatility Enough?

- Current market designs depend on price volatility to insure adequacy.
  - It is assumed that sufficient price volatility will insure adequacy.
  - Energy only price volatility adds uncertainty to the reliability problem.
  - Political price caps prevent adequate revenue to insure adequate capacity.
  - The mechanism for converting adequacy to security remains unclear.

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Reliability Services Effects

- Do Reliability Services reduce price volatility?
- Does price volatility reduce the need for Reliability Services?
- How are reservation costs assigned?
- Does the concurrent dispatch of energy and Reliability Services result in indeterminate prices?

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Non-Overlapping Intervals

- Can these problems be resolved by designing a market that uses non-overlapping intervals?
  - The market would provide a balanced solution at a predetermined interval before real-time. For example 1 hour.
  - The system operator would acquire the necessary Reliability Services in the market and dispatch those services after the market closes.

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Adequacy to Security

- The highest value added to electricity is value added by the system operator.
- Value is added by system operators converting from adequate capacity to adequate real-time security.
- This conversion is yet to be correctly captured in a market design.
- The following example demonstrates this conversion process.

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Reliability Services Dispatch

- Three 500 MW Units with 5% Droop.
- U1=450MW, U2=450MW, U3=375MW
- Unit 1 – Incremental Price = $30/MWh
- Unit 2 – Incremental Price = $40/MWh
- Unit 3 – Incremental Price = $50/MWh
- Response Req. of 150 MW for .3 Hz
- How should a 75 MW increase in balancing energy be delivered?

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Dispatch Alternatives

- **Alternative 1: Economics Based Decision - load Unit 1 to 500 MW, Unit 2 to 475 MW, & Unit 3 to 375 MW.**
  - **Additional Cost $ 1,150**
  - **Response Remaining 75 MW**
- **Alternative 2: Reliability Based Decision - load Unit 1 to 450 MW, Unit 2 to 450 MW, & Unit 3 to 450 MW.**
  - **Additional Cost $ 3,750**
  - **Response Remaining 150 MW**

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Response Cost

- Example Result:
  - 75 MW of additional response
  - Additional cost of response = $2,600
  - Incremental response cost $35 / MW
- The system operator adds value to the system by spending dollars to convert adequate capacity to security in the form of response available to manage system upsets.

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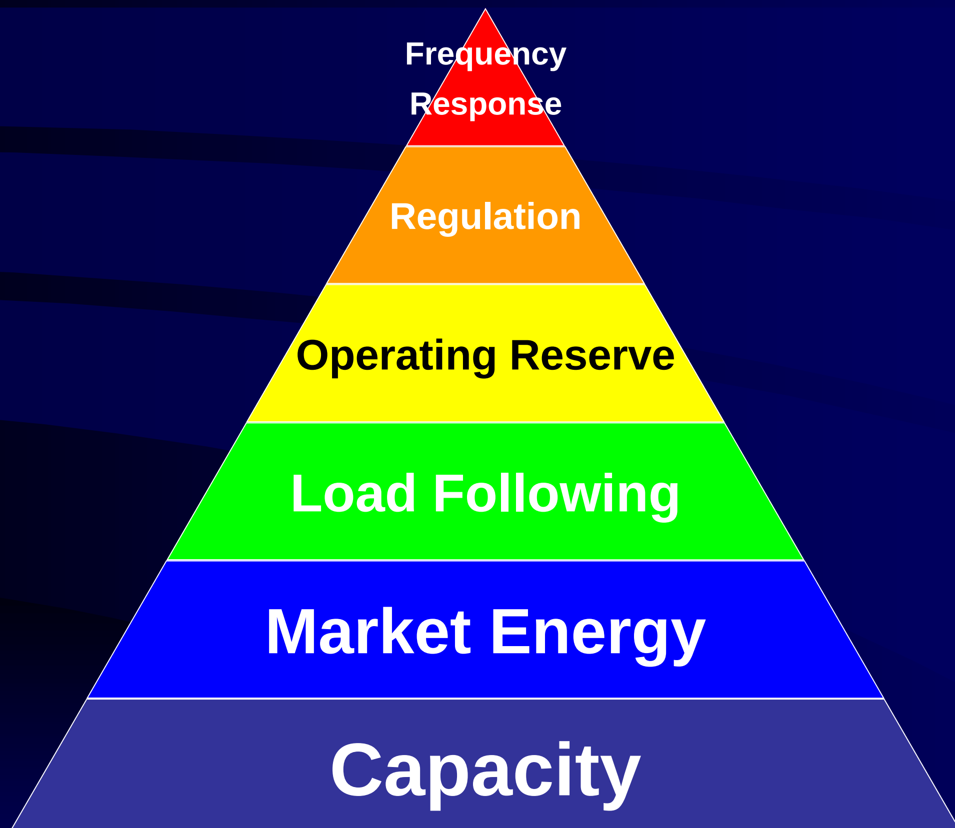
The Resource Pyramid



Response Time

Seconds

A Few to Several Minutes

10 to 15 Minutes

30 Minutes

Market Interval – One Hour

Response Not Defined

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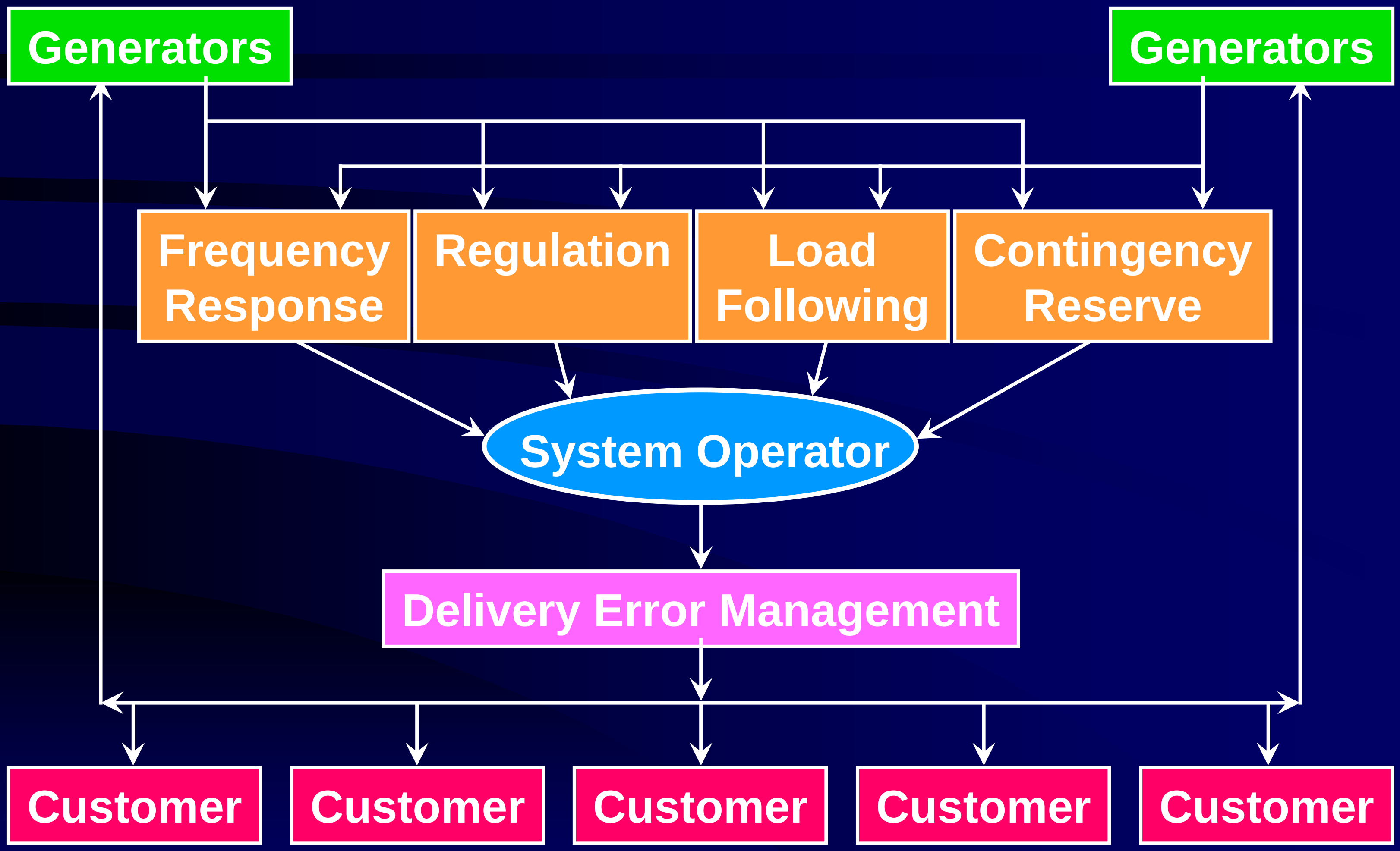
Reliability Services ?

- Are RS used by the customers? No!
- RS are used by the system operator.
- Are RS energy or options? Options!
- RS are energy put and call options.
- What do the customers get? Security!
- Security=>Delivery Error Management.
- System operators manufacture Delivery Error Management from RS.

Delivery Error Management



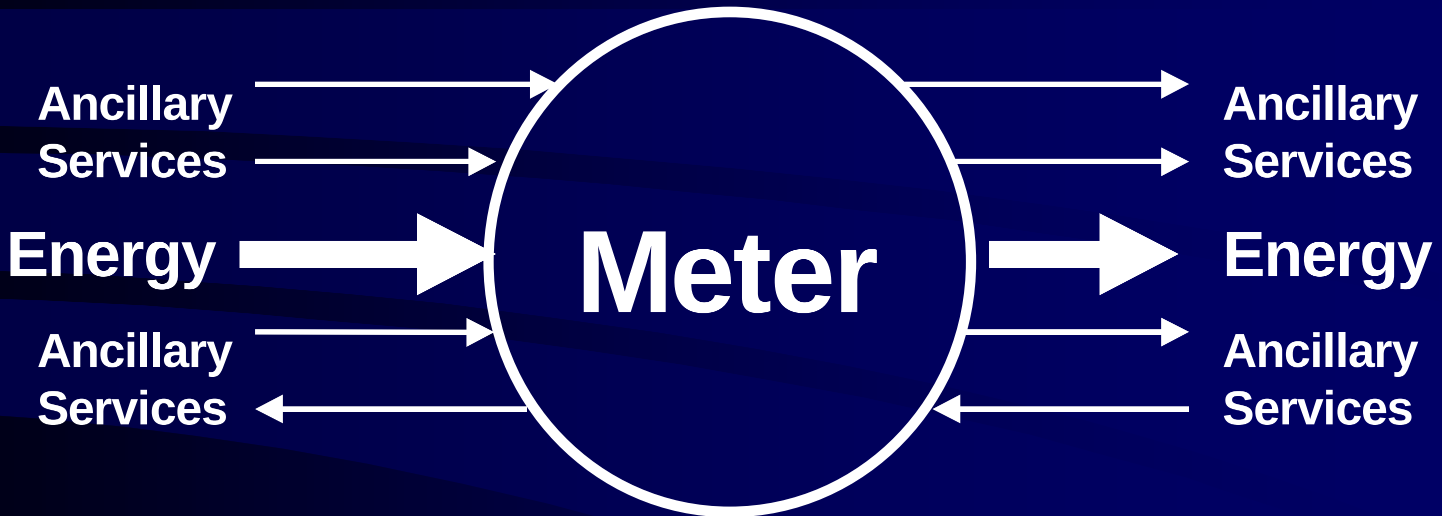
What is Known?

- Transmission constraint complexity
  - Complete unconstrained market first
- Size matters: Law of large numbers
  - Constrained response requirements
- Local Reliability Services markets
  - Reliability Services deliverability
  - Equivalent local reliability
  - Highest Price = Lowest Reliability ?

Unscheduled Energy Price

- The Single Meter Problem
- The ACE Equation
- CPS1 and Reliability Risk
- NERC IOS Contribution
- NERC JIITF Recommendation
- Per Unit Risk Valuation
- Including Transmission Reliability
- Generalizing the Solution

The Single Meter Problem



$$\text{Error} = \text{Meter Amount} - \sum \text{Schedules}$$

One Meter = One Error

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The ACE Equation

$$ACE = \Delta T - 10B_i\left(F_A - F_S\right)$$

CPS1 Equation

$$\mathrm{AVG}\left\{\left(\frac{\mathrm{ACE}}{-10B_i}\right)_1 \times \left(F_A - F_S\right)_1\right\} \le \varepsilon_1^2$$

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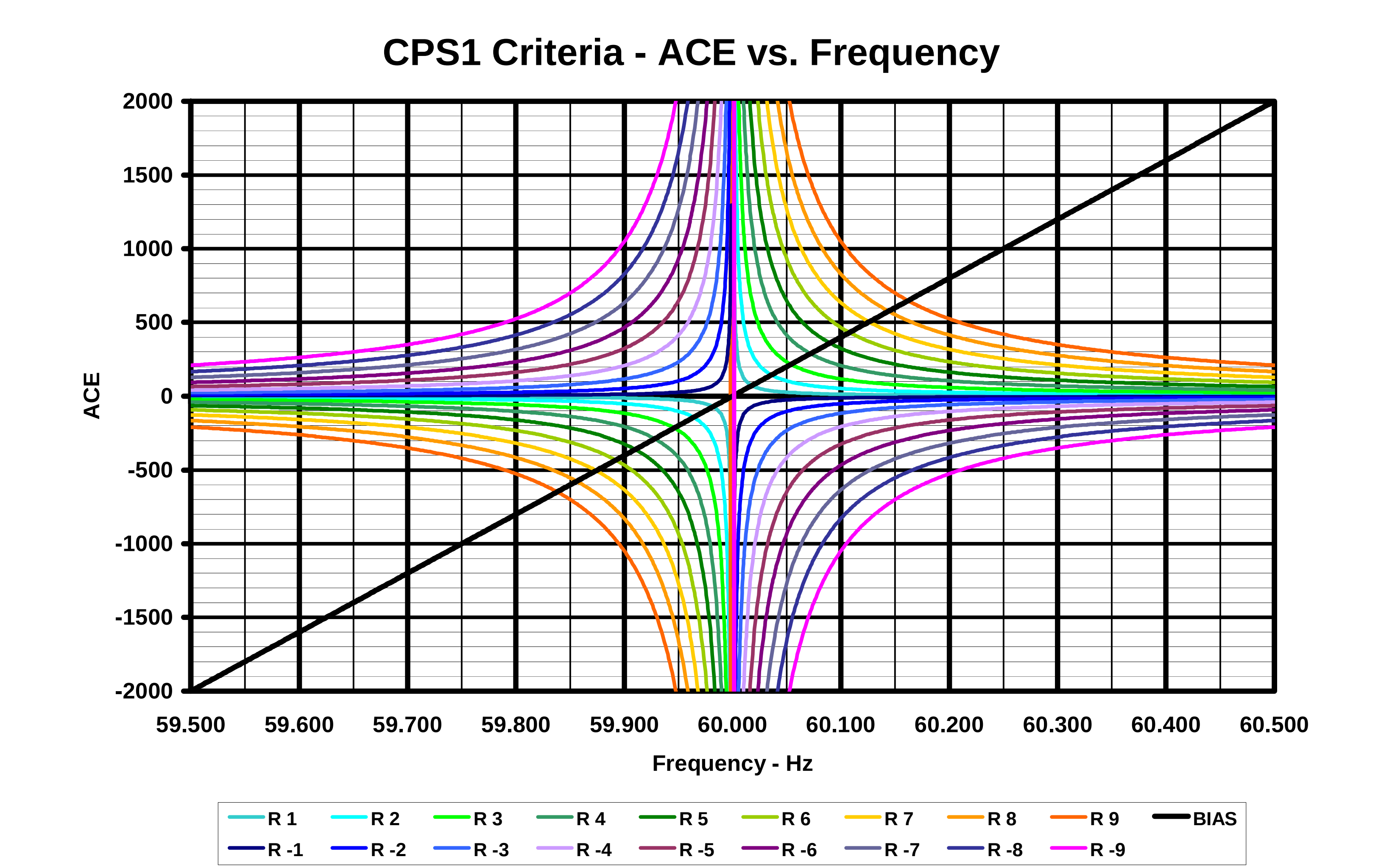
CPS1 and Reliability Risk



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NERC IOS Contribution

$$\frac{\mathrm{AVG}\left\{\left(\mathrm{E_U}\right)_1 \times \left(\mathrm{F_A} - \mathrm{F_S}\right)_1\right\}}{\mathrm{AVG}\left\{\left(\mathrm{F_A} - \mathrm{F_S}\right)_1^2\right\}} \approx \mathrm{AverageRisk}$$

NERC JIITF Recommendation

Inadvertent Interchange

- Three Component Price
  - Energy Component
  - Transmission Congestion Component
  - Frequency Control Component

$$FCC = \frac{\frac{1}{n}\sum\left(I_i \times \Delta F\right)}{\frac{1}{n}\sum \Delta F^2}$$

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Per Unit Risk Valuation

$$\frac{\text{Total} \cdot \text{Annual} \cdot \text{Cost}}{\frac{1}{n}\sum \Delta F^2} \approx \text{Per} \cdot \text{Unit} \cdot \text{Risk} \cdot \text{Cost}$$

$$n \times FCC \times \text{Per} \cdot \text{Unit} \cdot \text{Risk} \cdot \text{Cost} = \text{Frequency} \cdot \text{Control} \cdot \text{Cost}$$

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Transmission Reliability

- Constraints yield price differences.
- Frequency control prices don't over-ride but modify constraint prices.
- Constraint price differences yield settlement imbalances.
- Balances uplifted in proportion to unscheduled energy will support constraint pricing.

Adequacy Pricing

If unscheduled energy can be properly priced to include all of the costs of providing reliability, then the price of unscheduled energy can drive forward markets in both energy and Reliability Services that assure interconnection adequacy, security and reliability.

System Operator Function

The goal of having market solutions to support adequacy, security and reliability will be dependent upon how well the system operator responsibility can be supported with forward (Day-ahead markets) and multi-settlement markets that fully integrate operator reliability transition functions.

R & D Recommendations

- Determine if overlapping energy and Reliability Services dispatch yield indeterminate prices.
- Determine if Reliability Services should be integrated into the market as options instead of energy.
- Determine if integration of energy and Reliability Services as options can mitigate hockey stick bidding.

R & D Recommendations

- Determine the best way to integrate the system operator function into the market.
- Determine if the correct pricing of unscheduled energy can drive the forward markets in adequacy and security.
- Determine if an unconstrained market design can assure adequacy.

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R & D Recommendations

- Determine reliability requirements for various sized interconnections.
- Determine when constraints begin to cause regional reliability differences.
- Determine how the reliability needs of a constrained region differ from interconnection reliability needs.
- How should constraints affect Reliability Services prices.

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R & D Recommendations

- Investigate market designs that do not depend upon a central solution engine.
- Most of this work requires solutions for the unconstrained market first.

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Questions

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