Using Ammonia-Fueled Generation to "Firm Up" Intermittent Renewable Resources, Such as Wind Power

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Presented at Ammonia Fuel III

October 9-10, 2006
Golden, Colorado

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Biographical Sketch

- Attorney specializing in Energy Law, Small Businesses, and Non-Profits
- Executive Director, Northwest Hydrogen Alliance, Inc.
  - Oregon non-profit, 501(c)(3) created to promote a hydrogen economy in the Pacific Northwest and Alaska
- President, Preston Michie & Associates, LLC

  Energy and Business Consulting
- President, Team Soup, LLC

  Negotiations Training Services (services marketed by auxilium.com)
- General Counsel and Vice Chairman, World Botanical Gardens, Inc.
- Director, The Energy Trust of Oregon (non-profit); The Wetlands Conservancy (non-profit); and Ridgeline Energy LLC (wind company)

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Background

- NW Hydrogen Alliance, Inc discovers NH3
- Defining a value proposition for ammonia-powered generators to:
  - "Firm up" intermittent renewable resources; and
  - Provide rapidly responding back-up generation to support the power grid
- Oregon Governor Challenge
- ODOE Follow up

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The Problem of Intermittent Renewable Resources

- Production Tax Credit stimulated renewable resource development, particularly wind power, but also wave, solar, tidal, and other
- Wing projects are often characterized by low plant factors (about 30% to 40%) and intermittent output; alternative generation is needed to provide power when the wind doesn't blow (about 65% of the time)
- Intermittent resources provide "energy" to a utility system (the ability to do work), but limited "capacity" (the ability to do work NOW), particularly during "peak" periods
- Power system contingencies need to be managed by utilities
- Generation is often located far from loads, especially in the West, making transmission a key issue

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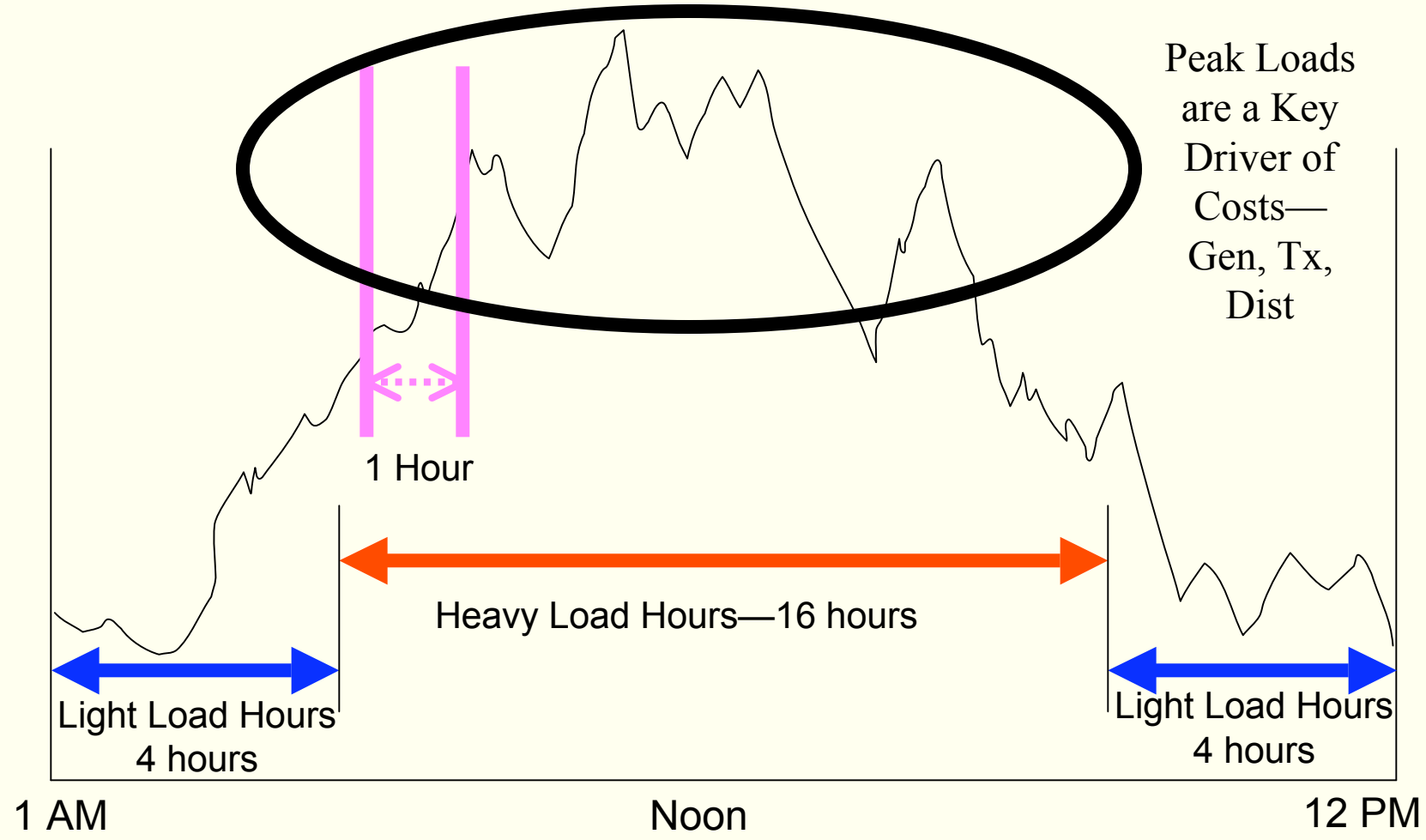
Electrical System Fundamentals
Typical Daily Load Shape



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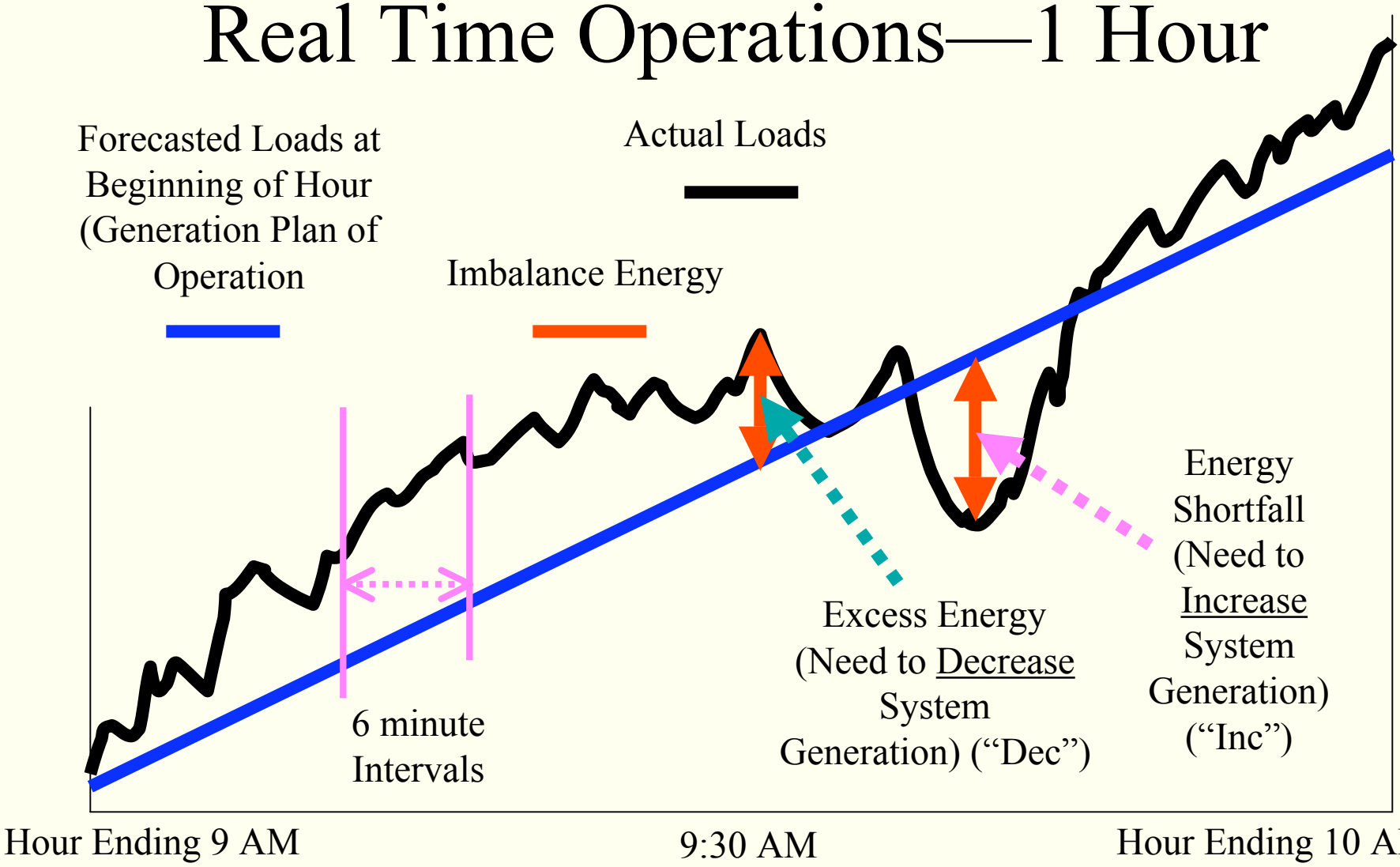
Electrical System Fundamentals
Real Time Operations—1 Hour



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What's Needed for Ammonia Fueled Distributed Generators?

- Non-Polluting Fuel (solution to Carbon Sequestration highly beneficial)
- High Energy Content Fuel
- Safe Storage and Handling
- Fuel Storage and Generation Close to Load (Read: In or Near Urban Areas)
- Rapid Response (2-4 seconds would be ideal)
- Two-Way, High Speed Communication
- Remote Control from a Centralized Point of Control Reliable Output
- Remote Monitoring
- Integration with Power System Operations
- Compatible with "The Energy Web"

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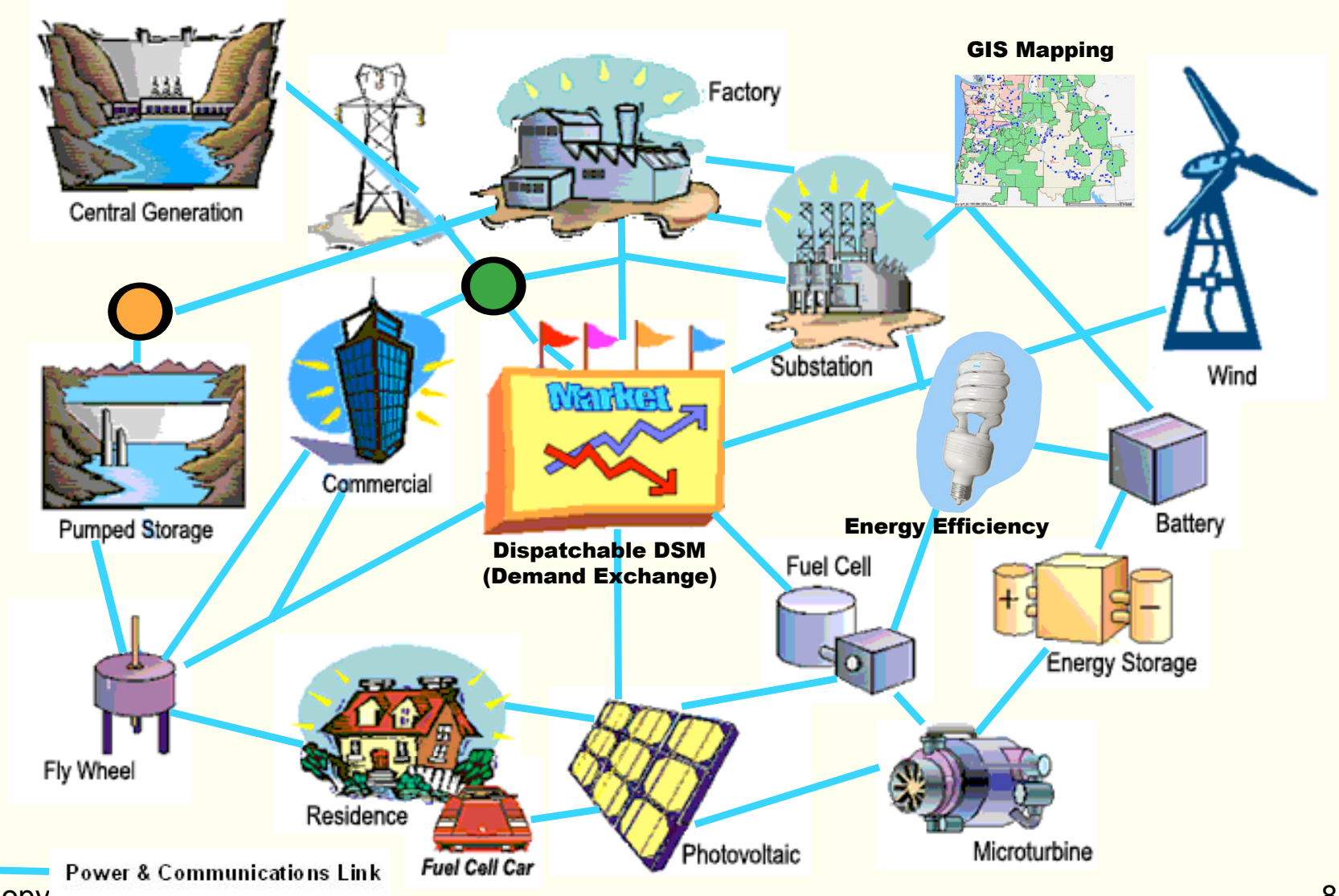
EnergyWeb



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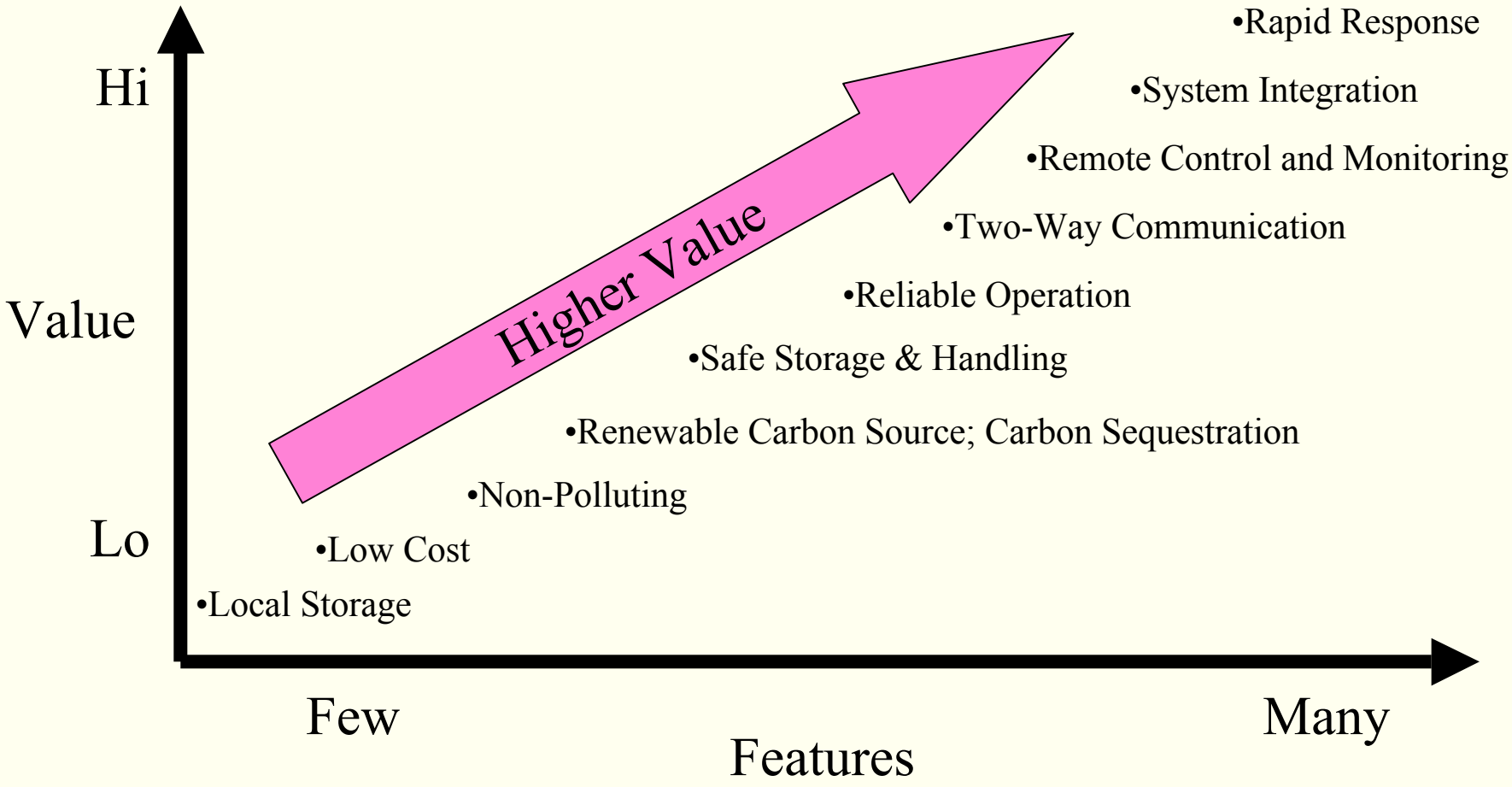
The Ammonia-Fueled Generator Value Proposition



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Key Value of Ammonia—Low Cost, Safe Storage In or Near Urban Areas

- A problem faced by proponents of the hydrogen economy is storing and handling hydrogen.
- A number of high-tech solutions have been proposed including metal hydrides, highly engineered exotic materials to trap hydrogen molecules, high pressure systems, and others

- Why not simply store hydrogen as ammonia to be used as needed as fuel?
- Placing generation near loads provides higher reliability, lower cost, lower power losses, and faster response.

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What is Demand Response?

Demand Response is the ability to control loads by turning them off (most commonly) or on in response to system conditions.

Demand Response also includes “behind the meter” distributed generators such as emergency back-up generation fueled by ammonia or other fuels.

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Benefits of Effective Demand Response, Including Distributed Generation, Such as Ammonia-Fueled Generation

- May defer the need to invest in generation, transmission or local distribution upgrades.
- May reduce system congestion and improve system reliability and stability.
- May reduce transmission losses from moving power from generation to load, particularly over heavily loaded lines.
- Creates an option to deal with contingencies, including price excursions.
- Helps deter the exercise of market power.

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High Value Benefits of Rapid Response—E.g., Underfrequency Response

When the system is short generation the system draws kinetic energy from spinning flywheels (turbines) to keep the lights on.

This causes the turbines to rotate more slowly from the loss of momentum as kinetic energy is drawn from the turbines to make power. If the problem isn't fixed within a few minutes, the system will go down—and the lights will go out.

The problem can be cured two ways—increase generation or decrease loads. Utilities must have the ability to increase power to cover these and similar contingencies.

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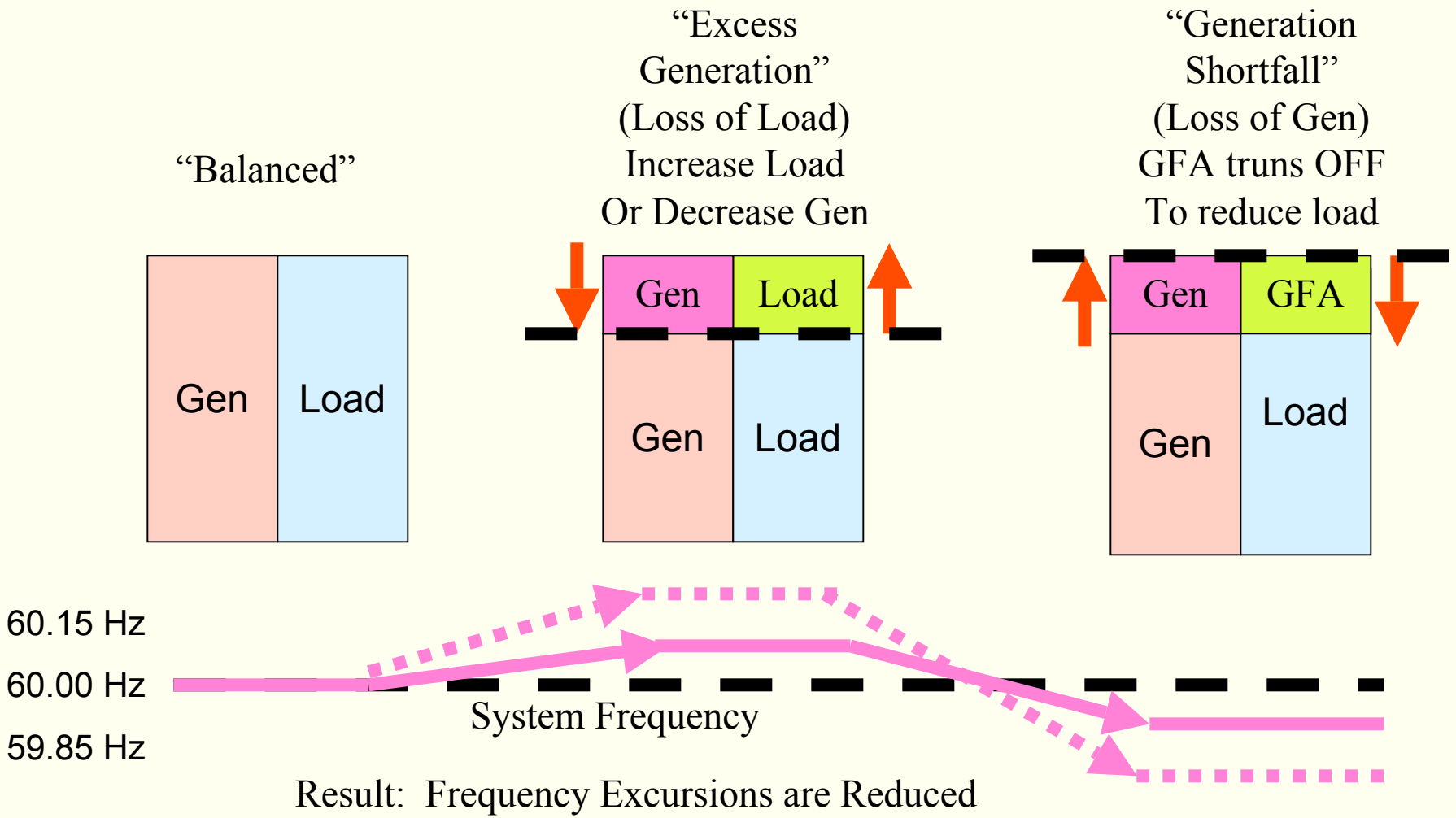
Managing Under- or Over-Frequency



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High Value Benefits of Rapid Response—Redispatch

Sometimes “congestion” occurs on the power grid.

“Congestion” means owners of lower cost generation cannot deliver to buyers because of transmission constraints (“flow gates”) between seller and buyer.

System power flows can sometimes be brought within system limits by increasing generation “behind” the constraint and decreasing generation “in front of” the constraint.

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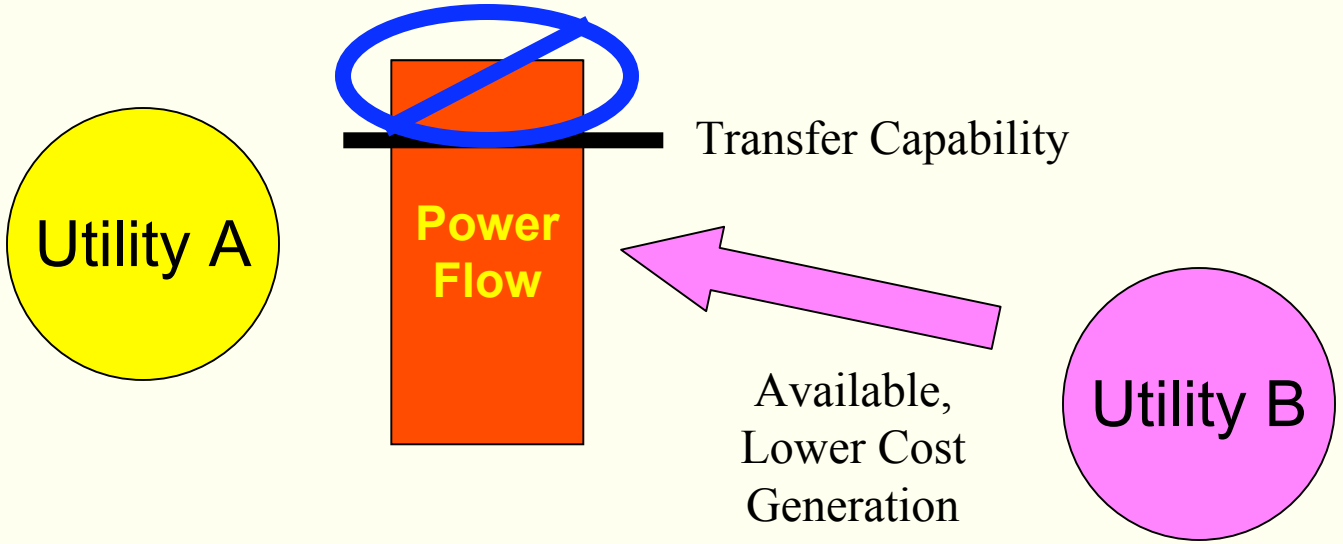
Redispatch Illustrated

Utility A wants to buy cheaper power from Utility B than it can obtain locally



Utility B has cheaper power available, but can't move the power to Utility A because of transmission constraints "between" Utilities A and B (the lines will become congested if Utility B generates additional power)

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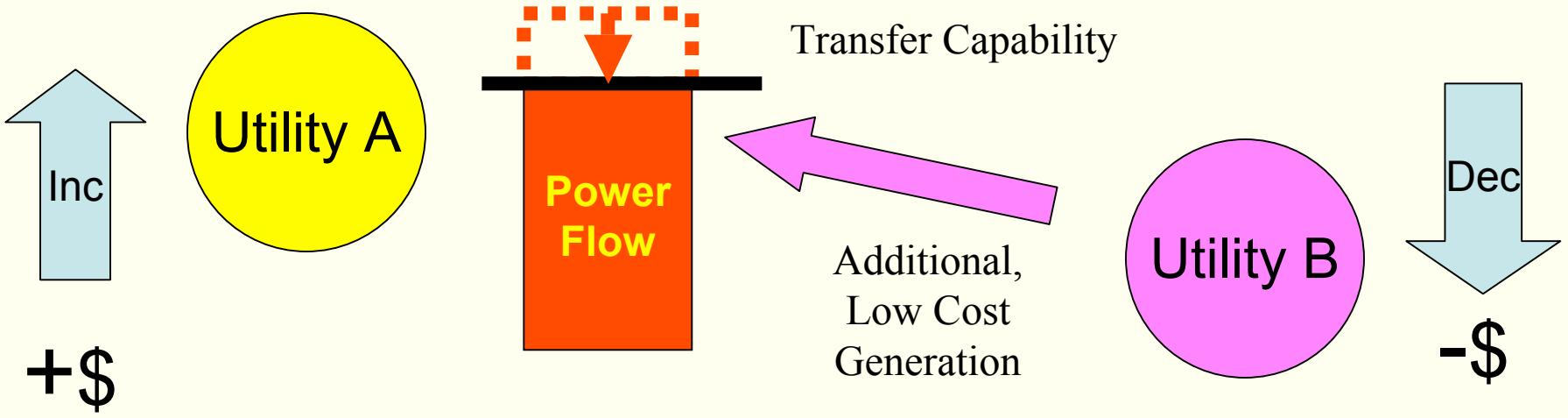
Redispatch Solution

Operators pays A to increase generation on the "load side" of the constraint (or decrease loads) (referred to as an "Inc"); and accepts payment from someone on the "supply side" of the constraint to decrease generation (or increase loads) (referred to as a "Dec") to keep the system balanced but to bring flows within applicable transfer limits



The fee for this service is the difference in cost of increasing generation (or decreasing load) on the "load side" of the constraint less the costs saved by not having to generate (or increase load) on the "supply side" of the constraint. It is economic to do this deal when the savings to Utility A of buying lower cost power from Utility B is less than the cost of the redispatch solution.

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Oregon Governor Kulongoski's Challenge

- Draft a Strategic Plan for Oregon to Promote the Creation of a Hydrogen Economy in Oregon
- Develop a Renewable Resources Hub in Oregon Featuring Hydrogen (Ammonia), Wind, Ocean, Biomass, and other Renewables
- Draft a Strategic Plan for Oregon's Hydrogen Economy
- NWHA agreed to help ODOE write Oregon's Strategic Plan for Hydrogen/Ammonia

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Proposal by NWHA and HEC

- NWHA and HEC will work with ODOE to operate an HEC GenSet for several months to test the feasibility of ammonia-fueled ICEs to provide back-up generation and ancillary services as needed by the power system
- The proposal has received interest from PNNL, Oregon State University, and Portland General Electric
- NWHA and HEC agreed to help ODOE write Oregon's Strategic Plan for Hydrogen/Ammonia

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Conclusion

- Ammonia-fueled generation has potential to provide high value services to manage intermittency from renewable power resources, particularly where clean fuel is needed
- Ammonia-fueled generation has potential to provide high value services to manage power system contingencies
- Ammonia has distinct advantages as a potential fuel to power distributed generation
- What is needed is a solution to each of the components of the value proposition for these services (particularly remote control and monitoring, rapid response)

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