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Can a Smarter Grid Slow Down Climate Change While
Accelerating Energy Independence?

Future of Energy Systems and
Unsustainability of the Status Quo

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Life Today

THOSE OF US LIVING IN THE DEVELOPED ECONOMIES TODAY ENJOY THE BEST QUALITY OF LIFE HUMANS HAVE EVER EXPERIENCED SINCE OUR SPECIES (HOMO SAPIENS) EVOLVED ON THIS PLANET AROUND 250,000 YEARS AGO.



OUR CURRENT PROSPERITY & QUALITY OF LIFE IS DEPENDENT ON THE READY AVAILABILITY OF ABUNDANT AFFORDABLE ENERGY.



Today's Energy Issues

(that will dominate the future)



Climate Change



Energy Security &
Risks of Harvesting
Fossil Fuel



Demand and
Supply

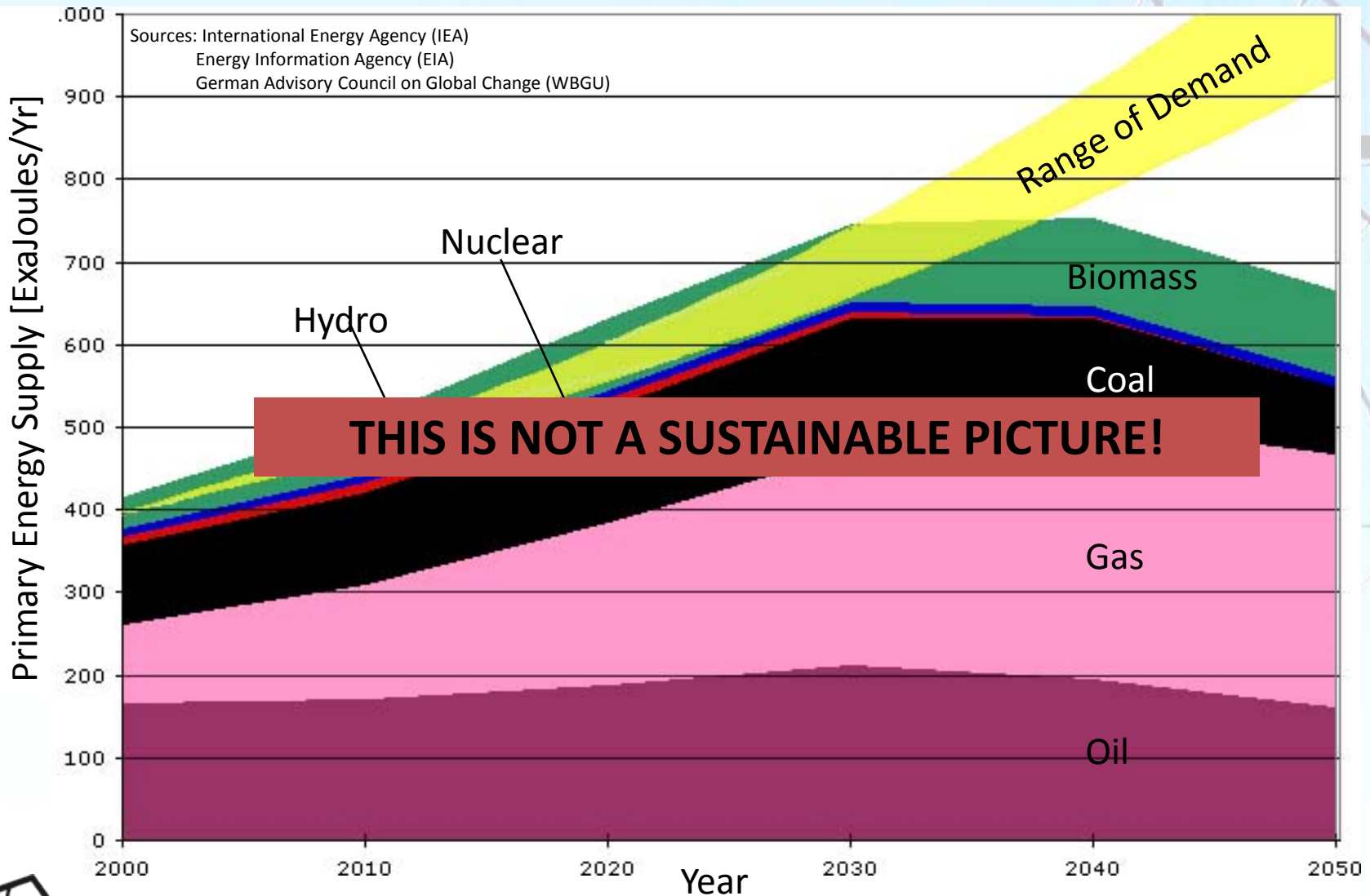
Demand and Supply in the long run – A key Question

**When will the Demand for Energy
exceed the Conventional Supply?**

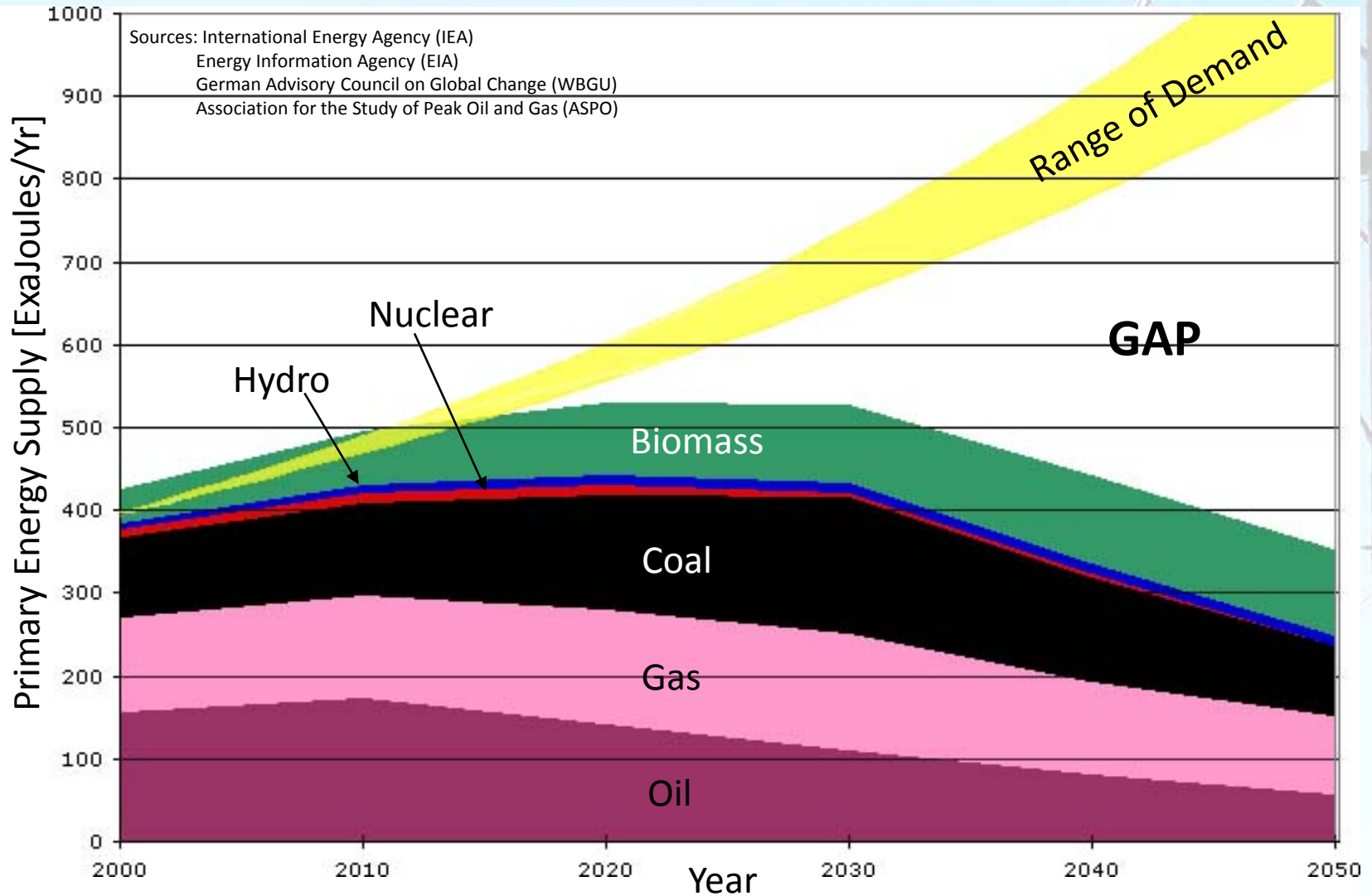
**When that happens, the price of
energy will rise substantially**



The Optimistic Supply Case



The Pessimistic Supply Case



Filling the Gap - 2 Solutions

**Increased Use of
Nuclear Energy**

**Entry of Renewable Energy
Sources & Systems into the
Mainstream of Generation**

Solar

Wind

Tidal

Wave

Small Hydro (Run of River)

Hydro-Kinetic Systems

“Hot Rock” Geothermal

Biofuels derived from Biomass

Big Hydro

Landfill Gas



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Climate Change and The role of the way Humans Generate their Energy



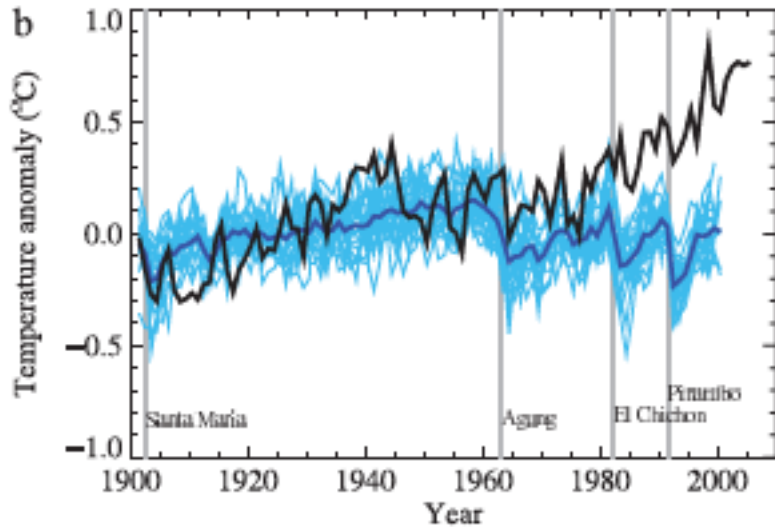
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Temperature Anomalies 1901 - 2006



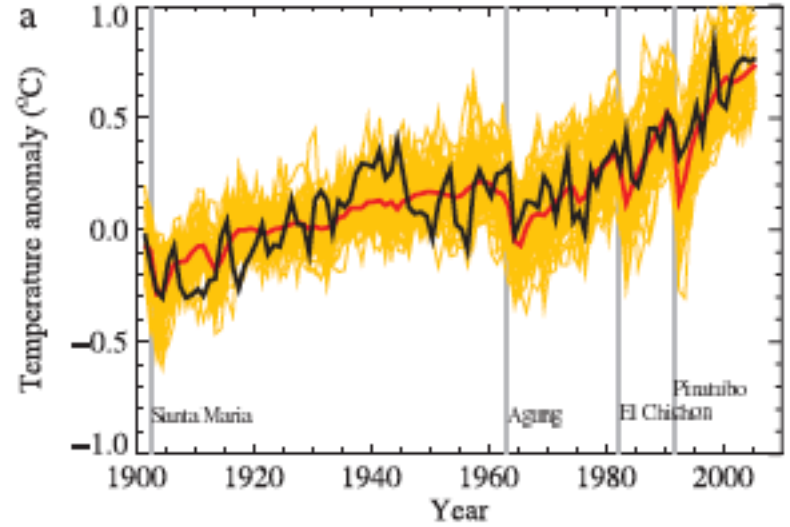
Anthropogenic Forcing
Not Included

19 Simulations
5 Models

- Measured Temperature
- Model Outputs
- Model Output Average



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Anthropogenic Forcing
Included

58 Simulations
14 Models

- Measured Temperature
- Model Outputs
- Model Output Average

Baseline: Observed temperature over the period 1901 to 1950

Source: IPCC Fourth Assessment Report, 2007 WG1-Chapter 9

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General Characteristics of Renewable Energy Sources

- **Inexhaustible**

- If they are managed properly



- **Secure & Low Risk**

- A local energy source



- **Environmentally Benign**



Properties of Renewable Sources

Renewable Energy Sources are either intermittent or strongly location dependent, or both

How can we create Renewable Energy Systems that are capable of generating FIRM renewable power anywhere?



The Answer Lies:

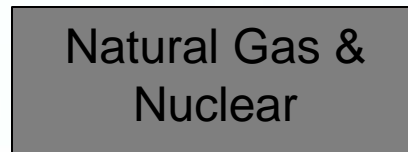
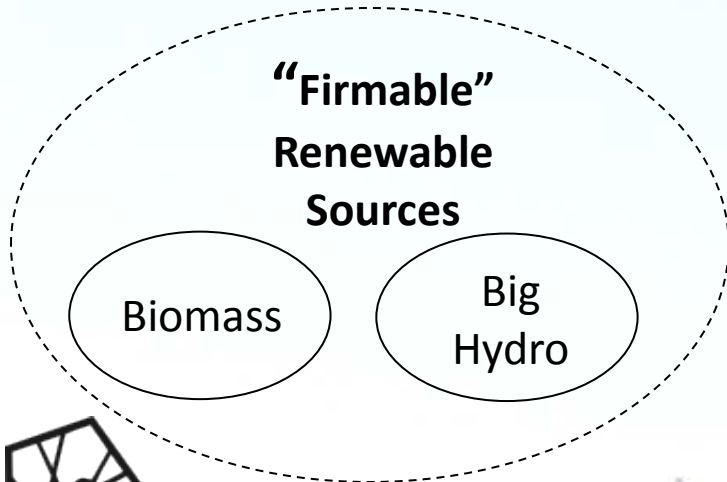
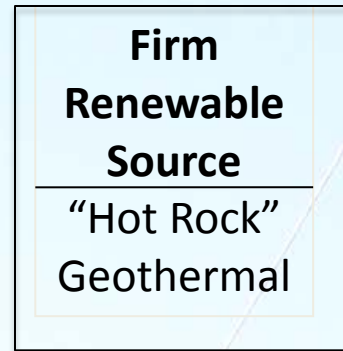
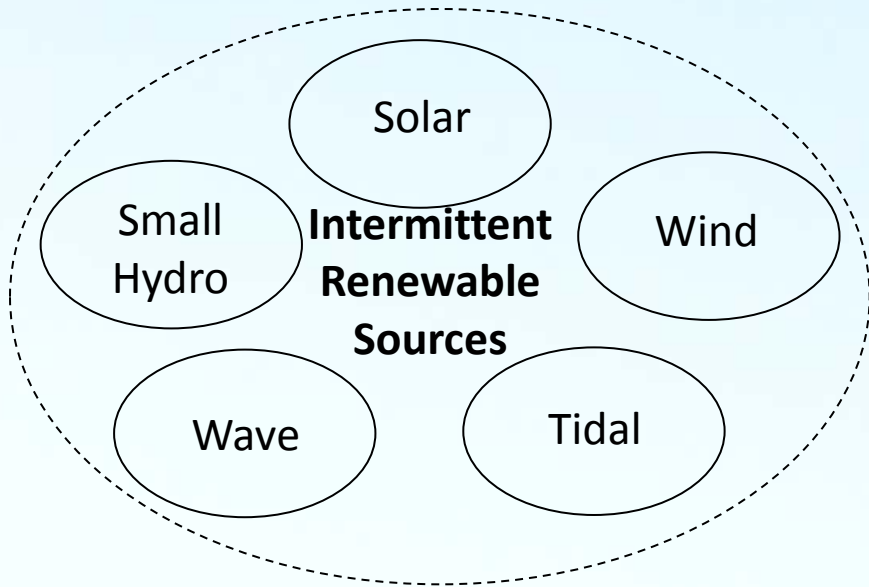
In using a variety of renewable sources together.

- In understanding that Renewable Energy is LOCAL ENERGY so in developing a renewable generation system.....
 - The first question you ask is NOT “What technology will I use?”
 - The appropriate question is **“What sources are here and what are their characteristics?”**
- **There is no “Silver Bullet”**

Types of Renewable Sources

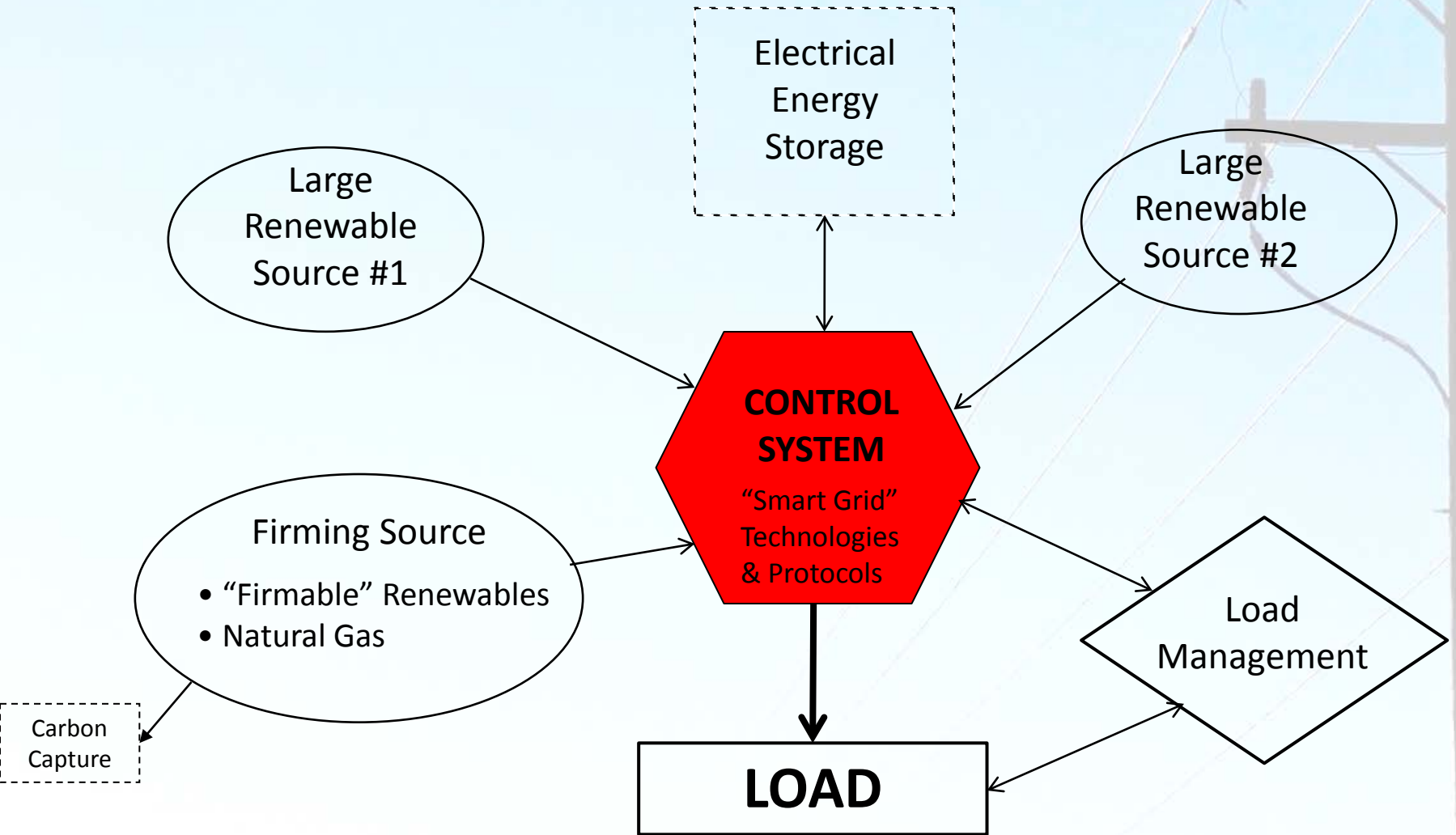
Source	Intermittent or Firm?	Zero Fuel Cost?	Comment
Solar	Intermittent	YES	
Wind	Intermittent	YES	
Tidal	Intermittent	YES	Energy Production is predictable
Wave	Intermittent	YES	
Small Hydro	Intermittent	YES	
Hydro Kinetics	Intermittent	YES	
“Hot Rock” Geothermal	Firm	YES	Strongly Location dependent
Biomass	Firmable	NO	Can be managed to be firm
Big Hydro	Firmable	YES	Can be managed to be firm

What May be Available



Leads us into a
**Distributed
Generation/Micro-Grid
Architecture
in the long run**

A FUNCTIONAL CONCEPT



Summary

Major and fundamental changes will become necessary in our electrical supply systems. In the long run, the new systems will be dominated by Renewable Sources. The changes will be driven by **price**.

- There is a strong link between quality of life and *Affordable* Energy
- Increased demand for energy will be driven by the desire for developed economy lifestyle on the part of advanced developing economies
- The current electrical energy system is inefficient and operates on basic principles developed more than a century ago.
 - It assumes that only generation can be controlled to balance the system
 - Participation of the Load in system balancing is possible today, it was not 100 years ago
 - Efficiency can be increased and cost reduced by employing Load Management in balancing
- The Electrical Energy of the future will come mainly from LOCAL sources
 - Increased security, Less transmission infrastructure, Higher efficiency, etc.
 - Architecture: Smart Micro-Grids & Distributed Generation



Summary (cont.)

- Changes will become necessary as atmospheric GHG concentrations and energy prices rise
- These changes will be driven mainly by **economic considerations**
- Utilities will have enormous challenges
 - Maintaining Energy Delivery while making fundamental changes
- Timing is very uncertain - It could happen sooner than we expect
- It will be a very large undertaking and will not be easy
- It will be expensive, difficult and take time (decades?) to complete
- Urgency may be a factor
- New technology, new thinking and new principles will be necessary
- **The Energy Industry is not at all prepared for this**
 - Renewable Energy Industry is immature
 - Oil, Gas & Coal industries do not like the idea
- **Given all these factors, the time to begin is NOW**



THANK YOU



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