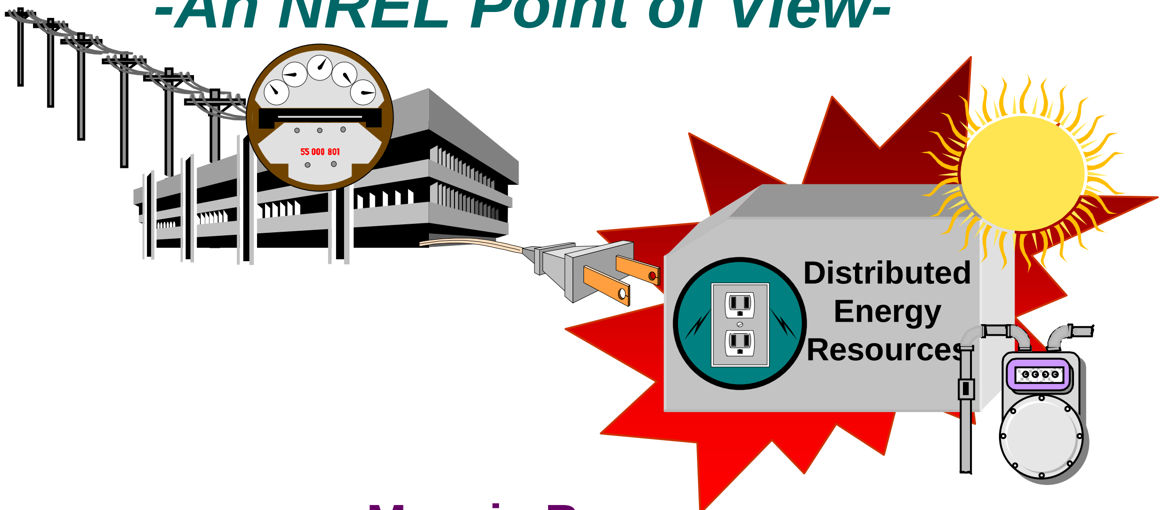
National Renewable Energy Laboratory

Clean Energy Opportunities

The Linkages of Renewables & Natural Gas in Distributed Energy Resources Markets

-An NREL Point of View-



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Presented at

National Science Foundation and Institute for Sustainable Technology and Development

At the Georgia Institute of Technology

Workshop on Sustainable Energy Systems

November 29 - December 1, 2000 Georgia Tech campus in Atlanta, GA

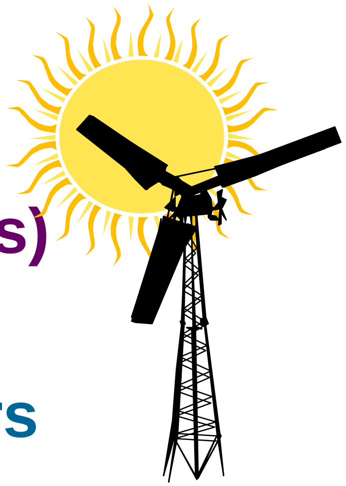
The National Renewable Energy Laboratory (NREL) is...

The U.S. Department of Energy's premier Laboratory for renewable energy & energy efficiency research, development & deployment.

Its mission is to lead the nation toward a sustainable energy future by developing renewable energy technologies, improving energy efficiency, advancing related science and engineering, and facilitating deployment.

The Challenge: Market Competitiveness of Renewable Energy "Product" Attributes

- **Excels:**
  - **Very favorable environmental characteristics**
  - **Indigenous, inexhaustible fuel supply not subject to price volatility**
  - **Relatively low O&M (especially fuel costs)**
- **Room for Improvement:**
  - **Intermittent availability - minutes to years**
  - **Relatively high costs - capital & unit**



In today's U.S. electric market, grid-connected renewables in most cases must compete with bulk power produced by fossil-fueled central station generators at commodity wholesale prices approaching historical lows.

There is good news and bad news for the cost of renewable generation.

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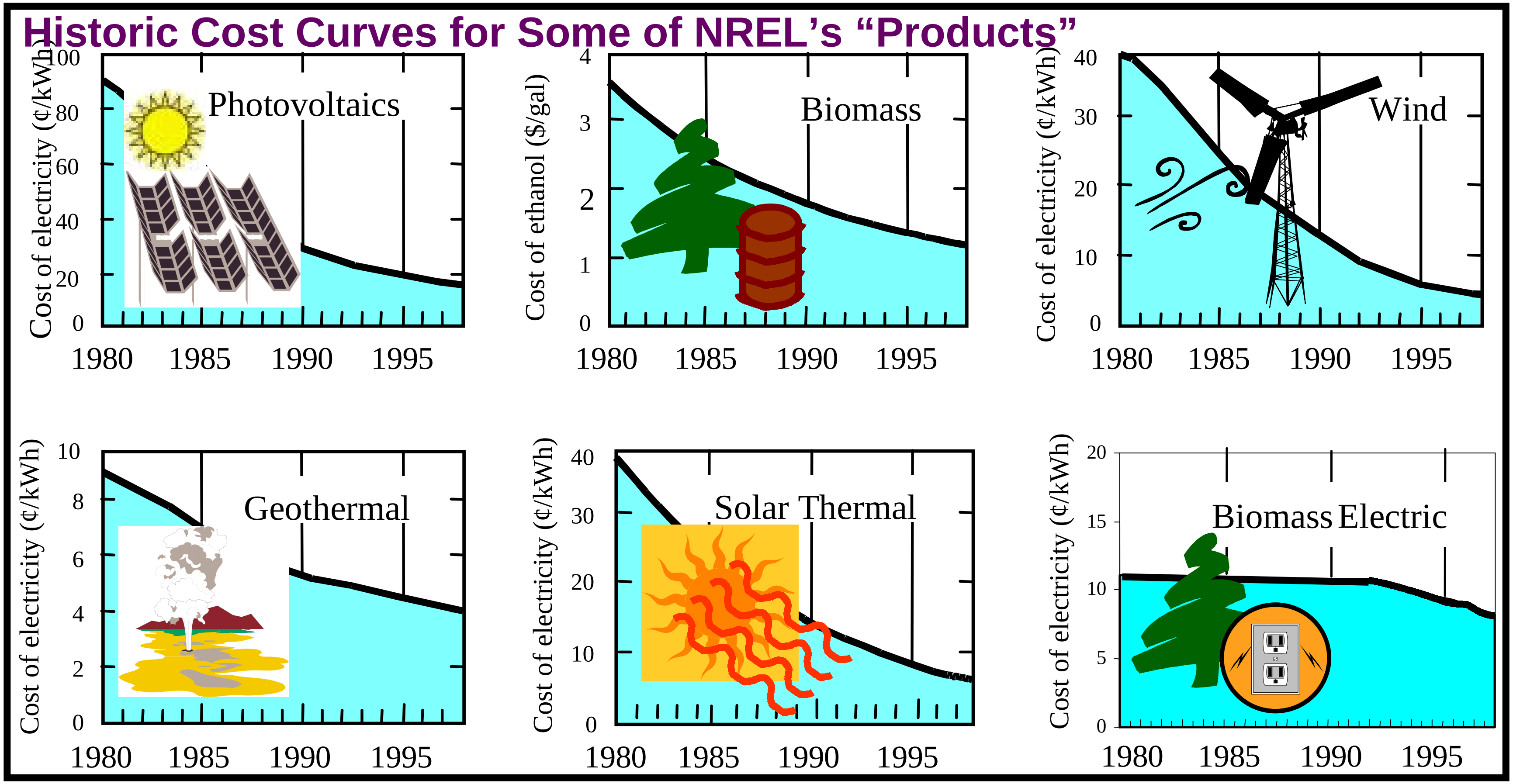
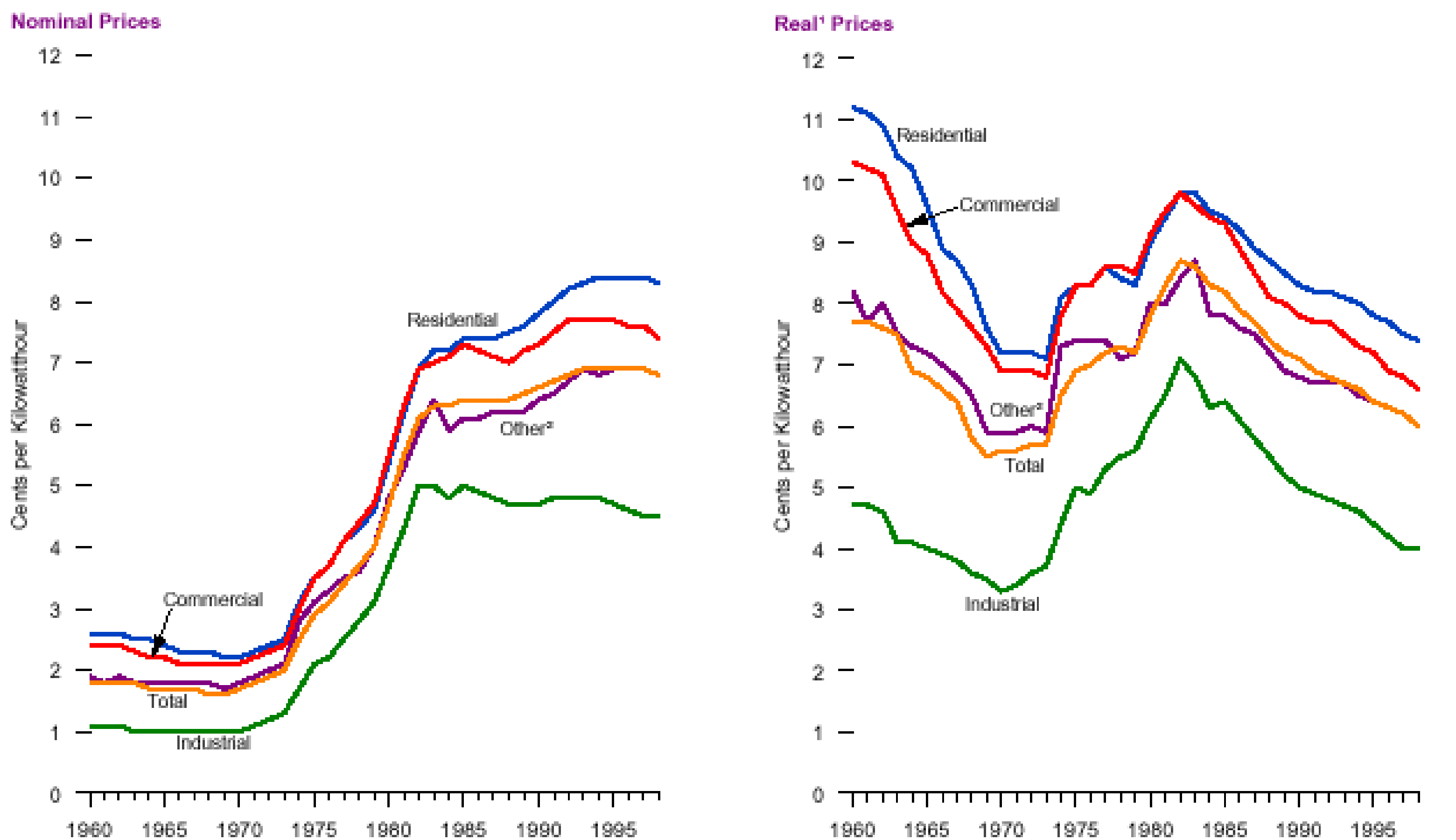


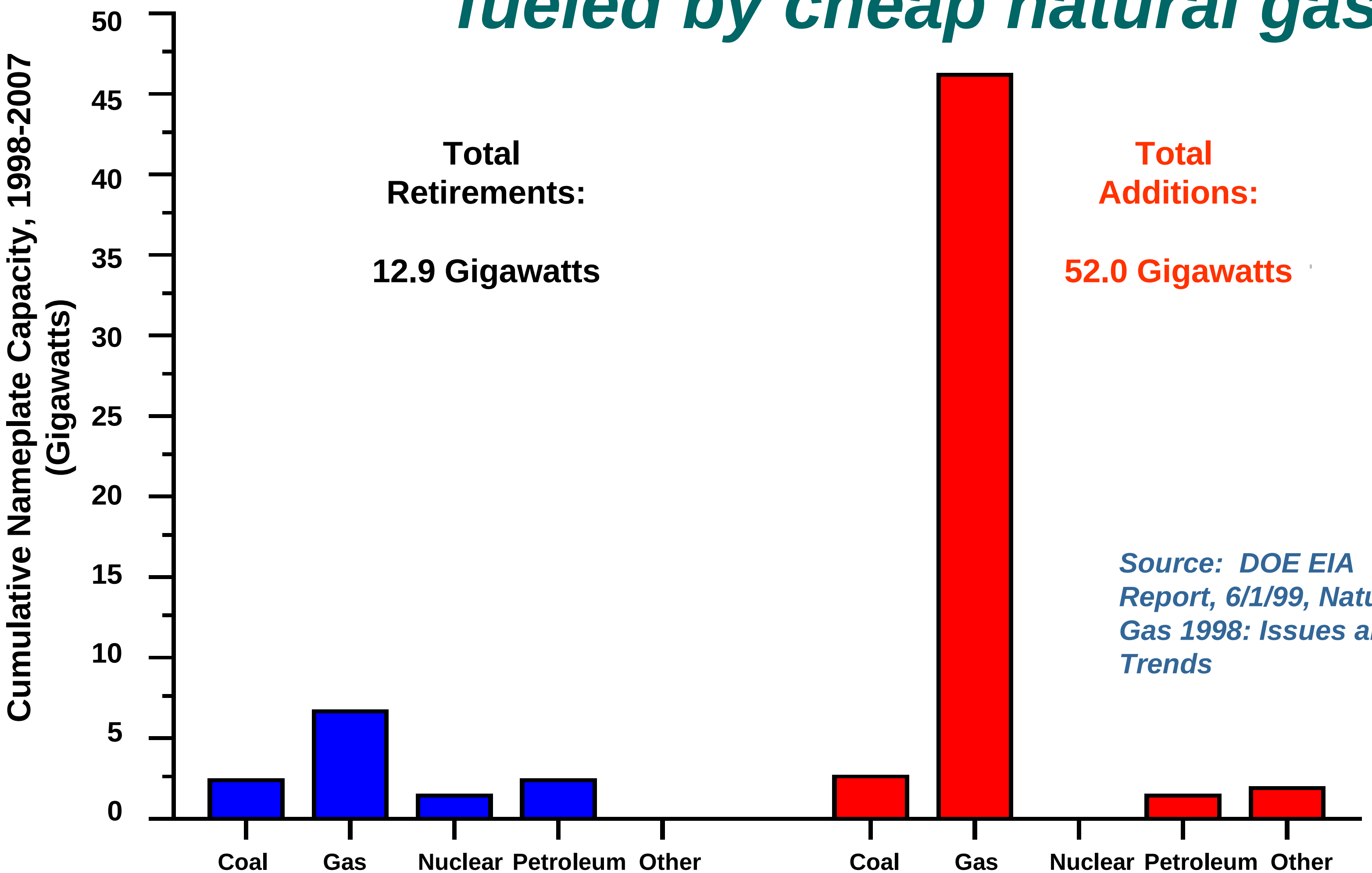
Source: Billman, Advances in Solar Energy submission, 1/8/99

The costs of renewables have steadily decreased over the last few decades, but so have the costs of other energy forms...

In real terms, electricity prices have declined in the last two decades.

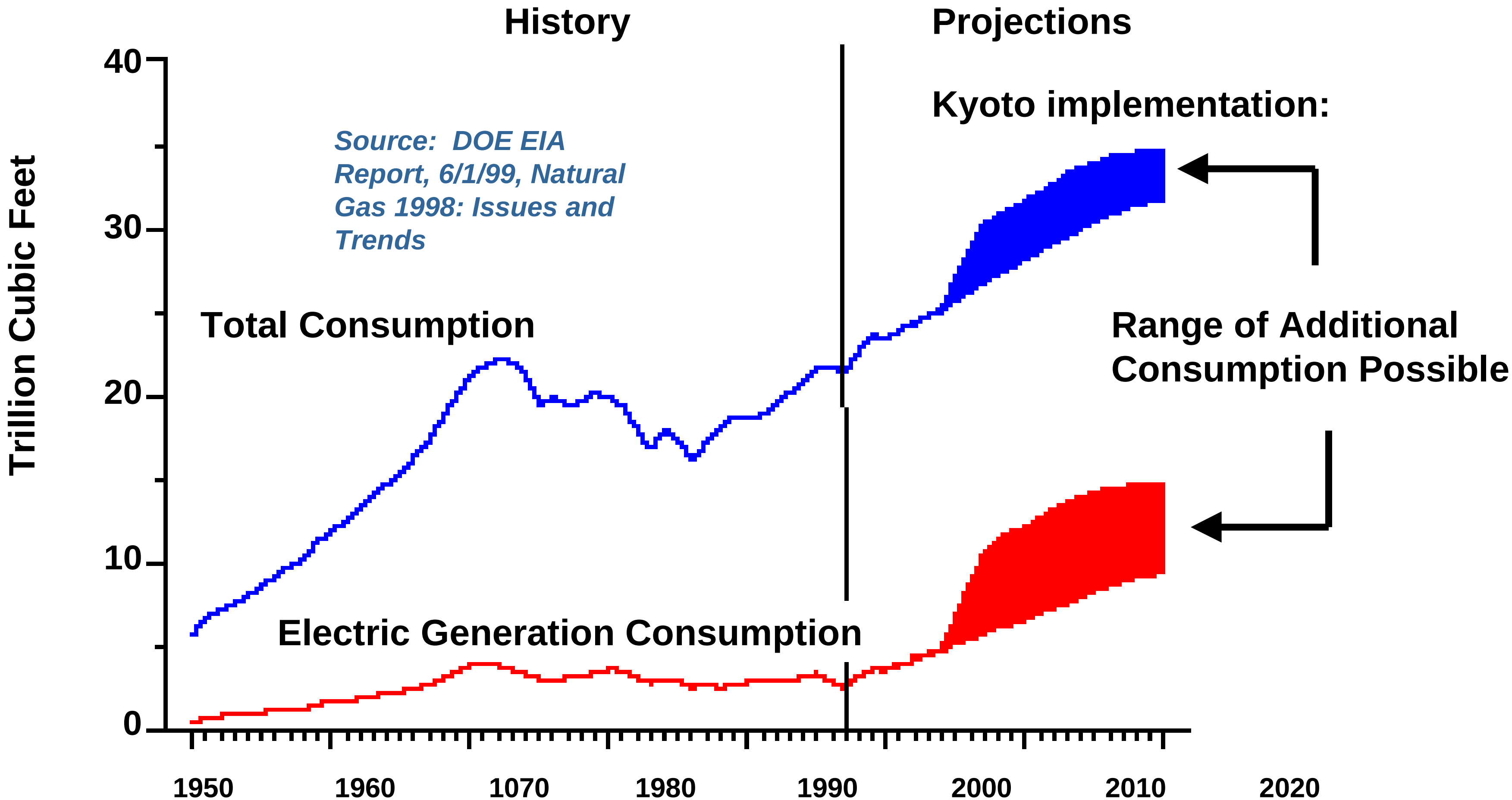


Most new electric capacity additions are expected to be fueled by cheap natural gas...



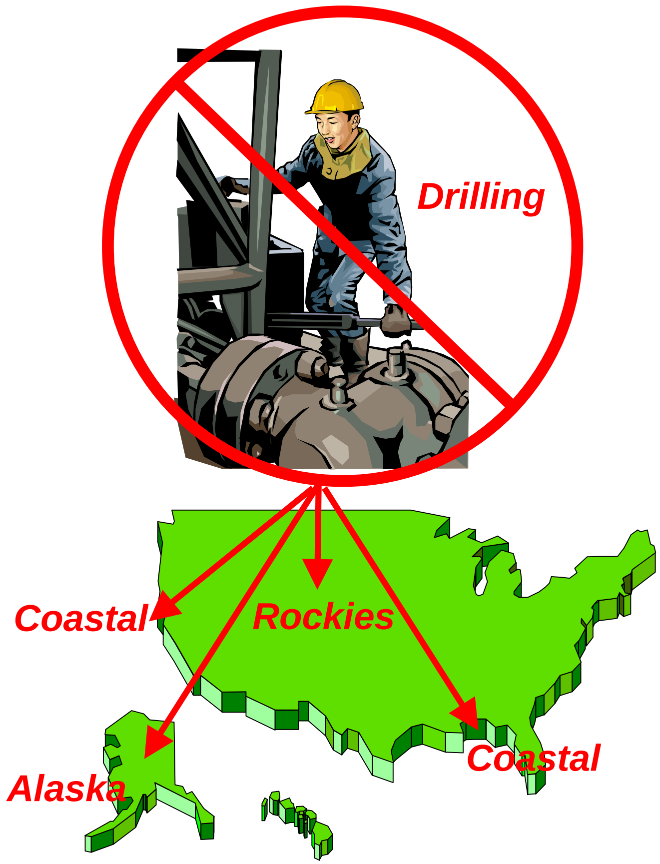
Source: DOE EIA Report, 6/1/99, Natural Gas 1998: Issues and Trends

Natural gas consumption is expected to increase about 50% by 2020….*And even more if the Kyoto Protocol is implemented*



Can this much gas be found, produced and delivered, and at what cost?

The long term outlook for domestic natural gas supplies contains uncertainties that might have cost and price implications.



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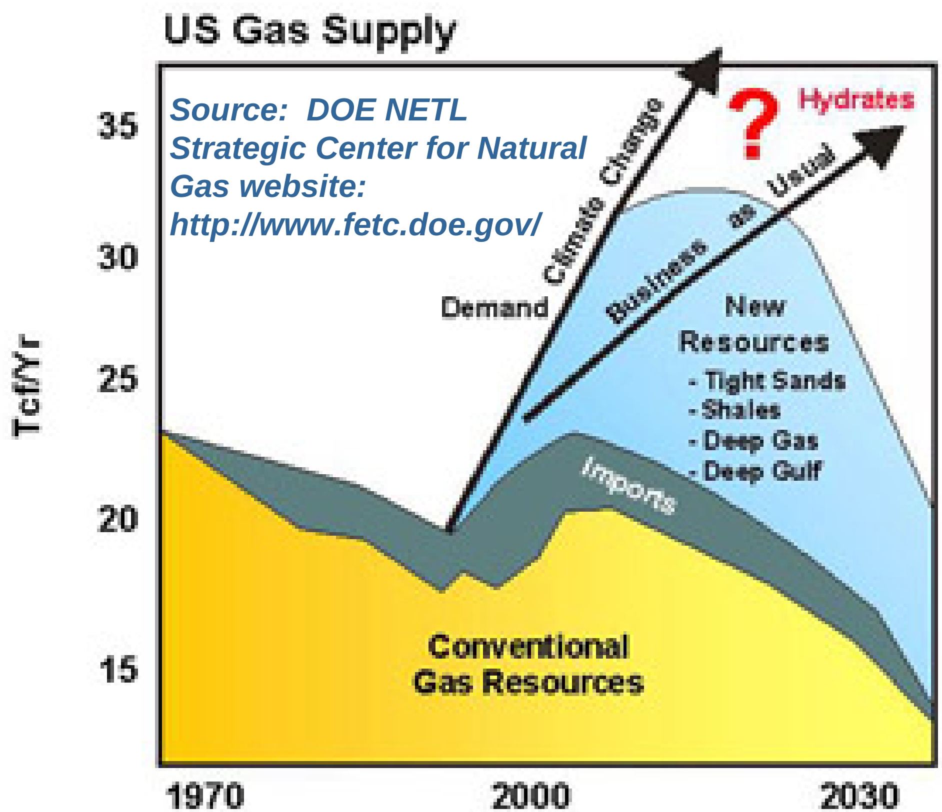
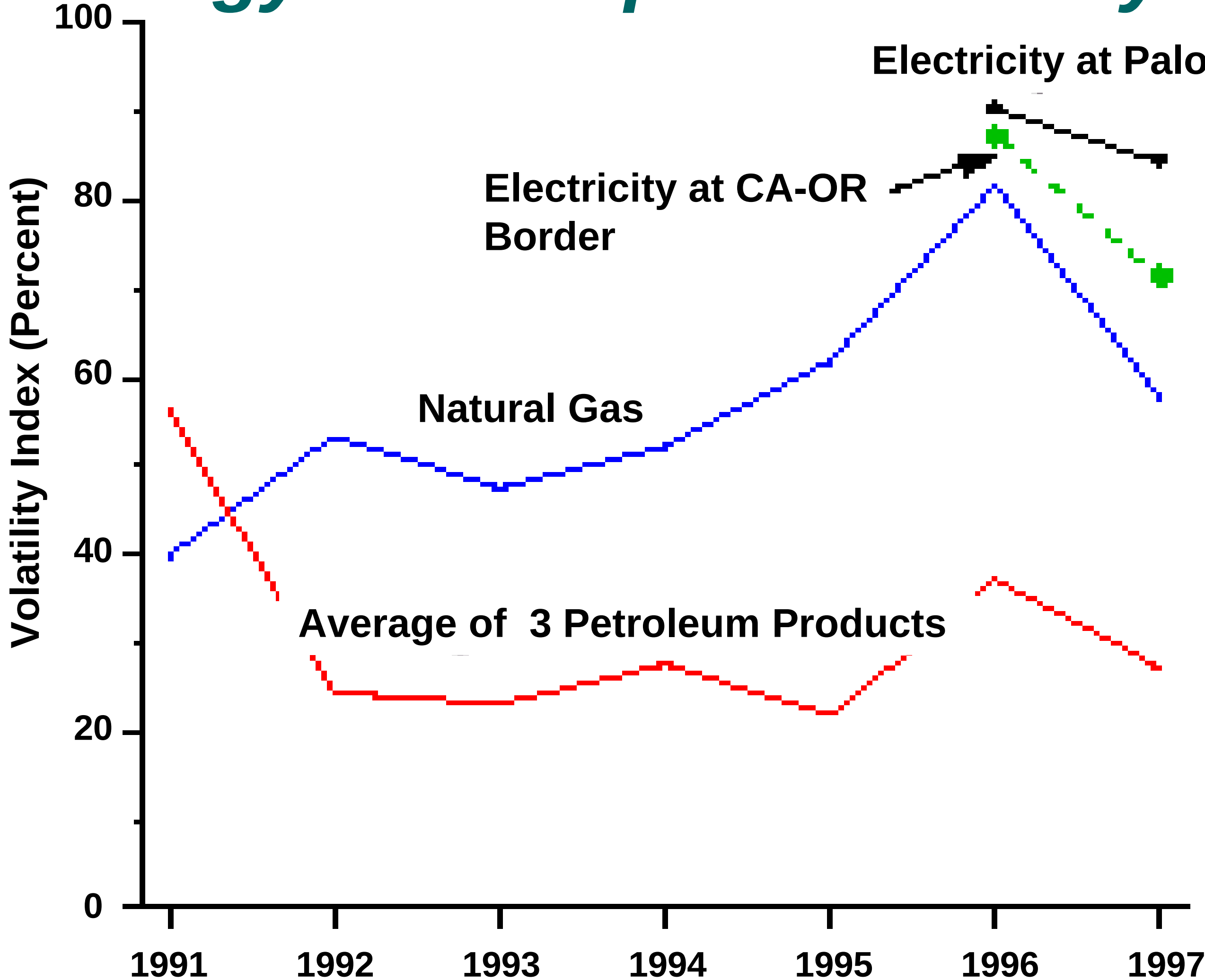


The National Petroleum Council estimates $750 B investment required over next 15 years to find, produce and deliver natural gas for a 30 Tcf market.

Can the gas industry compete for sizable investment capital against financially high-performing high-tech investment opportunities?

Natural gas is 2nd only to electricity in energy futures price volatility.



Source: DOE EIA Report, 6/1/99, Natural Gas 1998: Issues and Trends

Market Competitiveness of Natural Gas "Product" Attributes:

- **Excels:**
  - **Relatively clean - cleaner than coal & oil**
  - **Relatively low fuel costs**
  - **Relatively plentiful, there's a lot of CH_4 in the world**
- **Room for Improvement:**
  - **Contributes to greenhouse gases - CO_2 & CH_4**
  - **Long term supply: large reserves, but uncertain access and recovery costs**
  - **High infrastructure investment rates ($750B next 15 years) Can natural gas attract capital?**
  - **Price volatility - second only to electric**

Natural gas is clearly the dominant fuel of the foreseeable future, but some consider it a transition fuel because of long term environmental and supply issues.

Image taken from National Gas & Oil Technology Partnership website:http://132.175.127.176/ngotp/ngotp.htm

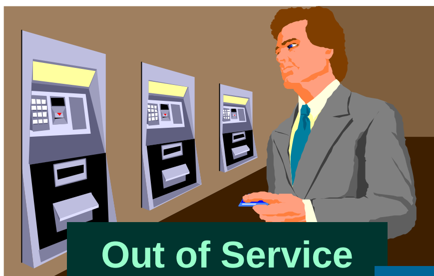
Given this market situation, what's the future for renewables?

Can renewables compete on cost alone?

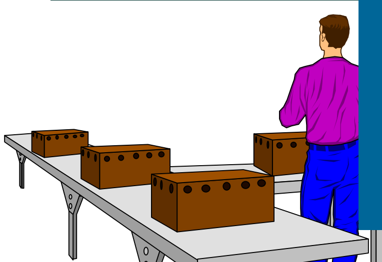
Do they have to compete on cost alone?

It depends on consumer preferences…

"It is not the cost of electricity that drives our decision-making process, rather it is the cost of NOT having electricity."*



Out of Service



Production Line Down

Remote & Village Power

High-Value Situations

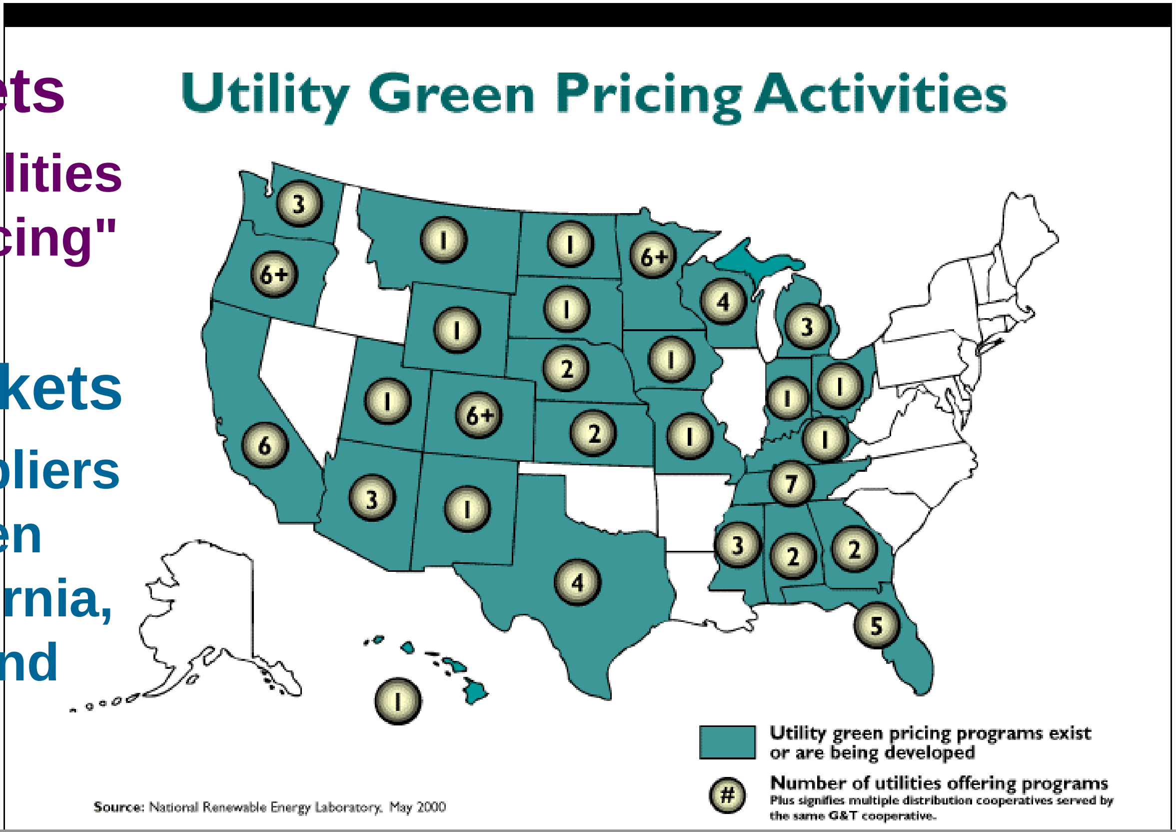
- Reliability
- Power Quality

The costs of not having electricity can be quite high in terms of human and financial health, e.g., outages of fractions of a second can cost millions of dollars in some businesses.

*Jeff Byron, Energy Director, Oracle Corp., at the E Source Distributed Energy Summit 2000

More than 25% of U.S. customers can choose to purchase some type of "green power" today.

- **Regulated Markets**
  - More than 50 utilities have "green pricing" programs
- **Competitive Markets**
  - Alternative suppliers are selling "green power" in California, Pennsylvania, and New England



The reason is that many customers, ratepayers and tax payers are will to pay a premium for "green power.".

The profile of a modern energy consumer...

- **Playing in an increasingly open and competitive energy marketplace**
- **Encountering global competition, so cost matters**
- **Increasingly digitized, i.e., requires greater reliability**
- **Increasingly concerned with health and**
- **environment**
- **Becoming more globally connected, market sophisticated, and independent**
- **Demanding greater product and service differentiation**

… which lead to complex value propositions, where cost isn't everything, creating a need for new products and services.

Out of restructuring a new breed of energy providers is emerging that is:

Focusing on customer service instead of assets

&

Seeking new products and services that will be the "cell phone" equivalent for the new energy service business

How can renewables be offered as an energy product that serves both needs, and thereby bring significant benefit to the modern energy consumer?

Natural gas and renewables have many compatible strengths:

Natural Gas:

"The Transition Fuel"

- Low cost
- Plentiful, with high availability factor
- Moderately clean
- More popular than coal and nuclear, per public surveys
- Employs modular technology
- Mature extensive industry value chain infrastructure (but not ubiquitous)

Renewables:

"The Sustainable Future"

- "Free fuel"
- Sustainable
- Very clean and a balanced carbon cycle
- More popular than any other energy form, per public surveys
- Employs modular technology
- "Home" delivery; doesn't require a complex delivery infrastructure

Should they be working together instead of competing?

Actually, renewable/fossil hybrid generators working together have been around for sometime.

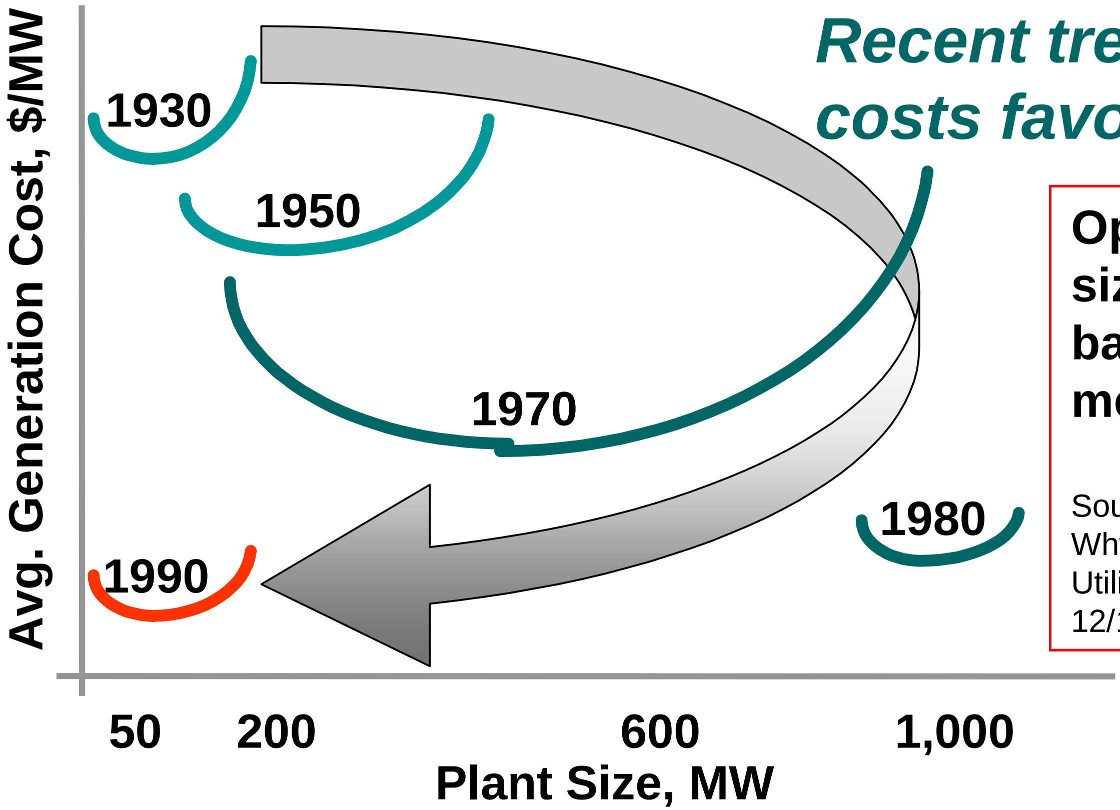
But can hybrids be moved from the villages to the cities?

Natural gas and renewable hybrids might have the potential to:

- **Compensate for the intermittency of renewables**
- **Bring a more “green” and “sustainable” image/reality to natural gas generation**
- **Provide more robust market distribution channels for renewables**
- **Mitigate investment risks and improve asset utilization for natural gas delivery infrastructure investments**
- **Soften the impacts of high first costs for renewables**
- **Provide price risk mitigation against natural gas market volatility**

… Offer new superior products for the natural gas and renewable industries, that compensate for the deficiencies and build on the strengths of each.

Distributed Energy Resources



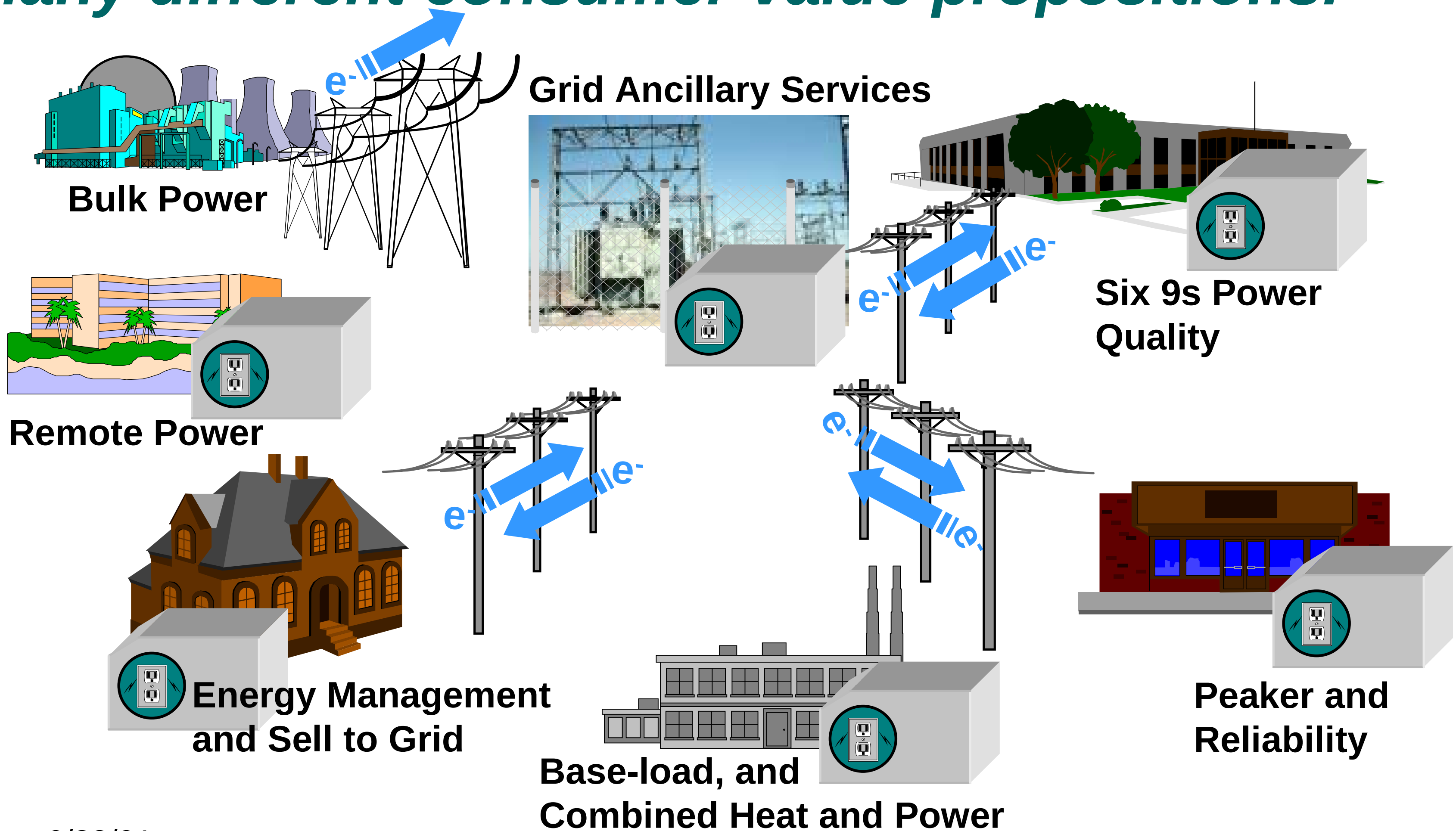
Recent trends in generation costs favor small unit sizes.

Optimal generation plant size for a single plant based on cost per megawatt [MW], 1930-1990

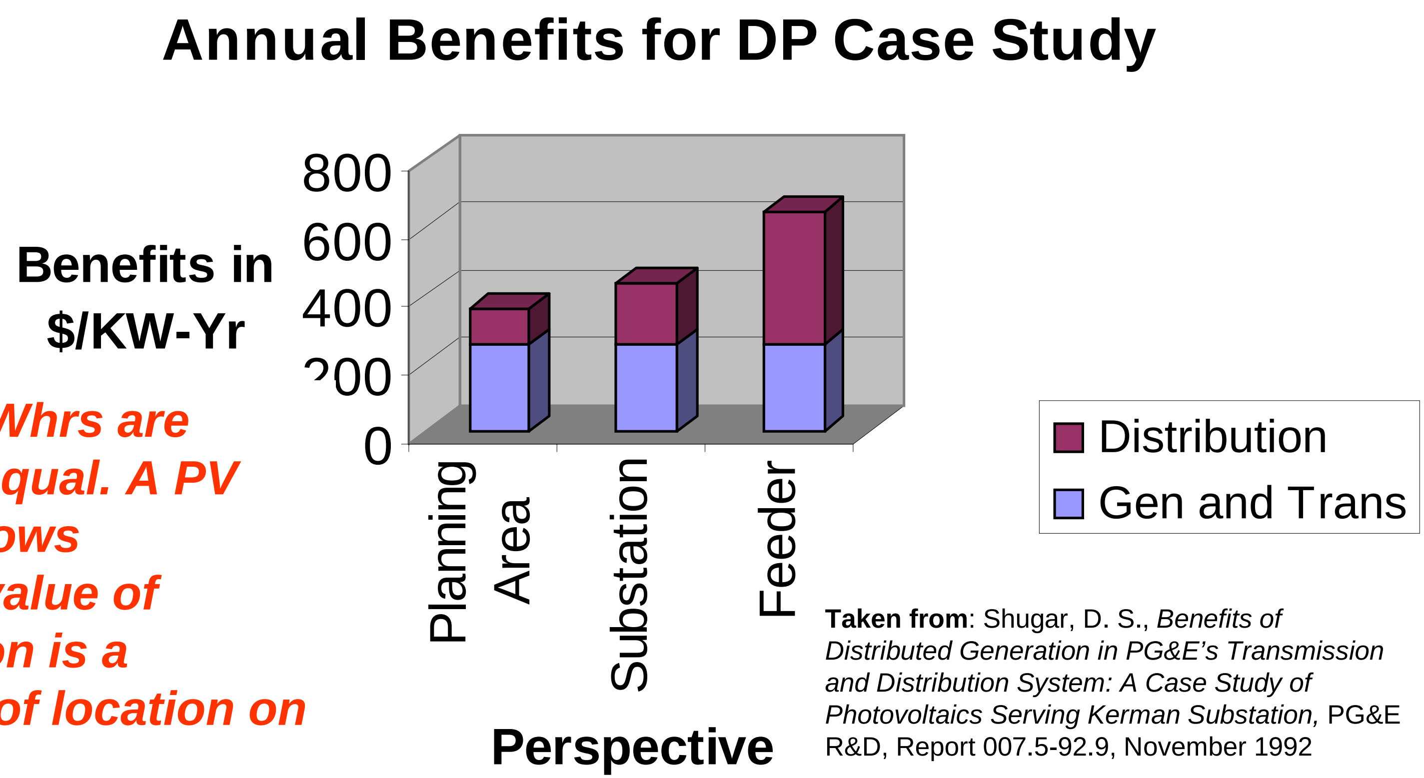
Source: Charles E. Bayless, "Less is More: Why Gas Turbines Will Transform Electric Utilities." Public Utilities Fortnightly 12/1/94

Power plant financing and siting, typically done by large companies, like public utilities, may now be feasible for smaller companies and energy consumers, enabling a new generation market paradigm: **Distributed Energy Resources**

Distributed energy resources are emerging as a new way of producing electricity that can satisfy many different consumer value propositions.



The value of electric power generation can vary considerably depending on where it is deployed.

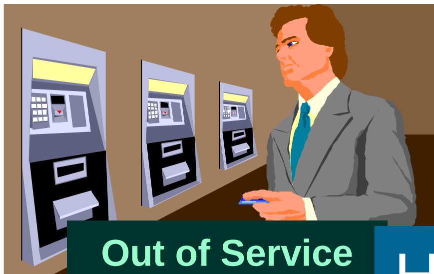


Taken from: Shugar, D. S., *Benefits of Distributed Generation in PG&E's Transmission and Distribution System: A Case Study of Photovoltaics Serving Kerman Substation,* PG&E R&D, Report 007.5-92.9, November 1992

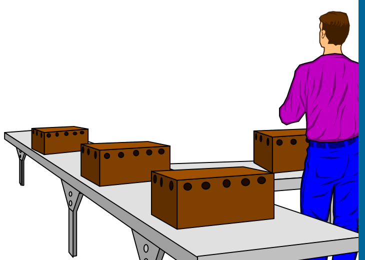
Not all KWhrs are created equal. A PV demo shows that the value of generation is a function of location on the grid

The value of electric power can be highest when deployed as "distributed energy resources."

Today, distributed energy resources are being deployed in a few high-value niche markets.



Out of Service



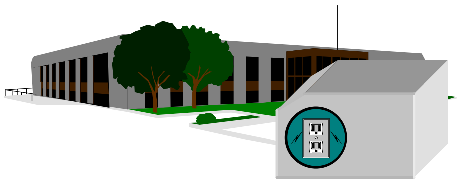
Production Line Down

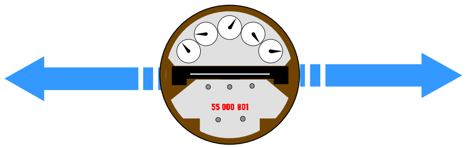
High-Value Situations
- Reliability
- Power Quality
- Independence

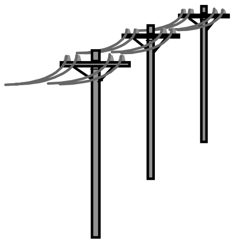
Remote & Village Power

But "Remote & Village Power," primarily non-grid connected applications in emerging economies, and "High-Value Situations," primarily grid-connected applications in mature economies, do not yet exploit the potential of distributed energy resources.

Distributed energy resources can produce many benefits on both sides of the electric meter.







Consumer-Side Benefits

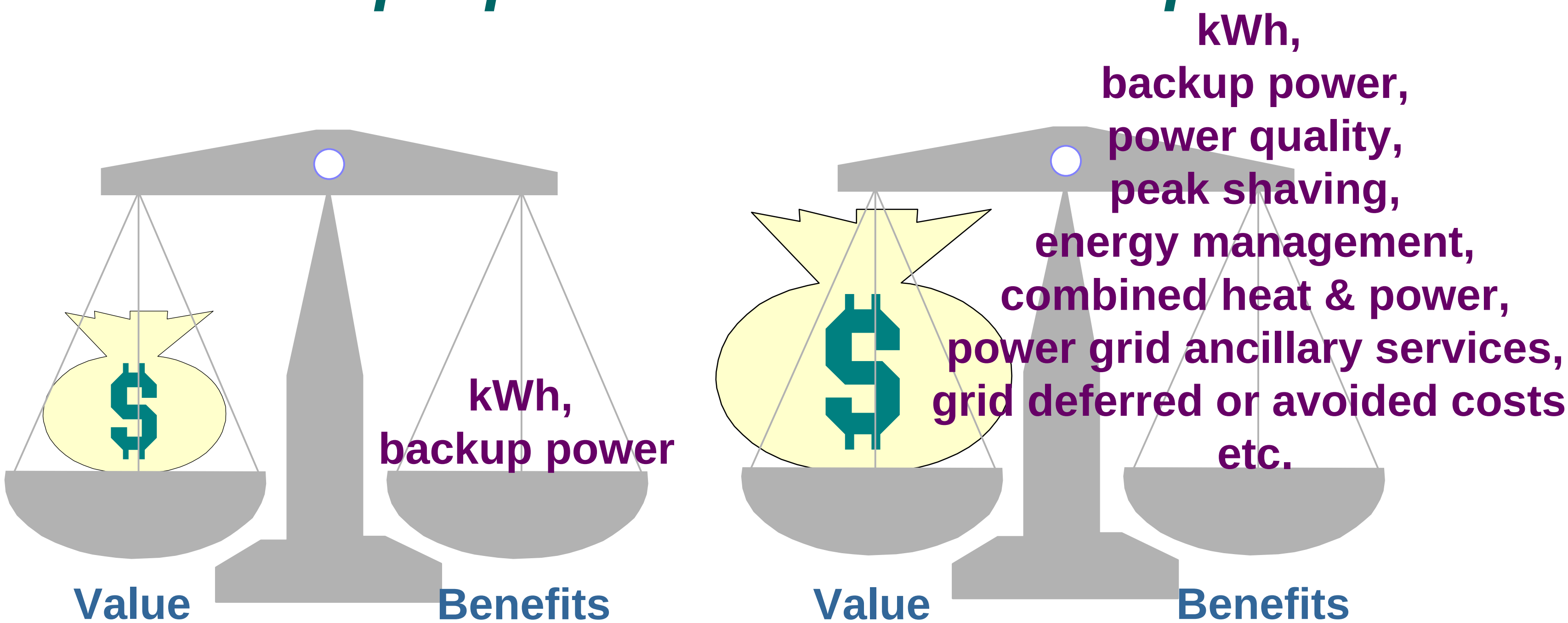
- Lower cost electricity
- Greater price risk mitigation
- Greater reliability and power quality
- Energy and load management
- Cogeneration capability

Grid-Side Benefits

- Reduced electric line loss
- Reduced upstream congestion
- Grid investment deferment
- Improved grid asset utilization
- Improved grid reliability
- Ancillary services, such as voltage support or stability, VARs, contingency reserves, and black start capability

In ideal "full-value" deployment, the distributed energy resources "owner," through either contractual or regulatory arrangements, realizes the value of direct local benefits to the energy consumer, and also the economic value of the additional benefits created for the local grid.

The value of grid-integrated distributed energy resources is proportional to benefits provided.



The number of benefits provided and their value depends on where, when and how the distributed energy resources system is deployed.

Case Studies: Value to Utilities of Distributed Energy Resources

Southern California Edison Suburban PV

Benefit	$/kW
Distribution facility deferral	186
Distribution losses	53
Voltage regulation	-4
Transmission capacity	282
Transmission losses	38
Generation capacity	***624***
Energy displacement	***1,110***
Environmental externalities	339
Total Value	**2,628**

Southern California Edison Rural Wind Farm

Benefit	$/kW
Distribution losses	217
Voltage regulation	-4
Transmission capacity	88
Transmission losses	44
Generation capacity	195
Energy displacement	***1,580***
Environmental externalities	***520***
Energy Policy Act	297
Total Value	**2,936**

Courtesy of Henry W. Zaininger, Zaininger Engineering Co., Inc.,
9959 Granite Crest Ct., Granite Bay, CA 95746, taken from CEC
Energy Innovations '99, October 25 - 27, 1999

Case Studies: Value to Utilities of Distributed Energy Resources, Cont'd.

Georgia Power Company Suburban PV

Benefit	$/kW
Distribution losses	62
Voltage regulation	-4
Transmission capacity	86
Transmission losses	32
Generation capacity	288
Energy displacement	***567***
Total Value	**1,031**

Florida Power & Light Suburban PV

Benefit	$/kW
Distribution losses	45
Voltage regulation	-3
Generation capacity	***733***
Energy displacement	***428***
Total Value	**1,203**

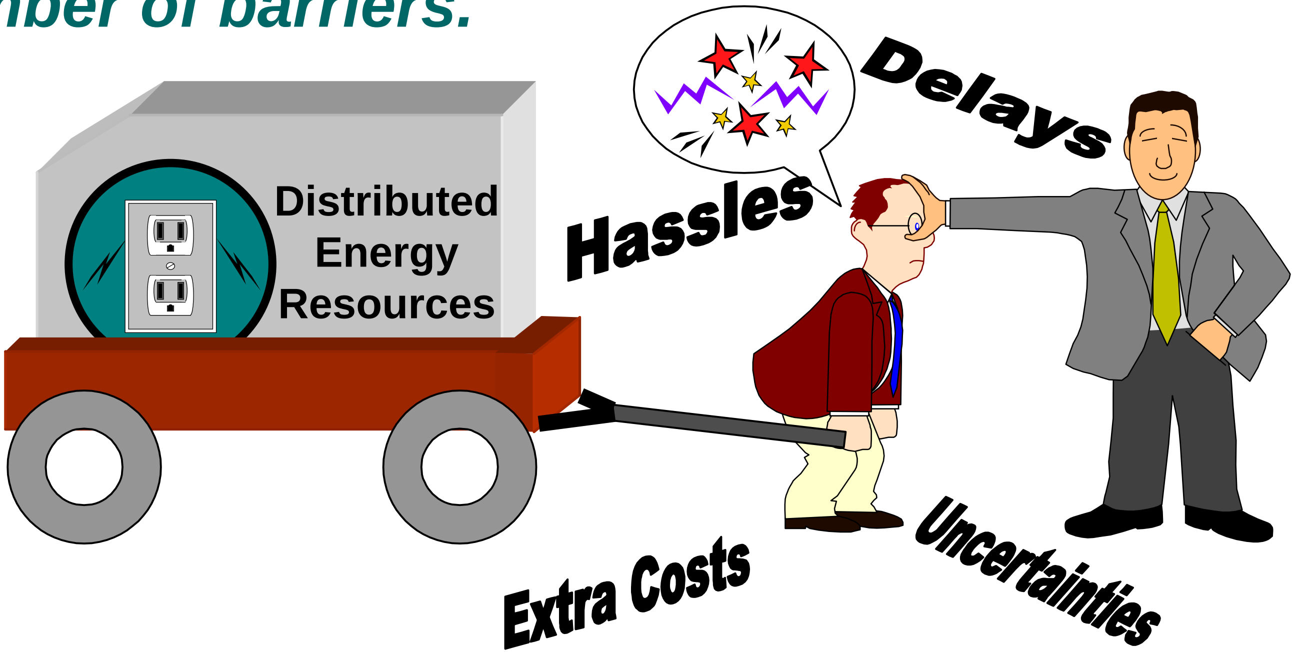
Courtesy of Henry W. Zaininger, Zaininger Engineering Co., Inc., 9959 Granite Crest Ct., Granite Bay, CA 95746, taken from CEC **Energy Innovations '99, October 25 - 27, 1999**

This Analysis Suggests Two Market Destinations for Distributed Energy Resources.

- **The *Early Niche Markets* destination is reached with the emergence of a healthy distributed energy resources industry serving the high-value needs of early adopters in specialized situations.**

- **The *Full-Value Markets* destination is realized when market structures, policies, and technologies have evolved to the point that distributed energy resources systems can be deployed to produce multiple benefits on both sides of the electric meter and their "full-value" can be captured.**

But as vendors of distributed energy resource systems try to bring these new products to market, they face a number of barriers.



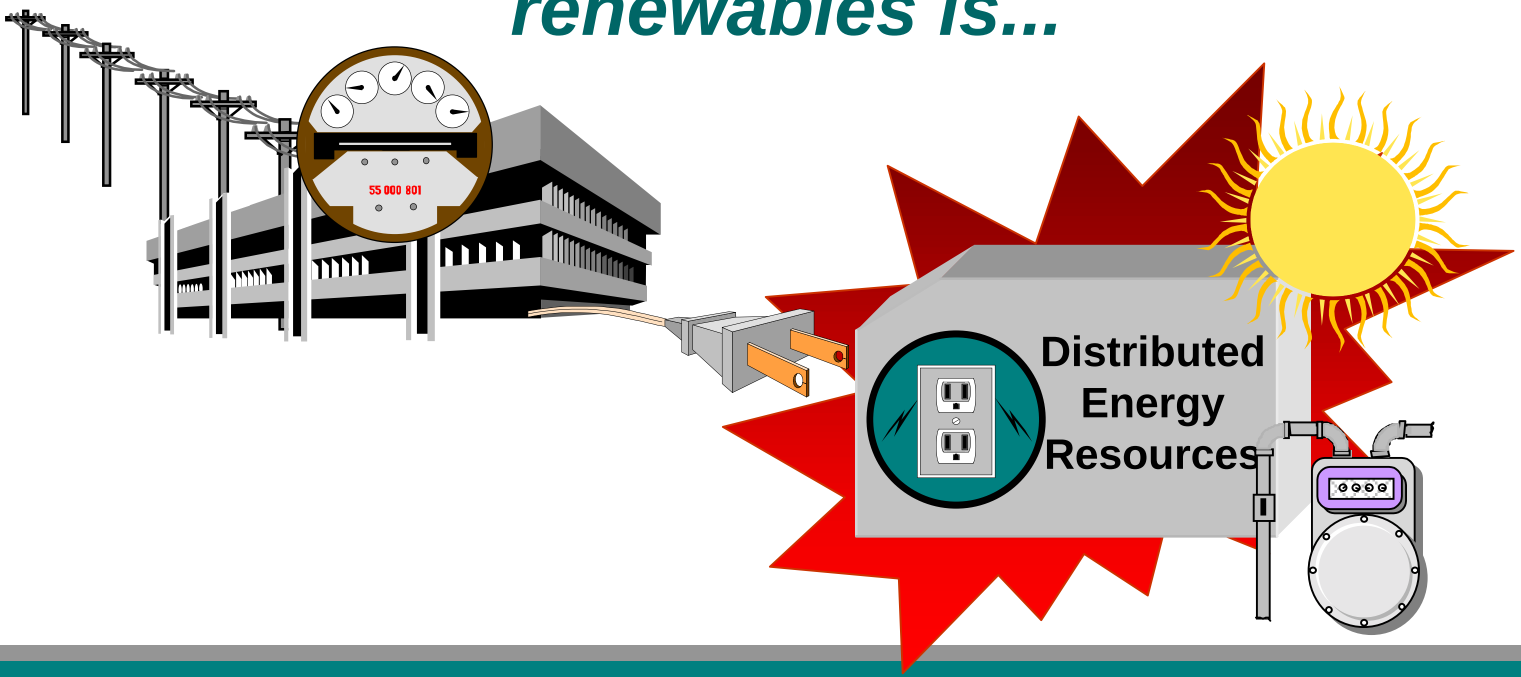
Many barriers are artifacts of the old regulated electric markets that have lost their relevance in a deregulated market. Others arise from a lack of knowledge and experience associated with this relatively new form of providing energy services.

Most of these barriers can be mitigated by addressing four sets of issues.

- **Technical requirements for grid interconnection**, e.g., safety and power quality
- **Permitting**, e.g., environmental, building codes, etc.
- **Rules of engagement** for interconnection, e.g., legal, economic, financial and regulatory
- **Obtaining "full value"** for benefits of the distributed energy resources installation.

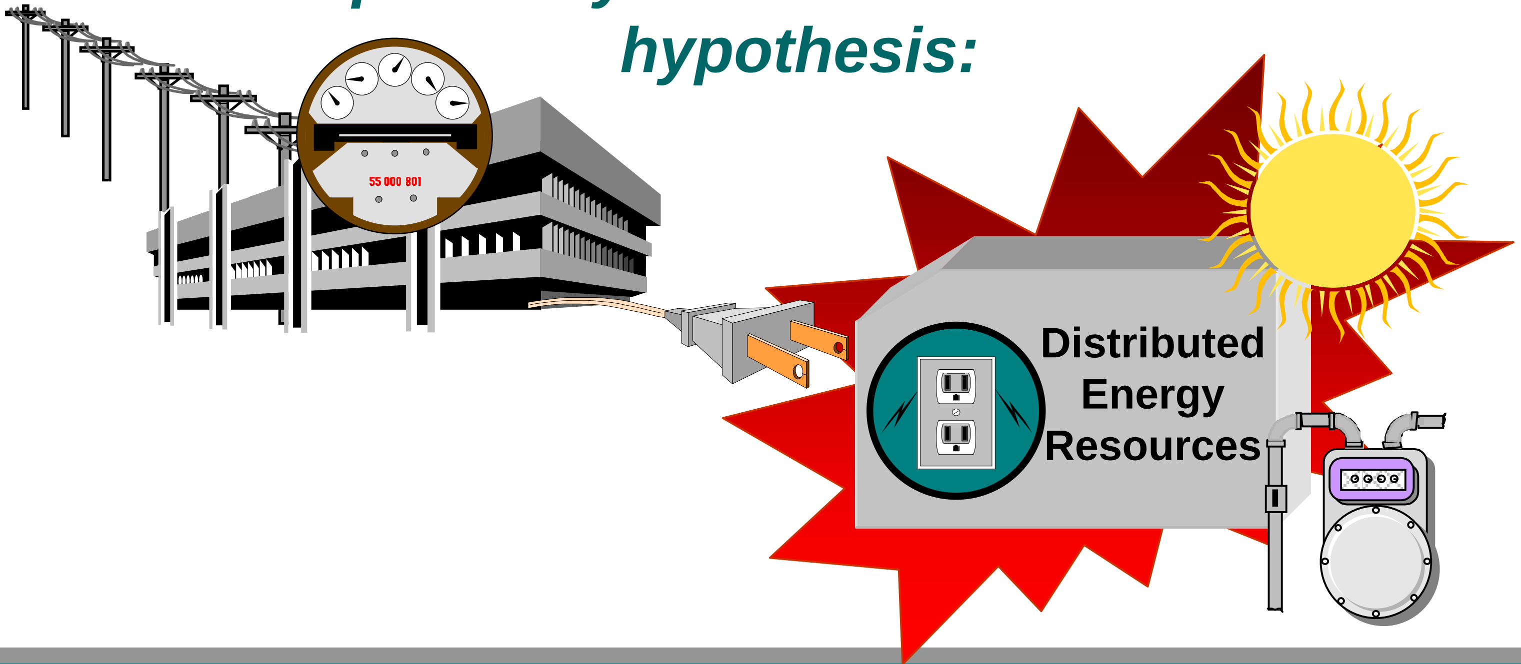
The first three issues relate to near term market barriers; the fourth issue is one facing the long term prospects for the ultimate "full-value" deployment of distributed energy resources.

Then the vision for the 21st century for renewables is...



… barriers to DER deployment are removed; market structures, policies and technologies that allow "full value" DER deployment are in place, and renewables and natural gas/renewable hybrids are providing considerable value to energy consumers and society.

The vision for renewable and renewable/fossil hybrid distributed power systems is based on the following hypothesis:



Hybrids of natural gas and renewables can result in superior generation products by combining the advantages of both energy resources. Furthermore, deployed as distributed energy resources (DER), renewables and hybrids would enjoy the competitive advantage of serving high value markets. To "test" the hypothesis...

More short term understanding and long term assessments of natural gas and renewable hybrids are needed to answer these questions:

- **Which combinations of attributes of natural gas and renewables produce the most benefits under what circumstances?**
- **What is the relative importance to Modern Energy Consumers of energy costs, compared to environmental, reliability, etc., attributes?**
- **Do hybrids face any special technical, policy or market barriers?**
- **In which markets are hybrids the most competitive?**

Two main strategic elements for advancing distributed energy resources systems integration are proposed:

First Strategic Element: "Act Quickly to Remove Barriers to Distributed Energy Resources in Near Term Markets"

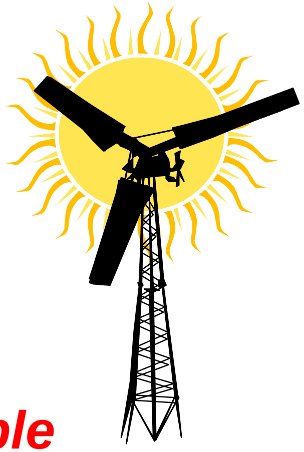
> ***In the "Early Niche Markets," the timely emergence of a healthy distributed energy resources industry is required to serve the basic needs of early adopters. Quick action required to avoid similar delays in distributed energy resources deployment that were seen in the 10 - 20 year transition to competition in telecommunications.***

Second Strategic Element: "Develop Tools and Structures for 'Full-Value' Markets for Distributed Energy Resources Systems"

> ***Distributed energy resources provides highest value in electric markets that approach "full-value" exploitation of its many benefits. What's needed over the long term are technical "tools" and establishment of market structure and rules that are conducive to the deployment of distributed energy resources in "'Full-Value' Markets".***

Concluding Summary

Summary: Assessment of Renewable Energy Market Competitiveness



- Grid-connected renewables mostly must compete with fossil-fueled central station generators at commodity wholesale prices approaching historical lows.
- *Natural gas is clearly the dominant fuel of the foreseeable future, but some consider it a transition fuel because of long term environmental and supply issues.*
- Many energy consumers have complex value propositions where lowest cost is not always the only driver.
- Renewables have a number of attributes that appeal to many modern energy consumers
  - Clean
  - Sustainable
  - Indigenous
  - Low-price volatility

Summary: Assessment for Renewable Energy Market Competitiveness - cont'd

- Can natural gas/renewable hybrids combine the strengths of both to offer improved products and open new markets for the natural gas and renewable industries?
- Deployed as distributed energy resources, a renewable or hybrid generator, by virtue of its location and functionality, could potentially provide higher marginal value, and hence enjoy a better competitive position, than in a wholesale central station market.
- "Full-Value" distributed energy resources markets represent the best opportunity for many renewables and hybrids.