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A Natural Gas Enabled Smart Grid Opportunities for Distributed Energy Resources

Solid State Energy Conversion Alliance

July 24, 2012

Pittsburgh, PA

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Electric Power Research Institute

Fuel Cell R&DD at EPRI

we help move technologies to the commercialization stage

Smart Grid

Aggregation

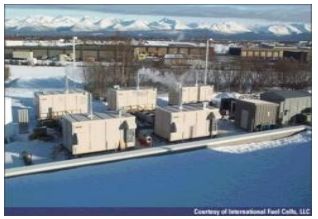
1980

1990

2000

2010

2020



5 – 10 MW PAFC | 200 kW – 1 MW PAFC | 2 MW MCFC | 1.5 kW - 3 MW SOFC

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You are working on Game Changing Technology !

However….

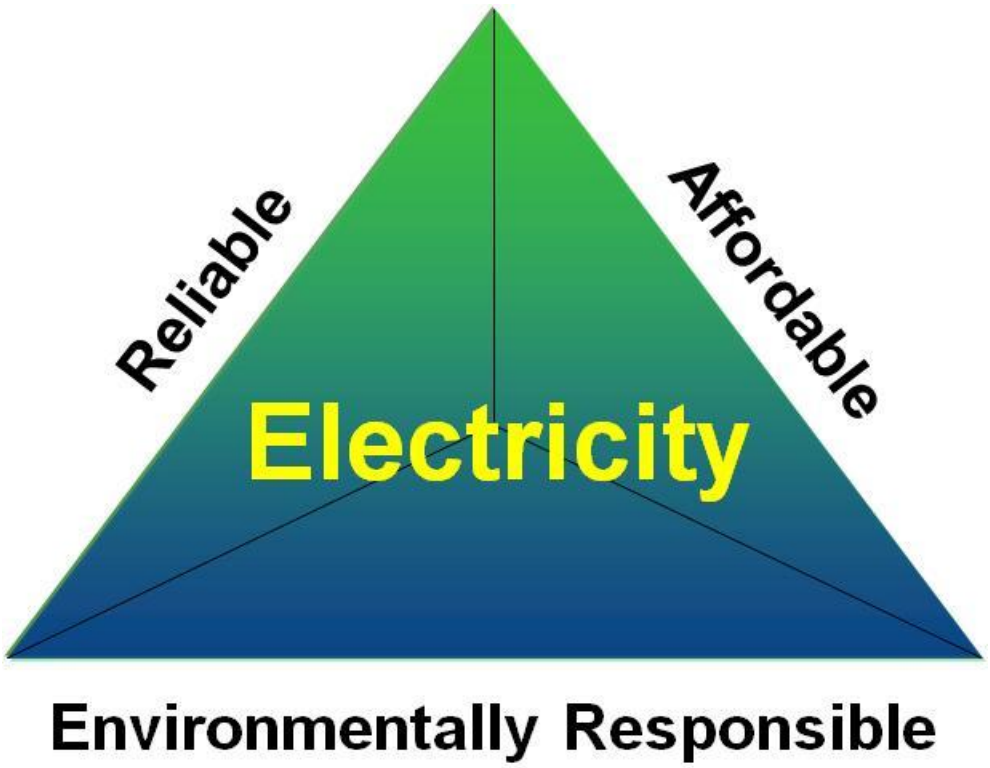
- Great technology is not enough
- Does it solve a problem or address a “pain” point?
- Where are markets, early adopters, channels to markets?
- Is there a compelling business case?

Discussion Outline

- Industry Challenges; Key Issues and Drivers
- Natural Gas Bubble is Back !
- Roles for natural gas in the Electric Sector
- Technology Options and Distributed Gen
- Paving the way for opportunities with Fuel Cells in evolving Smart Grid
- Summary

The Challenge

Provide society with…



. . . while transforming the Power System to a cleaner, more efficient, modern generation fleet, and an interactive electrical grid.

Key Industry Strategic Technical Issues

Smart Grid

Energy Efficiency

Long-Term Operations

Renewable Resources and Integration

Near Zero Emissions

Water Resource Management

Potential for SOFC Value

Industry Driver: Generation Options

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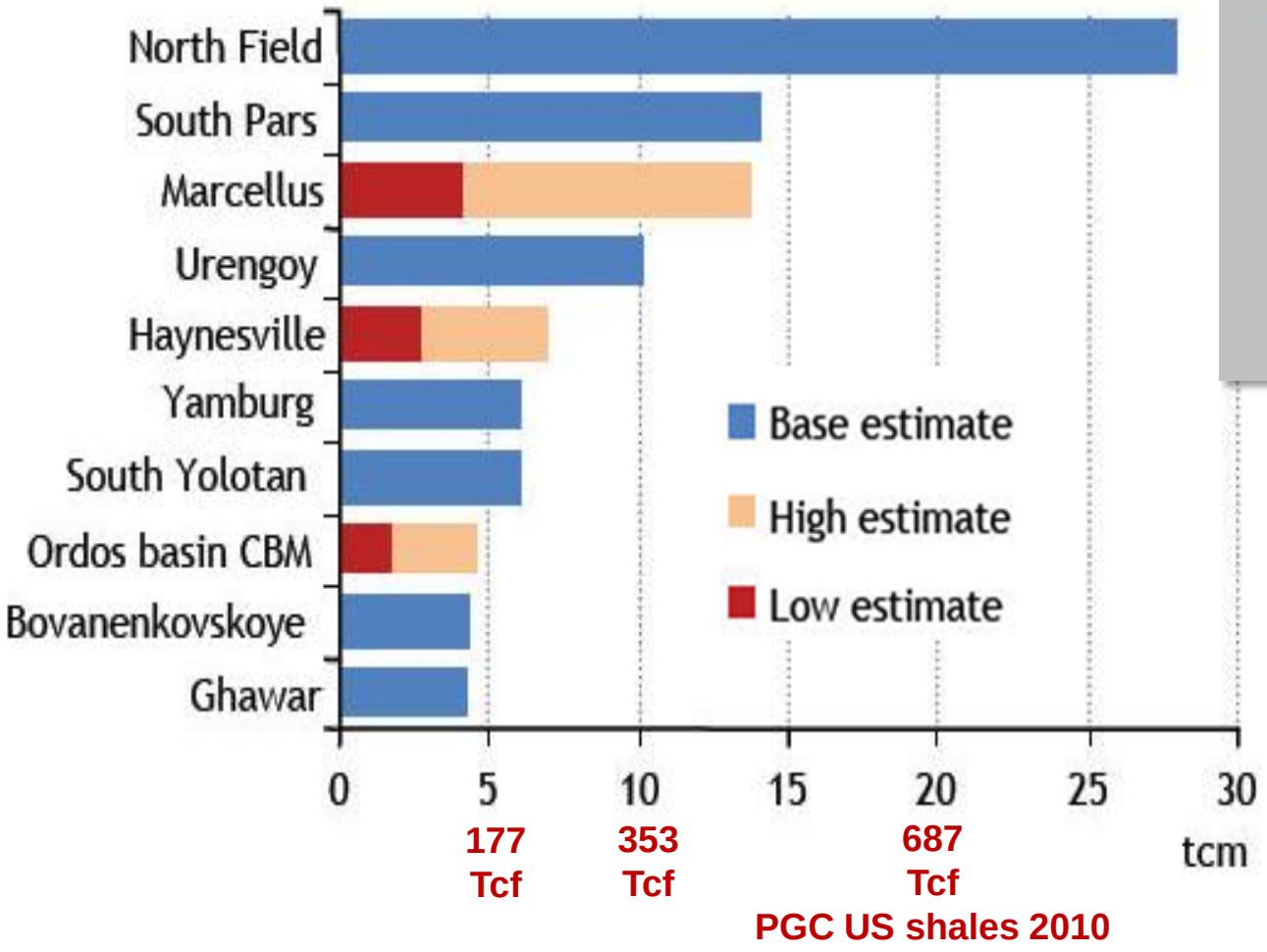
Driver: Global Availability of Natural Gas

Some of World's Largest Natural Gas Fields

Initial Recoverable Resources



http://www.iea.org/weo/docs/weo2011/**WEO**2011_**GoldenAgeofGas**Report.pdf

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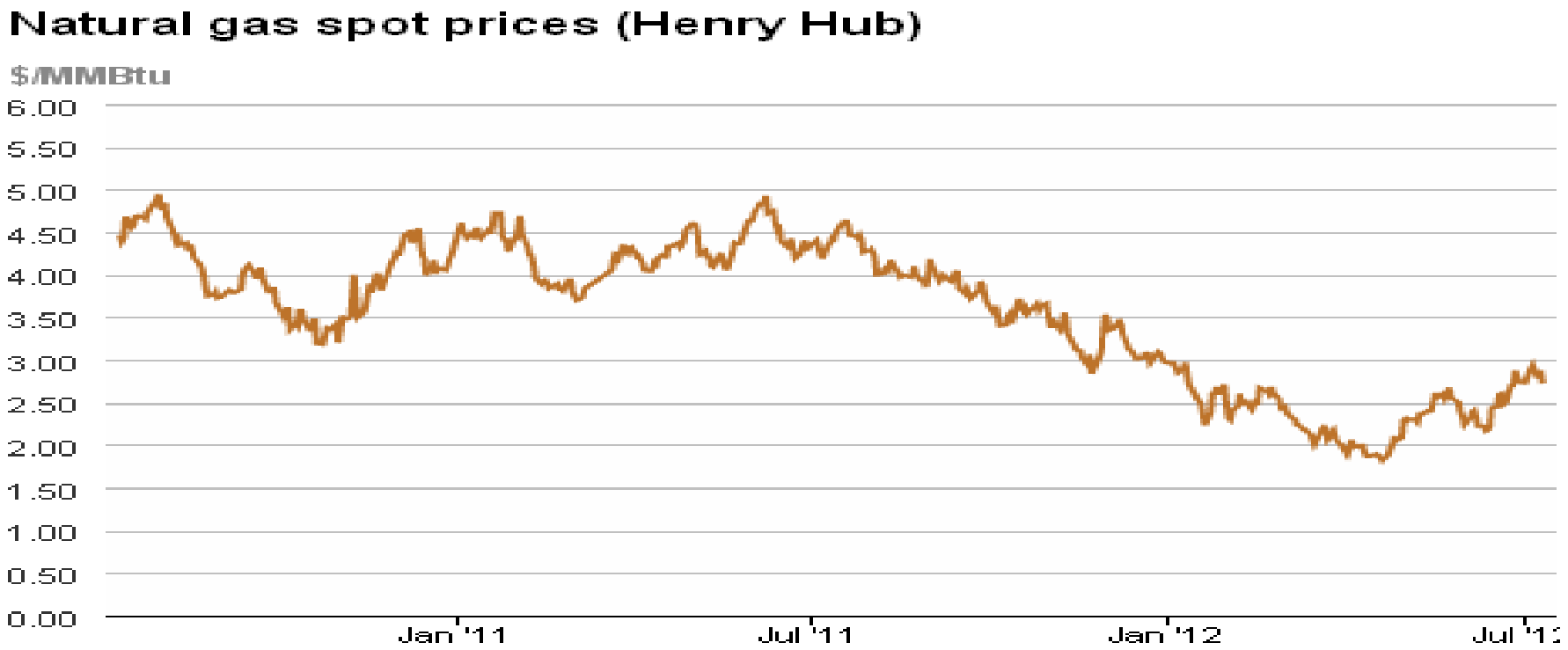
Natural Gas Price Trends



eia Source: Natural Gas Intelligence

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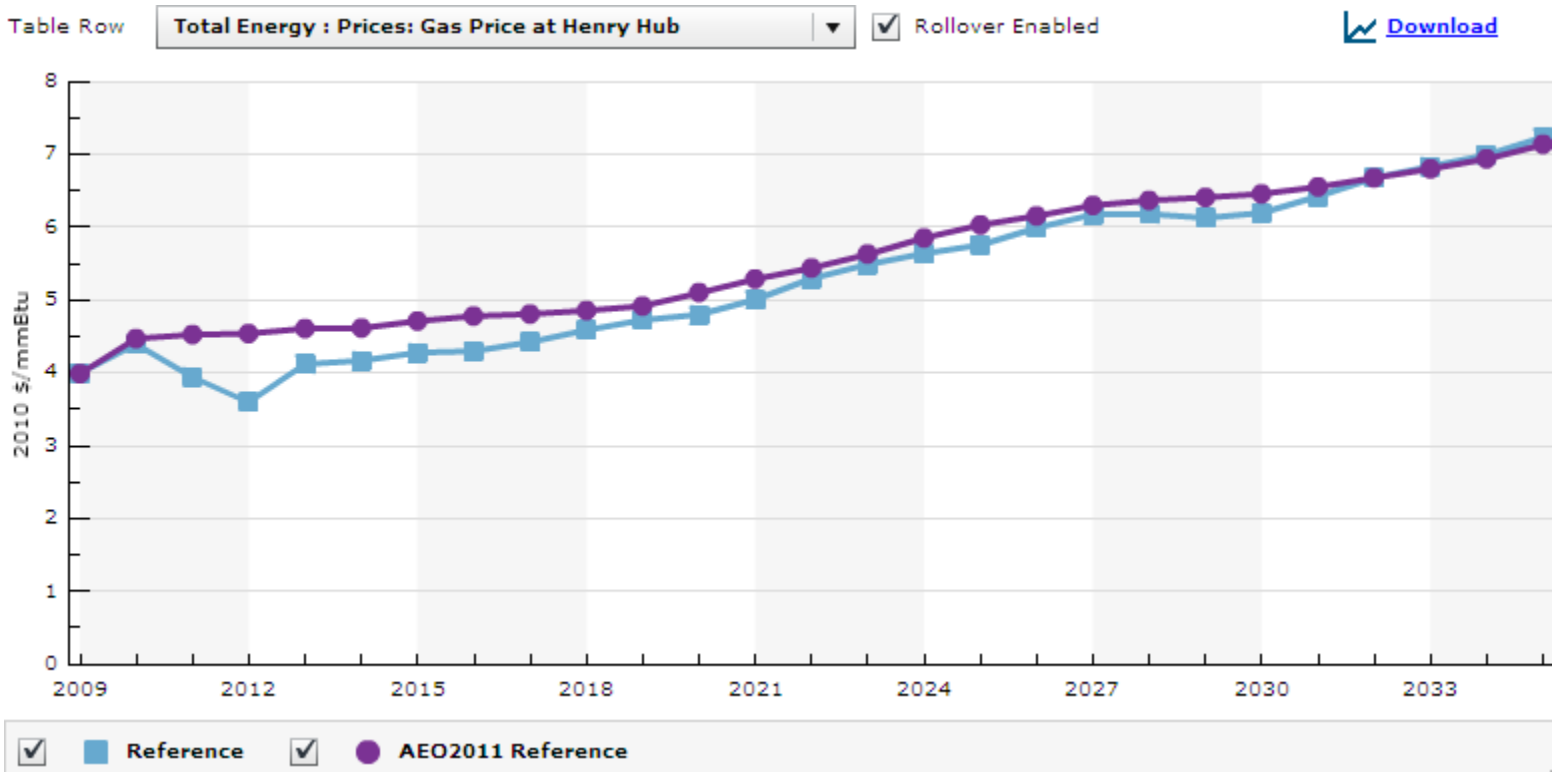
Natural Gas Price Trends

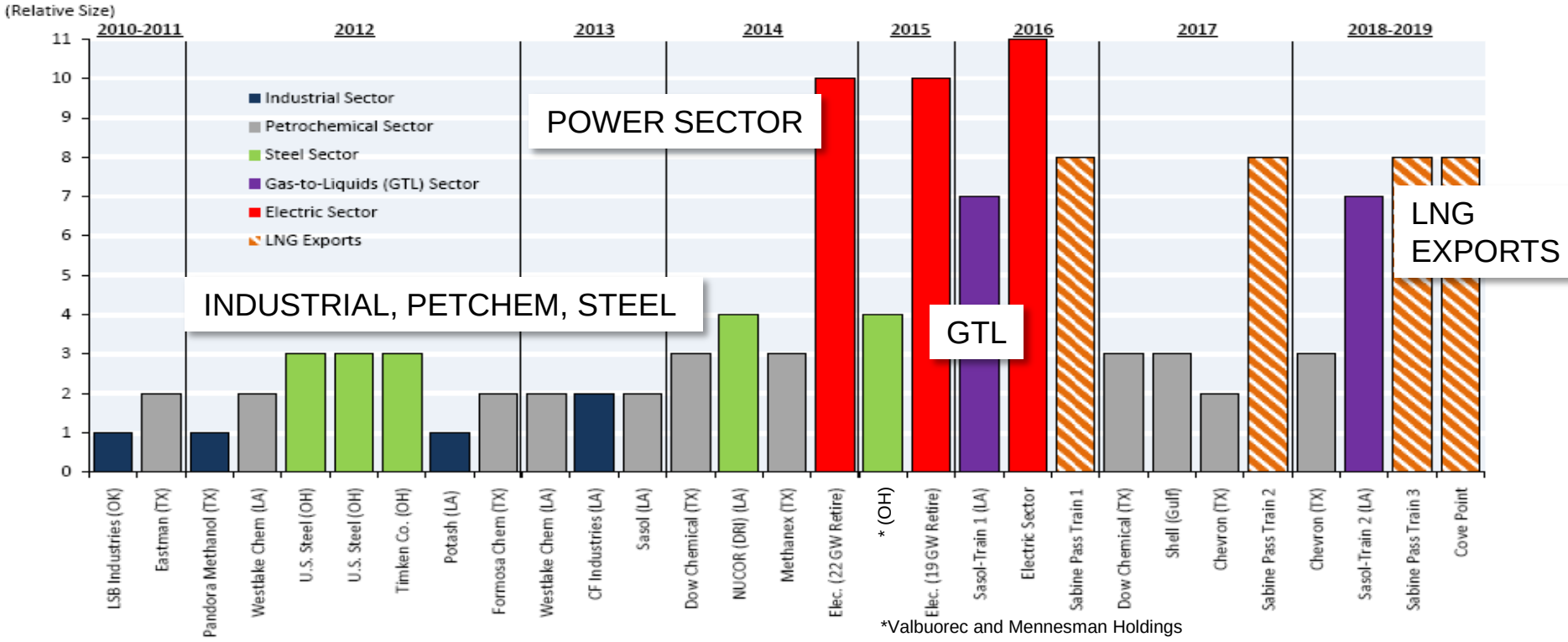
AEO 2012 Natural Gas Price Outlook (HH, 2010$)



CITI 2020 forecast: medium floor at $ 5-$6 mmbtu

Demand Growth

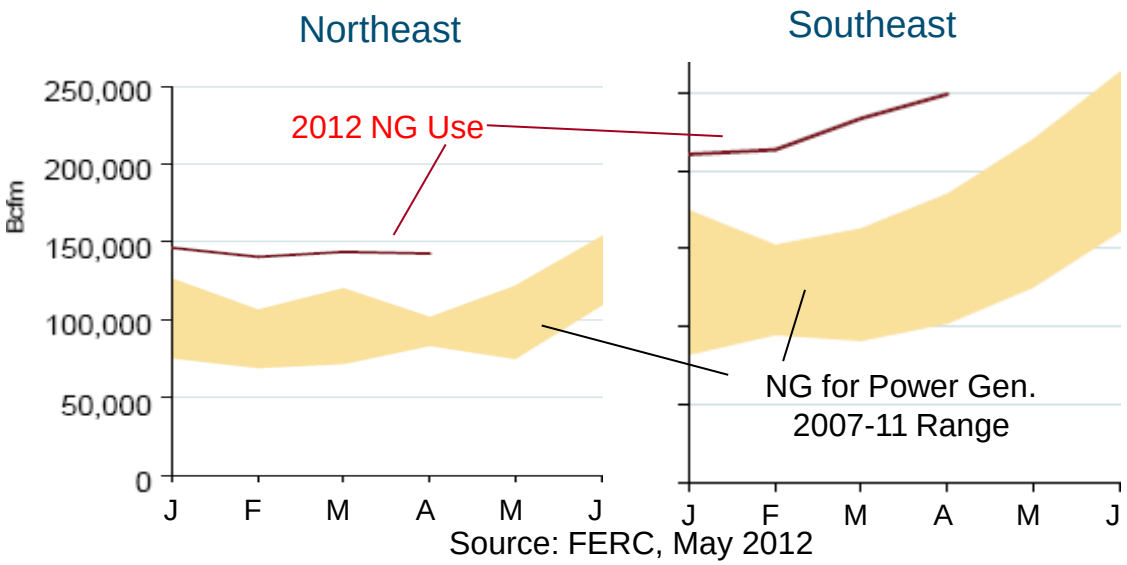
- **Low prices and extreme oil/NG price disparity sets feedbacks in motion.**
  - Industrial; power sector; LNG exports; GTL; transport?



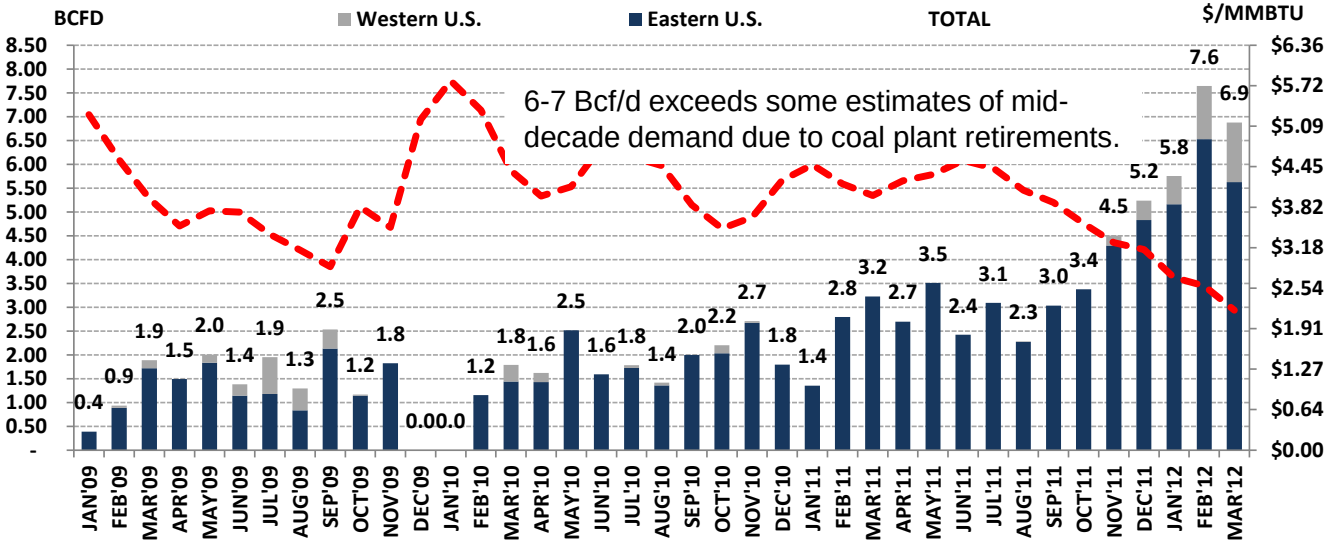
Source: EVA to EPRI, Feb. 2012. forthcoming analysis

Coal Retirements and Displacement 1635 MWs in 2012

- Unprecedented
- Greatest effects in Southeast, Mid-Atlantic, Northeast; occurring farther west.
- Immense coal & electric industry impacts



Source: FERC, May 2012

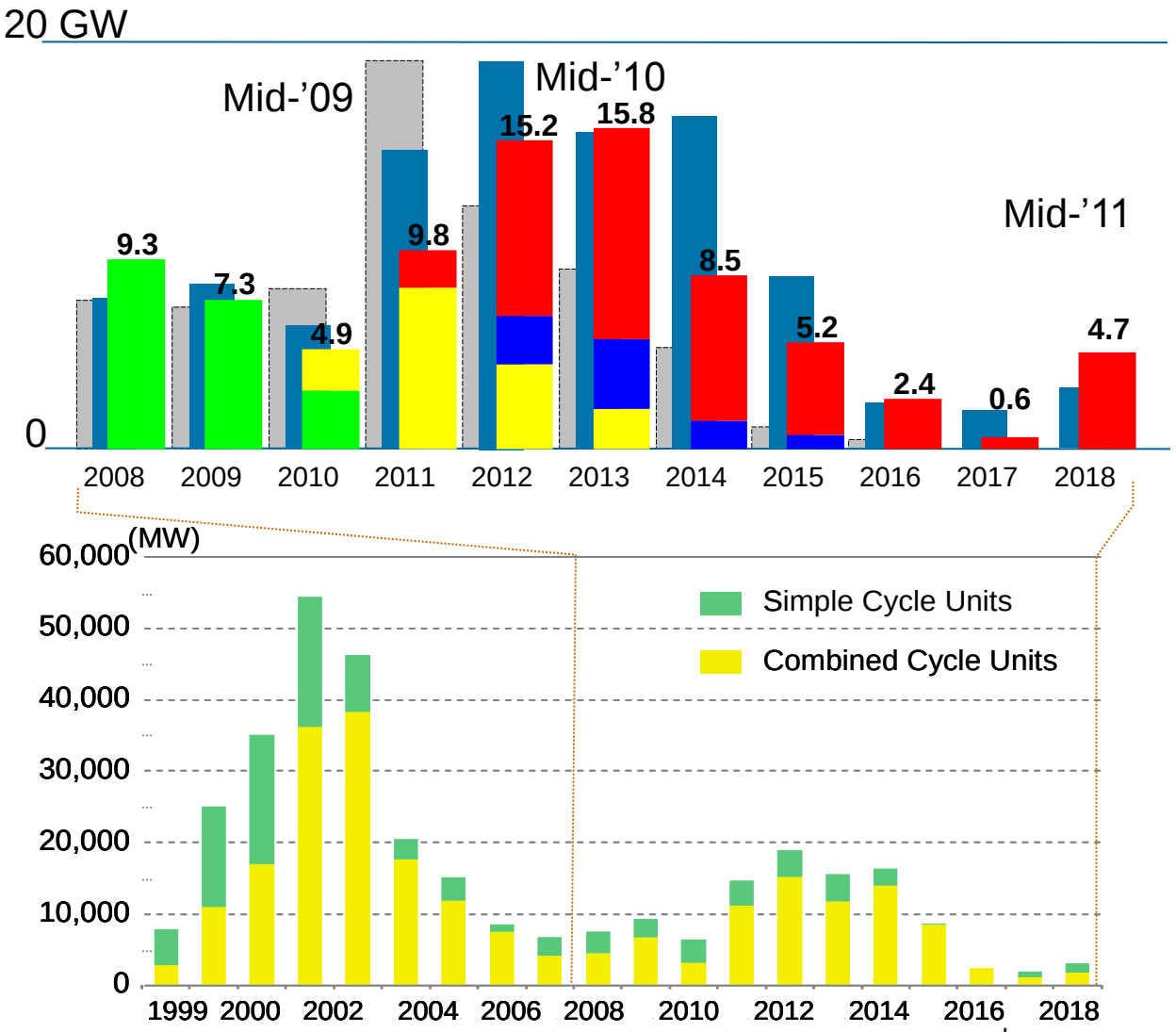


Source: Energy Ventures Analysis, Inc., July 15, 2012 .

Generation Capacity Expansion

Announced Natural Gas Capacity 2009-11

- Cheap gas puts all other resources options under pressure
- Even renew-able mandates are harder to swallow.



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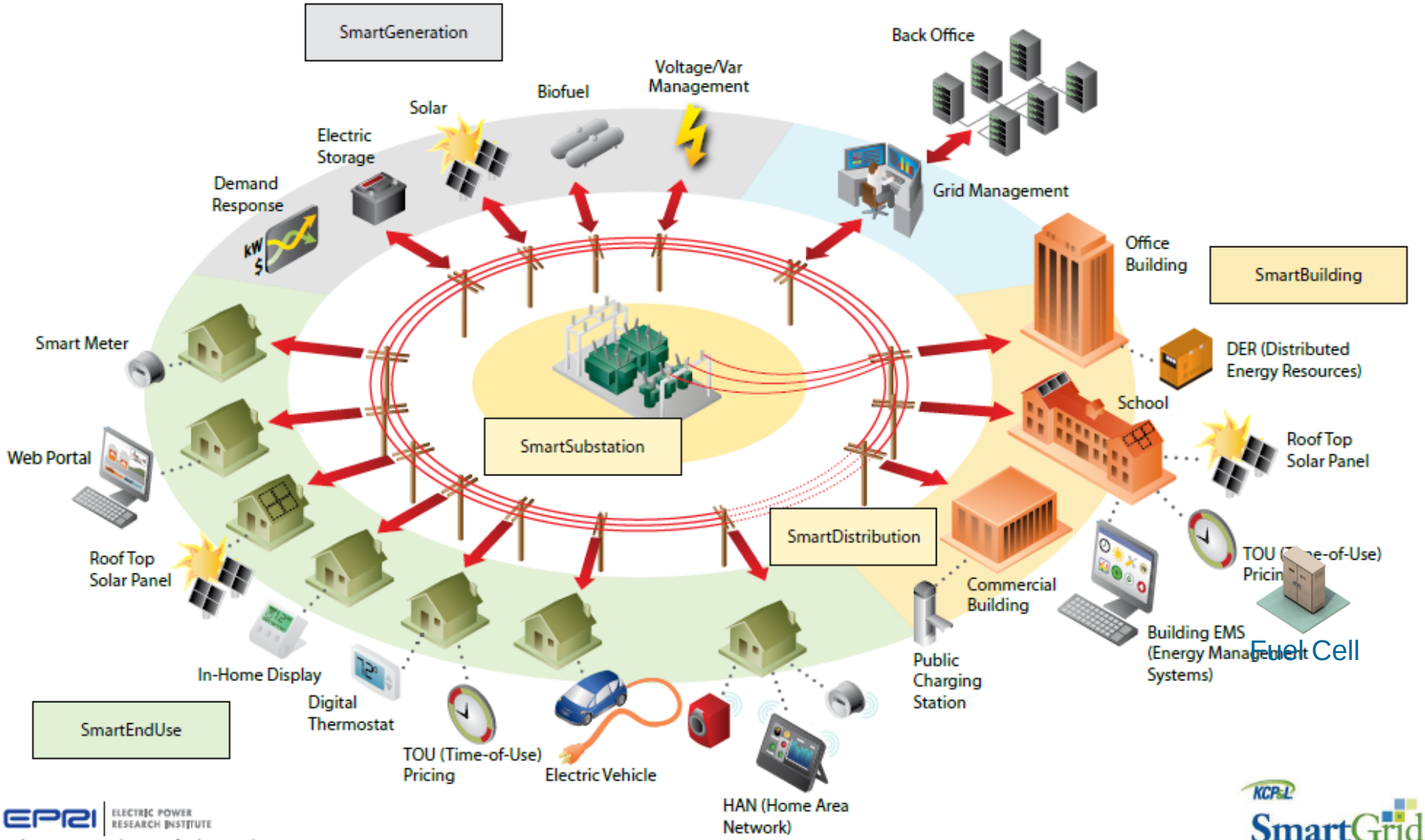
Industry Driver: Grid Infrastructure Investments for Delivery and Reliability

- Cost of Power Disturbances to the US Economy $ 180 B/year
- Cost of a massive blackout ~ $ 10 B / event
- CapEx in Transmission Investments ~ $ 10 B / 2011
- CapEx in Distribution Investments ~ $ 20 B /yr 2010 growing to $ 35 B /yr by 2030
- By 2030: $1.5trillion to $2.0 trillion. (+ $15.5 B with Renewable Penetration)

What if we could Generate, Store and Deliver Electricity "when and where" it was needed?

Smart Grid Deployments and Learning

Paving the way for DER and Fuel Cell Integration



Smart Grid Is Like the Internet

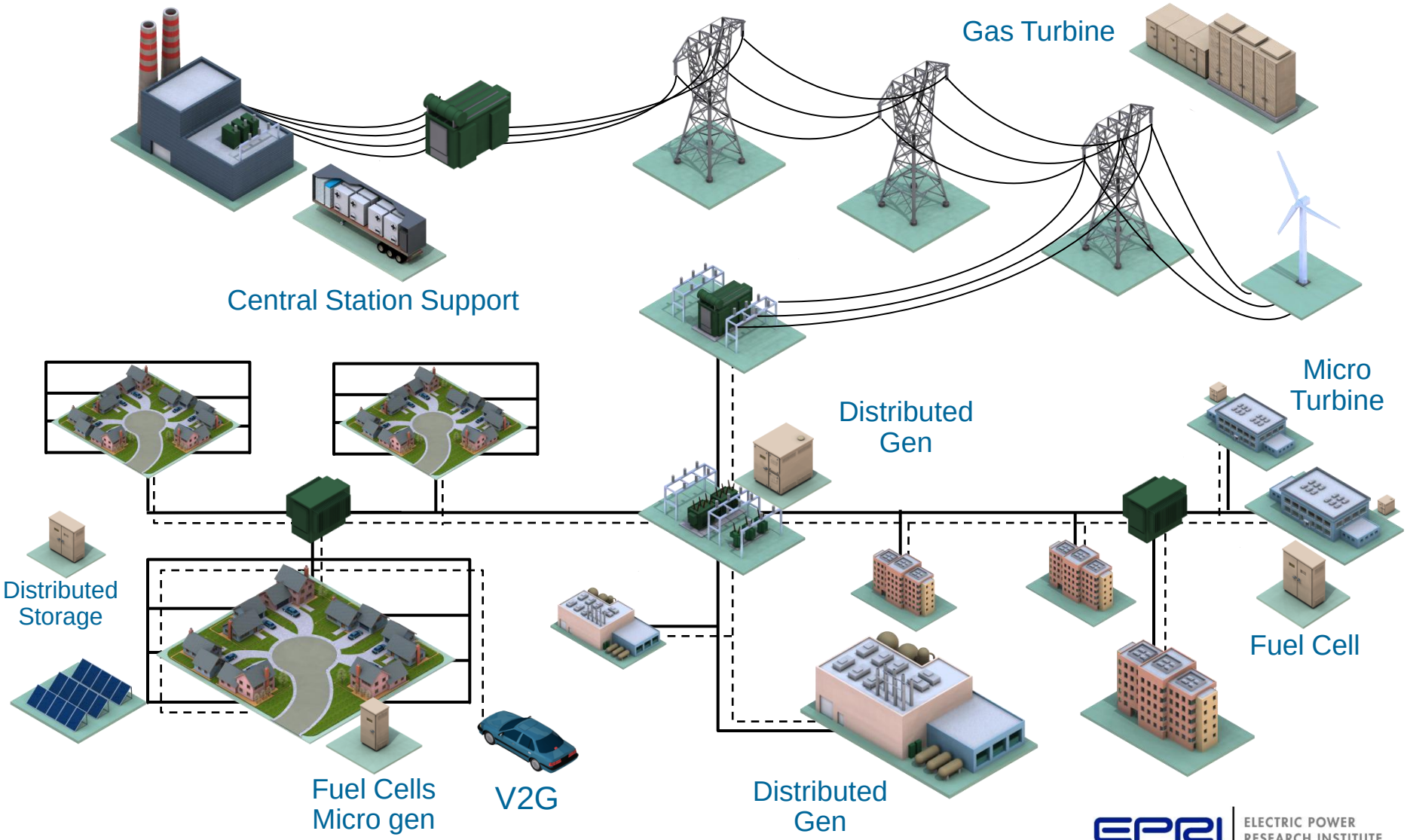
Fuel Cells, Storage, DG and DERs are the APPS!

Returned Interest in Distributed Generation

- Good “Spark Spread”
- Renewable Integration
- Retirement Coal Plants
- T&D Constrained Areas & Load Pockets
- High Retail Rates
- Economic Development
- Smart Grid Infrastructure

APPs for Distributed Energy Resources on the Grid

Utility / customer side of meter; central to distributed; "clean "capacity and energy mgt when and where it is needed.



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Distributed Energy Resources - Current Options

Efficiencies shown are all electric (LHV) systems
CHP applications would have efficiencies in the 75-85% range.

50 MW - 1 MW

Aero-derivative CT's
- 25-60 MW
- 40+ % Eff.

Small CT's
- 1-5 MW
- ~ 40% Eff

IC Engines
- 0.5 0 2 MW
- 36% Eff.

1 MW - 1.5 kW

Microturbines
- 30-300 kW
- 25-30% Eff

Fuel Cells
400 -1000 kW
- 40-45 % Eff

Micro IC engines
- 1-2 kW
- 30 Eff.

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Distributed Energy Resources - Emerging Options

Efficiencies shown are all electric (LHV) systems
CHP applications would have efficiencies in the 75-85% range.

Solid Oxide Fuel Cells

- 2 kW – 100 kW

~ 55%-60% Efficient

SOFC – Hybrids

- 1 MW – 60% Eff

PEM Fuel Cells

- 1 – 5 kW
- ~ 40% Eff

Stirling Engines

- 1-5 kW
- 15-25% Eff

Currently, U.S. CHP Capacity is at 82 GW

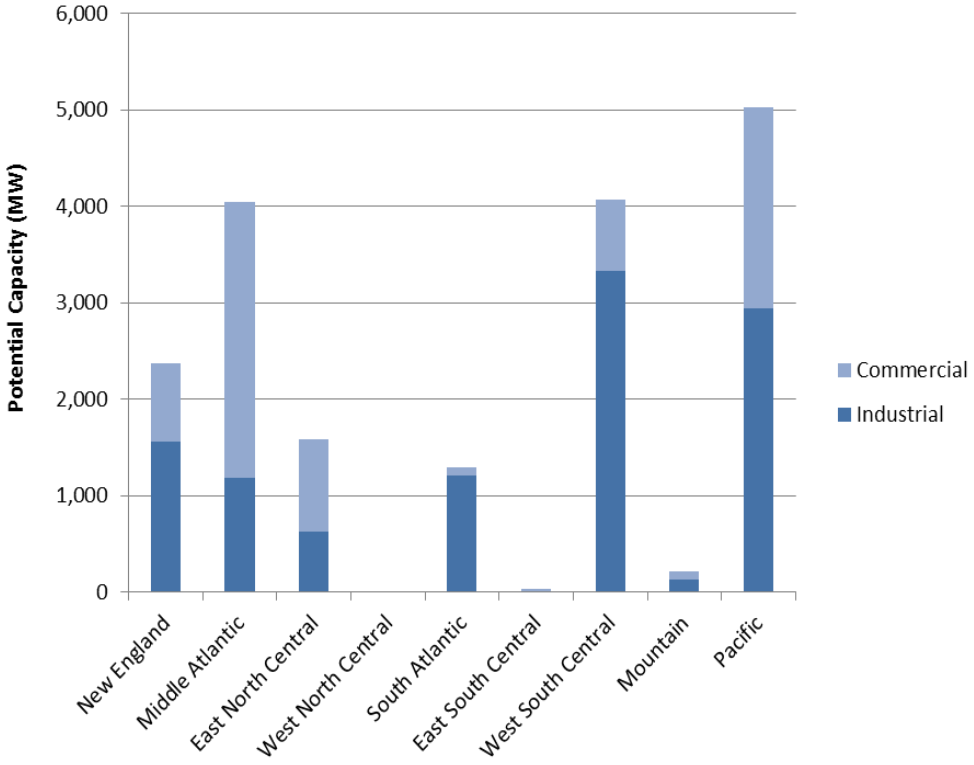
- Usually favorable regulatory treatment or incentives combined with higher retail electric rates
- Higher current activity in infrastructure applications such as universities, hospitals, and wastewater treatment
- Industrial Facilities using coal boilers

CHP Market	Market Data
Installed Capacity (2011)	81.7 GW (7.5% of current U. S. capacity)
Number of Installations	3,700 industrial and commercial facilities
Locations	Almost half (38 GW) is concentrated in TX, CA, LA, and NY Most states have over 200 MW of CHP
Source: ORNL/DOE CHP Installation Database	

Future Opportunity – 2012 Analysis

U.S. DER / CHP Economic Potential

- 18.6 GW Opportunity:
  - 11 GW - Industrial
  - 7.6 GW - Commercial
- Based on 2010 electric utility tariff pricing and state average natural gas prices
- 10 % Investment Tax Credit
- Examined for Microturbines (30 kW – 1 MW), Engines (30 kW – 10 MW), Turbines (1 - 50 MW)



National Averages:

$ 9.2/Mbtu for commercial Bldgs

$ 5.2 / Mbtu for industrial facilities

Source: Resouce Dynamics Inc

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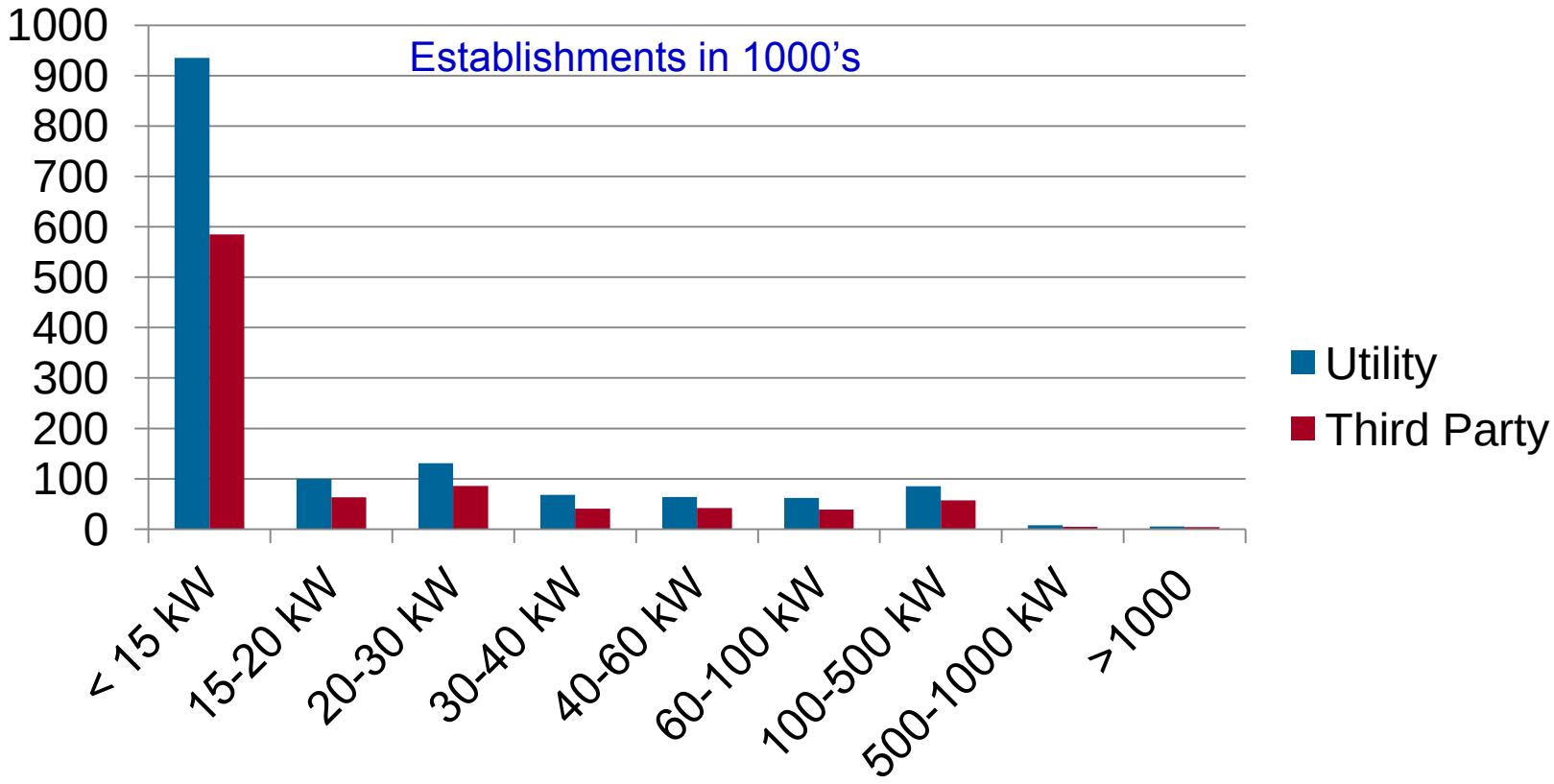
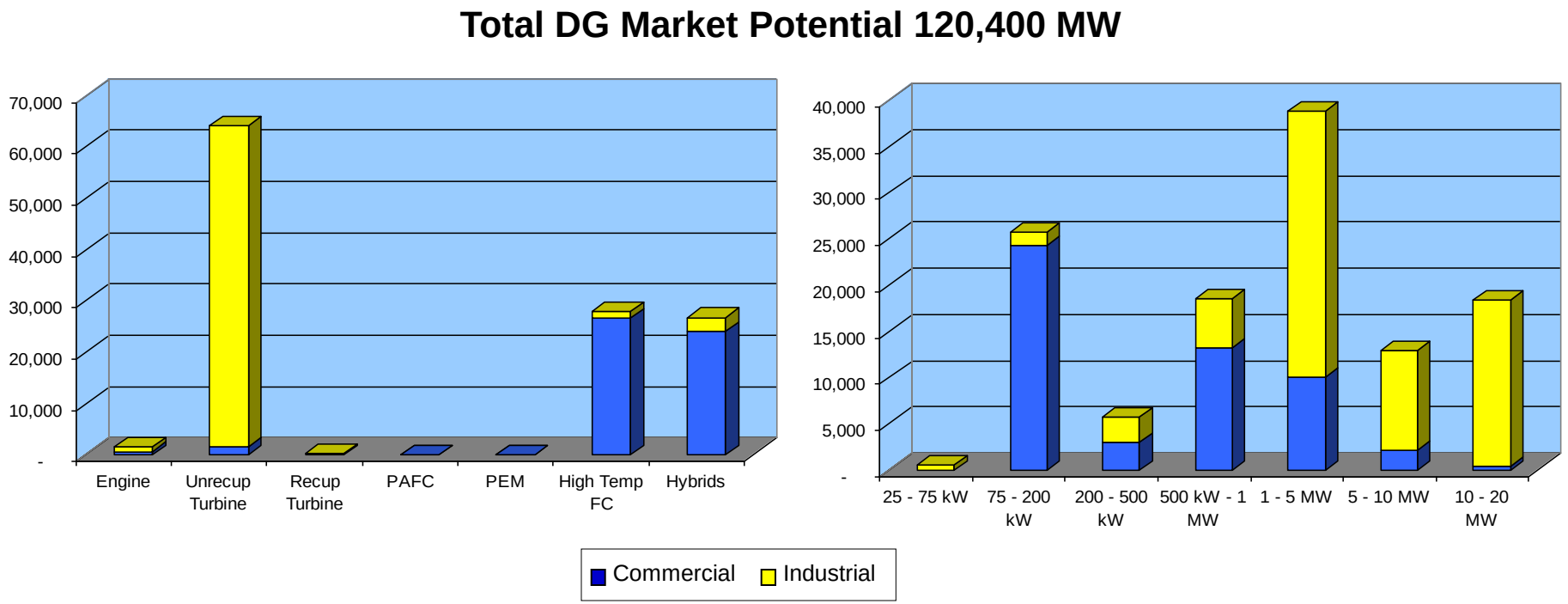
U.S. SOFC Market Potential^
of Potential Establishments by Size Range



^ Commercial Sector SOFC Business Assessment EPRI TR-106645; Aug 1996

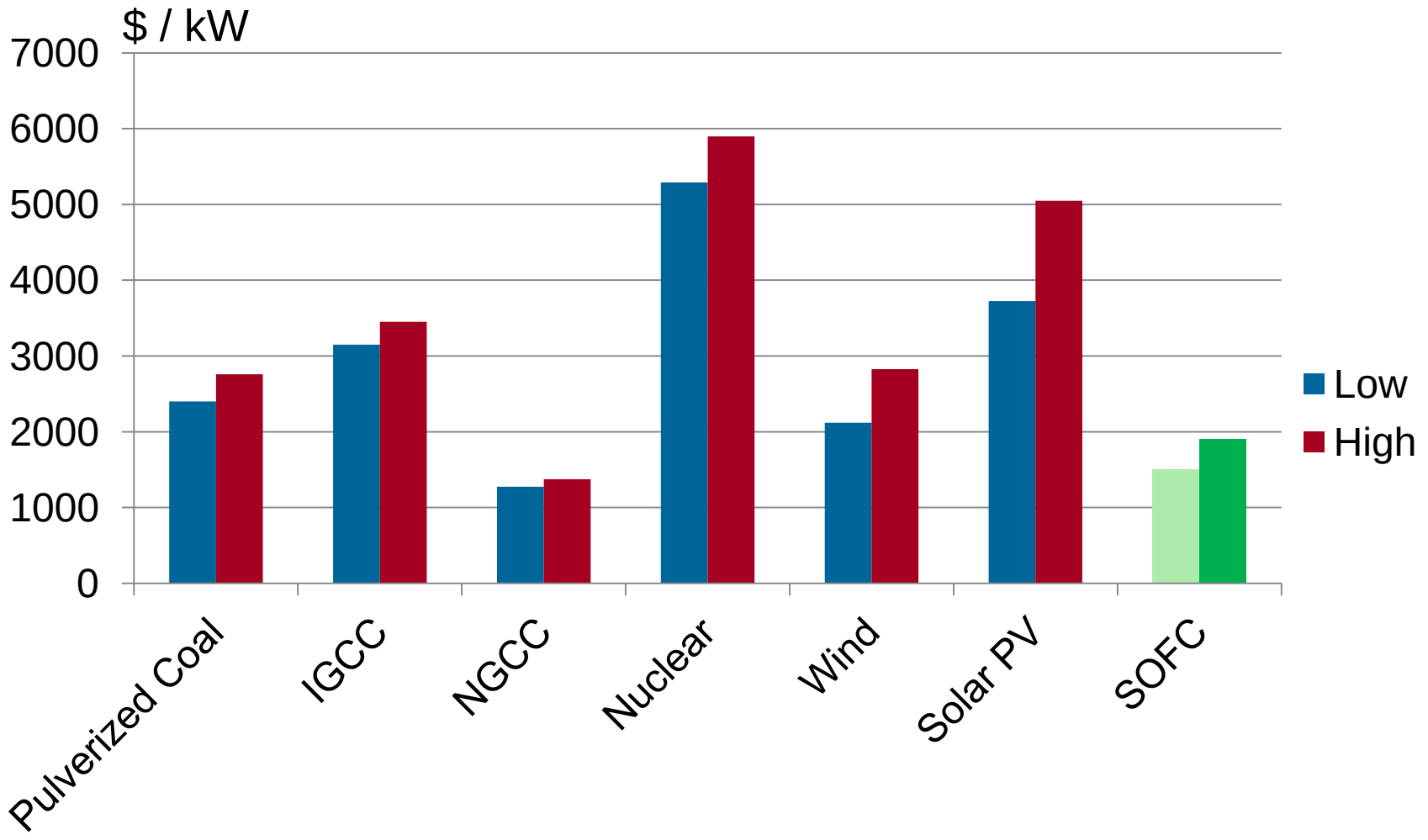
EPRI 2008 Market Potential Research
Case 5: Grid Sell-Back /Net Metering



- **Units sized to meet site peak demand;**
- **Market share goes up because larger sized units are installed**
- **Total fuel cell market size estimated ~ 54,600 MW**

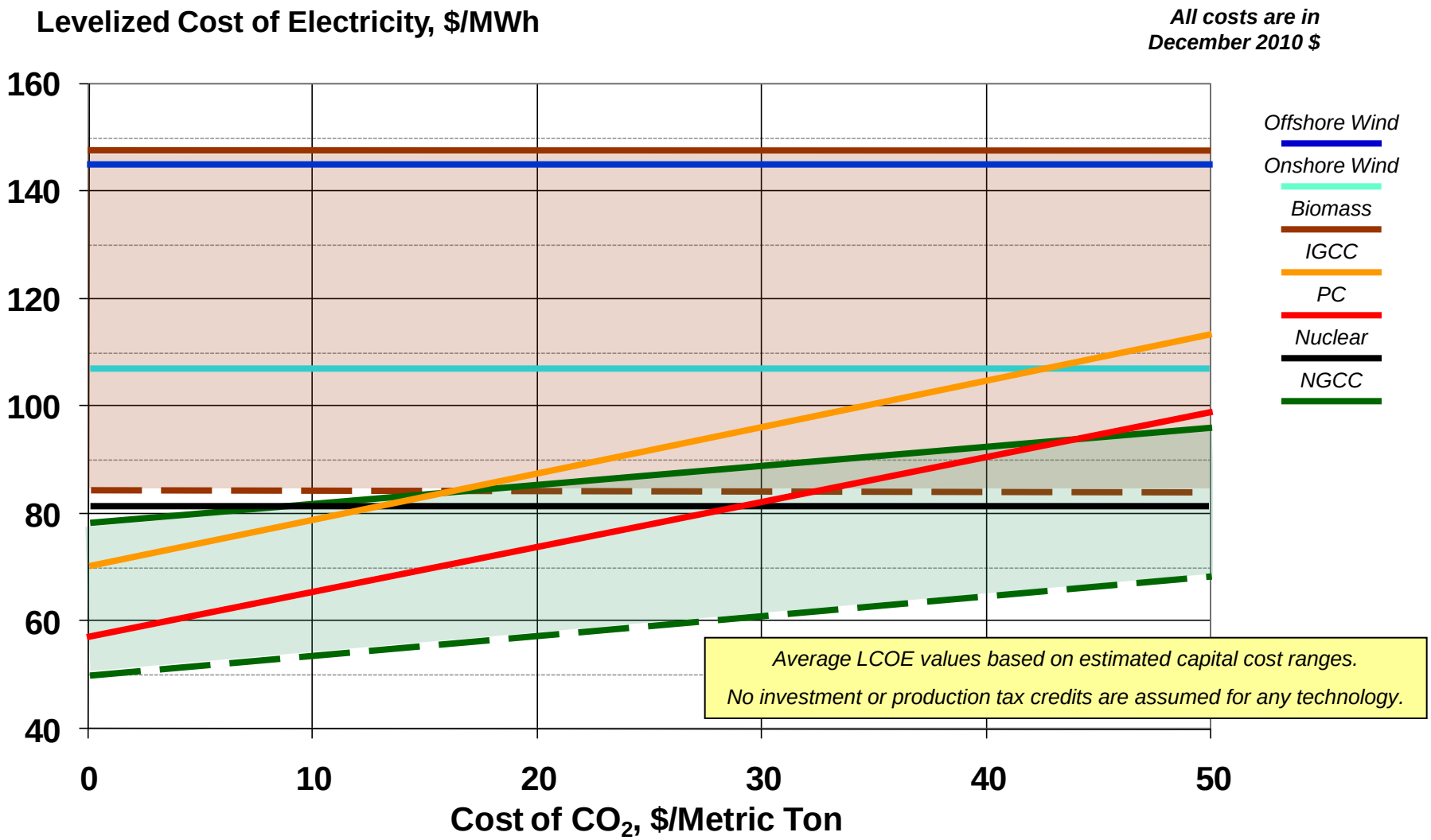
Cost of Generation Options 2015 Estimates

SOFC Installed Costs - Estimated



- **Source: EPRI's Integrated Generation Technology Options Report (1022782)**

Generation Options
Comparative Levelized Costs of Electricity – 2015



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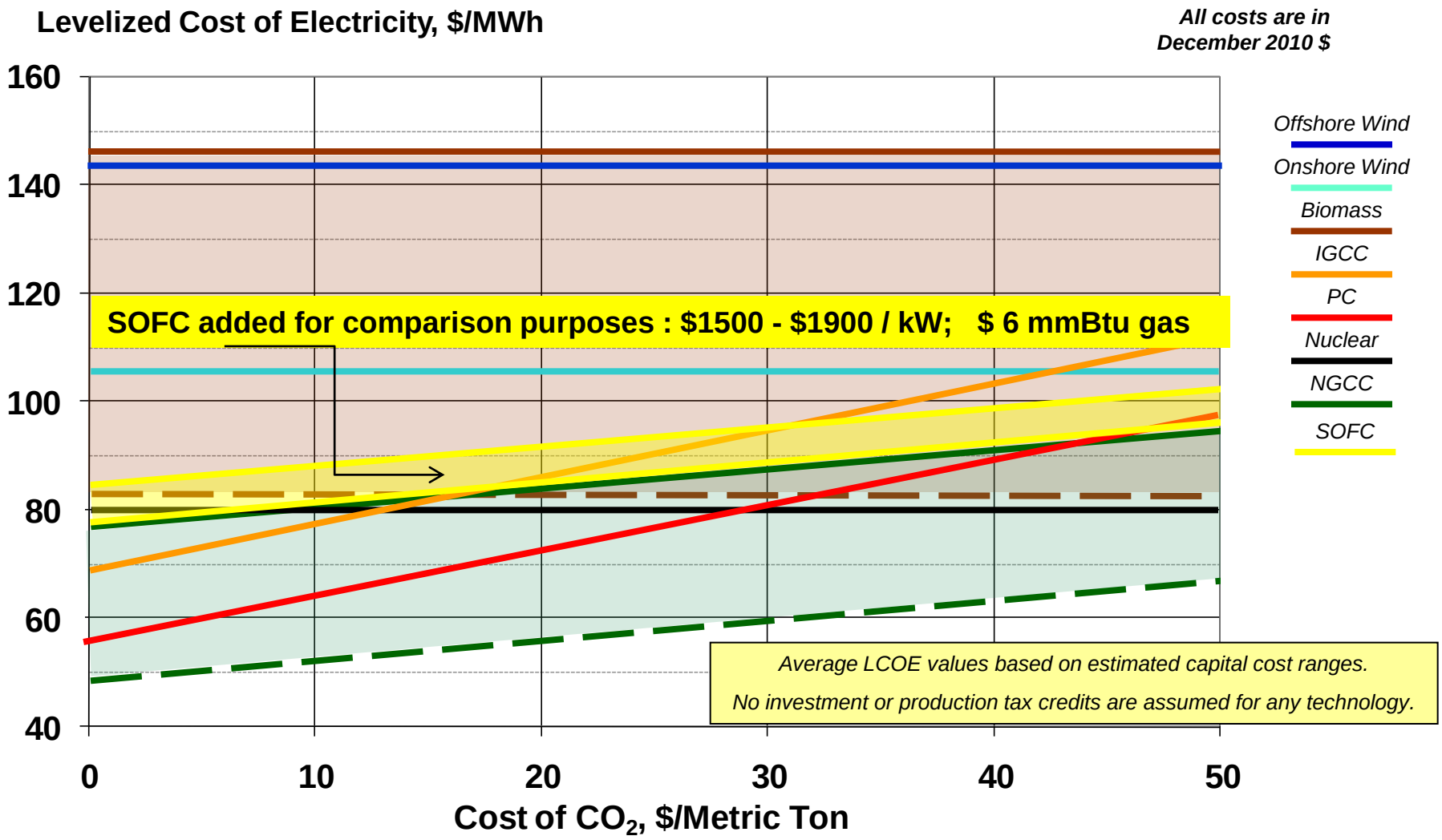
Generation Options
Comparative Levelized Costs of Electricity – 2015



Based on EPRI's Integrated Generation Technology Options Report (1022782),

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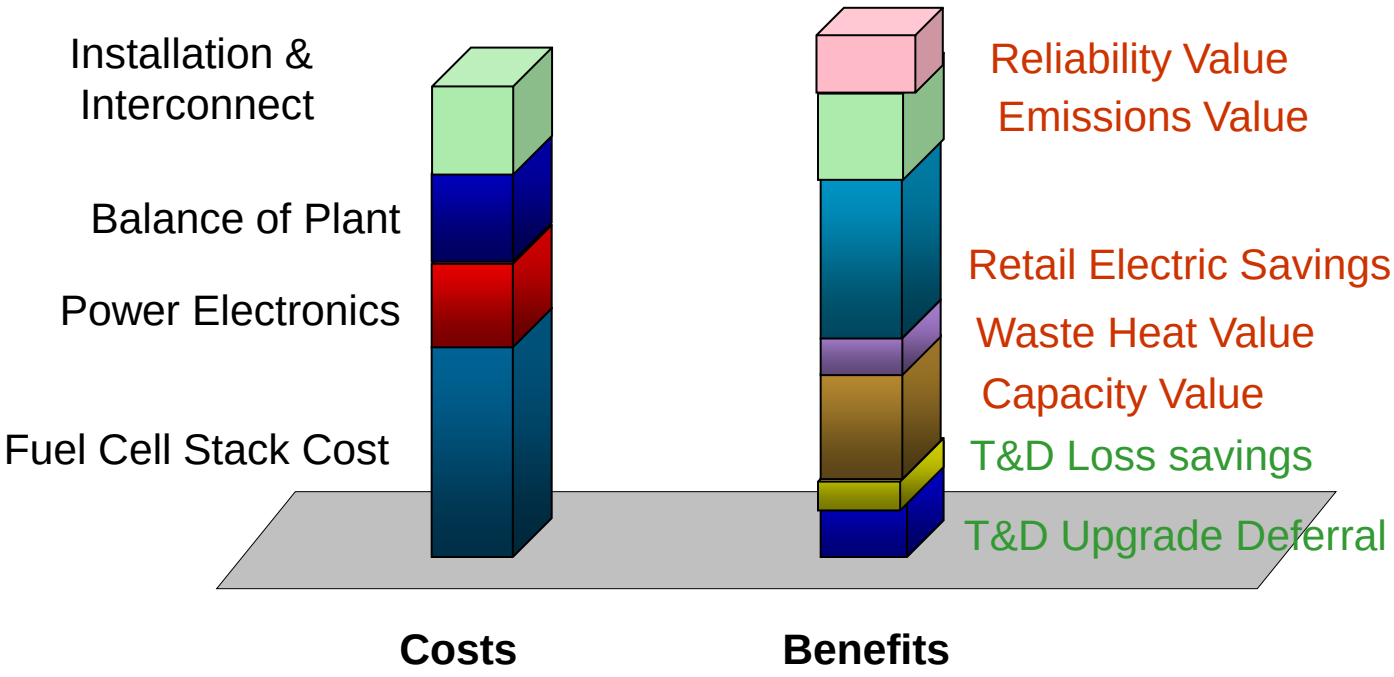
Fuel Cell Systems must make Economic Sense

Monetizing of "Distributed Benefits" across various stakeholders is Key to Business Case and Market Adoption

Monetizing the Value of Distributed Fuel Cells can result in lower "delivered" electricity than NGCC

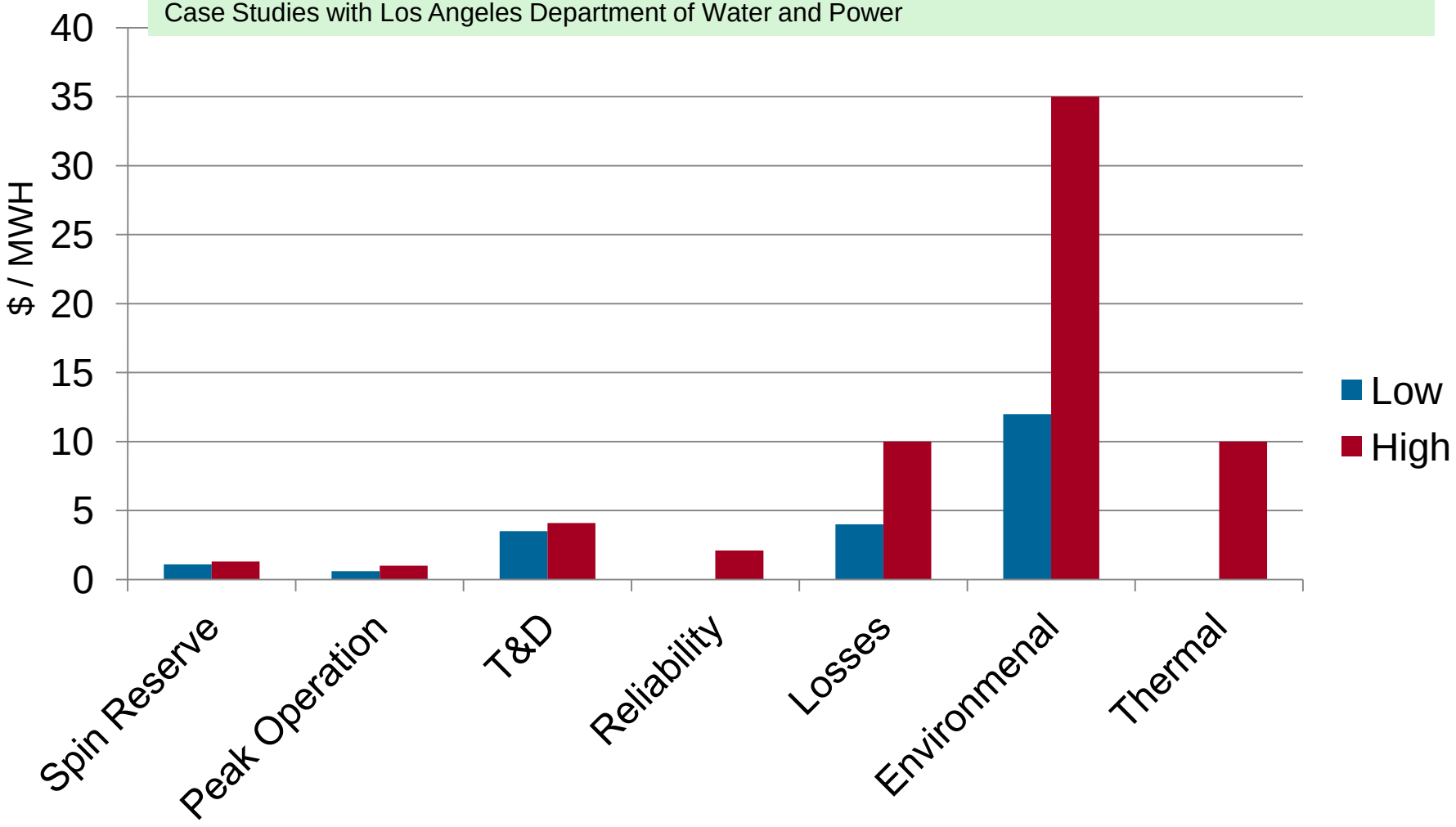


Values are Illustrative

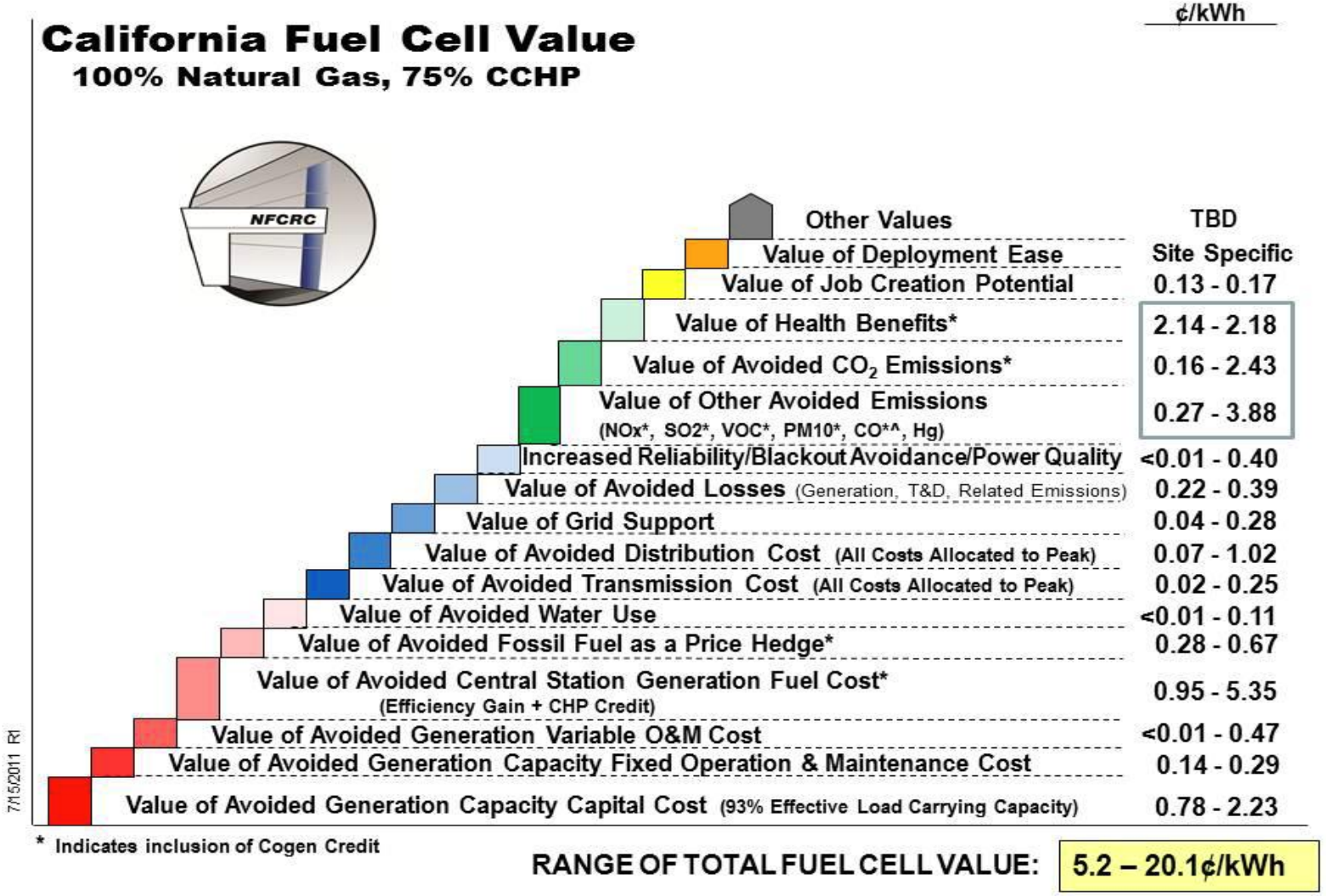
Estimation of the Value of Distributed Benefits Utility, Site and Application Specific

Source: EPRI TR-100686 Fuel Cells as Distributed Generation Resources; May 1992

Case Studies with Los Angeles Department of Water and Power

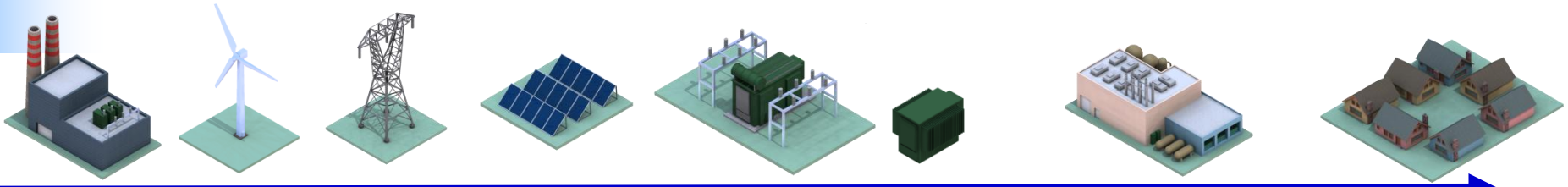


Potential Range of Benefits
California SGIP and Fuel Cells



Ref: **Build-Up of Distributed Fuel Cell Value In California: 2011 Update Background and Methodology; NFCR July 2011**

Fuel Cell System Business Models



APP: Wholesale Power | Substation Grid Support | End-User-Energy Management

Regulatory Agency: FERC / ISO's | State PUCs | State PUCs if IOU participates

Near Term Markets and Application Opportunity →

Business Model:

Utility Owned

IPP – PPA

PJM, CAISO, NYISO

Fuel Cell Options:

- MCFC
- SOFC
- Hybrids

Business Model:

Utility Owned

- Use as Smart Grid Asset

IPP owned w/contract

IOUs

Rural Electric Co-ops

Municipals

Fuel Cell Options:

- PAFC, PEMFC, MCFC
- SOFC; Hybrids

Business Model:

Customer Owned

ESCo w/Aggregation

IPP owned

Utility / Customer / ESCo

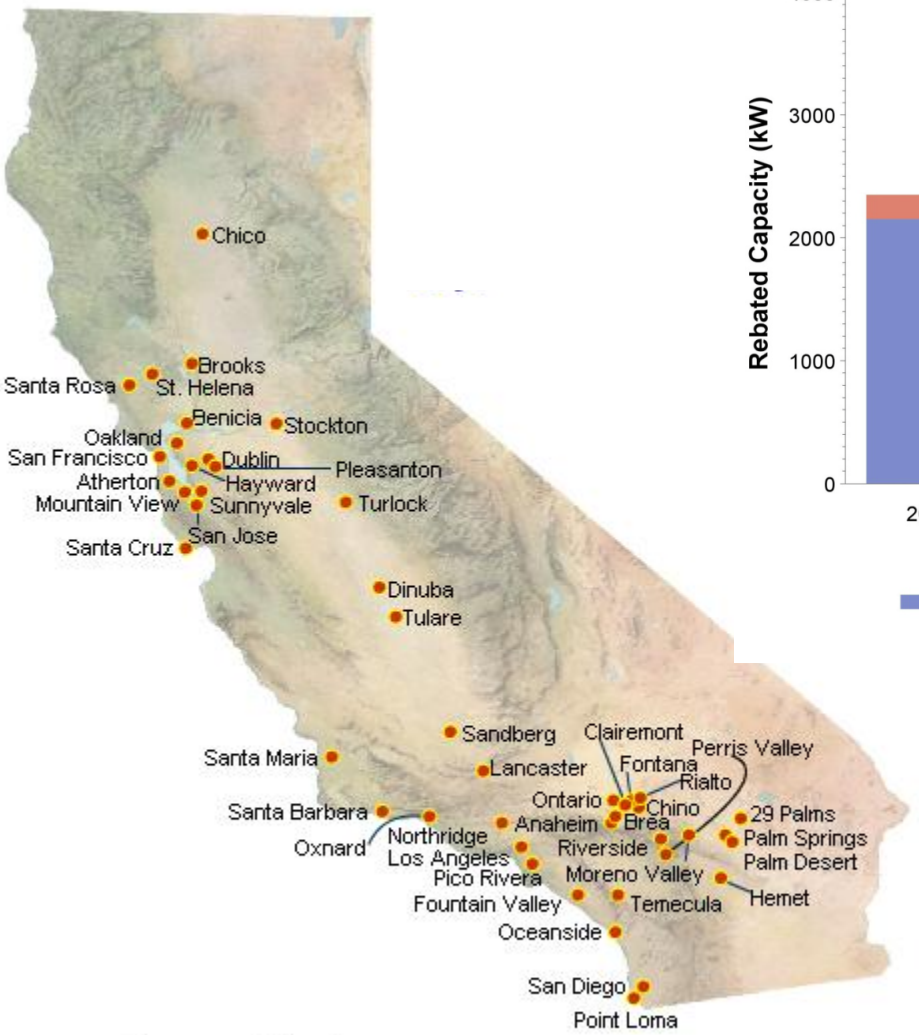
Efficiency Program

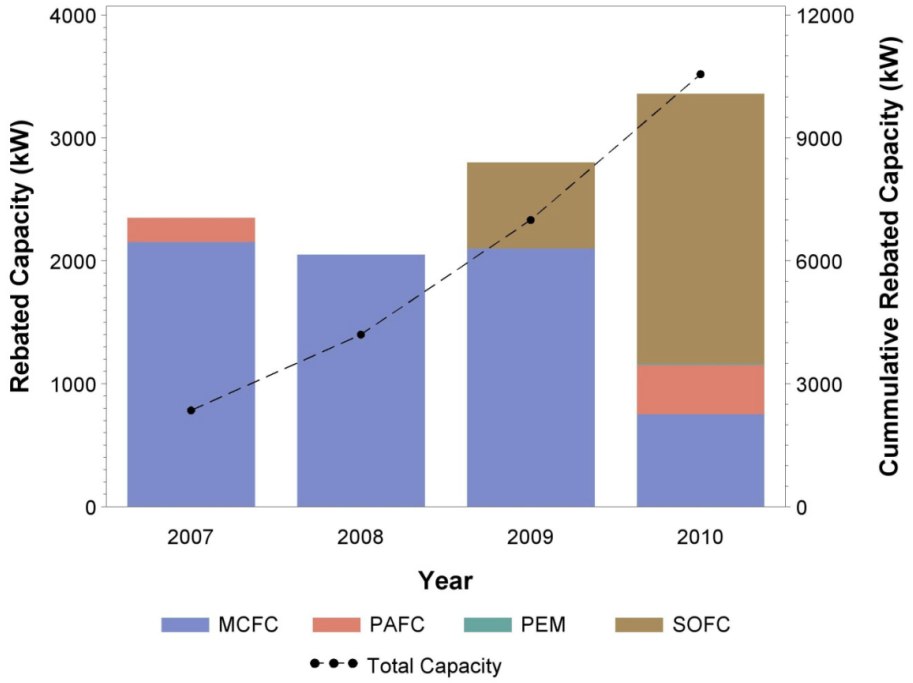
Fuel Cell Options:

- PAFC, PEMFC
- MCFC, SOFC
- Hybrids

California Policy and Market Leading the Way

35-40 MW of Fuel Cells Estimated Installed





- Favorable Policy
- MCFC and SOFC leading
- End-user, PPA models
- Limited utility cases

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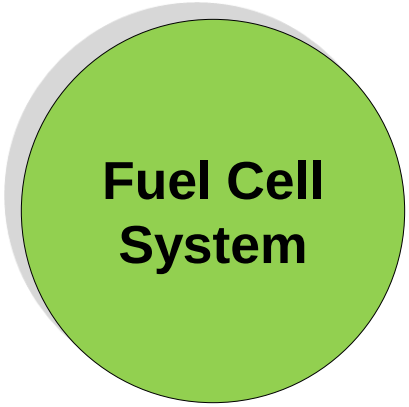
Paving the Way for Distributed Generation Solutions

Fuel Cells must be a complete product...

Power Conditioning System

- Fuel to AC conversion
- Reactive power management
- Integration point to the grid

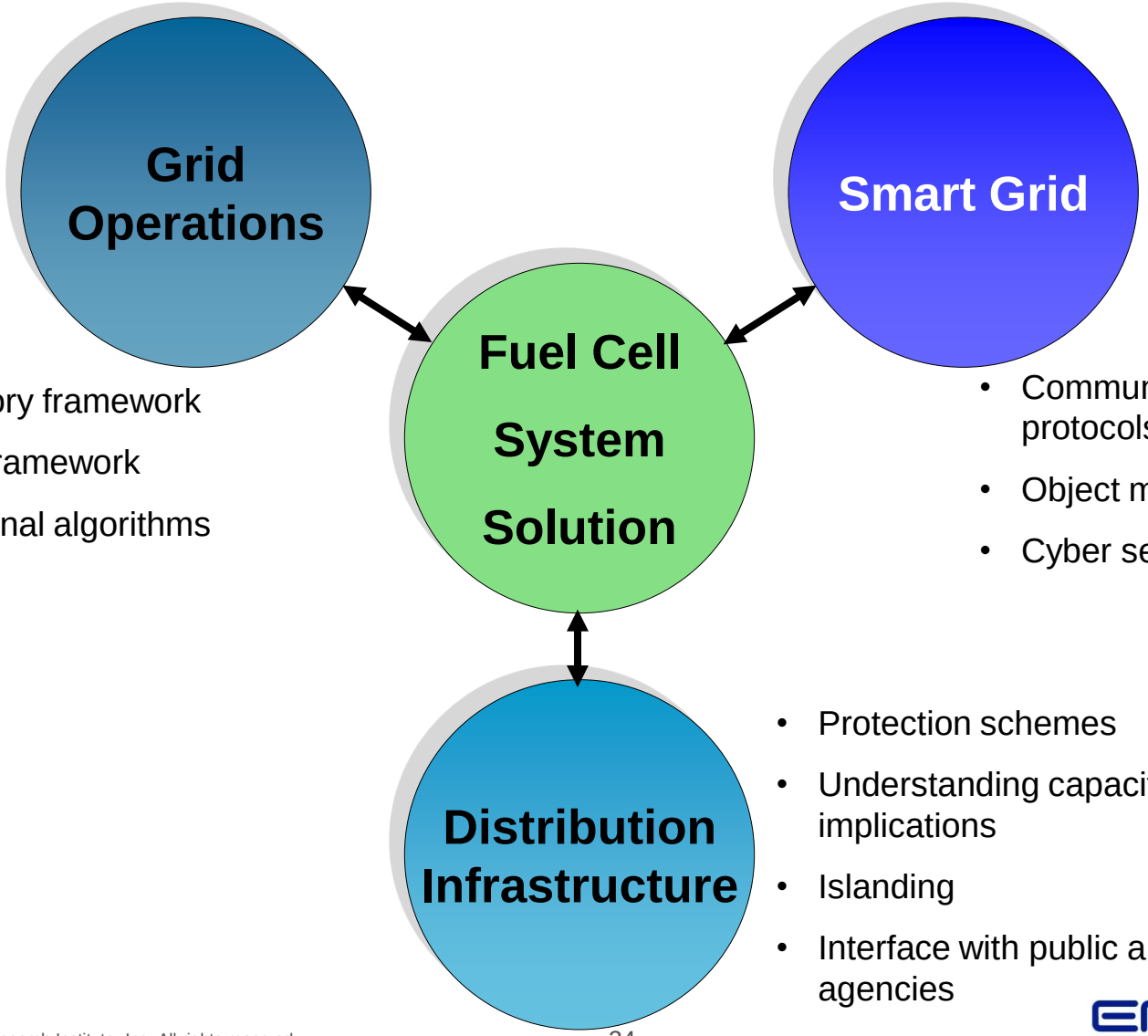


Balance of Plant

- Data acquisition and controls
- Heat Recovery option
- Communication and Control
- Physical structure
- Shipping and Installation
- Easy Interconnection

All components must be safe, reliable, low-cost, and seamlessly integrated with the Grid

Fuel Cell Systems must be integrated with the Grid



- Regulatory framework
- Market framework
- Operational algorithms

- Communications and control protocols
- Object models
- Cyber security

- Protection schemes
- Understanding capacity implications
- Islanding
- Interface with public and local agencies

Historical Barriers to Adoption of DG

Improvements Have Been Incremental, Barriers Still Exist

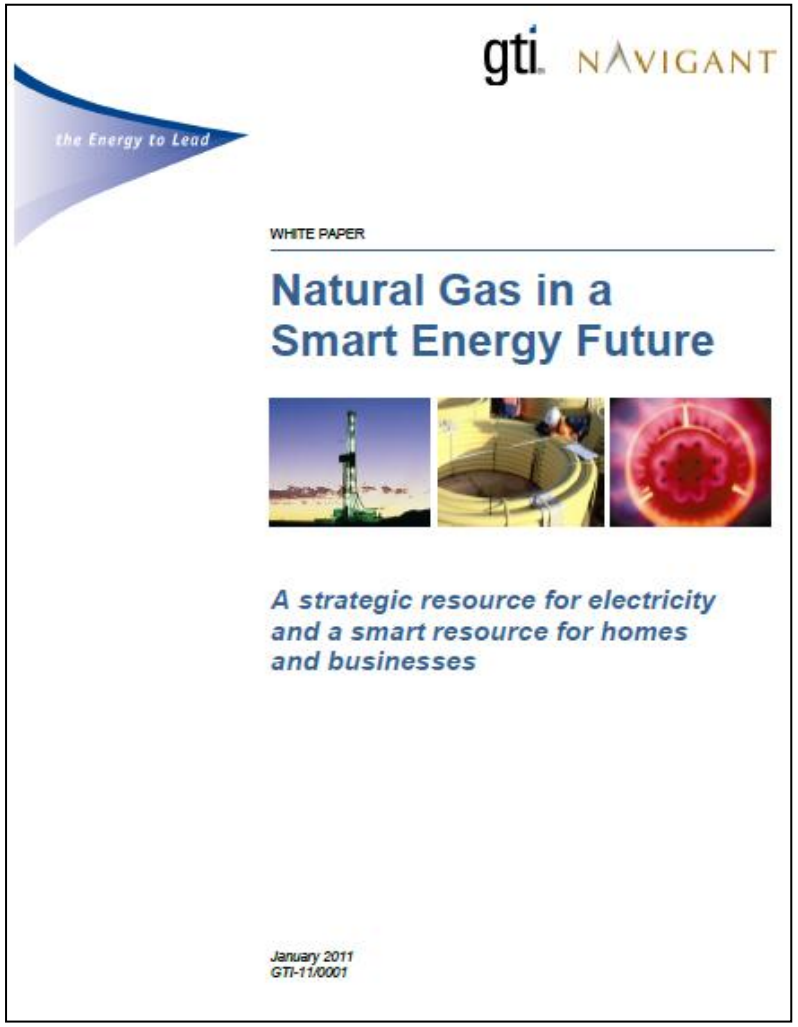
- Contractual & technical interconnection requirements
- Utility tariffs requiring surcharges for standby service
- Environmental & permitting requirements
- Average cost pricing of utility services
- Patch work of State Regulatory Policy
  - In many jurisdictions utilities can not own DG
- End-users want providers to offer “Energy Services”
- Utility Business Model?

Natural Gas Industry Stakeholders have Articulated a Clear Vision for an Integrated Natural Gas – Smart Grid

1. A Strategic Resource for Homes and Businesses
2. Improved Safety, Energy Security, Environmental Performance
3. Improved Demand Response for Electric Distribution through DER
4. Greater Consumer Choice resulting in maximun energy value
5. More Optimized value from Renewable Wind and Solar

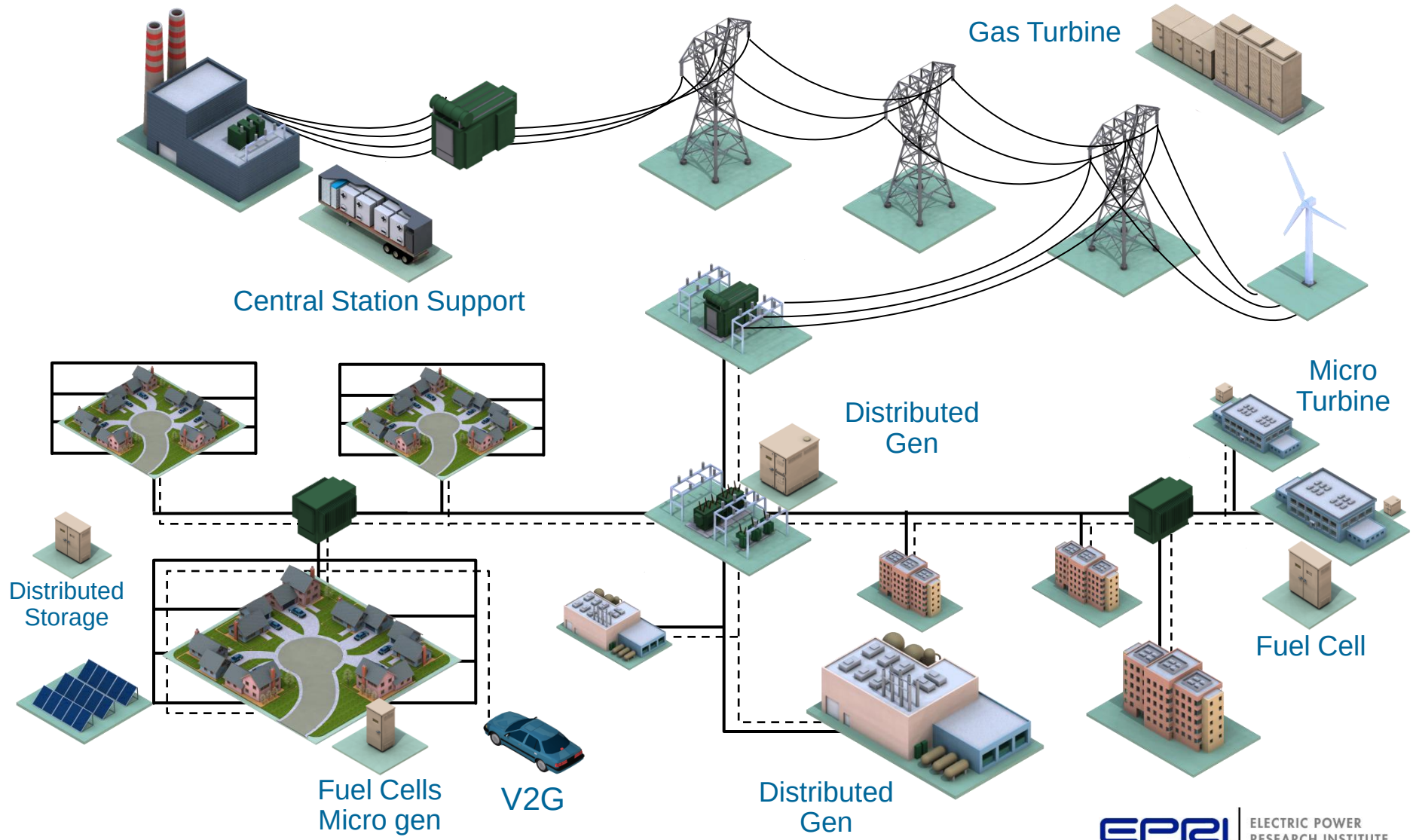
Estimated benefits to 2030:

- $ 213 B in Consumer Savings
- 200,000 GWh Electric Savings per year
- 50 GW avoided Generation Capacity Additions of $ 210 Billion



Value of a Natural Gas Enabled Smart Grid ?

Electric Industry Needs Assessment of Value and Business Case for DER APPs



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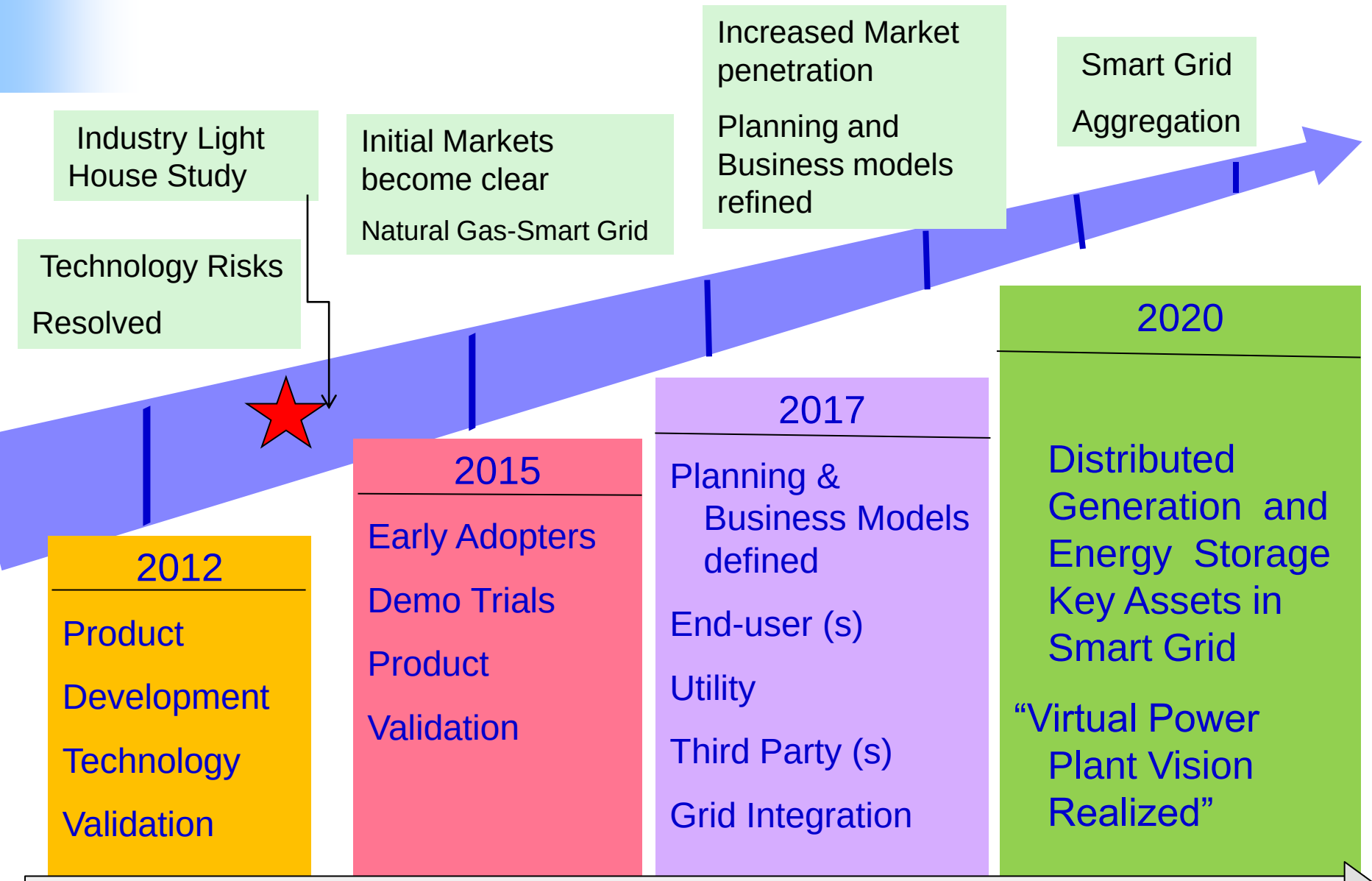
Paving the Way for DG Integration

A Light House Study is Needed

1. Quantify the value of integrated DER APPs to the Electric Enterprise
2. Detail Utility Business Models to inform Policy
3. Establish an Integrated R&D Roadmap with the Gas Industry
4. Deploy and Demonstrate DER Pilots to address and resolve integeration and aggregation gaps and establish best practices.
5. Analysis to Inform Policy to support member needs.

Road Map for SOFC Deployment & Adoption



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Summary

- Industry Drivers -- Creating New Opportunities for Natural Gas Distributed Generation;
- Many DG technology options – SOFCs are uniquely positioned for a variety of applications & markets;
- SOFC systems have to be a complete product and be “smart grid” ready;
- Monetizing “distributed APPs benefits” in context of Smart Grid –will be essential
- DG in Smart Grid Deployment is in its Infancy but is key path way for DG;
- Let us Work Together to Pave the Way for Solid Oxide Fuel Cell based Energy Solutions!

Together…Shaping the Future of Electricity

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