The Cost Effectiveness of DG with and without CHP/CCHP

ICEPAG 2010
February 11, 2010
Costa Mesa, California

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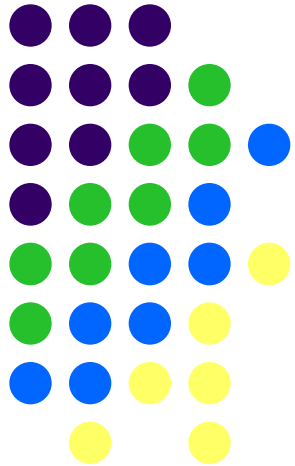
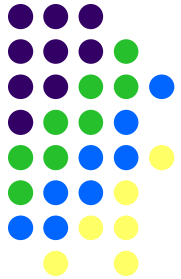


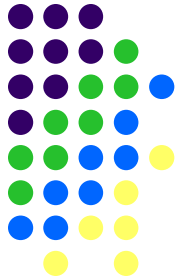
Empowered Energy™

Economic Analysis Can Inform Policy Debate & Implementation



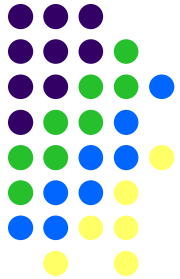
- Electricity sector often targeted by energy and environmental policies
  - Minimum generation/sales from renewable energy
  - Reduced emissions
- Political and policy mandates should be implemented as efficiently and cost-effectively as possible
- Economic analysis can inform the policy debate by assessing relative rankings of available generation technology options available to meet mandates
  - Distributed generation ("DG")
    - With and without Combined Heat & Power ("CHP") or Combined Chilling, Heat & Power ("CCHP")
  - Central station generation
- And is, more often than not, required.

Quantification of Fuel Cell DG Value Proposition Engaged the Debate



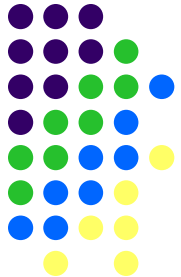
- Analyses performed on behalf of California Fuel Cell Manufacturer Initiative ("CAFCMI").
  - Initial effort quantified DG benefits
  - Expanded to a full benefit-cost analysis
    - Natural gas vs. renewable fuel
    - With CHP/CCHP vs. electric-only operations
- Benefit-cost analysis, in turn, led to extension of California Air Resources Board ("ARB") cost-effectiveness test for emissions reduction measures.
  - ARB proposed emissions reduction measures always entail ***cost*** per ton of reduced emissions
  - Head-to-head technology comparison may result in either costs ***or*** savings for reduced emissions.

Large-Unit Stationary Fuel Cell Value Proposition in California



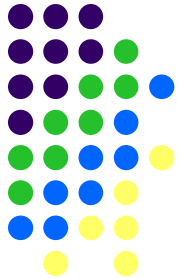
- Large-Scale Distributed Baseload Power Generation
  - Capacity: 100's of kW – 10's of MW
  - Availability: > 90%
  - Fuel Cell Technologies: Molten Carbonate ("MCFC"); Solid Oxide ("SOFC"); Phosphoric Acid ("PAFC")
  - CHP/CCHP: 60% of Total Installed Capacity
- Fuel
  - Natural Gas
  - Renewable – Digester Gas from Waste Water Treatment Plants, Landfill Gas, Other Biogas Sources: 30% of Total Installed Capacity

Four Broad Categories of Benefits Quantified (1 of 2)



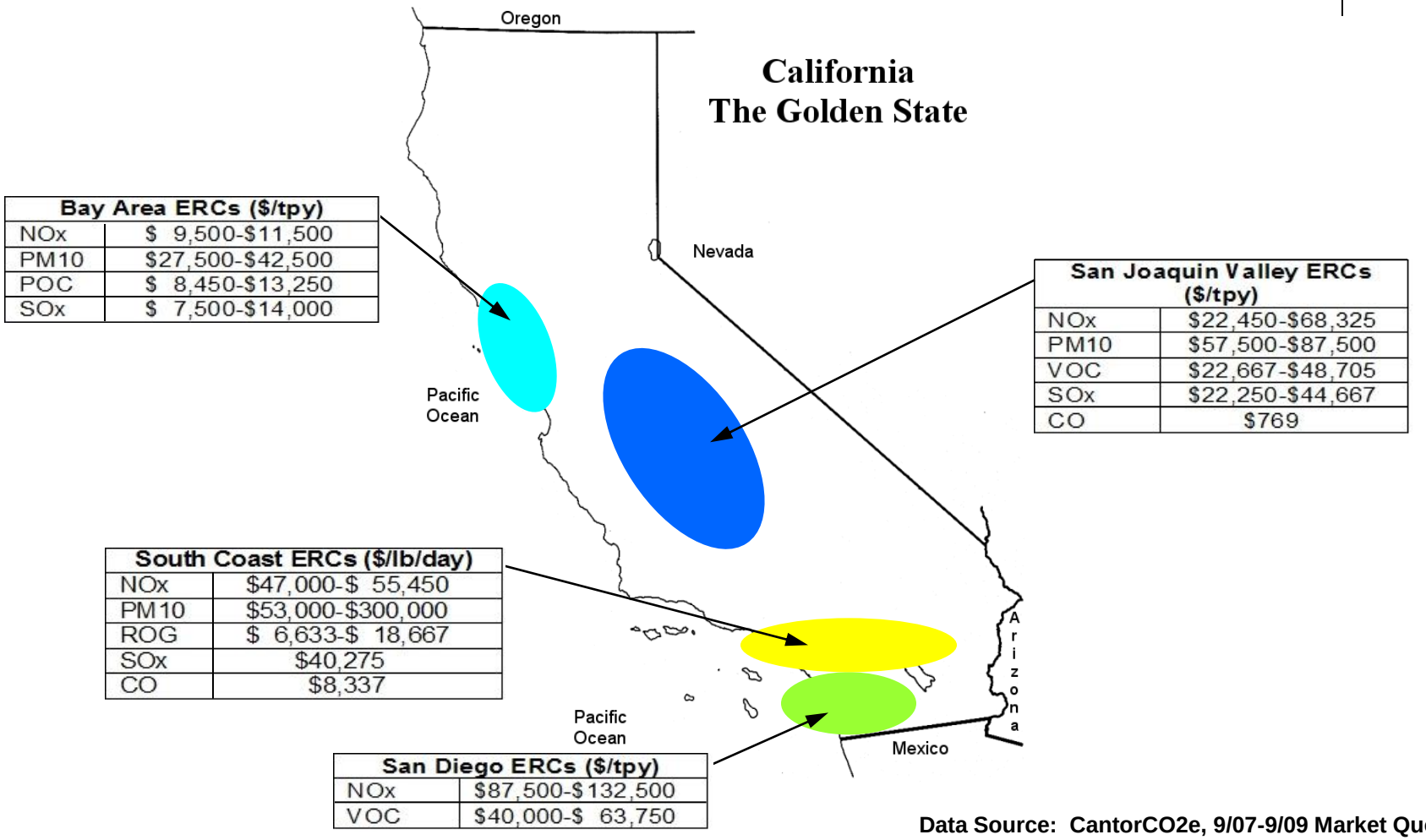
- Generation-Related (1)
  - Avoided Generator
    - In-State Natural Gas Combined Cycle ("NGCC") or
    - Out-of-State Pulverized Coal Central Plant
  - Natural Gas ("NG") Savings & Related Avoided Emissions
    - Higher Fuel Cell Electrical Efficiency
    - Avoided Boiler Fuel Input due to CHP/CCHP
    - Avoided Flared Gas Emissions from Digester Gas Use
- Grid-Related (2)
  - Increased Reliability and Blackout Avoidance: Value Increases as Fuel Cell Market Penetration Increases
  - Increased Power Quality

Four Broad Categories of Benefits Quantified (2 of 2)



- Emissions- and Health-Related (3)
  - Avoided Emissions
    - Value Depends on Location of Avoided Generator
      - Cost of Emissions Reduction Credits ("ERCs") varies widely
  - Value of Health Benefits
    - Limited to Avoided In-State Emissions
- Job Creation Potential (4)
  - Initially Only Fuel Cell Installation
  - Potential for Future In-State Fuel Cell Manufacturing Capacity Adds Significant Value

Value of Avoided Emissions Depends on Geography



Bay Area ERCs ($/tpy)	
NOx	$ 9,500-$11,500
PM10	$27,500-$42,500
POC	$ 8,450-$13,250
SOx	$ 7,500-$14,000

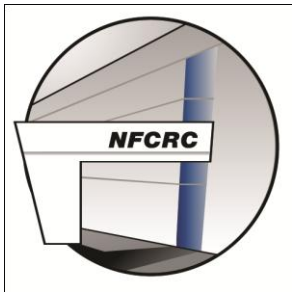
San Joaquin Valley ERCs ($/tpy)	
NOx	$22,450-$68,325
PM10	$57,500-$87,500
VOC	$22,667-$48,705
SOx	$22,250-$44,667
CO	$769

South Coast ERCs ($/lb/day)	
NOx	$47,000-$ 55,450
PM10	$53,000-$300,000
ROG	$ 6,633-$ 18,667
SOx	$40,275
CO	$8,337

San Diego ERCs ($/tpy)	
NOx	$87,500-$132,500
VOC	$40,000-$ 63,750

Data Source: CantorCO2e, 9/07-9/09 Market Quotes.

Build-Up of Large Stationary Fuel Cell Value In California



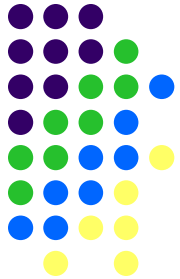
	¢/kWh
Other Values (4)	TBD
Value of Deployment Ease	Site Specific
Value of Job Creation Potential	0.11 - 0.26
Value of Health Benefits*^	2.34 - 2.54
Value of Avoided CO_2 Emissions* (3)	0.11 - 2.21
Value of Other Avoided Emissions (NOx*^, SO2*, VOC*, PM10^, CO*^, Hg)	0.11 - 1.90
Increased Reliability/Power Quality/Blackout Avoidance	<0.01 - 0.22
Value of Grid Support (2)	0.03 - 0.40
Value of Avoided Losses (Generation, T&D, Related Emissions)	0.26 - 0.64
Value of Avoided Distribution Cost (All Costs Allocated to Peak)	0.06 - 0.97
Value of Avoided Transmission Cost (All Costs Allocated to Peak)	0.01 - 0.24
Value of Avoided Water Use	0.00 - 0.26
Value of Avoided Fossil Fuel as a Price Hedge*^	0.36 - 0.96
Value of Avoided Generation Fuel Cost*^ (Efficiency Gain + Cogen Credit + 30% Renewable Fuel Use) (1)	1.28 - 7.03
Value of Avoided Generation Variable O&M Cost	0.00 - 0.25
Value of Avoided Generation Capacity Fixed Operation & Maintenance Cost	0.22 - 0.29
Value of Avoided Generation Capacity Capital Cost (93% Effective Load Carrying Capacity)	1.71 - 2.31

7/29/2007 R7

* Indicates inclusion of Cogen Credit
^ Indicates inclusion of Digester Gas Credit

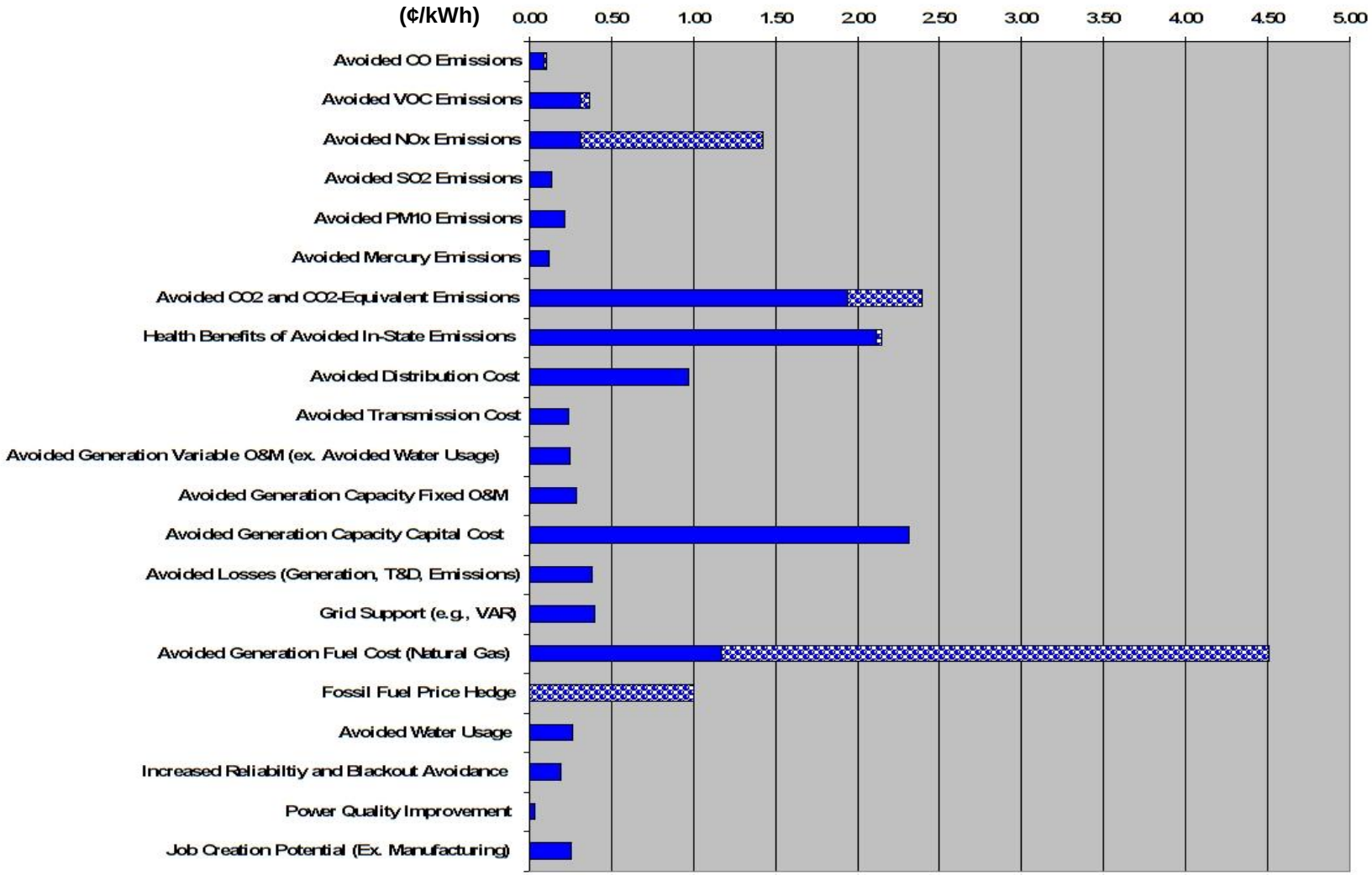
RANGE OF TOTAL FUEL CELL VALUE: **6.6 – 20.5¢/kWh**

CHP/CCHP Increases Fuel Cell Value Proposition by >50%



- 100% Natural Gas, No CHP/CCHP
  - 4.4-12.0¢/kWh
- 100% Natural Gas, With CHP/CCHP
  - 6.7-18.0¢/kWh
- 70% Nat Gas, 30% Renewable, With CHP/CCHP
  - 6.6-20.5¢/kWh
- 100% Renewable Fuel, No CHP/CCHP
  - 6.0-27.2¢/kWh
- 100% Renewable Fuel, With CHP/CCHP
  - 8.4-33.3¢/kWh

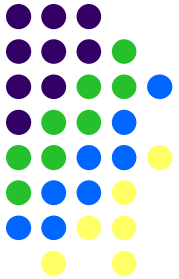
CHP/CCHP Adds Value in Avoided Fuel & Emissions, Health Benefits



Fuel Cell DG: 100% Natural Gas, without CHP/CCHP

Fuel Cell DG: 100% Natural Gas, Added Value from CHP/CCHP

Added CHP Value Recognized in AB 1613 CHP Feed-In Tariff



- Eligible CHP must be sized to meet thermal load of host
- CHP FIT applies only to excess generation
  - Export capacity limited to 20 MW
  - CHP FIT availability may change CHP operating strategy
- CHP FIT Structure:
  - (1) Fixed Component of 2008 MPR (10-Year Contract) – GHG Compliance Costs
  - (2) Monthly Natural Gas Index + Local Distribution Cost, Converted at 2008 MPR Heat Rate
  - (3) 2008 Variable O&M Cost
  - Total of (1)-(3) Multiplied by Applicable TOD Factor
  - 10% Location Bonus
    - For CHP in areas with Local Resource Adequacy requirements (defined, transmission-constrained local areas)

CHP FIT: Illustrative Calculation for FEB 2010 Contract Date

2010 MPR Fixed Component: **$0.02230/kWh**

+

FEB 2010 NYMEX Settlement: $5.32/MMBtu

Basis to CA Border: ($0.22/MMBtu)

Local Distribution: $0.35/MMBtu

NG Component ($/MMBtu): $5.32/MMBtu - $0.22/MMBtu + $0.35/MMBty = **$5.45/MMBtu**

NG Component ($/kWh): $5.45/MMBtu x 6,924 Btu/kWh x 0.000001 MMBtu/Btu = **$0.03774/kWh**

+

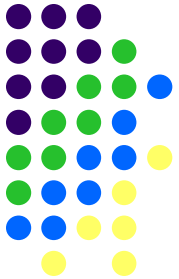
2010 MPR Variable Component: **$0.00451/kWh**

Operation Year	Inputs from 2008 MPR	$/kwh
2009	Fixed component	0.02186
	Variable O&M Adder	0.00443
2010	Fixed component	0.02230
	Variable O&M Adder	0.00451
2011	Fixed component	0.02274
	Variable O&M Adder	0.00459
2012	Fixed component	0.02319
	Variable O&M Adder	0.00466
2013	Fixed component	0.02365
	Variable O&M Adder	0.00474
	[illegible]	0.02367
		0.00483

CHP FIT = $0.02230/kWh + $0.03774/kWh + $0.00451/kWh = $0.6455/kWh*

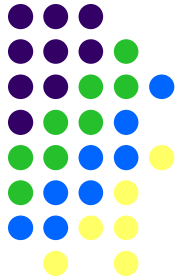
*** Prior to TOD Factor and Locational Adder**

Traditional Benefit-Cost Tests Includes Only Dollars & Cents



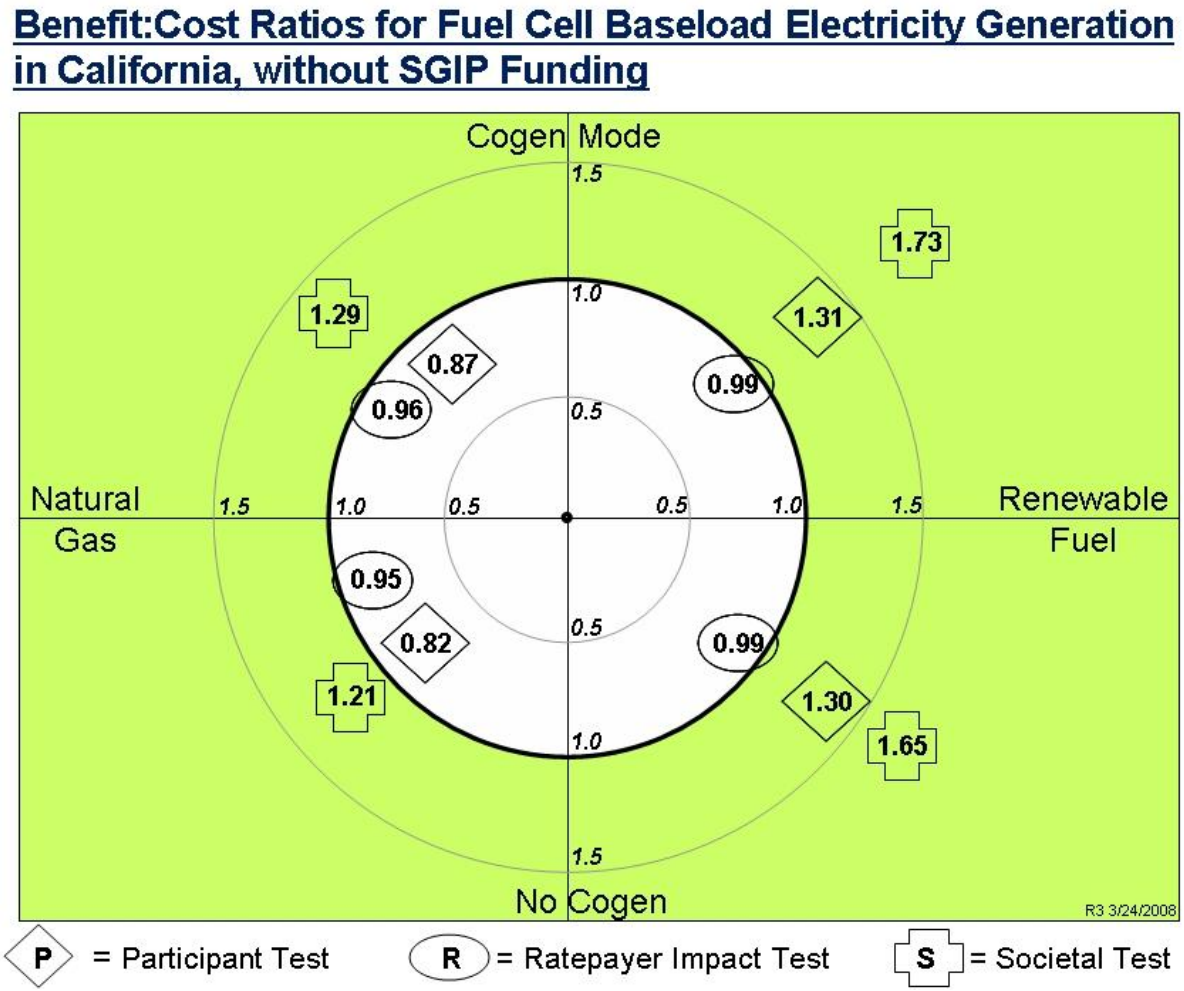
- Participant Test
  - Do (utility) cost savings offset project investment and operating costs?
- Ratepayer Impact Measure ("RIM") Test
  - How does project affect utility ratepayers?
  - Measures relative changes in revenues vs. costs
    - Average cost-based revenues vs. marginal cost
- Societal Test = Participant Test + RIM Test
  - Is "society" as a whole better off?
    - Definition of "society" important
    - Longer-term, broader perspective
- Use only transparent, market-traded $$$ values

Expanded Societal Test Includes All Waterfall Benefits



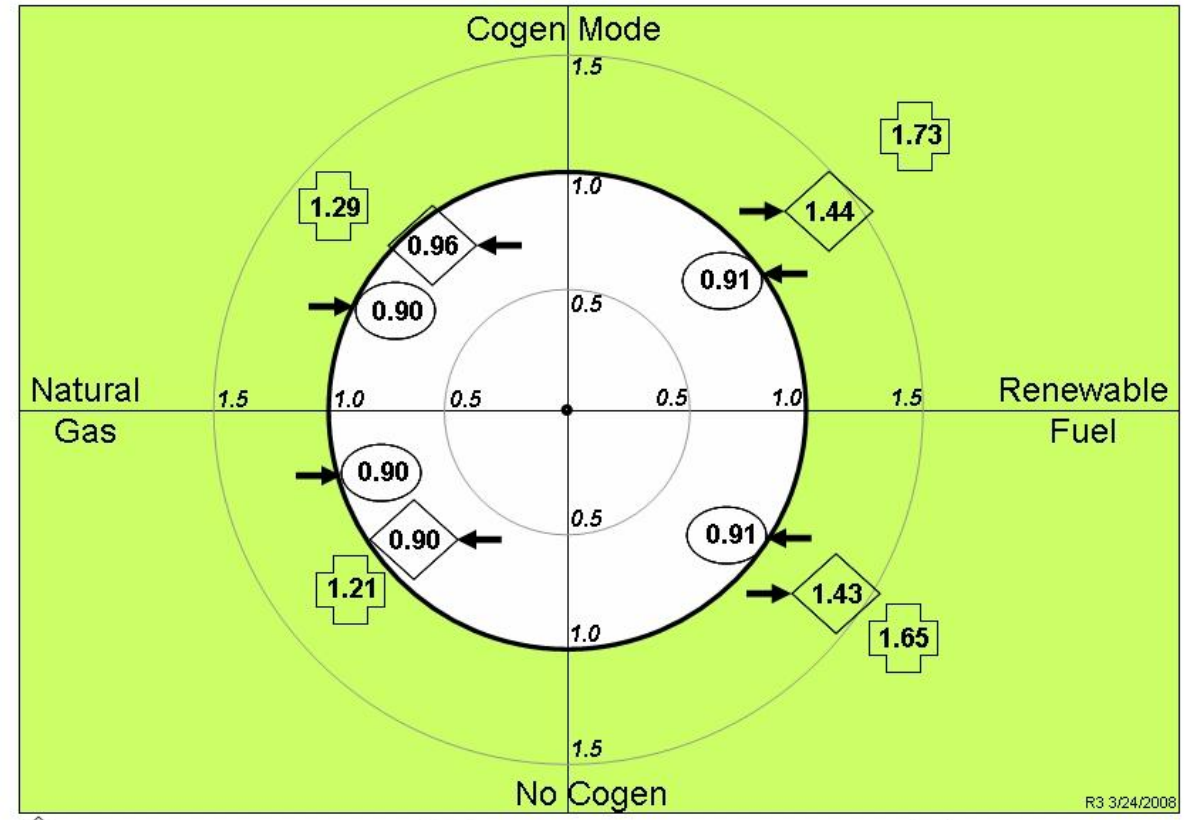
- Traditional benefit-cost tests used by California Public Utilities Commission ("CPUC") exclude externalities due to quantification difficulties
  - Externalities may be significant and either +/-
  - Many waterfall benefits implicitly valued at zero
- Expanded analysis incorporated waterfall benefits into traditional benefit-cost analysis
  - Societal Test
    - Value of Avoided Emissions and Related Health Benefits
    - Value of Grid Support & Improved Power Quality
    - Value of Fossil Fuel Price Hedge (Renewable Fuel Only)
    - Value of Job Creation

Societal Test Results Support Self-Generation Incentive Program

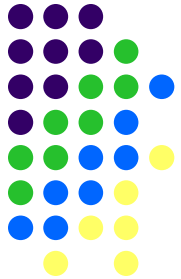


SGIP Moves NG-Based Fuel Cells Toward Cost-Effectiveness

Benefit:Cost Ratios for Fuel Cell Baseload Electricity Generation in California, with SGIP Funding **($2,500/kW, up to 1 MW)**

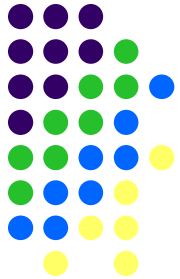


CPUC Cost-Effectiveness ≠ ARB Cost-Effectiveness



- Lesson learned: *Clarify definitions at the outset!*
- CPUC cost-effectiveness focus depends on benefit-cost test
- ARB cost-effectiveness focus is specifically on cost per unit of avoided emissions
  - Traditional cost-effectiveness = Cost of emissions reduction measure / quantity of avoided emissions
  - Head-to-head technology comparison expanded application of cost-effectiveness concept

Adding CHP/CCHP Increases Fuel Cell Avoided Emissions and Value



Step 1: Value Incremental CO_2 Emissions; Apply to Technology Cost Difference

1A. Fuel Cells without CHP/CCHP

Incremental CO2 Market Cost/(Value) ($/MWh)	vs. Simple Turbine ($/MWh)	vs. NGCC ($/MWh)	vs. Microturbine ($/MWh)	vs. Diesel Engine ($/MWh)
PAFC	(0.35)	2.63	10.26	(9.28)
MCFC	(3.33)	(0.35)	7.29	(12.25)
MCFC/T	(9.89)	(6.92)	0.72	(18.82)
PEMFC	(1.55)	1.43	9.06	(10.47)

1B. Fuel Cells with CHP/CCHP

Incremental CO2 Market Cost/(Value) ($/MWh)	vs. Simple Turbine	vs. NGCC	vs. Microturbine	vs. Diesel Engine
PAFC	(8.41)	(5.44)	2.20	(17.34)
MCFC	(8.53)	(5.55)	2.08	(17.45)
MCFC/T	(9.89)	(6.92)	0.72	(18.82)
PEMFC	(1.55)	1.43	9.06	(10.47)

Fuel Cells + CHP/CCHP Competes Head-to-Head with NGCC

Step 2: Calculate Cost-Effectiveness of Fuel Cell Emissions Reductions

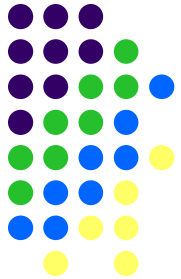
2A. Fuel Cells without CHP/CCHP

CO/NOx/VOC Cost-Effectiveness (NPV$/ton)	vs. Simple Turbine	vs. NGCC	vs. Microturbine	vs. Diesel Engine
PAFC	(216,327)	380,823	No Emissions Reduction	(25,630)
MCFC	(217,375)	288,793	No Emissions Reduction	(26,104)
MCFC/T	(184,049)	40,518	No Emissions Reduction	(28,292)
PEMFC	(29,933)	97,594	No Emissions Reduction	(19,296)

2B. Fuel Cells with CHP/CCHP

CO/NOx/VOC Cost-Effectiveness (NPV$/ton)	vs. Simple Turbine	vs. NGCC	vs. Microturbine	vs. Diesel Engine
PAFC	(129,769)	(11,030)	No Emissions Reduction	(29,386)
MCFC	(146,249)	10,056	No Emissions Reduction	(28,560)
MCFC/T	(204,509)	6,101	No Emissions Reduction	(29,569)
PEMFC	(72,011)	44,413	No Emissions Reduction	(24,115)

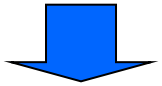
Pushing the Analytical Envelope to Inform the Policy Debate



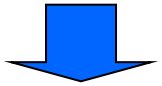
- Quantification of waterfall benefits
- Inclusion of waterfall benefits in traditional benefit-cost analysis
- Application of ARB cost-effectiveness in head-to-head technology comparison
- CRUX: Transparent analysis an absolute must for credibility & replication of results
  - You may not agree with the underlying assumptions, but you know what they are

Conclusion: Steps to Inform Policy Debate & Implementation

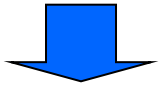
Identify Technology-Specific Attributes



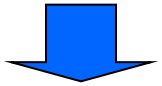
Quantify Technology-Specific Value Proposition



Rank Power Generation Technologies by Value Proposition and Suitability for Achieving Policy Mandates

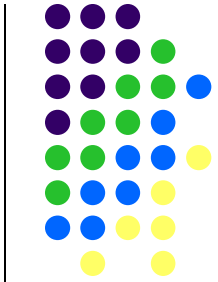


Contribute to the Efficient Achievement of Policy Mandates at Minimum Cost



Enable Evolution of Next Generation Products:
(i) Flexible Fuel Hybrid DG;
(ii) Natural Gas- & Coal-Fired Hybrid Central Plant Generation.

Acknowledgments



- For Providing Data and Financial Support:
  - Altergy Systems
  - FuelCell Energy, Inc.
  - HydroGen LLC
  - Hydrogenics Corporation
  - Idatech, LLC
  - Plug Power Inc.
  - Rolls-Royce Fuel Cell Systems (US) Inc.
  - Siemens Power Generation, Inc.
  - UTC Power Corporation

- For Collaboration and Project Coordination:
  - National Fuel Cell Research Center