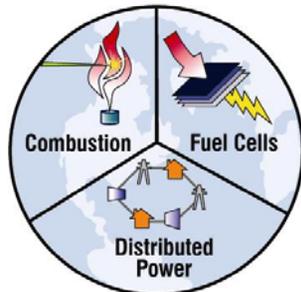


Evaluating and Capturing Benefits of Renewable Energy for California

Lori Schell, Ph.D., UC Irvine/Empowered Energy

California Energy Commission
IEPR Lead Commissioner Workshop
Sacramento, California
April 12, 2012



**Advanced Power
and Energy Program**

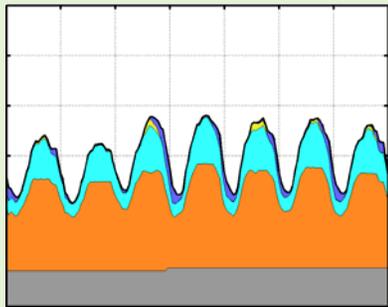
UCIrvine | UNIVERSITY
OF CALIFORNIA



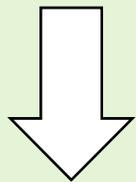
More Renewables, More Challenges

→ Increasing Renewable Penetration Level

0%

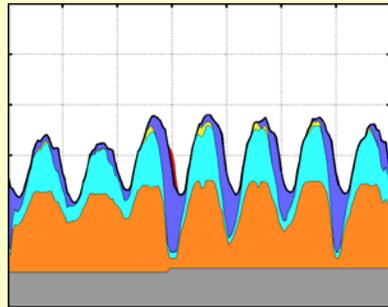


Minimal Effects

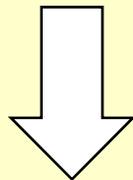


Cost and Performance

20%

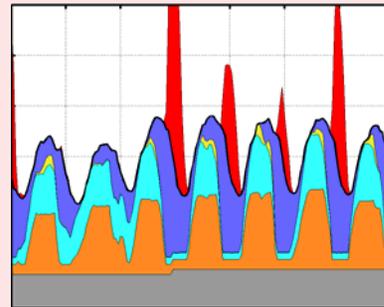


Generation Portfolio and Management

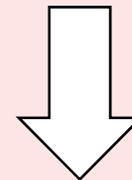


Cost and Performance

33%

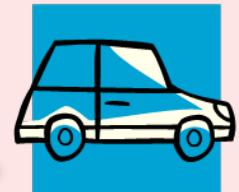


Portfolio, Management, Operation and Integration



Performance, Cost, Economic Life, Role of Complementary Technologies

50%



100%



Economics to Guide Added Grid Flexibility

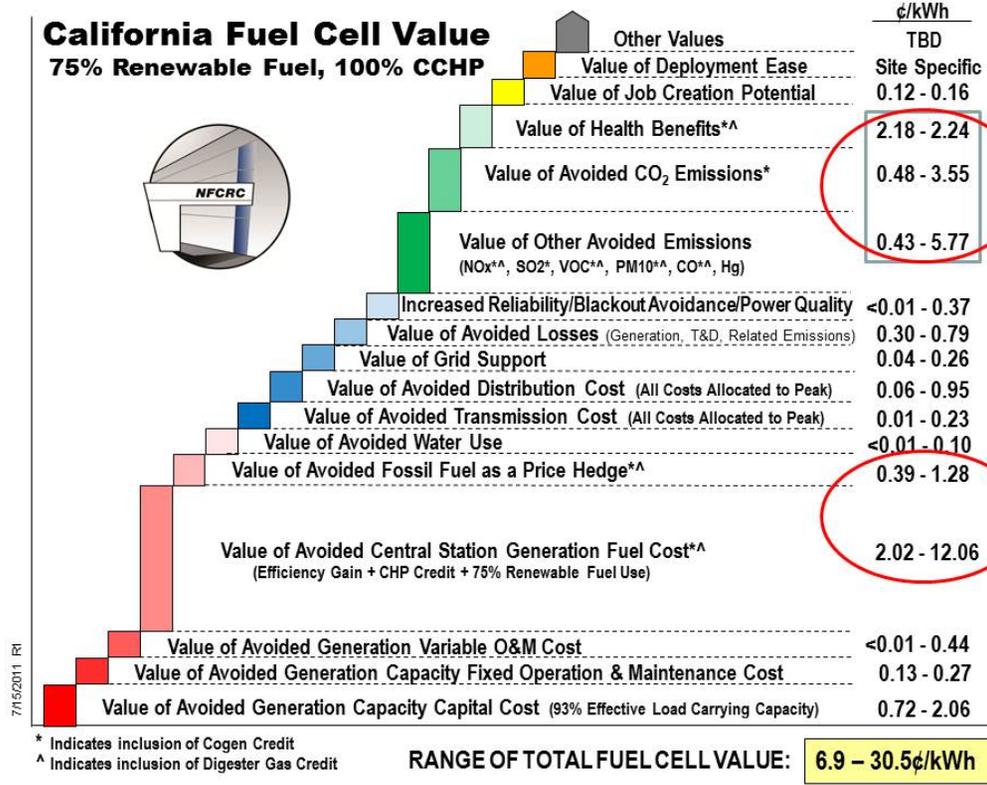
- **Existing and future technologies needed to buffer intermittency of wind and solar**
- **Baseload Generation**
 - **Fuel cells: Distributed; efficient; low emissions**
 - **Geothermal: Efficient; low emissions**
- **Dispatchable Generation**
 - **Peakers: Natural gas; distributed; inefficient; relatively high emissions**
 - **Solar thermal with storage**
- **Complementary (Non-Generating) Technologies**
 - **Demand Response (DR)**
 - **Energy Storage: Pumped Hydro, CAES, Batteries**



Initial Technology-Specific Valuation...

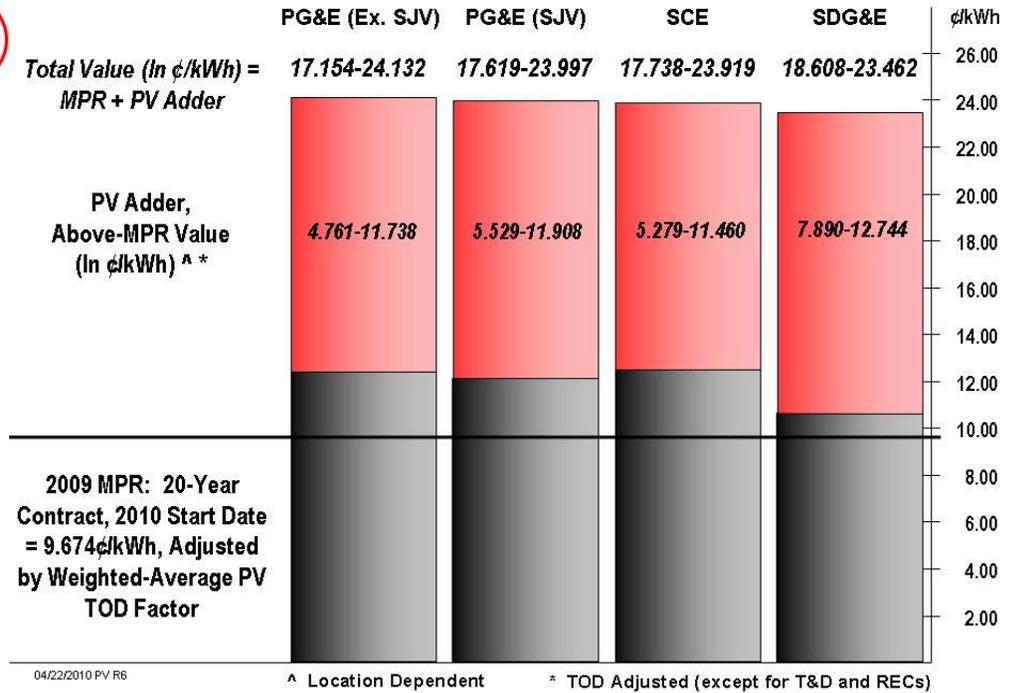
California Fuel Cell Value

75% Renewable Fuel, 100% CCHP



- Value depends on what generation is avoided (e.g., peak, baseload)

Small-Scale Solar PV in California: Total Value (2009 MPR + PV Adder)



- Value depends on timing (e.g., avoided fuel costs, emissions allowance costs) and technology



Feeds Simultaneous & Systematic Analysis

- **Each technology impacts every other technology**
- **Each technology creates benefits**
 - **Avoided T&D and related grid support**
 - **Avoided emissions & related health benefits**
 - **Job creation potential**
- **Each technology imposes costs**
 - **Need to to offset renewable intermittency**
 - **Electric vehicle charging (depending on timing)**
- **Grid-wide valuation captures inter-related and potentially offsetting technology-specific impacts**
 - **Peak load reduction/shifting due to DR/solar**
 - **Emissions impact of required balancing generation**

