The Benefits of Distributed Fuel Cell Power Plants and Their Role in the Hydrogen Transition

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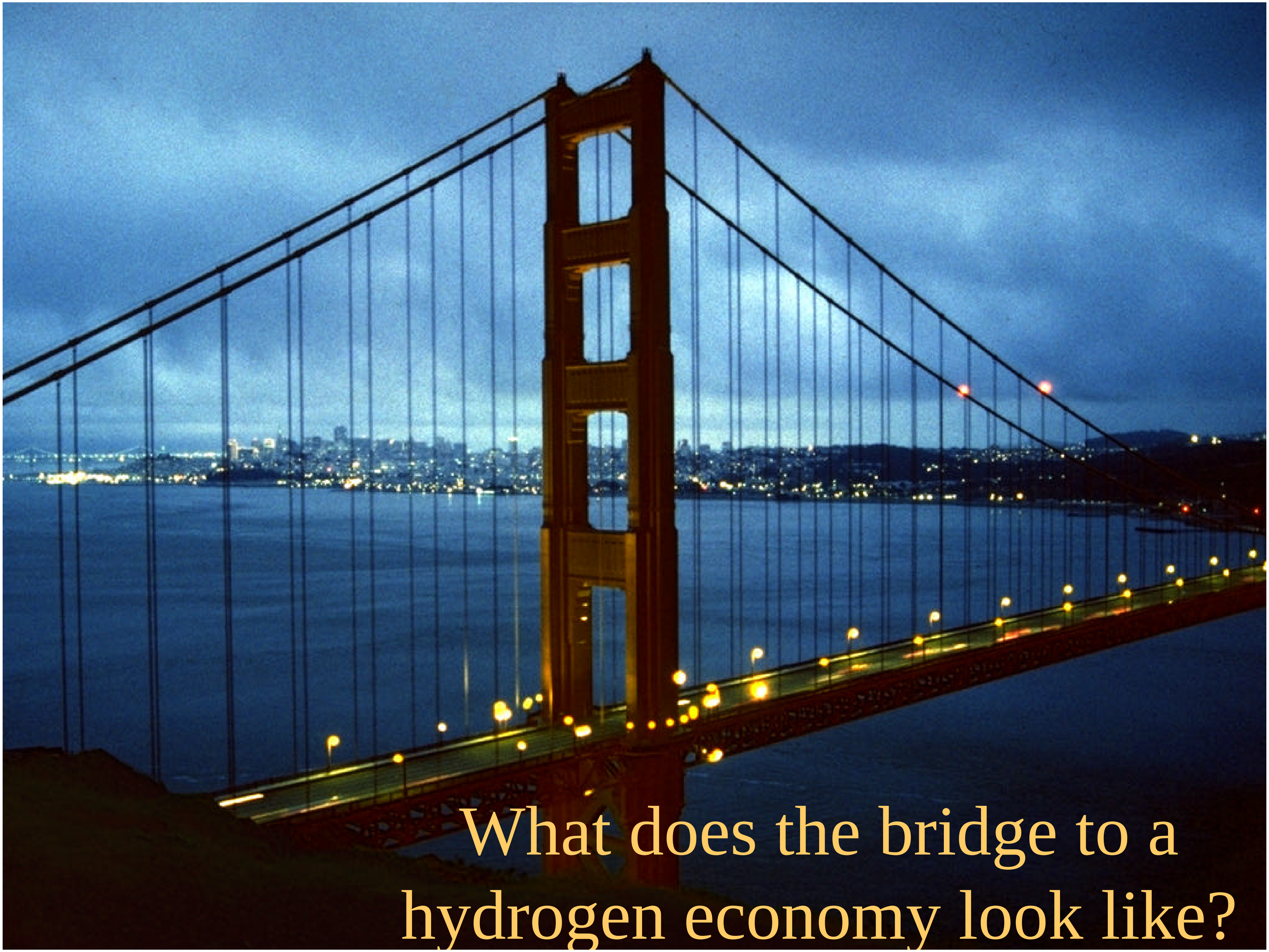
Courtesy of International Fuel Cells, LLC

The Hydrogen Transition - Why?

- Hydrogen (H_2) is neither a final product with any inherent demand nor a new source of energy that exists in any significant quantity (on Earth)
- Rather, H_2 is an intermediate energy carrier for which there is presently almost no existing infrastructure for production and delivery
- And, there is the ‘chicken-and-egg’ problem:
  - – No incentive to develop H_2 delivery infrastructure until there is substantial demand from H_2 users
  - – No incentive to produce H_2 technology (e.g., cars) until there is adequate H_2 delivery infrastructure

On the Other Hand, the Hydrogen Transition...

- …offers the potential for near-zero emissions at the end-use (hot water for onboard espresso…)
- …sets the stage for the emergence of fuel cell technology in vehicles and for stationary power
- …provides a potential way to store electricity from central, intermittent renewable generation
- …suggests a possibility of carbon-free energy delivery from ‘scrubbed’ fossil fuels


What does the bridge to a
hydrogen economy look like?

Fuel Cells and the Hydrogen Economy: A Practical, Profitable Transition Path

1. Stationary fuel cells first in buildings for efficient cogeneration
    - Fuel with natural-gas reformers or off-peak electrolyzers

2. Introduce H_2-ready vehicles
    - Fleets (return nightly to the depot for refueling)
    - Customers who work near buildings that have fuel cells
        - Use buildings' hydrogen appliances for refueling
        - Sell kWh and ancillary services to grid when parked
        - Earn back part of the cost of car ownership

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3. As H_2 appliances get cheaper, put them at "gas" stations
4. As both H_2 and fuel-cell vehicles become widespread, bulk production and central distribution of hydrogen becomes feasible
5. Produce H_2 via electrolysis with renewable electricity
   - H_2 storage makes wind/PV power firm and fully dispatchable, able to capture 'distributed benefits'

Necessary (but not sufficient!) Prerequisite Conditions for the Hydrogen Transition

1. Stationary fuel-cell cogeneration in buildings - Capture the distributed economic benefits inherent in a clean, dispatchable, reliable source of power

   - Realizing economic value is key to early market adoption of stationary fuel-cell generation, step #1 in the H_2 transition!

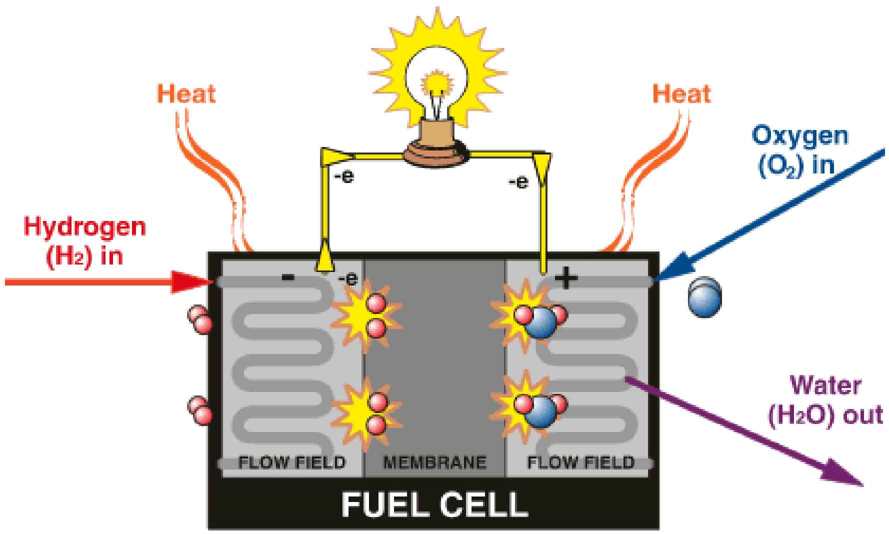
   - I will discuss these distributed benefits further...

2. H_2 fuel-cell vehicles - Radically improved (~3x) efficiency in vehicle platform physics (weight, drag)

   - Makes the fuel cell affordable

   - Makes room for the H_2 (and the passengers and cargo)

   - (I *won't* discuss this further - see www.hypercar.com)



Economics of Fuel Cell Generation

- Fuel cells are a *high-capital-cost*, *low-energy-cost* power source.
- There are two ways to reduce fuel cells' capital cost disadvantage against central combined-cycle stations:
- One way is to reduce the *cost of fuel cells*, and numerous manufacturers are working hard to achieve cost reductions in each of the fuel cell technologies under development, as they enter high-volume production.
- The other way is to build the *value side of the equation*—to find additional economic benefits that fuel cells can deliver by virtue of their smaller size and greater flexibility, their quiet, clean operation, and their ability to co-generate heat and electricity.

Changing Economics of Central Generation

- Utilities can no longer build hugely expensive nuclear and coal-fired plants with full confidence of recovering capital costs.
- The reasons include industry restructuring, environmental constraints, reliability needs, new technology, aging and deterioration of the existing power supply infrastructure, and renewed concerns about energy supply security.
- Central steam-turbine generation plants stopped getting more efficient in the 60s, stopped getting cheaper in the 70s, stopped getting bigger in the 80s, and stopped getting built in the 90s.
- Similarly, T&D can no longer be considered simply an extension of the generation system - the costs might not be justified.
- Increasingly today, "small is profitable."

Economic Benefits of Distributed Energy

- – Electric energy and capacity value
- – Thermal energy value (co-generation)
- – Option values and risk management
- – Savings in grid cost and ancillary services
- – Utility and customer reliability value
- – Externalities: emissions, noise, etc.

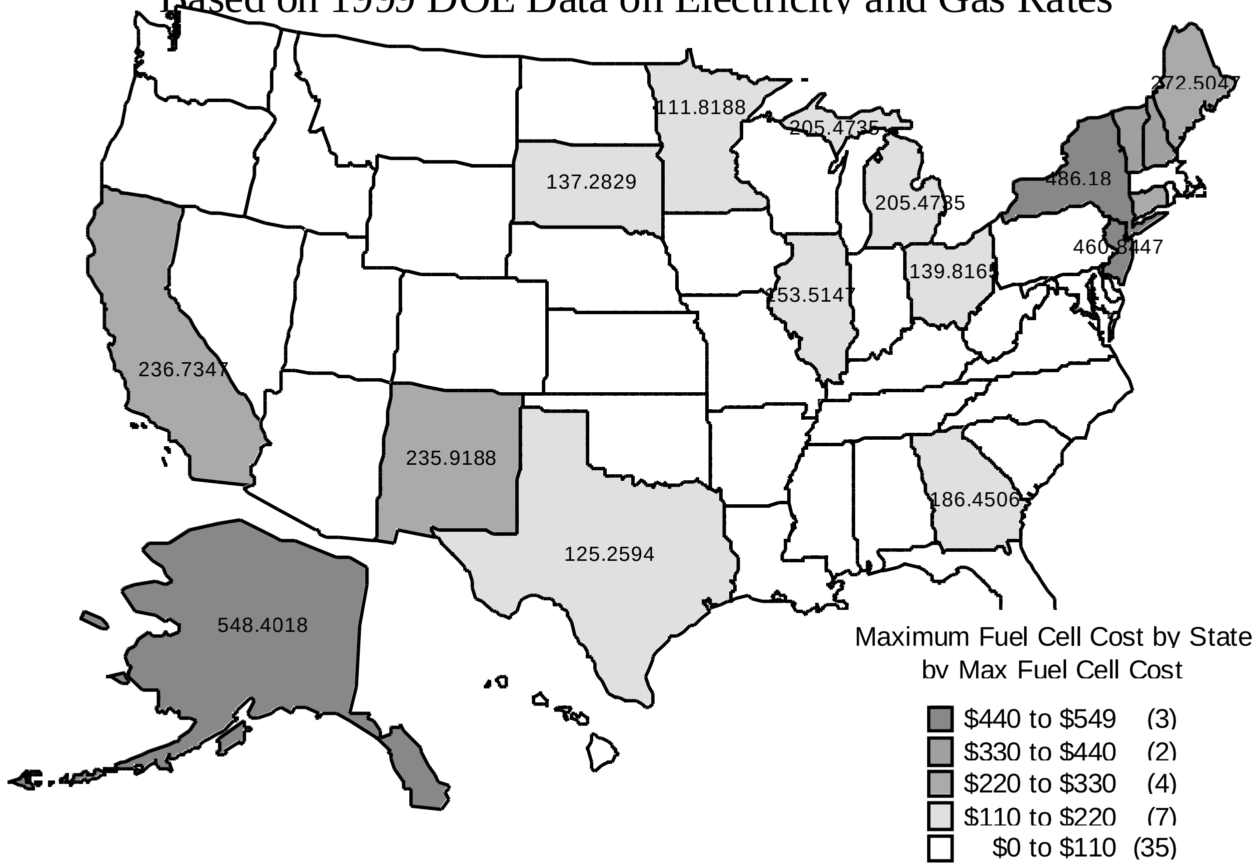
Energy Values

Energy value of power generated from a DG source depends on:

- System size and voltage level of connection
- Customer load factor (variability of load)
- Co-generation potential (thermal energy value)
- Relative electricity and gas prices (the ‘spark spread’) for gas-fired sources
- The applicable utility pricing structure & regulations

Energy value is very sensitive to electric and gas prices...

Based on 1999 DOE Data on Electricity and Gas Rates



Option Value of DG Sources

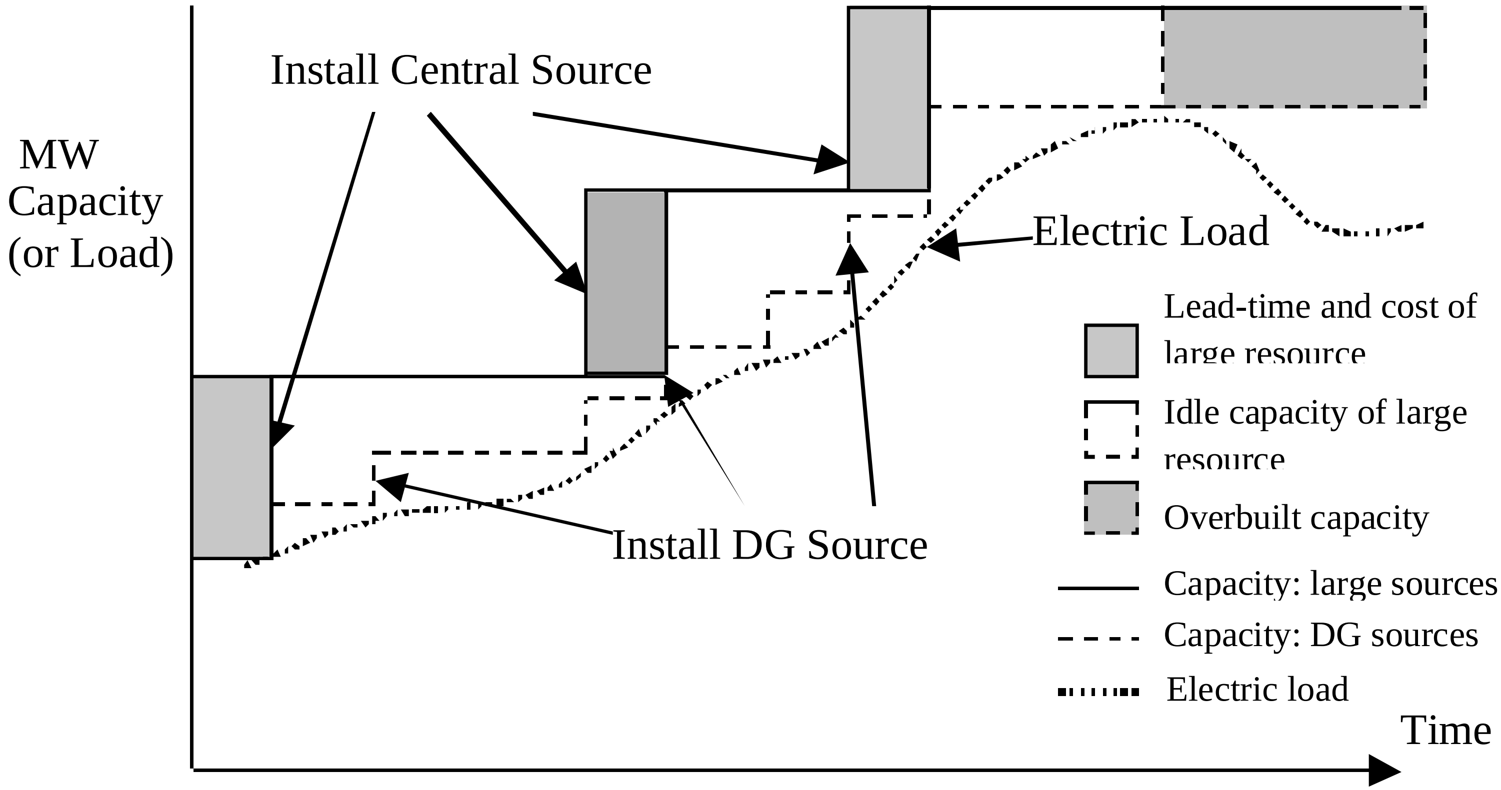
Small scale and modularity provide an option value from:

•Increased planning flexibility

•Shorter lead-time, and

•Decreased risk of overbuilding

•Optionality: low cost to start, stop, defer



Analysis approach to estimate deferral value and other distributed utility benefits:

Area- and time-specific (ATS) utility costing

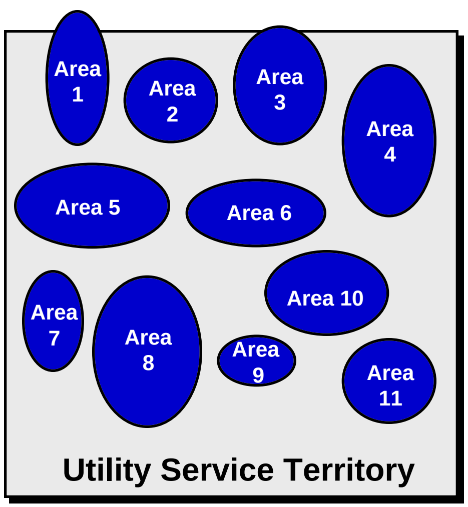
- Based on analytic advances in determining utilities' area- and time specific (ATS) marginal costs
- Depend most on distribution and local transmission costs (unlike the system-level costs, which depend most on generation and bulk transmission costs)

Benefits of this approach:

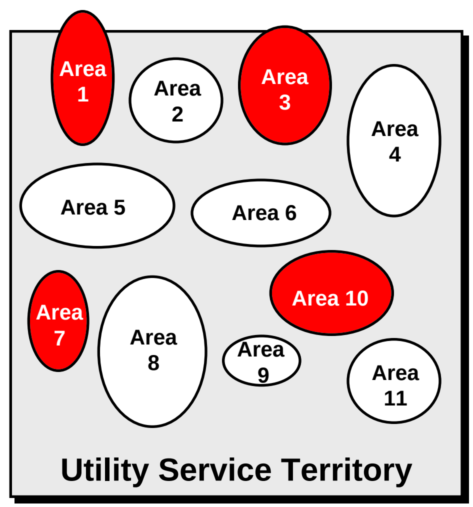
- Prioritizing DG plant siting to maximize cost-effectiveness
- Targeting high-impact DSM programs by area and time
- Understanding T&D cost structure
- Improving T&D planning criteria

Comparison of conventional plant-siting or DSM to targeted (ATS-based) approach

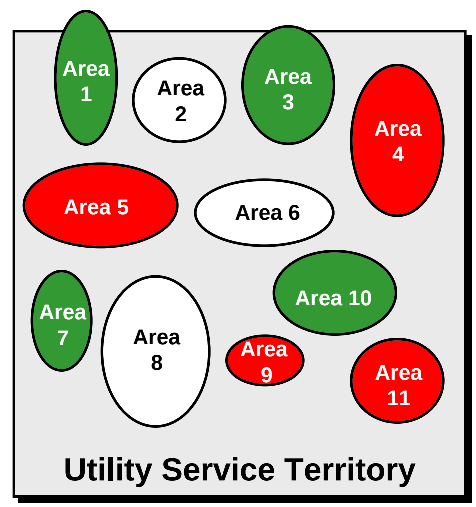
‣ Conventional approach:	Distributed generation or targeted DSM:
‣ Based on system-level costs	Based on area- and time-specific costs
‣ Each area looks the same!	High-cost (red) areas move around in time!



High Cost Areas – Year 1

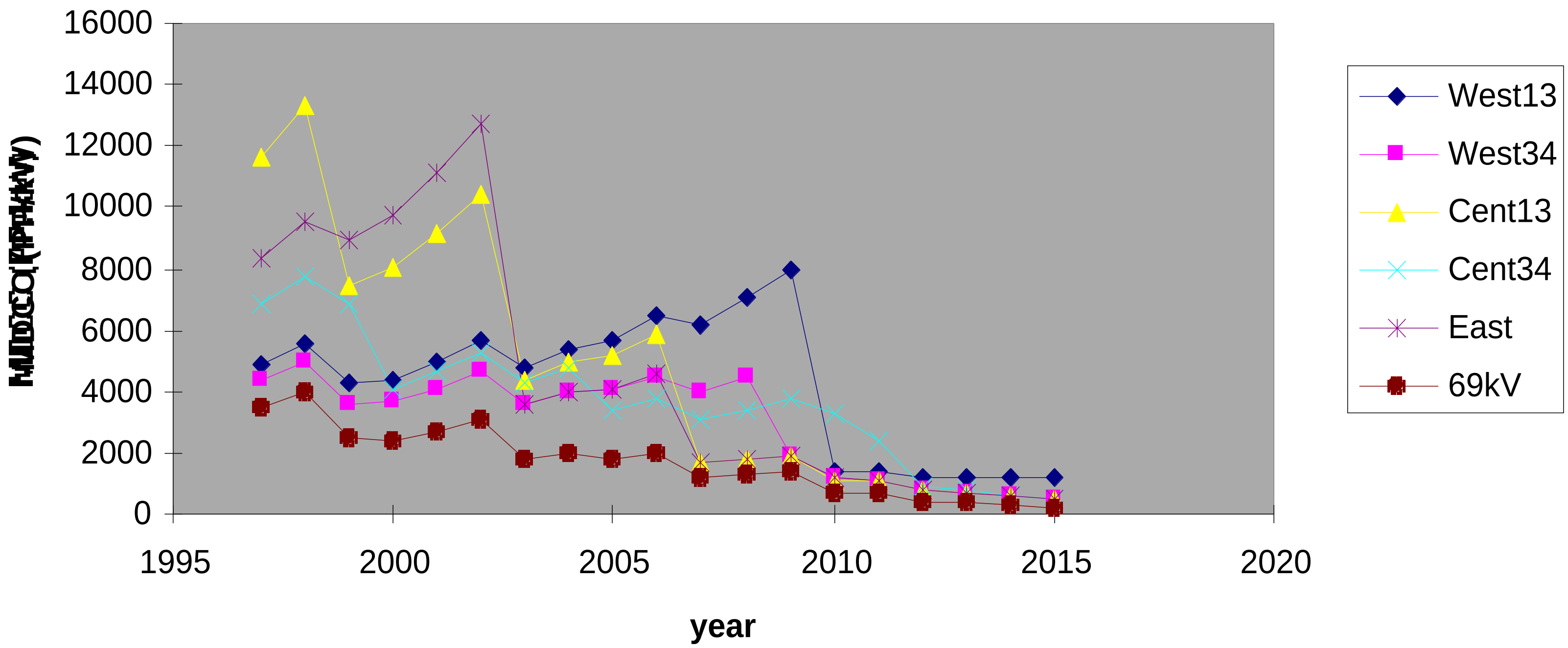


High Cost Areas – Year 5



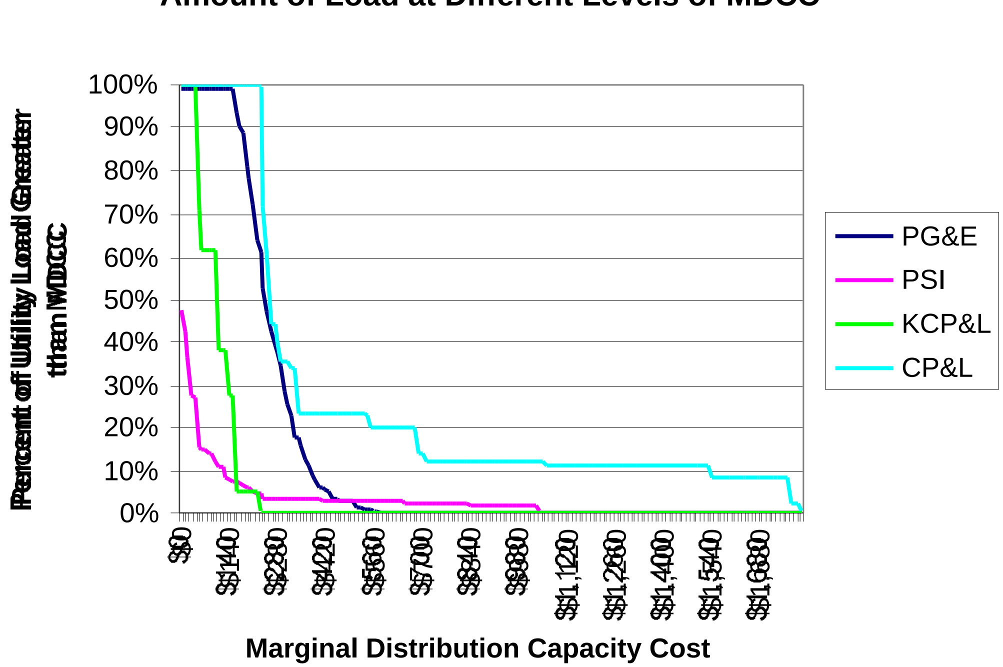
ATS Marginal Capacity Costs

Cepalco ATS marginal capacity costs (excluding low-voltage works)



Deferral Value - based on area MDCCs

- The deferral value depends on the marginal distribution capacity cost, which varies by location and time.
- The MDCC value can range from zero to over $1000/kW, with most areas at $100-$400/kW.
- By selecting high cost areas, a utility can offset their revenue loss in cost savings through deferral of capacity increases in high-cost areas.



Engineering Cost Savings and Ancillary Service Value

In a common “problem area,” DG operation can:

- Eliminate the need to re-conductor feeders
- Improve voltage levels at the feeder ends
- Eliminate the need for capacitor banks
- Provide reactive power (VAR) compensation
- Eliminate the need for voltage regulators
- Reducing feeder loading and delay replacement
- Reduce line losses and transmission system load

Power supply reliability/resilience

EPRI-website synthetic satellite image, 10 August 1996…utilities routinely keeping the lights on. But ~98–99% of U.S. outages are caused by the grid. For example...

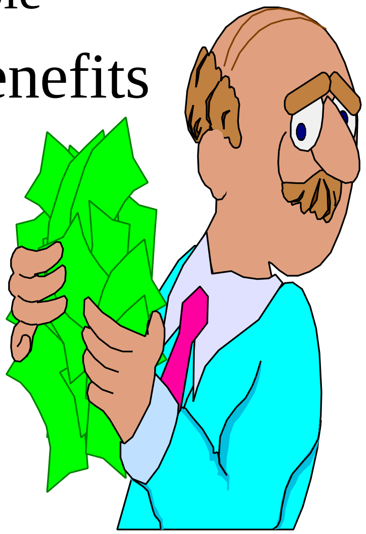
35 seconds later, after an Oregon powerline sags into a tree limb, operational goofs plus poor communications black out four million people in nine Western states and parts of Canada. Local supply can prevent that—and up to 95+% of grid failures are in the* distribution *system

Customer Reliability Value

- By itself, a DG source cannot provide *peak availability* as high as wires-only solution
- DG requires *redundancy* to improve reliability
- But if most of the reliability value depends on specific, critical loads, wires-integrated DG can achieve more value than a wires-only solution by *improving reliability for critical loads*
- DG can give *critical uses premium power quality and reliability* (>99.9%) if *"islanding"* is feasible
- DG can provide improve reliability *even if backup power must be non-firm* (to avoid standby charge)
- On-site renewable sources can provide additional insurance against *fuel interruption*, price volatility

The bottom line – there are many sources of DG value, but few occur together

- All of these values are site- and technology-specific
- Similar value also provided by DSM, T&D band-aids
- Realizing the value requires distribution utility cooperation
- Most values are difficult to monetize in the present market
- Competition with other distributed generation technologies
  - Problems for turbines and engines: must be clean and quiet
  - Problems for renewables: must be dispatchable and reliable
- Early market niches with substantial distribution benefits
  - High-cost distribution 'hot spots'
  - Premium reliability markets
  - Non-attainment areas with NOx emission constraints
  - Portable generation support for T&D grid



Four Times Square, NYC

(Condé Nast Building)

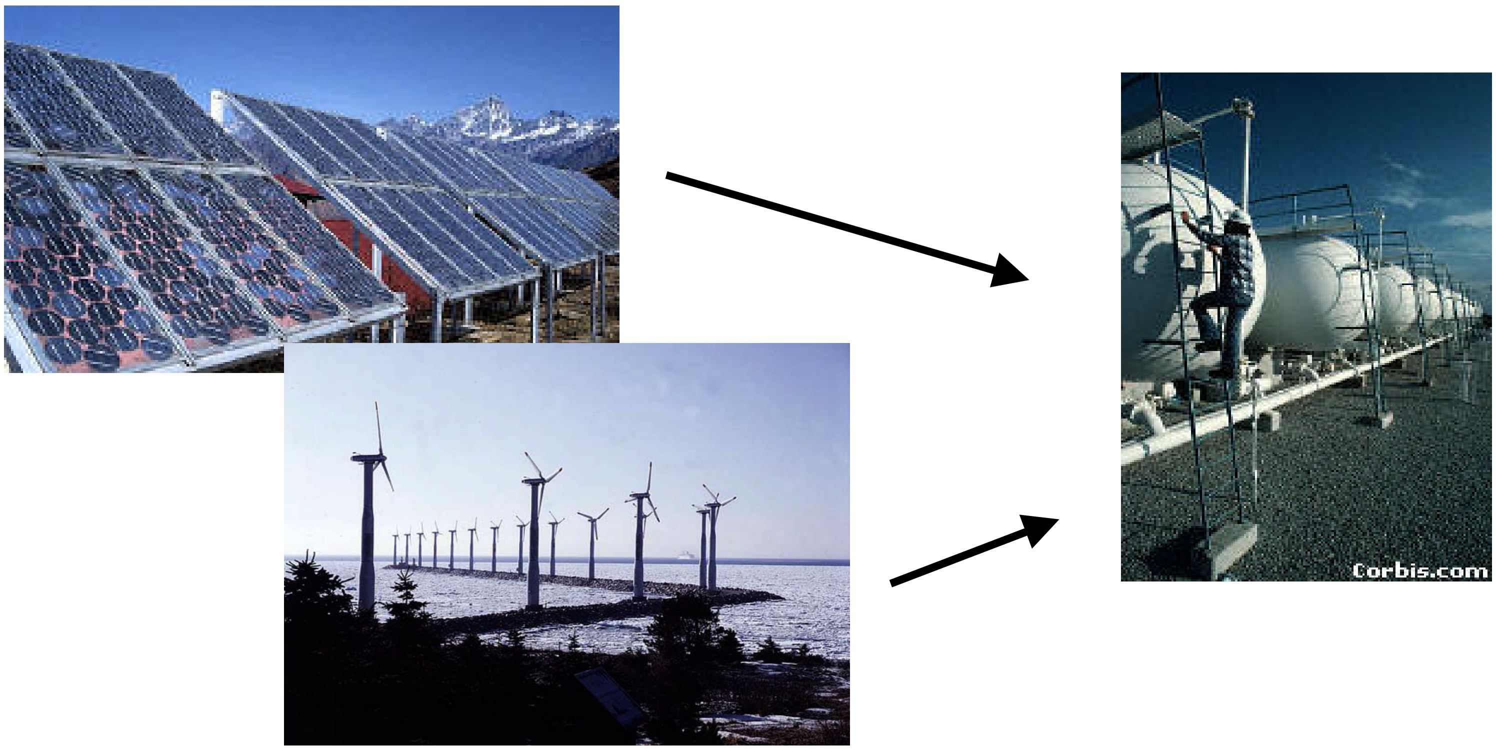
- 149,000 m^2; 47 floors
- non-toxic, low-energy materials
- 40% energy savings/ft^2 despite doubled ventilation rates
- Gas absorption chillers
- Fuel cells
- Integral PV in spandrels on S & W elevations
- Ultra-reliable power helped recruit premium tenants at premium rents
- Fiber-optic signage (signage required at lower floor(s))
- Experiment in Performance Based Fees rewarding savings, not costs
- Market average construction cost

Which distributed benefits apply to each resource?

Type of distributed benefit:	Targeted DSM	Distributed co-generation	Renewable sources
Option value	Yes	Yes	Yes
Electric energy value	Yes	Yes	Yes
Thermal energy value	Possible	Yes	Unlikely
Deferral value, engineering cost savings, ancillary services	Possible	Possible	Difficult for intermittent source
Reliability	Some (reduced cost of backup)	Yes, with modular design	Difficult, but can provide fuel independence,
Environment	Yes	Depends on technology	Yes

H_2 from Renewable Sources

The ultimate goal, but demands a deliberate approach along a difficult, complex path



Bottom line: The H_2 economy needs Hypercar® and DG more than Hypercar® and DG need the H_2 economy

Distributed Benefits and Utility Planning

- **Distribution utilities can realize cost-saving measures revealed by ATS costing methods**, which can be integrated into their expansion planning at the local level, i.e., via local integrated resource planning (LIRP).
- In a competitive market, this provides a market niche for distributed generation and targeted DSM.
- With regulated distribution utilities, this provides for least-cost expansion planning.
- **Now labeled energy resource investment strategies (ERIS)**, **this planning approach is making a comeback** with municipal utilities and local energy authorities, such as the SF PUC and Hetch Hetchy Water and Power.