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Environmental Energy Technologies Division   Lawrence Berkeley National Laboratory

Distributed Generation: Trends and Solutions in US

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International Forum on Energy Transitions

Suzhou, China

October 29-31 2016

劳伦斯引入大团队科学研究
劳伦斯伯克利国家实验室：能源部第一个国家实验室

13 Nobel Prizes


Luis W. Alvarez


Melvin Calvin

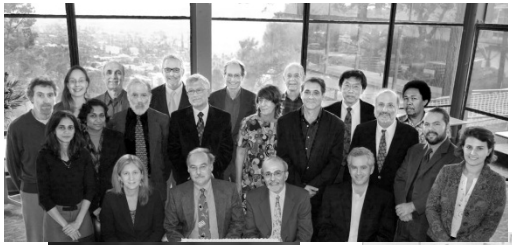

Owen Chamberlain


Steven Chu

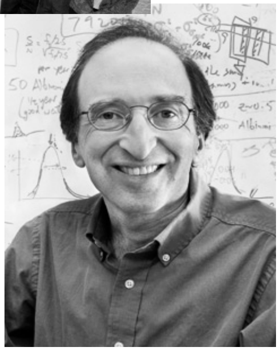

Donald A. Glaser


Ernest Orlando Lawrence


Yuan T. Lee


Intergovernmental Panel on Climate Change (IPCC)


Edwin M. McMillan


Saul Perlmutter


Glenn T. Seaborg


Emilio G. Segrè


George F. Smoot

Presentation Outline

- Distributed Generation: trends and policies in US
- District Energy System Optimization Tools
- Distributed Energy System/Microgrid pilots

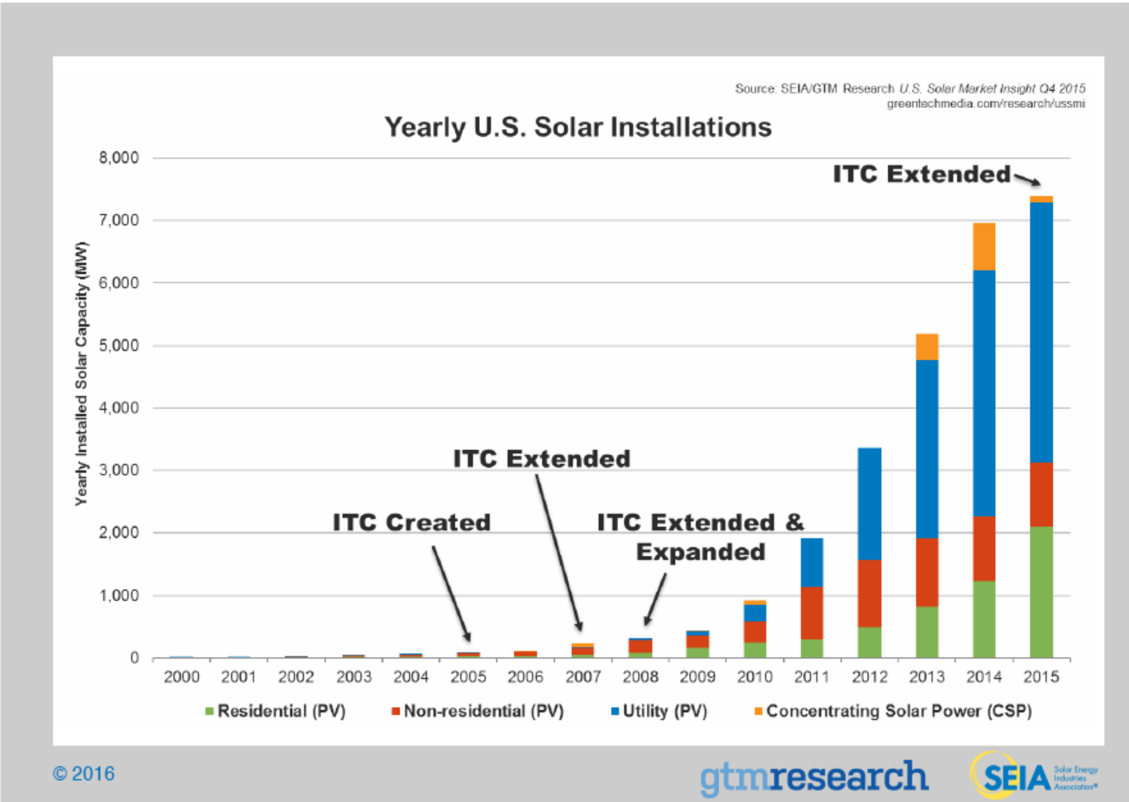
Trends in Distributed Generation in US

- Distributed Generation
  - a variety of technologies that generate electricity at or near where it will be used, such as solar panels and combined heat and power.
  - Distributed generation may serve a single structure, such as a building, or be part of a microgrid, such as at a industrial park, a military base, or a large college campus.
  - Solar, gas turbine/engines, fuel cells, biomass

- The Major sources of Distributed Generation includes
  - Rooftop solar, ***fastest growing***
  - CHP, the largest source, about 8% of power capacity

- Increasing interests in District Energy Systems with microgrids to improve resilience

Growing at 60%, expected to reach 20 GW by 2020



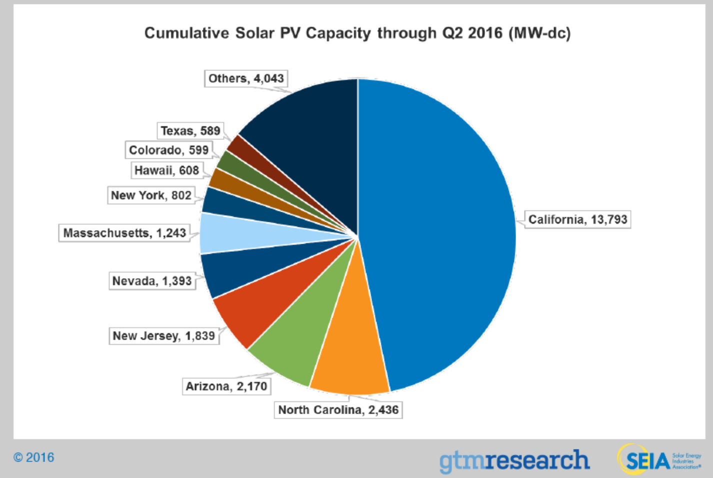
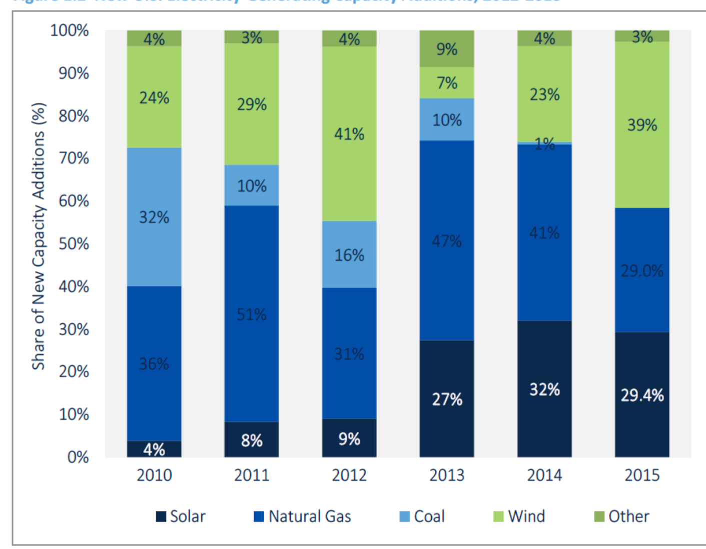


Figure 1.2 New U.S. Electricity-Generating Capacity Additions, 2012-2015



Source: GTM Research (solar) FERC (all other technologies)

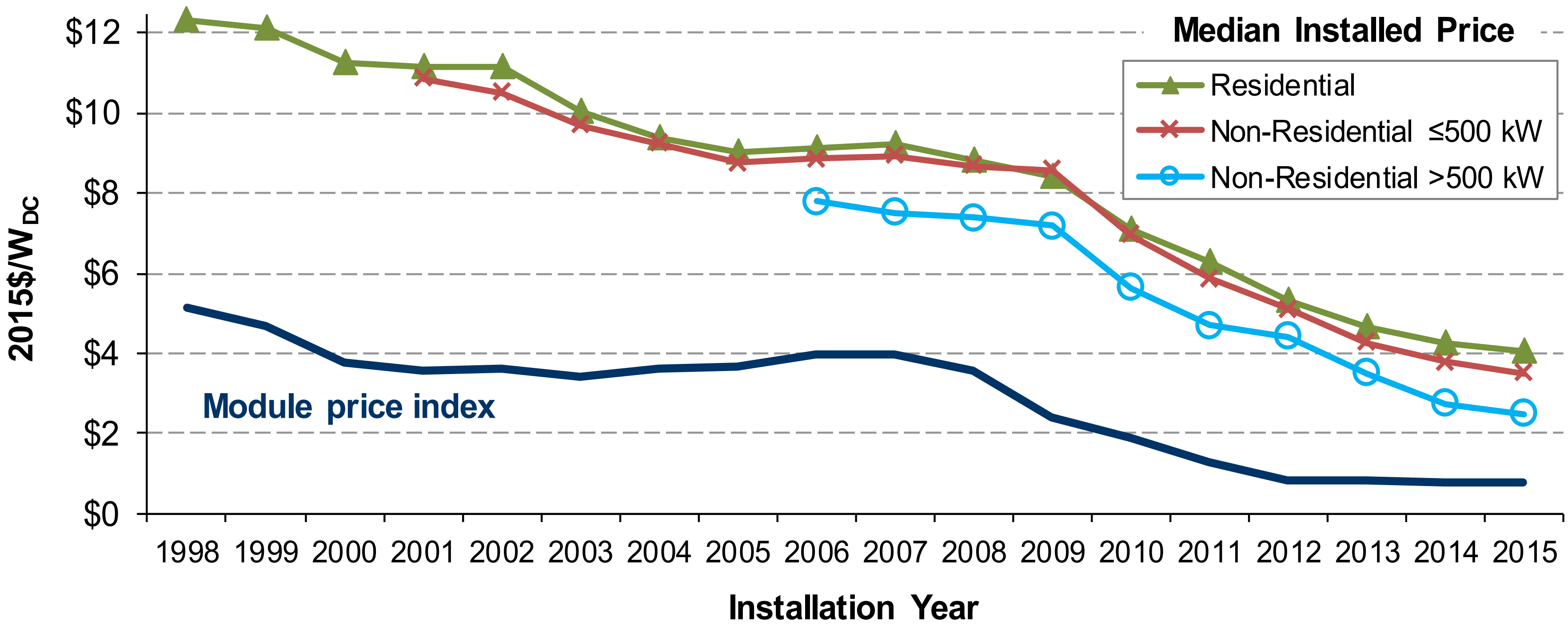
- Diversified market: utility, residential, commercial
- 1% U.S. electricity supply in total (DG PV = 0.3% nationwide, 6% HI, nearing 2% CA/NJ)
- 2016 expectation: ~16 GW new installation

Multiple Deployment Drivers

- **Falling costs and improving performance**
- **Policy intervention at national and state levels**
- Business and financing innovations
  - third party ownership
  - private loans, PACE, etc.
  - shared / community solar

Prices for Distributed Solar Continue to Decline

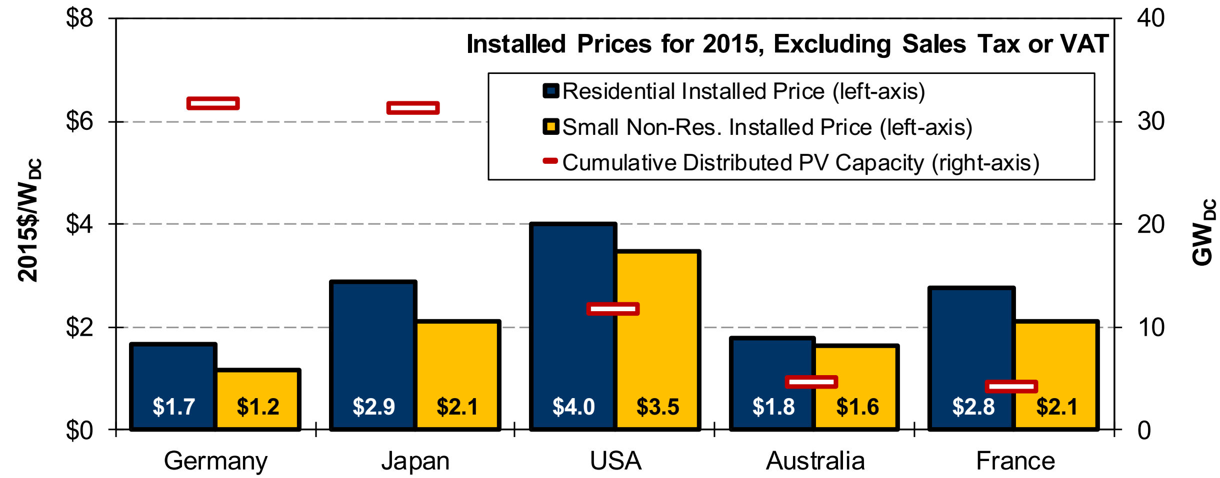
Average annual decline since 2009: **11%** per year (res.) to **16%** (large non-res). **From 2014-15: 5%** per year (res.) to **9%** (large non-res.)



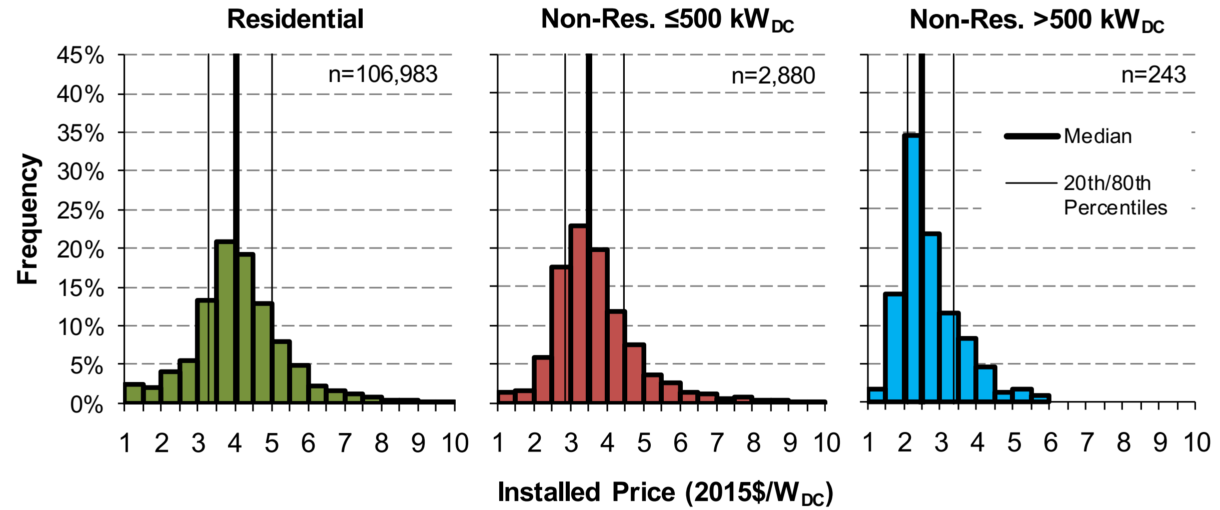
Median installed price series is based on data from 451,693 systems, assembled by Berkeley Lab (trackingthesun.lbl.gov). Module price index is from SPV Market Research.

Even Lower-Cost Systems Are Commonplace: potential for further price declines

Comparison of 2015 PV System Prices across Countries

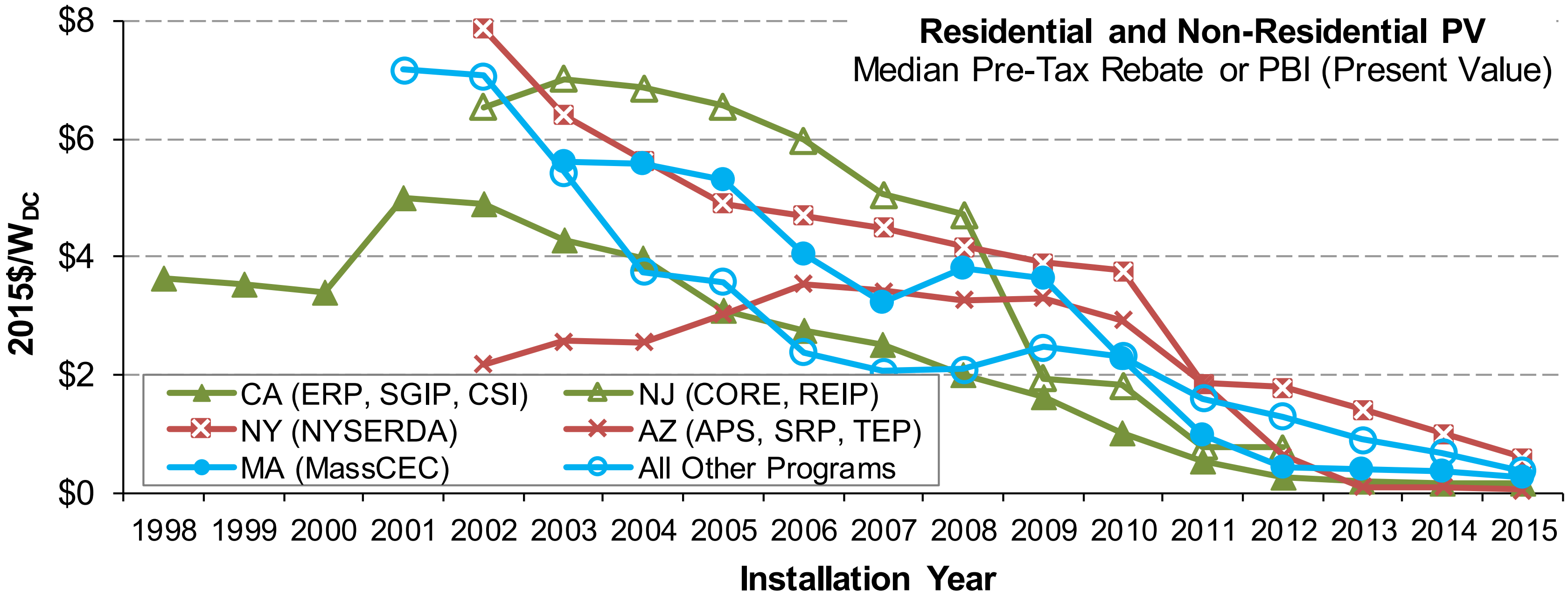


Installed Price Distributions for U.S. Systems in 2015



Installed Price Declines Have Been Partially Offset by Falling State and Utility Incentives

Reductions in rebates and PBIs since their peak equate to 60% to 120% of the corresponding drop in installed prices

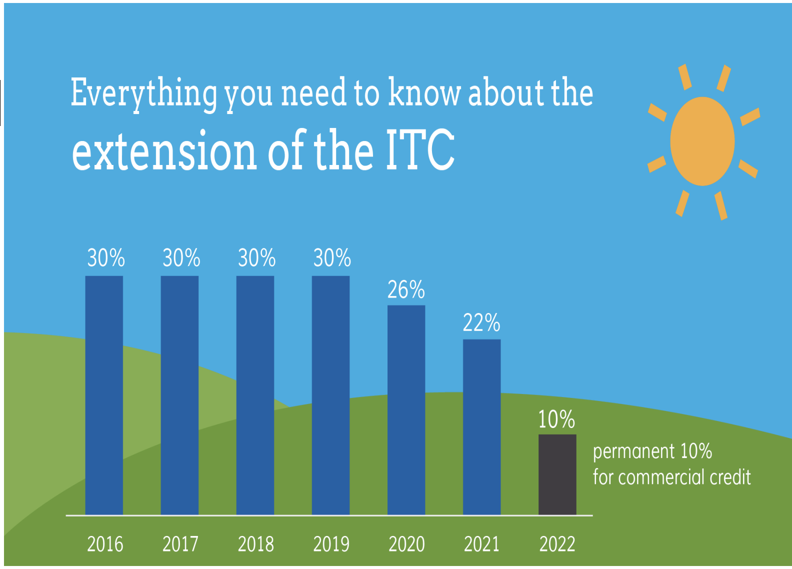


Notes: The figure depicts the pre-tax value of rebates and PBI payments (calculated on a present-value basis) provided through state/utility PV incentive programs, among only those systems that received such incentives. Although not shown in the figure, a growing portion of the sample received no direct cash incentive.

Federal Policy Drivers:

- 30% investment tax credit (ITC)
  - Extended to 2021 (for projects started)
  - Drops to 10% for commercial entities, phased out for residential customers

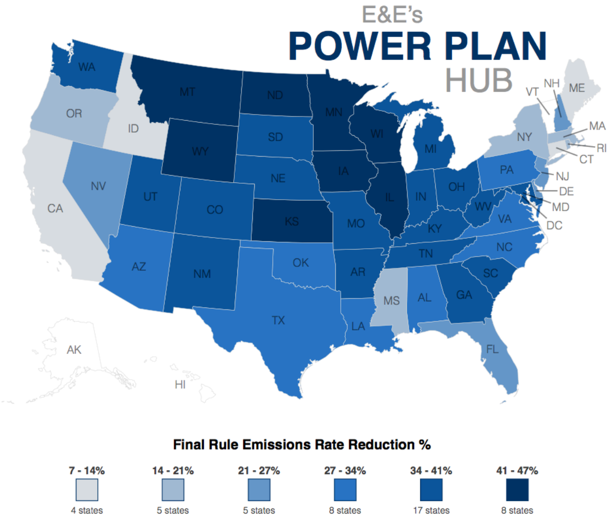
- Accelerated tax depreciation
  - 5-year term
- Clean Power Plan
  - Potential impacts after 2020
  - Fate and impact highly uncertain



Source: http://news.energysage.com/congress-extends-the-solar-tax-credit/

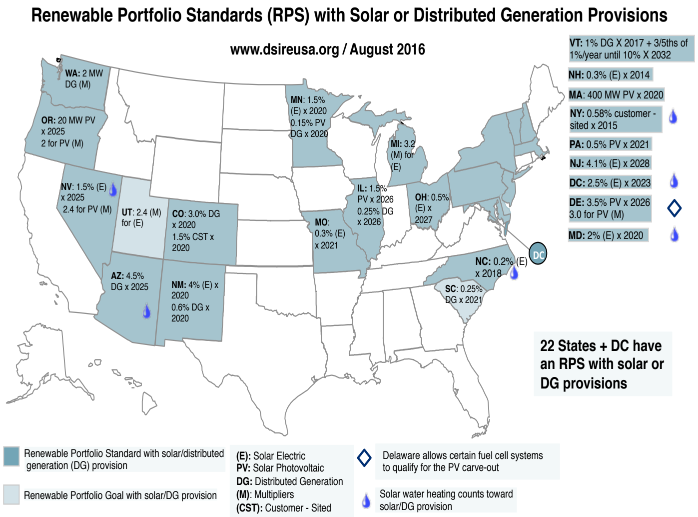
EPA Carbon Reduction in Power Sector

- Two components: new fossil plants, existing fossil plants
- New plants: new coal effectively precluded absent CCS
- Existing plants = Clean Power Plan (CPP), 32% reduction by 2030 relative to 2005, compliance period begins in 2022
- Many compliance options: rate- vs. mass-based, new complement, EGU vs. state measures, regional collaboration, set-asides, early incentive program→ decisions to be made at state level
- How will RE contribute? Who knows???
  - Depends on decisions, including states & obligated entities
  - EPA estimate: growth from 13% today to 20% by 2030
  - Supports growth consistent with past: deployment “floor”



State Policy Drivers

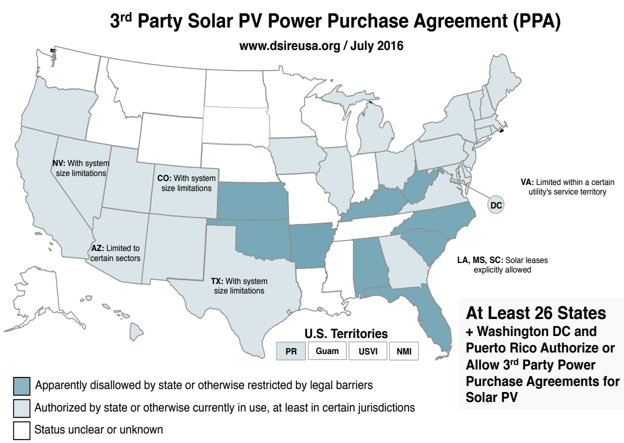
- Renewables Portfolio Standards
  - 22 States + DC have an RPS with solar or DG provisions



- Net Metering and Favorable Rates
  - 41 states and the District of Columbia require certain utilities to offer net metering to distributed solar customers as of the beginning of 2016.

- State Tax and Financial Incentives
  - State tax credits
  - State sales/property tax incentives
  - Up-front cash rebates
  - Performance based incentives

- 3rd Party Solar PV Power Purchase Agreement (PPA)
  - At Least 26 States + DC and Puerto Rico authorize or allow 3rd Party Power Purchase Agreements for Solar PV

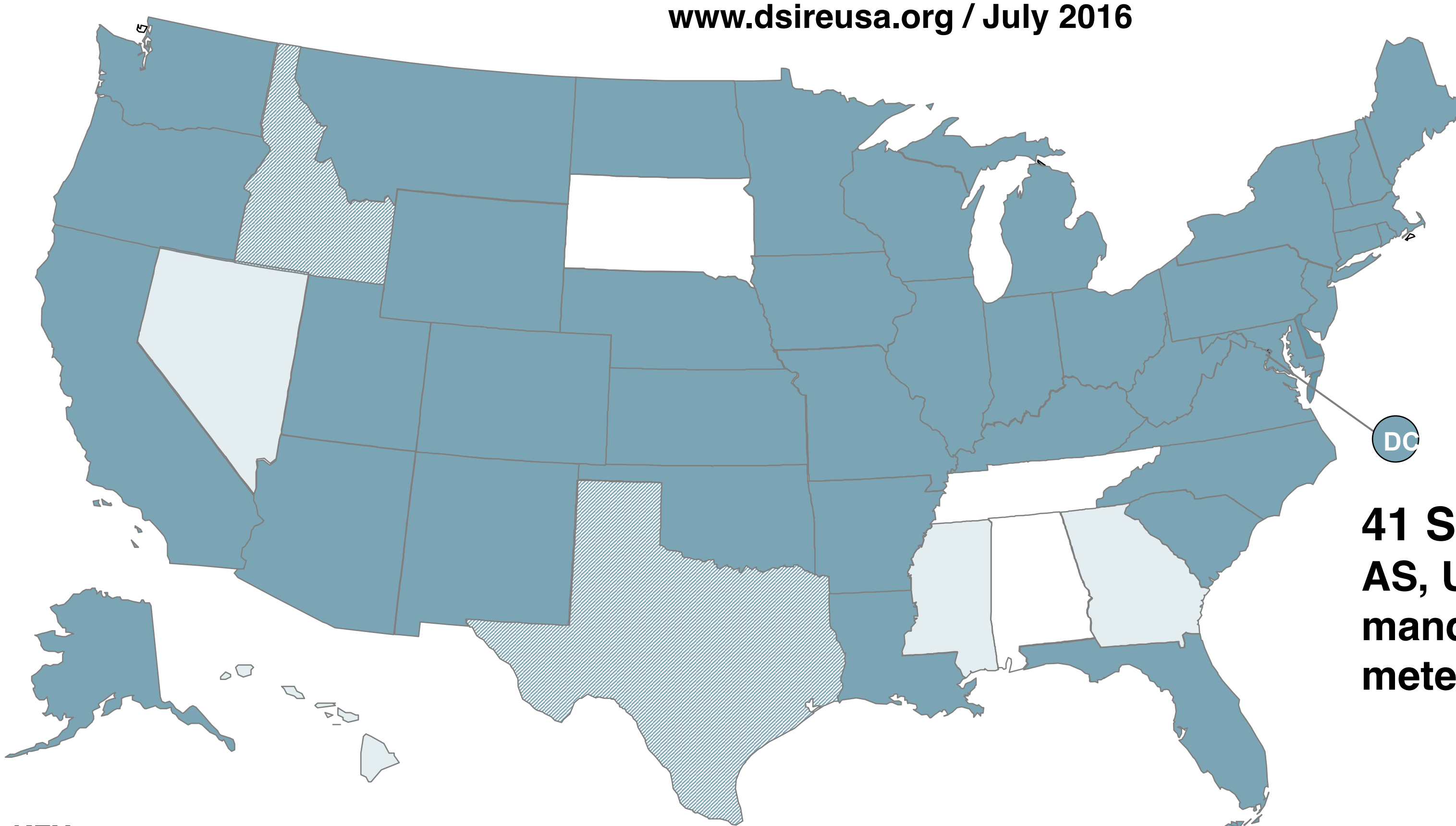


More information on solar programs and policies:
http://programs.dsireusa.org/system/program/maps

Net Metering Supports Distributed PV: Designs Vary

Net Metering

www.dsireusa.org / July 2016



41 States + DC, AS, USVI, & PR have mandatory net metering rules

KEY

- State-developed mandatory rules for certain utilities (41 states + DC+ 3 territories)
- No statewide mandatory rules, but some utilities allow net metering (2 states)
- Statewide distributed generation compensation rules other than net metering (4 states + 1 territory)

U.S. Territories:

AS PR

VI GU

Under Net Metering, Rate Design Is Key

California has been home to among the most attractive retail rates

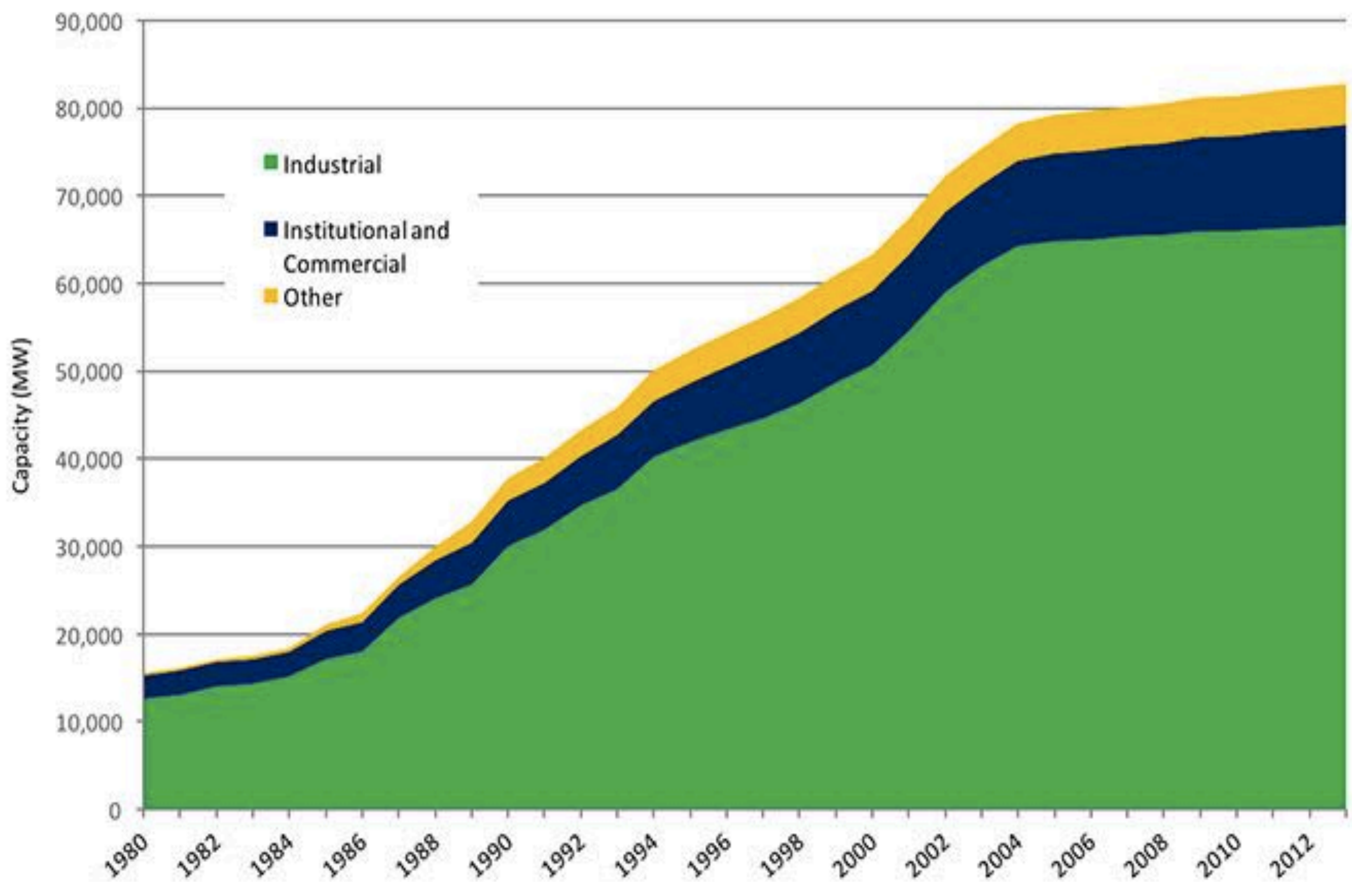
- Rate tiers that increase with usage
- Primarily volumetric rates, with low fixed charges

Rate designs that are less attractive for solar generally feature…

- Low overall retail rate levels
- Higher fixed customer or standby charges
- Demand charges tied to peak customer load

Trends in Distributed Generation: CHP

US CHP Capacity: 85% Industrial



Source: ACEEE, 2016. http://aceee.org/blog/2016/02/brief-history-chp-development-united

Trends in Distributed Generation: CHP

- CHP
  - 83 GW, ~8% of power capacity & 12% generation
  - Additional 40 GW target by 2030
  - In CA, the installed capacity in 2012 was 8,815 megawatts (MW), another 6,500 MW by 2030
  - However, the future is less clear for CHP to meet the long-term GHG target of 80% reduction.

Federal and State Policy Support: CHP

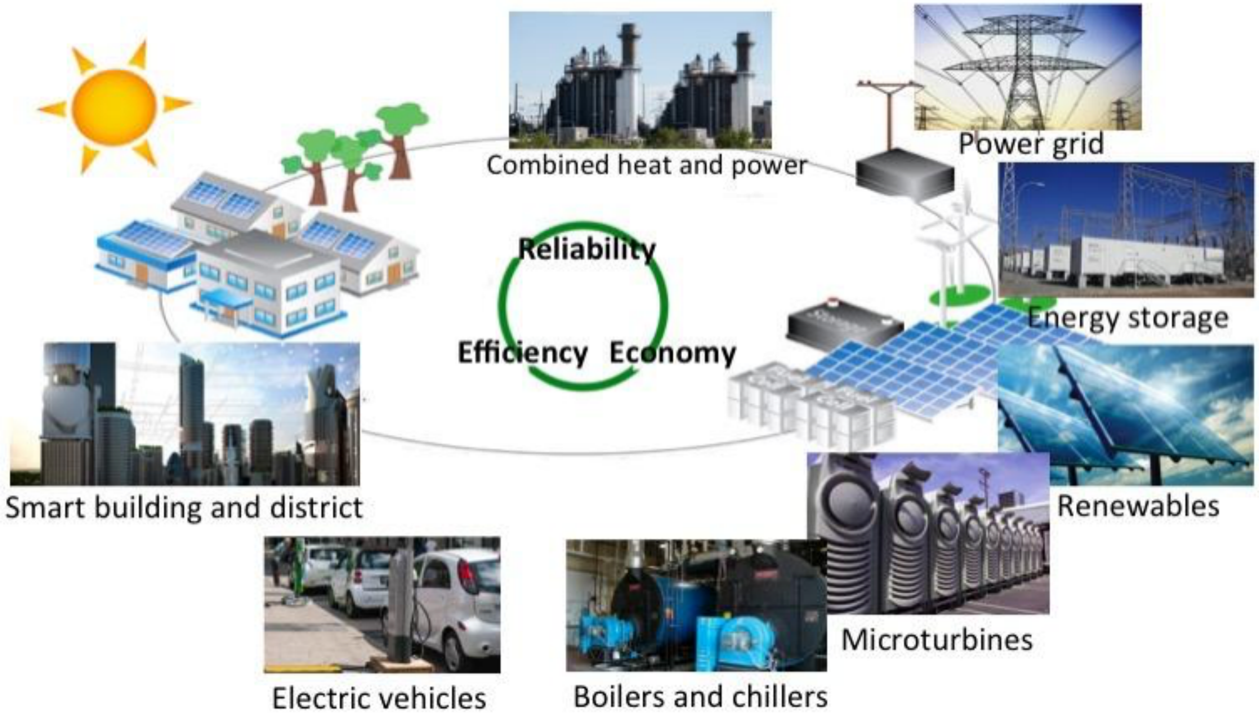
- Federal
  - Tax credit: 10% of expenditures of CHP (EE>60%)
  - DOE 7 CHP Technical Assistance Partnership
- CA incentives
  - SGIP
    - conventional CHP technologies $0.50/ watt and
    - fuel cells $2.25/watt for both electric only and CHP applications.
    - The biogas incentive $2/watt
  - PACE: non-residential buildings

伯克利区域能源优化模型简介

Berkeley Lab's District Energy Optimization Tool

MOD-DEM: Microgrid Optimal Dispatch with Demand-side Energy Management

Model concept 建模概念



Demand side

- Lower peak energy usage
- Bring higher capacity factor and security of distribution grids

Supply side

- Microgrid to integrate distributed generation and storage
- Combined heat and power

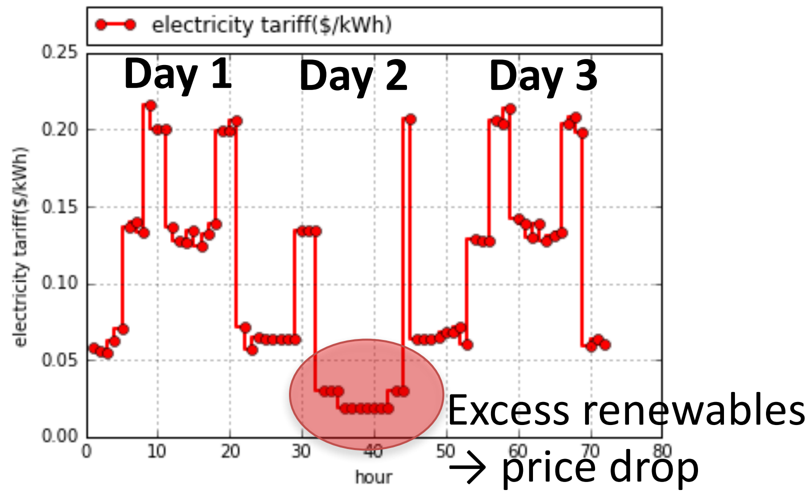
Challenge: *Coordinate both the demand and supply sides in a renewable-penetrated, storage augmented, DR-enabled microgrid*

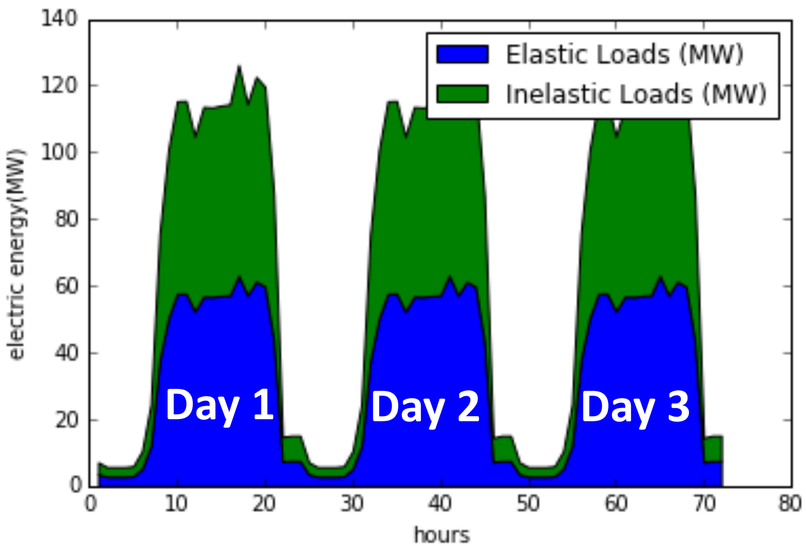
Motivation 动机

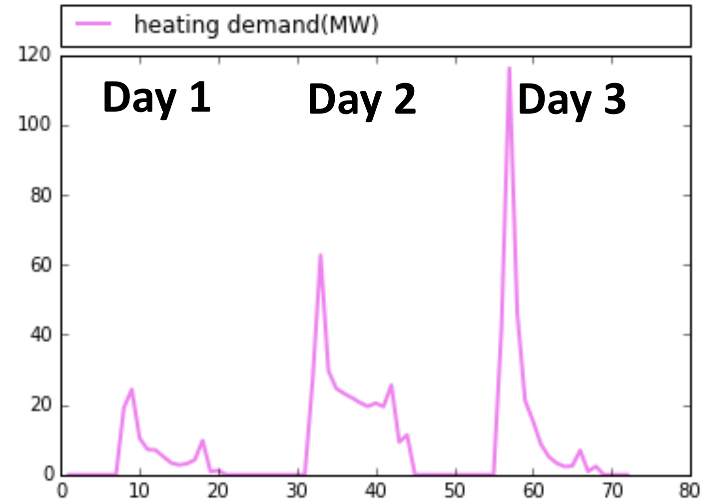
- DES as a smart ***prosumer***: 分布式能源作为一个智能能源参与者
    - Optimize operation by effective coordination of technologies (storages, CHP, etc.) in accord with renewable generation and demand response signals
    - Investigate dispatch strategies under uncertainty
- DES as a ***smart partner*** with the grid: 分布式能源是大电网的一个智能伙伴
    - Offer ancillary service for overall efficiency and grid stability
    - Encourage more demand side participation in the market and appropriately valuing demand response
- Retail market optimization 服务于能源零售市场

Case Study: Excessive renewables generation
案例：智能微网帮助消纳电网过剩的可再生能源

- Scenario:
  - Excessive renewables (wind/solar)→ triggers price drop →DR to prefer electricity
  - DES: heating + electric loads (elastic / inelastic)



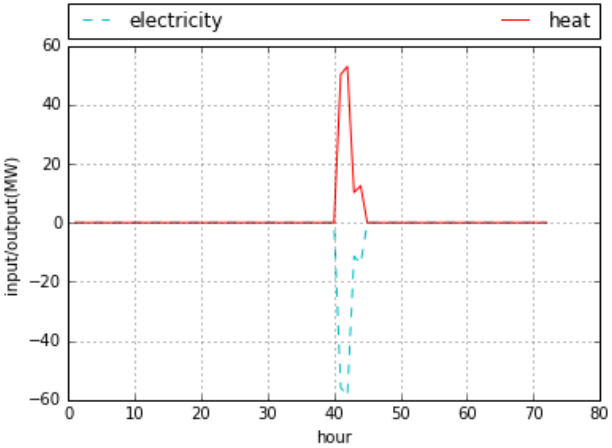




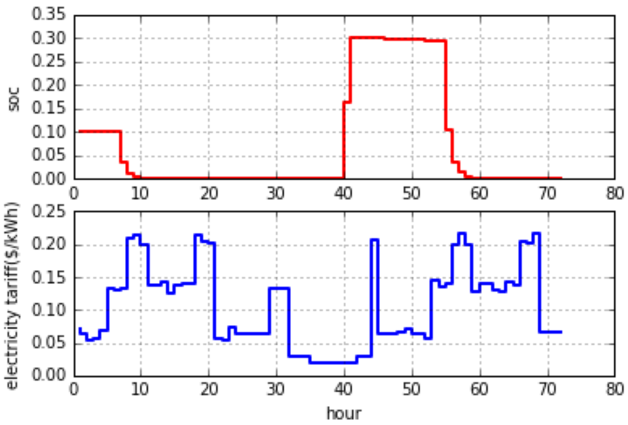
Case Study: Excessive renewables generation

- **Heating balance:** electric + natural gas boiler
  - NG is used as a default in most of the time
  - Shifting to electric boiler to use more electricity
  - Excess heat generation is stored for later use

Electric boiler switched on during DR to convert excess electricity to heat



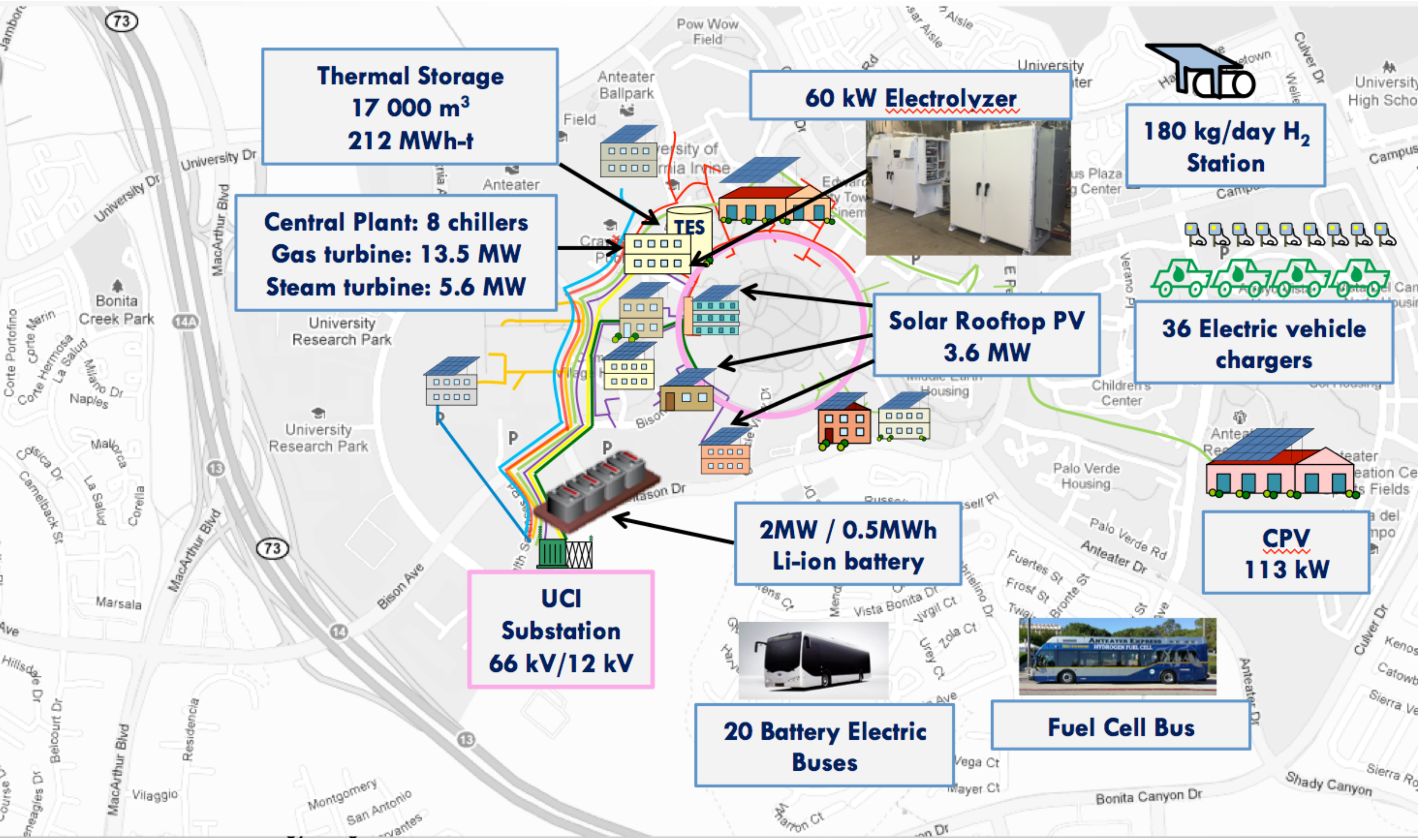
Heat tank is charged during DR



分布式能源微网案例分析

Distributed energy micorgrid case study

加州大学，欧文分校微电网/U.C. Irvine Microgrid



加州大学欧文分校微电网成本效益结果/ U.C. Irvine Microgrid Cost-Benefit Results

- Cost benefit analysis of microgrid technologies using microgrid tools
- 运用微网计算工具对分布式微网各种技术做成本效益后评估

NPV	CHP	PV	MgC	LiB
Cost	$ (1.2M)	$ (0.55M)	$ (46,000)	$ (20,000)
Benefits	$ 5M	$ 1.7M	$ 9.7M	$ 140,000
Net Benefit	$ 3.7M	$ 1.2M	$ 9.6M	$ 120,000
B/C Rat.	4.0	3.2	212	6.8

谢谢您

Thank you!

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