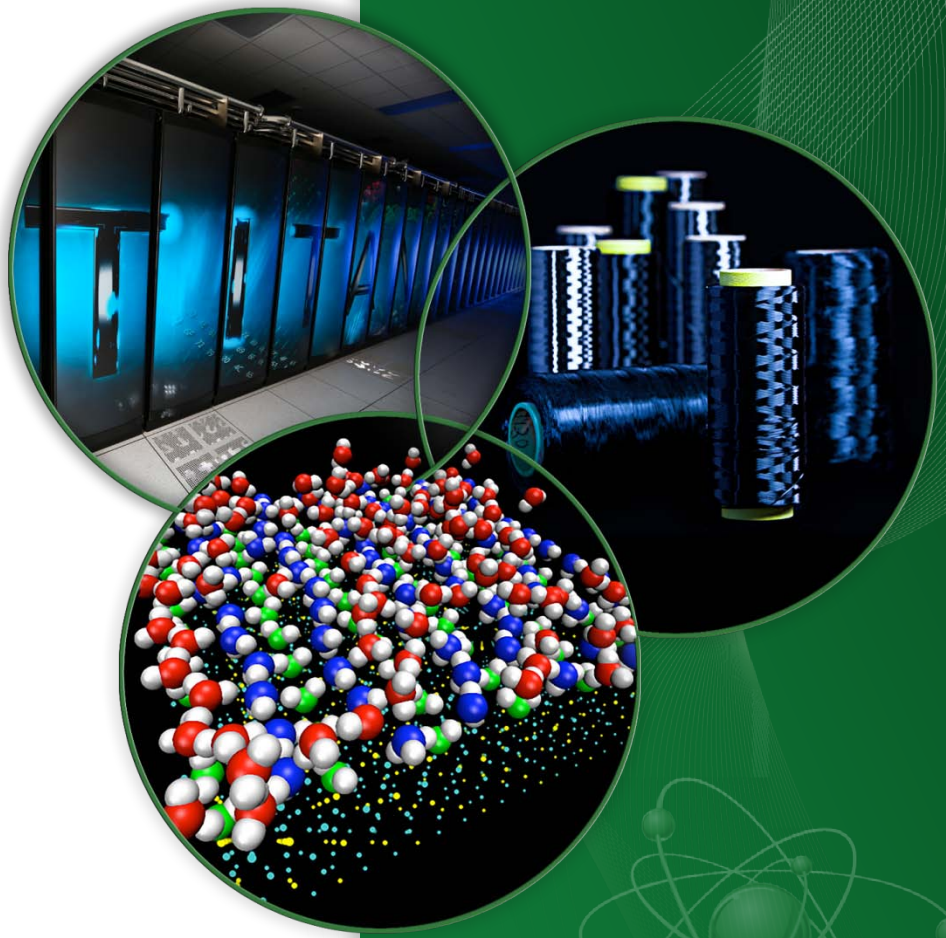
Distributed Energy Technologies in a Modernized Grid: Benefits, Costs, and Issues



Presented at the

Contemporary Issues Conference

sponsored by the

Indiana Utility Regulatory Commission

Oct. 23, 2014

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for the US Department of Energy

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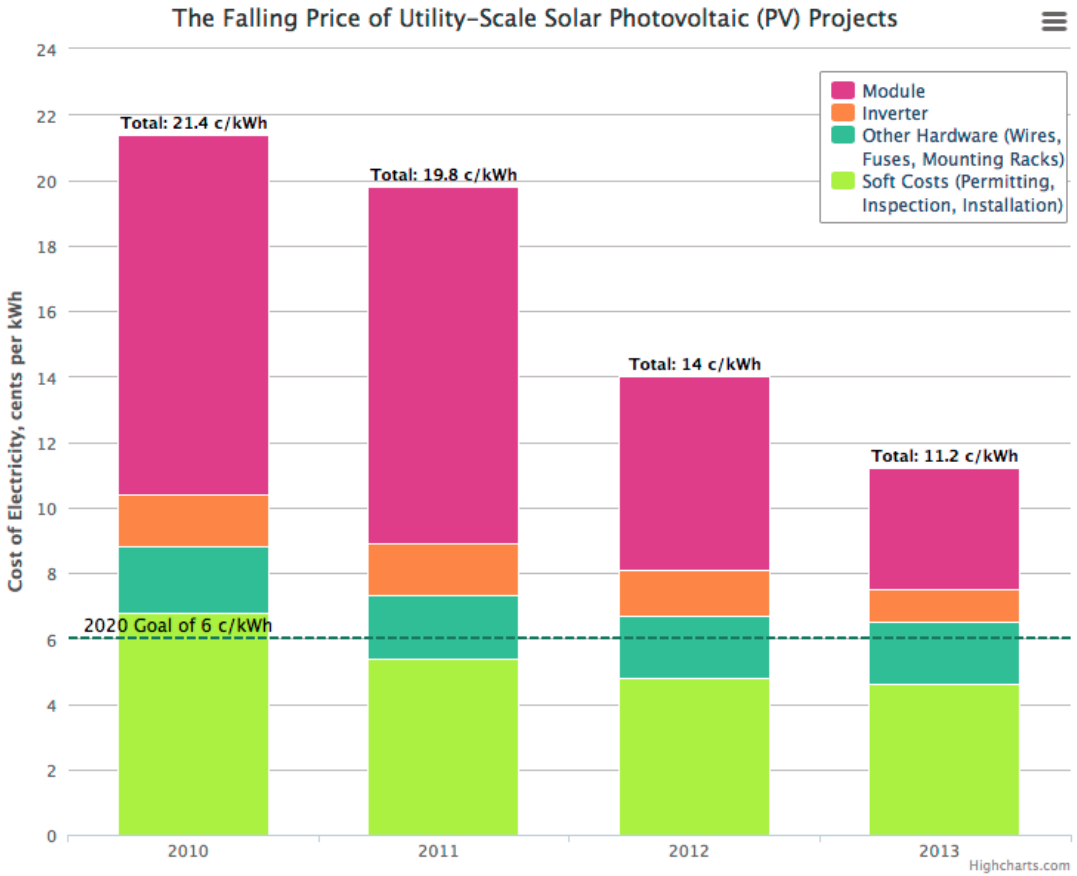
Introduction

- Our power grid historically has had central stations radiating out to customers.
- Technology advances increase opportunities for distributed energy technologies (DET) to change flows to and from the edges of the grid.
- Possible technologies include:
  - Solar, Wind, Combined Heat and Power, Storage, Electric Vehicles, small hydro, fuel cells, micro-turbines, etc.
- Main near-term focus is on distributed photovoltaic due to rapid price declines.

Cost of Solar rapidly declining

- Utility-Scale costs approaching DOE goal of 6¢/kWh
- Residential costs may be twice utility-scale costs
- "Soft" costs are large factor
  - Customer acquisition
  - Financing and Contracting
  - Permitting, Interconnection, and Inspection
  - Installation and Performance
  - Operations and Maintenance



Data courtesy of National Renewable Energy Lab. Chart by **Daniel Wood**.

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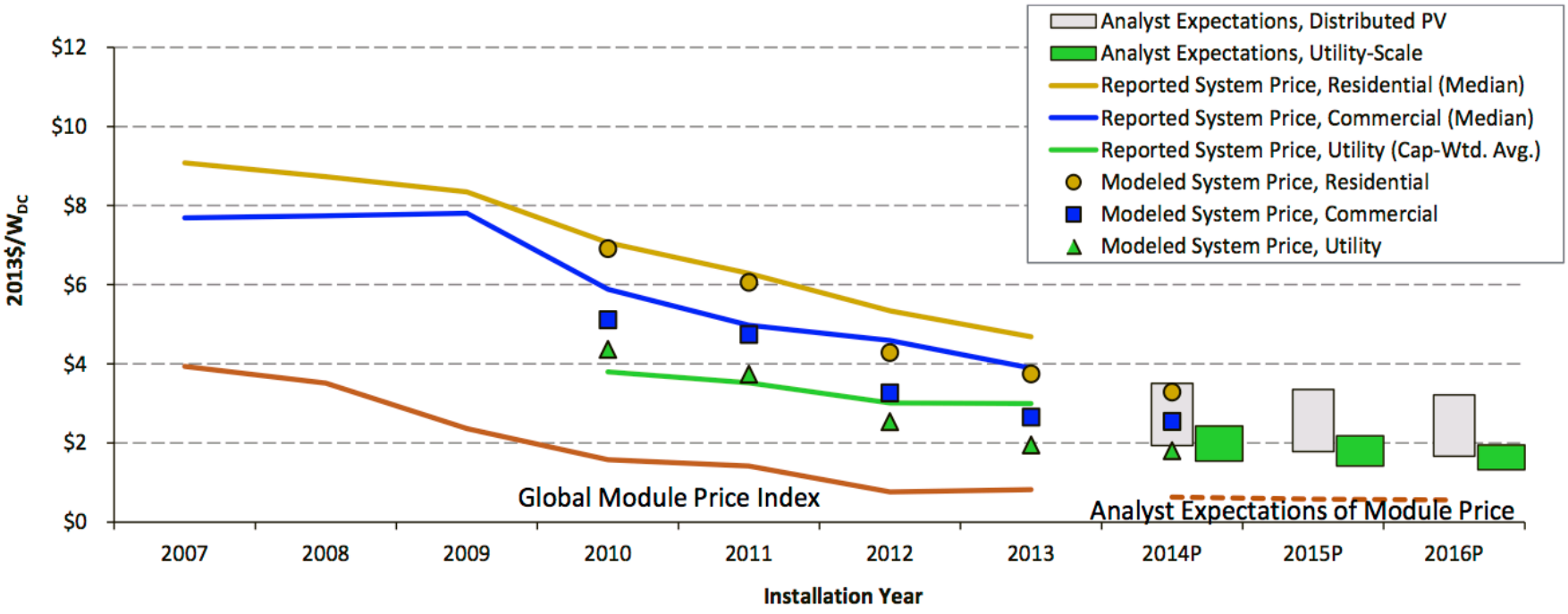
New trends report from NREL/LBNL current and future price estimates

Reported, Bottom-up, and Analyst-projected Average U.S. PV System Prices over Time



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What is DET's Value (Benefits – Costs)

- As utilities integrate DET into the mix they should have a reasonable estimate of its value
  - Possible payment to customers
  - Recognition of level of incentives or disincentives
- Stakeholders have different perspectives
- A variety of benefits and costs; some more quantifiable than others
- Rocky Mountain Institute list 7 main categories

- RMI Benefit & Cost Categories
  - Energy
  - Capacity
  - Grid Support Services
  - Financial Risk
  - Security Risk
  - Environmental
  - Social
- Other categories include
  - Avoided system losses
  - T&D system impacts

Stakeholders Perspectives RMI Benefit & Cost Categories

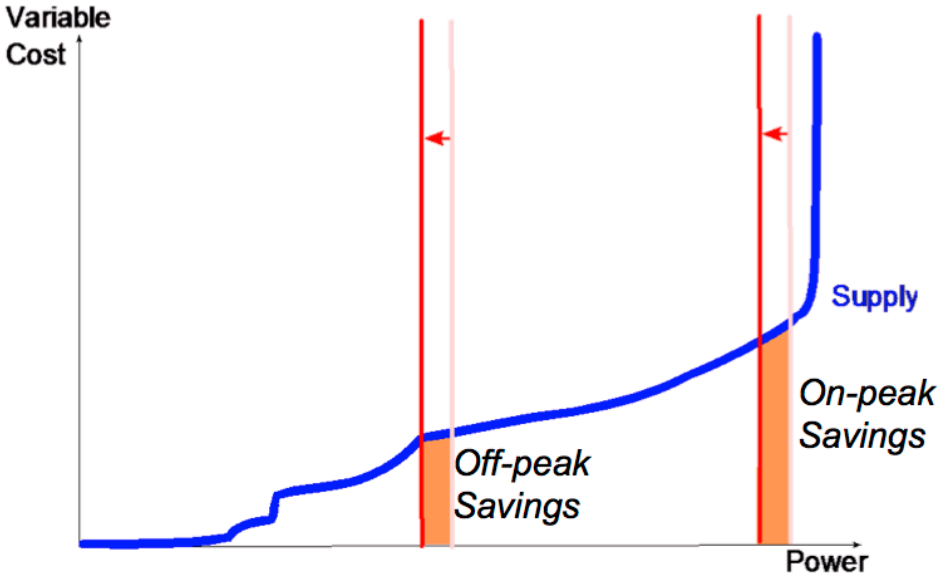
Stakeholder	Objective	Benefits	Costs
PV owner	- Predictable return - Compensation for benefits	- Reduced utility bills - Incentives - Tax credits	- Equipment Installation - O&M - Removal - Time
Other customers	- Reliable power - Lowest cost	- Reduced power delivery costs (energy, capacity, support)	- Administrative, - Rebates/incentives - Lost revenue
Utility	- Reliable and safe power at lowest cost - Increased shareholder value - Regulatory requirements	- Reduced power delivery costs (energy, capacity, support)	- Administrative, rebates/incentives - Lost revenue - Integration and interconnection
Society	Improved environmental quality and economy	Sum of all benefits & costs above plus those that accrue to society at large	

Source: Rocky Mountain Institute

Energy Savings Calculation

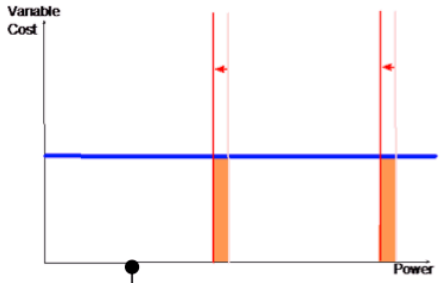
- Ryan Wiser of LBNL identifies three main questions:
  - When is the DG generating?
  - What is displaced by the DG during those times?
  - What are the variable costs of the displaced generators?

Net Demand Reduction on Supply Curve

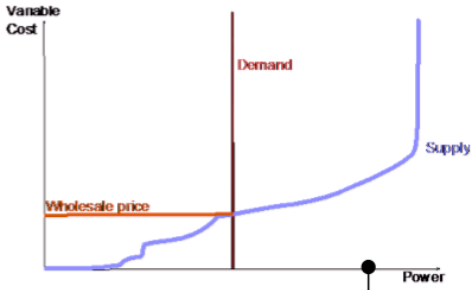


Six methods of increasing accuracy

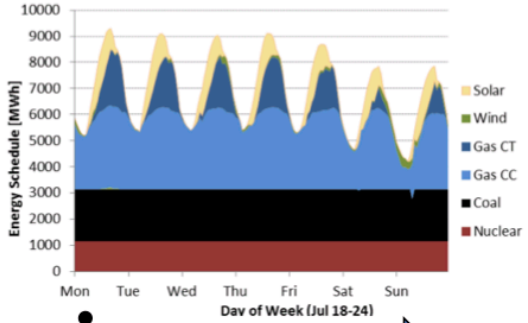
One type of unit always on the margin



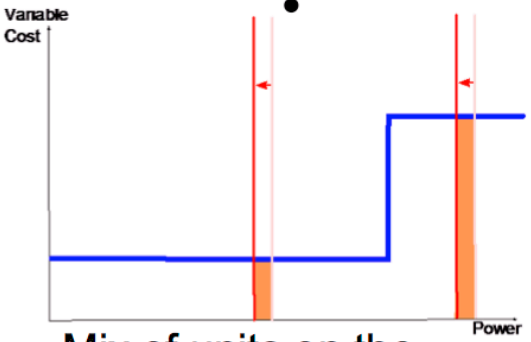
Historical marginal plant: wholesale prices, system lambdas, econometric methods



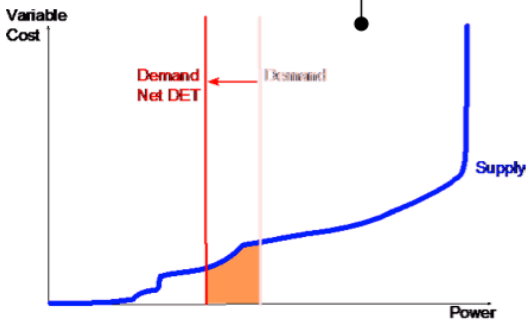
Production cost model: *static generation mix*



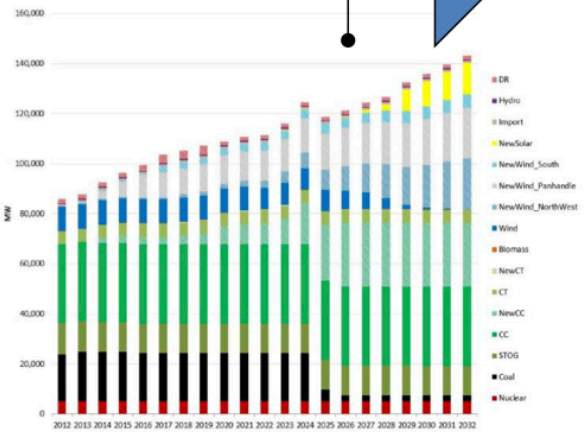
Increasing complexity of analysis



Mix of units on the margin, e.g. off-peak CCGT, on-peak CT



Simple merit-order dispatch



Production cost model: *dynamic generation mix*

Curtailment adds extra wrinkle to calculation

- Local or regional system constraints may require DET to be curtailed instead of displace generation
  - Variable costs are not reduced
  - Generation amount from DET is reduced
- Curtailment generally occurs when demand is low and DET generation is high, and magnified by:
  - Congestion due to transmission or distribution constraints
  - Inflexibility in other generation: high startup or shutdown costs, minimum run times, high minimum generation levels, environmental reasons (e.g., river flows for hydro)
- Only some energy value calculation methods can estimate curtailment needs

What is the Variable cost of the displaced generation

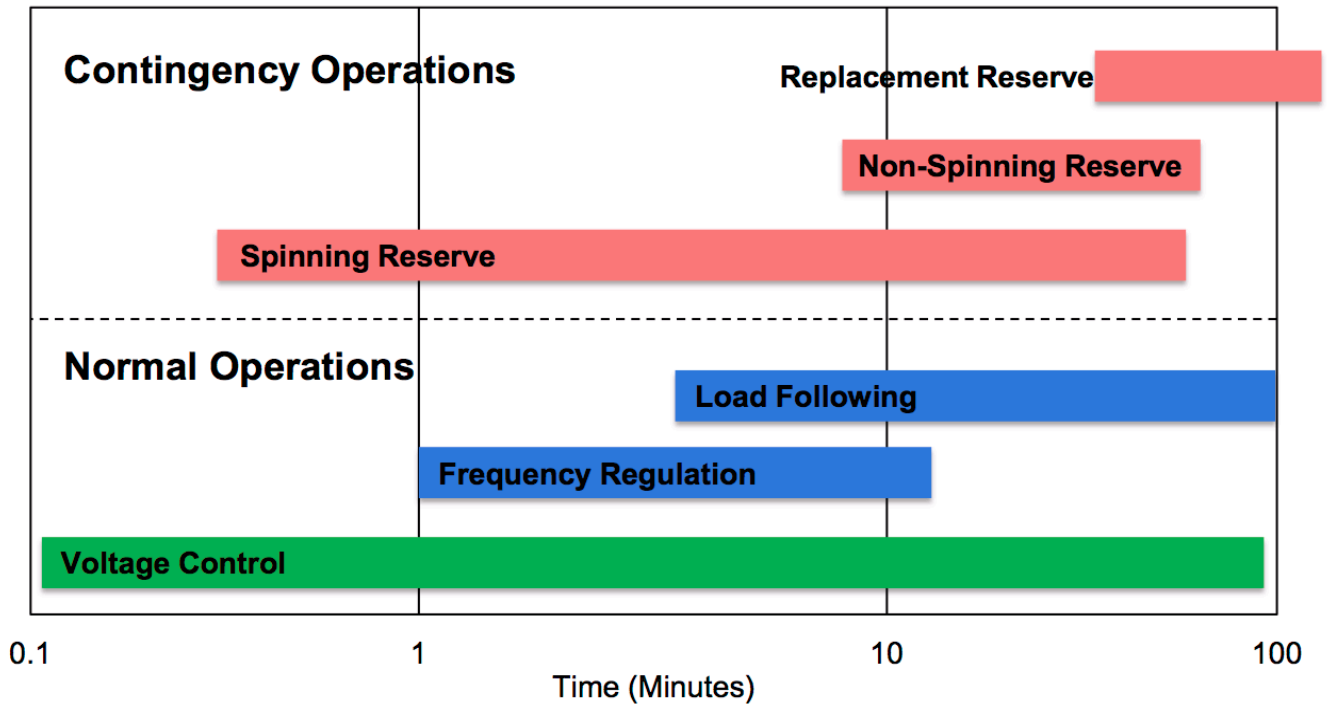
- Variable operations & maintenance (O&M) costs are relatively small
- Displaced market purchases depend on wholesale market price estimates
- Fuel costs are major factor and need to be estimated for the life of the DET (as much as 20+ years)
  - Natural gas and coal prices could vary over the period
  - Efficiency of displaced plants also affect fuel cost per MWh (e.g., combustion turbines versus combined cycle)
- Displaced generation could be other renewables or DET (e.g., wind or demand response) with very low (or negative) variable cost
- System losses amplify the value of the saved costs

Generation Capacity Savings

- DET capacity can avoid or defer investments in other capacity
- Capacity expansion model could reveal mixture of deferrals, market purchases, and/or change in technologies built (e.g., CCGT for CT or wind)
- Type and timing is dependent on demand projections and existing system reserves
- DET capacity may be only partially credited due to expected limited production during system peak (e.g. 4pm-7pm)
- Cost savings will depend on expected capital costs over time, including inflation and interest

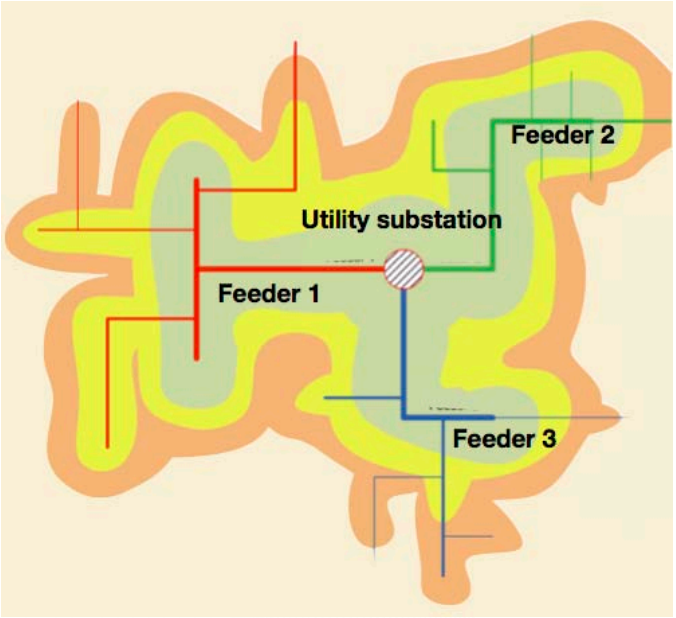
Grid Support Services

- Three broad categories of support services
- DET provision of service depends on technology and institutional systems (e.g., markets, policies)



T&D System Impacts can be positive, neutral, or negative

- Interconnection studies reveal how much DET can be added before major upgrades are required
- Upgrades to transformers, breakers, relays, lines may be needed
- Results can be very location- and line-specific, depending on other loads, length, type of line, etc.
- Smart inverters and communications with utility can improve power quality and system support



Financial Risk

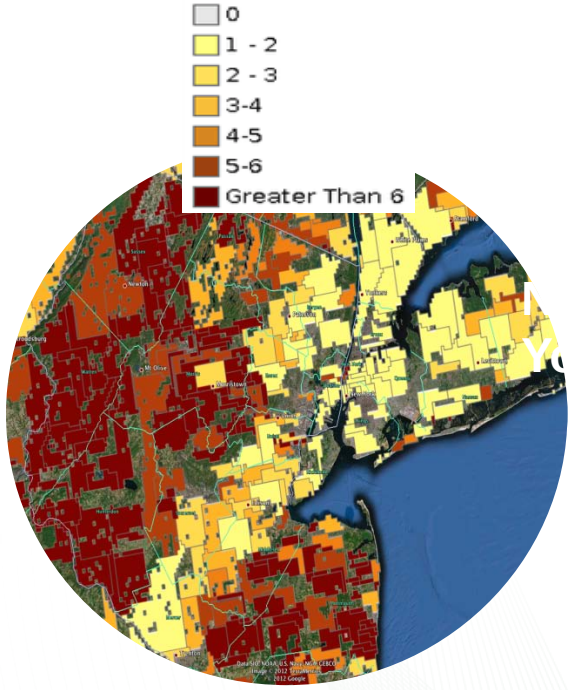
- Fixed ongoing costs may mean less volatility in overall costs
  - Depends on length of contract and power escalation clauses
- Lower fuel demands may lower market prices of fuel
  - Factor may already be incorporated in fuel cost modeling

Security Risk

- DET power spreads the location of generation and moves it closer to load
  - Reduces impact of single point contingencies
  - Lessens reliance on long distance transmission
- DET most helpful if it can provide power during grid outages
  - Requires improved microgrid technologies and institutional policies

SUPERSTORM SANDY

Outage (Days Before Power Is Restored) Color Code:



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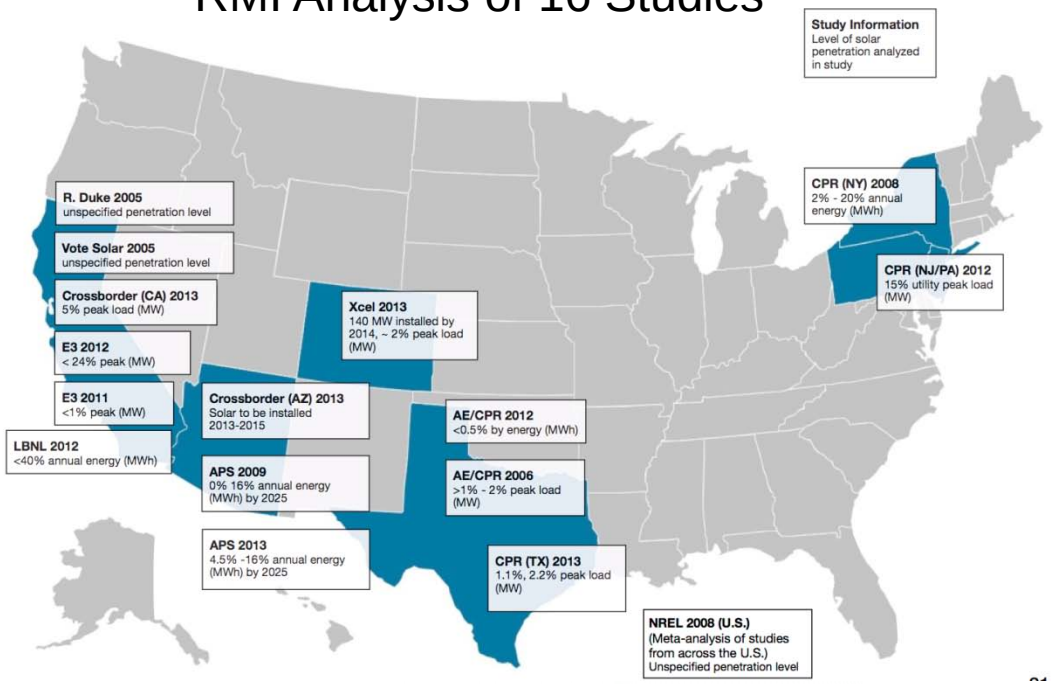
Environmental and Social

- DET are generally low or no air emissions so reduce system emissions (e.g., SO_2, NO_x, Hg, CO_2)
- Water utilization reduced; land utilization varies between technologies
- Value of reductions may be captured already in energy cost savings from fuel or O&M savings
- Debate on how to include non-explicit values
  - Non-regulated emission reductions
  - Economic benefits
  - Jobs development
- Renewable Energy Credits can make some values explicit depending on market availability

Numerous utilities and groups have calculated value/price for solar PV

- Austin Energy
- San Antonio
- Excel – Minnesota
- Nevada
- Georgia Power
- Others

RMI Analysis of 16 Studies



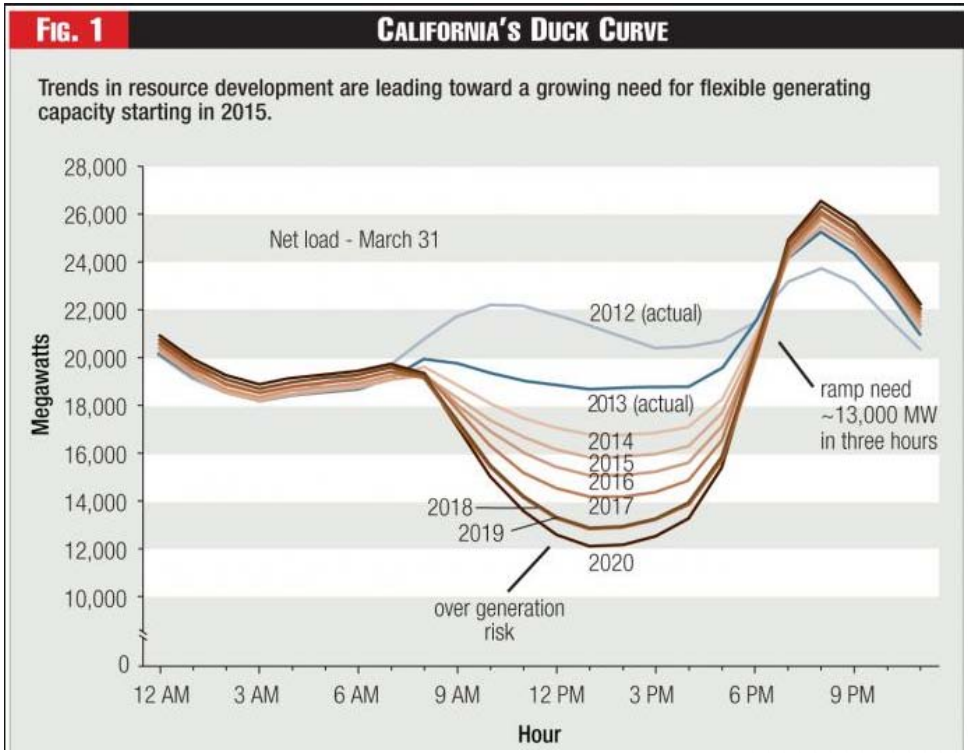
- Values can vary greatly depending on location, timing, components included
- TVA currently developing a transparent, fair, adaptable, and versatile methodology for DET Integrated Value

Critical Issues

- Two main areas of concern have been identified with increasing penetration of DG
- **Physical** issues have to do with integration of DG into the grid. Reliability, ramp rates, safety, needed equipment modifications, etc.
- **Financial** issues have to do with proper compensation, sustainability of funding, erosion of revenues, etc.

Physical Issues

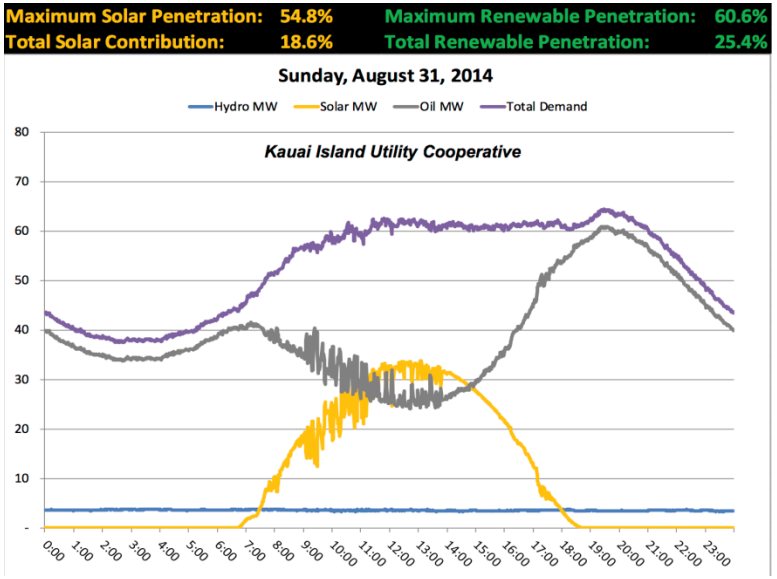
- Rapid expansion and significant penetration can create ramping issues when the sun comes up or goes down



- Distribution systems may need changes in equipment and connections to handle potential reversals of flow

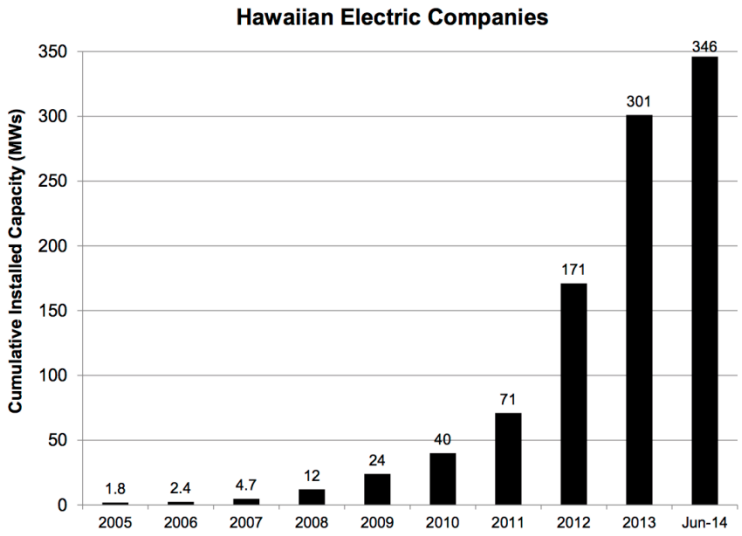
Hawaii is on leading edge in facing these issues

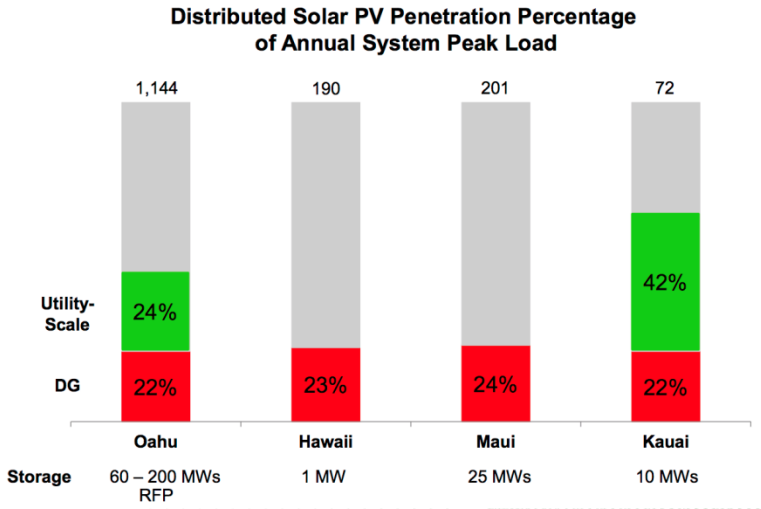
- High electric prices due to oil generation
- Exponential growth creates challenges
  - Between 6% and 24% of feeders have >120% of daily minimum load depending on island
- Interconnections have slowed due to safety, reliability and operational concerns
- Lack of control of PV leads to other renewable curtailment



Hawaii's Distributed Solar PV Penetration

Hawaii's Distributed Solar PV Capacity Growth





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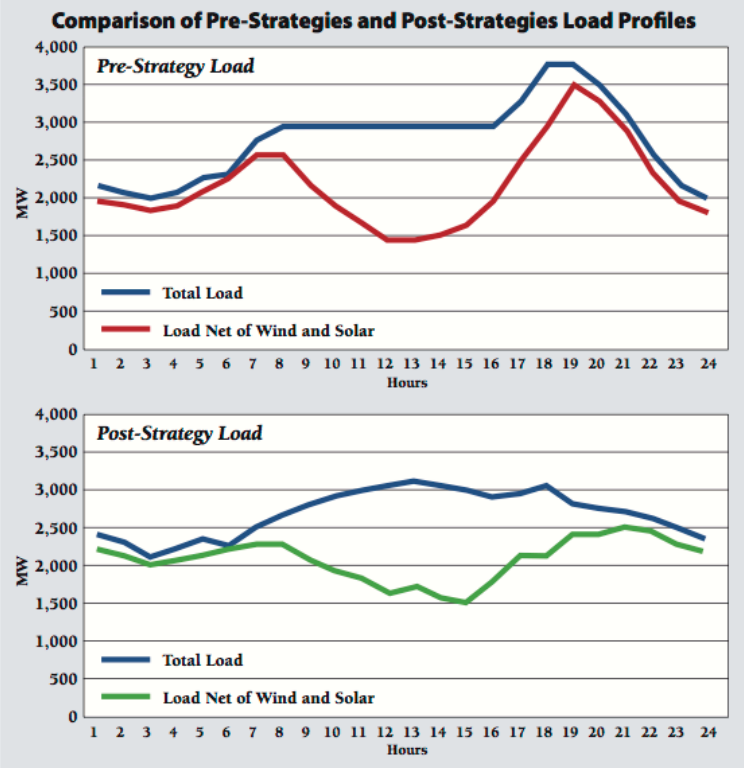
Lazar Study on "Teaching the Duck to Fly"

- Lists ten strategies to smooth load curve and DET generation
- Some more feasible than others



1. Target EE to ramping hours
2. Orient PV to the west
3. Substitute solar thermal with storage for some PV
4. Operator control of water heaters
5. New large air conditioners include thermal storage
6. Retire off-peak must-run plants
7. Focus demand charges on ramping hours
8. Deploy energy storage, including vehicle charging controls
9. Implement aggressive DR
10. Advance inter-regional trades for diversity

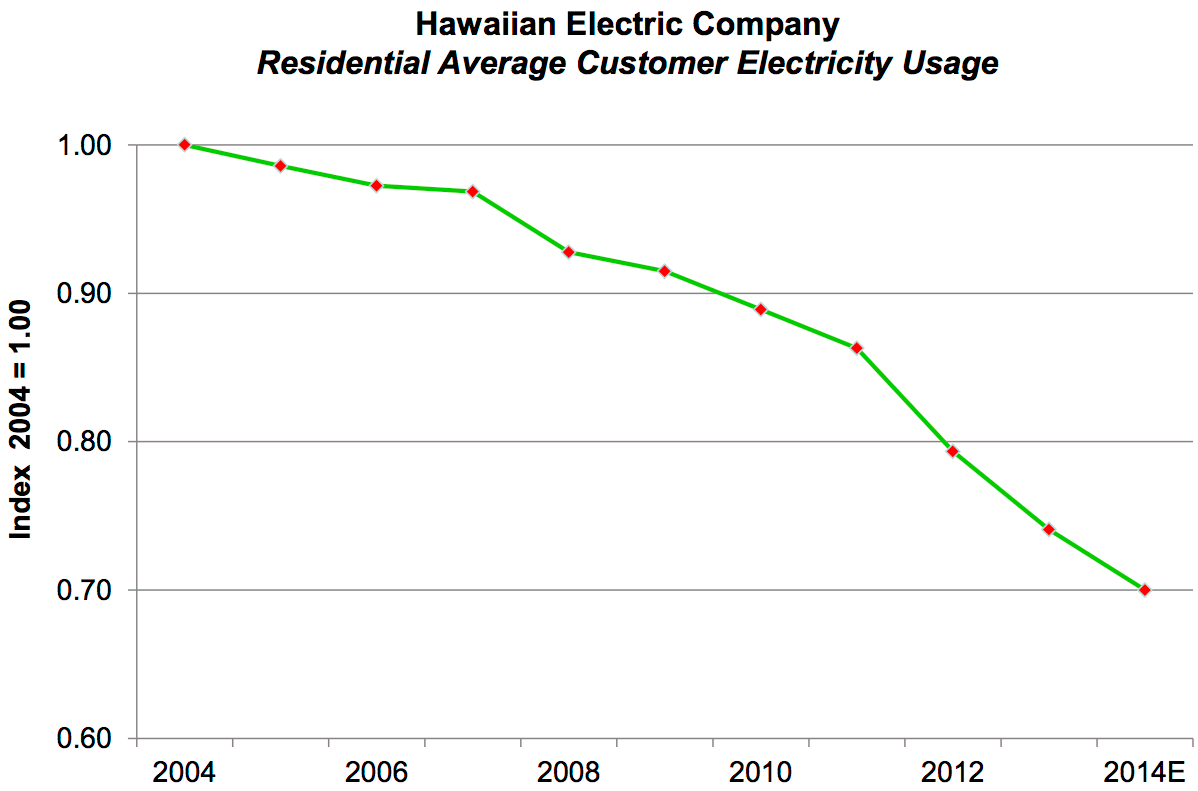
Financial Issues

- Net metering is billing mechanism that allows customers to “bank” generation not used immediately in exchange for energy and/or financial credits (SEPA)
  - Hawaii recognizes NEM as long-term unsustainable
- Somewhat independent of billing, DET customers reduce energy use directly
  - Reduces payment for fixed grid equipment and services
- Solution could be change in rate structure, customer self-supply only, separated sales to the grid, among others
- Soft costs vary widely between utilities, locations
  - Proper cost assessment between different owners, utilities and non-DET customers difficult

Hawaii residential customer sales decline significantly

- Combination of both PV and EE

Hawaii – Decline in Average Residential Electricity Usage



Summary

- Proper valuation provides appropriate economics for DET development while being fair to all
- DET provides value to the electric system, but the amount depends on a variety of factors:
  - Location
  - Displaced Power
  - Market structure
  - Regulatory policies
- Critical issues must be addressed before DET creates a significant market presence

Resources

- Rocky Mountain Institute, *A Review of Solar PV Benefit & Cost Studies, 2nd Edition*, Sept. 2013.*http*://www.rmi.org/Content/Files/eLab-DER_cost_value_Deck_130722.pdf
- Lazar, Jim, Regulatory Assistance Project, *Teaching the "Duck" to Fly*, Jan. 2014.http://www.raponline.org/featured-work/teach-the-duck-to-fly-integrating-renewable-energy
- NREL *Progress Report: Advancing Solar Energy Across America* http://energy.gov/articles/progress-report-advancing-solar-energy-across-america
- NREL/LBNL, *Photovoltaic System Pricing Trends*, Sept. 2014.http://www.nrel.gov/docs/fy14osti/62558.pdf
- Solar Electric Power Association, *Ratemaking, Solar Value and Solar Net Energy Metering—A Primer*, July 2013.http://www.solarelectricpower.org/media/51299/sepa-nem-report-0713-print.pdf
- Ryan Wiser (LBNL) and Michael Champley (Hawaii PUC) information from *DOE Workshop on Estimating the Benefits and Costs of DET Sept. 30-Oct. 1, 2014*. Results of workshop are still under finalization.