The many futures of demand response and distributed generation

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THE Brattle GROUP

In 2009, the FERC Staff submitted a report to the US Congress

- **The *National Assessment of Demand Response Potential* contained four scenarios of the impact that DR would have on peak loads during the next decade across the 50 states and the District of Columbia across four scenarios**

- **The first scenario represented "business as usual"**
  - Dominance of load curtailment over pricing
  - Dominance of wholesale over retail DR
  - Dominance of the commercial and industrial segments over the residential segment

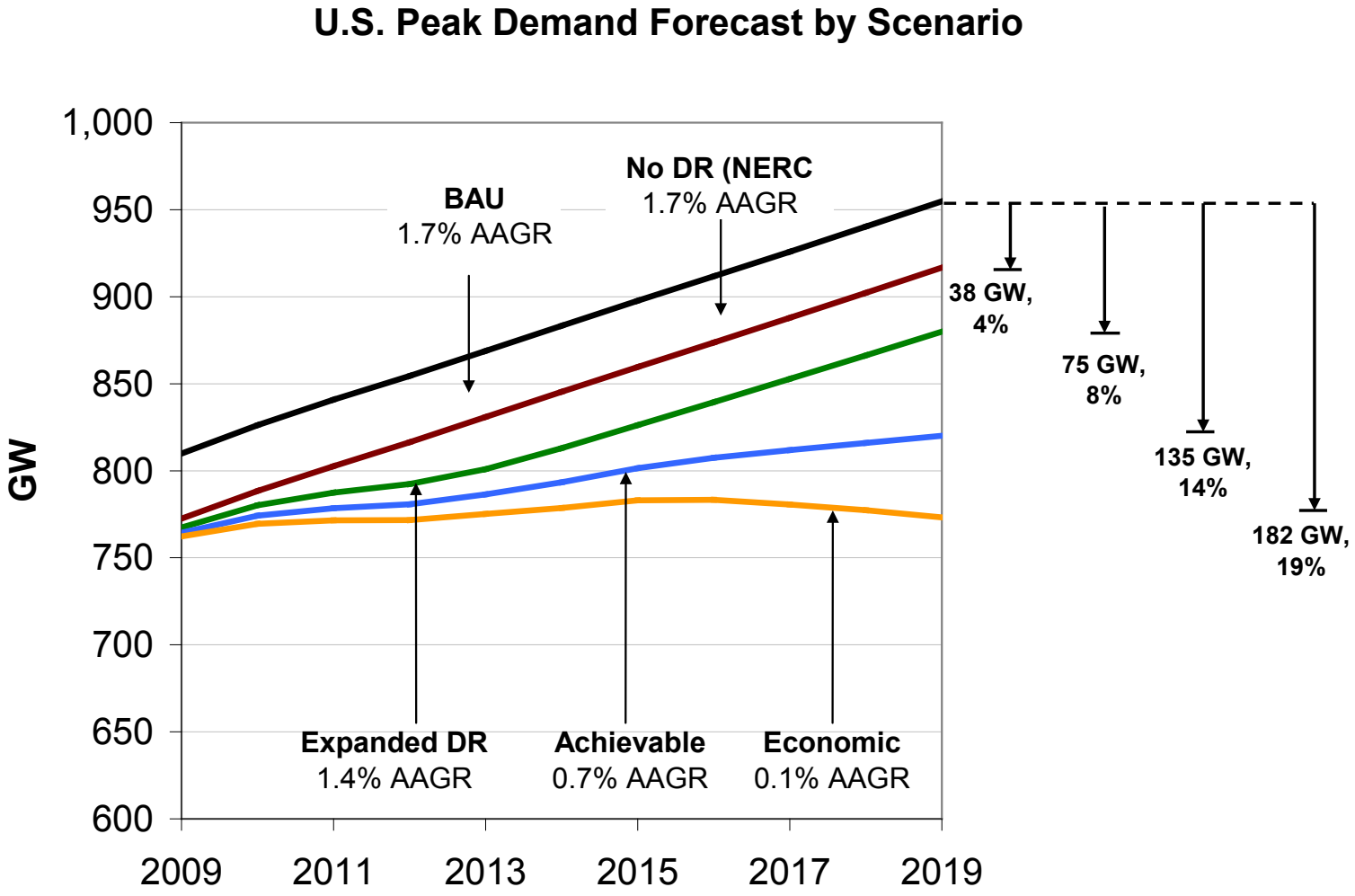
- **The second scenario simply expanded the geographical coverage of the first scenario**

The other two scenarios represented a significant departure from the first two

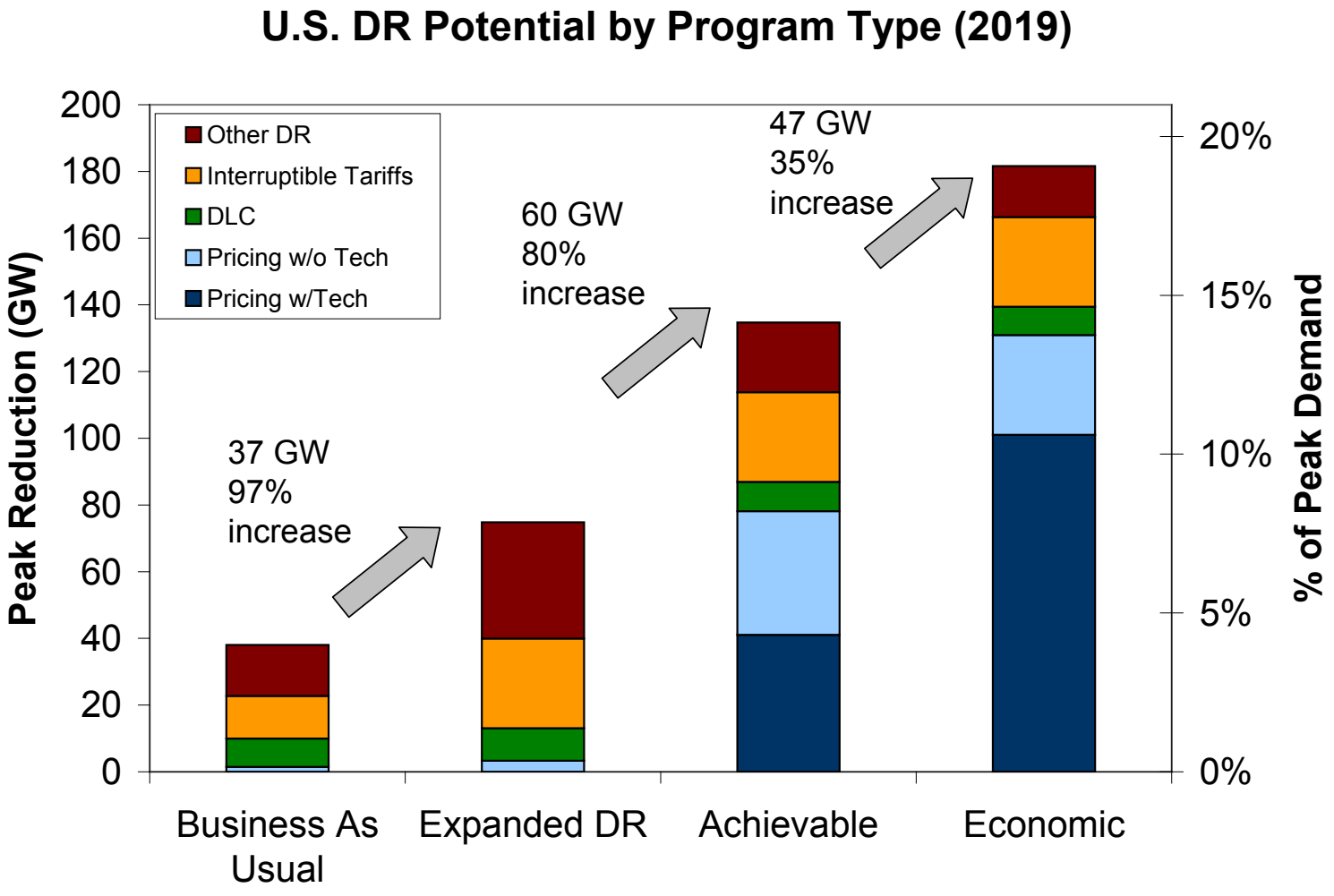
- The third scenario assumed that default dynamic pricing for residential customers would be adopted commensurate with the rollout of smart meters and measured achievable potential

- The fourth scenario assumed that dynamic pricing would be universally deployed for residential customers and measured economic potential

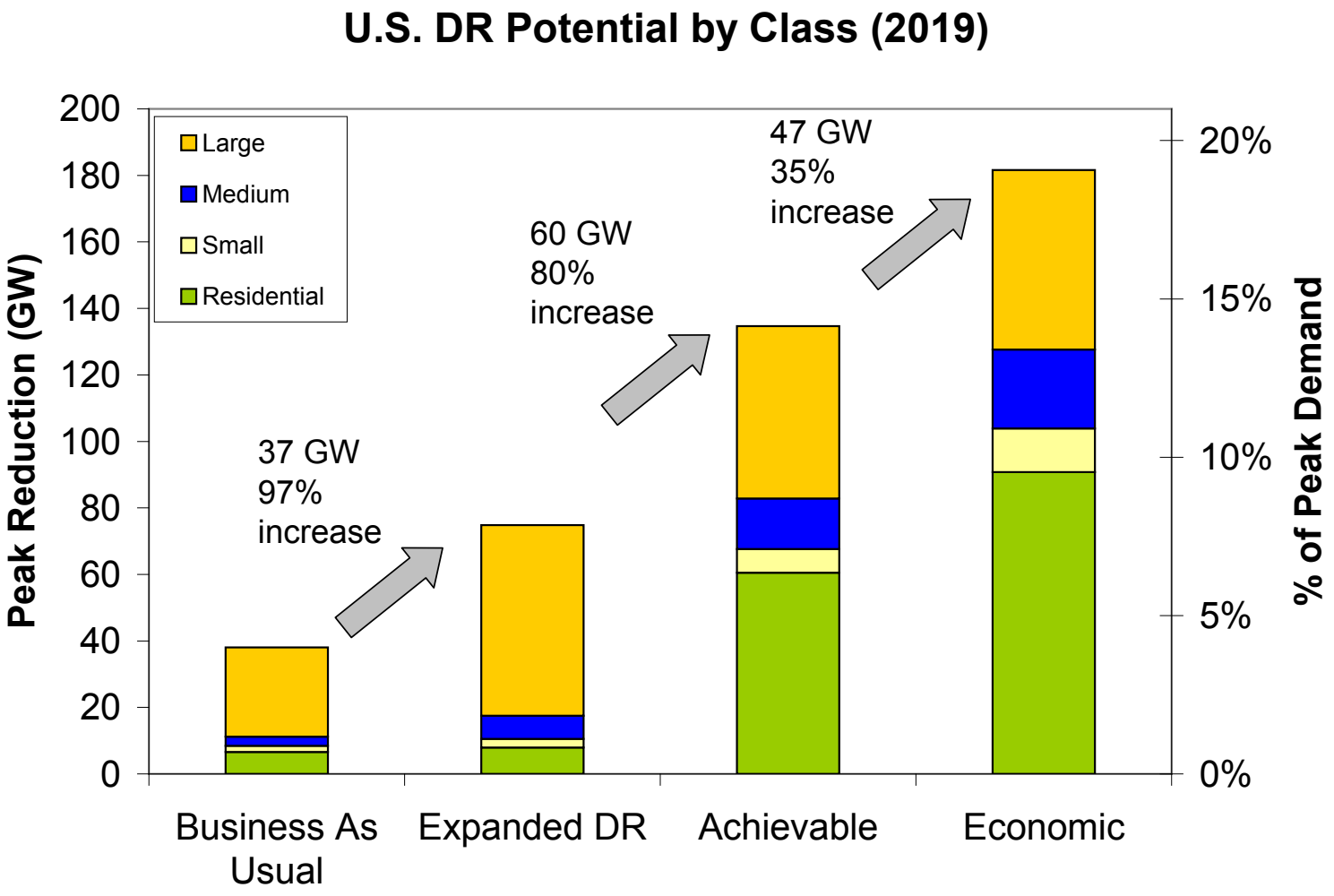
Across the four scenarios, peak demand was projected to fall between 4% and 19%



Price-based DR had the largest potential to reduce peak demand



The largest DR potential existed in the residential class



In the years that followed, the evolution of DR followed the second scenario

- **It was characterized by the following features**
  - Load curtailment as opposed to price-responsive demand
  - Wholesale markets as opposed to retail markets
  - Non-residential segments as opposed to residential

However, the future is evolving toward the third and fourth scenarios; indeed, a fifth scenario focusing on the need to integrate renewable energy resources has begun to emerge

Aggressive renewable energy standards will create a new application for DR

- The share of renewable energy resources in their generation mix continues to rise for most utilities
- The "duck curve" of net loads looms in the distance, not just in California, but in many parts of the country
- "Fast" DR, which combines pricing with enabling technology, can be used to integrate renewables into the grid
- In the early 1980s, the concept was first propounded by MIT's Fred Schweppe as "homeostatic control" and seconded by EPRI's Clark Gellings as "flexible load shaping"

Fast DR is Dynamic Pricing 2.0

- **Simple time-of-use (TOU) rates with fixed periods and rates that are fixed in advance will not suffice. We will need half-hourly real time pricing rates**
- **Enabling technology will allow customers to respond rapidly to changing prices**
  - Even without enabling technology, about 25,000 residential customers in Illinois are on real-time pricing today
- **OGE has about 20% of its customers on variable peak pricing, an advanced form of critical peak pricing (CPP) where the price during the critical hours varies in real time**
  - To facilitate customer response, every customer is provided a smart thermostat and load response is quite robust

Dynamic Pricing 2.0 (concluded)

- **In the house of the future, enabling technology will be commonplace:**
  - Smart thermostats, smart appliances, smart light bulbs and smart plug loads. In other words, home energy management systems will be pervasive
  - These will allow these households to manage their loads dynamically in real time
- **If prices fall in the middle of the day, as solar kicks in, customer loads will rise automatically. As prices rise later in the evening, loads will fall automatically**

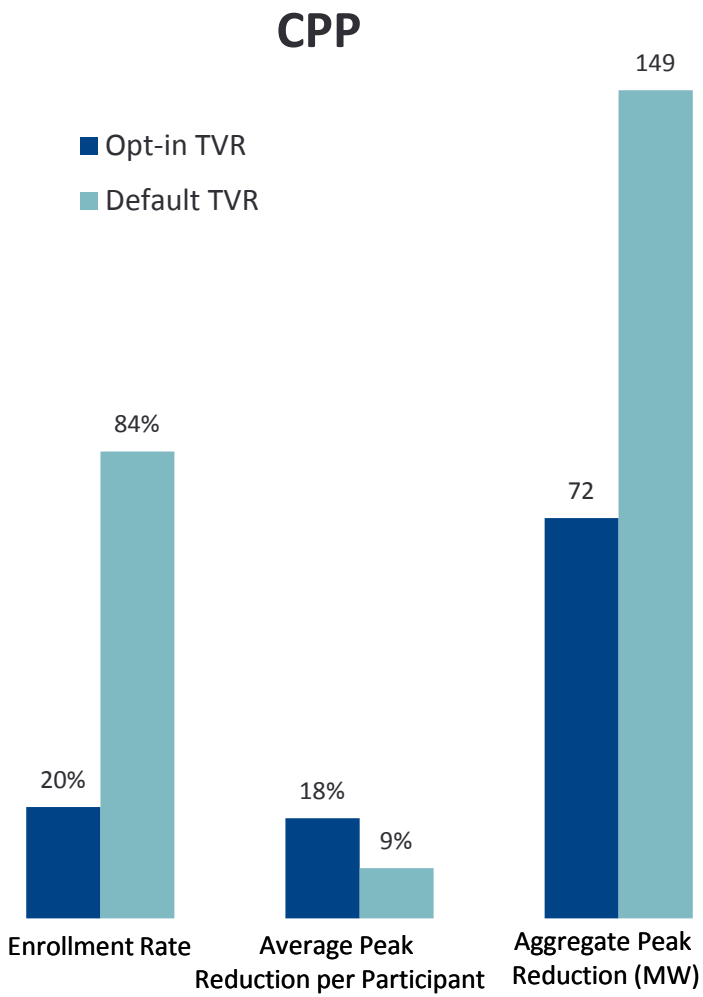
Organic consumers are emerging as a major force in energy markets

- These individuals are passionate about controlling their energy use not only to save money but also to lower greenhouse gas emissions and create a greener planet
- Energy efficiency comes naturally to the members of the organic consumer generation
- And unlike energy efficient folks from prior generations, they are armed with smart consumer electronics to live the efficiency lifestyle
- They bring a child's curiosity to all things digital such as smart meters, smart thermostats, and in-home displays

This generation can boost the future impact of DR on utility load shapes

- They are likely to be cognizant of the opportunities presented by dynamic pricing to lower energy bills and reduce emissions
- Their views may allow state commissions to rollout dynamic pricing as the default or universal tariff
- Further support will come from the successful deployment of time-varying rates to 4 million Ontarians and to 100,000 Californians in Sacramento
- The Massachusetts Department of Public Utilities has issued a straw proposal for default TVR

The benefits of default CPP pricing vastly outweigh the benefits of opt-in pricing

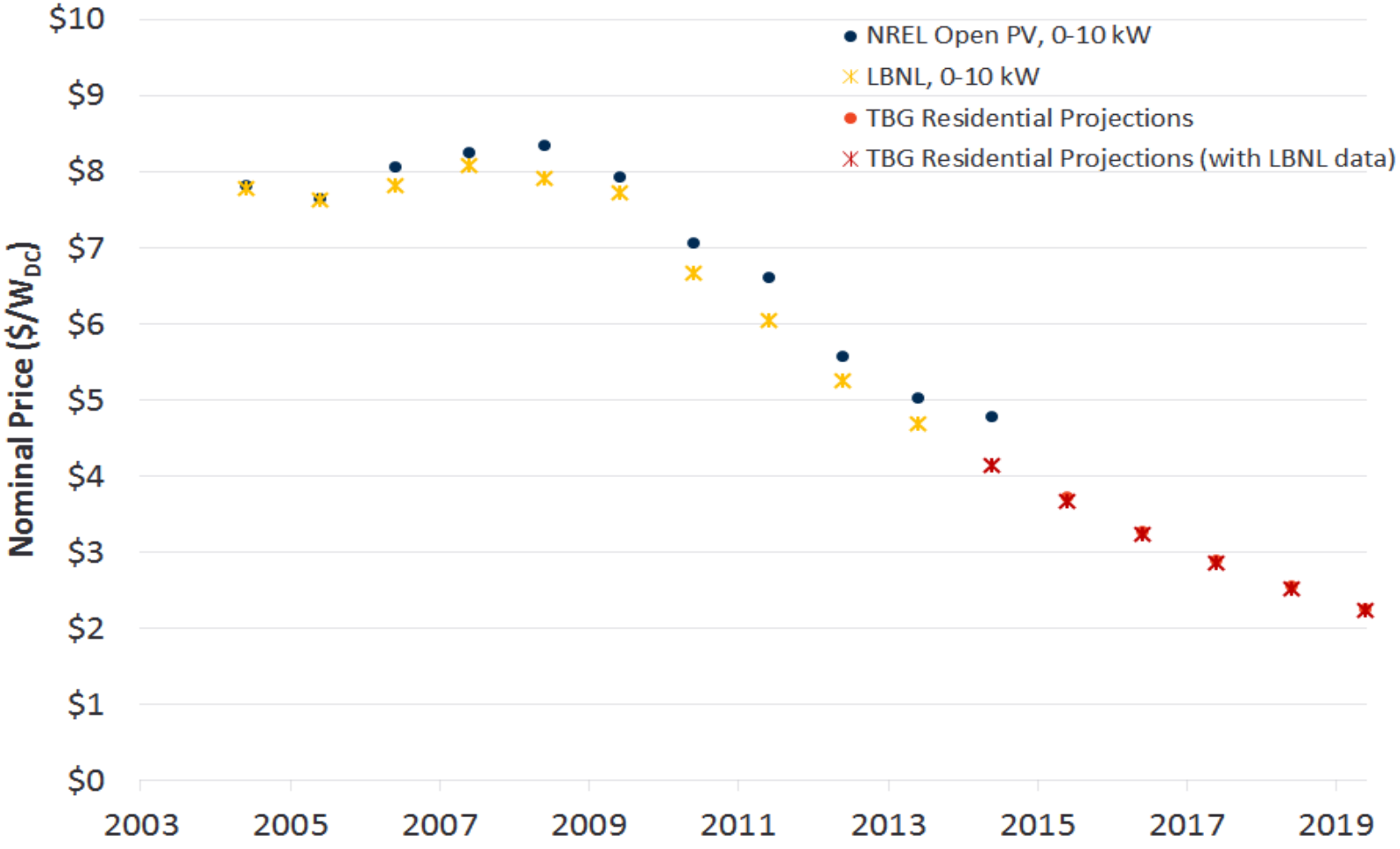


Aggregate peak reduction impacts (MW) are calculated for a hypothetical utility with one million residential customers and a coincident residential peak demand of 2,000 MW

The future of distributed generation (DG) will be shaped by five major forces

1. Decreasing cost of PV panels
2. Expiration of the income tax credit
3. Success of the leasing model
4. Rising utility rates
5. Changes in utility rate design

Residential solar PV prices are expected to continue falling

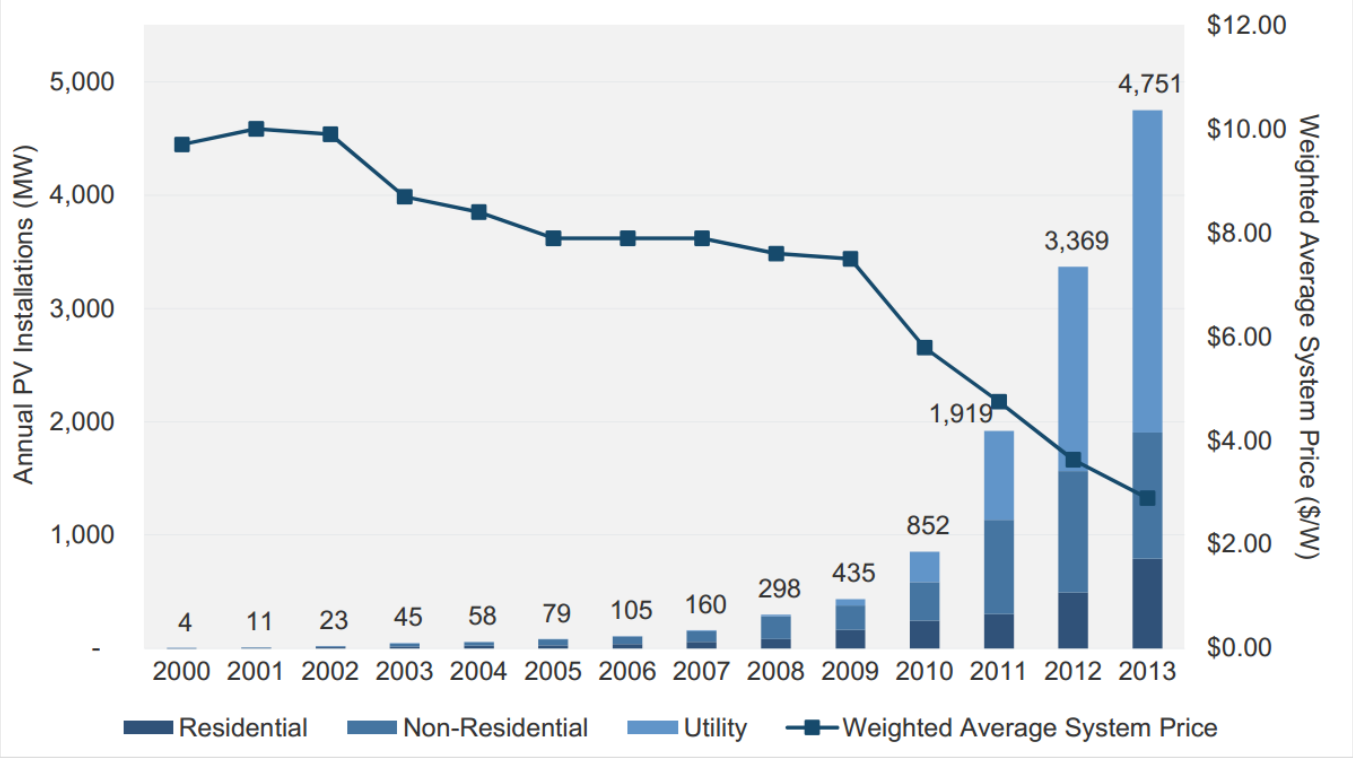


Source: The Brattle Group Analysis of the data from NREL Open PV Project, and LBNL,
Note: NREL reports simple averages; LBNL reports median values

The Investment Tax Credit (ITC) has provided a significant boost to distributed PV penetration

Until 2009, ITC of 30% was capped at $2,000 for residential system purchases. Effective January 2009, the cap has been removed and the ITC has been applied uniformly to residential and commercial systems

Figure 2.1 U.S. PV Installations and Average System Price, 2000-2013



Source: GTM Research

The ITC is scheduled to expire by the end of 2016

For residential leases, the ITC goes down to 10%, effective January 2017

For residential purchases, the ITC goes down to 0%, effective January 2017

This change in the tax code is expected to lead to further acceleration of the PV penetration through 2017 but its effect will greatly diminish henceforth

The solar lease model has accelerated PV penetration by addressing the upfront investment cost barrier

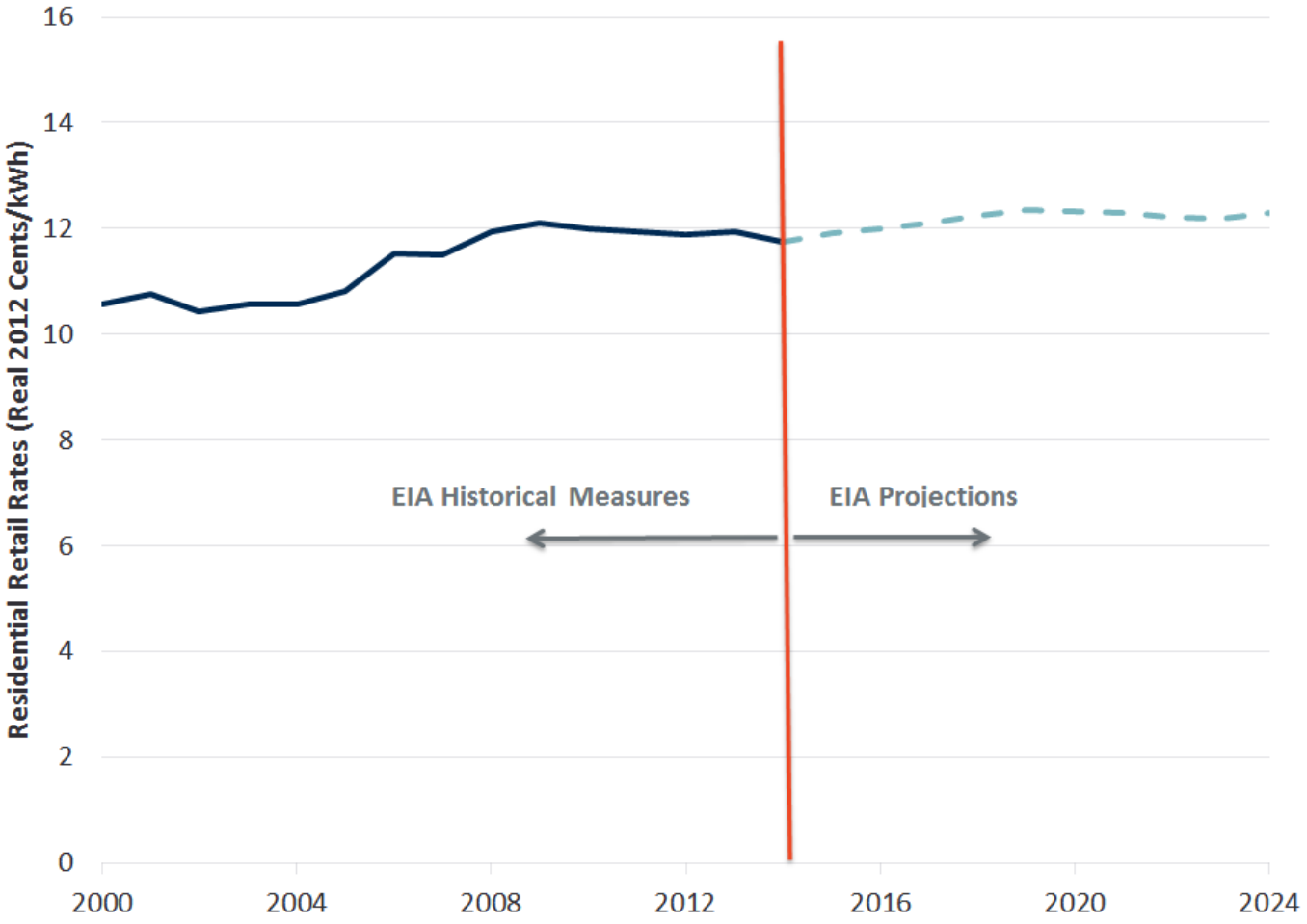
In this model, homeowner (lessee) enters into an agreement with the owner of the PV system (lessor) and agrees to make monthly lease payments in return for consuming the electricity generated

- Homeowners also get to keep net energy metering credits, if they are offered by their local utility

Solar lessors are able to depreciate the cost of the PV systems, on an accelerated basis

- Tax benefit of this depreciation is equivalent to 26% of the installed cost of the system; 12% of which comes from the ability to accelerate it over a 5-year period (LBNL, 2009)

Residential rates are projected to be virtually flat in real terms



Source: US EIA Electric Power Annual (historical), US EIA AEO 2014 (projections)
Note: The US Bureau of Economic Analysis Implicit Price GDP deflator was used to derive real prices

But rate design is expected to change

Today, a very large portion of utility costs are fixed but a very large portion of utility revenues are variable

- Most utilities use a two-part rate design with a monthly fixed charge and a volumetric energy charge
- Typically, the fixed charge is very small (in a few cases, it is zero) and does not come close to recovering even half of the utility's fixed costs

As sales growth slows down, this two-part rate design is guaranteed to not recover the utility's required revenues (unless rates are raised for all customers) for staying in business

To remedy this, utilities are moving to add demand charges to residential tariffs, creating unique opportunities for DR

The emergence of a residential three-part rate has become inevitable

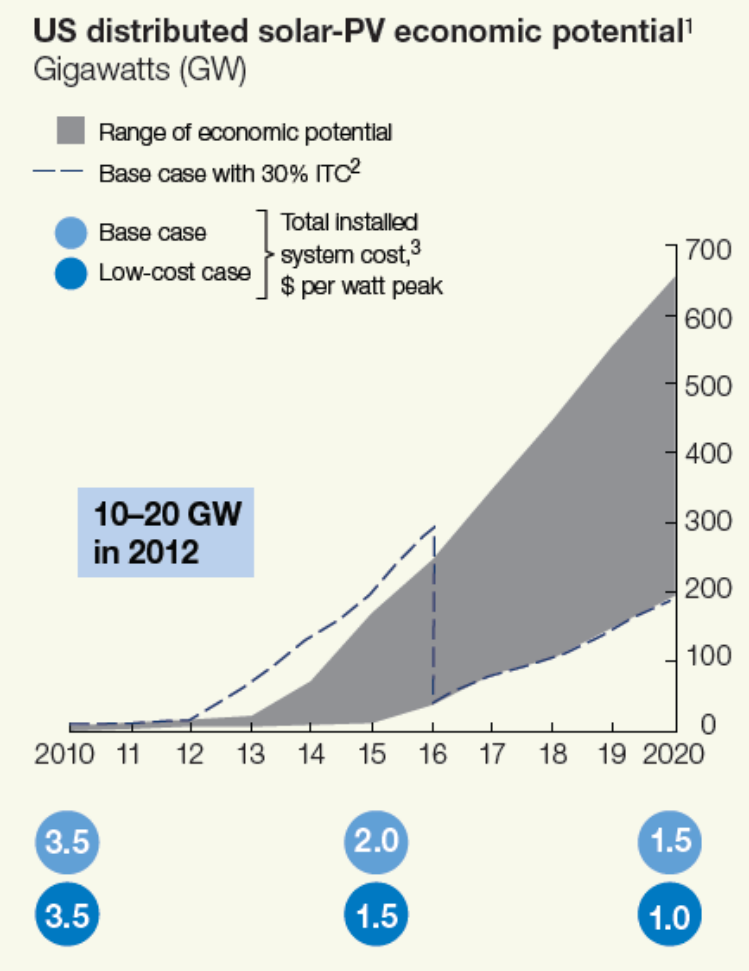
The concept is not new

- Three-part rates have ben widely deployed to commercial and industrial customers for the better part of the past century, backed up by a storied academic tradition that hearkens back to Hopkinson and Wright

Lack of metering and a concern that residential customers won't understand them have prevented their application to residential customers

State that such rates are being considered for DG customers, default or mandatory. Later on, we may see them being offered to all customers, default or mandatory

Solar DG capacity may reach 193 GW by 2020



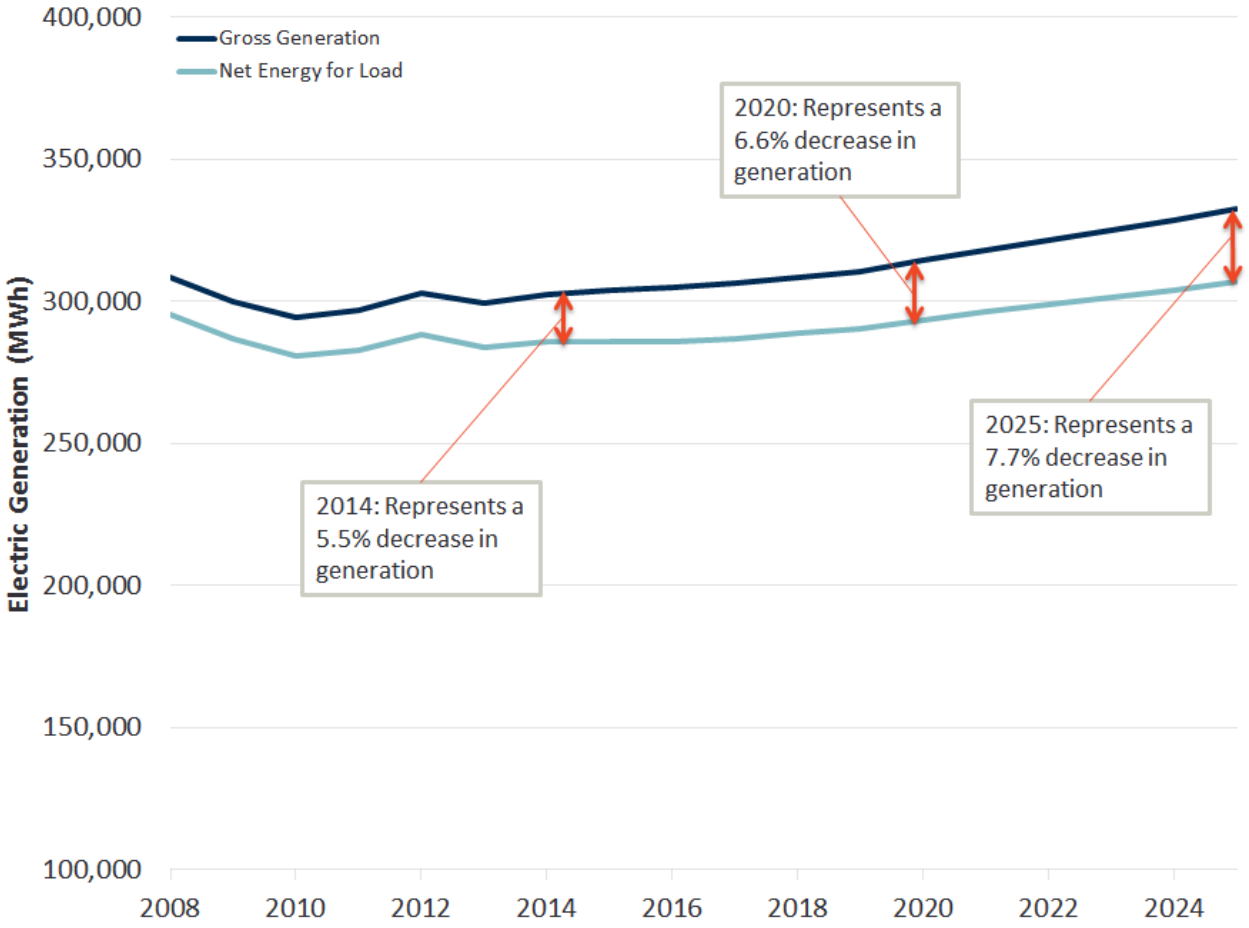
Source: McKinsey

McKinsey estimates that the distributed PV capacity may reach 193 GW by 2020 under a base case PV cost scenario ($1.5/W)

- This is 19% of the US projected generating capacity in 2020

A more aggressive scenario yields PV capacity reaching 650 GW in 2020, representing 64% of the projected US generation capacity

The California Energy Commission (CEC) projects a decrease in generation of 6.6% by 2020 due to DG resources



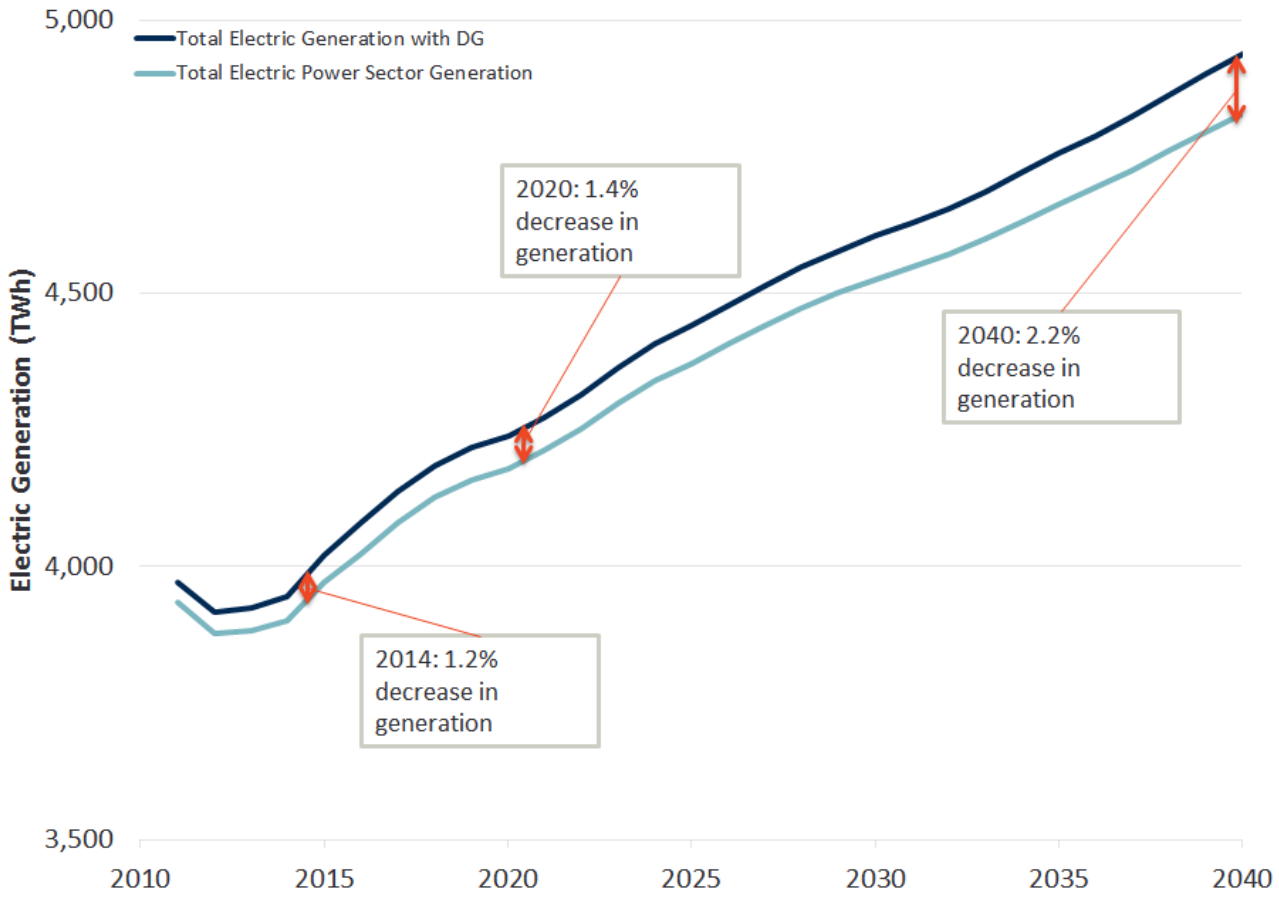
Generation from all distributed sources is expected to decrease gross generation by 6.6% in 2020

Distributed solar PV generation is expected to reach 1.8 GW by 2020 in California , representing 2.7% of generation capacity

Source: CEC Projections

Note: Net Energy for Load includes reductions from all private supply of distributed generation, not just solar PV.

The US Energy Information Administration (EIA) projects a decrease in generation of 1.4% by 2020

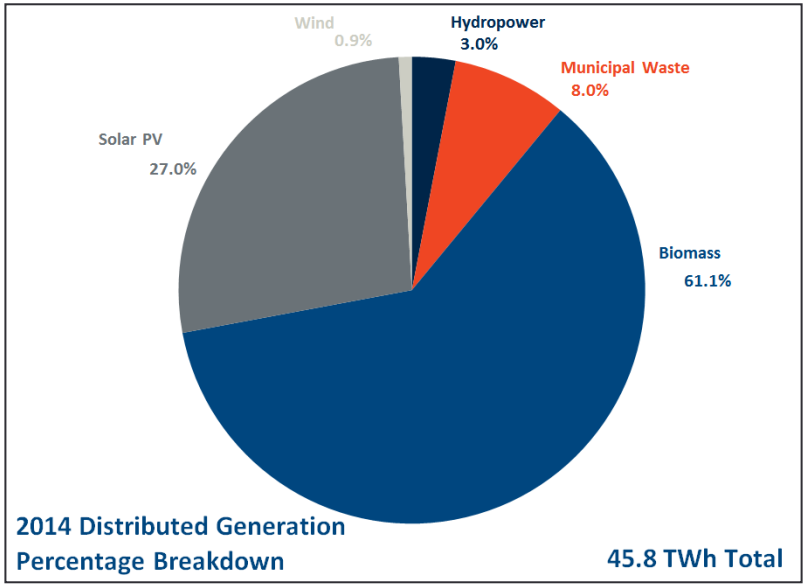


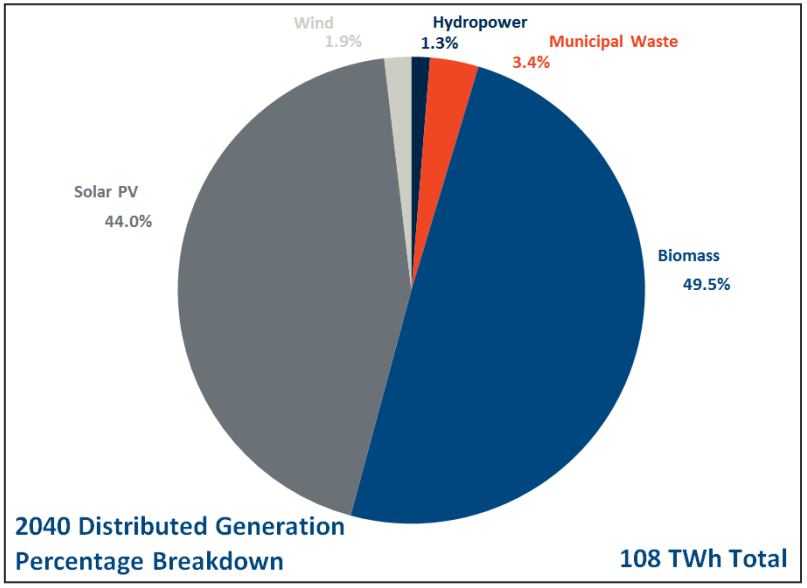
Source: EIA Annual Energy Outlook 2014
Note: DG numbers only include Renewable sources.

Generation from renewable DG resources is expected to decrease total U.S. electricity sector generation by 1.4% in 2020

Distributed solar PV generation is expected to reach 12.8 GW by 2020, representing 1.3% of total generation capacity

The share of solar PV will rise in DG





Source: EIA Annual Energy Outlook 2014

Conclusions

DR will flourish despite the slowdown in sales because load factors will worsen and because of the need to integrate renewable energy resources in the grid

The new DR will emphasize retail over wholesale, residential over non-residential and pricing over non-pricing programs

DG will continue to grow because of falling solar panel prices and rising electric rates

But DG's growth will be tempered by likely changes in the retail rate design

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Ahmad Faruqui, a principal with The Brattle Group, leads the firm's practice in understanding the changing needs of energy consumers. This work encompasses rate design, distributed generation, energy efficiency, demand response, demand forecasting and cost-benefit analysis of emerging technologies. During his career, he has worked for more than 125 clients, including utilities, system operators, and regulatory commissions, in the US and in Australia, Canada, Egypt, Hong Kong, Jamaica, Philippines, Saudi Arabia and Thailand. He has filed testimony or appeared before state commissions, government agencies, or legislative bodies in Alberta (Canada), Arizona, Arkansas, California, District of Columbia, Illinois, Indiana, Kansas, Maryland, Michigan and Ontario (Canada). He has spoken at conferences in Australia, Bahrain, Brazil, Egypt, France, Germany, Ireland, Jamaica, and the United Kingdom. His work has been cited in publications such as *The Economist*, *The New York Times*, *USA Today*, *The Wall Street Journal* and *the Washington Post*. He has appeared on Fox News and National Public Radio. The author, co-author or editor of four books and more than 150 articles dealing with energy issues, he holds bachelor's and master's degrees from the University of Karachi and masters and doctoral degrees from the University of California, Davis.