Itron's Integrated Energy Forecasting Framework

Data-driven insights to take action in the era of Distributed Energy Resources

When Thomas Edison first fired up his Pearl Street Station in 1882, he had a pretty simple approach to energy forecasting: he'd just walk through the nearby streets in Manhattan and count the streetlamps his first-ever power plant needed to illuminate. For nearly a century, forecasting energy demand remained a fairly straightforward proposition in a vertically integrated energy market powered by central station generation.

Energy forecasters analyze economic trends, customer data, load profile data and weather data to produce accurate load forecasts to support sound resource planning, wholesale market operations, power plant maintenance and distribution operations. Though accurate energy forecasting was certainly not a simple exercise, there were a manageable number of variables and ample margins for error.

This began to change dramatically in the 1990s when a wave of market restructuring began to unbundle generation and delivery. This period also introduced competitive electricity markets, where multiple suppliers would compete for end customers at both the wholesale and retail level.

Coupled with supply and capacity constraints in some markets, accurate demand forecasts took on new urgency and importance. The financial stakes for both energy suppliers and distribution utilities intensified, while system reliability hung in the balance in places such as California and Texas.

More Variables in Play

Today, producing an accurate energy demand forecast is even more challenging. The reason for this, of course, is the widespread adoption of Distributed Energy Resources (DER), especially customer-owned photovoltaic (PV) solar panels and wind energy, and the dynamic impact these resources have on overall energy demand. Production can change abruptly, forcing the utility or system operator to summon other costly resources quickly to meet demand and maintain grid stability. And DERs are not limited to solar and wind.

Demand response, on-site generation and microgrids, electric vehicles (EVs), energy storage (ES), and even energy efficiency can be considered part of this increasingly complex balance sheet of resources and demands.

In fact, DER capacity in the U.S. is expected to grow from 136 GW today to more than 530 GW by 2024, with DER capacity deployments outpacing central station generation by five-to-one in that time period.

All of these "non-wires" resources are conspiring to make life much more difficult for energy forecasters, as they must factor in an unprecedented number of variables to produce an accurate forecast. And that, in turn, makes life more difficult for market operators, resource planners, grid operators and financial planners, who depend on accurate forecasts to run the business successfully. For example, temperature data has long been a key input to an accurate forecast to gauge the demand for electricity based on the need for heating and cooling.

Now weather – the sun shining and the wind blowing – drives a rapidly increasing portion of the generation portfolio. Similarly, increased utilization of demand response, dynamic pricing and other programmatic resources impacted by human attitudes and behavior must also now be factored into the resource mix.

The bottom line is that both the complexity and the importance of accurate energy demand forecasting have increased significantly in the age of DERs. Accurate forecasting, factoring in the load impacts of DERs and the operational challenges posed by intermittency, is now a mission-critical need for daily operations, sound market/system planning and risk management.

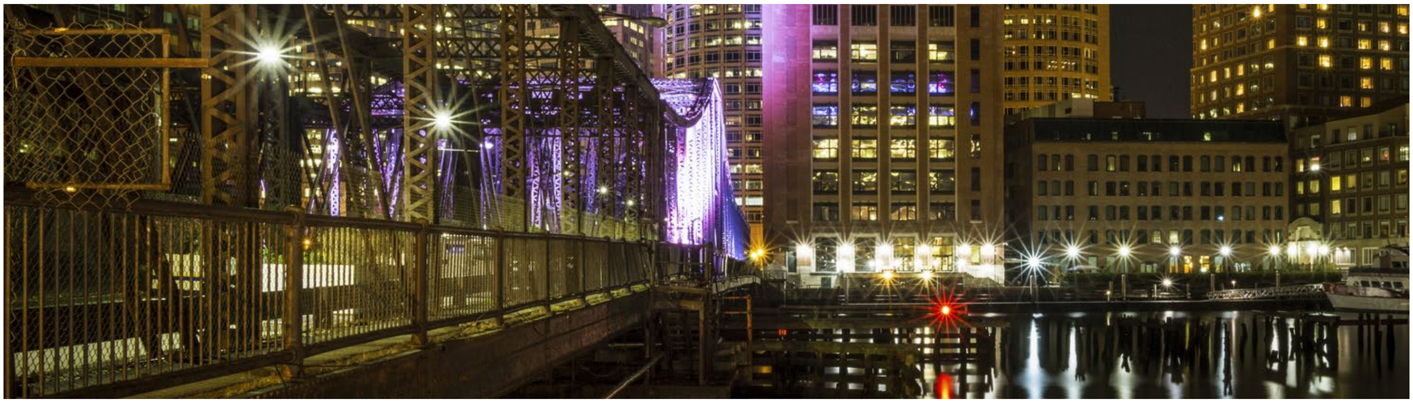
To avoid a greater reliance on costly spinning reserves to cover increased forecast uncertainty, operators need dynamic and accurate forecasting solutions that account for this added volatility. As many jurisdictions pursue increasingly ambitious renewable energy goals, these forecasting requirements will only intensify.

A New Approach

It is amid this increasingly complex business, regulatory and technology environment that Itron, the global leader in energy forecasting, pioneered the integration of DER resource forecasts into the real-time load forecasts that system operators require to manage the grid on a daily basis.

This concept of an Integrated Energy Forecasting Framework (IEFF) to accurately forecast the impacts of rooftop solar and other DERs has also been extended to long-term load forecasting. For instance, what will the daily load shape for single family homes in a specific geographic area look like in 2030, while factoring in a dozen variables ranging from climate change to aging population to the cost of PV. These are the questions Itron's IEFF is designed to answer.

The IEFF delivers the business intelligence and actionable outcomes system operators and utilities require to manage electricity supply, capacity and the grid amid an increasingly distributed and diverse resource portfolio. The IEFF is tailored to provided system operators and utilities with the specific analytic outcomes and actionable intelligence they require to manage risk and ensure success in this new market environment.



Itron's Integrated Energy Forecasting Framework Delivers:

- » Accurate forecast of hourly system load to support energy procurement, capacity planning, rate design and revenue forecasting
- » Accurate assessment of current and future impact of customer growth, technology penetration, TOU rate migration on:
  - System loads by geographic region and total footprint,
  - Energy, coincident & non-coincident peaks by class of service
- » Accurate forecasting of the load impact of customer migration to Community Choice Aggregators and other emerging alternative energy procurement programs
- » Load forecast uncertainty distributions that combine technology policy scenarios with variant weather patterns

NEW REQUIREMENTS AND CAPABILITIES

Itron's groundbreaking IEFF brings together industry-leading forecasting software, new intellectual property in the form of sophisticated algorithms and analytic toolsets, new high-resolution data sets and strong domain expertise to deliver a highly differentiated forecasting solution with the following attributes:

Updated End-Use Load Shapes

Using our latest research in end-use load shapes, and Itron's advanced Statistically Adjusted End-Use (SAE) modeling framework, the IEFF delivers significant and critical updates to existing residential, commercial, industrial and agricultural end-use load shapes.

Itron draws upon both high-resolution Advanced Metering Infrastructure (AMI) load data as well as the most recent end-use studies conducted by the Department of Energy's Energy Information Administration to develop end-use load shapes that are calibrated to observed behavior. Our hands-on experience in working with these data give Itron a distinct advantage in developing updated and highly detailed load shapes that capture the vagaries of DER forecasting.

Widespread Acceptance

By rapidly gaining acceptance at system operators and utilities across North America, Itron's forecasting methodology is quickly becoming the standard for energy forecasting for utilities interested in explicitly incorporating DERs, energy efficiency and other end-use technology trends into their long-term energy forecasts. Itron's SAE Users Group now includes more than 50 utilities and six system operators across the U.S.

Behind-the-Meter Insight

Itron IEFF delivers long-term forecasts of hourly behind-the-meter (BTM) distributed generation that extend to the planning area and sector levels. Itron has developed and integrated hourly generation profiles of existing BTM PV and other distributed generation resources into its model. Itron has done this by leveraging utility-supplied data on the characteristics and performance of existing systems and taking into account the diversity of system location across a utility's operating footprint. This enables Itron to deliver modeling and analysis of BTM distributed generation that result in estimates of "reconstituted" demand, which reflect the true demand for energy services.

Full Spectrum of DER and Impacts

Itron's IEFF dynamically models the impacts of DER technologies on hourly electricity demand on a scenario basis over time horizons necessary to support effective long-term planning. The DER technologies included in the framework are BTM solar, and other distributed generation such as micro wind and combined heat & power, ES and EV, energy efficiency and demand response.

IEFF Analysis Drives Accurate:

- » Revenue Forecasting
  - Rate Design
  - Rate Migration
  - Sales Forecasting

- » Transmission and Distribution Forecasting
  - Geographic Forecasts
    - Constrained Areas
    - High Technology Penetration Areas

- » Supply Forecasting
  - Resource and Capacity Planning

Weather Insight for Demand and Production

Itron's has developed for use in the IEFF a groundbreaking module that explicitly links weather patterns to not only weather-sensitive loads, but also to renewable energy generation. The IEFF's weather module, which already tracks the weather's influence on hourly demand, now tracks its hourly impact on renewable energy production across geographically diverse areas.

Time-variant Pricing Support

The Itron IEFF also includes a module that incorporates time-of-use rate structures to drive forecasts of hourly end-use demand, EV charging, and ES charging and dispatch. This module allows the impact of alternative TOU rate structures to be explored on a scenario basis within the same overall forecasting framework and with a high level of internal consistency. This capability is critical to developing effective price signals and rate structures to incentivize customer behavior with respect to operation of distributed resources and new loads that may pose a threat to grid stability.

Location-specific Insight

Itron's IEFF takes a bottoms-up approach to forecasting the impact of BTM and grid-connected DER. The framework provides results at high geographic and sector resolution. This capability enables users to aggregate system results to any level of population segmentation and temporal frequency suited to meet a wide variety of operational and business needs.

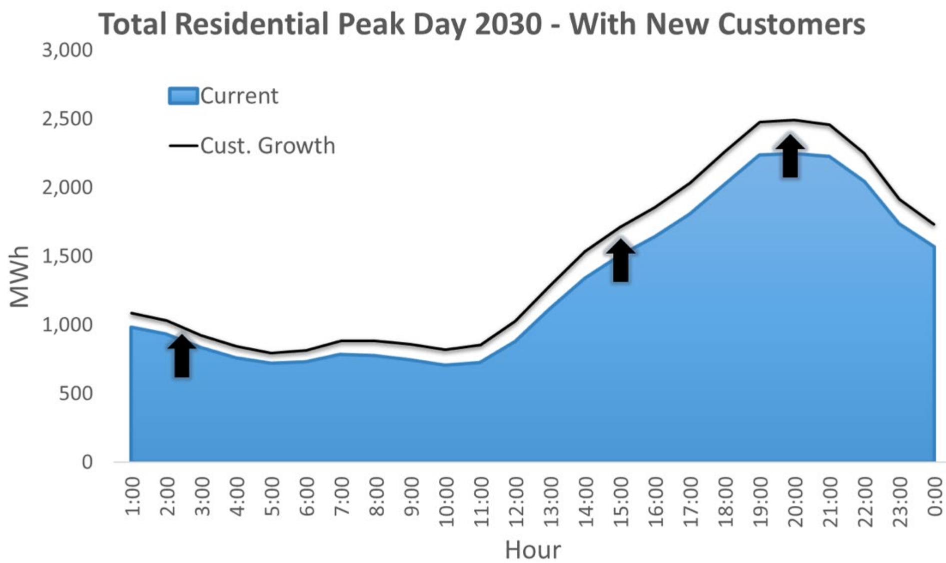
Weather and the Big Picture

Itron's IEFF also incorporates "uncertainty bounds" around weather-driven scenarios to provide clients with a full range of load impacts associated with extreme weather. This enables identification of the full spectrum of end-use factors that are driving consumption and supports a better understanding of the impact of DER on the load shape of demand. This innovative approach accounts for weather-based uncertainty to create a more complete understanding of the transmission and generation requirements associated with uncertain hourly demand.

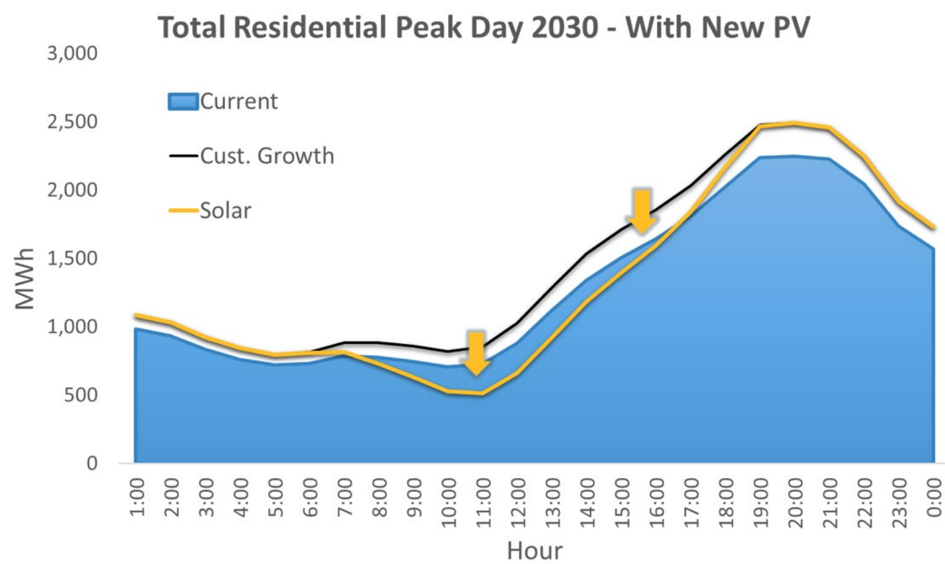
Taken together, these new capabilities of the Itron IEFF provide clients with a detailed understanding of how different DER technologies and programmatic efforts can be combined to reduce uncertainty and help achieve clean energy goals, while improving grid stability and reliability.

The IEFF enables our clients to explicitly take into account the impact of rapidly changing energy technology markets, changing weather patterns and changing energy consumption patterns in a unified forecasting framework that provides the resolution required to examine the system planning and grid management issues that are critical to clean energy goals.

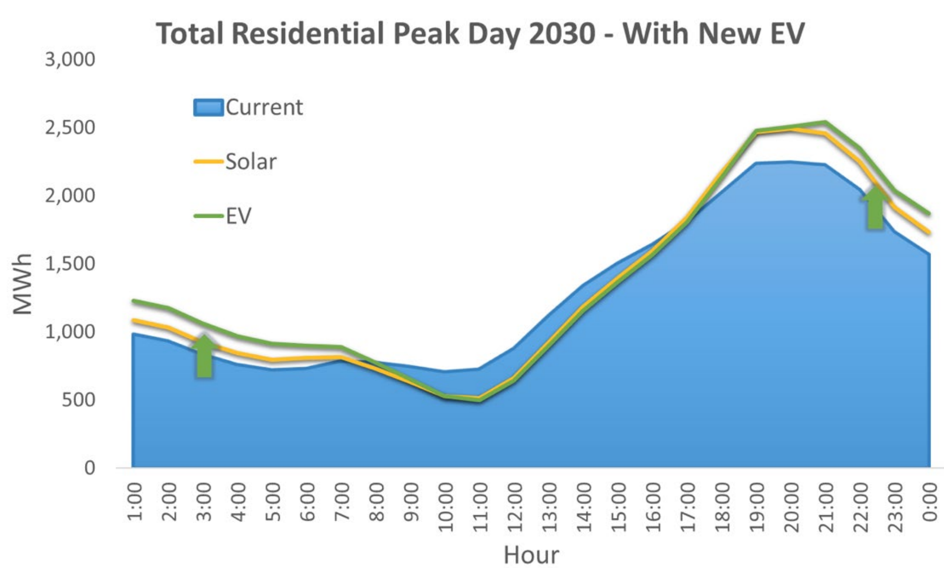
Customer Growth



Solar PV Growth



Electric Vehicle Growth



LEARNING IN CALIFORNIA

Nowhere are these market dynamics more mature and pressing than in the state of California. The state has established an extensive array of clean energy goals that are impacting the demand and supply for electricity, peak demand, the potential for over-generation and hourly ramps rates. Renewable portfolio standards and decreasing costs of PV have led to just under 6 GW of PV capacity currently installed in California.[1]

Installed PV capacity is expected to nearly double by 2024.[2] The increasing PV capacity has led to growing concerns over the potential for over-generation in the early afternoon, steep late afternoon ramp rates and uncertainty over the intermittent nature of PV generation.

The California Public Utility Commission (CPUC) also mandated recently that PG&E, SCE and SDG&E contract for a combined 1.325 GW of ES by 2020. Continued emphasis on EE, conservation, and advancements in building codes and appliance standards have led the CPUC to establish an efficiency savings goal of 4,500 MW and over 16,000 GWh for the 2012-2020 period.[3]

Increases in EV charging are forecasted to lead to substantial increases in per household electricity consumption by 2024, though less than 10% of EV charging is currently forecasted to occur on peak.[5] The recent announcement about plans to shutter PG&E's Diablo Canyon nuclear plant and its 2,160 MW of baseload generation capacity by 2025, and backfill it with renewable/distributed resources, has increased the urgency for accurate and actionable forecasting insight.

In total, the uncertainty associated with the combined impact of clean energy technologies on existing electricity consumption, peak demand and ramp rate requirements is introducing unprecedented complexity into the state's generation and transmission planning processes. These trends are magnifying concerns about the cost of maintaining the reliability of the grid with higher penetrations of distributed energy.

This is the exact scenario that the IEFF would be employed to analyze: how future changes in the mix of technologies and end-user consumption patterns will impact future system load shapes and associated grid management issues. Itron is working with its utility clients to improve forecasts of PV generation and ES discharge and update traditional end-use load shapes and load shapes associated with ES and EV charging. The improved accuracy of these forecasts, along with detailed geographic and temporal disaggregation, provides much improved insight to the current and future drivers of net electricity demand.

Furthermore, the forecasts of PV generation, ES discharge, end-use load shapes, DR impact shapes and load shapes associated with ES and EV charging will be tied together through weather and price simulations in the IEFF. The framework provides scenario forecasts simulating the impact of weather, prices and alternative clean energy policies on loads. The forecasts also provide a much clearer understanding of the landscape and scenarios needed to develop policies and programs to reduce the uncertainty in load forecasts, reduce the costs of implementing clean energy policies and improve the reliability of the grid.

The ultimate goal of the IEFF is to provide our clients with a much-improved understanding of the impact of DERs on energy consumption, peak demand and ramp rates over 10-, or even 20-year forecasting horizons. These improvements are achieved by producing more accurate estimates of DER load shapes and tying these load shapes to integrated energy forecasts designed to identify critical grid management issues and strategically align research and policy making to address those issues going forward.

The framework also provides a method for estimating the impact of alternative weather, prices, technology adoption rates and public policies on electricity consumption, peak demand and ramp rates on a scenario basis. The estimation of multiple scenarios helps to illustrate the uncertainty and range of net load forecasts and identify policies and technology pathways that are best positioned to successfully integrate intermittent PV generation with ES, DR and EE.

INNOVATION TO ADVANCE THE STATE OF THE ART

Itron's IEFF incorporates several innovations that are designed to not only expand forecasting capabilities but also help identify and overcome technical barriers to achieving clean energy goals and policy outcomes. For end-use load shapes, Itron provides critical updates to existing residential, commercial and industrial end-use load shapes using SAE modeling. The SAE model is designed to be used in conjunction with existing demand forecasting frameworks while also allowing for the development of hourly load impacts of EE measures, grid-connected solar and wind generation, grid-connected storage, BTM storage and solar generation, and price-sensitive and non-price sensitive EV charging and demand response. The SAE model provides increased fidelity in net load forecasts enabling a better understanding of hourly loads, ramp rates and uncertainty due to weather. Improved understanding of the hourly impact of DERs on the net load will, in turn, facilitate the development of policies to strategically reduce uncertainty and improve reliability. These innovations include:

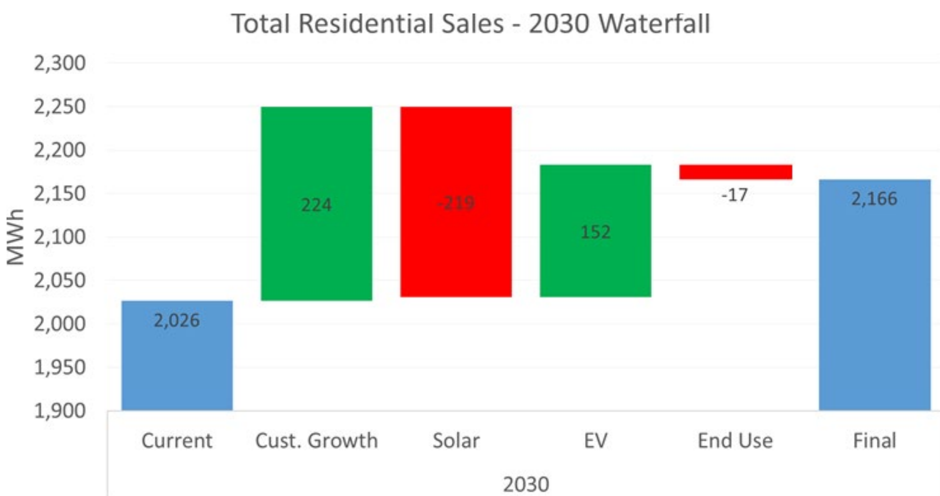
- SAE model that forecasts loads and supply at the hourly level by IOU, customer sector and climate region.
- End-use disaggregation of interval smart metering data.
- Extension of current capabilities beyond forecasting annual consumption and system peak demand.
- Additional clarity on the impacts of weather on hourly loads and ramp rates.
- Additional clarity on how green technologies impact hourly loads and ramps rates.
- Integration of the impact of green technologies on demand and supply.

The IEFF models the dynamic impacts of DER technologies on both hourly electricity demand and supply on a scenario basis over horizons necessary for long-term planning. The model provides a detailed understanding of how different DER technologies and public policies can be combined to reduce uncertainty and help achieve clean energy goals, while improving grid reliability.

ENERGY FORECASTING EVOLUTION

	HISTORICAL CONTEXT	CURRENT CONTEXT	FUTURE CONTEXT
DRIVERS	» Generation capacity planning » EE and traditional load management	» T&D planning » Strategic R&D » Rise of solar PV, EV, storage	» Grid management » Large-scale DER integration » Climate change
DATA SOURCES	» Monthly bills » Ad hoc end-use data » Load research studies » EM&V studies	» AMI data » Comprehensive end-use data » DER performance data	» Big data
MODELING FRAMEWORK	» Total annual consumption » System coincident peak demand	» Total hourly demand	» Locational hourly demand

SAMPLE 10-YEAR AHEAD RESIDENTIAL SALES WATERFALL



BENEFITS OF THE IEFF

Itron's IEFF leverages the availability of hourly load data, the most recent end-use load shape data, and DER penetration and load impact data to create hourly forecasts of system loads and ramp rates over a long-term planning horizon. The model incorporates increasing penetrations of distributed energy technologies. The specific contributions to the state of the art in long-term forecasting are listed below.

- Long-term, hourly end-use load shapes calibrated to smart meter data that have been adjusted to account for BTM distributed generation.
- Weather sensitivity estimated directly from smart meter data by IOU, sector and climate region.
- Updated end-use load shapes that incorporate the most recent end-use baseline studies, program impact evaluation studies and forecasts of future technology advancements.
- Explicit incorporation of DER technology impacts on hourly demand.
- Explicit incorporation of grid-connected PV, wind and ES on hourly generation dispatch.
- Explicit incorporation of the influence of TOU rate structures on hourly end-use load shapes.
- Quantification of uncertainty in both hourly supply and demand due to weather.
- A unified forecasting framework for exploring grid operation risks due to supply over-generation and system reliability issues under alternative DER integration scenarios.

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To learn how Itron can improve the accuracy of your forecasts while reducing your resource commitments, contact us at:
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[1] There are current roughly 2.4 GW of BTM PV installed in California (https://www.californiasolarstatistics.ca.gov/), along with 3.4 GW of utility-scale PV (http://www.cpuc.ca.gov/NR/rdonlyres/A00F02FF-B55F-40AF-AECF-AA258DD74378/0/RPS_Project_Status_Table_2015_May.xls).

[2] http://www.caiso.com

[3] California Public Utilities Commission, 2008. Decision Adopting Interim Energy Efficiency Savings Goals for 2012 through 2020, and Defining energy Efficiency Savings Goals for 2009 through 2011. Decision 08-07-047.

[4] Kavalec, Chris, Nicholas Fugate, Bryan Alcorn, Mark Ciminelli, Asish Gautam, Kate Sullivan, and Malachi Weng Gutierrez. 2014. California Energy Demand 2014-2024 Final Forecast, Volume 1: Statewide Electricity Demand, End-User Natural Gas Demand, and Energy Efficiency. California Energy Commission, Electricity Supply Analysis Division. Publication Number: CEC-200-2013-004-V1-CMF.

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