WHITE PAPER

# The Electrification Challenge

lumin

CANARY CREATIVE

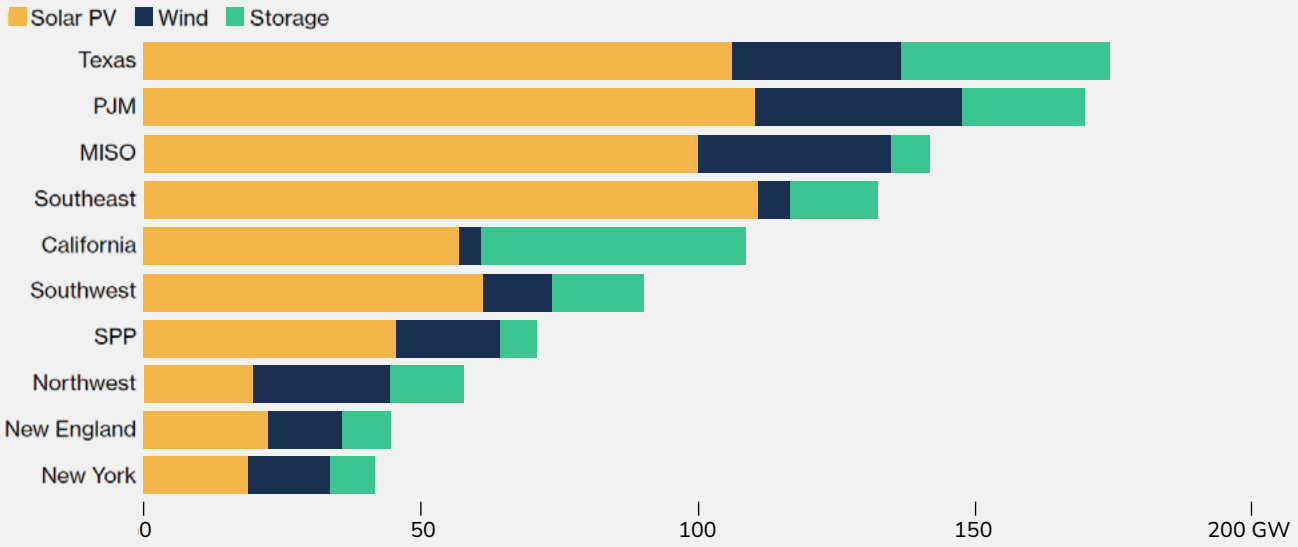
INTRODUCTION

# The energy transition is not happening fast enough

Clean energy deployments, such as solar and battery storage, routinely break records and have helped nudge U.S. greenhouse gas emissions lower. Yet progress is nowhere near sufficient to make an impact on climate change.

**U.S. to Add 1.2 Terawatts of Solar, Wind and Energy Storage by 2035**

Forecasted cumulative 2024-2035 new clean energy build by US region




Source: BloombergNEF

The U.S. federal goal to slash greenhouse gas emissions in half by 2030 appears increasingly out of reach as we near the halfway point of the "Decisive Decade" in the fight against climate change. Despite the challenges in reaching those goals, an expanding set of tools and technologies can dramatically accelerate decarbonization.

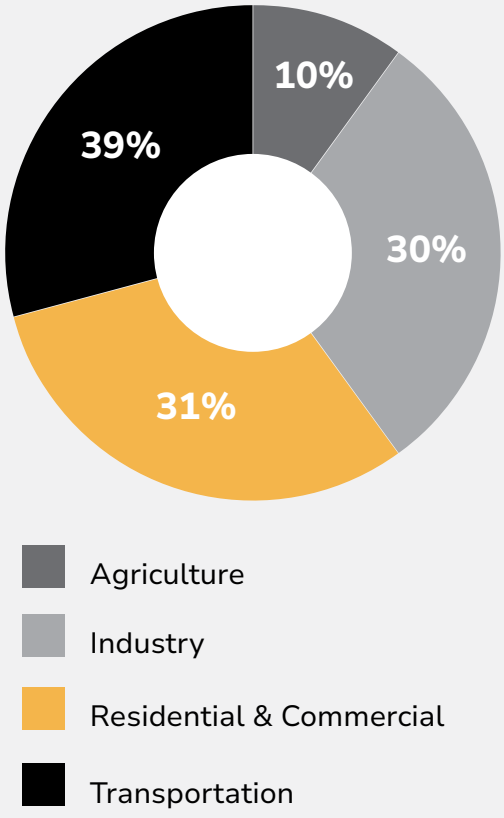
Mass electrification — the strategy of converting fossil-fuel technologies to their electric counterparts powered by clean energy — touches all sectors of society and is the foundation of a more rapid energy transition. That is because emissions from the commercial and residential sectors are one of the largest sources of greenhouse gases in the U.S.

Rapidly slashing emissions through electrification requires two connected steps. First, the electric power sector must quickly ramp up its deployment of clean energy and build on its recent decarbonization progress. In 2023, for example, the U.S. Energy Information Administration reported that energy-related emissions fell by 3 percent, almost entirely because of increased renewables and coal plant retirements in the electric power sector. Additionally, as the grid gets cleaner, end-use electrification in buildings must also expand, along with a more rapid deployment of distributed energy resources (DERs) and virtual power plants (VPPs).

This paper will examine:

- Challenges to utility-scale clean energy
- The promise of home electrification and DERs
- The process of translating home electrification into reality
- The role of smart panels in equitable home electrification

**Total U.S. Greenhouse Gas Emissions by Economic Sector Including Electricity End-Use Indirect Emissions, 2022**




Source: U.S. EPA

# The challenges to utility-scale clean energy electrification

One of the appeals of electrifying everything is its conceptual simplicity. Instead of using fossil fuels as a source of power for buildings and transportation, they would run only on electricity, which can become cleaner over time.

But things get quickly complicated in the real world, where everything from utility incentives and regulations to technology innovation, business models, and local and national politics collide. And for electrification to fully deliver on its economic and environmental potential, we must speed up progress on clean energy deployment and swapping out millions of fossil-fuel-powered machines for electric ones.

# Challenges to the renewable energy buildout

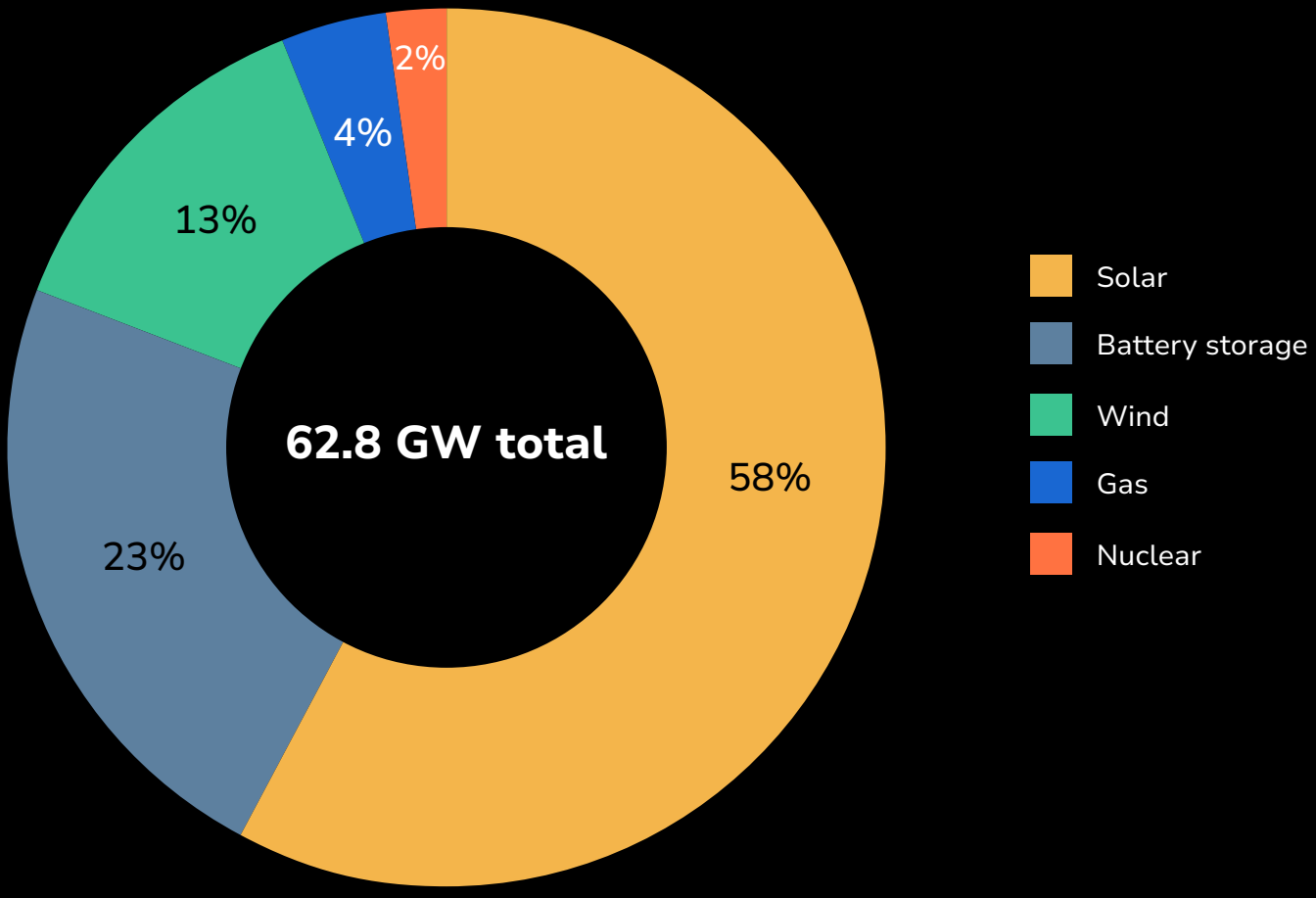
Solar provides the majority of new clean energy capacity in the United States. The U.S. Department of Energy (DOE) and the National Renewable Energy Laboratory's "Solar Futures Study" lays out a blueprint for solar to meet 40 percent of the country's electricity demand by 2035, up from just 3 percent in 2020. Achieving that objective requires building hundreds of gigawatts of solar capacity, much of it large utility-scale power plants, at a pace as much as five times faster than in recent years.

The obstacles to this transformation are daunting. A 2024 report released by Lawrence Berkeley National Laboratory found that 2,600 gigawatts of new generation and storage capacity were awaiting interconnection, the vast majority of which are from wind, solar, and batteries.

Interconnection is one of the many challenges to the utility-scale clean energy buildout that decarbonization demands. Local ordinances, zoning, and other permitting obstacles were cited as the leading reason that wind and solar projects were canceled between 2016 and 2023. Recent Federal Energy Regulatory Commission rulings and DOE action acknowledge the need to expand transmission capacity to deliver clean electrons to where they are needed.

# Almost all new U.S. grid capacity in 2024 will be carbon-free

Planned power plant capacity additions in 2024, by source

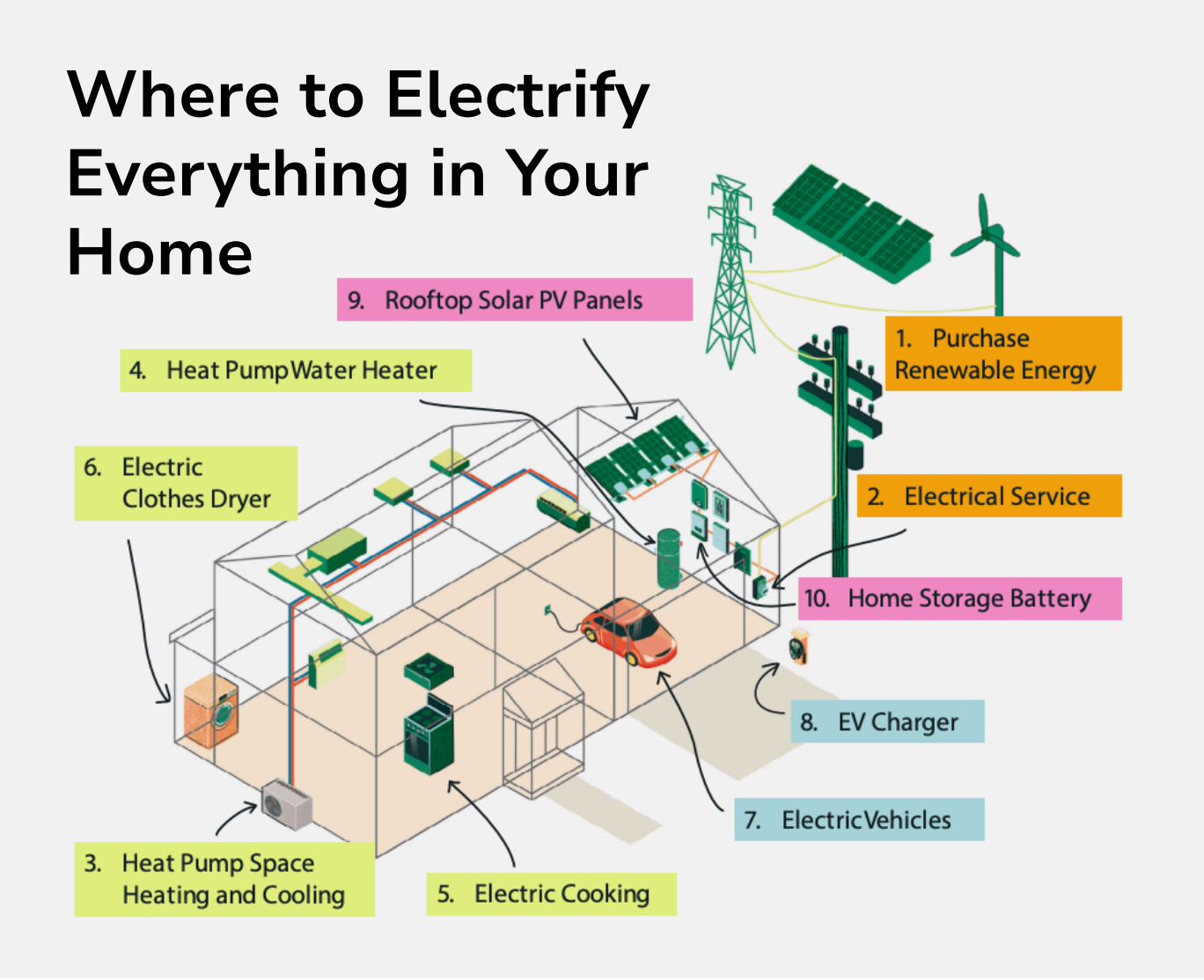



Source: Canary Media

# Home electrification can speed decarbonization

The key to electrification is swapping fossil-fuel-powered machines for electric ones.

At the household level, technology innovation, improved economics, policy support, and strong customer demand can combine to enable rapid and equitable electrification.




Source: Rewiring America

However, as with deploying renewables, challenges remain. Some electric appliances, such as cold-weather heat pumps, come with a higher up-front price tag than their fossil-fuel counterparts. There is a massive shortage of trained workers, such as electricians, to do this work, and efforts to address that problem are piecemeal.

The upside of electrified homes is massive. Indoor air quality improves. All-electric homes are more comfortable, as properly sized heat pumps provide more even heating and cooling to rooms than stand-alone ACs and furnaces or boilers.

Electric appliances can also support the grid rather than strain it. Distributed energy resources (DERs) in the home, like smart thermostats, rooftop solar, batteries, and heat-pump water heaters, can be aggregated into virtual power plants (VPPs) that simultaneously reduce electricity costs for homeowners and provide relief to the grid. The U.S. DOE wants to triple VPP capacity from about 30-60 gigawatts today to 160 gigawatts by 2030. This would meet 10 to 20 percent of peak electricity load and save $10 billion in annual grid costs.

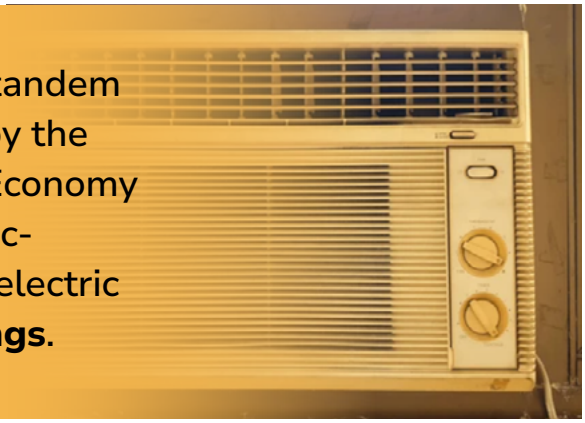
DERs that can participate in VPPs and provide financial benefits to homeowners are both readily available and in high demand. In just one example, heat pumps outsold gas furnaces by more than 20 percent in 2023. Incentives from the Inflation Reduction Act (IRA), improving economics, and customer demand can further buoy sales of heat-pump water heaters and other home electric appliances.

## Scaling home electrification by focusing on equity

While the promise of home electrification is substantial, urgent action is necessary to reduce the barriers that stand in its way. For example, repeating the residential rooftop-solar deployment pattern would be counterproductive. Most early adopters of solar were able to afford the steep upfront cost. Low-income families — the majority of whom live in energy-inefficient homes and pay a disproportionate amount of their income on energy — have largely missed out on the benefits of residential solar.

To help spur equitable adoption, the IRA included billions of dollars in rebates for low- and moderate-income consumers to buy electric appliances like induction ranges and heat pumps. Those funds are just beginning to flow to states. Additionally, the U.S. Environmental Protection

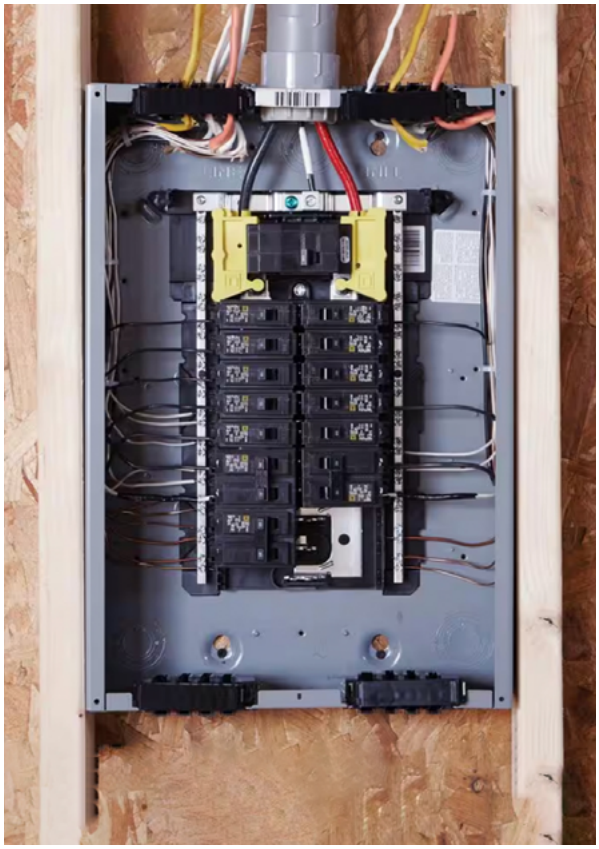
Agency recently doled out $20 billion for green banks across the country that will provide low-cost loans and other support for rooftop solar, efficiency retrofits, electric heat pumps, EV charging, and other carbon- and pollution-reducing projects, with a focus on low-income and disadvantaged communities.



If low-income households can electrify in tandem with higher income ones, a recent report by the American Council for an Energy-Efficient Economy found that replacing fossil-fuel and electric-resistance appliances with more-efficient electric options could result in **$96 billion in savings**.

# Electric homes can also be smarter

Incentives and tailored programs that support an equitable energy transition are important. However, to reach the full potential of household electrification, these technologies eventually need to win in the marketplace without government support. One way that electrification will get cheaper and scale faster is for intelligent home-energy-management tools to be affordable to anyone who wants them.



Bolstering the intelligence of a home's electric panel is a pivotal step in optimizing energy management. Traditional electric panels play a vital role in safely delivering electricity from the grid to the loads in a home. Also called service panels or circuit boxes, electric panels take the electricity from the grid and route it to circuits serving individual loads, like a hot-water heater, heat pump, pool pump, electric stove, or washing machine. Circuit breakers halt the flow of electricity and avoid potentially dangerous overloads and short circuits when there is a surge of current or other unsafe conditions.

# Smart panels can make home electrification more affordable

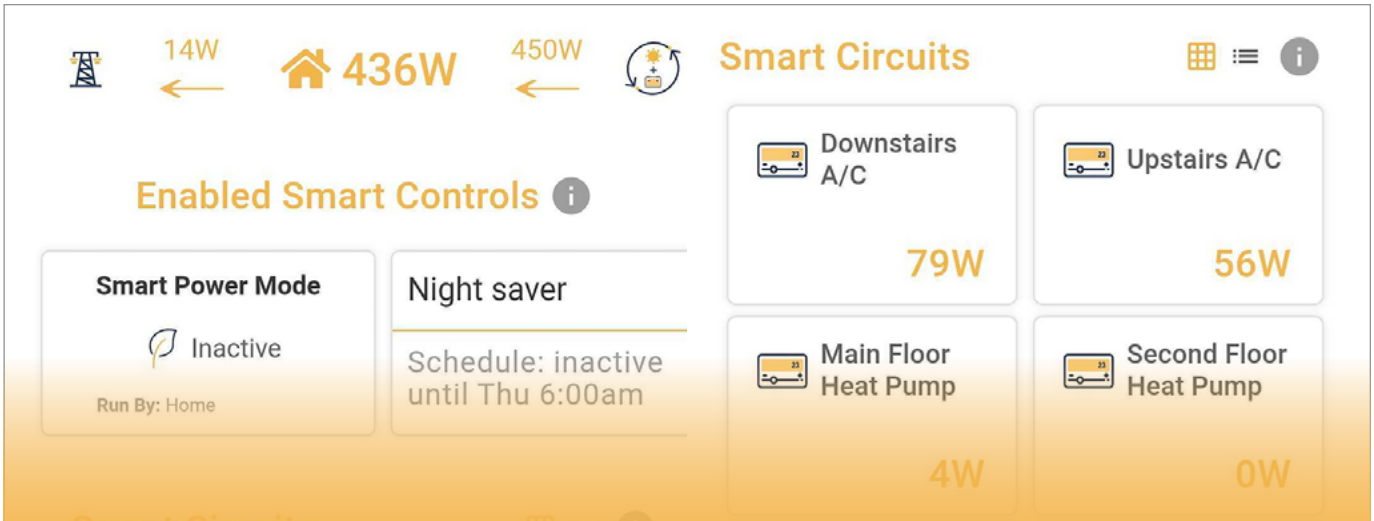
Electric panels are essential, but their lack of intelligence is a barrier to widespread home electrification. To accommodate new loads such as electric-vehicle chargers, heat pumps, and induction stoves, homes typically need a 200-amp panel. However, as many as 48 million U.S. homes don't have an electric panel that can handle the current needed to electrify all household loads. The cost of a utility service and panel upgrade varies depending on the location and the existing panel and infrastructure. In much of California, for example, it can range anywhere between $2,000 and $30,000.

Smart panels, like those made by Lumin, provide sophisticated home-energy management through intelligence and control  that can make the upfront costs of home electrification more affordable and increase its long-term financial benefits. Unlike full-panel replacements, the Lumin Smart Panel connects to existing electrical panels, reducing installation labor fees for homeowners and simplifying the job for electricians. The retrofit smart panel adds monitoring, data collection, analytics, and automation to enable granular circuit-level control of loads inside a home. These capabilities provide opportunities to improve the financial upside of home electrification, which is critical to its equitable adoption.


A Lumin Smart Panel being installed at Solar Energy International's headquarters. Source: Lumin.

Smart panels can grant a homeowner direct control over connected circuits or provide passive load management based on a set power threshold and the homeowner's priorities. For example, a smart panel can cap the total aggregated load in a home at a predetermined level; a 100-amp panel can be capped at 80 amps.

Along with capping a home's aggregated load, a smart panel can automatically prioritize and manage the loads within a home that matter most in order to ensure that air conditioning is available in the summer and an oven is ready to use at mealtimes. Uniquely, Lumin also enables customers to set schedules for individual circuits, allowing them to turn off loads during peak times or at night when they're not needed — providing additional energy-saving capabilities.

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## Ongoing savings by supporting the grid

Why does this matter? Capping the total aggregate household load and automatically prioritizing and managing the most important loads based on a homeowner's preferences reduces the costs of home electrification because it allows an existing panel and electrical infrastructure to handle added loads without expensive utility-service upgrades. Smart panels also provide homeowners with opportunities to seize ongoing energy savings.

Many utilities have deployed time-of-use rates to incentivize consumption when the supply of electricity is abundant and cheap and discourage it during periods of peak demand. A smart panel can automatically respond to utility price signals by ramping down electricity usage when rates are high and rescheduling EV charging and other flexible loads when electricity is cheap. The

economics of home electrification also improves when a smart panel can accelerate the payback on investments in technologies like energy storage.

For example, California's controversial net-energy-metering 3.0 (NEM 3.0) reforms have reduced the return on investment (ROI) for rooftop solar installed without a battery. NEM 3.0 incentivizes energy storage, but fully capturing its ROI depends on dispatching stored electricity at optimal times. This requires the intelligence and automation a smart panel can provide.

Lumin's latest product, Lumin Edge, offers the same appliance-level monitoring and control as the Lumin Smart Panel in a modular platform, enhancing cost-effectiveness by scaling to specific needs, particularly for electrification and grid services. Comprising an Edge Hub and multiple Edge Controllers, Lumin Edge can be installed on individual load wires to manage as many loads as needed. This modularity allows cost-effective scaling to meet homeowner preferences, utility program requirements, and electrification goals by controlling the largest loads in the home. For example, during a utility demand-response event, Lumin Edge can turn off major loads, such as a water heater or pool pump, encouraging grid resilience and enabling homeowners to receive compensation for participation in utility programs.

Home electrification coupled with load-management strategies can bolster grid resilience and exemplify the mutually beneficial utility-customer partnership that decarbonization demands.

The granular household and appliance-level data that smart panels and Lumin Edge provide to utilities gives them the confidence to rely on VPPs and demand response as resources to manage peak demand and other grid constraints cost-effectively. While more complex strategies, like advanced metering infrastructure 2.0, may someday be able to provide some of this control capability, the first wave of smart meters vastly underdelivered the customer functionality and savings that utilities said they would.

## CONCLUSION

# Decarbonizing the economy is appropriately described as the most complex and monumental challenge humanity has faced.

Yet, clean-energy-powered electrification is the main pillar in any realistic strategy to reduce greenhouse gas emissions dramatically.

Home electrification can scale rapidly and provide support and services to the grid, helping utilities meet growing electrical demand and reducing the urgency for expensive infrastructure upgrades. Grid-edge technologies, like smart panels, are key to speedier and more equitable home electrification. They provide data-gathering capabilities, intelligence and automation, smart panels and other grid-edge technologies that can reduce upfront electrification costs and improve the return on investments in energy storage, solar, heat pumps, and other DERs. Smart panels can also empower utilities to manage more electrical demand within existing infrastructure.

Perhaps most importantly, smart panels empower households to achieve their unique decarbonization and financial objectives while enhancing their comfort and quality of life. Intelligent, turnkey technology solutions that affordably translate household energy priorities into reality must play an increasingly central role in enabling rapid and equitable mass electrification.

Visit LuminSmart.com to learn more about Lumin's pioneering technology in home energy management, or contact Lumin directly at hello@luminsmart.com.

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