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Service Upgrade Avoidance for U.S. Homes: Smart Alternatives to Residential Electrical Service Overhauls

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Abstract:
The shift toward the use of electricity within U.S. residential building is gaining momentum, with many factors contributing to this trend including climate goals, the increasing number of electric vehicles (EVs) being purchased, heat pumps, and induction cooktops; however, there are challenges to be overcome as the electrification of these structures increases - one major issue is the limitation of existing home electrical panel's capacity. According to research from Pecan Street, an estimated 48 million single family homes throughout the United States could potentially require electrical service panel upgrades prior to full home electrification. Upgrading a home's electrical service panel can cost thousands of dollars and take weeks to complete. In this study, we will identify the key issues related to upgrading a home's electrical service, discuss the various stakeholders impacted by the issues identified, and evaluate proposed solutions for reducing the need for electrical service upgrades for those considering the electrification of their homes, such as smart electrical panels, AI-powered HEMS (home energy management systems), and changes to the NEC (National Electrical Code) effective January 1, 2026. Data used for the analysis includes data collected from industry sources including Rewiring America, Pecan Street, SPAN, Schneider Electric, Eaton, and the U.S. Energy Information Administration. Results show that utilizing intelligent load management techniques at the panel level can effectively reduce a homeowner's peak household demand enough to delay or prevent the need for an electrical service upgrade for most homes undergoing electrification, which represents a significant amount of money saved nationally, potentially in the hundreds of billion dollars. [1][2]

Keywords: Electrical Service Upgrade, Smart Electrical Panel, Home Electrification, Load Management, AI Energy Optimization, Residential Energy Management, NEC 2026.

1. INTRODUCTION

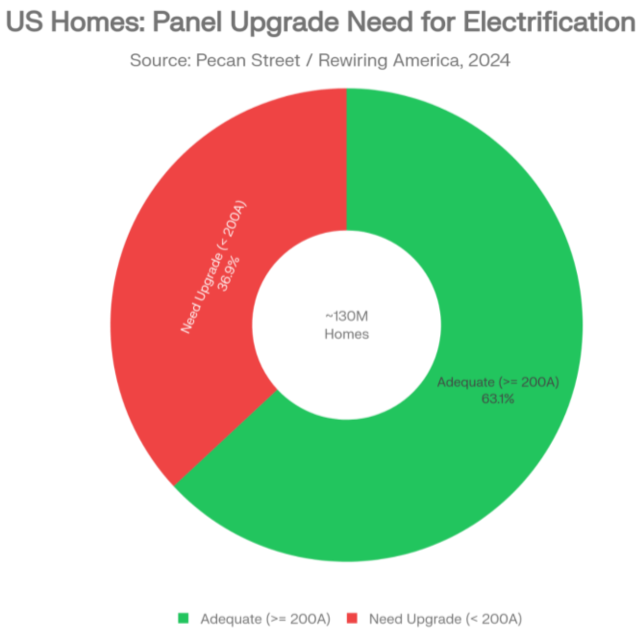
In the U.S., residential electricity usage is changing structurally. Electricity was named as the primary heating fuel source for 42% of all households in 2024, versus 35% in 2010; and natural gas fell from 49% to 47% during that same span. Of all new single-family homes started in 2024, about 54% will be heated using electricity as the primary heating fuel. Demand for household electricity will also continue to grow due to increased adoption of EVs, electric heat pumps, induction cooktops, and battery storage systems. In fact, home electric power demand is projected to grow by as much as 15% in 2025 alone. [3][4][5][6]
The dramatic growth in home electric demand has created a basic infrastructure issue at the individual home level. For the most part, U.S. homes built prior to the 2000s were built using a multi-fuel approach where natural gas was used for space heating, hot water heating and cooking. These homes' electrical panels were generally rated at either 100 or 150 amps and sized to accommodate the anticipated loads associated with the multi-fuel design.

Fully converting these homes to an electric-only environment, which would require installing a Level 2 EV charging station (40-50 amps), an electric heat pump (30-60 amps) and a heat pump water heater (15-30 amps), can exceed the panel's rated capacity [7][8].

An electrical service upgrade is the typical solution to this problem. This requires replacing the electrical panel, the meter base and potentially the electrical service drop and having the local utility company increase the amperage supplied to the residence. This is a costly and time consuming process for many homeowners, especially those of lower income. Therefore, this paper will assess the magnitude of the challenge presented by the need for an electrical service upgrade to accommodate growing household electrical load; evaluate smart panel and AI-based solutions to address this challenge; discuss how builders may take advantage of current electrical codes to avoid the need for future upgrades; and evaluate how changes in electrical codes will enable the avoidance of future upgrades.

2. THE SERVICE UPGRADE PROBLEM

2.1 Scale of the Challenge



The number of single-family home electrical panels with ratings lower than 200 amps in the United States is approximately 50 to 60 million. These make-up about 60 to 70 percent of the nation's entire housing stock. According to an analysis by Pecan Street, approximately 48 million of the aforementioned homes would require electrical panel upgrades in order for full electrification to be possible. Also contributing to this issue, Pecan Street estimates that more than half of the new homes constructed in 2020 had electrical panels that were unable to fully support electrification (i.e., 550,000 homes) and thus presented an unnecessary barrier to progress. [1][10]

2.2 Cost and Complexity

The financial burden of service upgrades varies widely depending on scope and location. Table 1.1 summarizes the typical cost ranges for residential electrical upgrades in 2024-2026.

Table 1.1: Residential Electrical Service Upgrade Cost Summary (2024-2026)

Upgrade Type	Cost Range (USD)	Typical Duration
100A to 200A panel swap	$1,300 to $3,000	4 to 8 hours[11][12]
200A panel + extra electrical work	$2,500 to $4,500+	8 to 10 hours[13]
Full 400A service upgrade	$8,000 to $12,000	Multiple days[13]
400A service in new construction	Up to $17,000 per home	Weeks (utility coordination)[3]
Utility service upgrade (underground)	$5,000 to $20,000+	Weeks to months[14]

Beyond the direct costs of upgrades, the process also includes other additional costs such as permits ($50-$300) in addition to possible waiting periods for utilities, and/or potentially transformer upgrades on the utility side. According to Rewiring America estimates that if every home in the United States required a $5000 service upgrade to be electric, total estimated costs would exceed $250 billion nationally.[14][15][9]

2.3 Who Is Impacted

The service upgrade barrier affects multiple stakeholders:

- **Homeowners** face upfront costs of $1,300 to $17,000+ depending on the scope, plus weeks of scheduling delays. Low-to-moderate-income households are disproportionately affected, as they are less able to absorb sudden capital expenditures.[9][1]
- **Utilities** must process upgrade requests, install new transformers where needed, and manage the cumulative grid impact of thousands of homes drawing more power simultaneously.[14]
- **Home builders** must decide whether to spec 200A or 400A service for new construction, a choice that can add $12,000 to $17,000 per home in development costs for the higher option.[3][16]
- **Electricians** and **contractors** face lengthening backlogs and complex coordination between homeowner, utility, and inspectors.[9]
- **Policymakers** must balance electrification mandates with the practical reality that tens of millions of homes cannot electrify without infrastructure investments.[17]

3. THE SHIFT TOWARD ALL-ELECTRIC HOMES

3.1 Demand Drivers

The trends driving demand for home electrification are coming together at an unprecedented rate in the United States. According to data from the U.S. Energy Information Administration (EIA), electricity is now the major source of heat for 42 percent of the country's houses, with that number on the rise. Moreover, the vast majority of U.S. homes (approximately 68%) currently use electricity for cooking. In addition, growth in EV sales will continue to increase, and each additional EV sold will add 40-50 amps to the household electrical panel. [7][4][18]

3.2 Existing Homes vs. New Construction

Older homes represent the biggest hurdles when it comes to converting to full home electricity. Since many older homes were constructed before 1980, they had electrical systems installed according to outdated electrical codes and wiring standards which were never intended to support the power requirements associated with today’s modern appliances. Typically, to convert one of these older homes to full electric requires a complete replacement of the electrical panel along with a rewiring of the house and possibly upgrading the grounding system and coordinating with your local electric provider, all of which could potentially run you over $5,000. [12][9][19]

Newly constructed homes present entirely different issues. Since approximately 2015, new single-family homes have typically come equipped with 200A electrical service. Even so, a 200A electrical service may still prove insufficient for a completely electrified home with two EVs, a heat pump, and electric cooking. As reported by builders, increasing the electrical service to 400A for a completely electrified home can add $12,000 or more to the cost of building one home. As noted by Richard Korthauer, senior vice president of Home and Distribution at Schneider Electric, "that could add 'up to $17,000 in developer costs per home'." If you are building hundreds of homes, those costs quickly become unaffordable and will slow the adoption process. [3][12]

4. SERVICE UPGRADE AVOIDANCE STRATEGIES

4.1 Understanding Peak vs. Average Load

The key to developing strategies to minimize the costs of upgrading your electrical services is recognizing the great disparity between peak and average household electrical loads. Rewiring America's analysis with SPAN data show that peak household electrical loads are generally 10 to 20 times greater than the average electrical loads during a given period of time. Data collected by Rewiring America from thousands of households with SPAN devices showed that the household electrical loads seldom combine in a manner that pushes demand above 80 amps, and such peak conditions usually last no longer than 12 minutes. The home energy analytics company, Sense, reported that a household would only need to manage its EV charger to remain within 100A service limits less than 1% of the time. [14][10]

As such, the typical method of sizing electrical equipment based on the maximum possible combination of loads, where every device operates simultaneously, grossly overestimates the actual required electrical capacity.

4.2 Smart Electrical Panels

Smart electrical panels are the most developed solution to avoid the need for a utility service upgrade. Smart electrical panels allow circuit level monitoring and control, with software based load management, unlike traditional electromechanical breaker panels that have been virtually unaltered for nearly a hundred years.

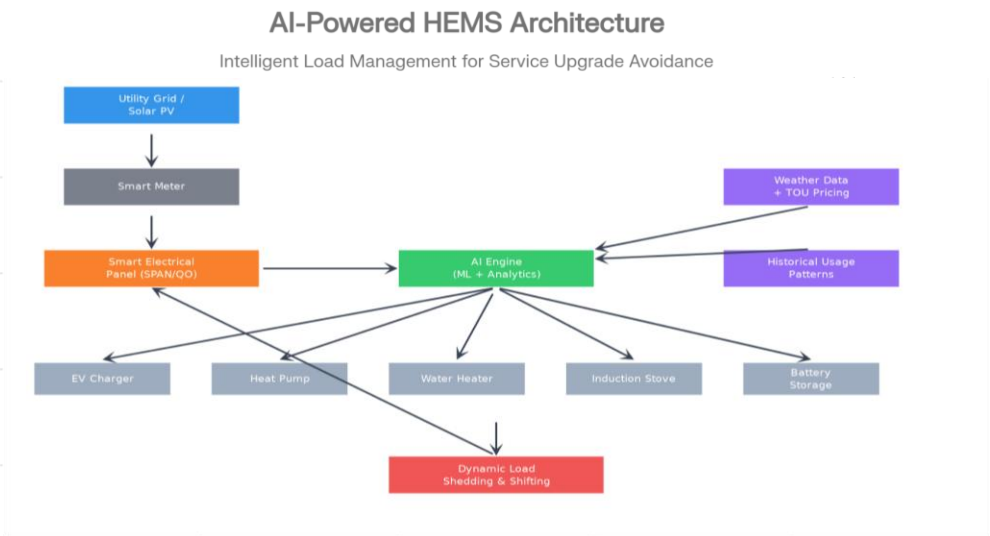
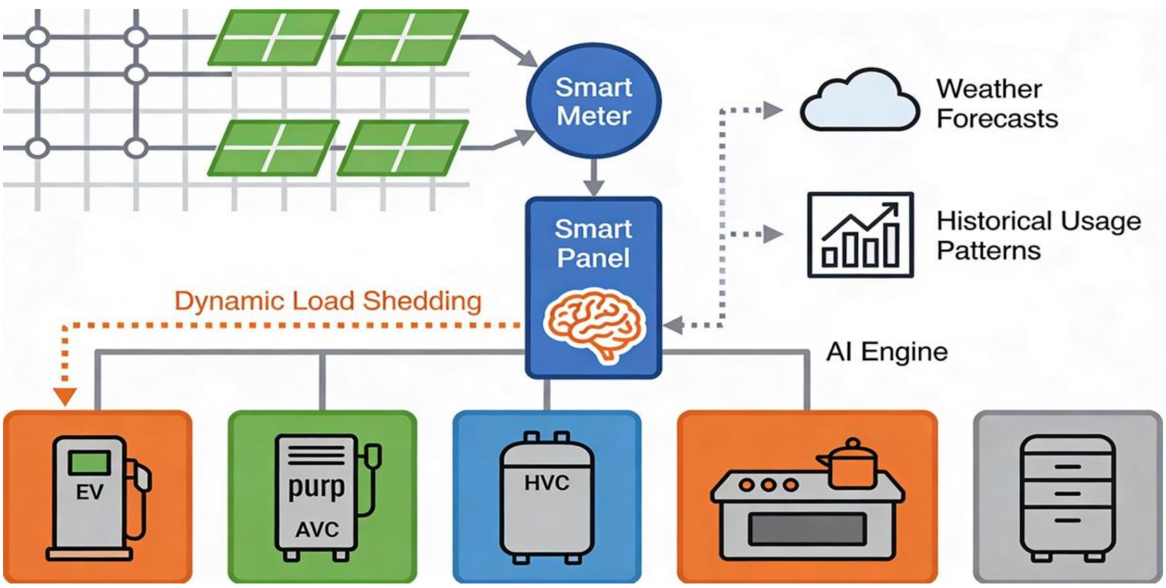


Table 1.2: Leading Smart Panel Solutions for Residential Service Upgrade Avoidance

Product	Manufacturer	Key Feature	Approx. Cost
SPAN Panel	SPAN	PowerUp dynamic load control, 32-circuit management	$3,500 to $5,500[14][20]
Square D QO Smart Panel	Schneider Electric	Smart Power Manager load shedding	$2,000 to $4,000[3]
Smart Circuit Breakers	Eaton	Retrofit smart breakers for existing panels	~$1000[21]
Lumin Smart Panel	Lumin	Retrofit load management for any panel	~$3,000[8]
Savant Power	Savant Systems	Utility-grade load control, FPL pilot	~$900

The PowerUp technology from SPAN will enable homeowners to add new major appliances, such as Level 2 EV chargers, heat pumps, and water heaters, and still maintain their current connection to the electrical grid through a utility service upgrade. When the homeowner is using all of the available power on the panel and total demand approaches the panel's maximum capacity, the system will either turn off or throttle non-critical loads (for example; an EV charger or water heater) for a short time.[14][22][23] Schneider Electric's Smart Power Manager, announced in January of 2025 at the International Builders' Show, has similar software-based load shedding capabilities for its Square D QO panel platform. Users will be able to choose which loads to shed first using the Schneider Home App, or allow the system to automatically determine which loads to shed and how much to reduce overages.[3]

4.3 AI-Powered Home Energy Management



AI-Powered Home Energy Management: Smart Panels Evolved With Artificial Intelligence (AI), smart panels are evolving beyond the simplicity of a "rule-based" load-shedding strategy to one of adaptive and predictive energy management. AI-powered Home Energy Management Systems (HEMS) utilize machine learning to take into consideration all relevant factors when making decisions as to when and how to allocate power across household loads; such as historical energy usage patterns, forecasted weather conditions, Time-of-Use (TOU) electricity prices, and current data from sensors.

Key AI capabilities in residential energy management include:

- **Predictive load scheduling**: Using machine learning to anticipate energy needs based on forecasted weather conditions and/or past solar production, to optimize when and how energy-intensive tasks such as electric vehicle charging occur, during times of maximum solar output and/or low-cost/off-peak electricity rates.[25]
- **Self-learning optimization**: Identifying patterns in appliance usage through machine learning, and adjusting schedules to take advantage of lower-cost/cleaner energy opportunities. Deep learning will allow for understanding of interactions between appliances and identify inefficiencies in near-real time.[25]
- **Non-intrusive load monitoring (NILM)**: Utilizing artificial intelligence driven appliance identification to provide real-time breakdowns of energy usage by appliance, identifying anomalies related to malfunctioning equipment, and providing customized energy-saving recommendations based on actual energy usage.[26]
- **Demand response integration**: AAI systems will facilitate coordination between the homeowner and their utility's demand response program(s); automatically decreasing energy consumption during peak grid events while maintaining household comfort.[27][24]

The Schneider Electric Wiser Home AI system represents a prime example of this approach; utilizing proprietary algorithms to continuously optimize EV charging, water heating, and eventually HVAC loads using data collected both locally and in the cloud. The system also coordinates EV charging with solar production and/or off-peak hours, without user intervention.[25]

In a recent survey conducted by Schneider Electric, it was reported that 43% of homeowners see smart home technology as an easy method to decrease their own energy usage; indicating a strong and ready-to-be-tapped market for AI-based energy management solutions. [25]

4.4 NEC 2026 Code Changes

The 2026 edition of the National Electrical Code introduces several provisions that directly support service upgrade avoidance:

- **Reduced general lighting load**: the dwelling unit lighting load is now based on a rate of 2 volts amps per square foot instead of 3, a reduction of 33%. This will result in lower load values which could result in smaller service requirements[28]
- **Lower base kVA threshold**: the first-tier load under the optional method is now based on a rate of 8 kVA at 100% instead of 10 kVA. This places more of the load into the second tier where the demand factor is 40% [28]
- **Formal recognition of Power Control Systems (PCS)**: as part of Chapter 1 of the 2026 National Electrical Code, the inclusion of PCS and Energy Management Systems, enables the use of smart panel capabilities by design professionals to officially justify the use of smaller service sizes when using these systems to manage loads [29] [28]
- **Improved existing dwelling calculations**: new demand factors were established for loads added to an existing electrical service; 80% for new Electric Vehicle Supply Equipment (EVSE), 50% for all other new loads. These new demand factors make it easier to add electric appliances to a dwelling without requiring a full service upgrade [28]
- **EVSE at 100%**: previously, EVSE was calculated at 125%; now they are calculated at 100%, and nameplate rated loads less than 7200 watts are now acceptable [28]

These changes to the National Electrical Code create a regulatory framework consistent with the technical fact that intelligent load management allows for safe levels of total connected loads within the capacity of the current electrical service.

4.5 Additional Strategies

Smart panel and AI technology are not the only ways to ensure that you do not have to upgrade your electrical services.

- **Energy efficiency improvements**: Improving energy efficiency through replacing old appliances with new, highly efficient appliances will allow you to release panel capacity by improving your overall energy efficiency. For example, if your house has an old electric furnace that is 20 years old and it uses 50 amps of power, when you replace it with a new heat pump that uses 10 amps of power, this will free up 40 amps of panel capacity. [8]
- **Load calculation reassessment**: n 2017, The National Electric Code (NEC), section 220.87 was changed to 120.87 in the 2026 version of the code. This change now allows electricians to calculate the amount of amperage that an appliance or group of appliances will require based upon twelve months of past usage instead of a calculated estimate of what they should be using based upon their name plate rating. As a result of this change, many people find out that there is significantly more available capacity than previously thought. [30][8]
- **Circuit sharing devices**: Using devices to share circuits: Companies such as NeoCharge and SimpleSwitch offer products that prevent two major loads (for example, an EV charger and a clothes dryer) from operating at the same time and using the same circuit. [14]
- **Low-power appliances**: Using low power appliances will also reduce the total amount of power being drawn from the electrical system. For example, heat pump water heaters which draw 15 amps of power instead of 30 amps and 120-volt EV chargers for charging vehicles while plugged into a standard outlet during overnight hours. [31]

5. THE BUILDER'S PERSPECTIVE

5.1 Cost Pressures in New Construction

Large residential developers have significant economic consequences to consider when selecting whether to utilize a 200A or a 400A electrical service for their developments. The cost of upgrading to 400A electrical service can range from $8,000 to $17,000 per home, depending upon the type of home. Therefore, if a developer were to construct a 200-home development, they would incur an estimated $1.6 million to $3.4 million in added costs (as a result of utilizing a 400A service) that could either be absorbed by the developer or added to the price of each home.

Currently, high building costs and increased mortgage interest rates are limiting the affordability of housing for many people; therefore, any additional costs associated with necessary infrastructure costs will further reduce builder competitiveness.[13][15][3]

Utilities have also reported that there are delays in coordinating 400A services, and they often request additional transformer upgrades, and/or additional fees. As a result, these added costs create additional delays for builders to complete their projects.[15]

5.2 Smart Panels as a Builder Strategy

Smart panels are being offered by Schneider Electric and SPAN as a direct solution for builders. By using smart panels with load management at 200A service, builders can provide homes that can accommodate electric vehicles, heat pumps, and all-electric cooking without having to spend thousands of dollars to upgrade to a 400A service.[15][3]

Schneider Electric's solution for smart panels is modular; smart controls can be installed on individual circuits as needed, and the system can work with main and sub-panels. This provides builders with the flexibility to design and offer homes that are ready to support electrification at a small percentage of the cost to upgrade a 400A electrical service.[3]

6. CONCLUSION

Electrifying U.S. homes is both a necessity for addressing the climate crisis and a significant infrastructure challenge. There could be as many as 48 million homes with current electric panels, which will need to be upgraded to accommodate future electric loads; and, even when constructing new buildings there is a risk that the amount of electrical service capacity installed will exceed what is needed for use. Together, smart electrical panels, artificial intelligence (AI) powered energy management systems, and revised National Electrical Code (NEC) sections create a viable solution to prevent unnecessary and expensive service upgrades while creating a pathway for full home electrification. The data collected by Rewiring America and SPAN indicates that intelligent load management can allow electrified homes to operate within their existing service limits under nearly all operating conditions. Therefore, investing in smart infrastructure at the panel level for builders, contractors, utilities and policymakers would be a far more cost effective approach than upgrading millions of service connections. Once the NEC 2026 formally includes power control systems in load calculations, the regulatory and technical foundation for avoiding millions of service upgrades exists.

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