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Low power electrification solutions enable affordable residential electrification by minimizing panel upsizing

Advances in Solutions to Address Electrical Panel Constraints

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BACKGROUND / INDUSTRY IMPACT

- Panel and service upsizing are a costly and time-consuming barrier to home electrification.
- Making home electrification projects more affordable and reducing the future costs of grid infrastructure will allow more low- and moderate-income households to decarbonize.
- Outcomes will help avoid unnecessary panel upsizing in tens of millions of homes, reduce grid infrastructure upgrade needs, and accelerate decarbonization of the US economy.

OBJECTIVES

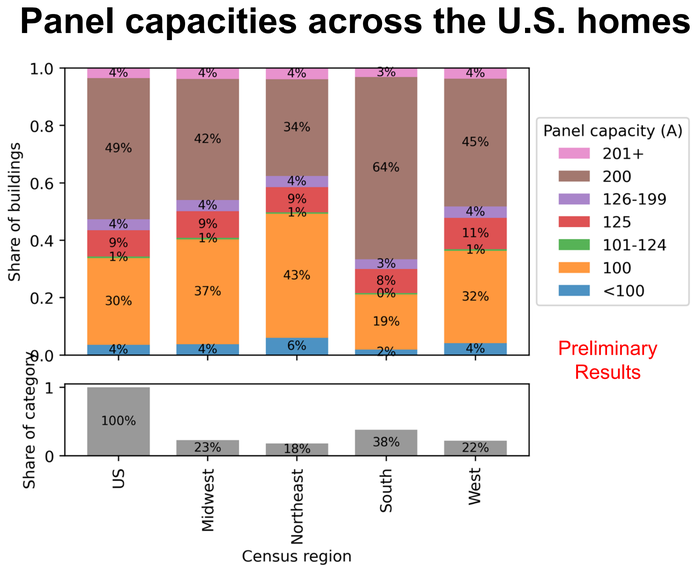
- Overcome low power electrification adoption barriers, including unfamiliarity, performance skepticism, and limitations of existing codes and standards.
- Improve modeling capability to address panel constraints and support low power electrification.

APPROACH

- Identify least-life-cycle-cost strategies to fully electrify the U.S. housing stock accounting for panel constraints, low-power solutions, upgrade costs, and proposed revisions to the National Electrical Code (NEC).
- Overcome current market barriers through field and laboratory demonstrations and development of industry standards for low power electrification solutions.
- Drive market transformation by including low power electrification solutions in modeling tools for industry adoption and in codes and standards.

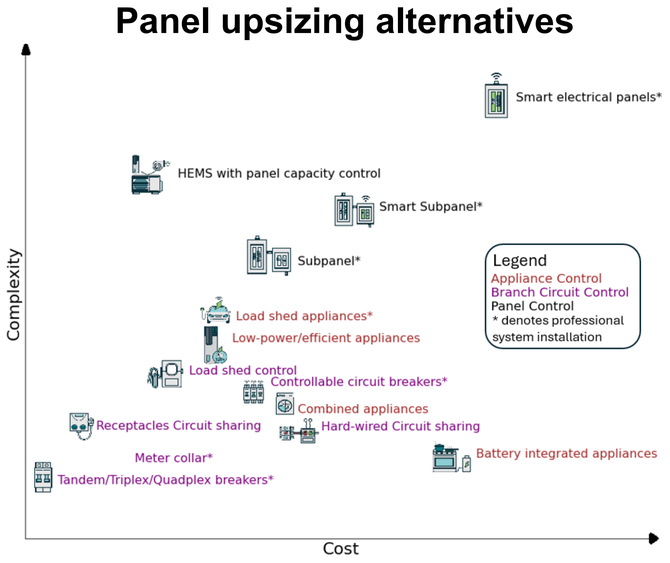
Research Outcomes

Panel capacities across the U.S. homes



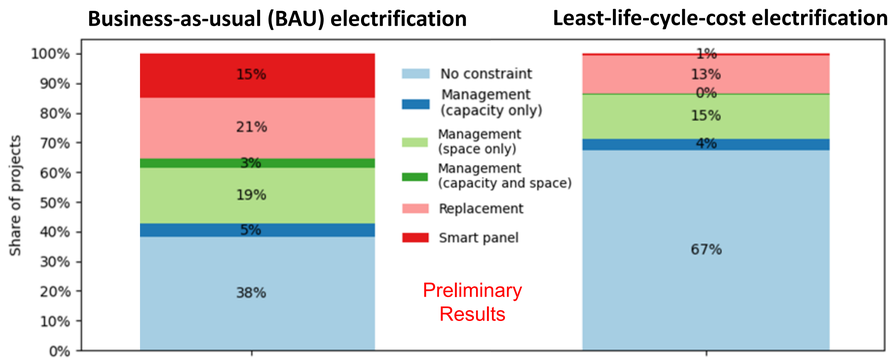
- Nationwide, 30% of single-family homes have 100A panels and 49% have 200A panels.
- Panel capacity varies with building vintage, floor area, type, state, and area median income.

Panel upsizing alternatives



- Existing solutions, with a wide range of cost and complexity, can be categorized into three levels: appliances, receptacle & branch circuit, and panel.
- Many solutions require professional installation and commission, whereas others can be DIY installed.

Techno-economic Analysis



- Under BAU electrification, 62% of homes face panel constraints. Capacity and/or space management can allow nearly half of those homes to keep their existing panels as least-cost solutions.
- With envelope upgrades and lower-power/higher efficiency equipment, 87% of homes can keep their existing panels as least-cost solutions.

Market Transformation

Changes Proposed for the 2026 NEC:

- Led the POWER NEC subgroup that submitted 17 public inputs and 7 public comments to the 2026 NEC revision process. Participated as a voting member of Task Group 4 of Code-Making Panel 2 in 1st and 2nd drafts.
- Outcomes (accepted as first revisions):
  - Reduce the demand factor of heat pumps from 100% to 50% for existing dwellings. Adjust the demand factor of EVSE and resistance heating to 80% (120.83).
  - Reduce the lighting and receptacle loads from 3 W/ft^2 to 2 W/ft^2 (120.82, 120.83, 120.84).
  - Appropriate treatment of power control system and noncoincident load controllers that address common use cases in dwellings (120.6 and 120.7). Include calculation examples in Appendix D.

Public-facing Training Materials:

- Case studies of low-power electrification from 12 existing dwellings
- Guide for stakeholders: NEC Load Calculation Guide | Low-power Solution Guide | Low-power Design Flow Chart

FUTURE WORK (FY25)

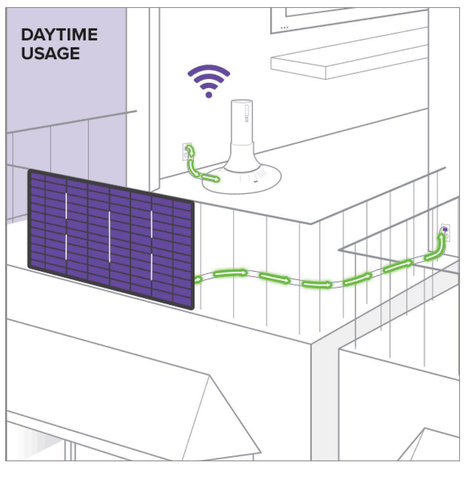
Low Power Electrification

Technologies to enable electrification without increasing peak demand will be investigated, including low power appliances, power sharing, load flexibility and DC microgrids. Power control strategies and wider use of DC power in homes will also be investigated.

Low Power Panel Emulator

This test rig allows evaluation of power sharing technologies, such as smart panels, subpanels, smart breakers, and responsive end-use devices.

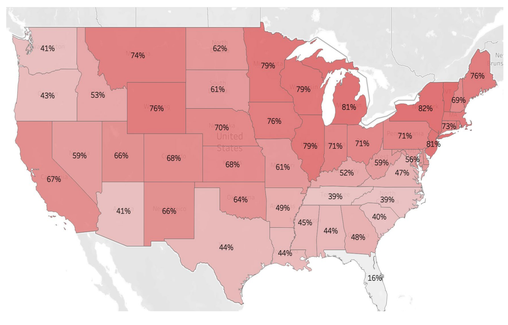
Direct Injection of Balcony PV



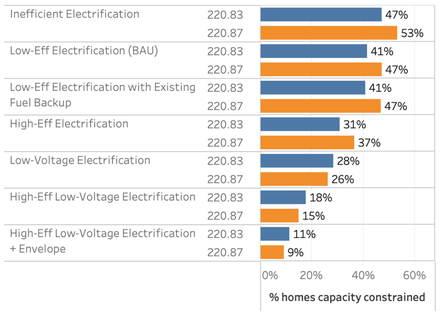
Many European apartments have small PVs attached to their balconies with power injected into the home's electrical circuit and a battery for modest storage. This system will be suitable for US homes after safety and compatibility issues are resolved.

ResStock Integration

Integrate developed capabilities into ResStock to evaluate panel upgrade requirement for electrification measures and make results publicly available through regular standard dataset releases



Share of homes facing capacity or space constraint under BAU electrification



Example of panel constraint outcome by upgrade measure

- Help utilities, communities, and other decision-makers enable affordable home electrification without straining the electric grid.
- Enable analysis of low power electrification by clarifying panel constraints and upgrade requirements and equitably delivering benefits to low-income and disadvantaged communities.

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