Whole-Home Electrification Project

Palo Alto, CA

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About Me

- Silicon Valley systems/software/hardware developer, semi-retired
- Highly technical and hands-on, still writing code
- Home automation enthusiast
- Technology policy interests: energy, electrification, grid modernization

Motivations

- Always wanted rooftop solar — grid-tied seemed incomplete, BESSes and EVs started getting good
- Gen-Z daughter very concerned about sustainability — urged us to "do better"
- Appointed to Utilities Advisory Commission, learned that natural gas is **bad**
- As a strong advocate for electrification, I believe in **practicing what I encourage others to do**

Starting Condition

- Purchased in 2015
- Needed a new roof
- Aging HVAC and water heater
- Kitchen appliances: functional but dated
- Electric service: **200A**, main and sub panels
- Second floor uncomfortably hot in summer, A/C ineffective
- Three ICE vehicles

Goals

- **Replace all gas appliances** with electric, disconnect from gas utility
- **Support EV charging** (potentially 2 EVs)
- **Resilience during grid outages**: rooftop solar (NOT grid-tied) + battery backup
- We plan to live here "forever" — quality of life and future-proofing outweighed budget concerns
- **Demonstrate** how a fully electrified home can actively participate in a dynamic, flexible grid
- Create a **real-world example** of smart load management, storage, and automation
- Become a working **laboratory** for energy and power management based on dynamic price, grid conditions, and household needs

Design Process

- Installed networked multi-circuit electric meter to **measure existing use**
- NEC load calculations are insanely conservative — a major obstacle to electrification
- Concluded whole-home backup better/more future-proof than partial-home
- Configurable & automated load-shedding during outages highly desirable
- Roughly **2+ years** of research and planning

Design Decisions

Component	Choice
Roof	Standing-seam metal, replacing aging Hardie-shake
Insulation	2.5" solid foam under roof + new attic insulation
HP Water Heater	Rheem 50 gal, 240 VAC, 30A
HP HVAC	Lennox variable-speed, multi-zoned
Solar PV	LG 400W panels, Enphase microinverters, rail-less mount
Battery	Tesla Powerwall 2 (three units)
Cooktop	50A induction hob
Panels	Two SPAN smart panels in series
EV + EVSE	Tesla Model Y + Wall Connector (Level 2, 60A)

Before & After: Service Entrance

Photos to be added — see image TODO list

SPAN Smart Electric Panels

- Home automation and energy management systems
- Real-time power monitoring of each circuit
- Controllable relay on each circuit
- Configurable automated load-shedding during outages

Photos to be added — see image TODO list

Before & After: HVAC and Water Heater

Before

- Aging gas furnace and gas water heater

After

- Rheem heat pump water heater (50 gal, 240V)
- Lennox variable-speed heat pump HVAC, multi-zoned
- All on separate 240 VAC high-amp circuits

Photos to be added — see image TODO list

New Roof and PV Panels

- Standing-seam metal roof with S-5! PVKIT rail-less mount
- LG 400W panels with Enphase microinverters
- Conduit from rooftops to service entrance routed through former furnace/WH flue

Photos to be added — see image TODO list

Induction Cooktop

- Induction cooktop in same location as gas
- Moderate kitchen remodel: new countertop, backsplash, new appliances, kept existing cabinets
- Moved ventilation hood into ceiling — no gas fumes to exhaust!

Photos to be added — see image TODO list

Disconnecting from Gas

Photos to be added — see image TODO list

Data: Monthly Grid Consumption

Pre-electrification: ~2000 kWh/month

Post-electrification: ~2500 kWh/month

But grid consumption actually **decreased** — from ~2500 to ~2000 kWh from grid.

The difference: **~750 kWh/month of PV generation**

Chart to be added — see image TODO list

Data: Monthly Total Consumption (Grid + PV)

Total consumption: ~2750 kWh/month

- Using ~250 kWh **more** electricity than pre-electrification
- But ~500 kWh **less** from the grid
- PV generation makes up the difference: ~750 kWh

Chart to be added — see image TODO list

Data: Instantaneous Grid Consumption

- Large baseline load of **~3 kW** with occasional large spikes/peaks
- (Mini "data center" in the basement!)
- Peaks of **15-20 kW** for a few hours — EV charging + cooking or dryer

Chart to be added — see image TODO list

Data: PV Generation 2024

- **8.2 MWh** total for 2024
- Monthly range: 0.2 MWh (winter) to 1.2 MWh (summer)
- Best day (~June 13): **6.2 kW** peak, **41.7 kWh** total

Charts to be added — see image TODO list

Conclusions from the Data

- On average, using **250 kWh more** electricity per month than pre-electrification
- But using **500 kWh less** from the grid
- PV generation makes up the difference: **750 kWh**
- **200A service is more than sufficient** — even without active load management
- Additional electricity cost without PV is immaterial
- With PV: completely electrified **and** lowered the electricity bill
- Gained **resilience** to grid outages

Life After Electrification

System	Experience
Insulation	Massive improvement — second floor never more than a couple degrees warmer. Added ~20% to roofing cost, money very well spent
Hot Water	Zero change, no problems. HP-WH always uses heat pump, never resistive coils
HVAC	Vastly improved A/C. Multi-zone variable speed = better comfort. Space heating: does the job. Very efficient and quiet
Induction Cooktop	Just as good, if not better. Electronic temp control arguably more precise
EV	Best vehicle I've ever owned. Level 2 home charging vastly superior to gas stations

> ***No compromises, sacrifices, or negative lifestyle impacts.*** *Electrified life outperforms in every way — plus it's cleaner, safer, and guilt-free.*

Service Feed Size

- Based on experience and data, **200A is more than enough** for nearly all homes
- 400A service seems unnecessary — NEC load calcs are insanely conservative
- What about homes with **100A service**?
  - EMS/PCS technology (UL 916 smart panels) can intelligently manage total load
  - Most 100A homes can electrify **without a costly service upgrade**
  - Smart panel investment pays for itself through avoided upgrade costs

> *Existing service feed size is NOT an obstacle to electrifying most homes.*

Grid Impacts of Electrification

- Data suggests grid impact projections may be more conservative than necessary
- Current adoption rates for HP-WH and HP-HVAC have modest grid impact
- No need to hold back motivated customers while waiting for grid upgrades

The opportunity:

- Support customer adoption while upgrading the grid **in parallel**
- Crawl, walk, run — start now and scale gradually
- Rethink grid management: balance responsible management with ongoing electrification

Smarter Grid Management with Smart Controls

Historically, grids were designed to handle worst-case peak load with no active demand management.

Today: EMS/PCS technology in smart panels offers real-time, per-customer load management.

Key question:

How does the cost of installing EMS/PCS panels at every home compare to grid modernization?

Example: 15K homes x $1K = $15 million

With granular control, the distribution network no longer needs to be oversized for unconstrained demand. Demand can be optimized in real time — **deferring or avoiding costly infrastructure upgrades**.

Where the Puck Is Going

- **Hourly dynamic pricing** via open protocols like OpenADR 3.1
- **Bi-directional pricing** — addressing NEM concerns, incentivizing storage
- **V2X-enabled EVs** — household backup power and flexible grid resource
- **Fixed connection charges** based on service feed size: $(100A) < $(200A) << $(400A)
- **All high-load appliances** will be network-connected and demand-flexible (CEC FDAS)
- **Home automation** going mainstream via Matter — active energy optimization

"Nobody Else Can Afford This!"

I respectfully disagree. Many people can do most of this, **over time**, with planning:

Component	When
HP Water Heater	When your WH needs replacing (10-12 years)
HP HVAC	When your HVAC needs replacing (15-20 years)
Induction Cooktop	Kitchen update
EV	Plan for your next vehicle to be electric
Battery	Wait for V2X-EVSE + EV — no need for dedicated BESS
Smart Panel	At 100A service: cheaper than a service upgrade
Solar PV	Totally optional — your choice

Electrification is a journey, not a single project.

Surviving a Grid Outage (Electrified)

Need	With Battery Backup	Without
Fridge, lights, Internet	Easy	Same as anyone
Hot water	HP-WH very efficient on battery	50+ gal tank lasts a while
Cooking	Possible but big drain — use outdoor BBQ	Gas cooktops can be manually lit
HVAC	Possible but significant drain	Gas furnace needs electricity too
EV charging	Would drain all capacity — keep EV charged!	N/A
Laundry	Defer until power restored	Same

> *Keep your EV charged. Most gas appliances need electricity too. Battery backup covers essentials.*

Final Thoughts

- Practicing what we preach: fully electrified, lower bills, better comfort, grid resilient
- 200A service is sufficient — smart panels make even 100A work
- Grid impacts are manageable — start electrifying now, upgrade grid in parallel
- Dynamic pricing + smart controls = the future of grid management
- **No compromises.** Electrified life is simply better.