Trials and Tribulations of Home Electrification

January 5th - 12:00pm - 1:00pm

Profiles in Electrification
The Realities of De-Carb Efforts: Challenges & Opportunities

Outline:
1. Profile of home
2. Background of De-Carb efforts
3. Future plans
4. Challenges
5. Recommended strategies

Format:
- 3 Speakers, 15 min/each
- 15 min Q&A
1. 1980’s 1470 sq ft, single story w/ attic and crawl space.
2. 100 Amp panel and underground service.
3. Electric range, 40 Amp w/ 50 Amp circuit breaker (CB).
4. Electric dryer (electric resistance), <17 Amp, 30 Amp CB.
5. Level 2 EV charger, 32 Amp, 40 Amp CB:
   • This is the big hit, but a flexible load.
   • On/off Control by Sonoma Clean Power (SCP).
Heat Pump Water Heater

- Rheem, 15 Amp, 80 gallon.
- BTU/H: 4200 (HP) + 7670 electric resistance.
- “Middle” Amp (lower 120V model not available).
- Resistance backup good for a larger family.
- Large storage for flexible off peak “charging.”
- Cost $6K (simple install) somewhat driven by a small number of utility rebate approved contractors. Rebates and tax credits $2K, net $4K (~2x cost of replacement gas heater).
- SCP wants to control, but wants to overheat water (to 160 F) and mix (I set to 120F).
- WiFi controller/monitor very disappointing.
- Noise not an issue.
- Standby losses greater than hoped.
Future Plans:

1. Replace gas furnace with heat pump:
   - Mini split: 2 ton with 3 zones ($13.5K - $2.9K rebates).
   - Ducted split: $15K + $8K for duct replacement (?).
   - Sanden 15 KBTU/H (+ $8.5K +).
   - + Double attic insulation and seal house ($4.8K - $1.2K)

2. Replace electric dryer with HP (free up Amps):
   - Note HP and condensing dryers are not the same.

3. EV controller (variable charging based on total house draw - see subsequent slide).

4. Smart House controls to optimize scheduling and flexibility as well as grid response.
Granular Data vs. Hourly Data

1-Minute Data Provides Acute Insight to Electricity Use

1-minute data shows the actual capacity use of the heat pump that wouldn't have been exposed with the 15- or 60-minute data

Source: Evergreen Economics
Add Circuit Level Metering

<table>
<thead>
<tr>
<th>Load</th>
<th>Energy %</th>
<th>Peak 15 min Watts</th>
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<tbody>
<tr>
<td>EV Charger</td>
<td>14</td>
<td>7210</td>
</tr>
<tr>
<td>Dryer</td>
<td>13</td>
<td>5330</td>
</tr>
<tr>
<td>Range</td>
<td>10</td>
<td>2670</td>
</tr>
<tr>
<td>Coffee pot and dishwasher</td>
<td>10</td>
<td>1310</td>
</tr>
<tr>
<td>General lights &amp; outlets incl. furnace &amp; exhaust fans</td>
<td>36</td>
<td>1216</td>
</tr>
<tr>
<td>Other kitchen outlets</td>
<td>3</td>
<td>728</td>
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<tr>
<td>Bath outlets</td>
<td>&lt;1</td>
<td>489</td>
</tr>
<tr>
<td>Fridge and hood</td>
<td>9</td>
<td>406</td>
</tr>
<tr>
<td>Heat pump water heater</td>
<td>9</td>
<td>406</td>
</tr>
<tr>
<td>Washer</td>
<td>1</td>
<td>257</td>
</tr>
<tr>
<td>Whole House</td>
<td>105</td>
<td>8100 (~34 A)</td>
</tr>
</tbody>
</table>
Challenges:

1. Hard to get bids.
2. High cost and slow transactions inhibit mass deployment.
3. To achieve scale, must overcome above, provide additional value, and maintain level of service/utility.
4. 100-Amp panel limitations (?):
   - $4,425 bid to replace panel, much more to replace underground service.
   - But closer scrutiny of actual hourly load showed we never went over 10 kW in 2021.
Recommended Strategies:

1. Use heat pumps for dryer, space, and water heating. If resistance used, more sophisticated controls required to avoid upgrade of 100-Amp service.

2. Level 2+ EV charging is the big hit when electric capacity constrained, but charging can be variable and schedule can be flexible (along with water heating and perhaps other appliances).

3. Study actual peak loads, not circuit breaker sizes, but need to address code compliance issues.

4. Don’t forget efficiency - our water heater losses > use.

5. Need a path to scale (sexy smart devices/controls key - the next Nest).
Alan Meier  
(April 2020 - Dec 2021)

The house  
➔ 3000 ft², (built ~1925 in stages), 4 levels including a studio apartment  
➔ lots of knob and tube wiring  
➔ Panel was a dangerous Federal Pacific (100 amps)  
➔ 4 gas furnaces, 2 gas stoves, gas DHW, gas dryer

RETROFIT SEQUENCE WAS CRUCIAL

Prius died … → EV acquisition … → panel upgrade (200 amps)  
and EV level 2 charger … → 3 of 4 gas furnaces died … gas water heater died and immediately replaced with same → …

... → upgraded all wiring, some lighting → dead gas dryer replaced by electric → …

... → asbestos removal … → 4 dead furnaces replaced with 1 large HP with 3 heads & 1 mini-split … → PV (7.6 kW) + 16 kWh battery installed … → chimney removed … → wall & attic insulation

Still to do:  
• Induction stoves (2)  
• HP water heater  
• HP clothes dryer  
• Washlets (2)
HVAC

Direct unit in remote bedroom & wall insulation holes

3 thermostats (proprietary) operate independently

One of 2 air handlers

Not shown: 3 new windows

Our “grand canyon” of insulation in attic

Main outside unit -- 36 kBtu/hr -- with ADU mini-split in background

Mini-split for ADU
Many, many contractors to coordinate!

1. Berkeley Electric (EV charger, panel, wiring) $$$
2. Ally Solar $$
3. Aarvaks HVAC $$$$  
4. McHale’s insulation $$
5. Synergy Enterprises (asbestos removal) $$
6. International Masonry Specialists (chimney removal/stabilization) $$
7. Galvin appliances (electric clothes dryer)  
8. Roemer Painter/Plasterer $$$

Meet the General Contractor: my wife (Harvard-trained)
Chris Stratton
Wen Lee
House basics

Built 1963
1400 square feet
3bed/2bath
5000 square foot lot
Suburban SoCal location
(walk score: 56)
After
Insulation + Air Sealing
Insulation + Air Sealing
Ventilation
Electrification
Wall Assembly

Before
- 2x4s 16” on center
- stucco
- 0.5” plaster, 0.5” drywall
- uninsulated cavities

~R-4

After
- 0.5” air gap for drying
- 3” polyisocyanurate foam
- 0.5” structural plywood
- 1” polyisocyanurate foam
- 1.5” service cavity (2x3s spaced 24” on center)
- 0.5” drywall

~R-27
Vaulted Ceiling Assembly

Before (vented attic) ~R-12

- 2x6 rafters, 24" on center
- ~5” of blown fiberglass on attic floor

After ~R-45

- 2” roof deck vent (eave and ridge vents)
- 3” polyisocyanurate foam
- 5.5” fiberglass batt
- sistered 2x12 rafters
- 1” polyisocyanurate foam
- 1.5” service cavity
- 0.5” salvaged T&G flooring
- ~5” of blown fiberglass on attic floor
Envelope Leakage

BEFORE:
18.3 ACH$_{50}$

AFTER:
3.5 ACH$_{50}$
## Pre vs. Post Retrofit

<table>
<thead>
<tr>
<th></th>
<th>Natural Gas</th>
<th>Electricity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consumption</td>
<td>Net Consumption</td>
<td>Consumption</td>
</tr>
<tr>
<td><strong>PRE RETROFIT</strong></td>
<td>Jan 2014 – Dec 2014</td>
<td>7,032 kWh</td>
<td>4,007 kWh</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>$176</td>
<td>$970</td>
</tr>
<tr>
<td><strong>POST RETROFIT</strong></td>
<td>Sep 2019 – Aug 2020</td>
<td>-</td>
<td>1,142 kWh</td>
</tr>
</tbody>
</table>

Note: Cost calculations done using 2020 energy prices
Renovation Costs

Total cost: $114,925

Labor costs mitigated by ~4,800 hours of “sweat equity” labor by building owner
Lessons learned/barriers to replication

Initial cost -
- deep retrofits are a bad financial investment right now
- per LBNL work, lighter retrofits (+PV?) a better investment

No guarantee that home value will increase (it did in our case)
- Home sold in June 2020 (hard to parse hot market v. upgrade premium)

Difficult to find contractors who were competent/knowledgeable (Hence DIY)

Fossil gas is still way too cheap (we desperately need a price on carbon)

Location is more important than efficiency
- we need density/walkability and MORE HOUSING (we’re moving!)
Chris Stratton
Wen Lee
frugalhappy.org
Speaker Contacts + Web Link

1. Dale Sartor - dasartor@lbl.gov

2. Alan Meier - akmeier@lbl.gov

3. Chris Stratton - christratton@gmail.com

Weblink

https://homes.lbl.gov/decarbonizing-homes