

**Hydronic Heat Pumps:
Data, Costs, and Lessons
from Closter**

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NJ Sierra Club

Building Electrification Network



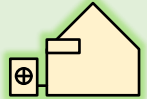
Topics for this talk



Electrifying New Jersey homes with radiators



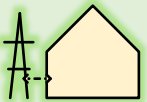
My home weatherization project



My hybrid heat pump retrofit



Intelligent automation and load shifting

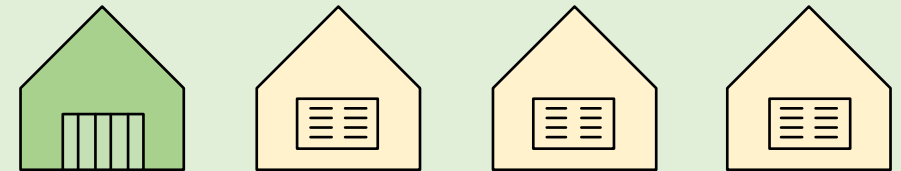
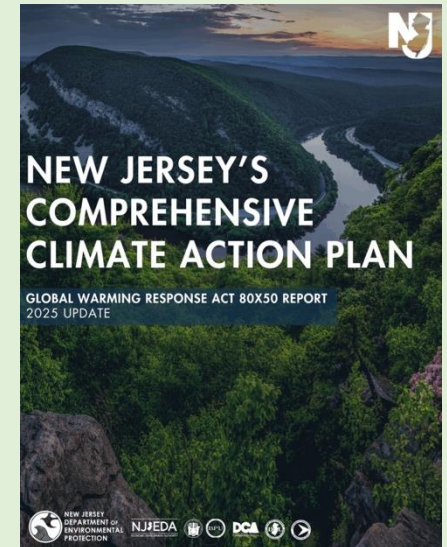
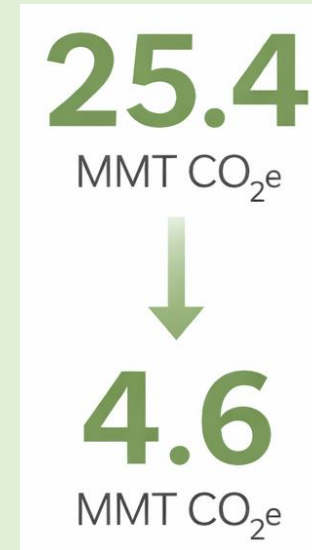


How flexible electric homes can help the grid



Why buildings matter in New Jersey

- Buildings are about **25%** of NJ emissions
- 2022: NJ buildings emitted **25.4 MMT CO₂e**
- 2050: NJ CCAP target **4.6 MMT CO₂e**
- About 1 in 4 NJ homes, or **850,000**, use steam or hot-water boiler heat
- **Hydronic retrofit is a significant part of the electrification challenge**



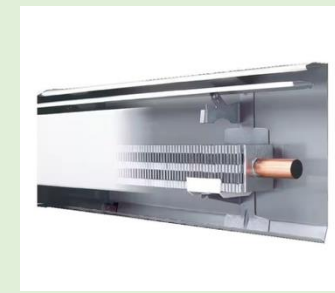
About my home

Overview

- Closter, Bergen County, NJ
- Constructed 1950s, expanded 1990s, occupied by us in 2010s
- 5BR/3.5bath/3300 sq ft
- PSE&G (gas) and ORU (electricity)

Equipment

- Gas boiler feeding 6 hydronic zones; indirect storage tank; cast-iron and slant-fin radiators
- 5-ton central ducted AC
- EV charging but no solar due to shading



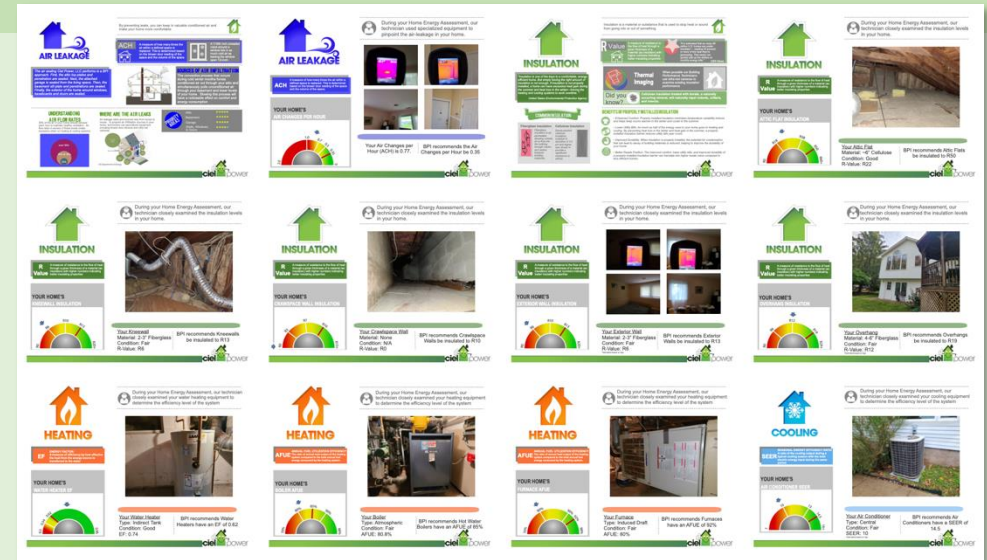
Stage 1: Weatherization

Home energy efficiency audit (2021)

- Ciel Power, LLC
- Comprehensive inspection of sealing, insulation, HVAC
- Projected energy savings 32%

Weatherization project (2023)

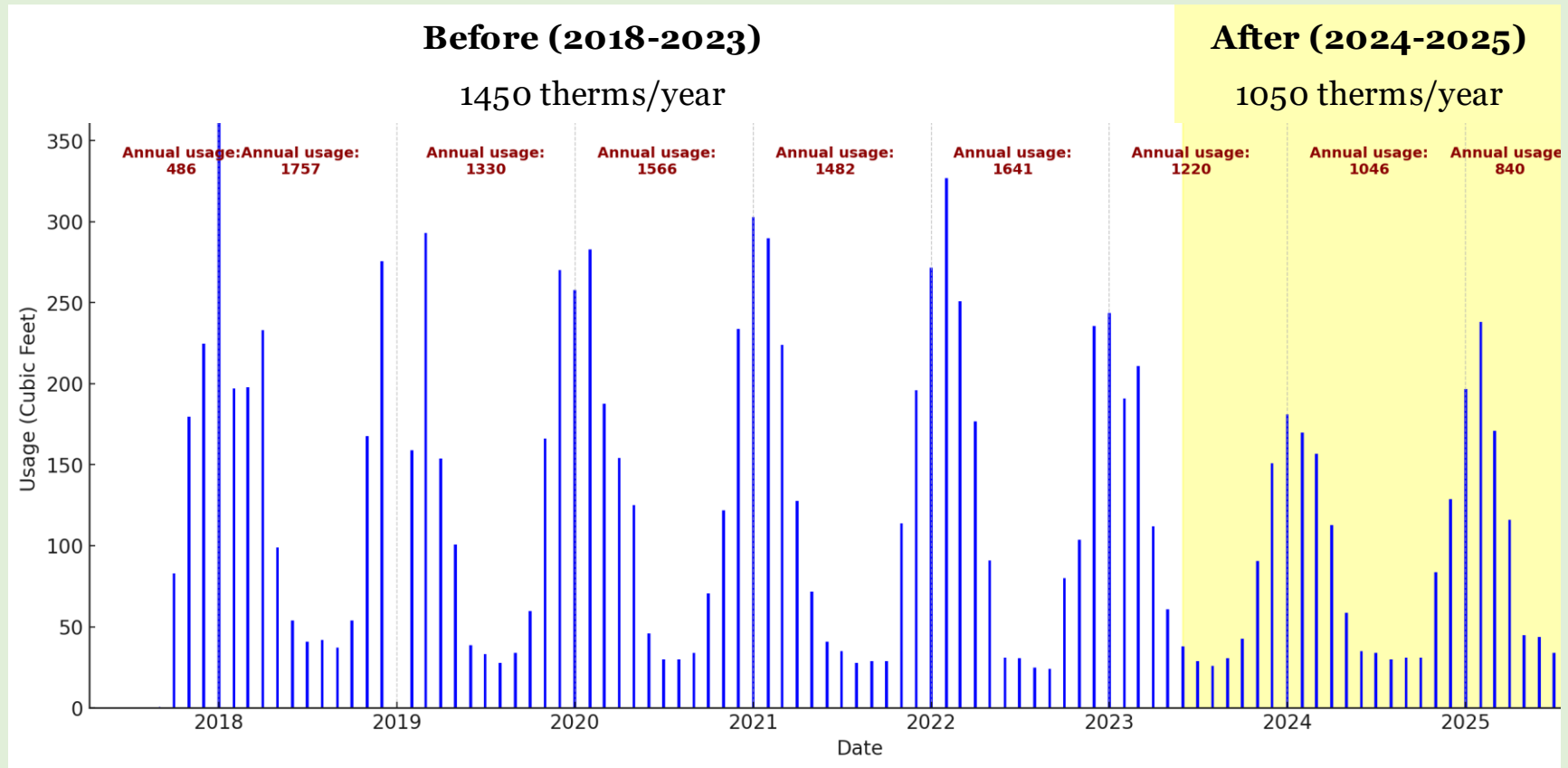
- Insulation in attic, siding, crawl space, flooring; door sealing
- Pearl Score of 745 (“Silver”)
- Cost \$19k - \$5k HPWES incentive
- 0% / 10yr financing; \$114 monthly charge on gas bills



MEASURE	BEFORE	AFTER	COST
Attic insulation 1,257 sq ft	R-13.6	R-60	\$7,500
Wall insulation 1,387 sq ft, 2x4 frame	R-0 - R-2	R-13	\$4,500
Crawl space Converted to conditioned	Unconditioned	R-13 walls	\$3,500
Air sealing 20% leakage reduction	5,940 CFM50	4,752 CFM50	\$3,000
Floor insulation	R-0	R-35	\$500
Total			~\$19,000

Stage 1: Weatherization

Weatherization alone reduced gas usage by 28% / 2.1 metric tons CO₂



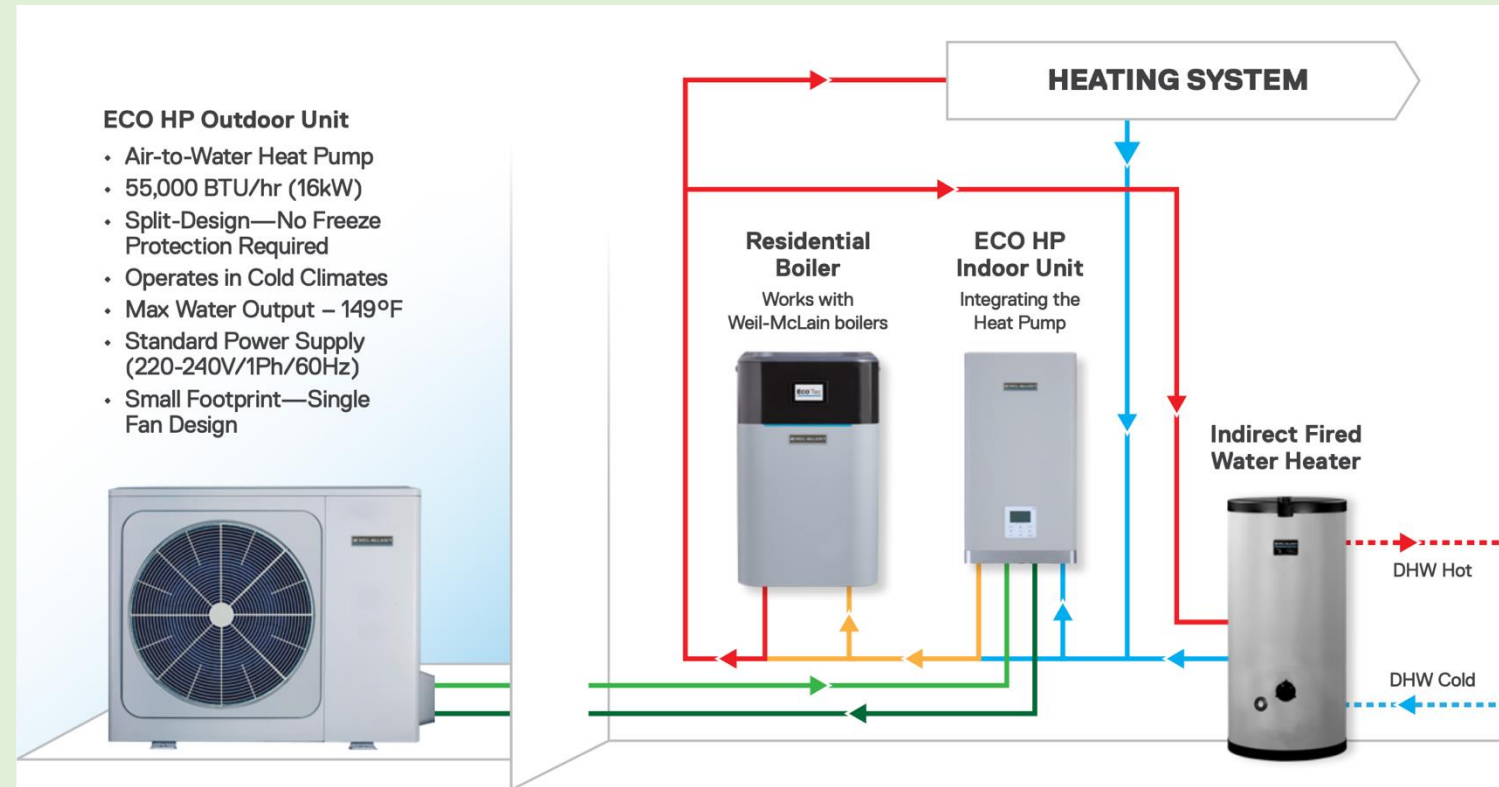
Stage 2: Hydronic heat pump

Air-to-Water HP advantages

- Reuse existing radiators/pipes, no ducting install required
- Keep existing gas boiler for hybrid / dual-fuel operation
- Quiet, no forced air, provides domestic hot water (DHW)

Project scope

- Reuse radiators/pipes, indirect water tank; replace all pumps, valves, manifolds, zone controllers
- Replace 1994 boiler with similar 133K BTU unit (84% efficient, same chimney vent, not modulating-condensing)
- Install Weil-McLain Eco-Hybrid heat pump (55K BTU)



Stage 2: Hydronic heat pump

Performance projections

- Manual-J report using CoolCalc.com
- Load curve/bin analysis from Weil EcoCalc
- HP/boiler switchover temperature has a strong effect on cost / carbon tradeoff

ORU Custom Decarbonization Rebate

- Rebate of \$300 per MMBtu gas displaced, capped at 70% of HP cost
- \$21k net (boiler \$18k, HP \$10k, rebate \$7k)

Special thanks! 🙌

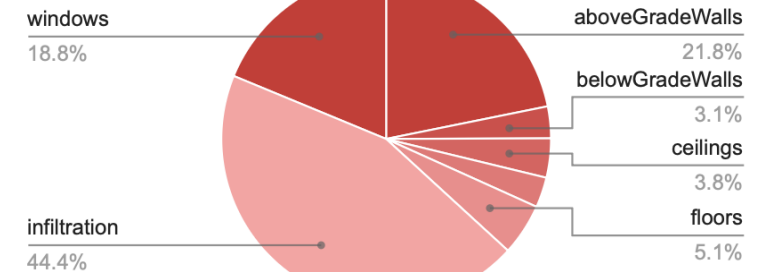
- Res. Air Systems: Steve Hernandez
- Weil McLain: Konrad Witek, Bill Edelman
- ORU/RECO: Kyle Haddock, Cristina Mariscal

Weil-McLain Eco-Calc projections

Switchover	Op. cost impact	NG reduced	Carbon reduced
43°F	-5% (~\$180 saved)	~70 MMBtu	~38%
34°F	Neutral	~110 MMBtu	~60%
28°F	+8% (~\$300 more)	~130 MMBtu	~72%



Heating Loads



LOAD CALCULATION TOTALS

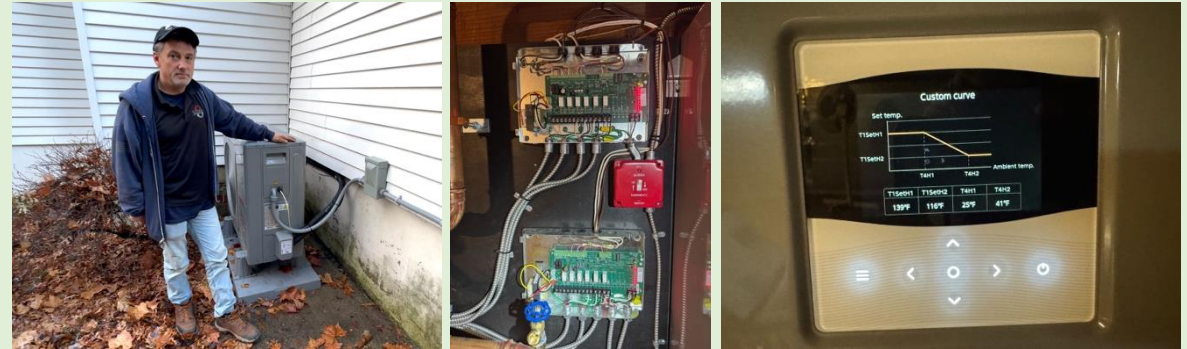
HVAC System: Hydronic Heat

Heated square footage:	3,610	Heating BTUH:	60,500
Cooled square footage:	0	Cooling BTUH:	0
Heated volume (above grade CF):	29,568	CFM:	1,000
Cooled volume (above grade CF):	0	Sensible cooling:	0
Exposed wall area (SF):	2,802	Latent cooling:	0
		SHR:	

Stage 2: Hydronic heat pump

Installer search

- First NJ installation of a Weil-McLain heat pump
- Five HVAC installers declined; only Residential Air Systems (Cedar Grove) accepted the challenge
- Many preinstall discussions with Weil-McLain engineering



Installation process

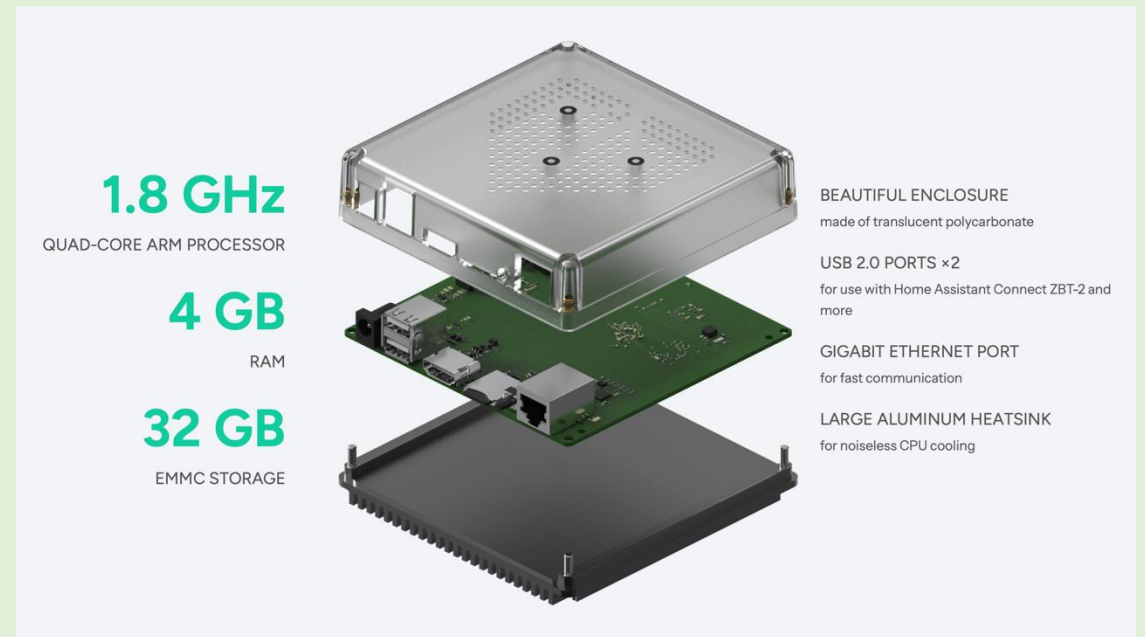
- Replacement of boiler only
- Panel prefab and mounting offsite
- Panel, HP indoor unit install
- Outdoor unit install and electric runs
- Software configuration



Stage 3: Intelligent controls

Home Assistant Green

- \$150 home automation computer
- Open-source, global community; not locked to Google/Apple/Amazon policies
- Connect many devices and data sources
- Implement custom controls and dashboards
- Monitor energy consumption and costs
- Reveal hidden system behavior and data



Stage 3: Intelligent controls

Home Assistant capabilities

- Runs locally, only 3W consumption
- Connect industrial and consumer devices via Wifi/USB/Zigbee/Z-Wave/Thread
- Control using web browser and phone app
- Automate home based on schedule, sensors
- Monitor energy consumption and costs

Notes for hackers

- Gas meters broadcast wireless, unencrypted data
- MODBUS common and easy to implement
- No Bluetooth – ESP32 Wifi/BLE workaround
- PJM Dataminer 2 API = free 5min grid data
- Claude AI very helpful for coding and debugging

Electricity usage (kWh)

Wifi → Shelly clamp meter in breaker panel



Gas usage (CCF)

RTL-SDR radio → 900MHz → gas meter



Heat pump and boiler status

*USB → RS-485
MODBUS → Weil HP controller*



Zone valve status

*Wifi → ESP32 → BLE
→ Taco zone controller*



Room temps and setpoints

Internet → Google Cloud API → Nest thermostats



Grid CO₂ emissions

Internet → PJM DataMiner2



EV battery status

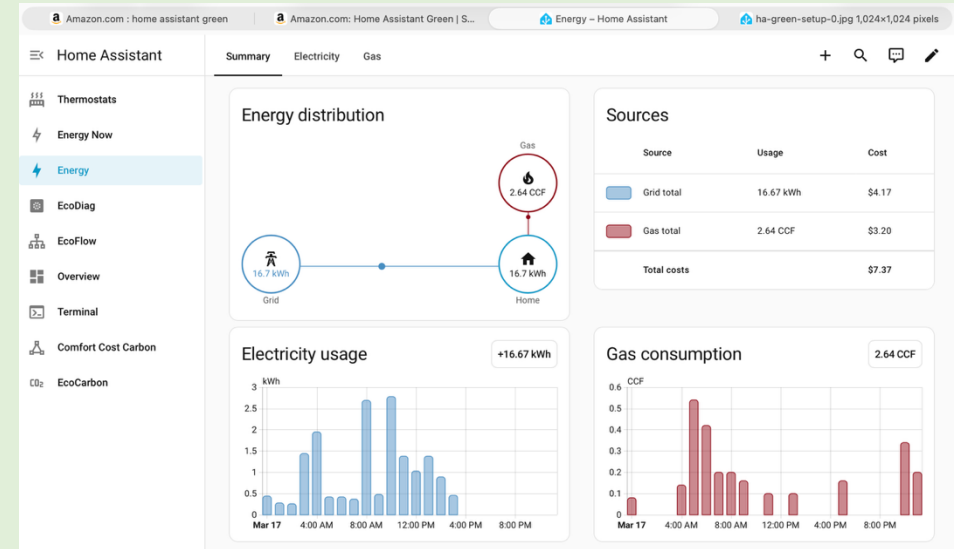
Internet → Cellular → Rivian



Stage 3: Intelligent controls

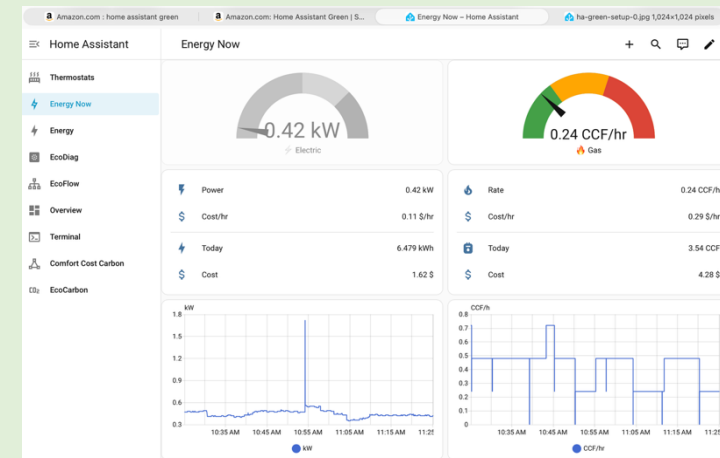
Stock dashboards

- Home Assistant's stock energy dashboard is already quite useful
- Consumption and cost over days, months, or years
- Electricity and gas both visible in one place



Custom dashboards

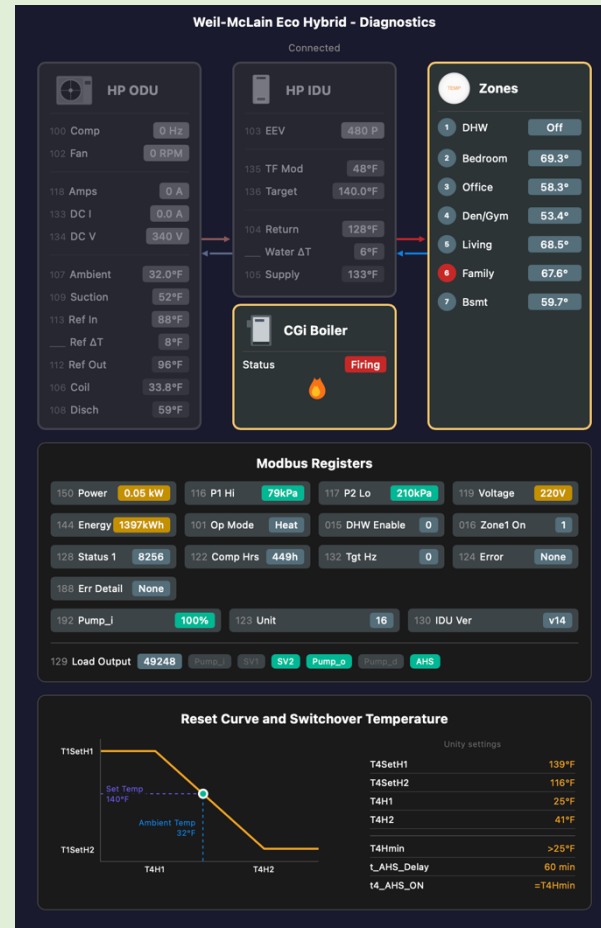
- My first custom dashboard focused on the past hour
- Indicates current heat pump and boiler activity
- That learning led to a more specialized dashboard next



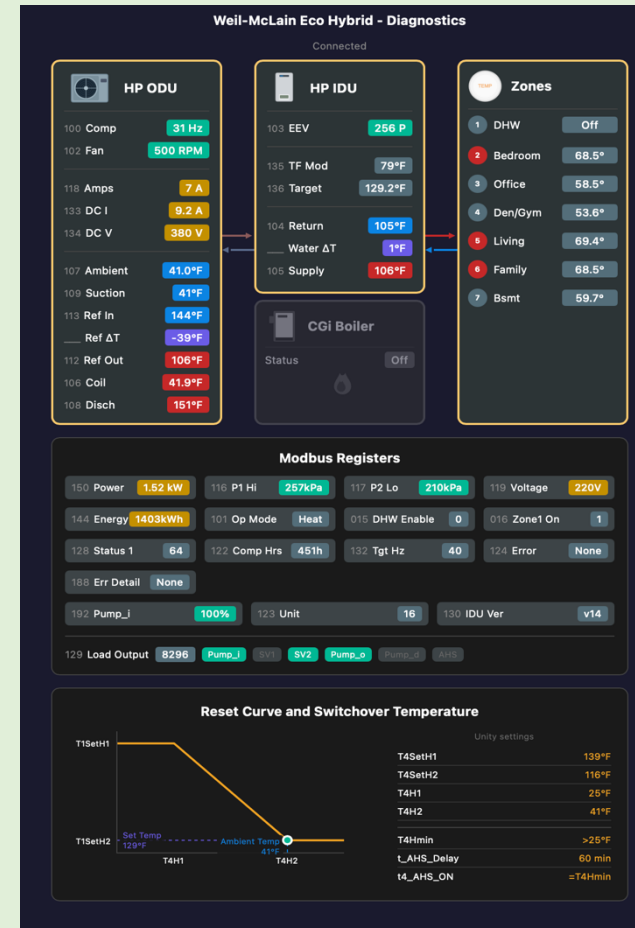
Stage 3: Intelligent controls

Custom Eco Hybrid Diagnostic dashboard

**Boiler mode
(gas)**
 Ambient 32°F
 Supply 133°F
 1 call for heat
 Boiler firing
 Compressor off



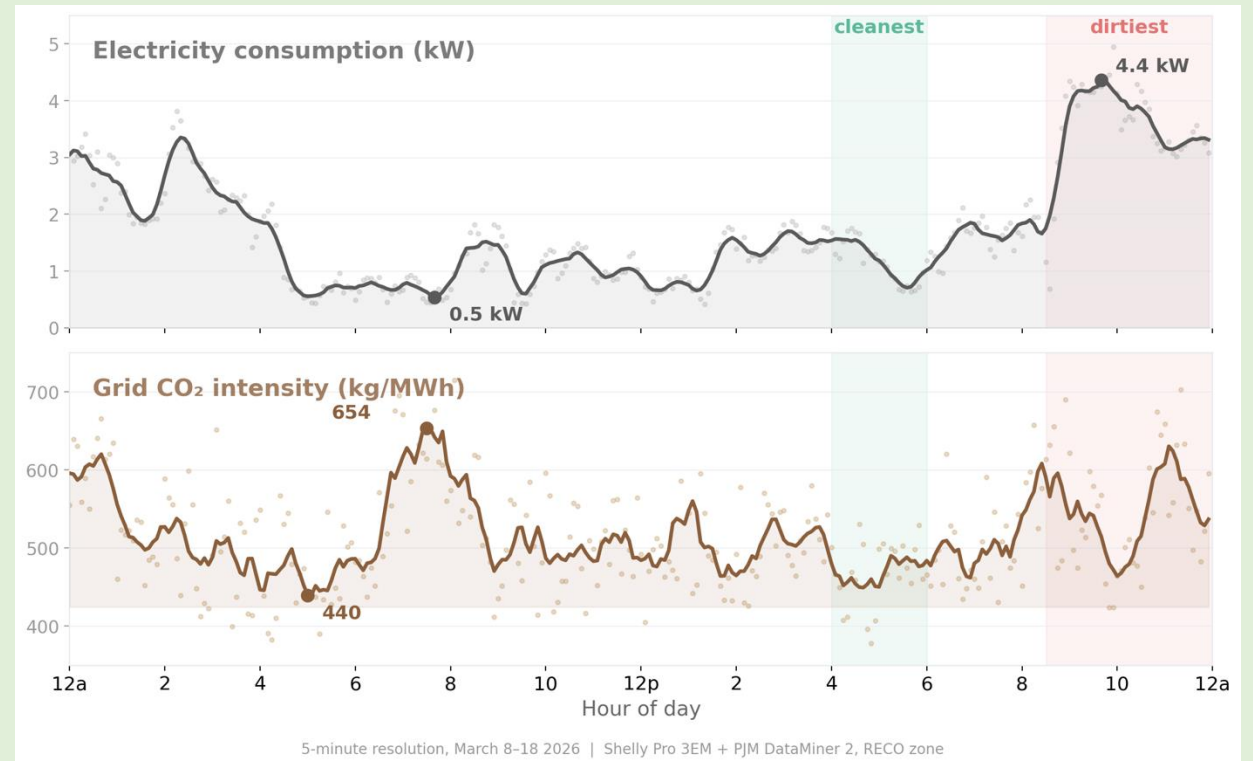
**Heat pump mode
(electric)**
 Ambient 41°F
 Supply 108°F
 3 calls for heat
 Boiler off
 Compressor 31 Hz



Stage 3: Intelligent controls

When is the grid cleanest?

- Grid carbon intensity varies by location, time of day, and season
- I expected cleanest hours to be overnight, when demand is lowest
- **Cleanest: 9 AM–4 PM** (solar hours)
- **Dirtiest: 10 PM–12 AM**
- **Off-peak ≠ low-carbon**
- Smart controls should follow **real-time, location-specific grid signals**



Stage 3: Intelligent controls

Your house is a thermal battery

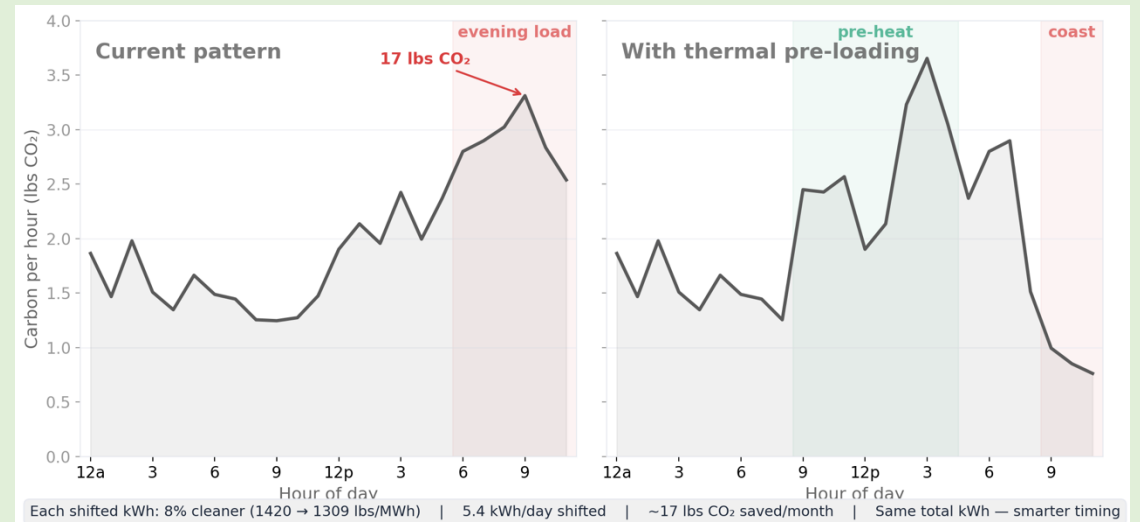
- VPPs are usually framed around **electrical loads** like batteries and EVs
- But homes can also shift **thermal loads**, especially heating
- Building mass, cast-iron radiators, and water tanks can store heat
- Shift without shopping!

Storage

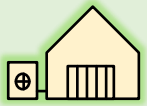
Thermal mass in home
40-gal hot water tank
EV charging
EV battery (V2H)
Tesla Powerwall

Shiftable energy

4 kWh/evening
2 kWh/day
15 kWh/day
50 kWh
13 kWh



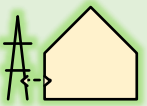
Lessons for decarbonizing NJ



Hydronic homes can electrify while keeping existing radiators and pipes



Smart controls and thermal pre-loading can reduce carbon, cost, and peak demand



Consumers, installers, and utilities must move faster to meet our stated goals



Mike Winka will now discuss the next step:
Virtual Power Plants

Contact me



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