

Alonetic Devices— The Means to Achieving Cost Effective Sustainability Using Flexible Loads

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Portland General Electric

822,000 customers, 52 cities served

Service territory population 1.6 million,
43% of state's population

4,000-square-mile service area

2,600 employees

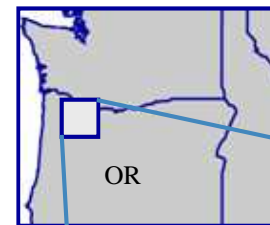
Summer peak load of 3,950 MW (2009)

Winter peak load of 4,073 MW (1998)

Number #1 in US by NREL in Renewable
energy sales and customers

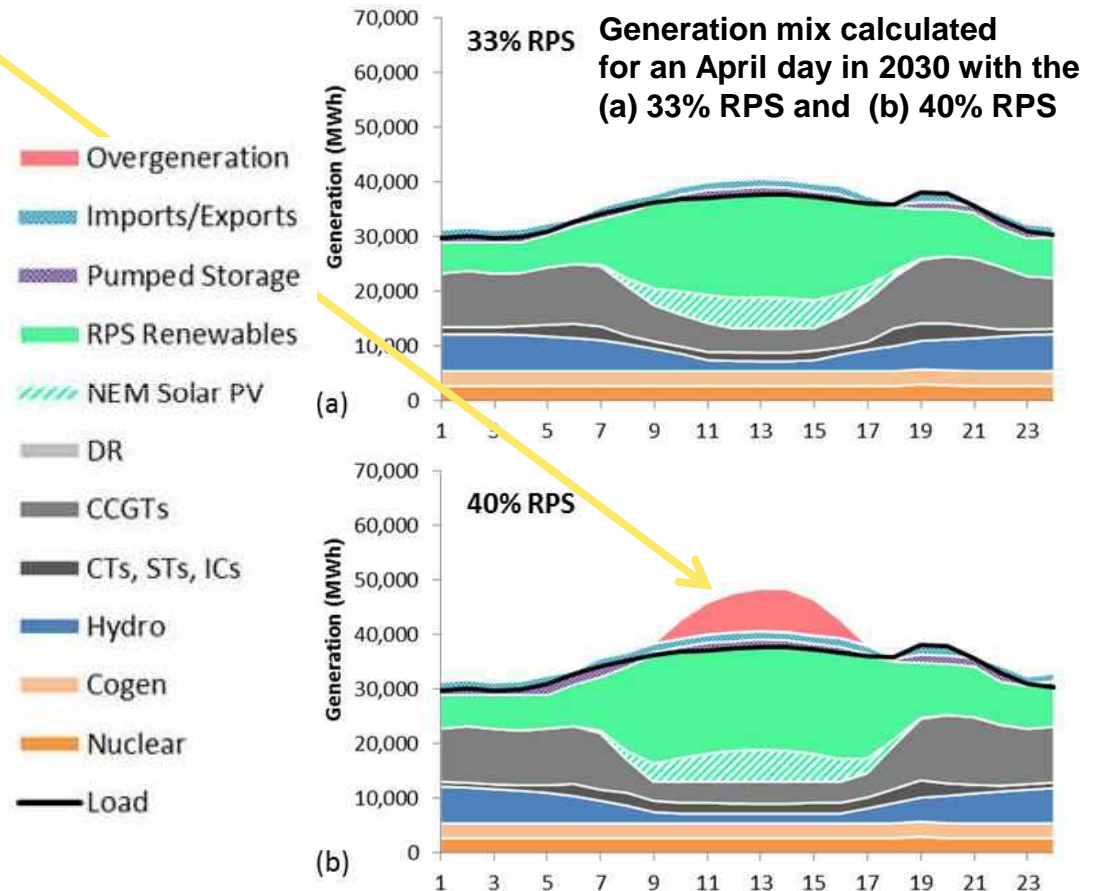
Largest Li-Ion battery-inverter system in
operation by a utility

First in industry effort to repower major coal
plant with 100% sustainable biomass



The Problem

- Solar generation with a capacity factor of 15% that peaks mid day
Note: PV Solar is only 46% of renewables energy in the figure (b)
- Wind 35% capacity factor but peaks at night
- Even when wind blows and suns shines, output variation significant compared to todays load/gen imbalance



Reference: *Investigating a Higher Renewables Portfolio Standard in California*, Energy and Environmental Economics, Inc., 101 Montgomery Street San Francisco, CA 94104. Jan 2014

The Solutions

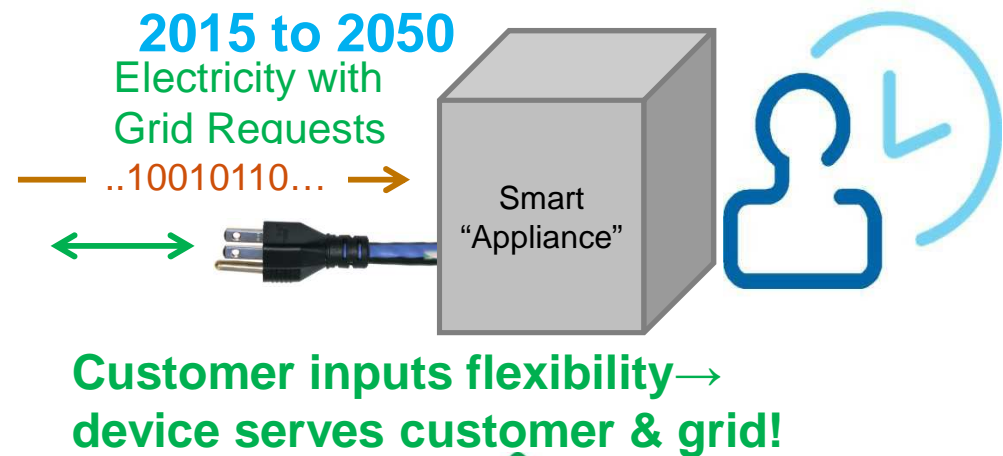
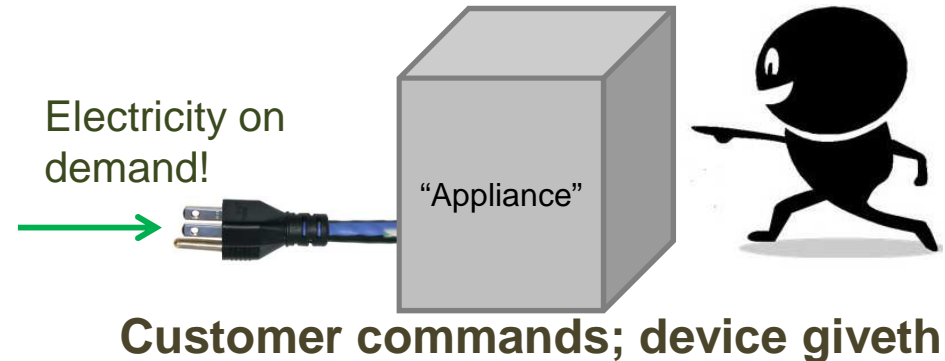
In order of cost effectiveness (low to high)

- Electric use shifted to periods of renewable generation production, when possible
- Thermal storage for space conditioning & water heating
- Electric storage
- Increased industrial manufacturing capacity that runs coincident with renewable production
- Synthetic oil and methane production from waste cellulose and 100% renewable electricity or bioengineered “bugs”

New Concept

- **For first 120 years**
 - Energy flows one way to customer
 - Customer loads and generation serve best interests of customer
- By 2008, renewables at scale everyone talks about storage
- By 2010, Idea: many loads can respond to price and control signals to help integrate renewable generation.
- **No word describes concept**

Then: 1890 to 2010



Word for an Emerging Concept

- In 2050 need most loads and distributed generation to be **alonetic**



- Word created in 2014
- Opposite of alonetic is **egonetic** which is the behavior of today's devices

Alonetic, adjective

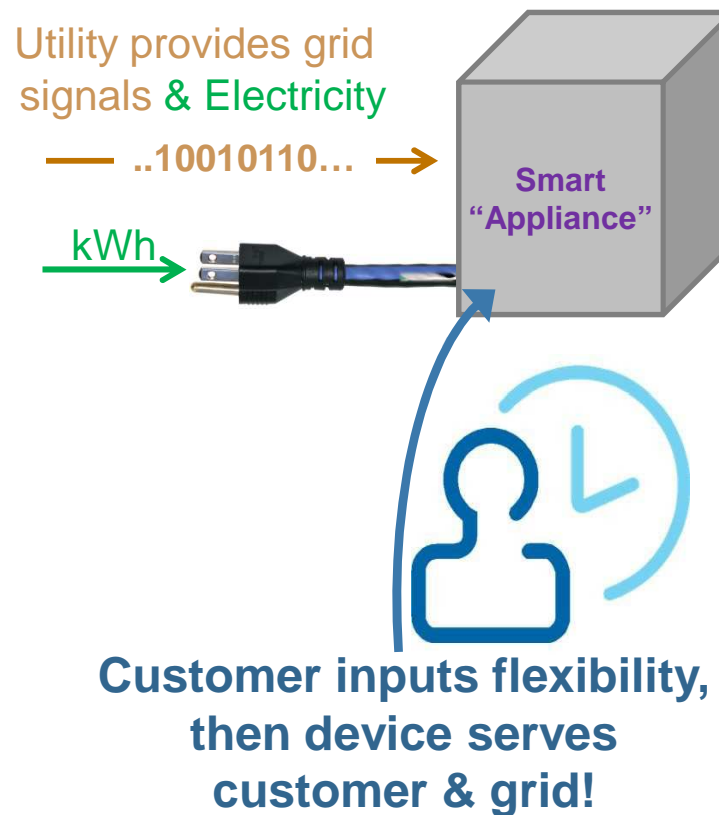
ăl • ō • nĕt' • ĭk

- **alo-** from Latin “to **support**”
- “**net**” as in the “electric grid **net**work”;
- **-ic** of, or **pertaining to**

Definition: The ability of an electric device to beneficially support operation of the electric grid

Why Alonetic Devices Create Win-Win

- In a nutshell: Customers benefit because they don't pay full cost of the new technology
- Utility provides “rebates” in return for control permitted by the customer
- Secret sauce in each **smart** device
 - Manufacturer provides simple way for **customer** to define **flexibility**
 - Device receives **utility signals via standard** communication
 - Control logic in device **maximizes grid benefit**, but ensures customer needs met



Early Targets for Alonetic Devices

Electric Device	Alonetic Design	Egonetic Design
PV System	Customer's Smart PV Inverter provides voltage support	Customer with Net Metering
Whole House Battery Backup	Battery serves: customer in outage, utility to reduce peak	Expensive asset used 0.02% of time
Water Pumping	Variable speed pumps vary output \propto renewable output	Tanks maintained between low/high set points
Com' HVAC: Fans/Chillers	Variable speed compressors/ fans vary output \propto renewable output	Temp maintained between low/high set points
PEVs	Charge rate \propto renewable output	Charge after evening commute
Heat Pumps	Variable speed compressors vary output \propto renewable output	Temp maintained between low/high set points
Com'l Refrigeration	Pre-cooling before peak causes reduced load during peak	Temp maintained between low/high set points
Water Heater	Always has hot water in top-third; bottom reheat to serve grid	Reheat after each cold water draw

Thermal Storage with Alonetic Control

- AO Smith Energy Smart[®] Water Heater
 - Power relay, electronic control, and communication interface
 - In EPRI managed pilot with twelve utilities, AO Smith provides a CEA-2045 interface
- **CEA-2045** Standard established Dec 2012
 - CEA-2045 is USB-like standard that allows a customer to connect a communication device
 - USNAP is to CEA-2045 as Wi-Fi is to IEEE 802.11
- **Potential by 2032, if on all water heaters today**
 - 90% of 3.5 million water heaters in Northwest would have the CEA-2045 interface;
 - 65% of the owners in alonetic program
 - → NW reduced peak demand by 1,600 MW
 - And more importantly, utilized 8,000 MWh of storage available daily to integrate renewable resources
 - Real-time control to follow renewable generation
 - US potential about ten times greater



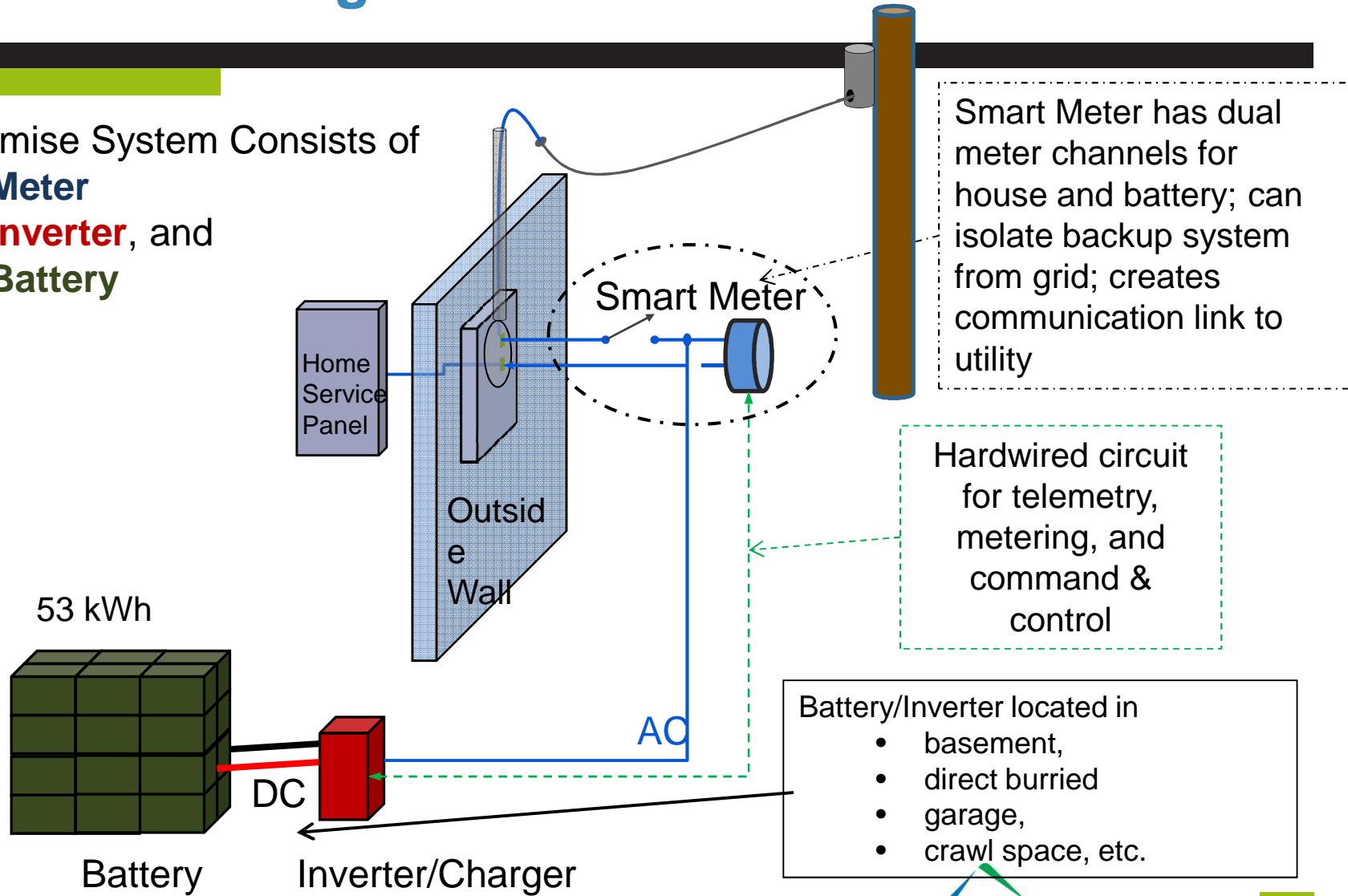
Battery-Powered Residential Microgrid

- PGE-directed research at Portland State University
- **Concept:** Utility-owned battery & inverter system connected at meter. 99.99% of time battery controlled by utility for multiple use cases. During outage, system serves to back-up customer's home or small business for up to two days; design allows recharge by hybrid electric vehicle to provide backup during extended outage periods. Customer pays small monthly fee for backup service. Fee covers small part of cost, but necessary to limit adoption to match resource needs.
5% of homes gives enough MW and MWh to serve all peak demand
- Key to concept is **new battery** made by Aquion Energy. Check it out! NaSO₄ used to create salt water electrolyte. Carbon and NaMnO electrodes. All materials low-cost and non-toxic. KEMA has tested battery to 5,000 cycles with no loss of capacity. Battery cells do not require management system; they need no regular maintenance.

One Line diagram

Premise System Consists of

- **Meter**
- **Inverter**, and
- **Battery**



Use Cases: Storage versus Conventional Peak Gen Plant

Application		Flex Resource CT	Large Battery co-locate Utility Renewable	Distribution Battery	Home Battery Back-up	Res'l Hot Water Storage
Capacity/Energy for Peak Demand	●	●	●	●	●	●
Frequency Regulation	◐	●	●	●	●	◐
Renewable In-Hour Load Following	◐	●	●	●	●	◐
Correct Hr-Ahead renewable forecast error	◐	◐	◐	●	●	◐
Store Excess Night Wind Energy	X	◐	◐	●	●	◐
Emergency Baseload Energy Resource	●	X	X	X	X	X
Feeder Voltage Control	X	X	●	●	●	X
Customer subsidy for outage back-up value	X	X	X	●	●	X
Reduce transmission cost to market	X	●	X	X	X	X
Credit for Reduced T&D Losses	X	X	○	●	●	●

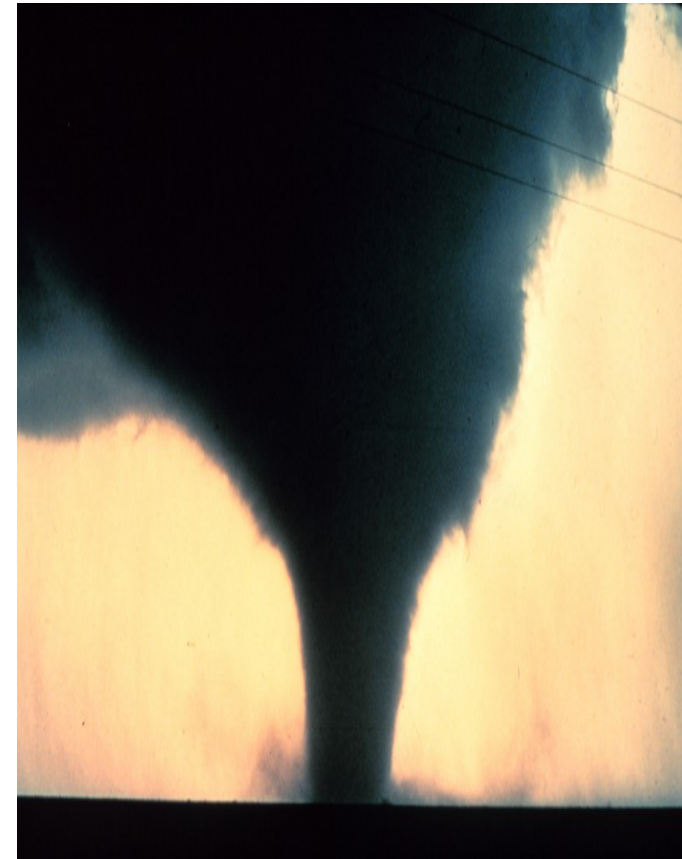
Not only best location, but also most economical system solution

- Best economics now, or after price drop
- ◐ Reasonable economics now, or after price drop
- Low benefit after price drop
- X No benefit possible

Price drop and or major development required before viable

Trip Report to 2050

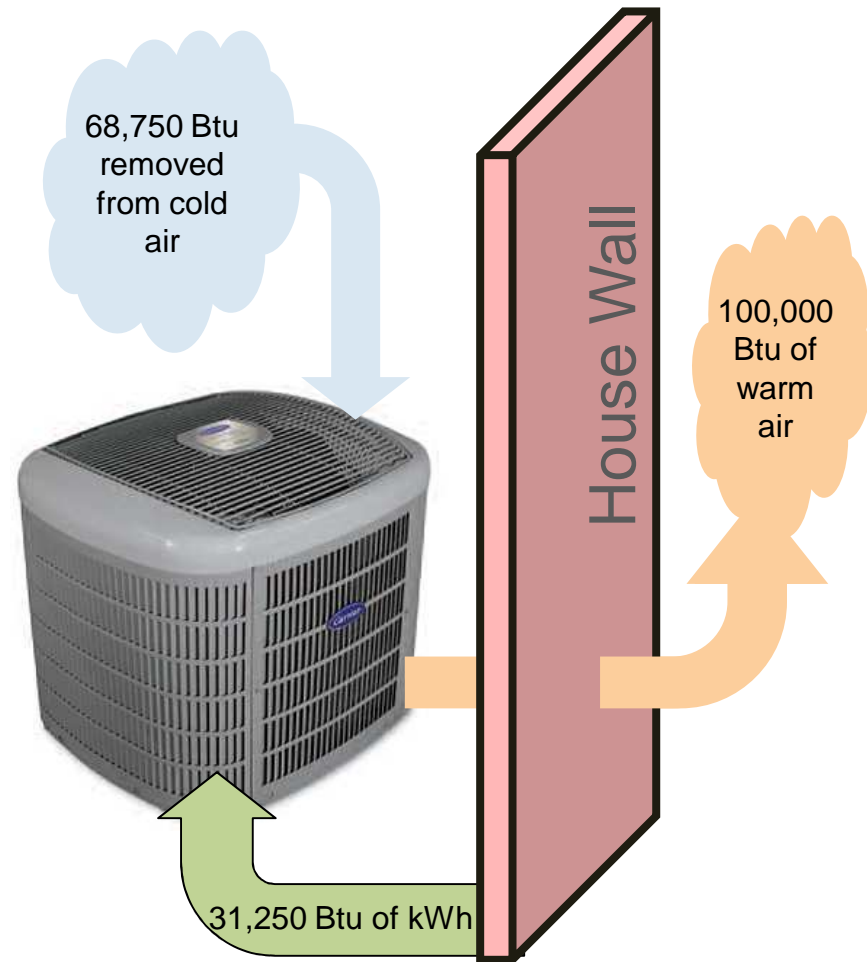
- Good News and Bad News
 - Global Weirding, Worse
 - NW leads US in Sustainability
- NW fuel mix could be
 - 32% hydro, 22% renewable, 9% coal, 4% nuke, 33% N. gas
 - CO₂/kWh 0.46 lb per kWh
- National mix could be
 - 3% hydro, 24% renewable, 16% coal, 24% nuke, 33% N. gas
 - CO₂/kWh 0.60 lb./kWh
- **WECC today** (western 11 states)
 - CO₂/kWh 0.84 lb./kWh



Heat Pump Opportunity, Today

Save Natural Gas, Reduce CO₂

- Today's variable speed heat pumps have efficiencies $\geq 320\%$.
- In WECC with 0.92 lb. CO₂/kWh (gen mix increased for T&D loss), a **therm of heat** takes 9.2 kWh \rightarrow **8.4 lb. CO₂**
- Compare to: **therm of heat** from 95% gas furnace \rightarrow **12.2 lb. CO₂**
- New variable speed heat pumps with a CEA-2045 interface and alometric controls could provide gigawatts of real time loading following capability in winter and summer seasons.
- Sustainability requires energy savings analysis at system level not device level!



Solution for 80% Renewable, all energy by 2100

- **2015:**
 - CEA-2045 on all major mass market devices
 - Standard 1-way grid signal to convey info to moderate power & guide energy shifting
 - Incent manufactures to create **alonetic** behavior in loads in table shown earlier
 - PGE is working on this now with water heaters
- **2018**
 - Significant scale battery deployment
 - Shift gas heating using **alonetic** heat pumps; shift demand with thermal storage
 - Shift mass market vehicles to PEVs with **alonetic** charging
 - PGE is working on these efforts now
- **2019:** Until shaping of solar generation is cost-effective, reform solar subsidy policy to promote steady growth of solar, but in a way that all citizens pay for subsidy equally.
- **2040** after perfecting synthetic kerosene from waste cellulose and electricity, require planes, trains, and trucks to adopt over twenty years. These chemical plants primarily run when renewable energy is excess
- **2100** 20% baseload of Nuclear and CCCT still desirable, and likely but carbon footprint of electricity can be reduced to about 0.03 lbs CO2/kWh, about 3% of US average today. US carbon foot print can be reduced by >90%

You Should Take Away This:

Alonetic devices at the premises are the key to **sustainability**

Join the future now:
Learn about, then demand,
CEA-2045 on all water
heaters

With 125 years of experience, PGE is ready to create win-win solution for our customers and the environment. PGE is **hiring** if you want to **help create this future!**

Think Alonetic!

