Remain the Trusted Energy Partner?

Utility Energy Conference

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852,000 customers, 52 cities served

Service territory population 1.8 million, 43% of state's population

4,000-square-mile service area

2,600 employees

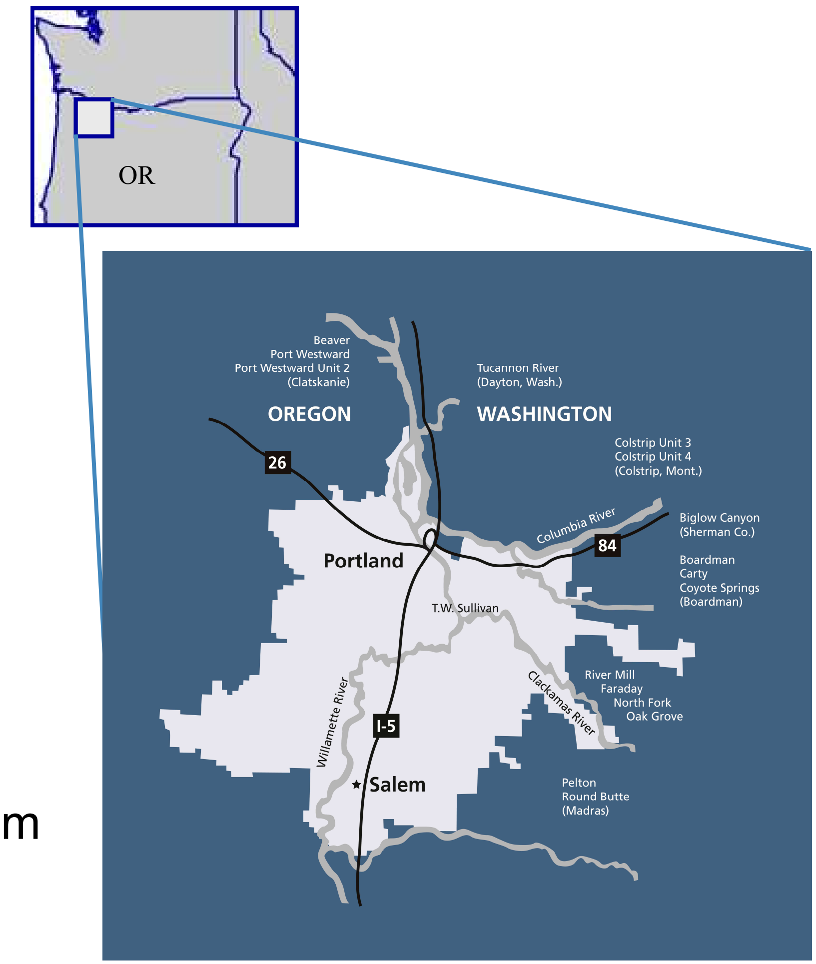
Summer peak load of 3,950 MW (2009)

Winter peak load of 4,073 MW (1998)

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

First multi-MW Li-Ion battery-inverter system placed in operation by a utility

21% of owned generation nameplate capacity is wind generation; 36% is renewable.



Industry under Metamorphosis

If the 20th century Grid was a caterpillar, the Grid will re-appear in 2050 as a butterfly.

Smart Grid

New Business Models

Distributed Generation

Smart Meters

Microgrid

Community Solar

Internet of Things (IoT)

Battery Storage

Net Metering

Thermal Storage

Rate Reform

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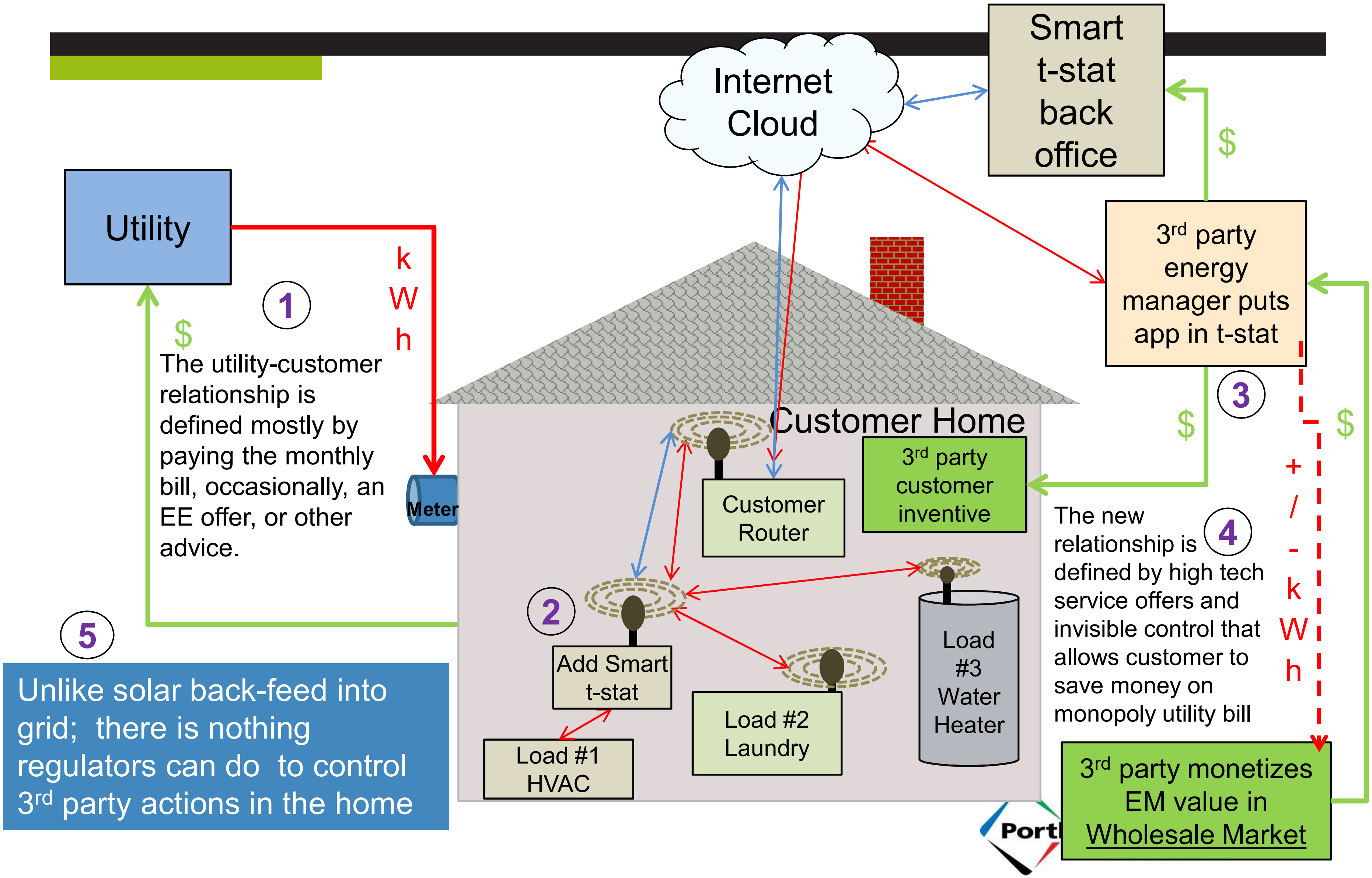
"Trust" in the Internet of Thing (IoT) World



IoT: Be Afraid, or at least, Be Wary

- Cisco Internet of Everything (IoE) Value = $19 Trillion
- Good News:
  - First Effort: Add connected features to product line
  - Second Effort: Connect with others
  - Present feature set: energy is only a simple control option
  - Monetizing energy-management value not in the high tech skill set, YET
- Bad News:
  - Connecting devices to meet customer expectations is difficult, expensive, and requires IT culture not found in utilities
  - We are big in aggregate, but act individually
  - And WORSE ==>

Connected "Players" Jan 2014 ---- in Billions ----

Industry	**Annual Revenue**	**Market Capitalization**
Auto Companies	$1,000	$400
Electric Utilities	$400	$900
Phone (Land and Mobile)	$350	$500
Walmart/Lowes /Home Depot	$600	$415
Cicso/IBM/Qualcomm/Ericsson	$215	$490
Apple	$170	$480
Samsung/Sony/Panasonic	$350	$200
Google	$50	$380
Comcast/Time W/Viacom	$110	$240
Verizon	$115	$140
Amazon	$61	$180

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The Driver for Industry Change

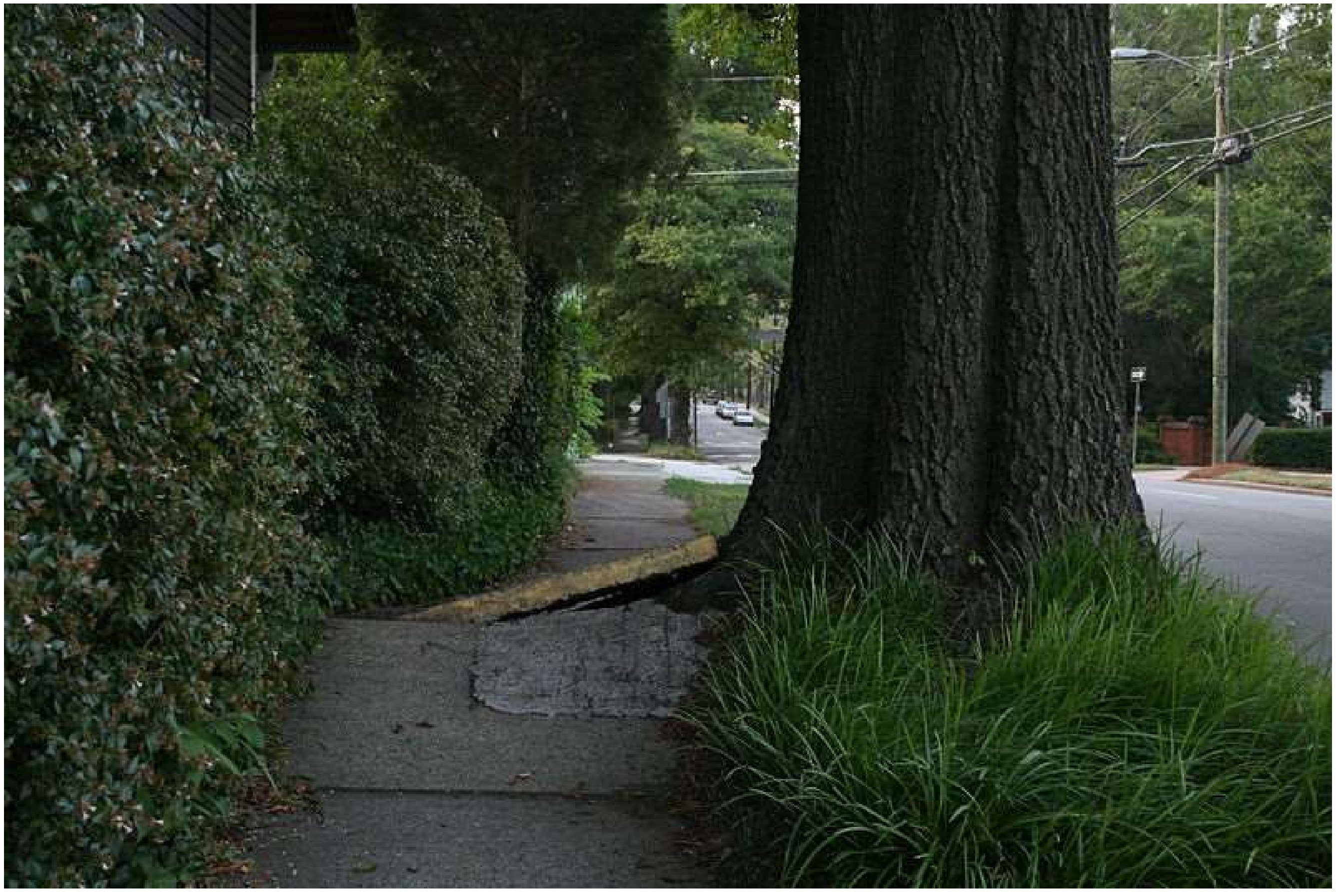

Photo Credit:
Ildar Sagdejev
http://commons.wikimedia.org/wiki/File:2008-06-28_Broken_sidewalk.jpg

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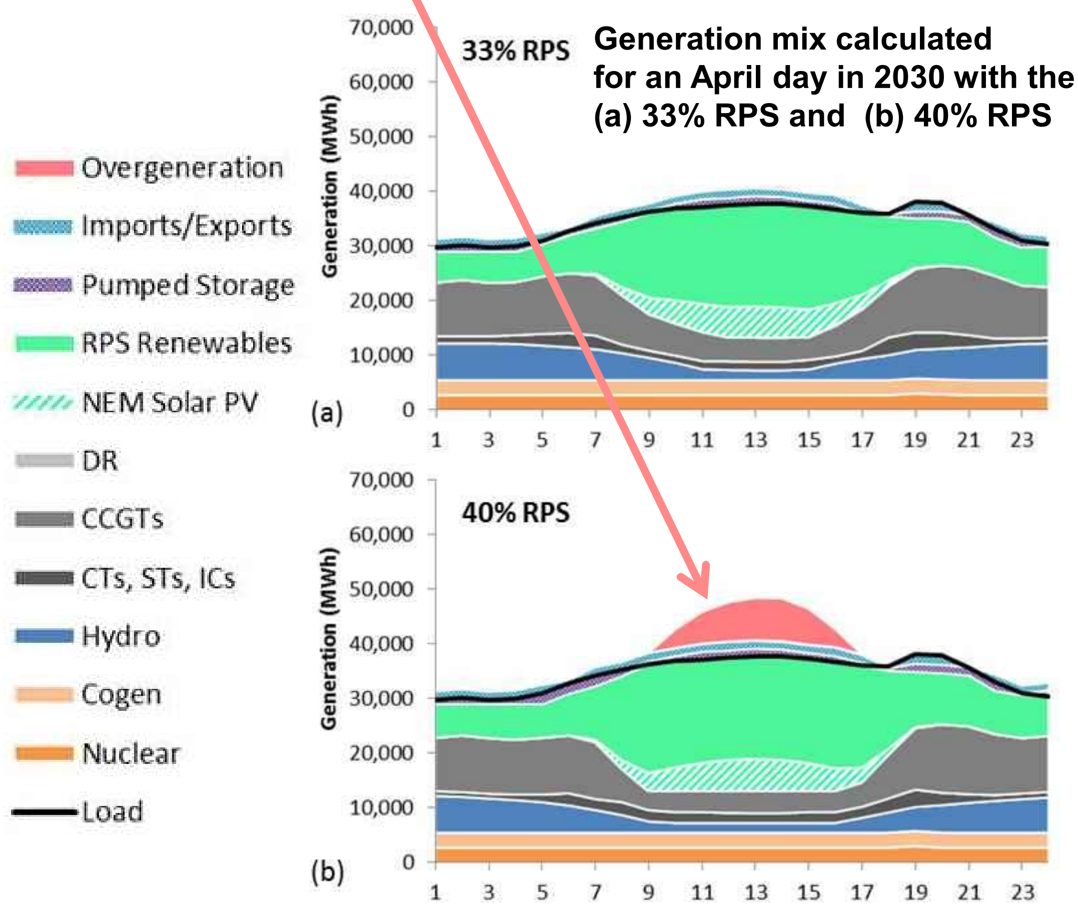
The Problem: High RPS ☛ Overgeneration

- Solar generation with a capacity factor of 17% that peaks mid day

  Note: PV Solar is only 46% of the renewable 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 today's 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 Five Solutions (To get to 100% renewables)

In order of cost effectiveness (low to high, and available sooner)

1. When possible, shift electric use to periods of renewable generation production
2. Heat Pumps draw on thermal storage for space conditioning & water heating
3. Electric storage (esp. stationary at each customer premises)

But are the next two solutions less expensive?

4. Modify industrial manufacturing process to add capacity that runs coincident with periods of excess renewable production
5. Synthetic oil and methane production from waste cellulose and renewable electricity or bio-engineered "bugs"

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PGE is Working the Steps

Implementing Solution #1

When possible, shift electric use to periods of renewable generation production

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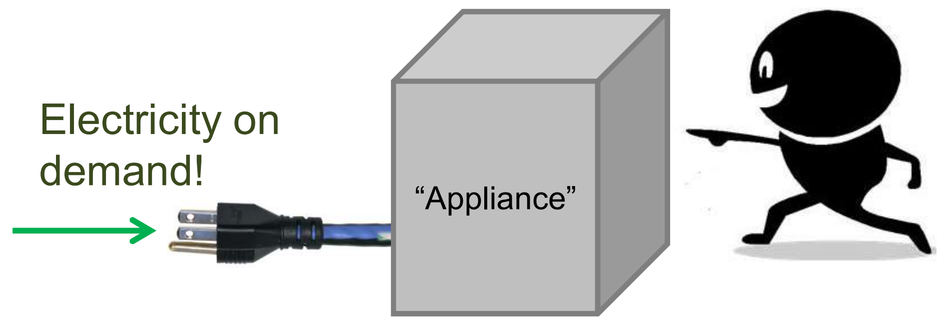
New General Concept

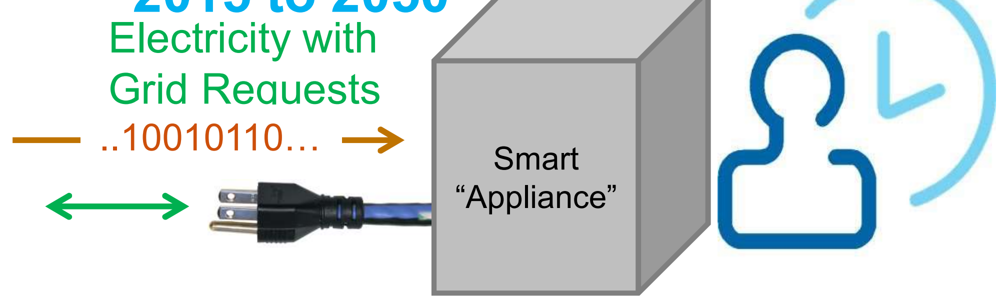
- **For first 120 years**
  - Energy flows one way to customer
  - Customer loads and generation serve best interests of customer
- By 2010, Idea: many loads can respond to price and control signals to help integrate renewable generation.
- **No word describes concept**

Then: 1890 to 2010



Customer commands; device giveth

2015 to 2050



Customer inputs flexibility→ device serves customer & grid!

Word for an Emerging Concept

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

- 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

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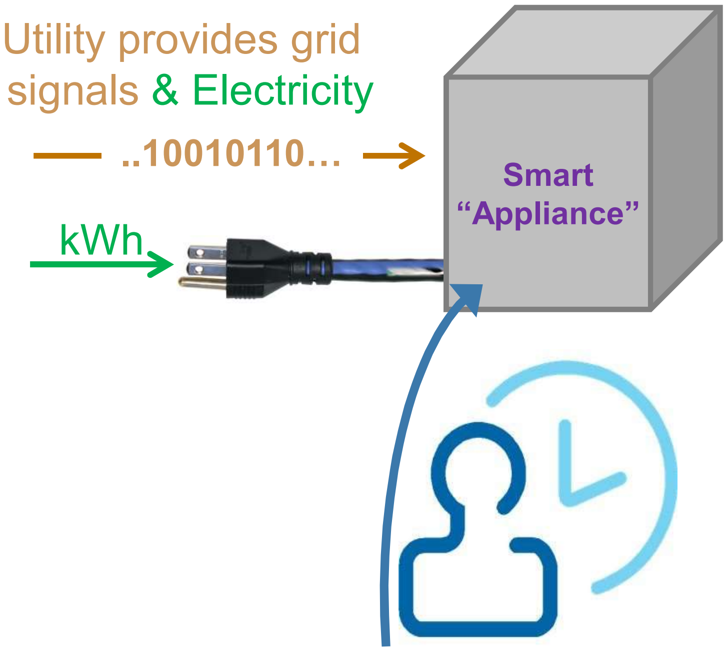
Why Alonetic Devices Create Win-Win

- 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 , i.e. CTA-2045
  - Control logic in device **maximizes grid benefit,** but **ensures customer needs met**



Customer inputs flexibility, then device serves customer & grid!

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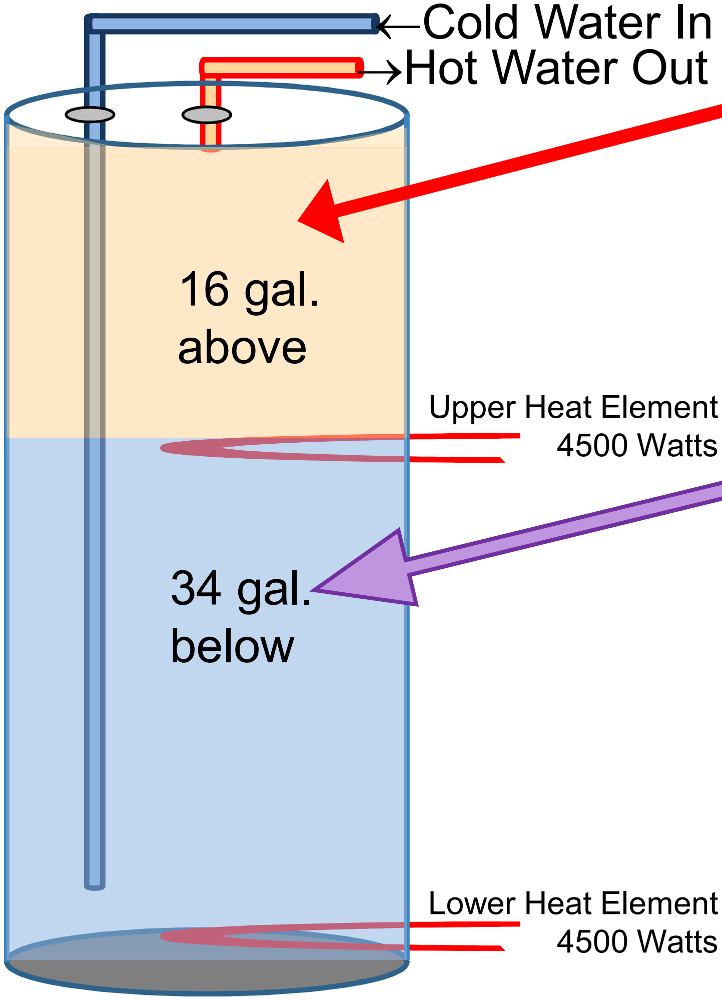
Alonetic Water Heaters Part of the New Solution



"Smart" tank keeps top 3rd of tank hot; learns use patterns to make ensure full hot tank before heavy use period

Control when, and rate, of re-heating bottom 2/3 of tank

Water Heaters also an example of thermal storage.

- **No in-out losses,**
- **1/10th the cost of batteries.**
- **45 million tanks already installed**

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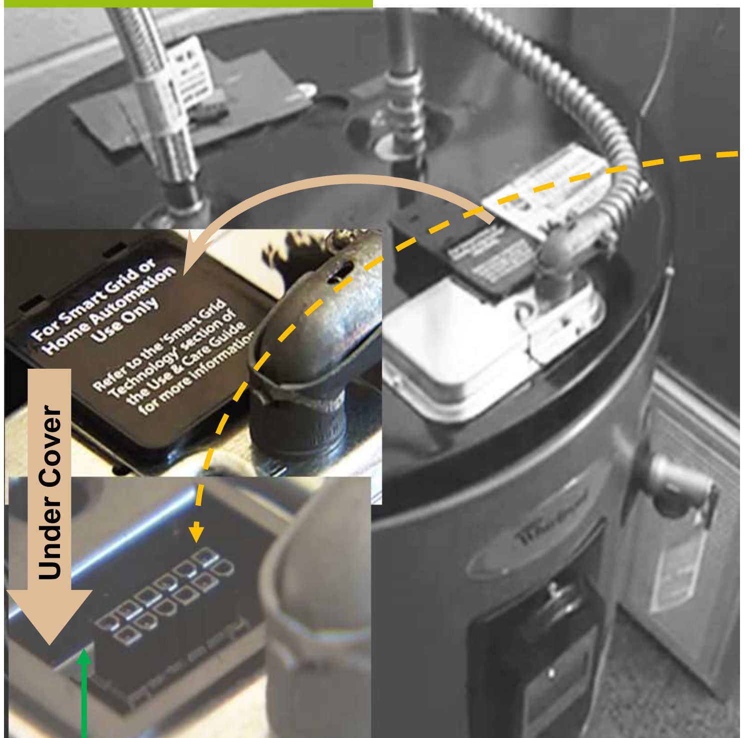
The Customer Install with CTA-2045 Socket



ANSI/CTA-2045 socket on tank

Like USB, Customer plugs the comm device into socket on tank

ANSI/CTA-2045 "plug" on communication device

Example of communication device from e-Radio

Wi-Fi Expansion Card

This E-Radio device "hears" control commands broadcast on FM radio and returns water heater status via Wi-Fi if enabled by Customer.
This option can work in 99+% of US, (including rural areas) **today**

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Example: Water Heaters in NW

- Beyond simple demand response; tanks provide ~4 kWh of thermal storage, 0 to 0.6 kW of flex load, everyday, to aid renewable integration.
- Times 3.4 million water heaters implies
  - 14,000 MWh of energy shifting ability
  - 1,700 MW of flexible load/capacity
  - Instead of running peaker to firm renewables, using water heaters instead would save 2.4 million tons of CO_2/year by avoiding use of 45 trillion Btu of natural gas.
- Economics work with heat pump water heaters too.

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16

Other Early Targets for Alonetic Devices

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

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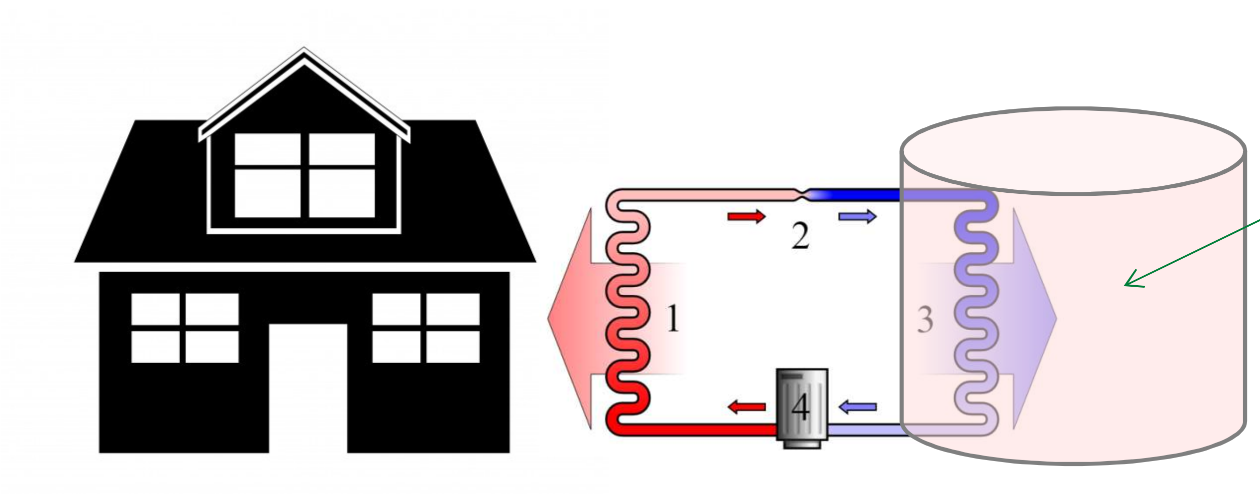
Implementing Solution #2

Heat pumps & thermal storage for space conditioning & water heating

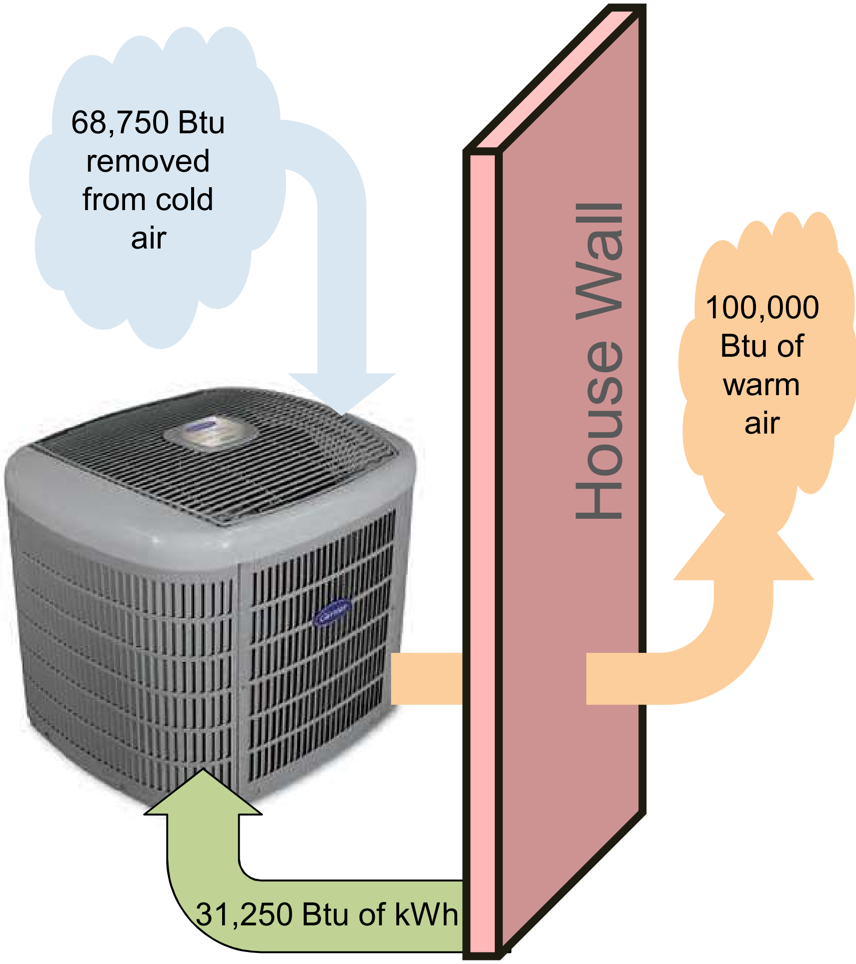
(a 2 for 1 solution)



Storage tank heat when desirable; move heat to house, as always.

Heat Pump Opportunity, Today, Save Natural Gas, Reduce CO_2

- Today's variable speed heat pumps have efficiencies ≥ 320%.
- In 2040 WECC with 0.37 lb. CO_2/kWh (gen. mix increased for T&D loss), a therm of heat takes 9.2 kWh → **3.4** lb. CO_2
- Compare to: therm of heat from 95% gas furnace → **12.2** lb. CO_2
- Add thermal storage in walls, tanks or other methods → 80% of energy use can be synched to times of renewable generation
- Heat Pump Water Heaters similar savings and storage ability



Example of Thermal Storage in Home

- Thermal mass of house: (allowing +/- 1 to 3 deg F in house temperature setting) For heating (cooling)
  - pre heat (cool) before peak event;
  - lower (raise) temperature during peak;
  - Add heat (cool) any time excess renewables exist
  - Use slightly more energy but bill lower with right price structure

- Add storage tank that supplies HVAC and Hot water

Photo Credit:
Sanden USA
http://www.sandenwaterheater.com/

Implementing Solution #3

Electric storage

(esp. stationary at each customer premises)

Photo Credit:
Aquion Energy
http://www.aquionenergy.com/products/stationary-energy-storage-batteries

"Killer App" Home, Battery-Powered Backup

- **Concept:** Battery-inverter system backs up home 0.02% of time, but 99.98% of time, utility uses battery, per agreement, to integrate renewable generation

- **If** 25% of homes have an 8 kW, 30 kWh system, US would have a 220 GW resource to [compare to installed generation base of 1,000 GW]
  - absorb excess renewable energy
  - serve system peak demand
  - Provide local voltage control

- **Enablers** to this scale:
  - Battery at $150/ kWh
  - Standardize methods to control the battery

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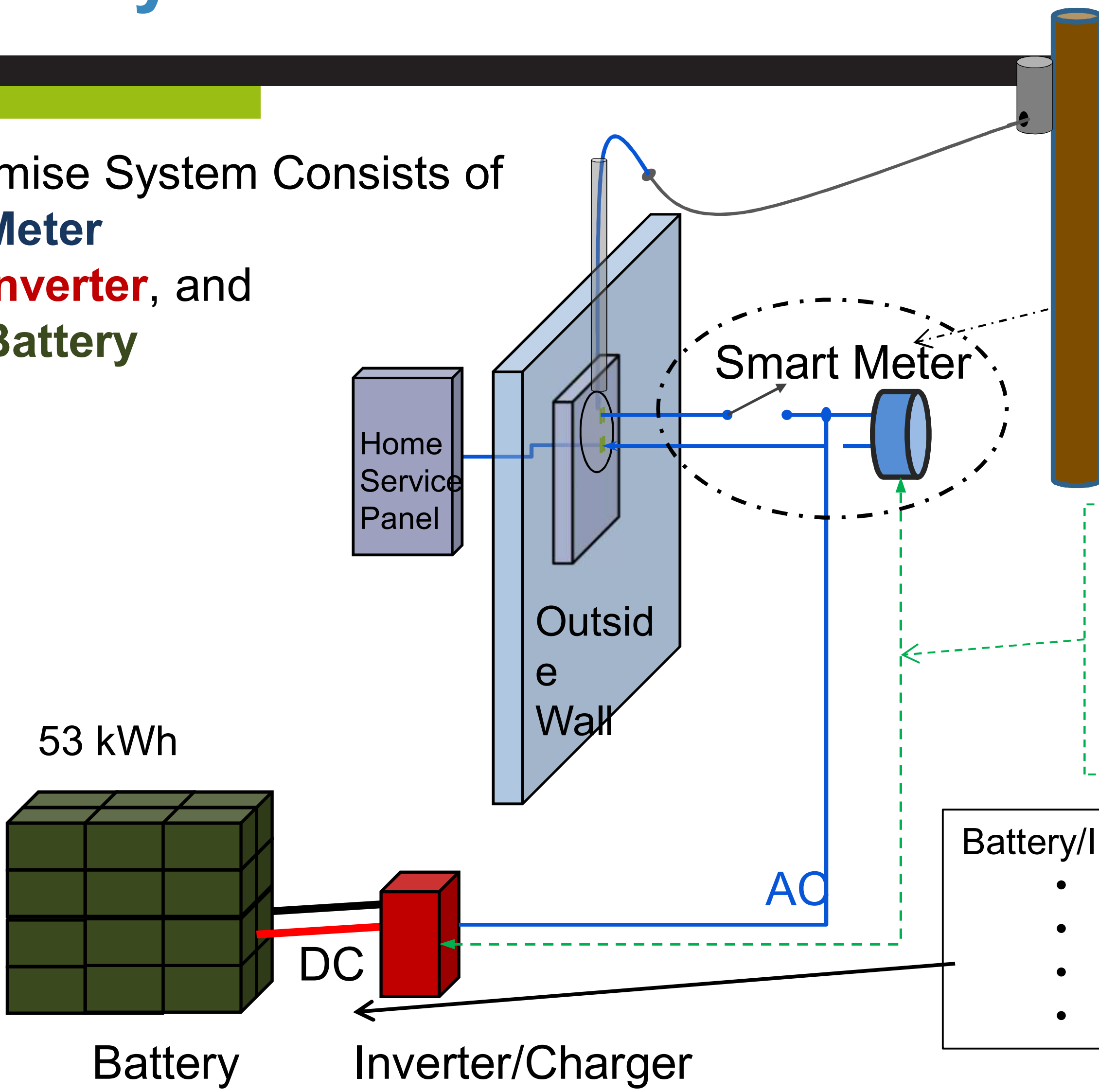
A Utility-Owned Version of the Killer App

Premise System Consists of
- **Meter**
- **Inverter**, and
- **Battery**



Smart Meter has dual meter channels for house and battery; can isolate backup system from grid; creates communication link to utility

Hardwired circuit for telemetry, metering, and command & control

Battery/Inverter located in
- basement,
- direct buried
- garage,
- crawl space, etc.

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Best Storage Location versus Flex Resource Gen Plant + Value by Use Case

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
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
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

Price drop and or major development required before viable

○ Low benefit

X No benefit possible

Implementing Solutions #4 & 5

#4: Increased industrial manufacturing capacity that runs coincident with renewable production

#5: Synthetic oil and methane production from waste cellulose and 100% renewable electricity or bio-engineered “bugs”

We need a plan, based on changing economics, of how to <u>use</u> over-generation!

Photo Credit:
Didier Descouens
http://commons.wikimedia.org/wiki/File:Morpho_didius_Male_Dos_MHNT.jpg

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Thanks for your Interest

- **Questions?**

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WECC Renewable Portfolio Standards Overview

1. California 50% by 2030 — not including 20% from existing Hydro
2. Oregon 50% by 2040 — not including 25% from existing Hydro
3. Montana 80% by 2050 — if ballot measure (8 Nov 2016); otherwise 15%

Laws about ten years old:

4. Washington 15% by 2020
5. Nevada 25% by 2025
6. Utah 20% by 2025
7. Colorado 30% by 2030
8. Arizona 15% by 2025
9. New Mexico 20% by 2020

10. & 11. Idaho and Wyoming no standard

Requirements apply to IOUs,
Publics often have reduced targets

Existing RPS standards increase renewables in WECC from 28% (mostly hydro) to 60%

http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

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A Problem and an Opportunity

Problem:

- Excess wind generation in off-peak
- Excess solar occurs mid-day

Technology Opportunity:

- Load devices that consume energy in periods of lowest energy price *(coincident with over-generation periods)*
- New loads that run in periods of over generation

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