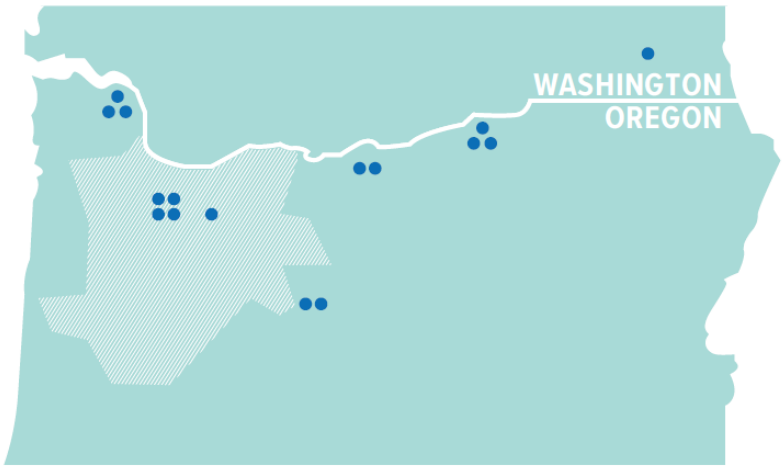
Standard modular interface improves customer experience

Conrad Eustis
March 21, 2018

Portland General Electric is a fully integrated energy company based in Portland, Oregon serving approximately 862,000 residential, commercial and industrial customers in 51 cities.



Diverse generation mix

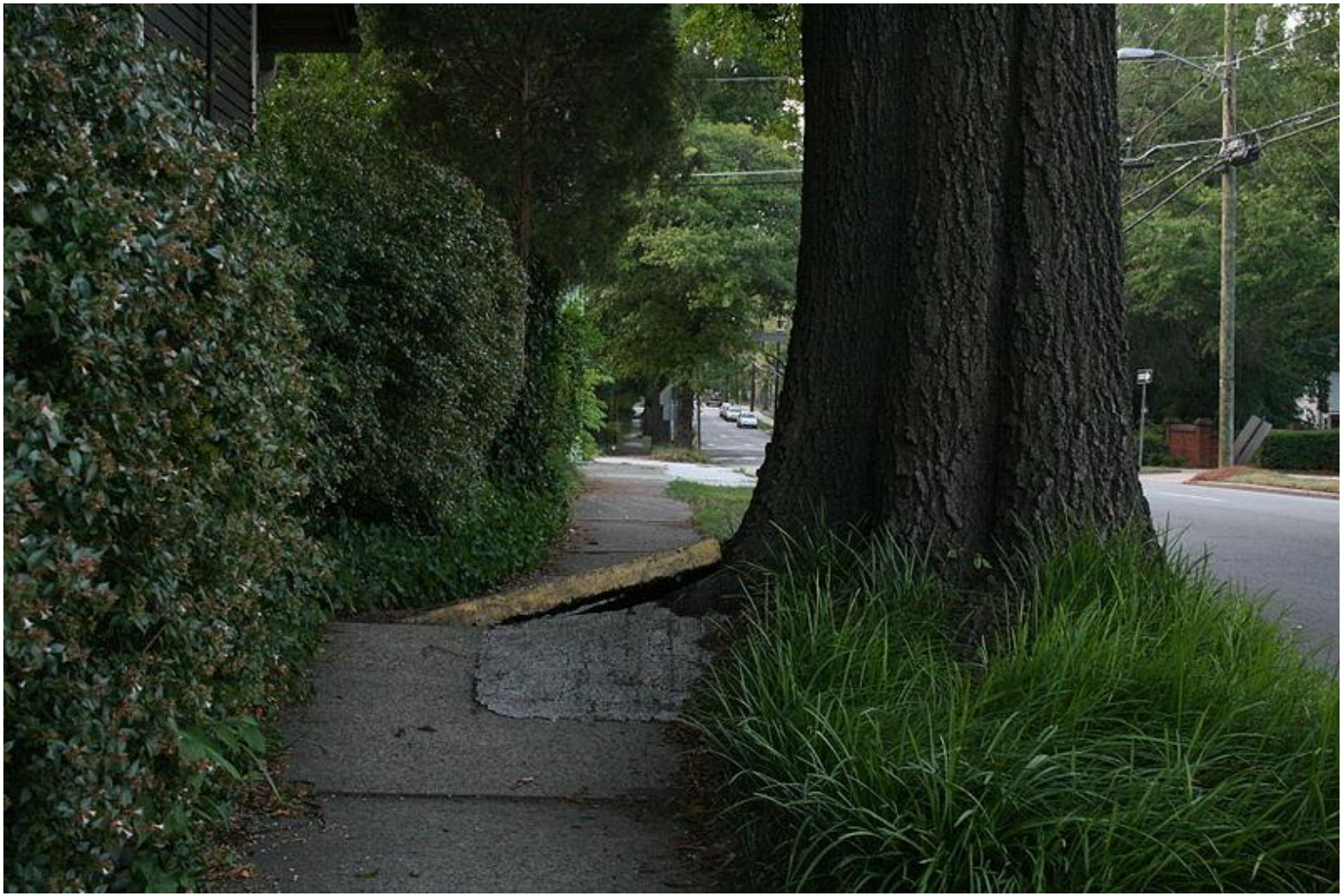
16 major generation plants providing a cleaner energy future

Quick facts about PGE

- 2,750 employees
- Retail customers 862,764
  - Residential 756,675
  - C&I 105,826
  - 44% of State's Population
- 18.9 million MWh delivered
- Peak load: Dec. 21, 1998 4,073 MW
- Summer Peak 2017 3,972 MW
- No. 1 renewable power program in the nation with 150K participating customers
- Top ranking in JD Power 2017 Electric Utility Business Customer Satisfaction Study
- First multi-MW Li-Ion battery-inverter system placed in operation by a US utility

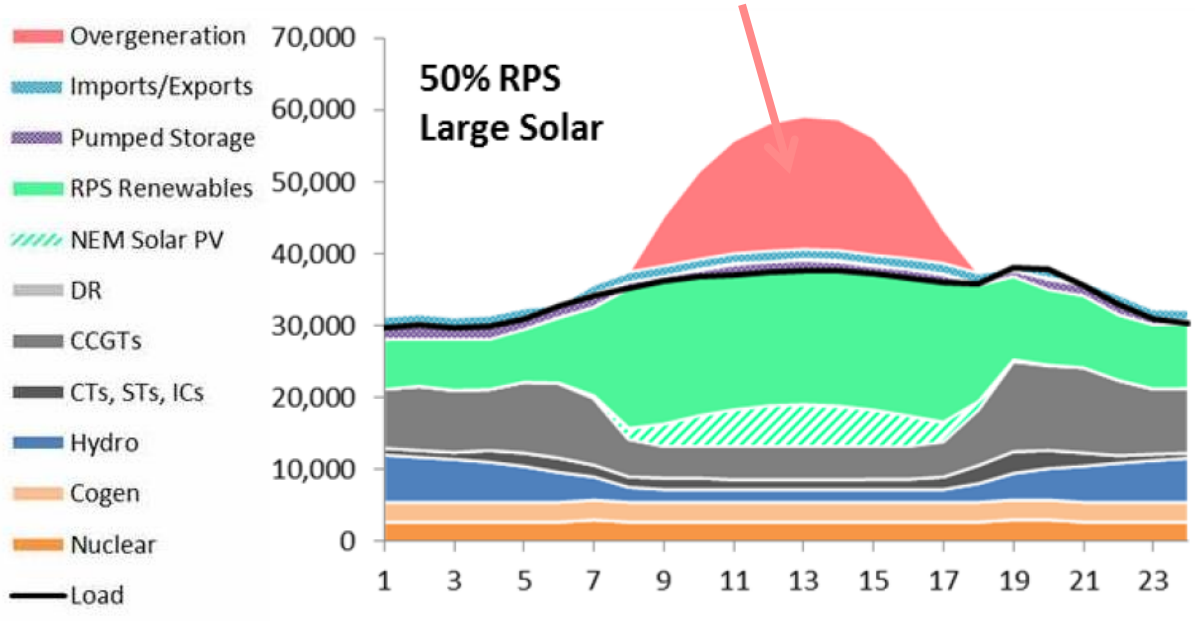
PNW needs flexible loads

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



PNW customers want 100% renewable generation but >30% (wind & solar) means Overgeneration

- Solar & wind produce energy in limited hours
- Output varies
- Energy with no place to go
- California at 31% in 2017



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

Barriers to Residential DR at scale

Credit: http://maxpixel.freegreatpicture.com

Customer perspective

1. Difficult customer experience
2. Concern that lifestyle won't be affected
3. Basic $ incentive not enough motivation for many

Utility perspective

4. Cost to physically connect one device

NW regional pilot objective: Demonstrate solutions

Participants

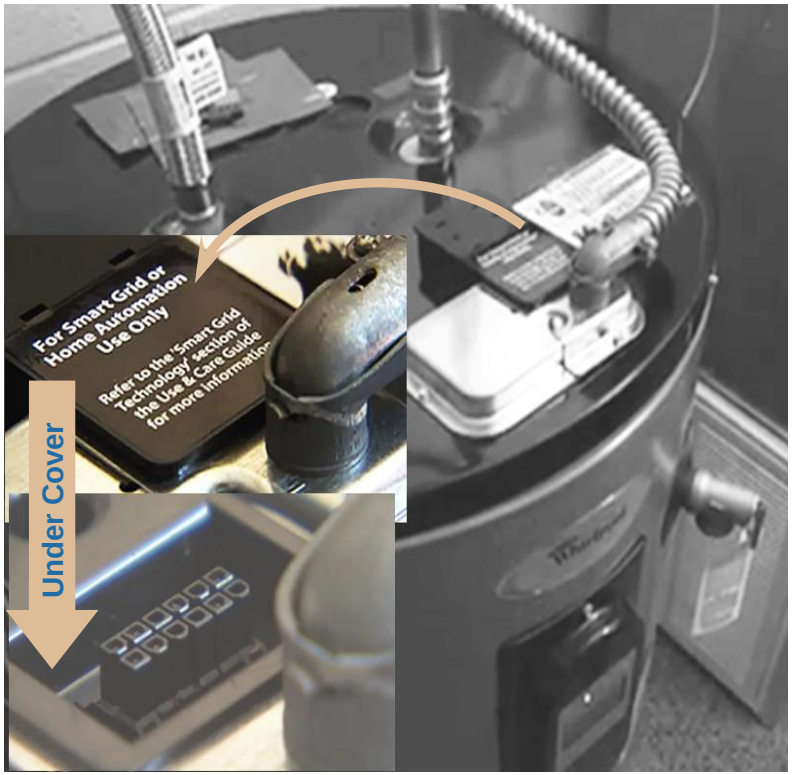
- Project funding: $1 million BPA TI 336 (BPA labor & cost share not included)
- Project Leads: Tony Koch, BPA & Conrad Eustis, PGE
- Primary BPA Support Staff: Eva Urbatsch & Phillip Kelsven,
- Suppliers: A.O. Smith, General Electric, e-Radio
- Major Support Organizations: NEEA (Geoff Wickes) & PNNL (Cheryn Metzger)

Utility Participants:

1. Portland General Electric
2. Tacoma Power
3. Puget Sound Energy
4. Clark Public Utilities
5. Emerald PUD
6. Snohomish PUD
7. Springfield Utility Board
8. Franklin PUD

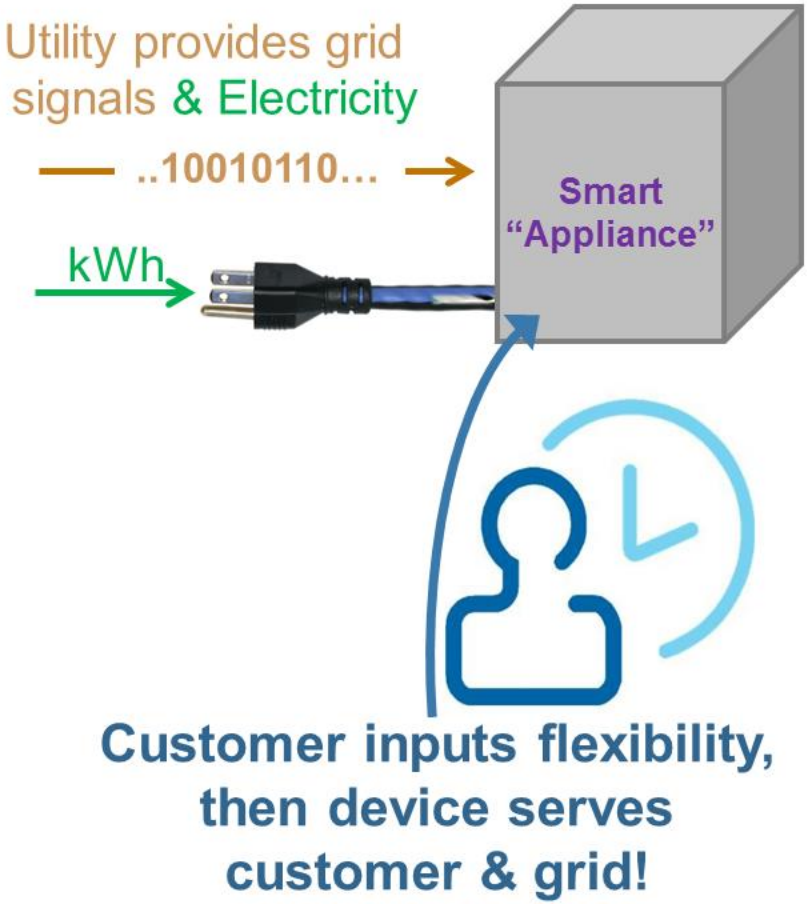
Objectives

- 175 heat pump water heaters.
- 90 resistance water heaters
- 24x7 Control, 365 days/yr.
- Quantify
  - peak load mitigation
  - energy shifting
- Customer acceptance
- Regional education
- **Market transformation plan**
- **Bus. case to justify MT plan**
- Anticipate > 3:1 benefit/cost



Vision behind project

- Imagine **standard port** on each appliance
- Appliance designed to receive utility signals **via standard data format**
- Manufacturer provides simple way for **customer** to define **their flexibility**
- Control logic in device maximizes grid benefit, but **ensures customer needs met**
- This solution solves barriers 1, 2, & 4



Project uses smart water heaters

“Smart” =

- modular communication interface
- Standard control language
- OEM defines DR response
- DR commands ignored to maintain sufficient hot water

Low Cost only if:

- Standard Physical Socket (e.g. CTA-2045, USB, etc.)
- Standard format for data packets
- Standard initial exchange of information

Does NOT depend on DR language

“Smart” Status:

- Only 5 to 10% of tanks sold
- All have proprietary interfaces
- Ready; but need smart adapter

Photo Credits: General Electric and A.O. Smith

Imagine the customer cost and hassle if….

- Every computer manufacturer had unique sockets that didn't look like this.

Connected devices deliver that hassle today

Smart = improved customer experience

Set & Forget Design

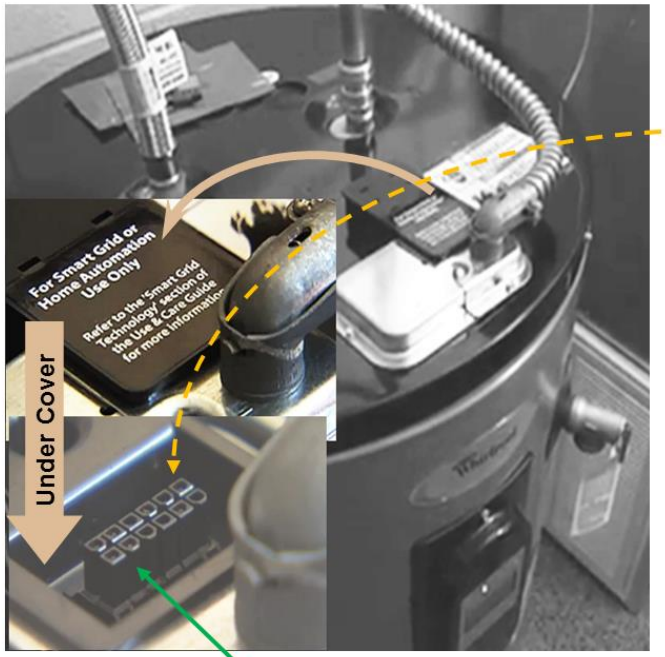
Today

- Easy for customer to curtail grid control
- Logic ensures hot water supply

Tomorrow

- Input for more comfort or more savings
- Learns peak hot water demand periods

Improved customer setup & future proof



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

Problems with Wi-Fi

- Must setup Wi-Fi password
- Customer nagged to reconnect
- 20% of US homes no Internet
- Can be hacked

Plug in and forget

Could be

- 5G (the future of IoT)
- Secure broadcast
- Proprietary link to HEMS

Customer can change any time

Open-in-cloud vs. open-at-device

- Open-in-the-cloud means home run to the device maker to interact with any 3rd party
- 3rd party needs legal agreements with every device maker to simplify customer experience.
- Open-at-device means customer is charge, and any architecture is possible

Photo credit EPRI

Vendor Vision

Consumer or Automation Vision

Design affects customer experience

Open-at-device; modular interface

- Supports grid control without using internet
- Supports participation without needing customers internet or passwords
- Supports easy use of 3rd party HEMS
- Future proof against 5G IoT architectures and business models
- Security fixes never involve device

Open-in-cloud

- Requires 3rd parties, like DR aggregators of utilities, to have agreements with 50+ device makers
- In major disaster, loss of Internet means loss of in-home energy management
- More revenue opportunities for device maker

Standard solves barrier #4

Control Method => Install Component	Control Box	CTA2045 on Tank
Factory tank modification	none	$15 (in volume; only $1 for heat pump WH)
Control box	$100	none (uses tank controls)
Communication device	included above	$50 -> $10 (in volume)
Installation & materials	$175 ($25 (average) for aborted starts)	$0 (customer-installed)
Join program incentive	$50 (to leave work to meet installer)	$0
Reserve to remove unit	$50	$0
Marketing	$M	50%*$M
Permit	$15	$0
Total	**$390 +$M**	**$80* -> $40 + 0.5*$M**

*Assumes 1 in 2 adoption

Societal Benefits

Water heater benefits as Flex Powerplant

- Expected peak demand benefits
  - HPWH
    - 0.18 kW load reduction;
    - 1.5 kWh as storage (twice a day)
  - Resistance
    - 0.35 kW load reduction;
    - 3 kWh as storage (twice a day)
- 24x7 ops reduces natural gas use at powerplants
  - ~ 2.9 million Btu per water heater/year used as flex resource

Daily control saves system energy

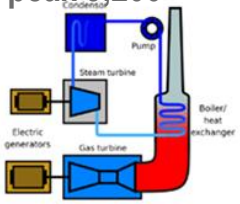
In 21st century, system energy savings more important than device efficiency

Assume 3 kWh stored per tank on 344 days per year

1. Daily Economic Dispatch on 180 days yields 1.1 mmBtu/year saved
2. Wind firming on 114 days yields 0.8 mmBtu saved
3. Sink excess renewables on 50 day yields 1.0 mmBtu saved

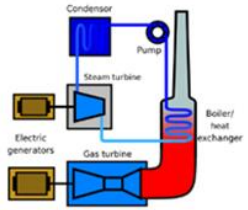
2.9 mmBtu saved can generate >390 kWh at the meter

Heat Rate during avg. daily peak 9,200



VS.

Night Heat Rate 7,100



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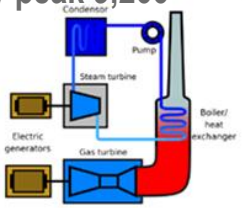

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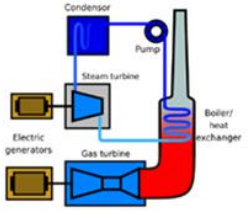
VS.

Baseload Heat Rate 6,826



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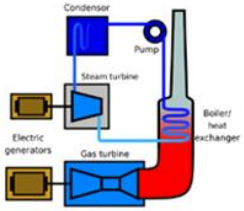

VS.

Northwest potential

Credit: http://www.publicdomainpictures.net/view-image.php?image=145778&picture=business-success

- Market:
  - 3.5 million WH
- Likely benefits (adoption at 50%)
  - After fifteen years (0.3 kW per tank)
    - 500 MW resource ~ $500 million
- Cost (customer adoption at 50%)
  - $15 per tank + $1 mil in engineering per manufacturer
  - $60 per enrolled tank (comm device and recruitment)
  - Accumulated cost after 15 years = $150 million (B/C = 3.0+)
- Daily storage benefit
  - ~ 2 kWh without mixing valve
  - 3,500 MWh at $300/kWh = $1.0 billion in value cf. to battery

Questions

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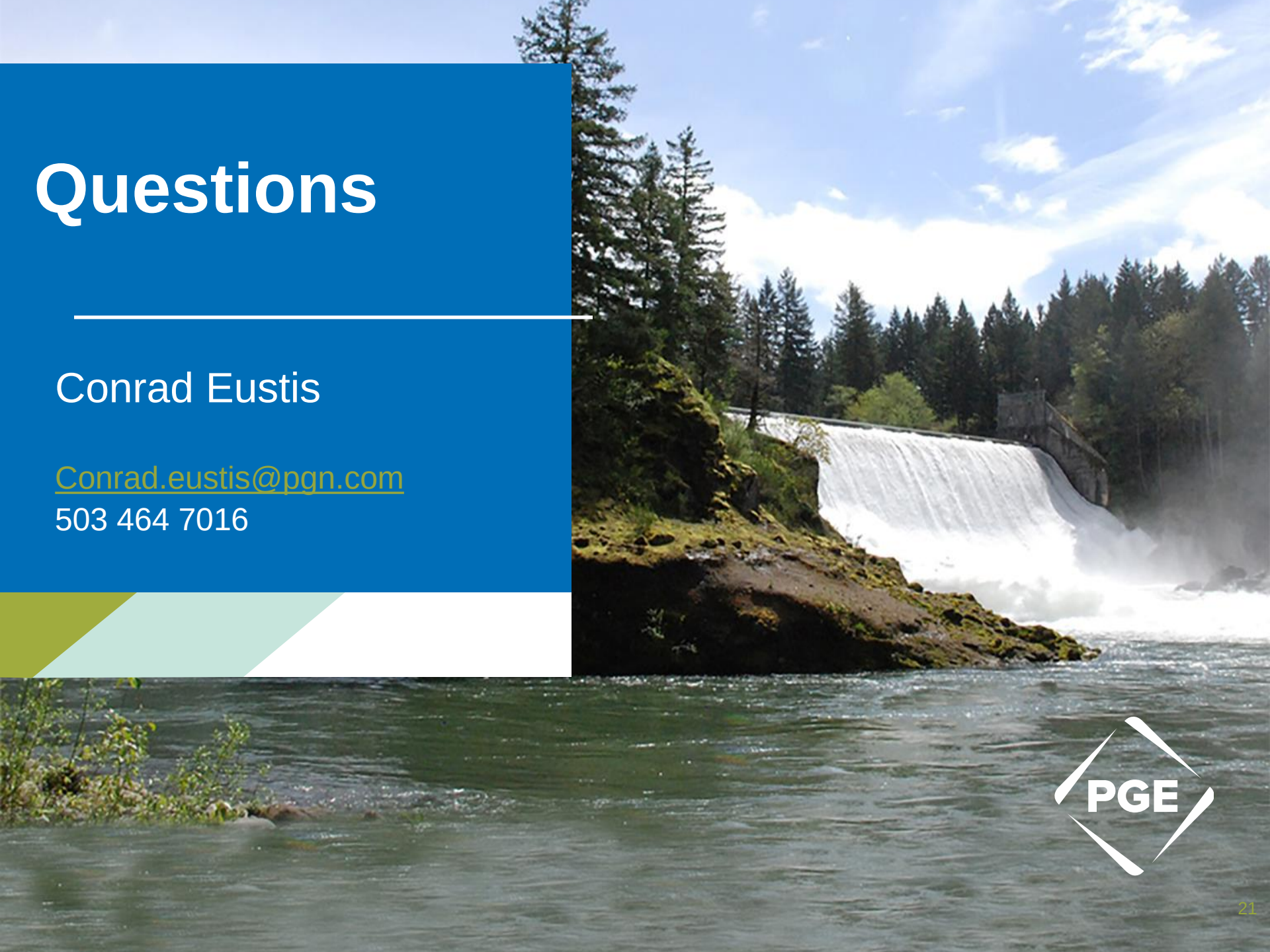
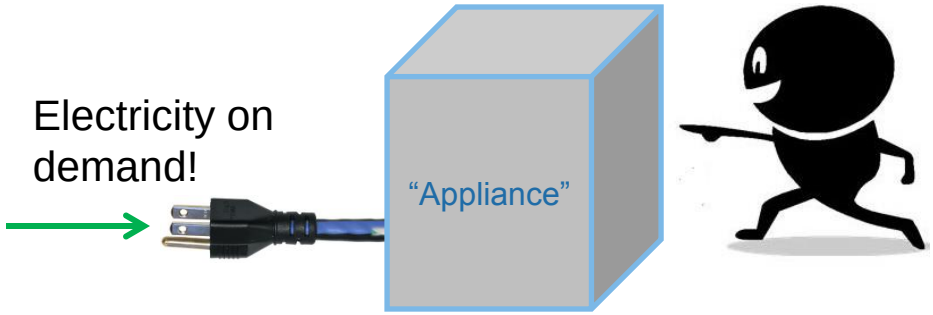


New concept

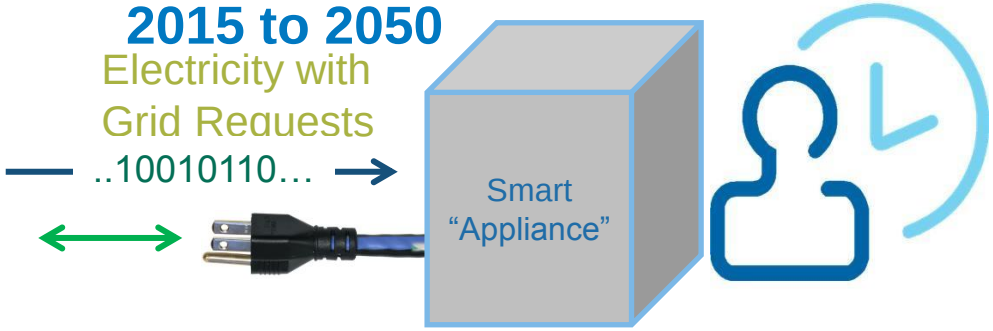
- **For first 120 years**
  - Energy flows one way to customer
  - Customer loads and generation serve best interests of customer
- **By 2008, renewables at scale everyone talks about storage**
- **By 2010, Idea: many loads can respond to price and control signals to help integrate renewable generation.**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

Then: 1890 to 2010



Customer commands; device gives

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***

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

Alonetic, adjective

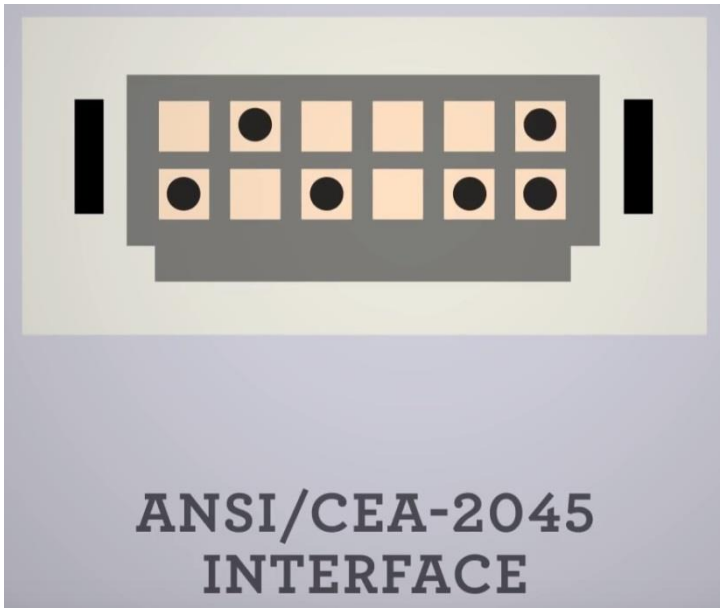
ăl • ō • nĕt' • ĭk

- **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

ANSI/CTA-2045 to the rescue

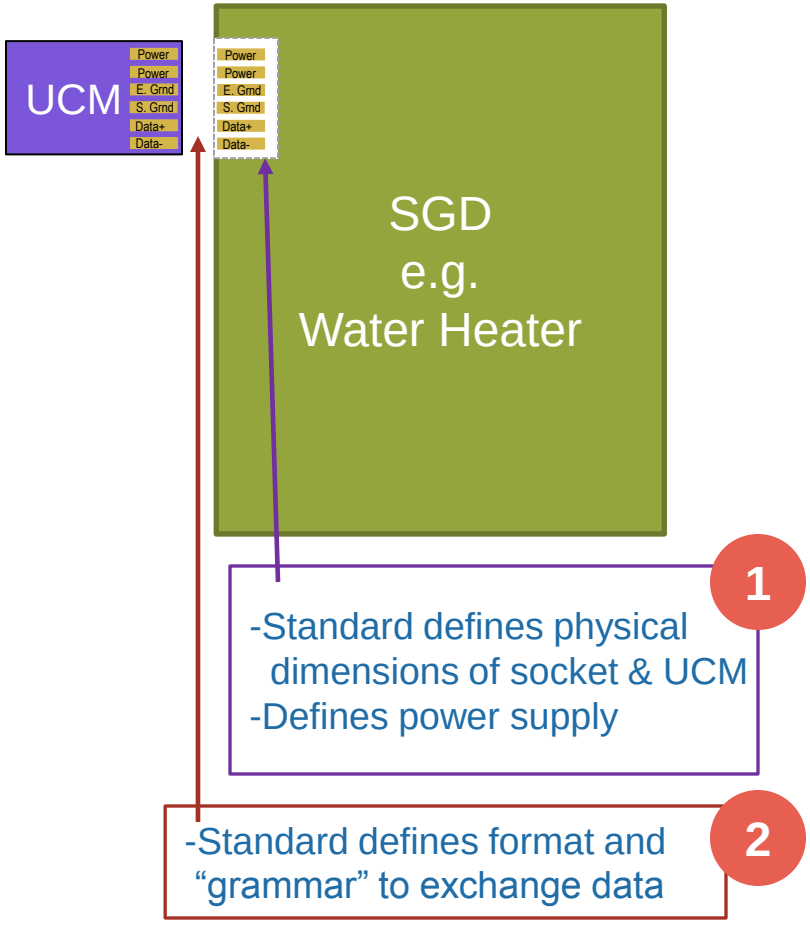
- CTA-2045 is the “one” and it’s gaining momentum
- Creates consistent customer experience
- Enables simple implementation for provider
- Standard creates volume for hardware, volume creates low cost



https://www.youtube.com/watch?v=BHMssq6_R94

CTA-2045 is 3 standards, 2 required

- The “appliance” is called a **Smart Grid Device**
- The **Universal Communication Device** does not come with the appliance; the service provider chooses the type of communication link: e.g. Wi-Fi, mobile carrier, etc.
- The UCM “speaks” whatever language the SGD does, e.g. OpenADR, **but defaults to a shed command defined by CTA-2045** if the appliance doesn’t speak a standard language



CTA-2045 enables other standards

“I don’t want responsibility to pick a standard.”

Four requirements for human communication

1. Same language: English, Chinese, Arabic, etc.
2. A conveyance method: Letter, email, phone, pigeon, etc.
3. Standard grammar: *The Elements of Style*
4. Physical apparatus: Eyes, ears, & voice box

Which two are the must haves?

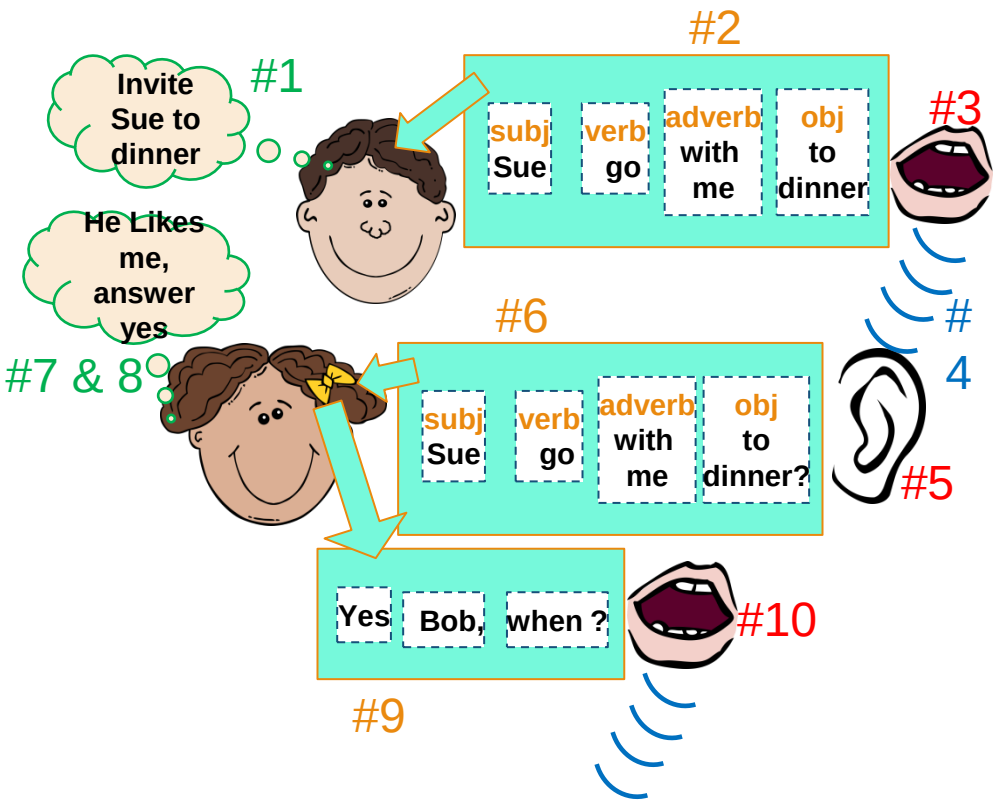
CTA-2045 is the only standard that provides the must haves, and enables any combination of the other two!

ANSI/CTA-2045

- Physical layer
  - Standard form factor
  - Standard physical process (RS-485 or SPI)
  - Provides standard power supply
- Data link layer (Exchange rules: “i” before “e” except after “c”)
  - Negotiates language to speak
    - SEP, OpenADR, BACnet, **Proprietary**, CTA-2045
    - TCP/IP pass through
  - Data format
  - ACK, NAK
- Optional application layer (except)
  - Shed & return-to-normal required

Information flows through “layers”, each requires a standards

1. LS: Bob conceives msg.
2. DLL: construct msg.
3. PL: create msg.
4. ➔ physical conveyance
5. PL: Sue Hears msg.
6. DLL: Deconstruct msg
7. LS: processes msg.
8. LS: conceives response
9. DLL: constructs response
10. PL: creates response



Language Standard
Exchange Standard
Physical Standard

Info at physical layer can travel distance

Language Standard	= (LS)
Exchange Standard	= Data Link Layer (DLL)
Physical Standard	= Physical Layer (PL)