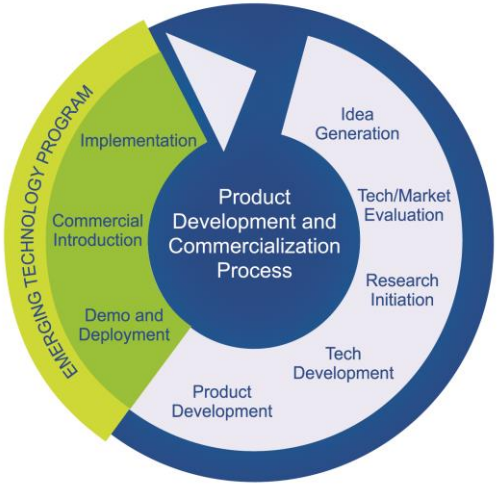
the Energy to Lead

Rheem H_2AC^{TM} Integrated Air and Water RTU



ACEEE Hot Water Forum
February 22, 2015

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GTI Overview

- 501c3 RD&D organization with 75 year history
- Facilities
  - 18 acre campus near Chicago
  - 200,000 ft^2, 28 specialized labs
  - Other sites in California, D.C., Texas, Massachusetts
- Staff
  - Approximately 250
  - 170 engineers, scientists covering all fields

CHP and Renewable Energy Lab

Residential & Commercial Lab

Flex-Fuel Test Facility

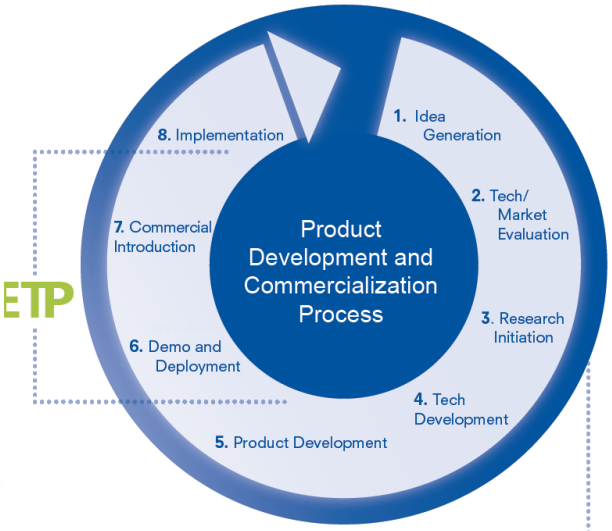
Natural Gas Industry Collaboration

Emerging Technology Program

ETP Emerging Technology Program

- Gas Technology Institute led, utility supported, **North American collaborative** targeting **residential, commercial,** and **industrial** solutions
- ETP's principle goal is to **accelerate** the **market acceptance** of emerging gas technologies

Alagasco
Ameren FOCUSED ENERGY. For life.
Research Foundation
CenterPoint Energy
CNG
DTE Energy
ENBRIDGE
INTERMOUNTAIN GAS COMPANY
Nicor Gas An AGL Resources Company
Energy Efficiency Program
National Fuel
neea
New Jersey Natural Gas
NW Natural We grew up here.
NYSEG
Pacific Gas and Electric Company
QUESTAR Gas
SDGE connected
A Sempra Energy utility
Southern Connecticut Gas Service First!
A UIL HOLDINGS COMPANY
Southern California Gas Company
A Sempra Energy utility
uniongas
A Spectra Energy Company
SOUTHWEST GAS
TECO PEOPLES GAS



ETP activities are "beyond development" stage: Field Testing, Demonstration, Pilot Programs, and Deployment – a focused effort to ensure market acceptance of next-generation emerging technologies

2015 Members Listed Above, SW Gas, NJNG contracts pending

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Technology Background

- The first-of-its kind Rheem H_2AC™ (H2AC) Packaged Rooftop Unit works by taking the heat removed from conditioned space — which would normally be rejected into the atmosphere — and uses it to pre-heat water, by switching from an air-cooled condenser to a water-cooled condenser.
- 2013 AHR Expo Product of Year Award

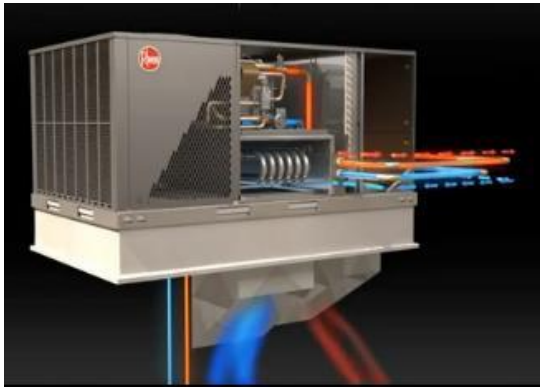


Photo source: Rheem

H2AC Technology Background

A. Cold water enters the tank

B. Room thermostat calls for cooling

C. Based on water temperature, H2AC sends refrigerant to the heat exchanger.

D. Outdoor fans stop

E. Pumps circulate water from tank

F. Temperature rises in tank, and waste heat is stored

G. Pre-heated water enters water heater from tank

H. Hot water is used at fixtures

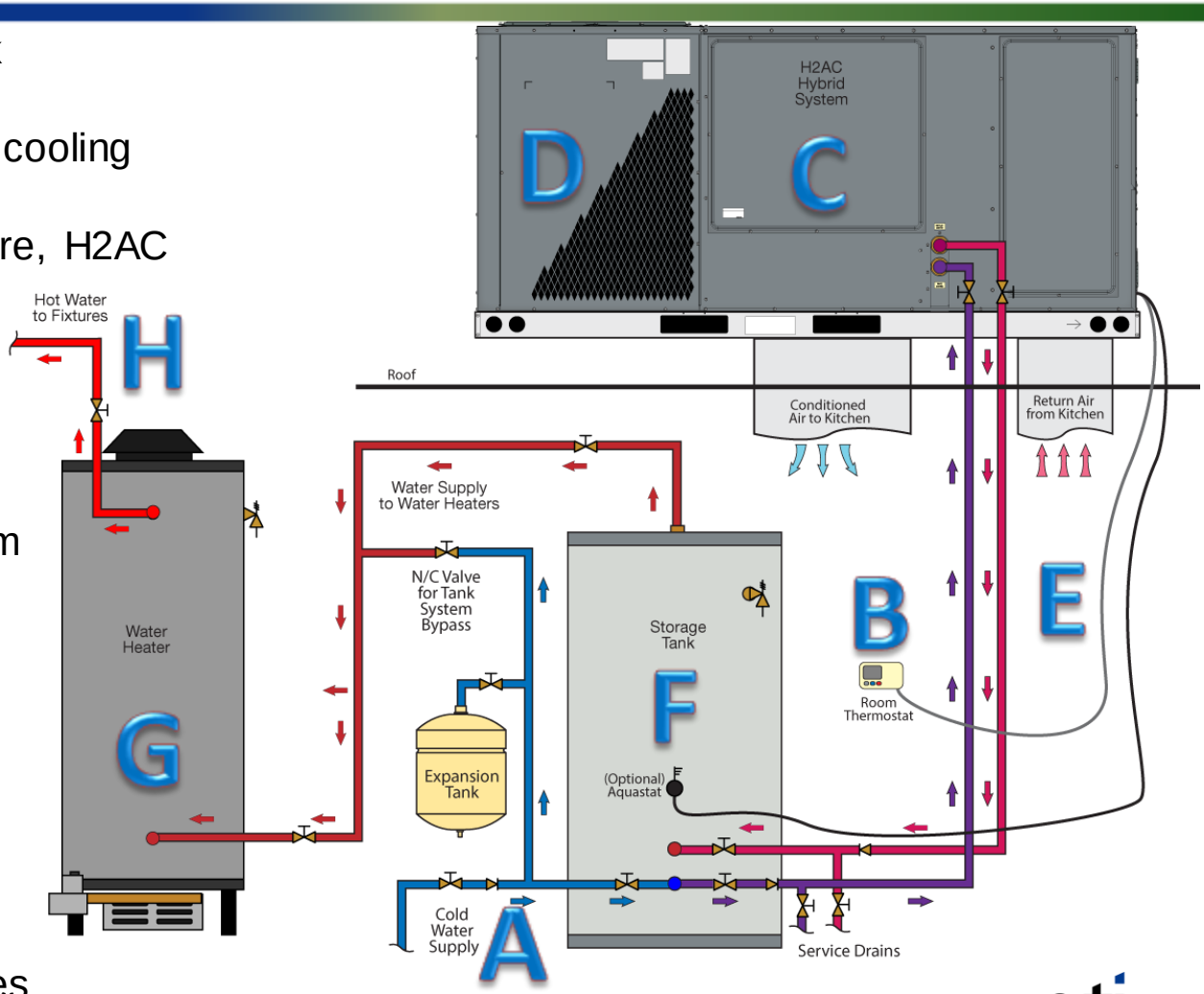
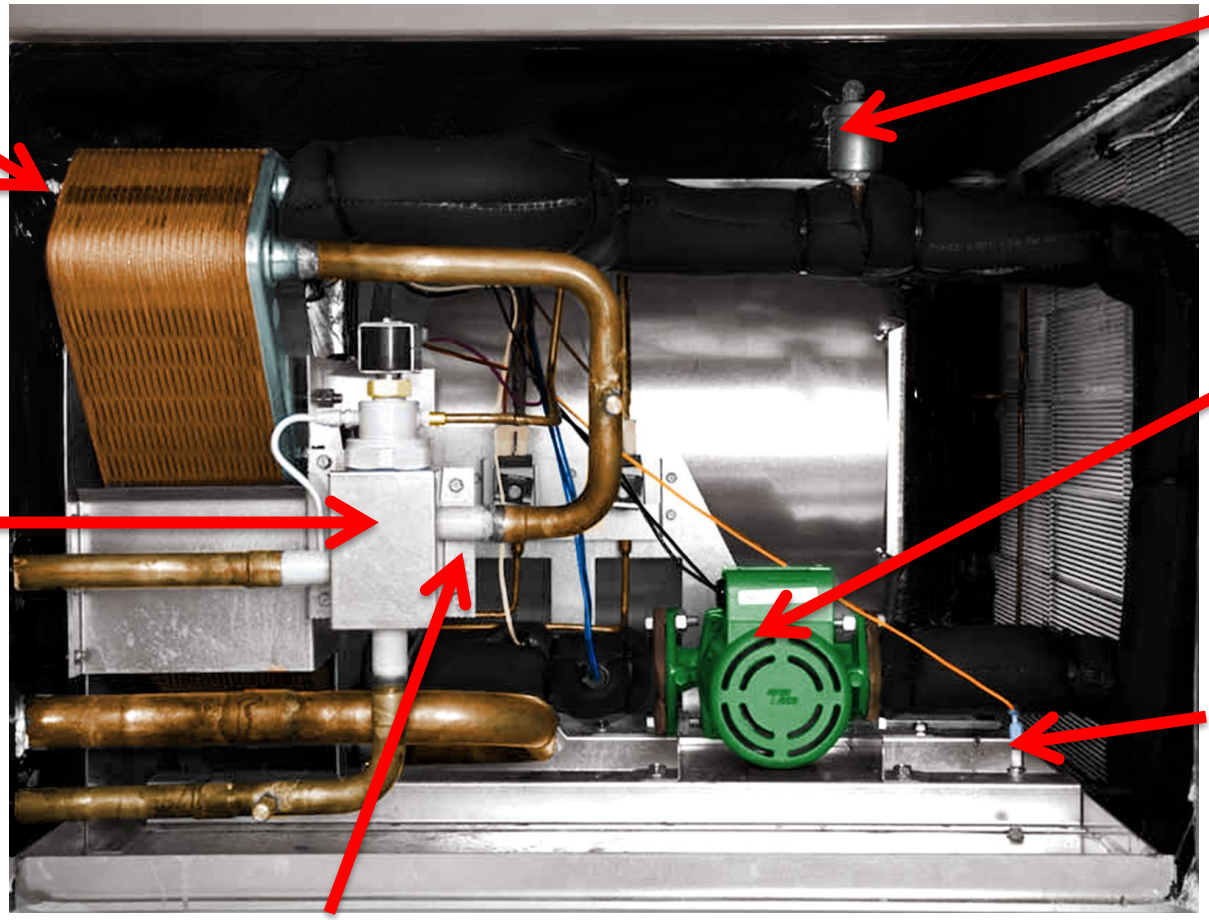


Photo source: Rheem

RTU-Integrated Approach



Refrigerant Transfer Controls For Return Oil Mode

Photo source: Rheem

Refrigeration Schematic

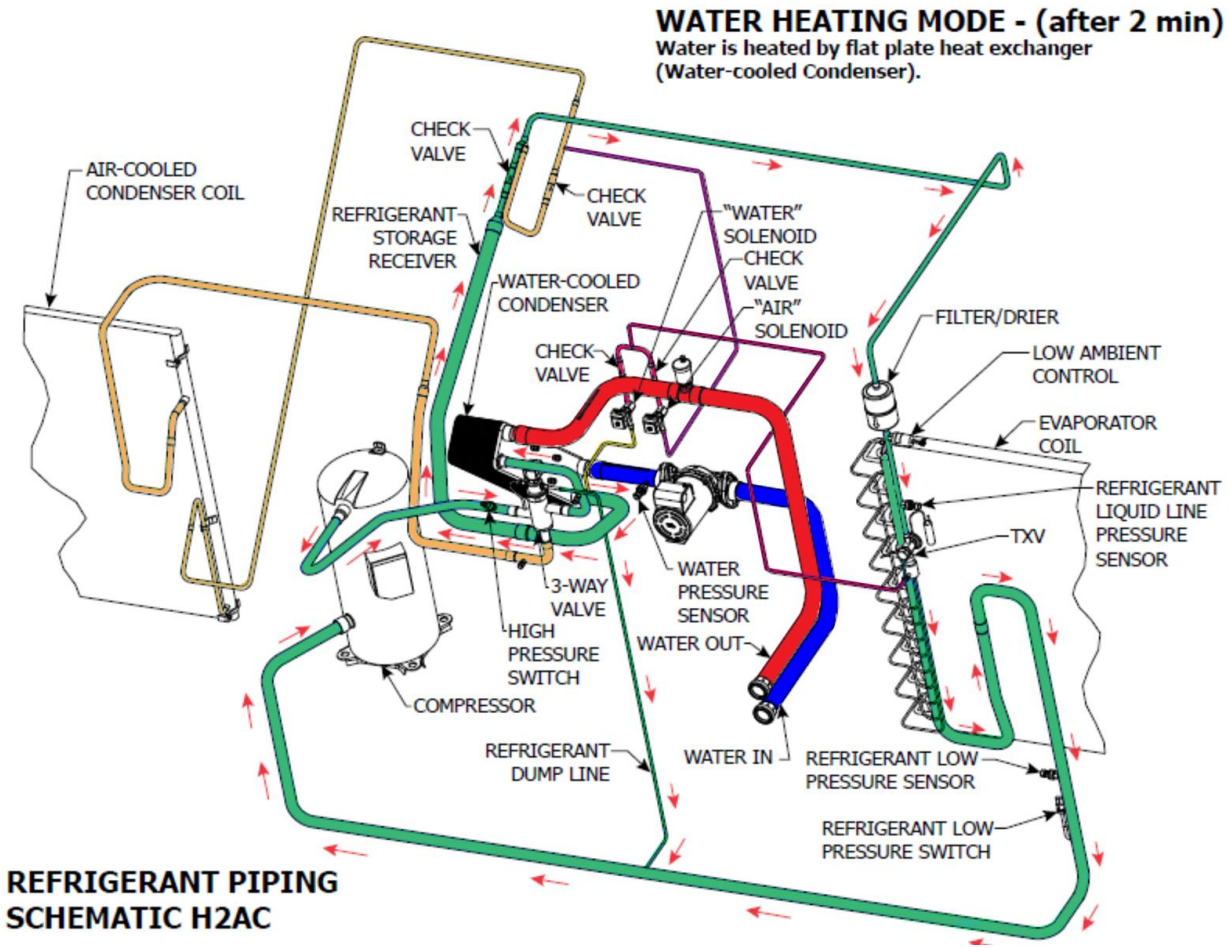


Photo source: Rheem

Technology Status

- **Market Ready**
  - H2AC RTU manufactured by Rheem
    - Factory assembled, installed, and leak checked
    - Integrated heat exchanger, water pump, and controls
  - Three ETP and GTI project demonstrations (3 sites)
  - Three SoCal Gas technology assessments (3 sites)
  - Rheem has several demonstration sites and is very committed to product
- Cooling-Dominated Climates (1800 CDD+ year)
- Target sites use 1,500 gallons hot water or more per day:
  - Restaurants, food processing, health clubs, hotels, assisted

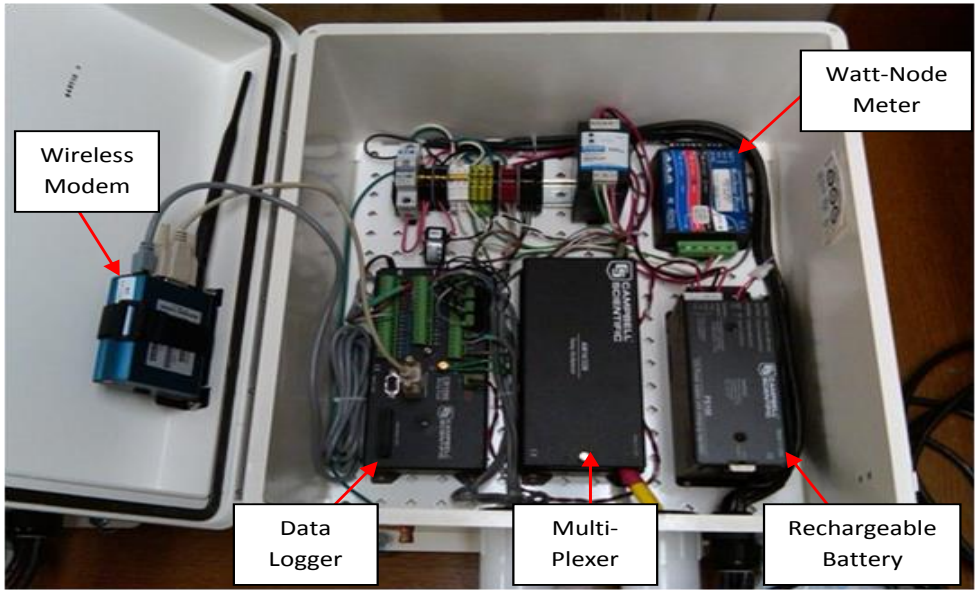
Photos provided by Rheem

Research Goals

- **System Performance:** How does the H2AC delivered efficiency vary with hot water usage patterns and ambient temperature/humidity? At full and part-load operation?
- **Economic Savings:** What are the actual energy savings and installed costs, and what is the ROI?
- **Market Barriers:** What are the market barriers to widespread adoption of the technology?
- **Project Funders:** Alagasco Gas, American Public Gas Association - Research Foundation, and San Diego Gas & Electric.

GTI Monitoring Approach

- Campbell Scientific CR1000 (pictured)
- Data was collected at one-minute intervals
- Available Remotely and Downloaded weekly
- Five Water Temperature Probes
- Two Water Flow Meters
- One Natural Gas Meter
- Two Electric Meters
- Three Barometric Pressure Transducers
- Three Air Temperature / RH probes
- Two duct differential Pressure Transmitters (for CFM)



Installation & Equipment Costs

ETP
Emerging Technology Program

	15 ton system with 120 gallon storage tank	10 ton system with 120 gallon storage tank	Baseline 15 ton RTU	Baseline 10 ton RTU
H2AC RTU w/gas heating (material only)	$13,717	$11,913	$11,400	$7,900
Curb adapter (material only)	$1,100	$900	$1,100	$900
Rigging/placing/reconnecting power and gas*	$3,300	$2,800	$3,300	$2,800
Storage tank (material only)	$1,100	$1,100	$0	$0
Rigging/placing storage tank*	$500	$500	$0	$0
Water piping and accessories (material only)*	$2,000	$2,000	$0	$0
Plumbing labor*	$1,500	$1,500	$0	$0
Annual Maintenance Costs*	$600	$600	$600	$600
Estimated total	**$23,817**	**$21,313**	**$16,400**	**$12,200**

*These are estimates and should be used for discussion purposes only. Actual costs will vary by site and contractor.

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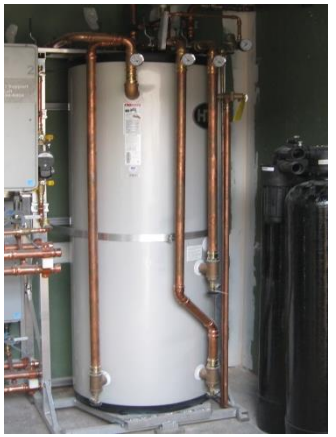
Oxford, AL Host Site

- Full Service National Chain Restaur that serves 285 meals per day
- 5,000 ft^2
- 10-ton RTU (Single-Stage System)
- 115 Gallon Storage Tank
- Baseline Water Heater: Four (4) Condensing Tankless
- Average Daily Water Usage: 1400 GPD
- 140°F Water Set Point
- Heat Transfer Fluid: Water
- Monitored 5/14 to 5/15
- ~35% hot water energy savings

Madison, AL Host Site



- Full Service National Chain Restaurant that serves 525 meals per day
- 6,000 ft^2
- 15-ton RTU (Two-Stage System)
- 119 Gallon Storage Tank
- Baseline Water Heater: Four (4) Condensing Tankless
- Average Daily Water Usage: 1750 GPD
- 140°F Water Set Point
- Heat Transfer Fluid: Glycol / Water Mixture
- Monitored 8/14 – 9/15
- ~25% hot water energy savings

Laguna Hills Host Site

- Full Service National Chain Restaurant that 475 dinner-only meals per day
- 6,000 ft^2
- 10-ton RTU (Two-stage System)
- 80 Gallon Storage Tank
- Baseline water heater: Storage tank
- Average Daily Water Usage: 1300 GPD
- 140°F Water Set Point
- Heat Transfer Fluid: Water
- Monitored 11/14 – 12/15
- ~30% hot water energy savings

Host / Contractor Feedback

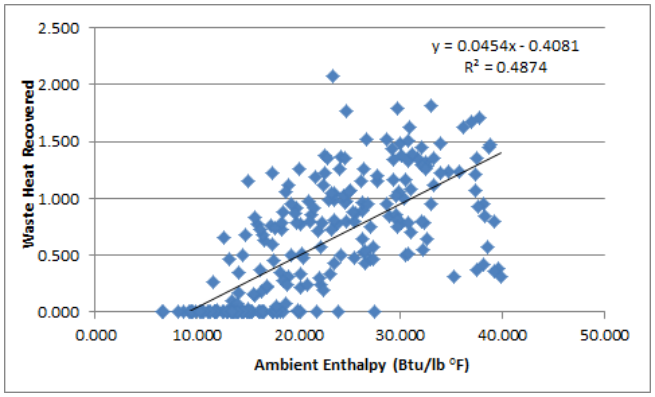
- Host sites had very positive experiences, and they would purchase the system, if competitively priced. No major issues or service calls.
- Contractors would recommend the product to their customers.
- Running water lines to/from the RTU is not an issue. The incremental cost of the system, and the location of the storage tank are the challenges to installation.
- Inspector may be unfamiliar with the technology, which will delay an installation and add cost. A best practice is to have a pre-meeting with the municipality and have plans approved.
- Contractors find out about new products from:
  - Supply house salesforce newsletters or luncheons
  - ASHRAE Tradeshows, emails, and literature from trade magazines.
  - Host sites find out about products directly from utilities.

Field Performance

Savings	Oxford, AL 10 ton RTU		Madison, AL 15 ton RTU		Laguna Hills, CA 10 ton RTU	
Baseline Water Heater	Tank	Cond. Tankless	Tank	Cond. Tankless	Tank	Cond. Tankless
Incremental Cost	$9,113		$7,417		$9,113	
2014 Local Nat. Gas ($/Therm)*	1.19		1.19		.83	
Electric Prices ($/kWh)*	0.11		0.11		0.13	
Water Usage (GPD)	1,386		1,723		1,210	
Annual Nat. Gas Savings (Therms)	1496	1054	2,359	1,723	1384	1009
Annual Savings (2014 Nt Gas Prices)	$1,784	$1,257	$2,812	$2,055	$1,144	$833
Annual Savings (Peak Nt Gas Prices)	$2,705	$1,906	$4,265	$3,115	$2,138	$1,557
Annual Electric Savings (kWh)	-1,101	-1,101	-679	-679	-1,481	-1,481
Emissions Savings (1000 lbs CO_2e)**	20.6	14.1	33.9	24.5	19.4	13.9
Simple Payback (2014 Nat Gas)	5.5	8.0	2.7	3.7	9.6	14.2
Simple Payback (Peak Nat Gas)	3.5	5.1	1.8	2.4	4.7	6.7

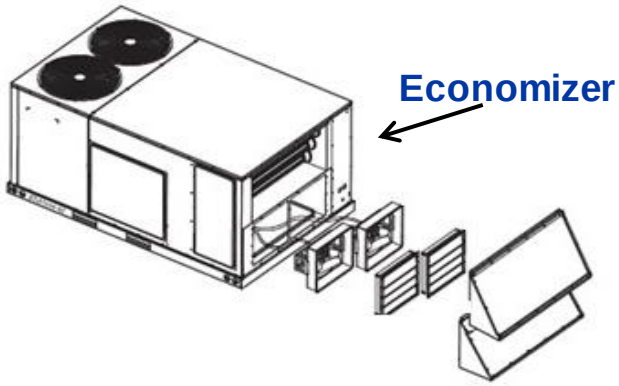
*Prices from the U.S. Energy Information Administration
**Calculated using state-level Carbon Management Information Center data

Performance and Savings Factors



- The largest factor on energy savings is ambient weather conditions (temperature & relative humidity, or enthalpy), as opposed to hot water usage.
- The systems have economizers, which are designed to save electricity during the cooler months.

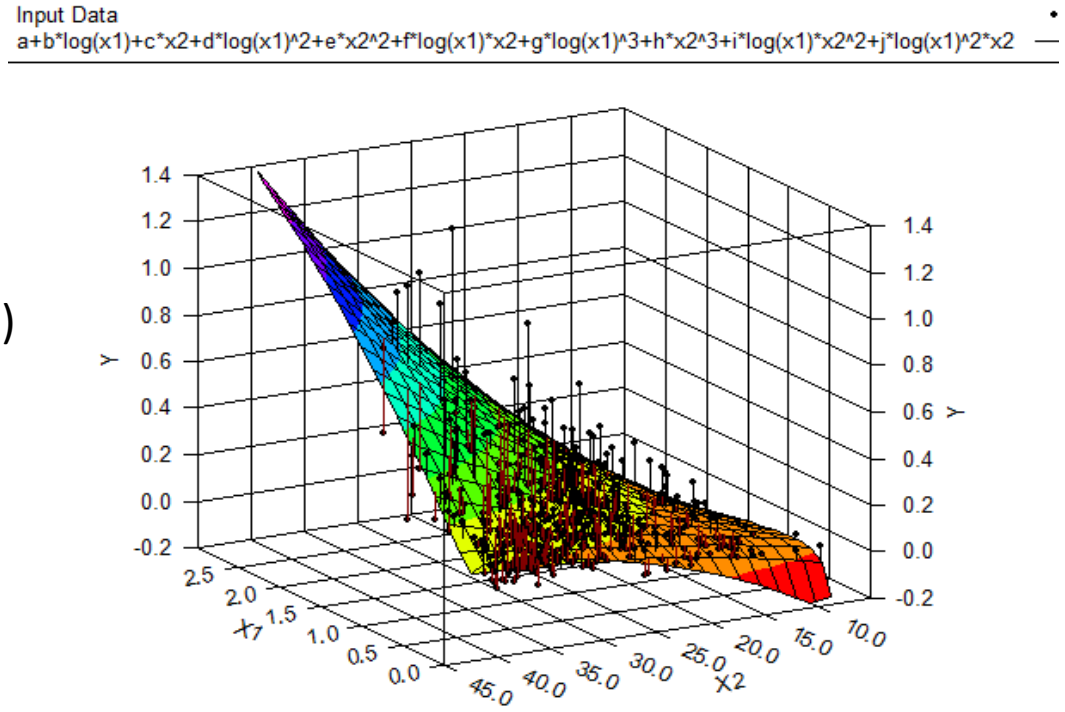
- With an economizer, the RTU continuously monitors indoor and outdoor air conditions (55°F or lower), and wherever possible opens dampers to allow outdoor air for ventilation and "free" cooling, in place of mechanical cooling. Waste heat recovery is available only when mechanical cooling is enabled.



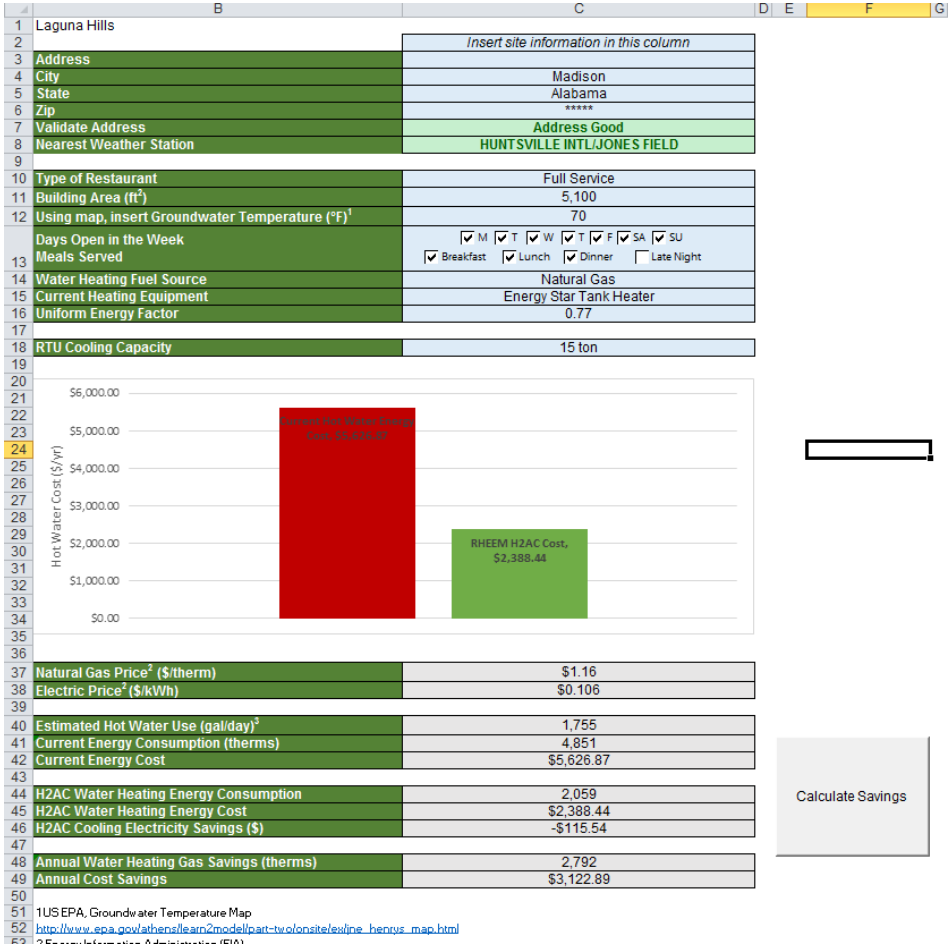
Energy Performance Model

Generated a polynomial function statistical model, using DataFit version 8.1 (Oakdale Engineering)

x1 = Daily Hot Water Load (MMBtu)
x2 = Daily Average Enthalpy (Btu/lb°F)
Y=Waste Heat Recovered (MMBtu)
r^2 = .59



H2AC Performance Calculator



1	Laguna Hills	
2		*Insert site information in this column*
3	**Address**	
4	**City**	Madison
5	**State**	Alabama
6	**Zip**	*****
7	**Validate Address**	**Address Good**
8	**Nearest Weather Station**	**HUNTSVILLE INTL/JONES FIELD**
9		
10	**Type of Restaurant**	Full Service
11	**Building Area (ft²)**	5,100
12	**Using map, insert Groundwater Temperature (°F)[1]**	70
13	**Days Open in the Week** **Meals Served**	☑ M ☑ T ☑ W ☑ T ☑ F ☑ SA ☑ SU ☑ Breakfast ☑ Lunch ☑ Dinner ☐ Late Night
14	**Water Heating Fuel Source**	Natural Gas
15	**Current Heating Equipment**	Energy Star Tank Heater
16	**Uniform Energy Factor**	0.77
17		
18	**RTU Cooling Capacity**	15 ton
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20		
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37	**Natural Gas Price[2] ($/therm)**	$1.16
38	**Electric Price[2] ($/kWh)**	$0.106
39		
40	**Estimated Hot Water Use (gal/day)[3]**	1,755
41	**Current Energy Consumption (therms)**	4,851
42	**Current Energy Cost**	$5,626.87
43		
44	**H2AC Water Heating Energy Consumption**	2,059
45	**H2AC Water Heating Energy Cost**	$2,388.44
46	**H2AC Cooling Electricity Savings ($)**	-$115.54
47		
48	**Annual Water Heating Gas Savings (therms)**	2,792
49	**Annual Cost Savings**	$3,122.89
50		
51	1US EPA, Groundwater Temperature Map	
52	http://www.epa.gov/athens/learn2model/part-two/onsite/esoline_henrys_map.html	

- User-Friendly Excel-Based Calculator to estimate performance across many climates, hot water loads, and baseline equipment scenarios.
- Estimates restaurant's hot water load
- Looks up Typical Meteorological Year (TMY) climate data, based on address.
- User inputs baseline equipment
- Limited to the loads and ambient conditions seen in the field. Extreme conditions are outside of model.

Performance Estimates

Performance Estimates Using the Calculator modeled the performance at four locations:

1. Tampa, FL
2. Birmingham, AL
3. Laguna Hills, CA
4. El Cajon, CA

Assumptions:

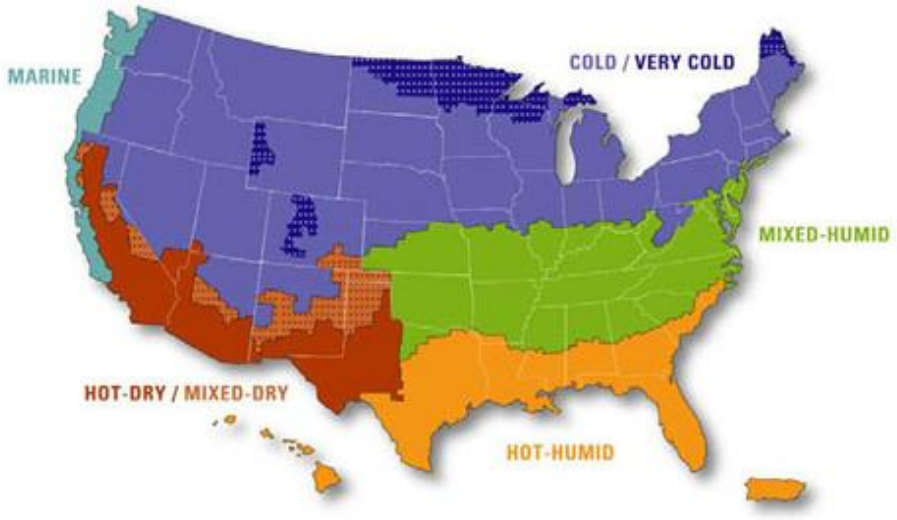
- 15-Ton System
- 1,750 GPD hot water use
- TMY Climate Data
- Baseline 100 Gallon Tank-Type Water Heater
- Natural Gas prices of $1 / therm

- Simple paybacks were less than 3 years in all four locations

Photo source: Rheem

Performance Conclusions

>The systems provided significant energy savings (between 25 – 35 percent). Simple paybacks were 5 years or less under most scenarios.
>Both contractors and host sites would recommend the technology.
>Climates
    >Hot-Humid; Hot-Dry / Mixed Dry; and Mixed-Humid Climates
>Target Sites use 1500 GPD+ hot water
    >food processing, laundromats, health clubs, hotels, and assisted living
> Ways to increase market share
    >Create model incentives program and/or energy efficiency rebates
    >Utility and supply house salesforce to get the word out to customers about the H2AC



Map Source: U.S. Department of Energy Building America Program. (2010). "Guide to Determining Climate Region by County", Prepared by PNNL and ORNL, Report No. PNNL-17211.

Questions?

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