ABSTRACT:
Affiliated Engineers, Inc. (AEI) is designing a new 386,000 square foot facility for the California Air Resources Board (CARB) in Riverside, CA. The building will house engine and chassis test cells, chemistry labs, and multiple floors of offices. Delivered under a design-build, stipulated sum delivery approach, the building is slated to achieve on-site zero net energy (ZNE), LEED Platinum, and CALGreen Tier 2. ZNE is achieved through onsite energy generation (3.5+ MW of solar panels) and by using 57°F chilled water to serve most of the building loads. Use of 57°F chilled water is made possible by: the higher-temperature, sensible-only loads of the test cell; applying active chilled beams in the chemistry lab and office areas; and using pre-cooling, sensible-only "dual coils" in most air handlers. Furthermore, because of the dry climate, hybrid fluid coolers can operate in water-side economizer to generate the 57°F chilled water for approximately 60% of the year. Traditional 42°F chilled water and low-temperature 36°F chilled water (no glycol) are generated for dehumidification and process loads respectively. Redundancy is achieved by interconnecting all chilled water types, allowing water to pass between four distinct circuits. All chillers use low-GWP, HFO refrigerants.

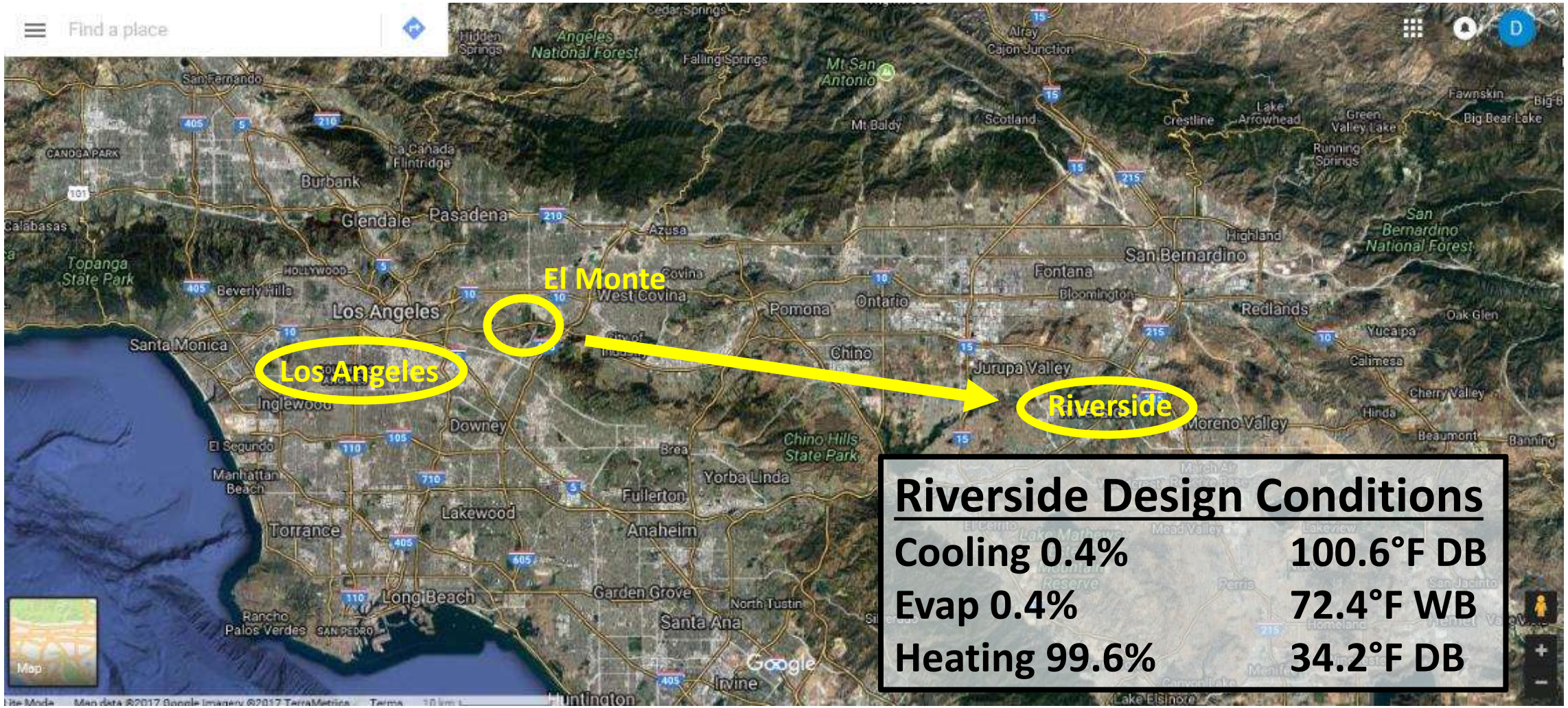
Achieving Zero Net Energy with 57°F CHW and On-Site Energy Generation

Brett Friedman, PE
Affiliated Engineers, Inc.

Garrett Roberts
Trane

California Air Resources Board (CARB)

Location



Riverside Design Conditions

Cooling 0.4%	100.6°F DB
Evap 0.4%	72.4°F WB
Heating 99.6%	34.2°F DB

Metrics

Ken Calvert, Mark Takano, Mark DeSaulnier and 6 others

1 29 40

Mary Nichols @MaryNicholsCA · Oct 27

Single largest #netzero energy structure in US, new state-of-the-art SoCal HQ builds on the legacy of #HaagenSmit lab & will provide CARB with tools & technology to continue to lead the #cleanair fight for generations to come! #CARB50 buff.ly/2y9ZWaU

- $368 Million
- 18.8 Acre Site
- 380,000 ft^2
- 3.5+ MW Solar Panels
- 1.5 MWh Battery
- 120 Vehicle Chargers
- **Largest ZNE in US**

* PV for future expansion indicated in aerial view.

ZNE

Analysis & Solutions

Keep it Simple and Smart

ZNE: Keep it Simple and Smart

- Technologies Considered
  - Hybrid 57°F Free Cooling
  - Dual Coils
  - De-coupled Dehumidification
  - Chilled Beams
  - Heat Recovery Chillers
  - Evaporative Humidification
  - Energy Recovery Wheels
  - Demand Ventilation Control
  - Geoexchange (Geothermal)
  - Natural Ventilation
  - VRF (Variable Refrigerant Flow)
  - Displacement Air Ventilation
  - Fuel Cells
  - Thermal Energy Storage Tank
  - Absorption Chillers
  - Radiant Floors / Ceilings / Walls

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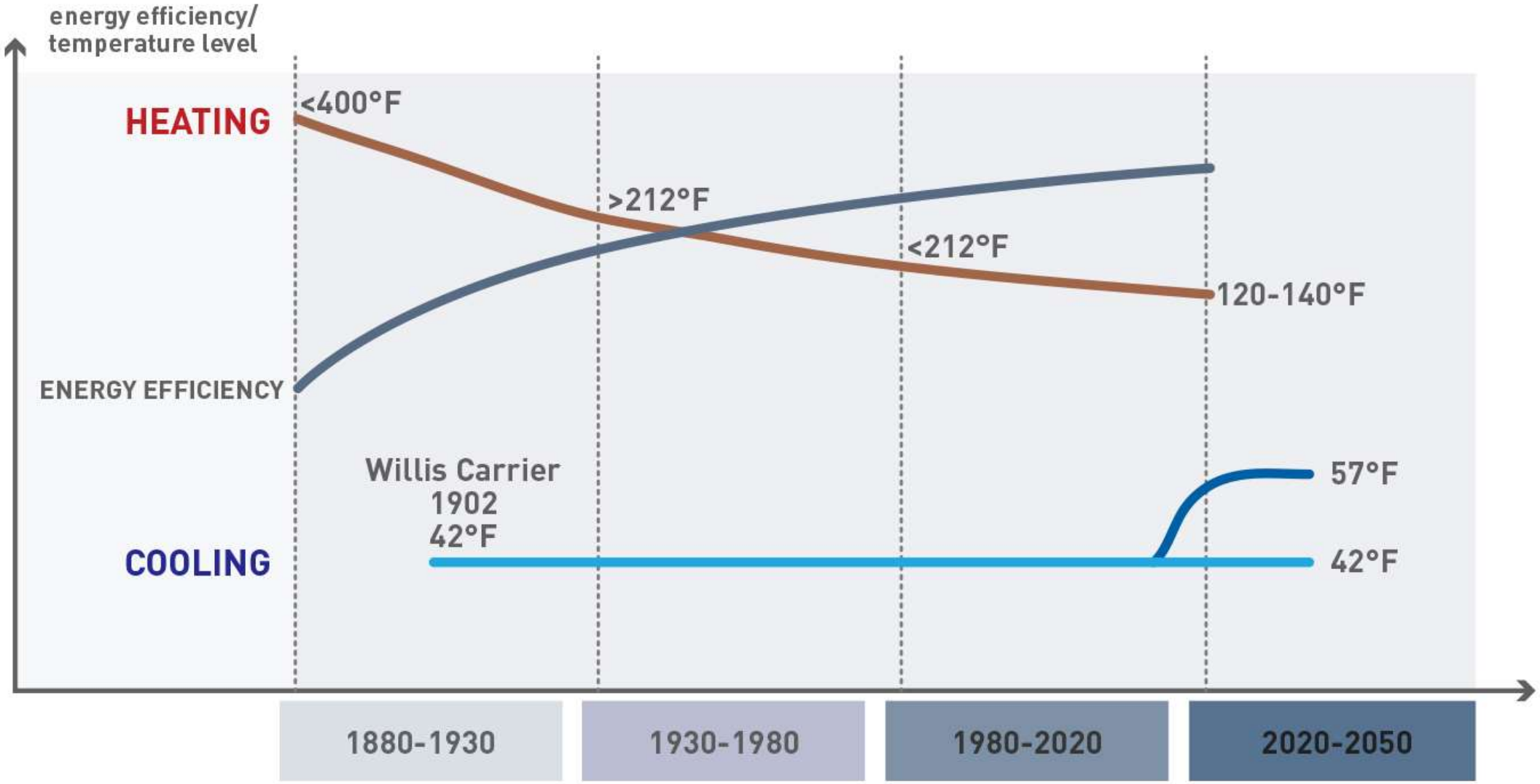
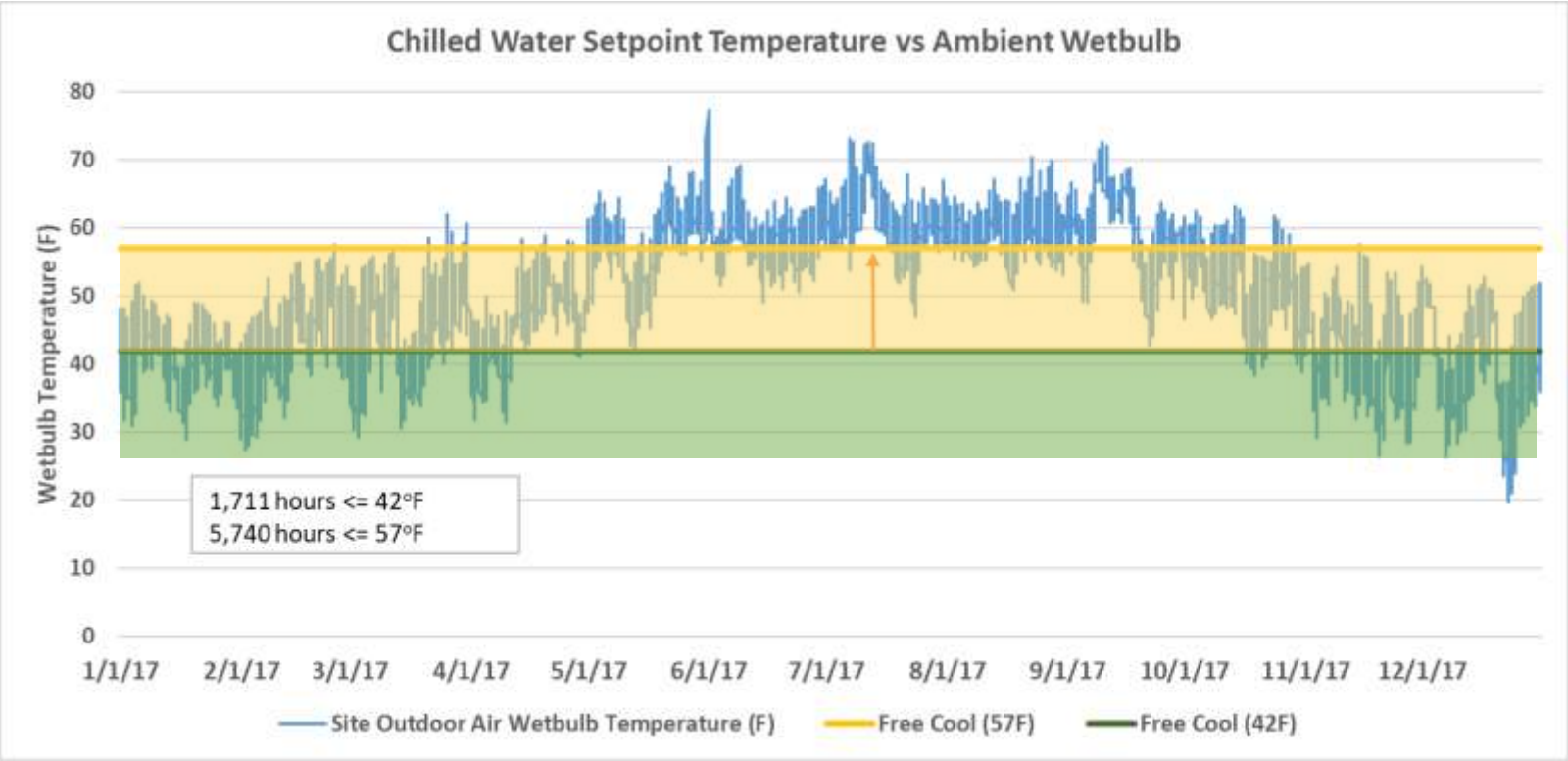
57°F

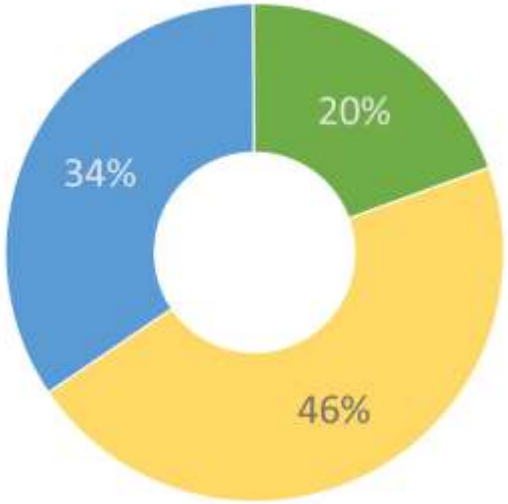
Waterside Economizer
Low Entropy
Hybrid Free Cooling

ZNE: Keep it Simple and Smart

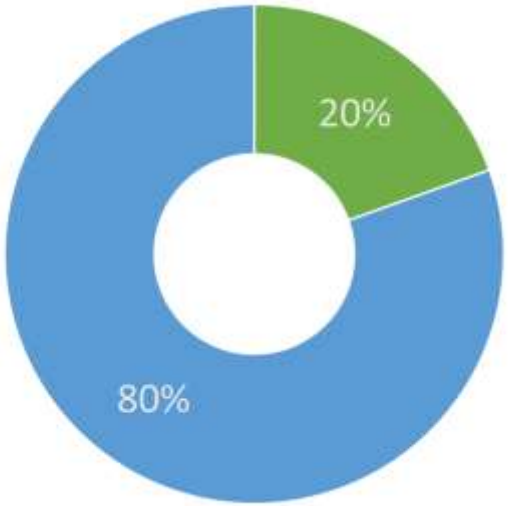


Waterside Economizer:
Free cooling potential 42°F vs 57°F





66% of hours with 57°F setpoint



20% of hours with 42°F setpoint

ZNE: Keep it Simple and Smart

57°F

Who Can Use It?

Dry Climates
Cool Climates
Low Dewpoints

How Do We Make It?

Waterside Economizer
Hybrid Fluid Coolers
Low-Lift Chillers
Control Strategy

Where Do We Use It?

Everywhere We Can

How Do We Use It?

Process & Sensible Loads

Pre-cooling & Decoupled Dehumidification

Partial Loads

Waterside Economizer:
Who Can Use It?

Riverside, CA
Evap 0.4%
WB = 72.4°F

Hours ≤ 57°F = 66%
Hours ≤ 50°F = **45%**

Seattle, WA
Evap 0.4%
WB = 66.5°F

Hours ≤ 57°F = 88%
Hours ≤ 50°F = **61%**

Denver, CO
Evap 0.4%
WB = 64.9°F

Hours ≤ 57°F = 89%
Hours ≤ 50°F = **72%**

El Paso, TX
Evap 0.4%
WB = 70.3°F

Hours ≤ 57°F = 72%
Hours ≤ 50°F = **55%**

Kansas City, MO
Evap 0.4%
WB = 79.7°F

Hours ≤ 57°F = 61%
Hours ≤ 50°F = **52%**

Columbus, OH
Evap 0.4%
WB = 76.7°F

Hours ≤ 57°F = 67%
Hours ≤ 50°F = **54%**

New York City, NY
Evap 0.4%
WB = 77.2°F

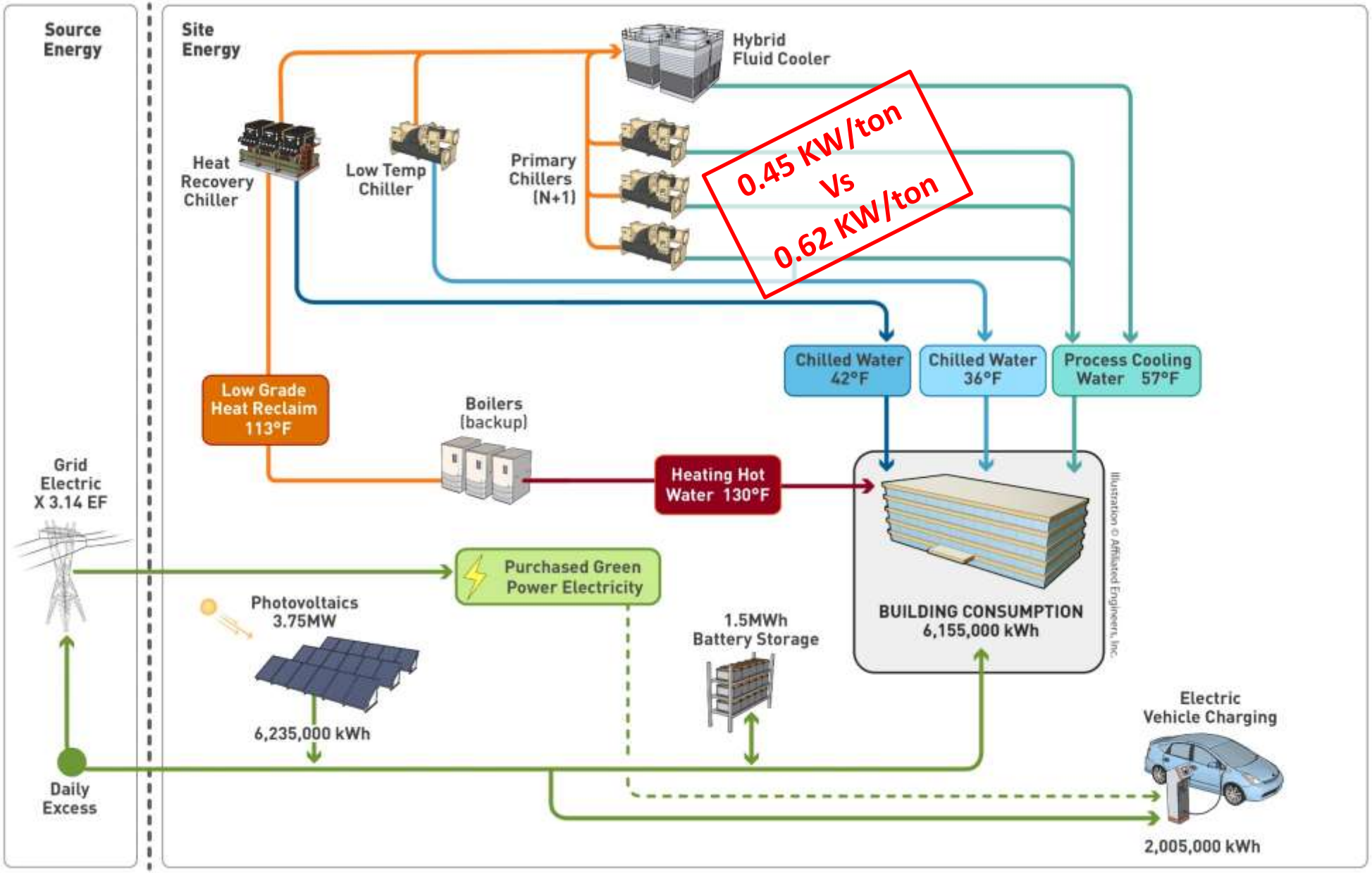
Hours ≤ 57°F = 66%
Hours ≤ 50°F = **55%**

Baltimore, MD
Evap 0.4%
WB = 78.1°F

Hours ≤ 57°F = 62%
Hours ≤ 50°F = **51%**

Waterside Economizer:

How Do We Make It?



Waterside Economizer:
Where Do We Use It?

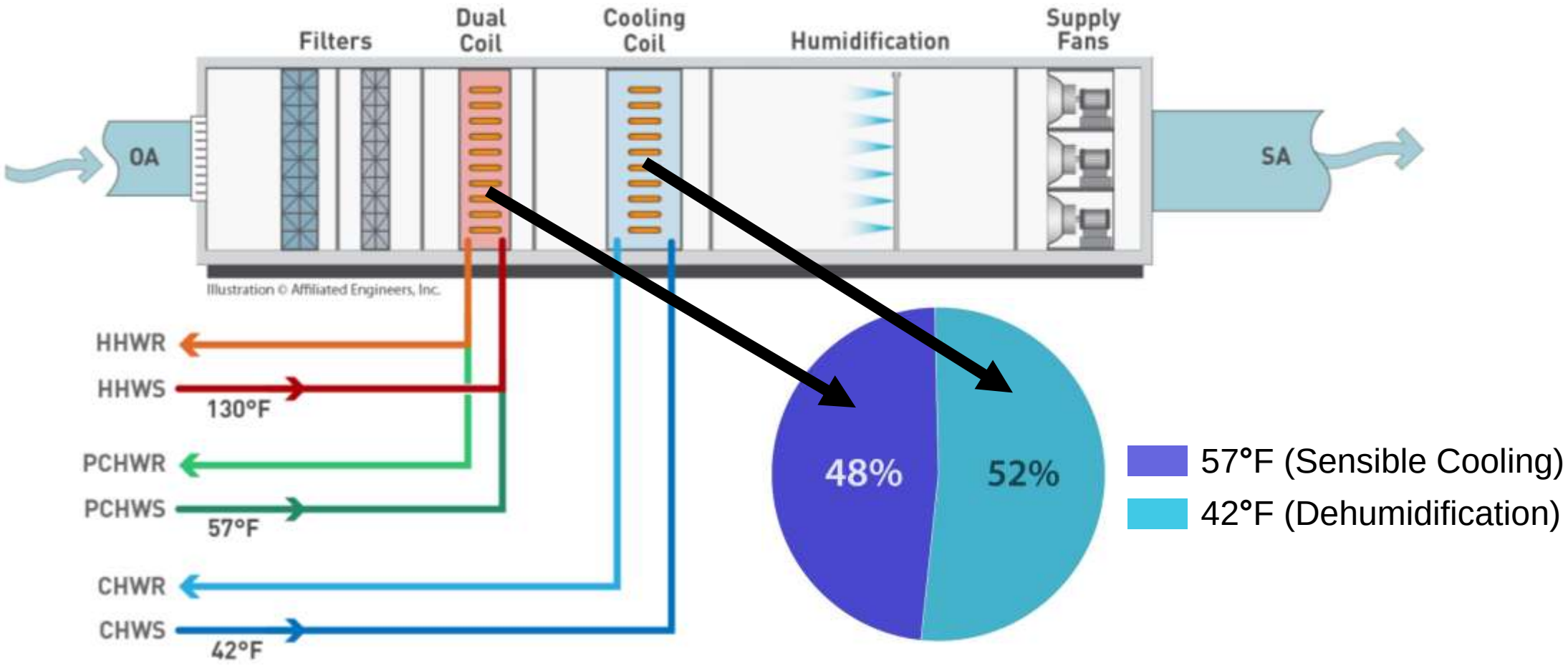
- RFP

57°F / 42°F
42°F

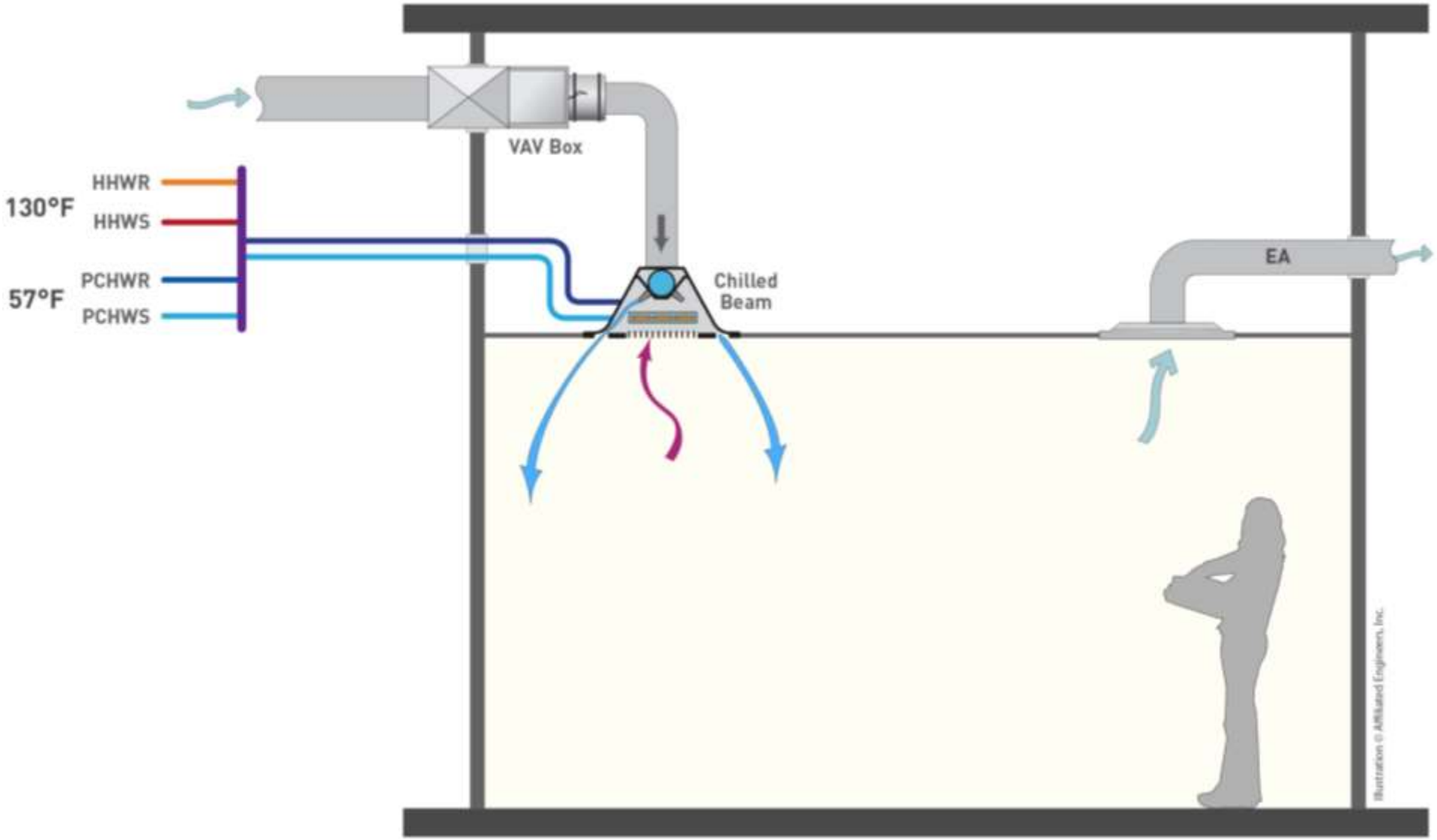
- Winning Design:

57°F / 42°F
42°F

Waterside Economizer:
How Do We Use It? – Dedicated Outside Air System (DOAS)

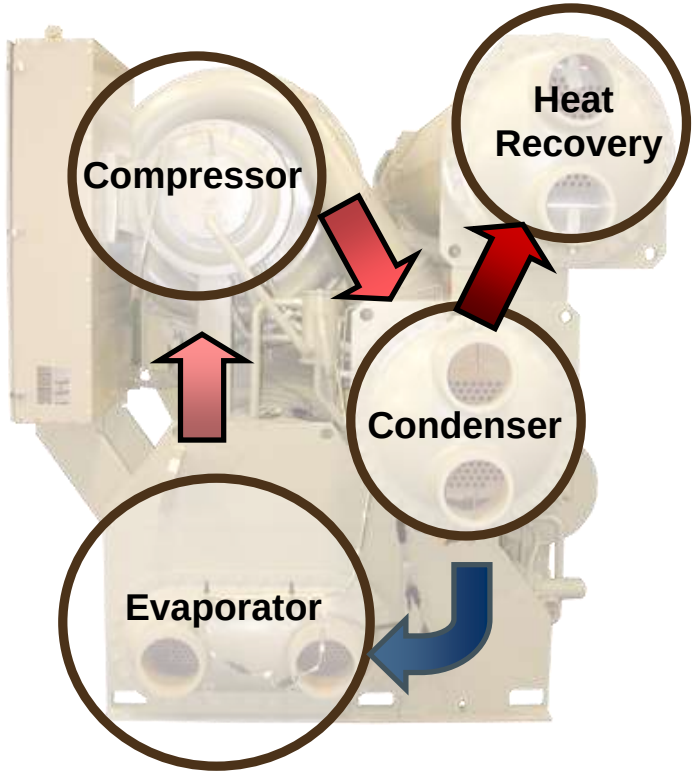


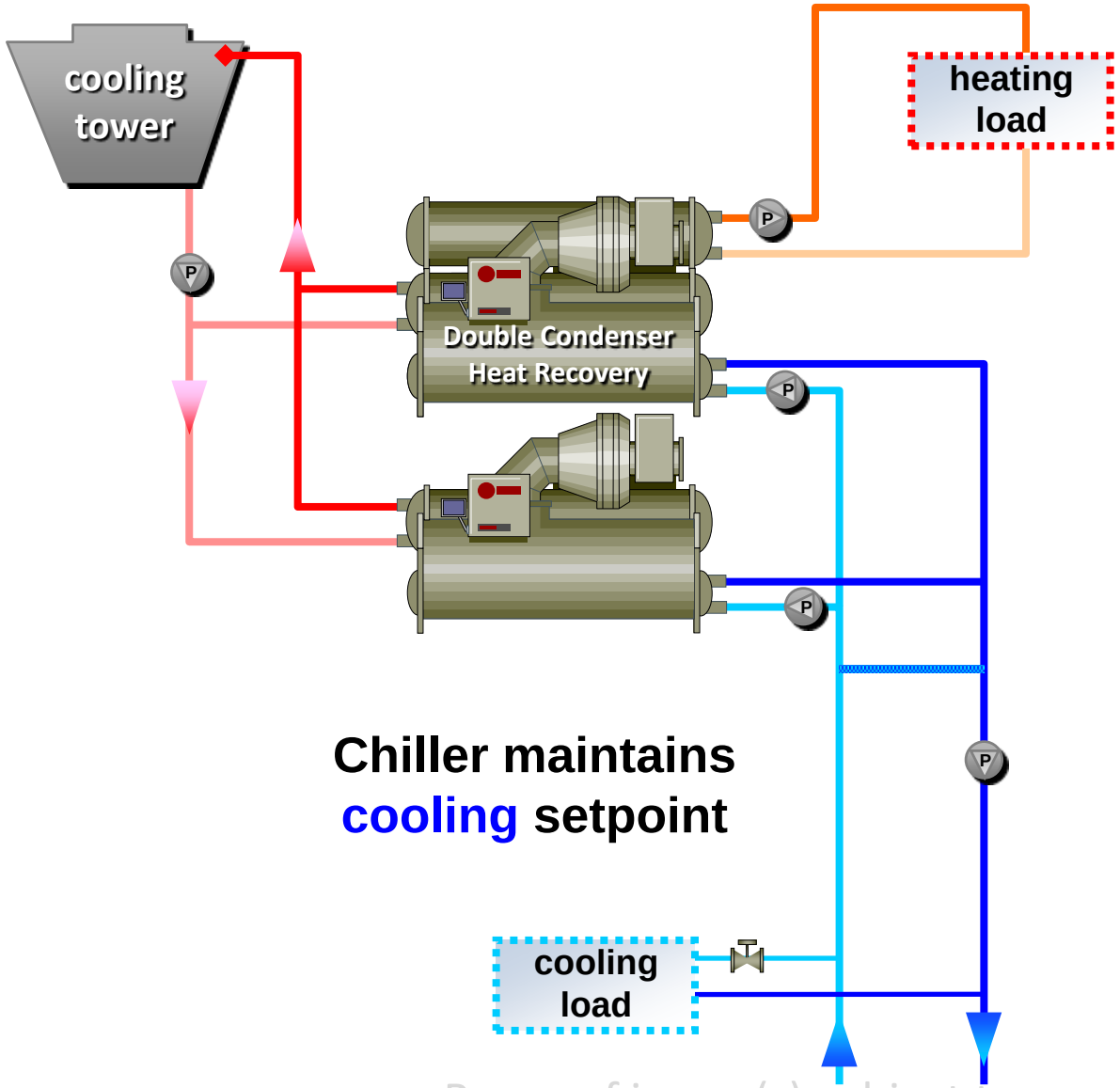
Waterside Economizer:
How Do We Use It? – Chilled Beams



Heat Recovery Chillers:
Operation

Standard Cooling with Dual Condensers

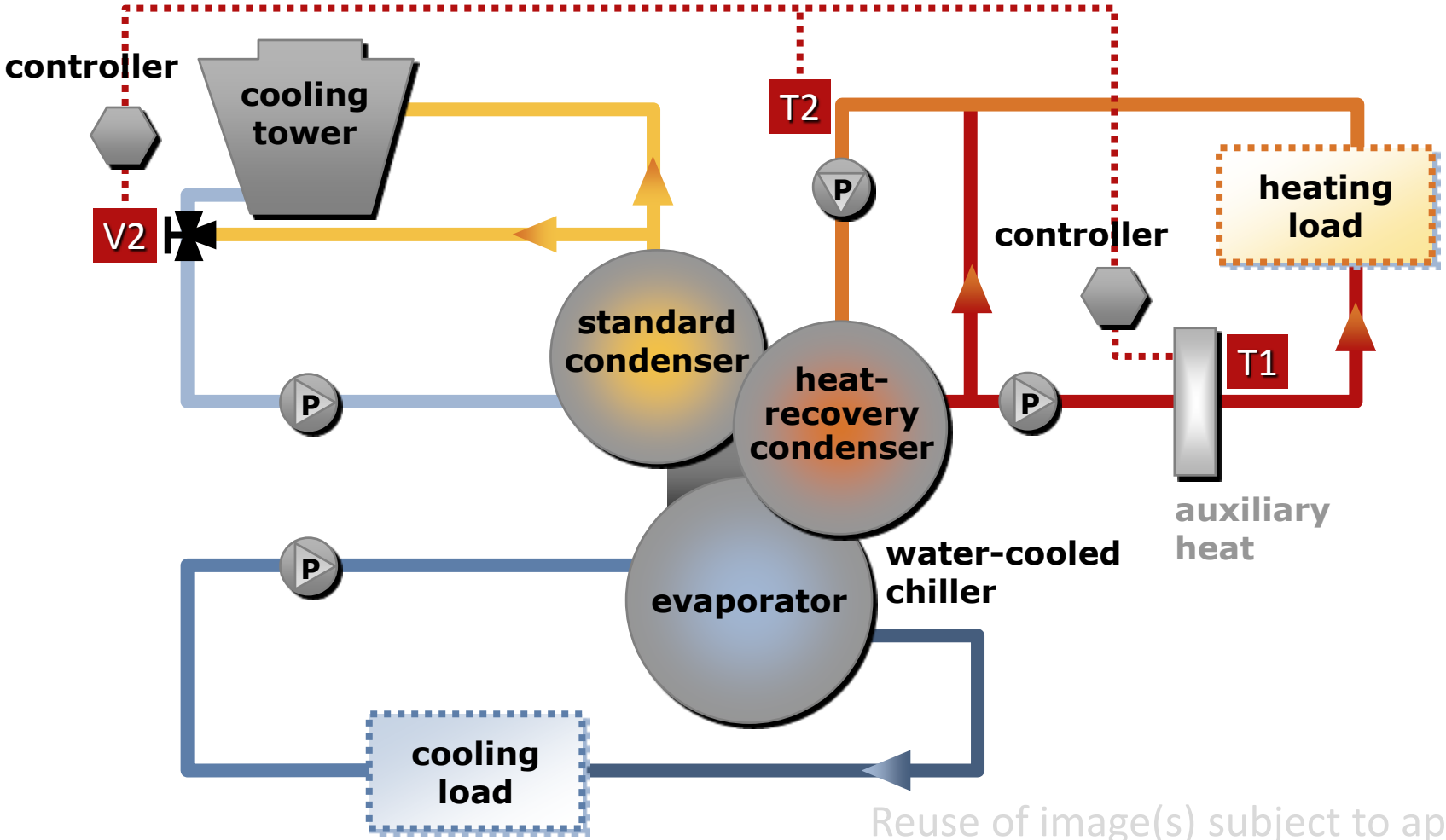




Chiller maintains cooling setpoint

Heat Recovery Chillers:
Control

Modulate Heat Rejection

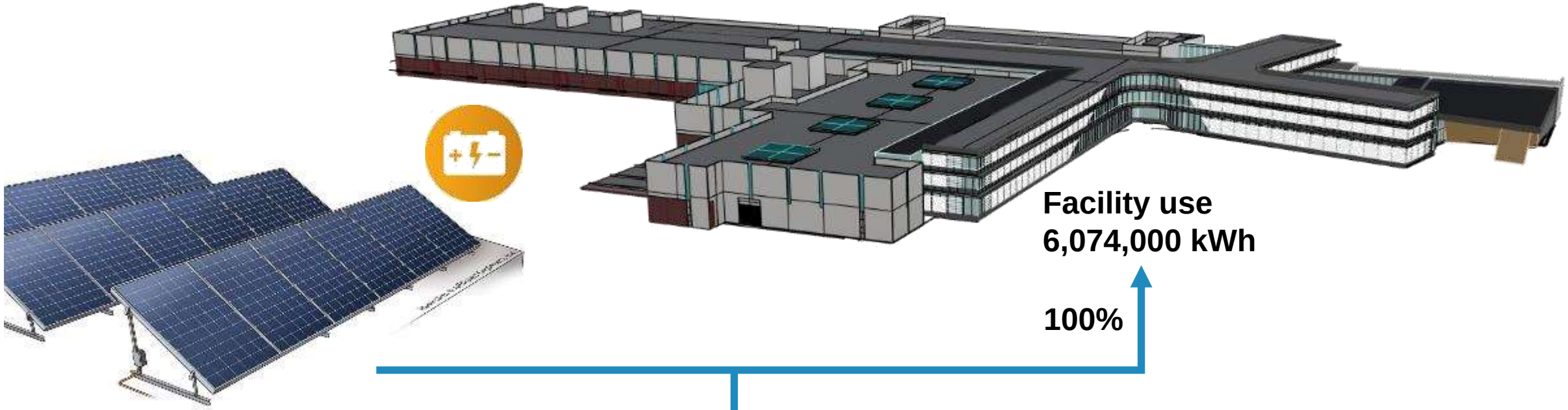


HFO Refrigerants:
Choices & Comparisons

Current	Transitional	Next-Gen

	Low Pressure			Medium Pressure			
	R-123	R-1233zd	R-514A	R-134a	R-513A	R-1234yf	R-1234ze
Flammability	Non (1)	Non (1)	Non (1)	Non (1)	Non (1)	Slight (2L)	Slight (2L)
Toxicity	Higher (B)	Lower (A)	Higher (B)	Lower (A)	Lower (A)	Lower (A)	Lower (A)
Fluid Efficiency	9.4 COP	9.3 COP	9.4 COP	8.5 COP	8.3 COP	8.2 COP	8.5 COP
Capacity Change	1	35% Gain	Same	1	Same	5% Loss	25% Loss
GWP	79	1	< 2	1300	573	1	1

On-Site Energy Generation:
Facility & EV Charging



Facility use
6,074,000 kWh

100%

6%

On-site PV
6,200,000 kWh

94%

EV charging
2,005,000 kWh

Purchase Green Power
1,879,000 kWh

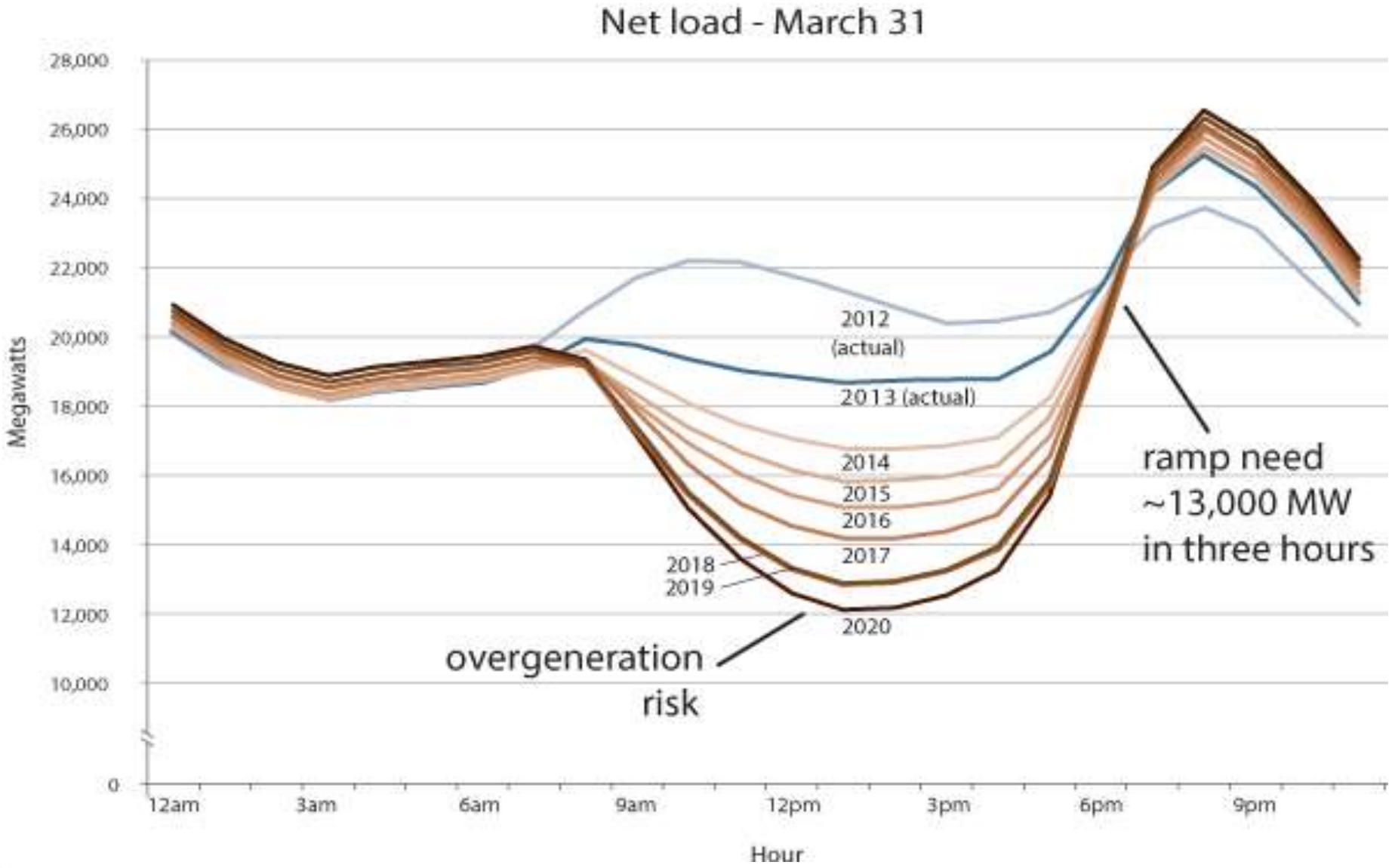
Additional Technologies Considered:
Demand Management

TES
- $24,000 / year demand savings
- $13,000 / year energy savings
- 40 year simple payback
- Provides some redundancy

1.5 MWh Battery
- $58,000 / year demand savings
- $0 / year energy savings
- 26 year simple payback
- Flexible demand reduction

Add 300 kW PV
- $14,800 / year demand savings
- $58,300 / year energy savings
- 9 year simple payback
- On-site ZNE

Thermal Energy Storage:
Future of Energy Rates and Demand Charges



TRANE AEI Affiliated Engineers

Thermal Energy Storage:
Time and Place

Construction Has Begun!