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

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California Air Resources Board (CARB)
Location

Riverside Design Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>0.4%</td>
<td>100.6°F DB</td>
</tr>
<tr>
<td>Evap</td>
<td>0.4%</td>
<td>72.4°F WB</td>
</tr>
<tr>
<td>Heating</td>
<td>99.6%</td>
<td>34.2°F DB</td>
</tr>
</tbody>
</table>
Metrics

- $368 Million
- 18.8 Acre Site
- 380,000 ft²
- 3.5+ MW Solar Panels
- 1.5 MWh Battery
- 120 Vehicle Chargers
- Largest ZNE in US
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

- **HEATING**
  - <400°F
  - >212°F
  - <212°F
  - 120-140°F

- **COOLING**
  - Willis Carrier 1902: 42°F
  - 57°F
  - 42°F

- **ENERGY EFFICIENCY**

- **Time Periods**
  - 1880-1930
  - 1930-1980
  - 1980-2020
  - 2020-2050
Waterside Economizer:
Free cooling potential 42°F vs 57°F

66% of hours with 57°F setpoint
20% of hours with 42°F setpoint

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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?

<table>
<thead>
<tr>
<th>City</th>
<th>Evap 0.4%</th>
<th>WB</th>
<th>Hours ≤ 57°F</th>
<th>Hours ≤ 50°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverside, CA</td>
<td>Evap 0.4%</td>
<td>WB = 72.4°F</td>
<td>66%</td>
<td>45%</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>Evap 0.4%</td>
<td>WB = 66.5°F</td>
<td>88%</td>
<td>61%</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>Evap 0.4%</td>
<td>WB = 64.9°F</td>
<td>89%</td>
<td>72%</td>
</tr>
<tr>
<td>El Paso, TX</td>
<td>Evap 0.4%</td>
<td>WB = 70.3°F</td>
<td>72%</td>
<td>55%</td>
</tr>
<tr>
<td>Kansas City, MO</td>
<td>Evap 0.4%</td>
<td>WB = 79.7°F</td>
<td>61%</td>
<td>52%</td>
</tr>
<tr>
<td>Columbus, OH</td>
<td>Evap 0.4%</td>
<td>WB = 76.7°F</td>
<td>67%</td>
<td>54%</td>
</tr>
<tr>
<td>New York City, NY</td>
<td>Evap 0.4%</td>
<td>WB = 77.2°F</td>
<td>66%</td>
<td>55%</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>Evap 0.4%</td>
<td>WB = 78.1°F</td>
<td>62%</td>
<td>51%</td>
</tr>
</tbody>
</table>

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Waterside Economizer:
How Do We Make It?

0.45 kW/ton vs 0.62 kW/ton
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)

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Waterside Economizer:
How Do We Use It? – Chilled Beams
Heat Recovery Chillers: Operation

Standard Cooling with Dual Condensers

Chiller maintains cooling setpoint

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Heat Recovery Chillers: Control

Modulate Heat Rejection

controller
cooling tower
V2

standard condenser
heat-recovery condenser
P

water-cooled chiller
evaporator

cooling load

heating load
controller
P

T1

auxiliary heat

T2
P

cooling tower

P

heat-recovery condenser

standard condenser

P

cooling load

P

controller

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## HFO Refrigerants: Choices & Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Low Pressure</th>
<th>Medium Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flammability</strong></td>
<td>Non (1)</td>
<td>Non (1)</td>
</tr>
<tr>
<td><strong>Toxicity</strong></td>
<td>Higher (B)</td>
<td>Lower (A)</td>
</tr>
<tr>
<td><strong>Fluid Efficiency</strong></td>
<td>9.4 COP</td>
<td>9.3 COP</td>
</tr>
<tr>
<td><strong>Capacity Change</strong></td>
<td>1</td>
<td>35% Gain</td>
</tr>
<tr>
<td><strong>GWP</strong></td>
<td>79</td>
<td>1</td>
</tr>
</tbody>
</table>
On-Site Energy Generation: Facility & EV Charging

- On-site PV: 6,200,000 kWh
- EV charging: 2,005,000 kWh
- Facility use: 6,074,000 kWh
- Purchase Green Power: 1,879,000 kWh

6% of On-site PV is used for EV charging, resulting in 94% of EV charging energy coming from Purchase Green Power.
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

Net load - March 31

- Ramp need ~13,000 MW in three hours
- Overgeneration risk

Megawatts

Hour

12am 3am 6am 9am 12pm 3pm 6pm 9pm
Thermal Energy Storage:
Time and Place
Construction Has Begun!

Questions?

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