A reference project for multi-family, mixed-use, net-zero energy design and innovation

David Shepler and Anthony Aebi
September 29, 2020
Overview

- Bios
- Inspiration
- Moving to zero-emission buildings
- Importance of Zero Place
- Energy targets

- Systems:
  - Envelope
  - HVAC and DHW
  - Solar
  - Operations

- Other features
- Cost analysis
- Data collection
Anthony Aebi

- Multi-time Housing Innovation Award winner from 2012 through 2019, including two Grand Prizes.
- Awarded the builder with the lowest HERS scores by NYSERDA for 6 years running.

David Shepler

- Founder of Zero Place
- COO of Elemental Cognition, an AI R&D company
- Formerly the Program Director of the Smarter Energy Research Institute at IBM
- Owner of a net-zero energy home
- Passionate about energy efficiency and climate change solutions
Inspiration
Moving to zero emission buildings

• Electrification of all systems (eliminates oil/gas)
• Making the building efficient
  • Envelope: walls, floor, roof, windows
  • HVAC & Domestic Hot Water
  • Solar: Offset electric demand
  • Operations: energy monitoring, tenant behavior
• Decarbonizing the production of electricity
• Mixed use, net-zero energy building
  • 46 residential units (25 2-bed, 21 1-bed)
  • 5 affordable housing units
  • Retail space: 8,400 sqft
• 100% privately financed with NY- and federal incentives
• Owner developed and operated by Net-Zero Development LLC
• Broke ground: Dec 2018
• To open: Dec 2020

87 N. Chestnut St
New Paltz NY
Importance of Zero Place

- Zero Place was a winner of NYSERDA’s first-ever Buildings of Excellence award in 2019.
- Reference project for the State of NY to assess the effectiveness of combining heating/cooling (HVAC) and domestic hot water (DHW) in a single building-wide geothermal system.
- NYSERDA independently monitoring the system.
- Will inform policy regarding means to achieve NY state’s aggressive goal of economy-wide net-zero carbon emissions by 2050.
Energy Targets Based on Modeled Performance

Normalized, modified end-use loads (MMBtu/yr)

<table>
<thead>
<tr>
<th></th>
<th>ENERGY STAR</th>
<th>ZeroPlace Target</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>6.4</td>
<td>2.1</td>
<td>33%</td>
</tr>
<tr>
<td>Cooling</td>
<td>2.6</td>
<td>1.2</td>
<td>46%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>6.1</td>
<td>1.3</td>
<td>21%</td>
</tr>
<tr>
<td>Lights &amp; Appliances</td>
<td>12.2</td>
<td>10.8</td>
<td>89%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>27.3</strong></td>
<td><strong>15.4</strong></td>
<td><strong>56%</strong></td>
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ENERGY STAR HERS Index Target

<table>
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<tr>
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<th>67</th>
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<tbody>
<tr>
<td>36 HERS Index w/o PV</td>
<td></td>
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<tr>
<td>-12 HERS Index</td>
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</table>

Reduce annual carbon emissions by 160 metric tons of CO$_2$e, equivalent to

- 34 Passenger vehicles driven for one year
- 174,916 Pounds of coal burned
- 55.8 Tons of waste recycled instead of landfilled
- 2,646 Trees seedlings grown for 10 years
- 188 Acres of U.S. forests in one year
- 6,981 Trash bags of waste recycled instead of landfilled

Note: 1 MMBTU = 293 kWh
Envelope

Features
• Insulated-concrete form (ICF) walls
• Triple-paned fenestration
• High-R slab and roof assemblies
• Air-tight construction strategy
• Thermal bridging reduction

Performance
• 37% better than code
• 65% tighter than NYS ECCC
• Saves 169,488 kWh/yr of energy
HVAC and DHW

- The heart of ZeroPlace’s energy innovation.
- Ground-source Heat Pump (GSHP) provides 100% heating, cooling, and hot water
- Summary
  - 15x, 500-ft wells, all within building footprint
  - Integrating DHW with building heating/cooling saved 15% system cost and achieves higher efficiency through balancing
  - Variable speed pump, and all ducting / distribution within building envelope
  - Unitary ERV systems for each unit with controls for CO$_2$, oven use, and tenant control
Bore field

- 15x 500-ft wells -- all within the footprint of the building
- Footprint of building would enable up to 28 stories above
- Insulating cap of the building above the bore field will contribute to the efficiency of the system
# 60 Geothermal Heat Pumps

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Capacity (Tons)</th>
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</thead>
<tbody>
<tr>
<td>50</td>
<td>Single-stage for apartments and hallways</td>
<td>0.75 – 1.0</td>
</tr>
<tr>
<td>2</td>
<td>Dual-stage for foyer and community bathroom</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>State of the art variable speed geothermal pumps for commercial spaces</td>
<td>1.0 – 6.0</td>
</tr>
<tr>
<td>2</td>
<td>High temperature hot water generating heat pumps for 100% of the domestic hot water</td>
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</table>
Domestic Hot Water Design

• 18% of the energy use of a building
• Zero Place will be only the 2\textsuperscript{nd} multi-family building to make 100% of DHW via the geo system
  • Note: Zero Place demonstrates the concept at scale at 4X the size of the other building.
• Uses rejected heat in apartment A/C mode to make hot water. Surprisingly, building is cooling dominant.
• Keeps the loop field colder, saving length (2 wells!)
• Savings of shorter loop field paid for the hot water system
• 4x 162-gallon storage tanks for peak hot water usage
• 2x heat pumps for redundancy

\textit{Key innovation of our geothermal design}
Other Design Features

• Central adaptive pumping solution
  • 2.3% pumping power

• Balanced header system
  • No balancing valves
  • No flow restriction, reduced pumping power

• Variable speed pumping
  • Only as much pumping power as needed
  • Revs up and down with the amount of heating and cooling needed and number of heat pumps operating

• No backup heat
  • No gas line in the building, completely emission free
Support for Our Geothermal System

NYSERDA
- $109,000 in efficiency rebates
- Did secondary design review
- Will be doing quality assurance inspections
- Performing independent energy monitoring and energy verification
- Zero Place is an important case study / reference project to educate policymakers
  - Not only for NY State
  - Demonstrate what is possible in the heat dominated Northeast

WaterFurnace
- In-kind support by installing 15x remote control and monitoring systems, each streaming 256 data points every 10 secs
Solar

- 246 kW of solar (683 panels @360W)
- 11,978 SF covered
- Total annual generation: 296,141 kWh/yr, 1,398 kWh/yr excess
- 84 metric tons/yr carbon offset
- SunPower Helix
- Installed on roof and solar awnings on south wall
- Note: evaluating a building-scale battery backup system for demand charge shaving
Operations

• Incentivizing tenants
  • Zero Place bundles power and water with rent
  • Building should largely run on its own, but tenants must not waste energy

• Monitoring infrastructure installed
  • Electric sub-metering of HVAC and plug load
  • Water sub-metering for individual hot and cold

• Custom mobile software developed to inform tenants

• Social incentives
  • Gamification
  • Posting a "leader board" and average consumption

• Lease agreement limits – payments for exceeding a threshold

• Tenant selection – select tenants to participate in the ethic of the building
Other Features

• 10 EV charging stations (with electric bike ports)
• 50 bicycle racks on the property
• Adjacent to Empire Trail
• Bus stop onsite
• ¾ mi from village center
• Bike lanes along street frontage
• Adherence to “complete streets” principles
• Seeking LEED Platinum and LEED pilot credit of Passive Survivability (maintains 50% F off grid)
Cost Analysis

• Estimate a 20% - 25% premium over NY ECC-code compliant building
• Estimate 8-10 year payback

<table>
<thead>
<tr>
<th>Feature</th>
<th>Increase over reference</th>
<th>Benefits</th>
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</table>
| ICF Walls           | $275,000                 | • Superior air barrier and insulation  
                       |                         | • Extended life-cycle and reduced mnx                                    |
| Solar PV            | $450,000                 | • Direct payback of 8.3 years, 12% IRR                                   |
| GSHP                | $500,000                 | • 5-7 year payback due to doubling efficiency of ASHP  
                       |                         | • Also ensures savings from peak demand charges                         |
| Eco-car Elevator    | $20,000                  | • 50%-80% less energy than conventional, regenerative drive  
                       |                         | • Savings on rooftop machining                                          |
Data Collection

• Electrical monitoring (eGauge)
  • All residential units (HVAC & plug loads)
  • Commercial/retail spaces
  • Landlord-utility service
  • Solar PV
  • Backup & storage: Gas-fired generator and battery system
  • Common areas (HVAC, lighting, plug) & parking lot (lighting)
  • Central GSHP system
  • Central DHW
  • EV car charging

• Geothermal system
  • Waterfurnace – provided 15 remote control and monitoring systems
  • NYSERDA independently monitoring and verifying system: water flow, electric power, and temperature

• Climate Monitoring
  • Residential apartments
    • CO2, RH, Temp
    • Duct sensor or a wall sensor
  • Common areas
    • CO2, RH, Temp
  • Commercial spaces
    • CO2, RH, Temp
  • Exterior of building / ambient conditions
    • CO2, RH, Temp

• Demand Controlled Ventilation (DCV)
  • Residential apartments (CO2, cooking range)
  • Common areas (CO2)
  • Commercial spaces (CO2)

• Water Metering
  • Building total use & common areas (cold & hot)
  • Residential apartments (cold & hot)
  • Commercial units (cold & hot)
• Zero Place lot historically used for auto-related businesses.

• Burned down in Feb 2015
Zero Place Project Team

- **Owners / Partners**
  - Founder: David Shepler
  - Anthony Aebi – Greenhill Contracting
  - Keith Libolt - Affordable Housing Concepts

- **Architect – Bolder Architecture**
  - David Toder

- **Builder – Affordable Housing Concepts**
  - Keith Libolt - Owner
  - Mike Scirbona – Construction Manager

- **Energy Modeling & Consulting – Integral Building & Design**
  - Pasquale Strocchia

- **Geothermal System and DHW**
  - Jens Ponikau – Buffalo Geothermal

- **Solar & battery storage**
  - Jeff Irish - SunCommon