

# MUZERO: “MUSE FOR NET “ZERO “ DESIGN

## ASHRAE LowDown Showdown

### 2018 Building Performing Analysis Conference and SimBuild

Building Type: Museum  
(including retail space and full service restaurant)

Total Floor Area: 6,608 m<sup>2</sup>

Location: Denver, Colorado

#### Total Energy Usage

317 MWh

#### Site EUI

48 kWh/m<sup>2</sup>

#### Annual Water Usage

1,200 m<sup>3</sup>

#### Annual Electricity Cost

1.7 \$/m<sup>2</sup>

#### Annual Water Costs

1.5 \$/m<sup>3</sup>

#### Total Annual Costs

\$13,025

#### CPSF

650 \$/ft<sup>2</sup>

#### Total Energy Generation

419 MWh

#### Net Zero Energy

-102 MWh

#### Carbon Equivalent

-76 Metric tons CO<sub>2</sub>

### Team

Engineer/Modeler  
Patrick Dempsey

Engineer  
Colin Hale

Designer/Modeler  
James Marsh

Engineer  
Michael Mowrer

Captain/Modeler  
Amir Rezaei-Bazkiaei

Engineer  
Conor Rielly

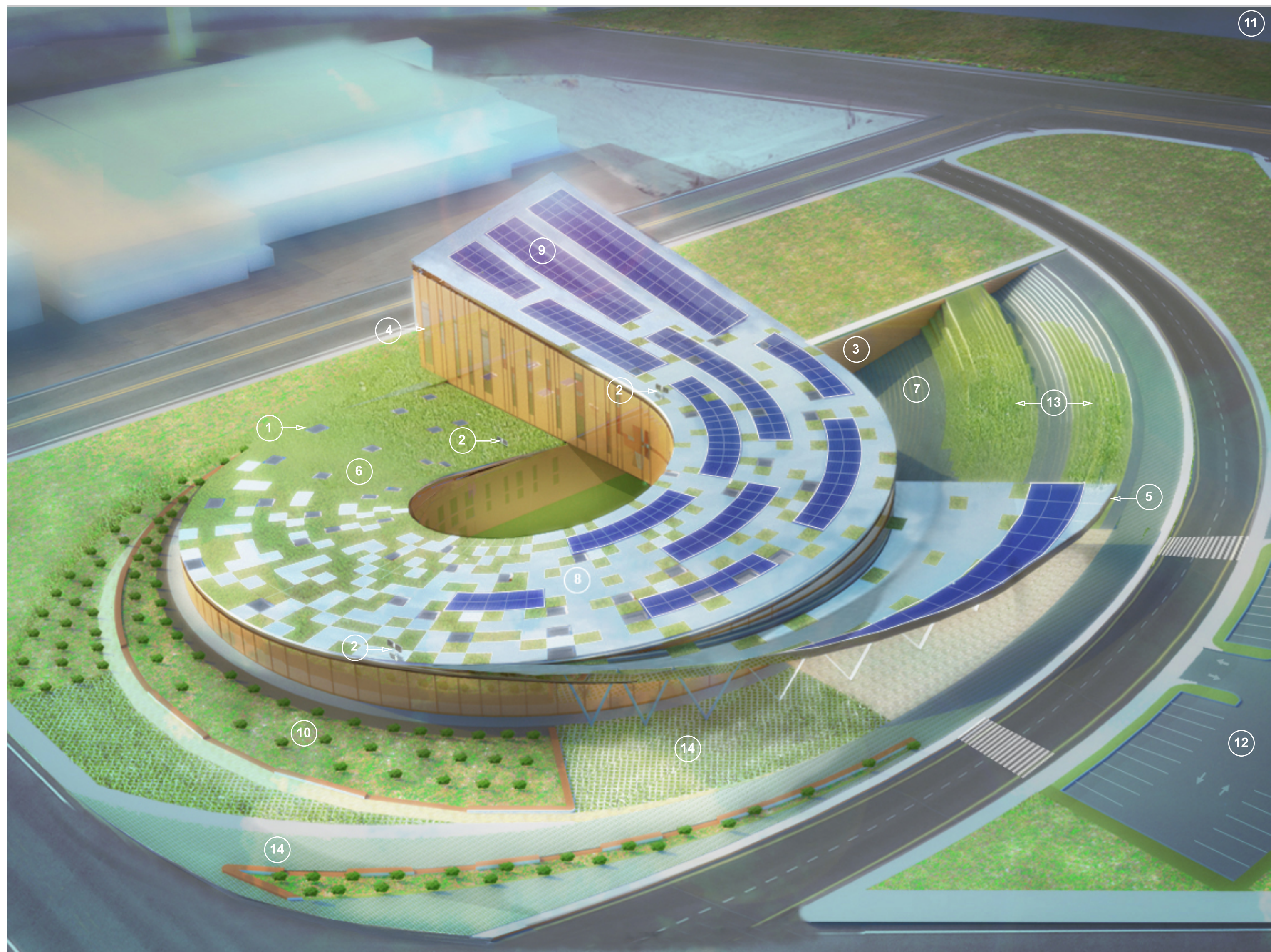
Architect  
Brian Bassett

Designer  
Nhan Bui

Architect  
Will Ransom

Designer  
Andy VanMater

Designer  
Leo Yang



### Overall Strategy: Reduce, then Produce!

The extremes of the Denver climate led to a strategy which fully utilizes the stable thermal conditions below grade, passively advantaged to meet the needs of exhibits spaces requiring constancy and control of temperature, humidity and light. Our integrated concrete structural system was designed to add high thermal mass as a nighttime thermal buffer with optimized skylight placement and PV distribution through computational design.

The form allows the exhibition spaces below grade to have an equal distribution of quality daylight via translucent skylights and fiber-optic daylight collectors, while the lobby, restaurant and administration spaces enjoy above grade views and daylight, minimizing heat loss and heat gain by utilizing “good” winter solar conditions.

Mechanical strategies include separate dedicated outdoor air systems (DOAS) for humidity-controlled zones (exhibit and storage) versus others. The DOAS units are equipped with enthalpy wheels and adiabatic humidification (winter)/evaporative precooling (summer) to significantly reduce humidification, heating and cooling loads. Remaining heating and cooling loads are met by water-to-air heat pumps (HP) connected to a closed-loop slinky heat exchanger using the Platte River water as heat source/sink source. The river water strategy was proposed as a means to reduce the installation cost of a geothermal system and/or a chiller/boiler plant while increasing thermal efficiencies. Additional water strategies include rainwater collection from rooftop (domestic/irrigation) and integrated bioswales (stormwater).

