Solar Decathlon Design Challenge 2020
Office Building Division
Team Composition

Composite + Positive = Compositive

Vision Statement

“Finding strength in diversity, Compositive pools the talents of an interdisciplinary team with the goal of positively changing the future of the built environment.”

com  ___________.
comfort
community
communication
complexity
compassion
comprehensive
compositive.
Building Team Compositive

7 Graduates + 21 Undergraduates

Team Compositive
Meet Team Compositive
Industry Partners
Living Building Inspiration

HVAC
Innovative Materials
Green Roof
Rainwater Harvesting
Daylighting

Sacred Heart
Stevens Library
Atherton, CA

Colab - HITT
Falls Church, VA

Brock
Environmental Center
Virginia Beach, VA

Rocky Mountain
Institute HQ
Basalt, CO
Design Process
The Four C’s [Design Goals]

- Conservation
- Community
- Comfort
- Cost Awareness
The Four C’s [Design Goals]

Conservation

Preserve Existing Ecology

Use of Reclaimed Materials

 iTREE Analysis
The Four C’s [Design Goals]

**Conservation**
- Preserve Existing Ecology
- Use of Reclaimed Materials
- iTree Analysis

**Community**
- Showcase to School Groups
- Encourage Green Communities
- Locally Sourced Green Roof
- Scenic Walk/Bike Paths
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- Individual Thermal Zones
- Low Velocity HVAC
- Radiant Floors
- Natural Daylighting
- Material Selection
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**Cost Awareness**
- Intelligent Constructability
- Financially Attainable
- Low Operational Costs
Introduction

Architecture

Comprehensive Plan
Crafted Views
Biophilic Design
Organic Materials
Accessibility
Public and Private

Comfort & Environmental
Community Connections

- Trails link to local schools + Connect to cutting edge landfill facilities + Provide rich outdoor learning environments = Backbone of Eco-Park

**Trail Masterplan**
- Educational Trail
- Stream
- Floodplain

**Community Connections**
- Pedestrian-oriented community encourages reduced use of vehicular transportation.

- Place Petal

- Community Connections
  - Trails link to local schools
  - Connect to cutting edge landfill facilities
  - Provide rich outdoor learning environments
  - Pedestrian-oriented community encourages reduced use of vehicular transportation.
Site Masterplan

Masterplan

- Building lot
- Landfill Property
- Woodland Buffer
- Wetland
- Active Landfill
- Parking
- Education Node
- Stream
- Connector Trolls
- Deep Wood Trail
- Wetland Boardwalk
- Boardwalk Steps
- Lighted Nightwalk
- Walking Bridge
- Vehicular Traffic

Site elements:

- Building lot
- Landfill Property
- Woodland Buffer
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- Lighted Nightwalk
- Walking Bridge
- Vehicular Traffic

Site features:

- Eco-Park Learning Center
- Lookout Theater
- Bus and ADA Entrance
- Stone Point
- The Ravine
- Active Landfill

Site analysis:

- Site Masterplan
- Building lot
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Site design:

- Eco-Park Learning Center
- Lookout Theater
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Site facilities:

- Building lot
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- Walking Bridge
- Vehicular Traffic
Form Generation

- Wetlands
- Courtyard
- Wetland Stairs
- Amphitheater
- Landfill Mounds
An Everchanging View

Projected Height of Mound in 2028
A Building That “Isn’t There”

Innovation

Market Potential

Financial Feasibility & Affordability

Resilience

Energy Performance

Operations

Engineering

Comfort & Environmental

Architecture

Financial

Feasibility &
Affordability

Innovation
Spatial Planning

**Research**
General Lab Equipment
Horticultural/Ecological Studies
“Live-In” Residence Programs
Mudroom

**Education**
3 Multipurpose Rooms
Outdoor Learning Areas
[Growing Beds, Woodland Buffer, Wetland]

**Community**
Outdoor Gathering Spaces
Indoor Gathering Spaces
[with Kitchen/Bar and Presentation Equipment]
Office Amenities

**Open Office**
Rentable office space for various tenants

**Closed Office**
10 Closed offices for Administration

**Kitchen & Break Area**
Located centrally to promote healthy eating and working habits

**Conference Rooms**
3 various sizes [2 located on the second floor]

**Breakout Rooms**
Provides secluded & sound-proof space for tenants to work

**Lactation Room**
Provides needed privacy for mothers
Comfort & Environmental

Glare Reduction
Individual HVAC Controls
Low Velocity Airflow
Mechanical Noise Reduction
Fresh Air Circulation
Generous Daylighting

- Skylight
- Lighter Surfaces Reflect Light
- Task Lighting for Open Office
Quality Acoustics

QRD Ceiling Panels

QRD Wall Panels
Quality Acoustics

Acoustic Partitions
Recycled Carpet
Quiet Mechanical Systems

Unconditioned top layer of air

Return Air

Supply Air

Low Velocity Displacement System

Hydronic Radiant Heated Floor
Engineering

High Performance Enclosure
Occupancy Sensors
Composting Toilets
4-Pipe Fan Coil Units
Hydroponic Radiant Heating
Displacement Ventilation
Building Enclosure

Modular Green Roof
Roof Membrane
XPS Insulation
Concrete Deck

- Bulk Moisture Control
- Moisture Vapor Control
- Thermal Control
- Air Control

Modular Green Roof
Roof Membrane
XPS Insulation
Concrete Deck

- Roof Detail
- Treated Wood Veneer
- Ventilated Air Gap
- Tyvek® CommercialWrap
- R-4 Windows
- Rockwool Insulation
- CLT
- Window Detail
- Drainage Mat
- XPS Insulation
- Foundation Detail
Mechanical Systems Flow Diagram

South Thermal Zones

Radiant Floor

Boiler

Heating Mode
Mechanical Systems Flow Diagram

- Air Handling Unit + ERV + Economizer (Fresh Air)
  - Cooling Mode
  - Displacement Ventilation
  - Chiller
  - South Thermal Zones
  - Radiant Floor
  - Boiler

- Heating Mode
Mechanical Systems Flow Diagram

- **South Thermal Zones**
  - Displacement Ventilation
  - Air Handling Unit + ERV + Economizer (Fresh Air)

- **Chiller**

- **North Thermal Zones**
  - Make-Up Air Unit + ERV (Fresh Air)

- **Boiler**

- **Fan Coil Unit**

- **Radiant Floor**

**Cooling Mode**

**Heating Mode**
Composting toilets reduce water demand by 50,000 gal., making Water Petal certification feasible.
Plumbing Layout

- Instant Hot
- CWS
- HWS
- Hot Water Tank
- RainFlo Treatment System

Instantaneous Hot Water Heater Location
Operations

Building Management System
Dormant Energy Reduction
Smartwall
Building Management System

- Occupancy Sensors
- Temperature Sensors
- Light Level Sensors
- Plug Load Management

Resilience
Energy Performance
Comfort & Environmental Engineering
Operations
Financial Feasibility & Affordability
Innovation
Smart Wall
105% PV Energy Generation.
 iTree Analysis.
 Plug Load Controls
Solar Array Parking Area

Retrofit & Reuse of an Existing Ballfield

+ 110 kW solar array from SunPower

+ Regulates car temperature

+ 5-minute walk to the Learning Center

South Facing Solar Canopy

Rain Garden & Vegetation Buffer

Shaded Vehicular Parking Area

Existing Parking Lot

Circulation

SunPower

Maxeon Gen

5 Solar Panels
iTREE Analysis

 iTREE Average Annual Benefits (First Year)

- Stormwater Services: $26
- Air Quality Benefits: $43
- Carbon Dioxide Sequestration: $564
- Summer Energy Savings: $344
- Winter Energy Savings: $1343

Total Energy Savings: $1687

Net Benefits: $2321

Tree shading passively reduces the energy demand of the Eco-Park Learning Center.
OpenStudio Analysis

Iteration #1: [Baseline Model]

ASHRAE 189.1-2009 Standard Construction Sets

10 Thermal Zones

Source EUI: 92.5 kBTU/ft²
OpenStudio Analysis

Iteration #1: [Baseline Model]
ASHRAE 189.1-2009 Standard Construction Sets
10 Thermal Zones
Source EUI: 92.5 kBTU/ft²

Iteration #2:
Four-Pipe Fan Coil System
17 Thermal Zones
Source EUI: 41.3 kBTU/ft²
OpenStudio Analysis

First Floor

Second Floor

Space Types

R-33 Walls + R-40 Roof + R-10 Slab = Source EUI: 39.5 kBTU/ft²
Resilience

Building Envelope
Site Resiliency
Food Production
Rainwater Harvesting

Energy Performance

Financial Feasibility & Affordability
Building Envelope

CLT Wall Section

Outside

- Treated Wood Veneer (1”)
- Ventilated Air Gap (1.2”)
- Tyvek® CommercialWrap
- Furring Strip (0.75”)
- Rockwool Insulation (6”)
- CLT (6.5”)

Inside

Temperature [ºF]

Water Content [lb/ft²]

Time
Site Resiliency

Eco-Park Learning Center

Embankment

Wetlands

Landfill

Architecture
Comfort & Environmental Engineering
Operations
Energy Performance
Resilience
Market Potential
Financial Feasibility & Affordability
Innovation
Food Production

1,000 sq. ft. of growing beds → 500 lbs. of produce / year = Protection in case of supply chain disruption
Rainwater Harvesting

Captures over 316,000 gallons per year

Two cisterns:
Green Roof Irrigation & Potable Uses

RainFlo purification system

= 125,000 gallons potable water available annually

Water Petal

100% of the building’s water needs are supplied by harvested and purified rainwater.
Market Potential

Municipal Space Expansion
Extraordinary Environmental Enterprise (E4) Participant
Startup Space
University & Research Partnerships

Financial Feasibility & Affordability
Market Potential

- Community Icon
- Nature Trails
- Net – Positive Energy
- Net – Positive Water

Eco-Park Learning Center
Market Potential

- Community Icon
- Nature Trails
- Net Positive Energy
- Net Positive Water

Eco-Park Learning Center

MUNICIPALITY
- Community Outreach
- Community Gathering
- Landfill Operations

Market Potential
Market Potential

Eco-Park Learning Center

**EDUCATION**
- Environmentally Conscious Landfill
- Research opportunities

**MUNICIPALITY**
- Community Outreach
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• Community Icon
• Nature Trails
• Net - Positive Energy
• Net - Positive Water

Architecture
Comfort & Environmental Engineering
Operations
Energy Performance
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Innovation
Market Potential

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**EDUCATION**
- Environmentally Conscious Landfill
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**MUNICIPALITY**
- Community Outreach
- Community Gathering
- Landfill Operations

**INDUSTRY**
- Rentable coworking space
- Research Potential
- Replicability

- Community Icon
- Nature Trails
- Net Positive Energy
- Net Positive Water

**Financial Feasibility & Affordability**

**Market Potential**

**Architecture**

**Comfort & Environmental Engineering**

**Operations**

**Energy Performance**

**Resilience**
Financial Feasibility & Affordability

Minimize Operation Costs
Material Selection
Potential Income
Cost Breakdown

Contingency & Fees [25%]

Sitework [8%]

MEP [26%]

Superstructure [27%]

Substructure [25%]

Interior Finishes [5%]
Cost Benefit Analysis

- Four-Pipe Fan Coil System
- Glazing System
- Building Position and Solar Shading
- Solar Array
- Rainwater Harvesting
Cost Comparison

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Standard Office</th>
<th>Eco-Park Learning Center</th>
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<tbody>
<tr>
<td>Construction Cost</td>
<td>$6.3 M</td>
<td>$10.5 M</td>
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<tr>
<td>Energy Consumption</td>
<td>14.48 kBTU</td>
<td>77.6 kBTU</td>
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<tr>
<td>Energy Cost</td>
<td>$77,800</td>
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Rentable Space
Rentable Space

Community
Large Gathering Area
Access to Outdoor Gathering Areas
Kitchen & Bar
Rentable Space

Education
3 Multipurpose Rooms
Access to Outdoor Educational Areas
Rentable Space

Office

- Open Office Space
- 8 Closed Offices
- Central Kitchen & Break Areas
Innovation

Embodied Energy
Material Selection
Saving a Stream

Financial Feasibility & Affordability

Conclusion
Responsible Interior Materials

- CLT Interior Wall Finish
- Hardwood Flooring
- Green Wall
- Quartz Countertop
- Recycled Carpet
- Earth Brick
# Embodied Energy

<table>
<thead>
<tr>
<th>Process</th>
<th>LF or SF Measurement</th>
<th>PLF or PSF Amount</th>
<th>Embodied Energy (Mj/kj)</th>
<th>Conversion Factor (430)</th>
<th>Total Embodied Energy (BTU/lbs)</th>
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</thead>
<tbody>
<tr>
<td>Steel Structure</td>
<td></td>
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<td>22.8 Million</td>
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<tr>
<td>Gluelam Structure</td>
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<td></td>
<td>10.5 Million</td>
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<tr>
<td>Traditional Brick</td>
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<td>36.1 Million</td>
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<tr>
<td>Compressed Earth Block</td>
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<td>Standard Carpet</td>
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<td>250.2 Million</td>
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<td>Carbon Neutral Carpet Tile</td>
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<td></td>
<td></td>
<td></td>
<td>0 Million</td>
</tr>
</tbody>
</table>
Responsible Landscape Materials

- Reclaimed Log Posts
- Reclaimed Wood Decking
- Prairie Grasses
- Recycled Glass Brick Pathway
- Earth Blocks
- Glass Aggregate Concrete
Saving a Stream

Powell's Creek
“Save the Stream”

Bike Share &
Woodland Trail System
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