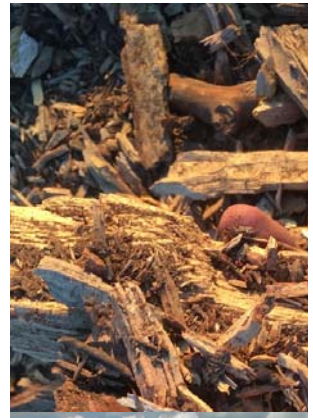
OSU Cascades – Net Zero Campus

Recommendations

February 20, 2017

Viable Net Zero Options

- Building Energy Efficiency
  - Better – 30% better than code
  - Best – 50% better than code
- Electrical energy
  - Photovoltaic energy
- Thermal Energy
  - Biomass boiler
  - Combined biomass and geoexchange system



Net Zero Options Comparison

Option	Description	PV Fits on Campus	CapEx	Utility	O&M	75 Year LCC	Simple Payback (yrs)
Good	Biomass central heat Distributed cooling Buildings designed to Code	No	$41m	$150k	$890k	$140m	28
Better	Biomass central heat Distributed cooling Buildings designed to be better than Code	Maybe	$49m	$100k	$600k	$120m	32
Better+	Campus EUI = 49 Biomass and geoexchange central heating and cooling Buildings designed to be better than Code	Maybe	$54m	$75k	$500k	$112m	34
Best	Biomass central heat Distributed cooling Buildings designed to be passive where applicable	Yes	$59m	$65k	$400k	$104m	37
Best+	Biomass and geoexchange central heating and cooling Buildings designed to be passive where applicable	Yes	$61m	$45k	$300k	$100m	38

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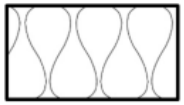
Proposed System

THERMAL

POWER

Very Efficient Buildings:
- Super-insulated
- Daylighting
- Reduced plug load

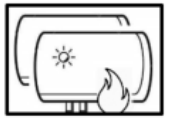


Heating
Cooling

Geo-Exchange:
- "Slinky" under field, open areas
- Benefits from Site Re-grading

Heating
Cooling

C.U.P.:
- Biomass boilers

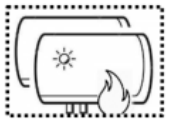


Heating

Reduces heating, cooling demands

Provides blend of heating and cooling well suited to OSU's demand profile

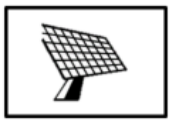
Future Flexibility



Heating
Electricity

Can Re-Tool CUP for Co-Generation

Solar PV:
- Building Integrated
- Ground mounted & canopy
- Can Be 3rd Party



Electricity

Excellent Resource in Bend Climate

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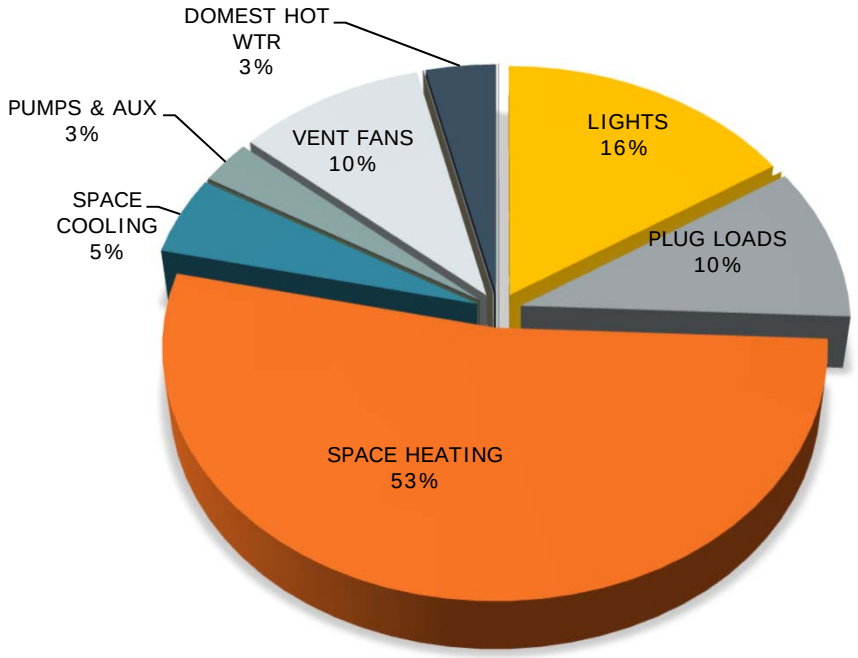
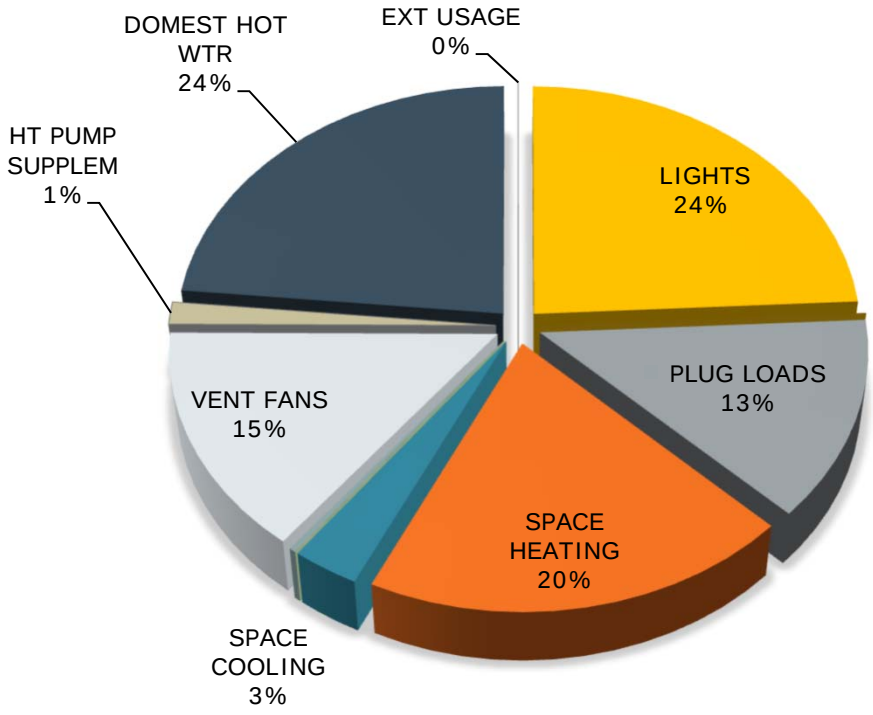
Code Energy Use Breakout

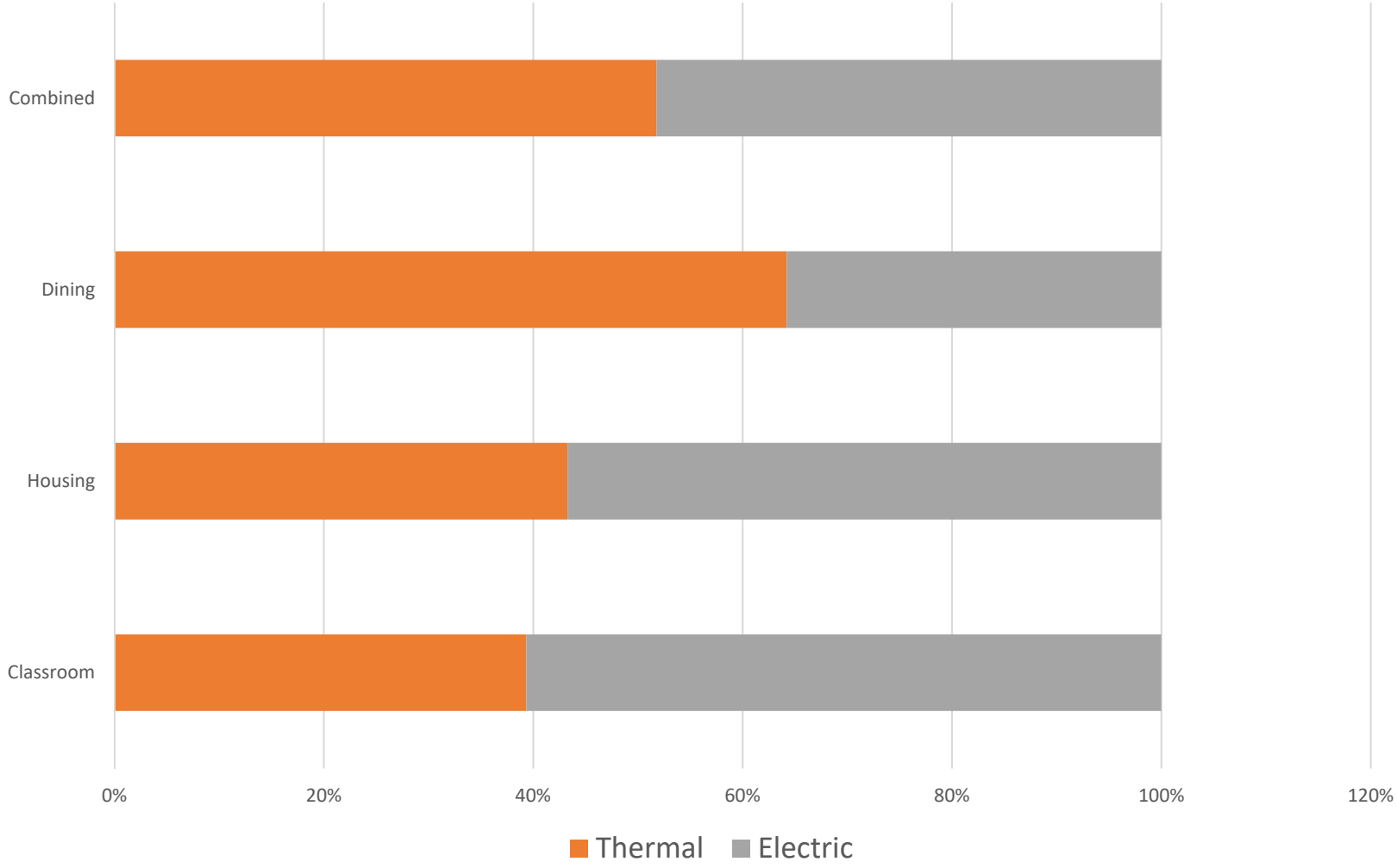
Classroom Building



Housing Building



Energy Mix - Current



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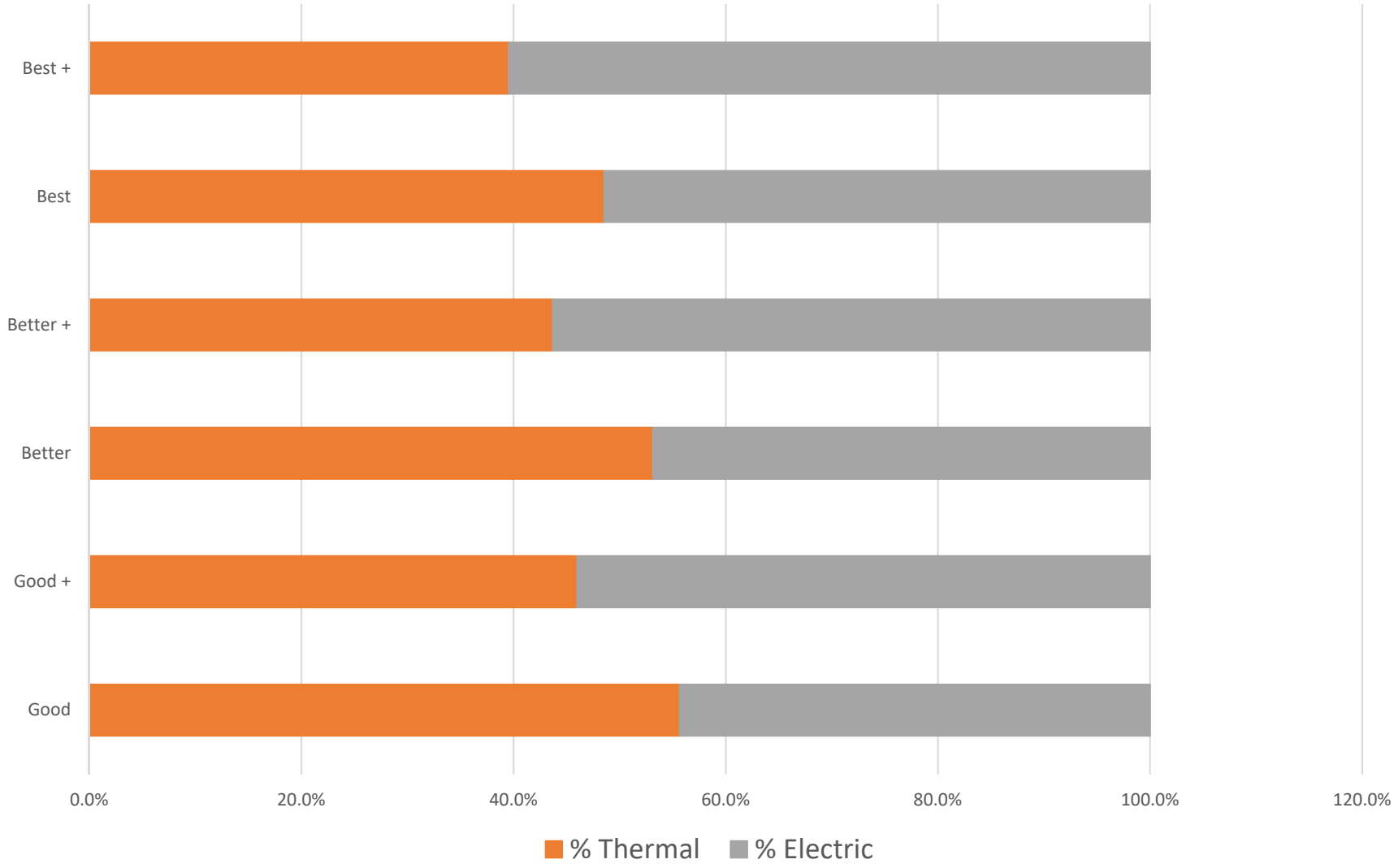
Energy Mix – Build Out



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Business As Usual

- Buildings designed to Code minimum.
  - Code minimum envelope
  - Code minimum lighting
  - Chillers or DX Rooftop units at each building
  - Natural gas boilers at each building
- No central thermal energy systems.
- No on-site power generation.
- Same as “Good” option but without the Biomass Central Utility Plant (CUP) and Photovoltaic arrays.

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Preliminary Phasing Plan

Phase	Year	New housing (# of beds)	New Academic Area (sqft)	New Building Area (sqft)	Total Building Area (sqft)	% of Full Buildout
Existing	2016				203,008	14%
1	2017-2019	0	55,000	55,000	258,008	18%
2	2019-2021	300	-	105,000	363,008	26%
3	2021-2023	300	105,000	210,000	573,008	41%
4	2023-2025	300	45,222	150,222	723,230	52%
5	2025-2027	400	100,512	240,512	963,742	69%
6	Beyond 10 yrs	400	299,615	439,615	1,403,357	100%

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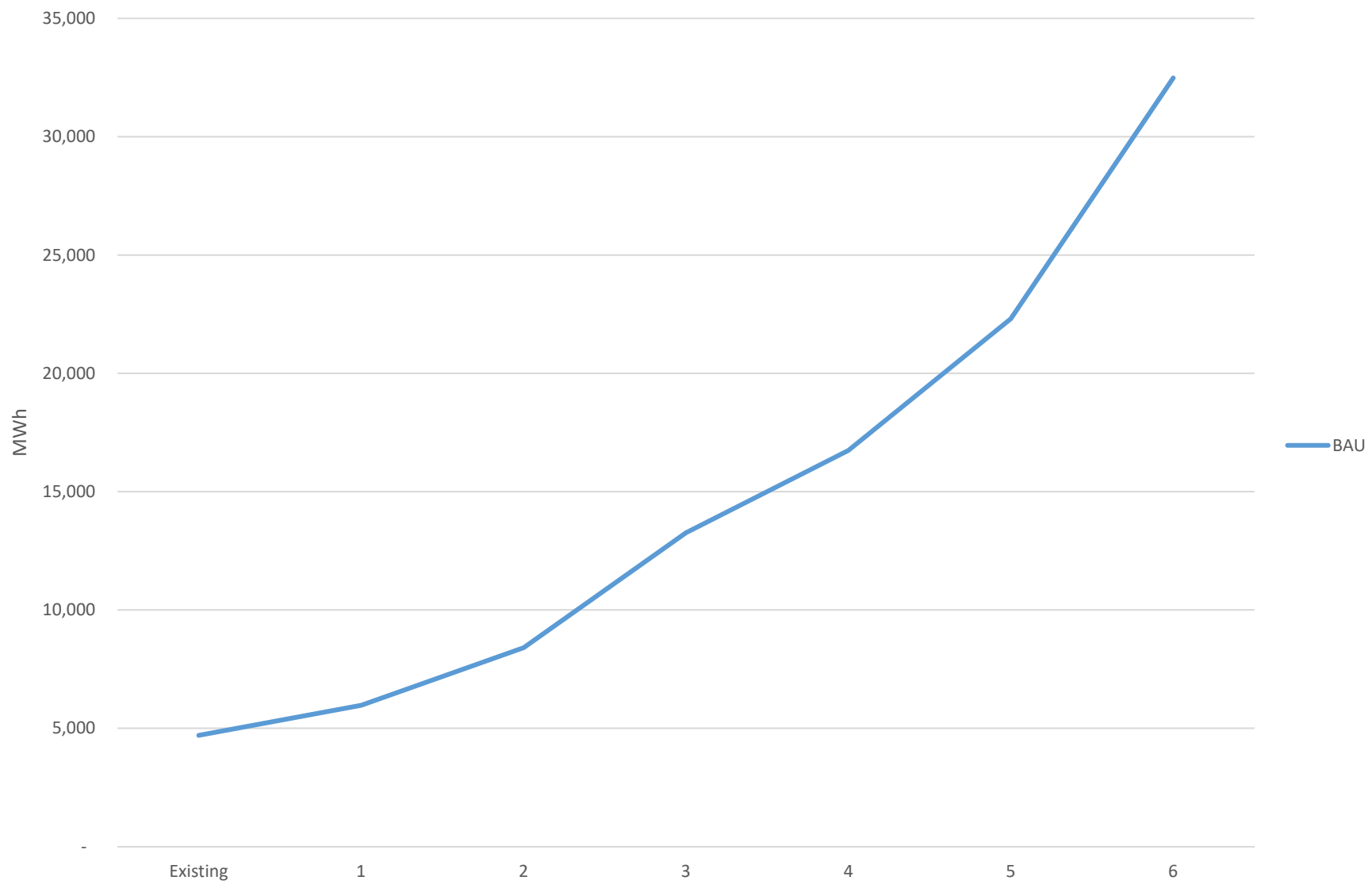
Phased Energy Consumption - BAU



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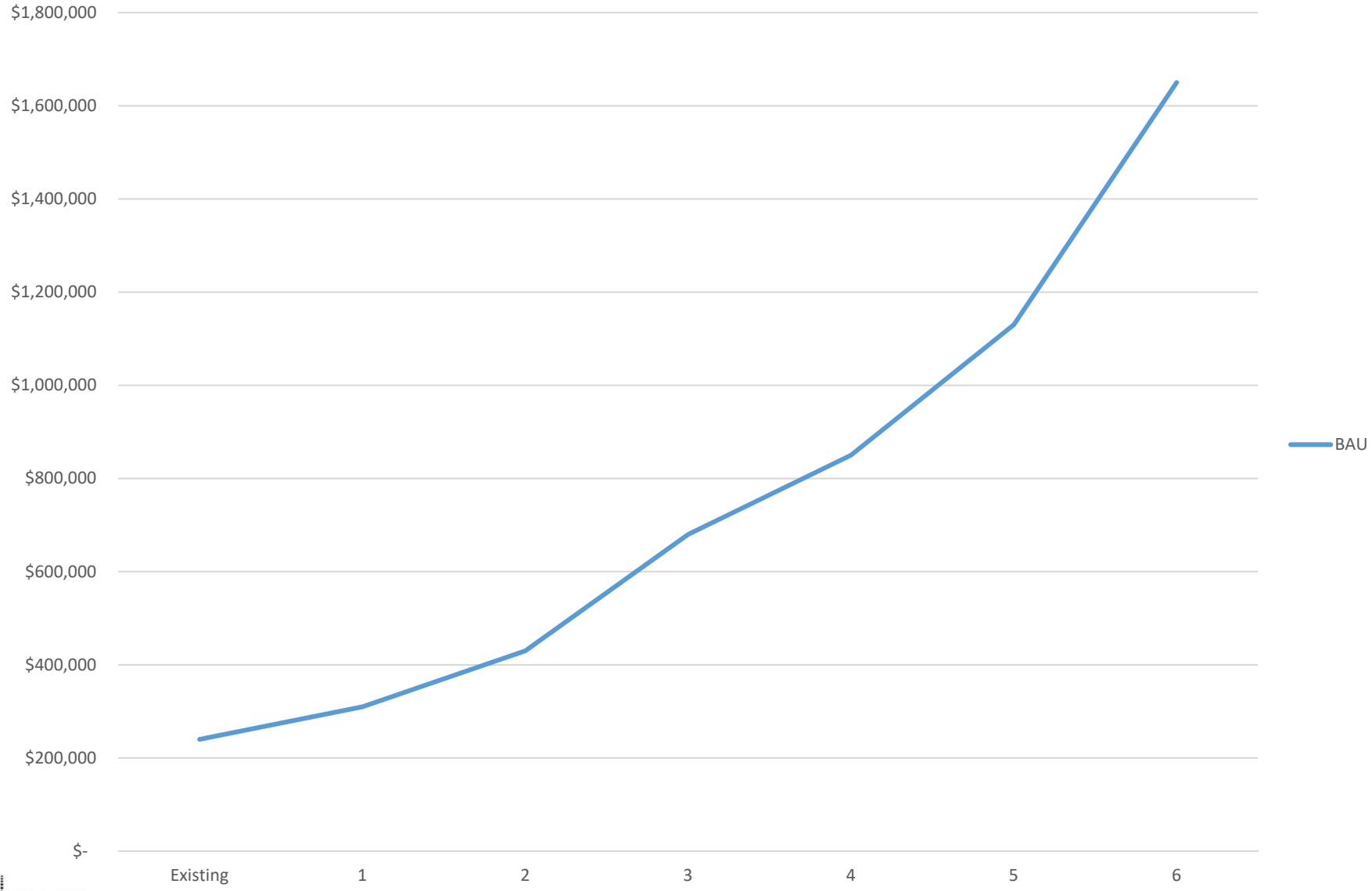
Phased Utility Costs - BAU



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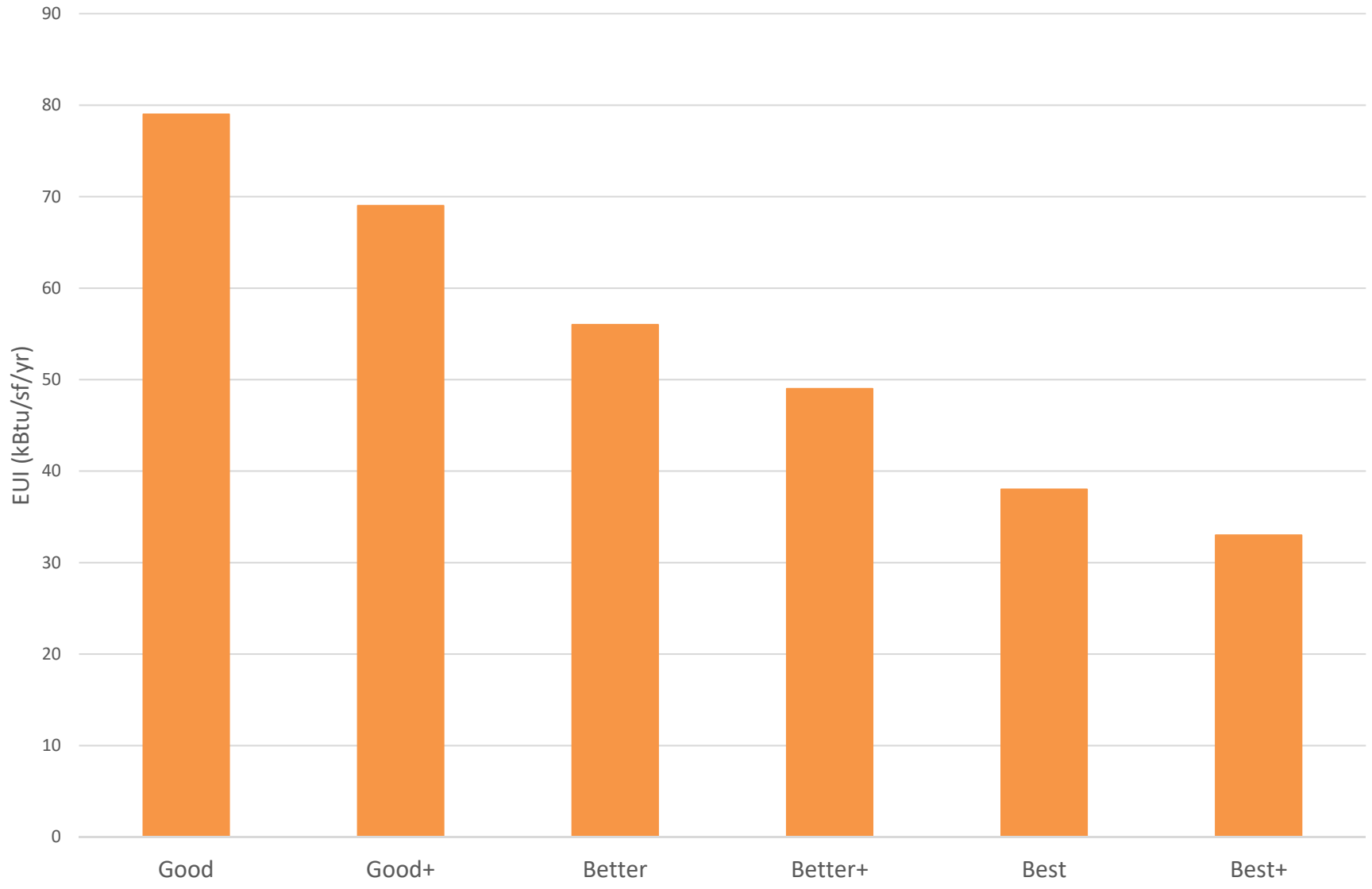
Campus EUI Comparisons



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Energy Use Reduction Standards

Envelope

- Roof Insulation: R-50
- Wall Insulation: R-30
- Window Performance: R-5.6 (includes frame)
  Optimize solar heat gain
- Air Sealing

Benefits

- Reduces the size of the mechanical system
- Reduces energy consumption
- Improves occupant comfort
- Lasts for the life of the building

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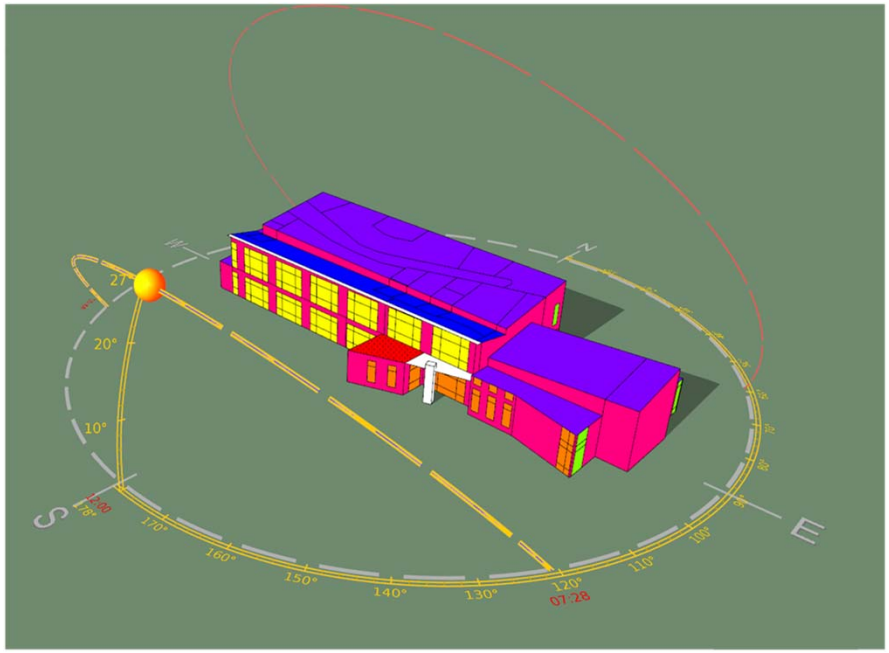
Energy Use Reduction Standards

Passive

- High performance envelope
- Buildings oriented on an east/west axis
- Minimal east and west windows
- Strategically placed and sized north and south windows
- Overhangs on south facing windows
- Operable windows
- Ventilation stacks
- Exposed mass or phase change materials

Benefits

- Reduces the size of the mechanical system
- Reduces energy consumption
- Increases occupant control of space
- Lasts for the life of the building
- Increases daylighting opportunities



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Energy Use Reduction Standards

Lighting and Plug Loads

- Efficient lighting and daylighting
- LED task lights
- Ultra-low energy computers and monitors
- Energy star appliances
- Restrictions on mini refrigerators and space heaters in dorm rooms
- Occupancy sensor controlled receptacles
- Metering of loads

Benefits

- Daylighting improves occupant comfort and productivity
- Reduced energy consumption
- Reduces the size of the mechanical systems

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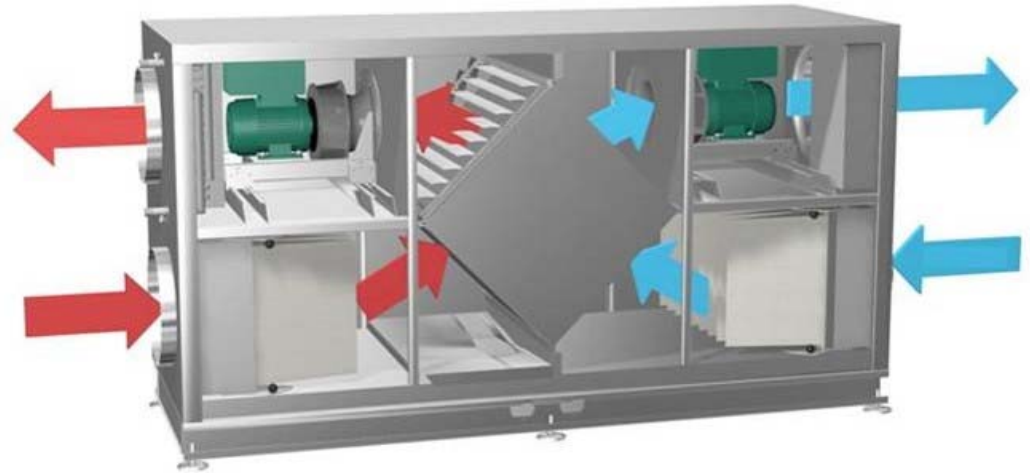
Energy Use Reduction Standards

Mechanical

- Dedicated Outside Air Units with Heat Recovery
- Water source heating/cooling equipment
- Water cooled VRF Systems with Heat Recovery
- Radiant heating and cooling
- Hydronic Distribution

Benefits

- Dedicated outside air improves air quality, reduces energy consumption and reduces duct and equipment sizes
- Water based heating and cooling distribution is more efficient than air and allows for decreased floor to floor heights.



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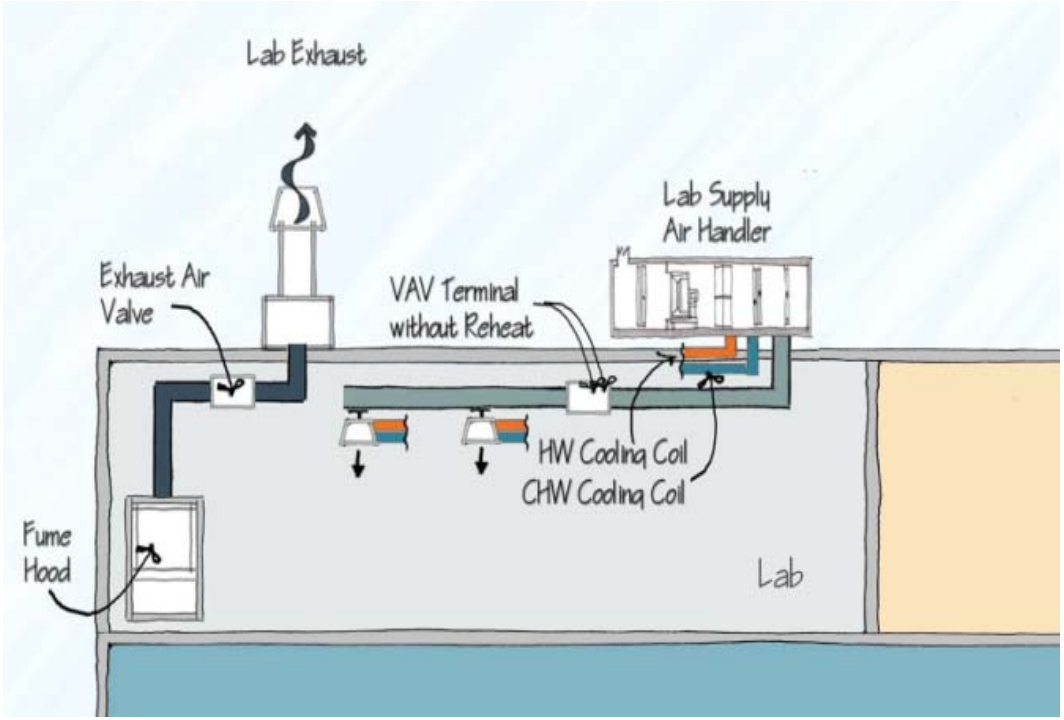
Energy Use Reduction Standards

Laboratory

- Low flow fume hoods
- Variable volume airflow control
- Run around heat recovery

Benefits

- Safe, reliable fume exhaust
- Fan energy savings
- Heat recovery



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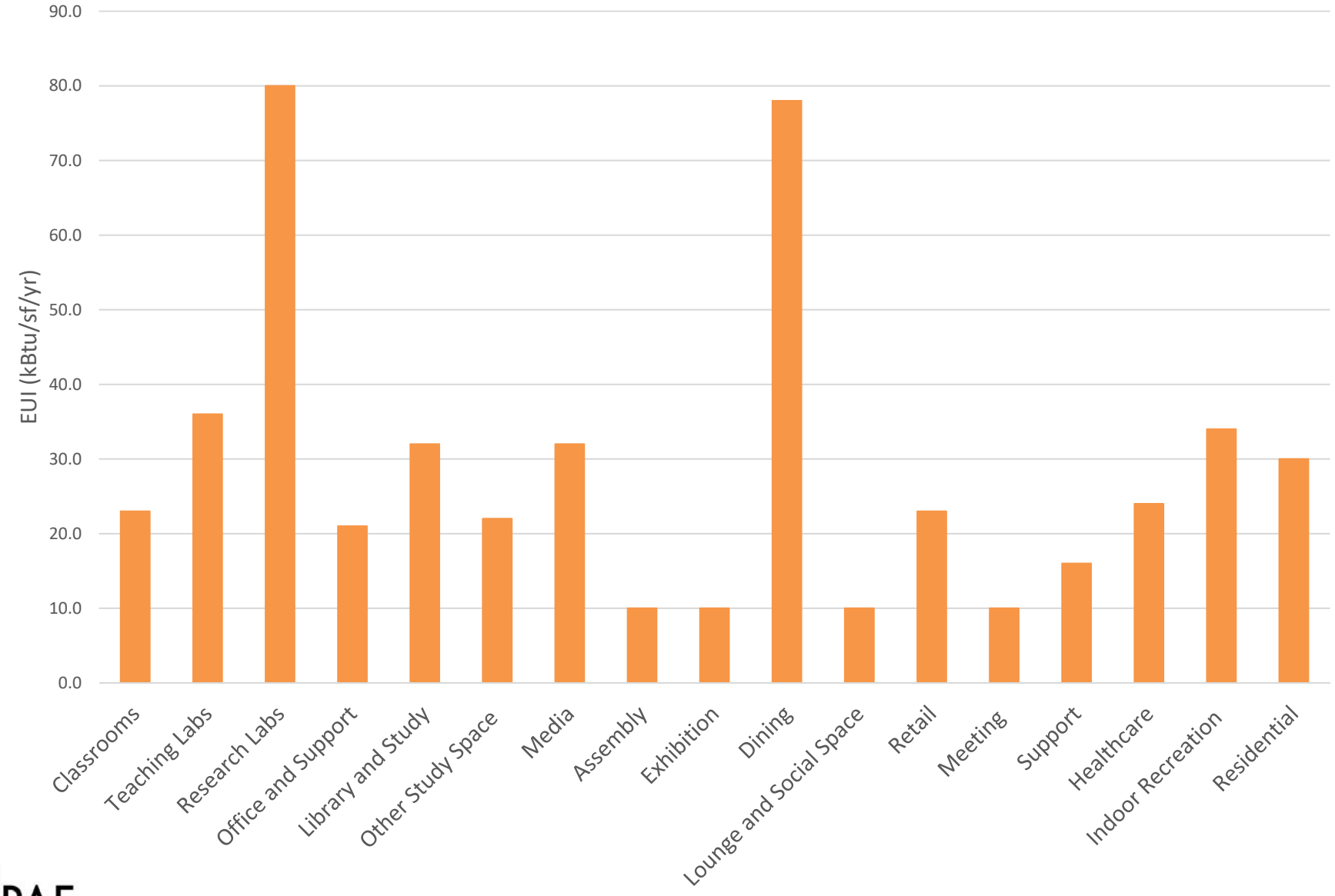
Building EUI Standards



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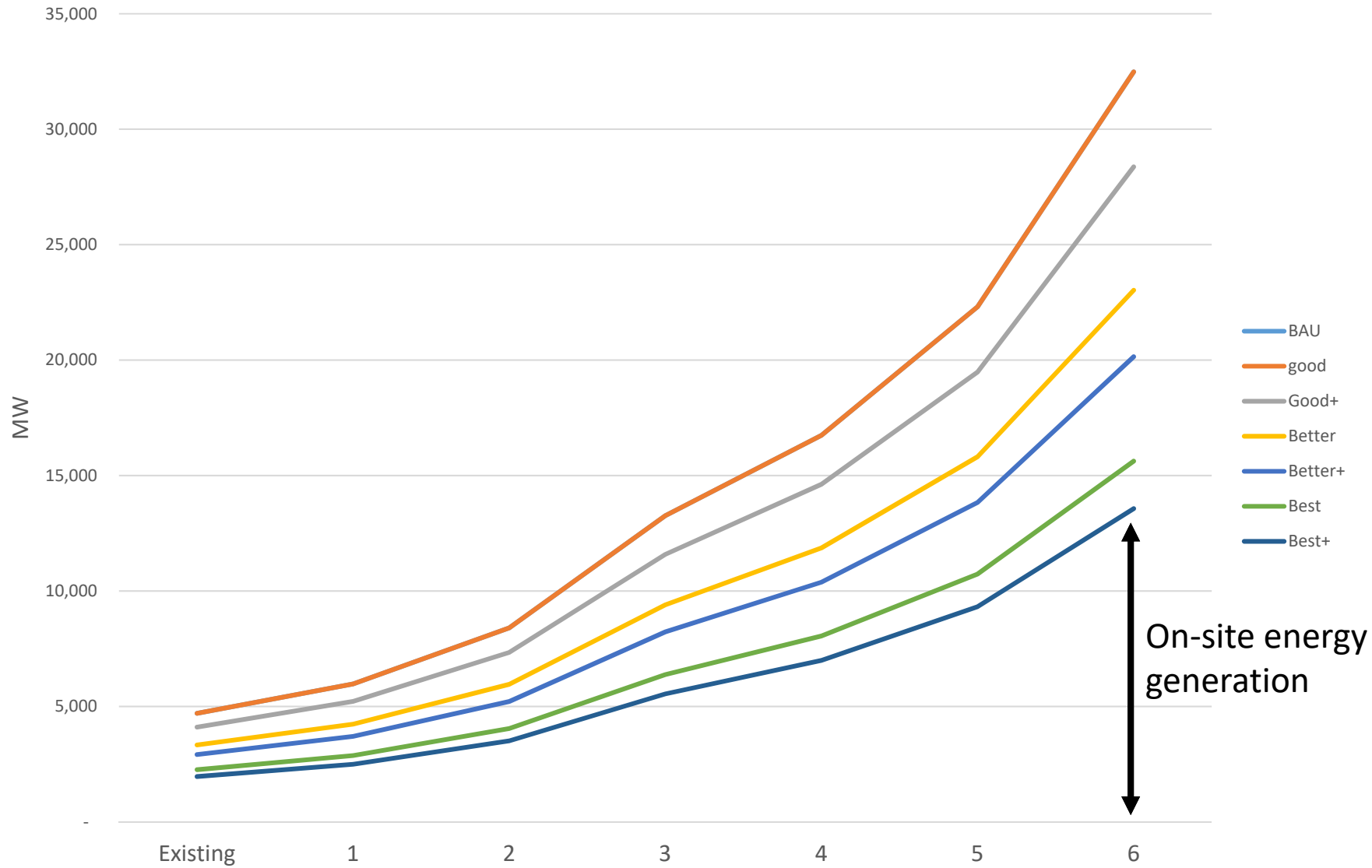
Energy Consumption by Phase



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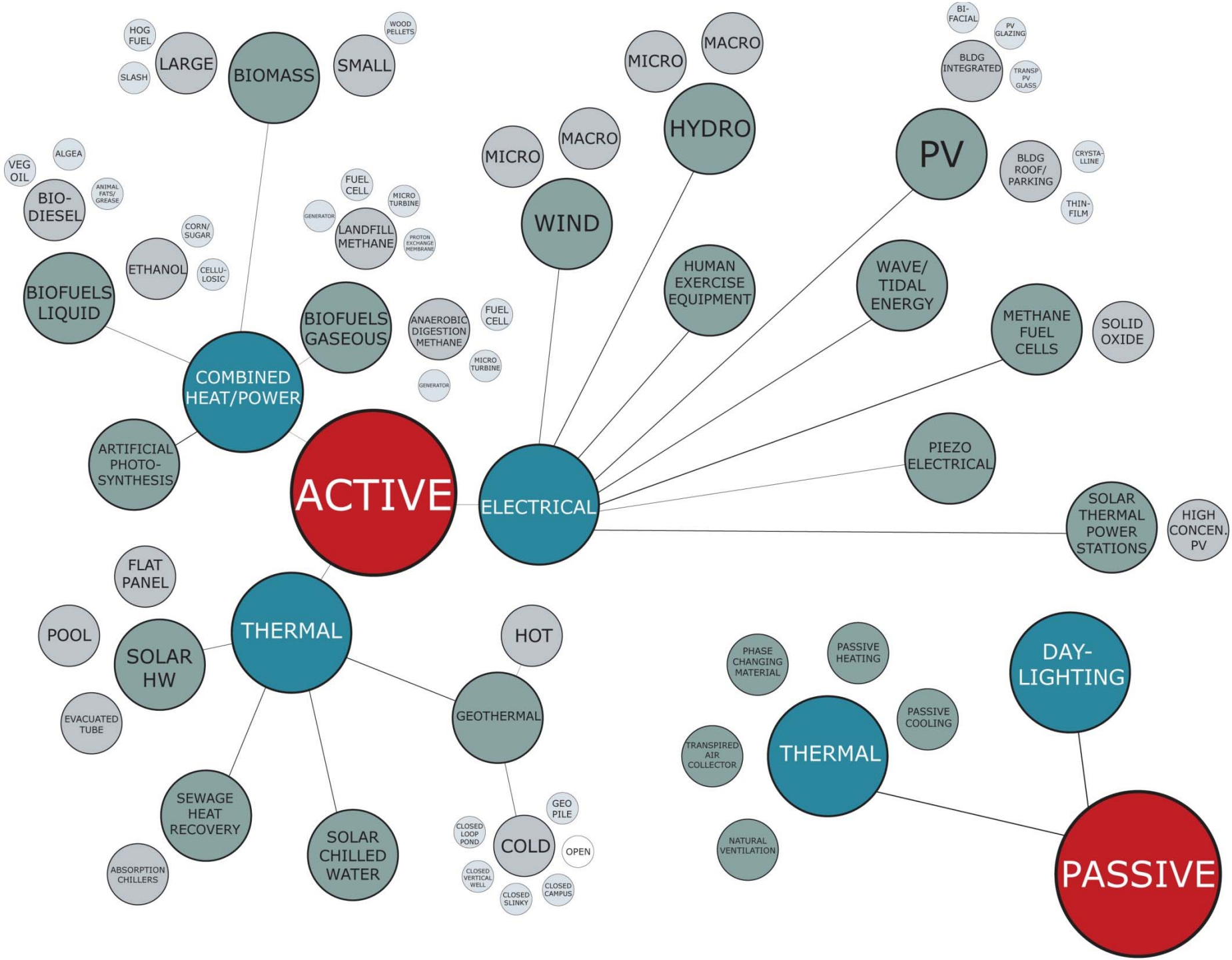
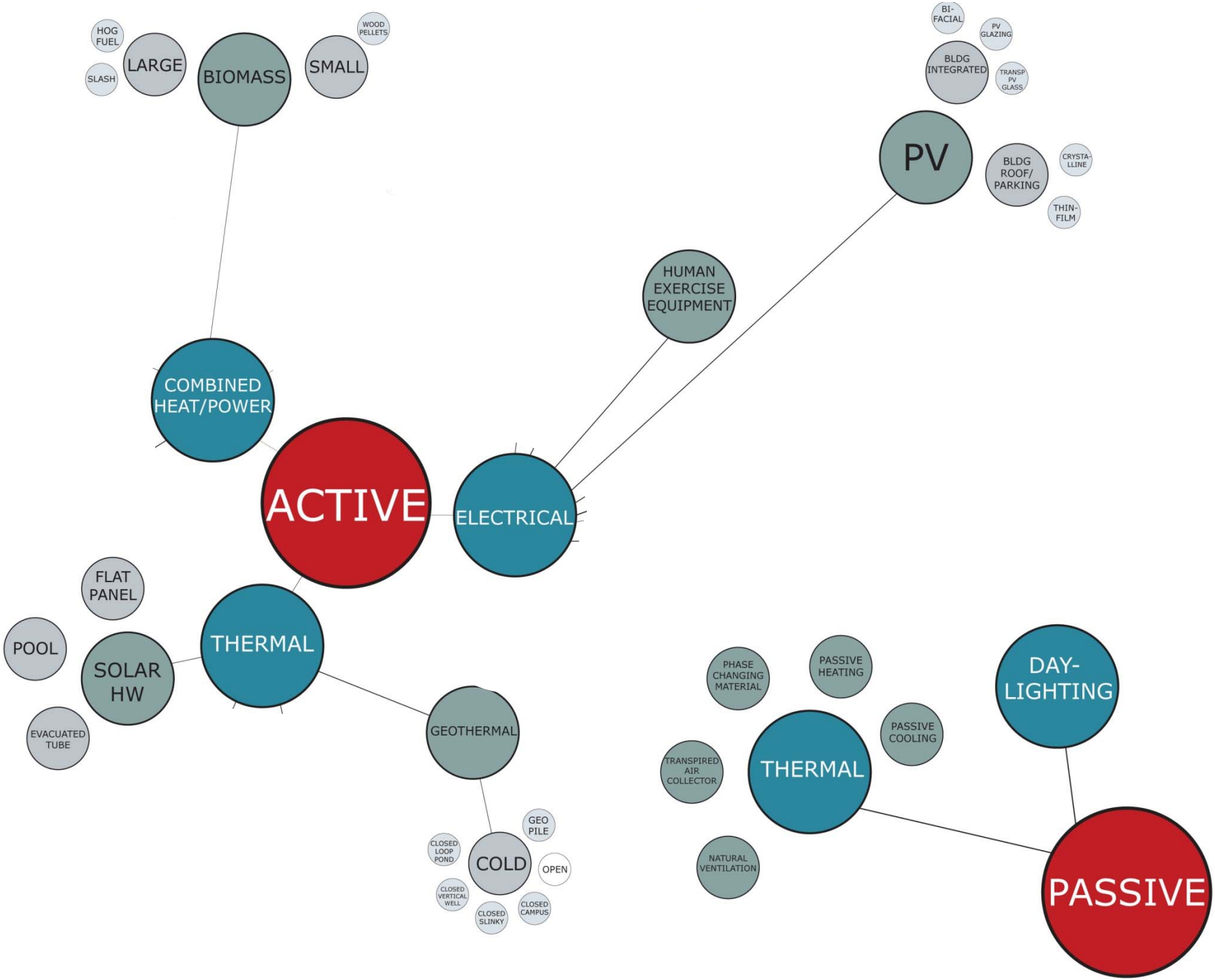

ACTIVE
PASSIVE
ELECTRICAL
THERMAL
COMBINED HEAT/POWER
BIOMASS
LARGE
HOG FUEL
SLASH
SMALL
WOOD PELLETS
BIOFUELS LIQUID
VEG OIL
ALGEA
BIO-DIESEL
ANIMAL FATS/ GREASE
ETHANOL
CORN/ SUGAR
CELLU-LOSIC
BIOFUELS GASEOUS
LANDFILL METHANE
FUEL CELL
GENERATOR
MICRO TURBINE
PROTON EXCHANGE MEMBRANE
ANAEROBIC DIGESTION METHANE
FUEL CELL
MICRO TURBINE
GENERATOR
ARTIFICIAL PHOTO-SYNTHESIS
WIND
MICRO
MACRO
HYDRO
MICRO
MACRO
HUMAN EXERCISE EQUIPMENT
PV
BI-FACIAL
PV GLAZING
BLDG INTEGRATED
TRANSP PV GLASS
BLDG ROOF/ PARKING
CRYSTA-LLINE
THIN-FILM
WAVE/ TIDAL ENERGY
METHANE FUEL CELLS
SOLID OXIDE
PIEZO ELECTRICAL
SOLAR THERMAL POWER STATIONS
HIGH CONCEN. PV
FLAT PANEL
POOL
SOLAR HW
EVACUATED TUBE
SEWAGE HEAT RECOVERY
ABSORPTION CHILLERS
SOLAR CHILLED WATER
GEOTHERMAL
HOT
COLD
GEO PILE
OPEN
CLOSED LOOP POND
CLOSED VERTICAL WELL
CLOSED SLINKY
CLOSED CAMPUS
PHASE CHANGING MATERIAL
PASSIVE HEATING
PASSIVE COOLING
TRANSPIRED AIR COLLECTOR
NATURAL VENTILATION
DAY-LIGHTING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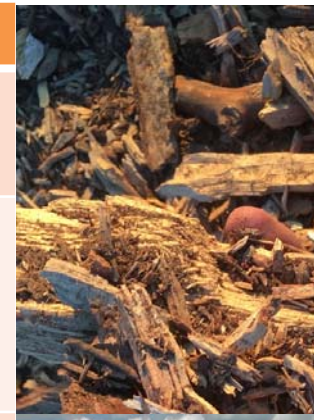
DAY-LIGHTING
PASSIVE COOLING
TRANSPIRED AIR COLLECTOR
THERMAL
NATURAL VENTILATION
PASSIVE

Thermal Energy Sources

Option	Description	Comments	Evaluated?
Natural Gas	Central or de-centralized. Creates heating water and domestic HW.	Fossil fuel based.	No
Biomass	Central or de-centralized. Creates heating water and domestic HW. Uses wood	Carbon neutral. Needs separate cooling source.	Yes
Biomass w/ Geoexchange	Horizontal “slinky” system using the ground as a heat sink. Geo provides full cooling and 30% of heating.	Low temperature system. Provides future flexibility.	Yes
Geoexchange	Horizontal “slinky” system using the ground as a heat sink. Geo provides full cooling and 100% of heating.	Heating/cooling loads unbalanced. Ground temperature issues. Not cost effective.	No
Geoexchange w/ air source HP	Horizontal “slinky” system using the ground as a heat sink. Geo provides full cooling and some % of heating. Heat pumps provide balance of heating energy.	Heat pumps increase need for PV.	No



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Electrical Energy Sources

Option	Description	Comments	Evaluated?
Wind	Renewable energy using multiple turbines. Connect to utility grid.	Inadequate wind resources. Higher maintenance needs. Intermittent generation.	No
Photovoltaic	Roof mounted, canopy mounted, and ground mounted photovoltaic panels. Connect to utility grid.	Abundant solar resources. Low maintenance. Costs declining.	Yes
Biomass w/ Cogeneration	Using an organic Rankine cycle generator with the biomass boiler to generate electricity along with heat. System sized for the heat load of the campus.	Can combine with any of the thermal biomass options. Would not run in the summer unless a need for heat was found. Additional maintenance.	No. Consider for future.

Systems Overview

Renewable System Size Comparison

Energy System Size				
Option	Campus EUI	Biomass Plant (kW)	Geoloop (sqft)	Ground Mount PV (sqft)
Business as Usual	79	Not applicable	Not applicable	Not applicable
Good	79	13,000	-	530,000
Better	56	9,000	-	350,000
Better +	49	7,000	1,400,000	370,000
Best	38	6,000	-	190,000
Best +	33	4,000	900,000	200,000

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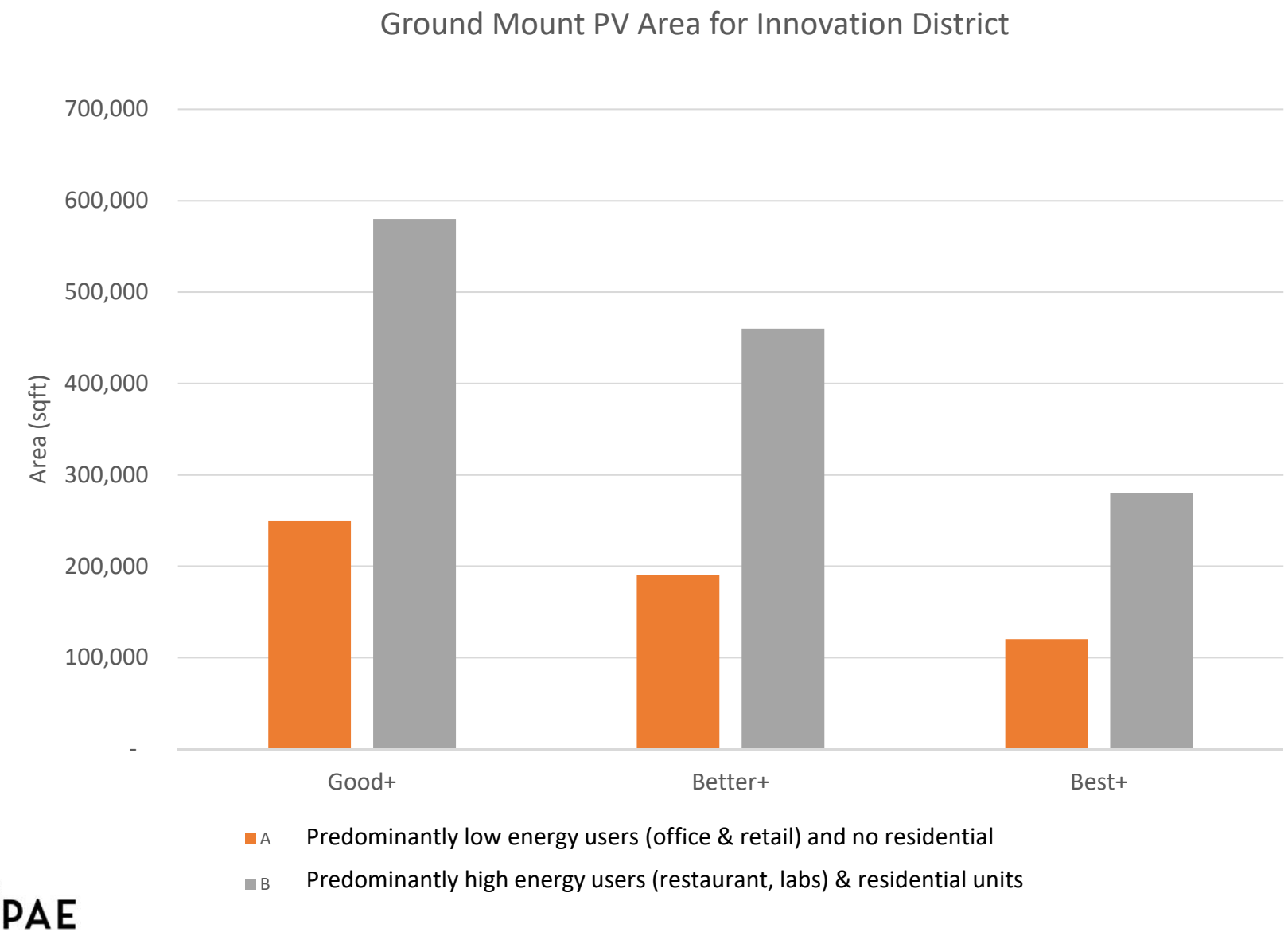
Innovation District Effects



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Renewable System Size Comparison

Best Scenario: 200,000 sqft ground mount PV

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Renewable System Size Comparison

Best with Innovation District: 400,000 sqft ground mount PV

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Renewable System Size Comparison

Better Scenario: 360,000 sqft of ground mount PV

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Renewable System Size Comparison

Better with Innovation District: 690,000 sqft of ground mount PV

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Renewable System Size Comparison

Good Scenario: 530,000 sqft of ground mount PV

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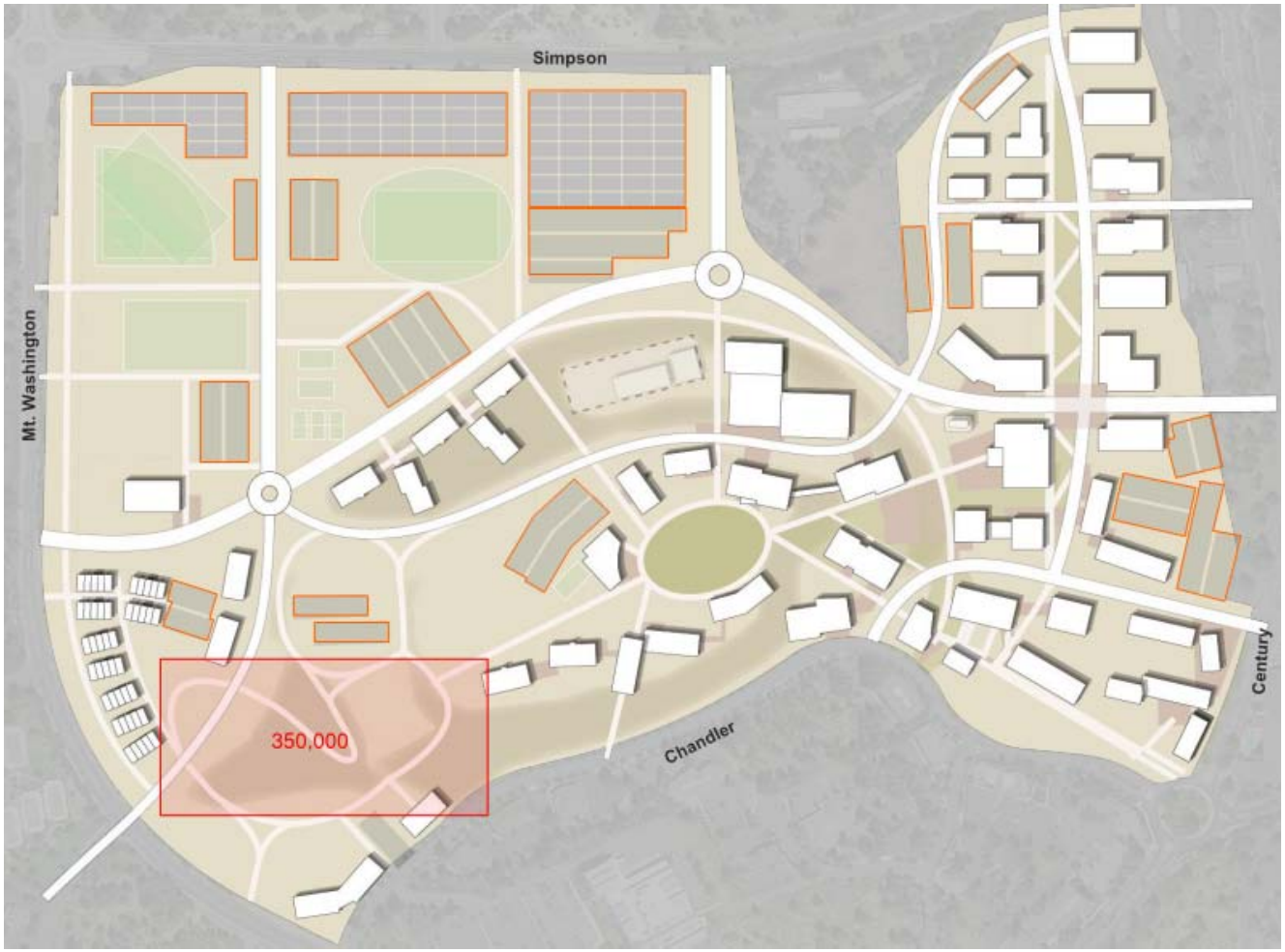
Renewable System Size Comparison

Good with Innovation District: 950,000 sqft of ground mount PV



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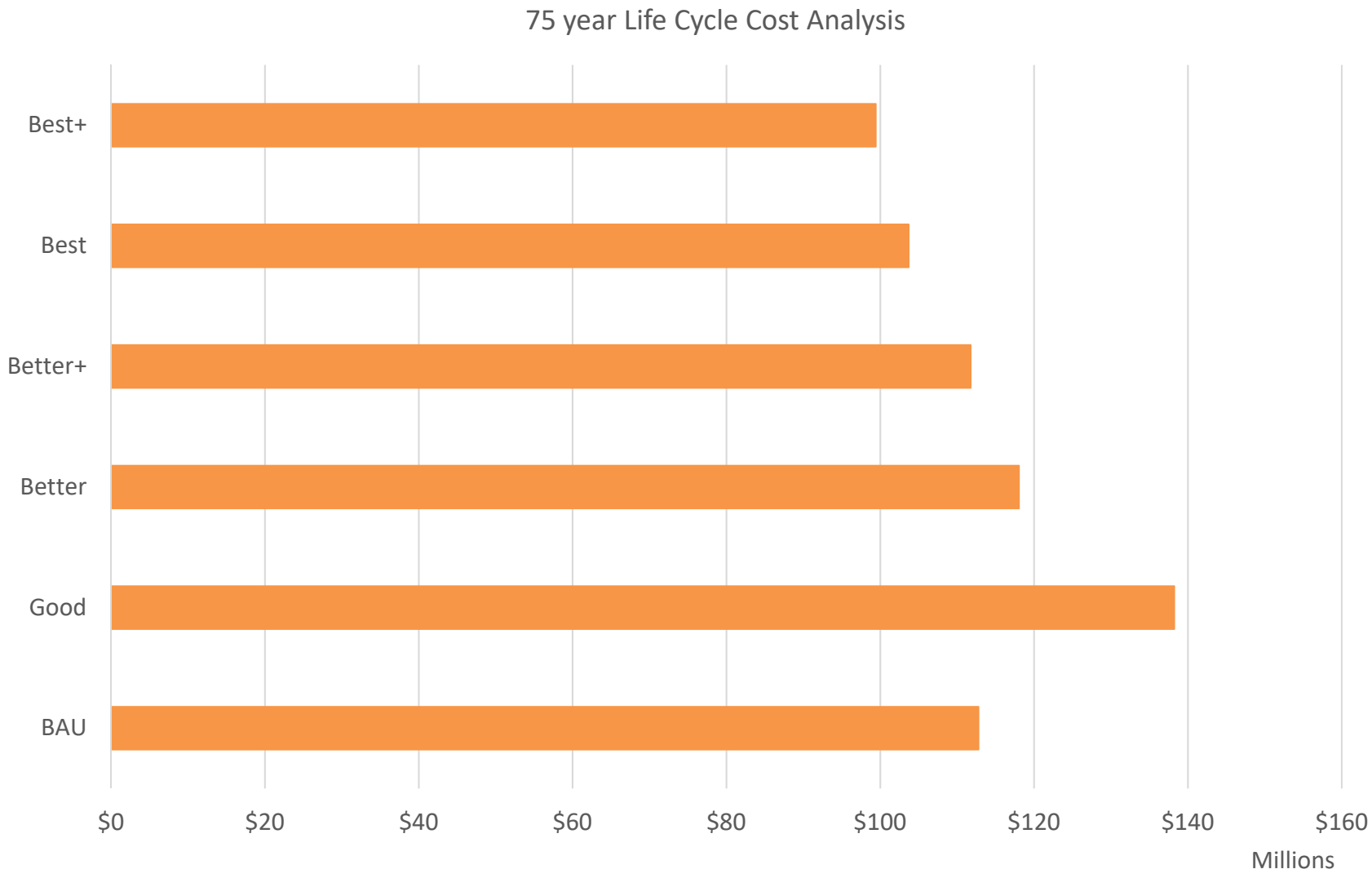
Options Comparison



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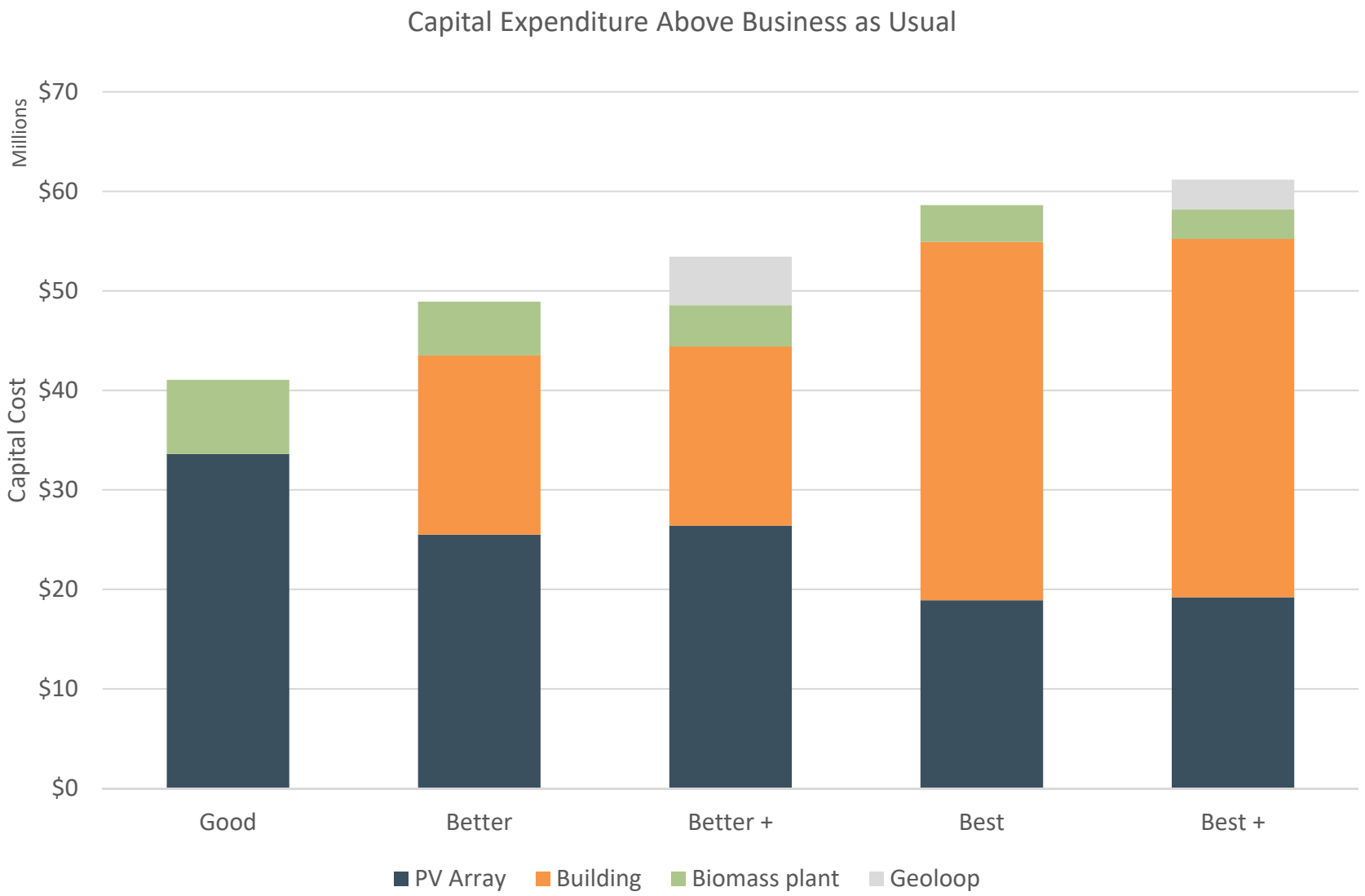

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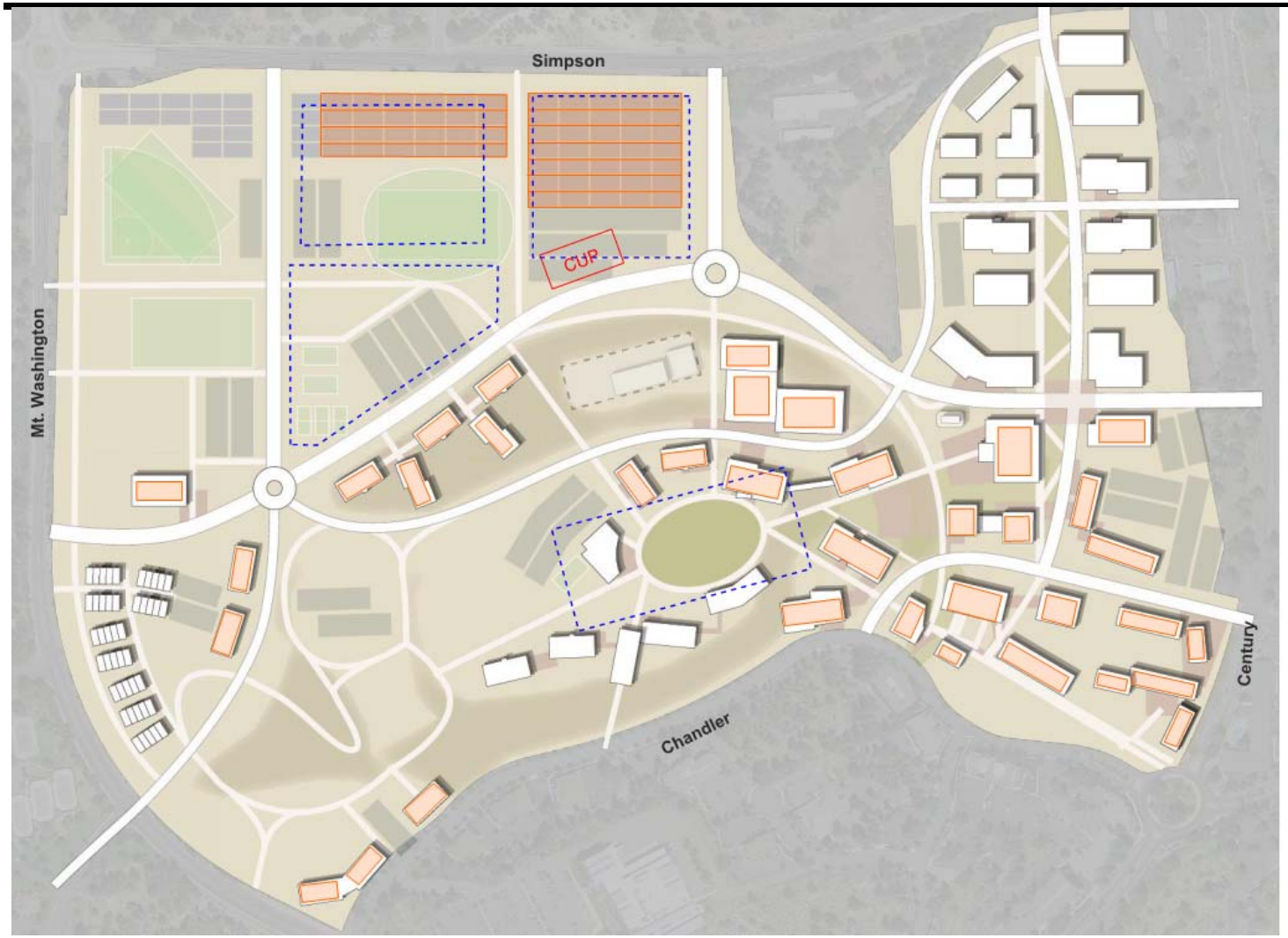
Recap



OSU-Cascades Long Range Development Plan

- Geoexchange Loop
- PV array
- Biomass Central Utility Plant

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Creating a better environment

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