LISLE JUNIOR HIGH SCHOOL

By Team engiNUity

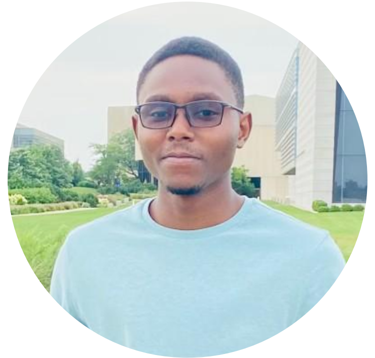
LJHS+

Northwestern University
DOE Solar Decathlon 2023
Education Building Division

OUR TEAM

Polen Ton
3rd Year Undergrad
Civil Engineering

Alonzo William
3rd Year Undergrad
Civil Engineering



Nasser Nduhi
3rd Year Undergrad
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Dylan Meretsky
2nd Year Undergrad
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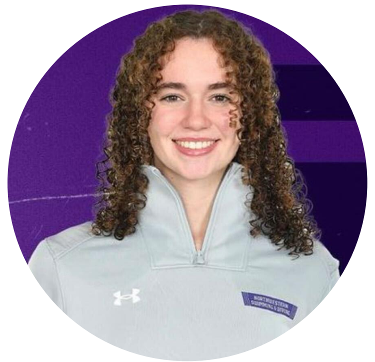
3rd Year Undergrad
Civil Engineering



Lola Mull
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Josh Holtgreive
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LJHS+

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FACULTY ADVISOR

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Dr. Giorgia Chinazzo
Assistant Professor of Instruction and Director of Architectural Engineering and Design Program

INDUSTRY PARTNERS

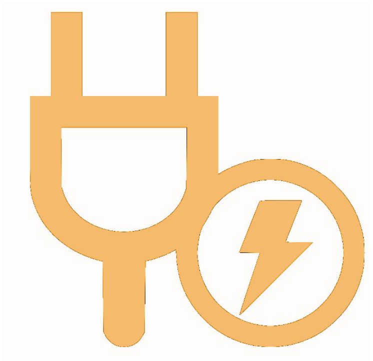
LISLE JUNIOR HIGH SCHOOL

ARUP

NORTHBROOK PARK DISTRICT

THE PROBLEMS

Environmental Impacts of schools in the US



336 Trillion BTU of Energy

81% of US Energy from Fossil Fuels

6% Commercial Water Usage

National Center for Education Statistics (1999), “How old are america’s public schools?”
Facility Executive (2021), “U.S school facilities face $85 billion funding gap a year”
US Energy Information Administration (2016), “Commercial building energy consumption survey”
Watersense (2012), “Saving water in education facilities”

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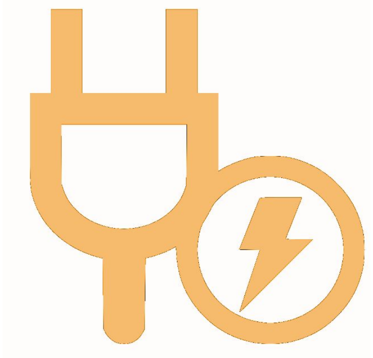

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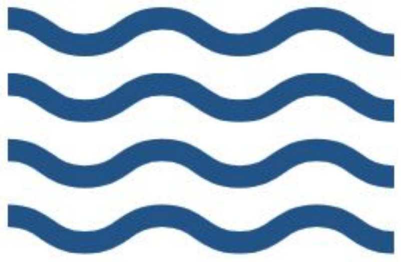
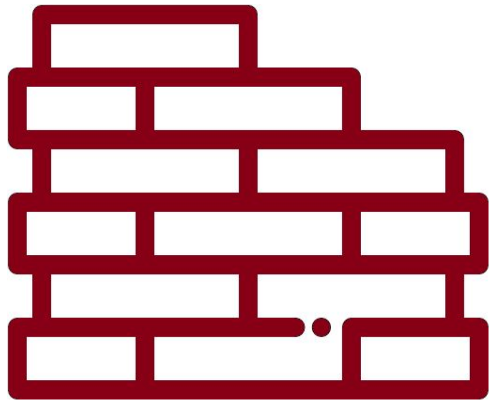


6% Commercial Water Usage

Social problems of schools in the US



Aging School Infrastructures

67 years on average in Northeast and central states

$110 billions every year on maintenance, operation, and capital construction in PK-12 public school facilities

National Center for Education Statistics (1999), “How old are america’s public schools?”
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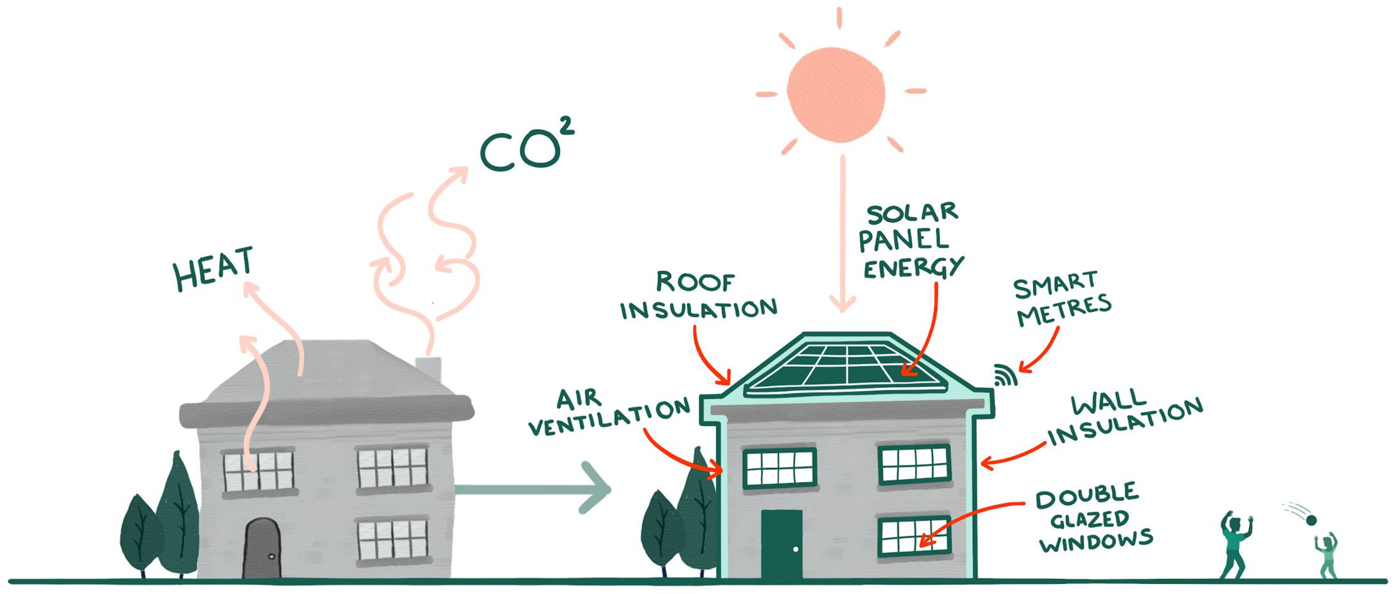
WHY RETROFIT MAKES SENSE



- Building operations in the Midwest have a large environmental impact
  - Due to a combined effect of **reliance on coal power** and an **extreme climate**

- Retrofitting an existing building brings cost benefits and energy reduction over a **75 year lifespan**
  - Retrofits are more likely to be approved by school boards and taxpayers than new constructions
- It takes **10 more years** for a new building to overcome negative impacts associated with construction.

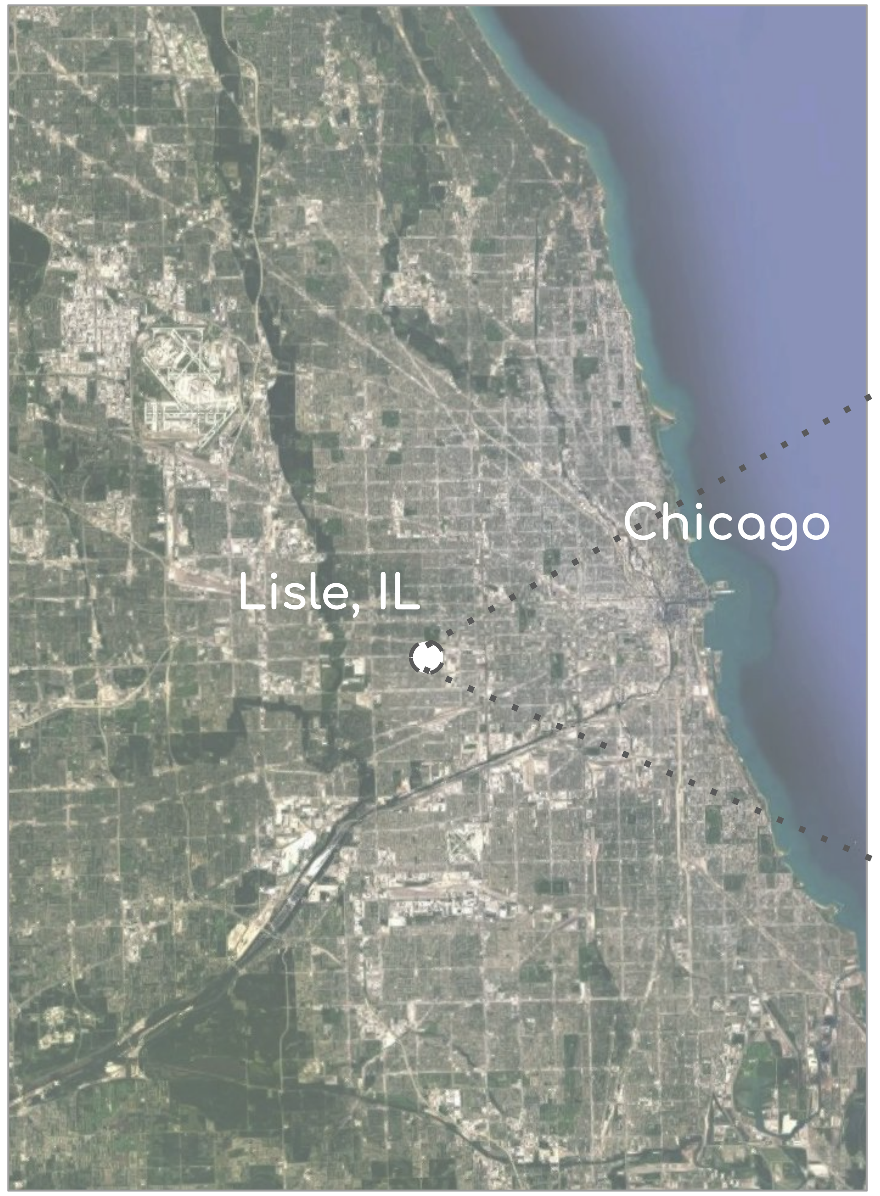
Optimised Retrofit Wales, “Resident Information”
Zimmer et al (2011), “What Types of School Capital Projects are Voters Willing to Support?”
Preservation Green Lab (2022), “The Greenest Building: Quantifying the Environmental Value of Building Reuse”

MISSION STATEMENT

The retrofit of Lisle Junior High School aims to serve as a sustainable and feasible **“prototype”** for existing public schools in the US, by prioritizing the needs of our students and the surrounding community.

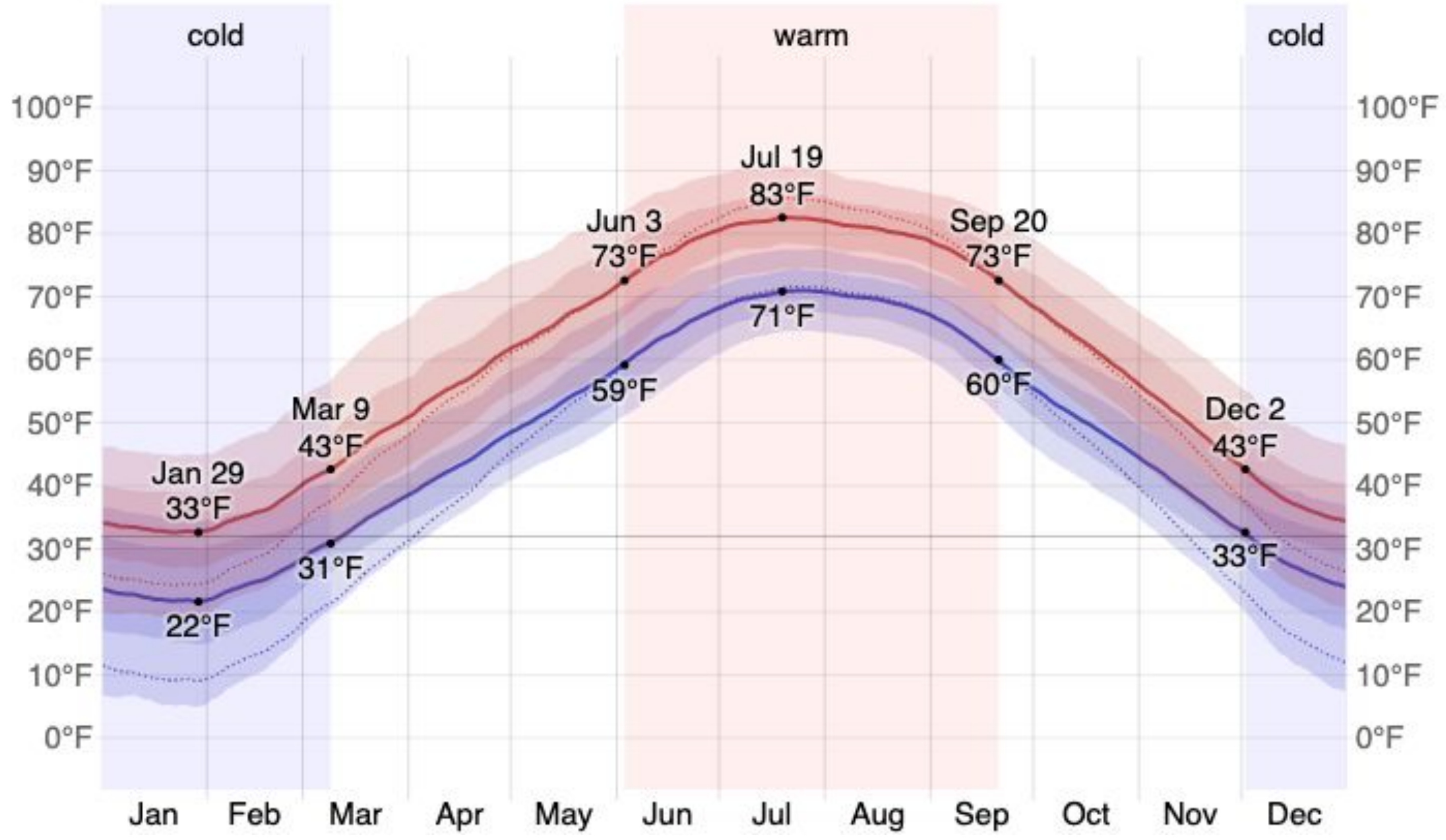
SITE CONTEXT

Climate Zone: 5A



Lisle Junior High School

Temperature curve



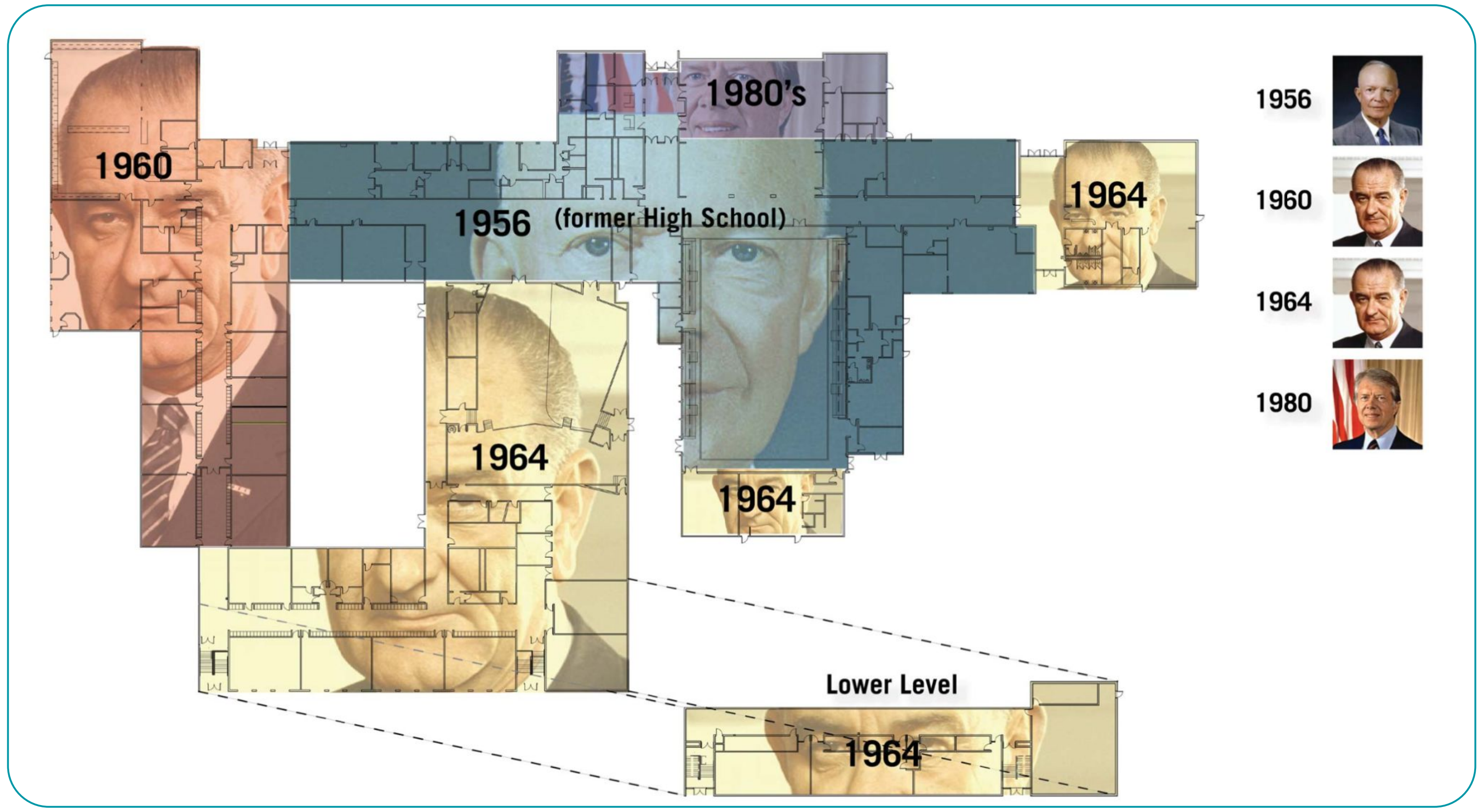
Precipitation curve

Weatherspark (2023)," Climate and Average Weather Year Round in Chicago"

SITE CONTEXT

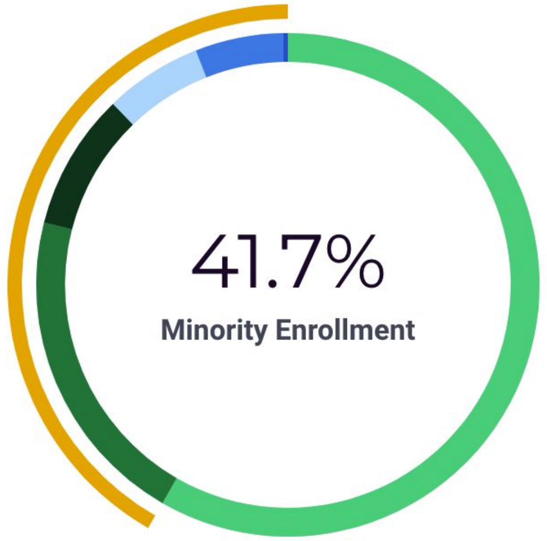
Existing LJHS

Building Chronology by President at time of construction



400 GRADE 6-8

Student Diversity



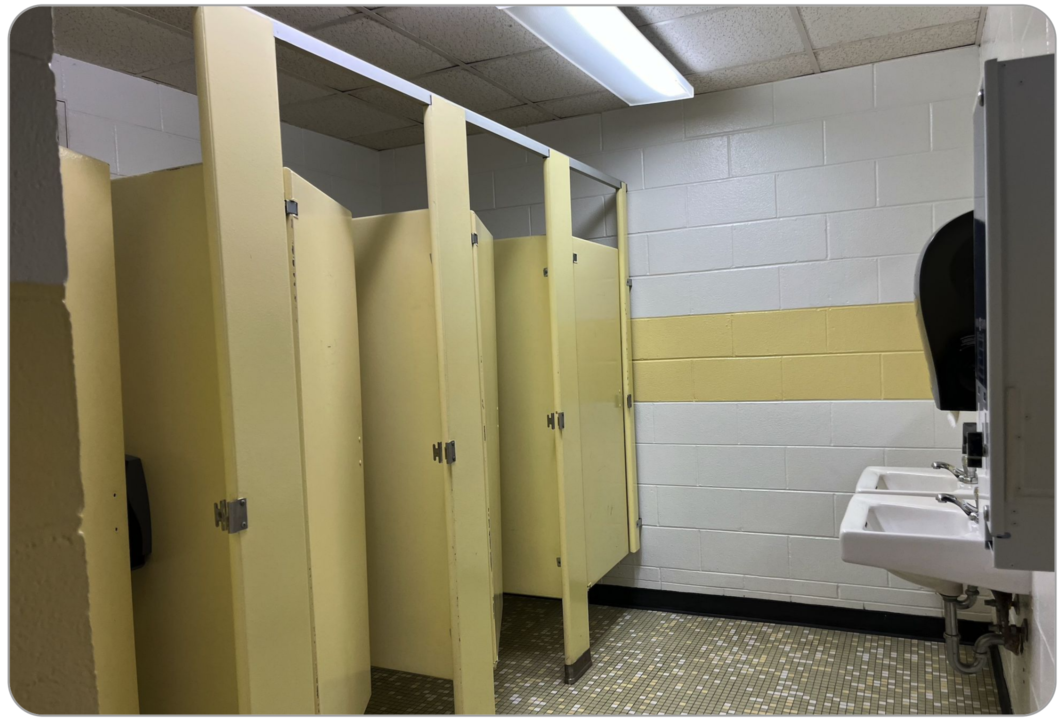
- **41.7%** Minority Enrollment
- **58.3%** White
- **20.7%** Hispanic/Latino
- **8.8%** Black or African American
- **6.3%** Two or more races
- **5.6%** Asian or Asian/Pacific Islander
- **0.3%** American Indian or Alaska Native

Native Hawaiian or Other Pacific Islander is not included in this breakdown due to an enrollment of 0%.

EXISTING CONDITIONS

Uncollaborative setup

Inaccessible & Exclusive



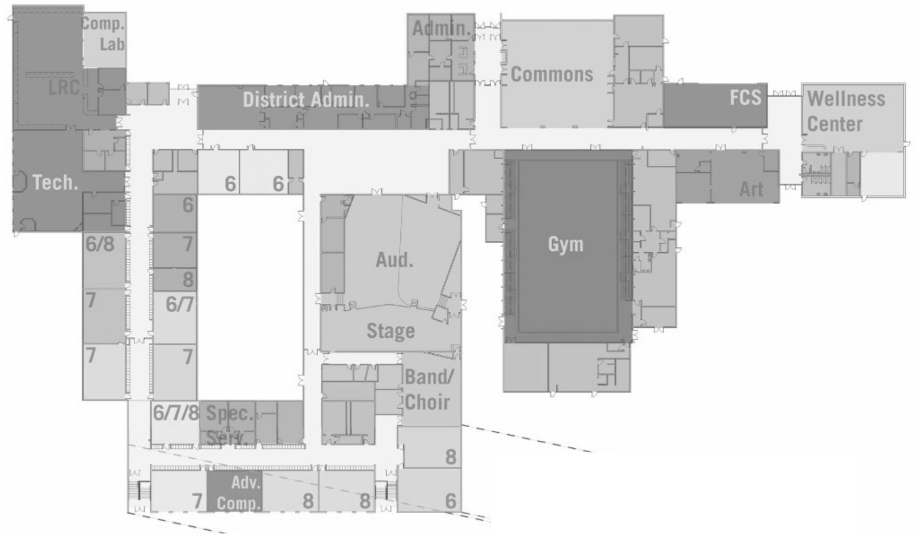
Lack of outdoor spaces

Lack of thermal barrier

Lack of natural light

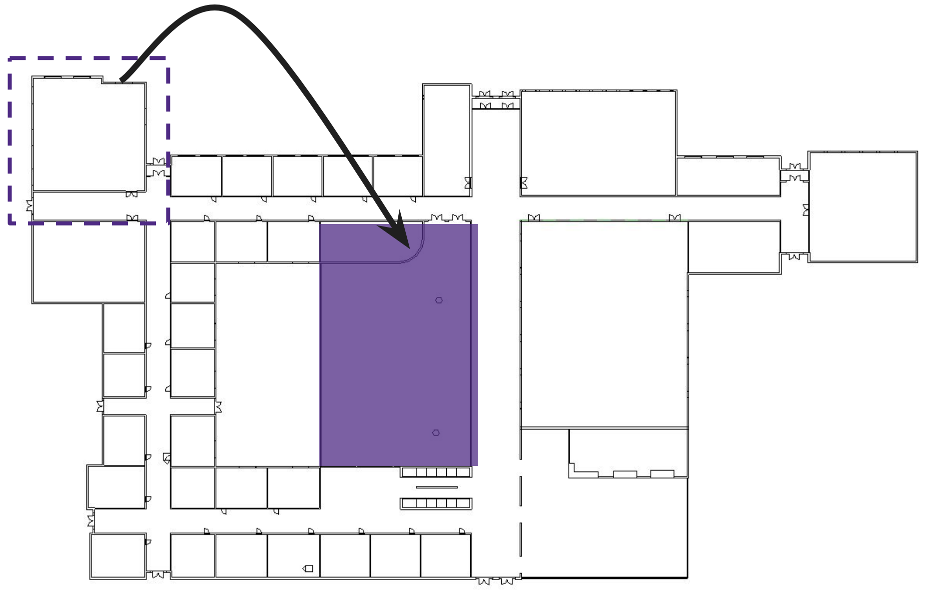
Inefficient windows

DESIGN PRINCIPLES



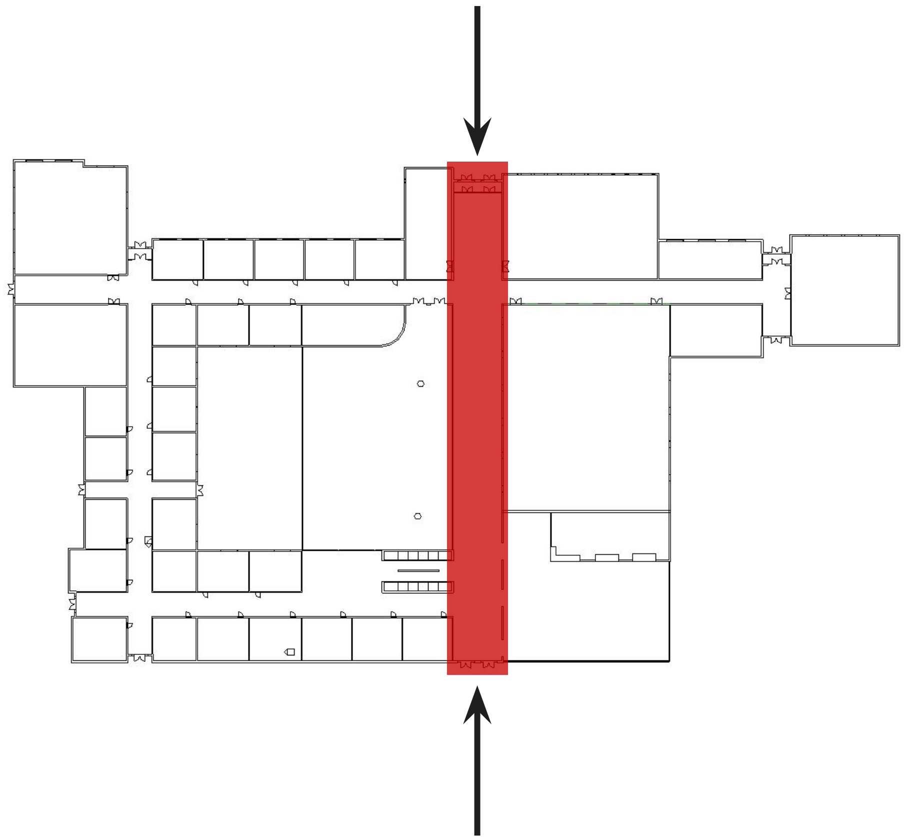
EXISTING

Programming is **splintered** and **not organized** around a **central principle**



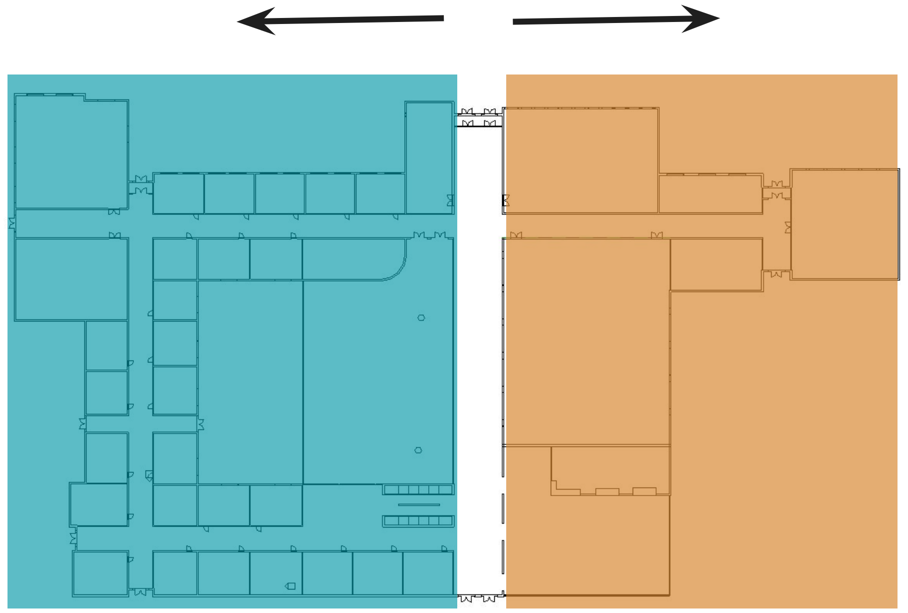
CENTRALIZE LIBRARY

Increase the size and **relocate** critical program at **the heart of school**



CREATE NEW ENTRANCE

Establish a strong linear axis **threading** major programs



SEPARATE PRIVATE FROM PUBLIC PROGRAMS

New entrance creates clear **separation** of academic environment and community programming for stronger **security** year round

OUR CHALLENGES

CHALLENGE 1:

OUTDATED LEARNING ENVIRONMENT

CHALLENGE 2:

ANTIQUATED BUILDING OPERATION AND DESIGN

OUR APPROACHES

APPROACH 1:

CULTIVATE AN ENGAGING LEARNING ENVIRONMENT

APPROACH 2:

ESTABLISH A RESILIENT & SUSTAINABLE CAMPUS

OUR APPROACHES

RETROFIT TO COLLABORATIVE ENVIRONMENT

- Centralize the programmes
- Provide flexible learning opportunities
- Promote interactions through indoor & outdoor activities
- Develop a more inclusive and accessible space

APPROACH 1:

CULTIVATE AN ENGAGING LEARNING ENVIRONMENT

APPROACH 2:

ESTABLISH A RESILIENT & SUSTAINABLE CAMPUS

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RETROFIT TO COLLABORATIVE ENVIRONMENT

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APPROACH 1:

CULTIVATE AN ENGAGING LEARNING ENVIRONMENT

RETROFIT TO NET-ZERO ENERGY CAMPUS

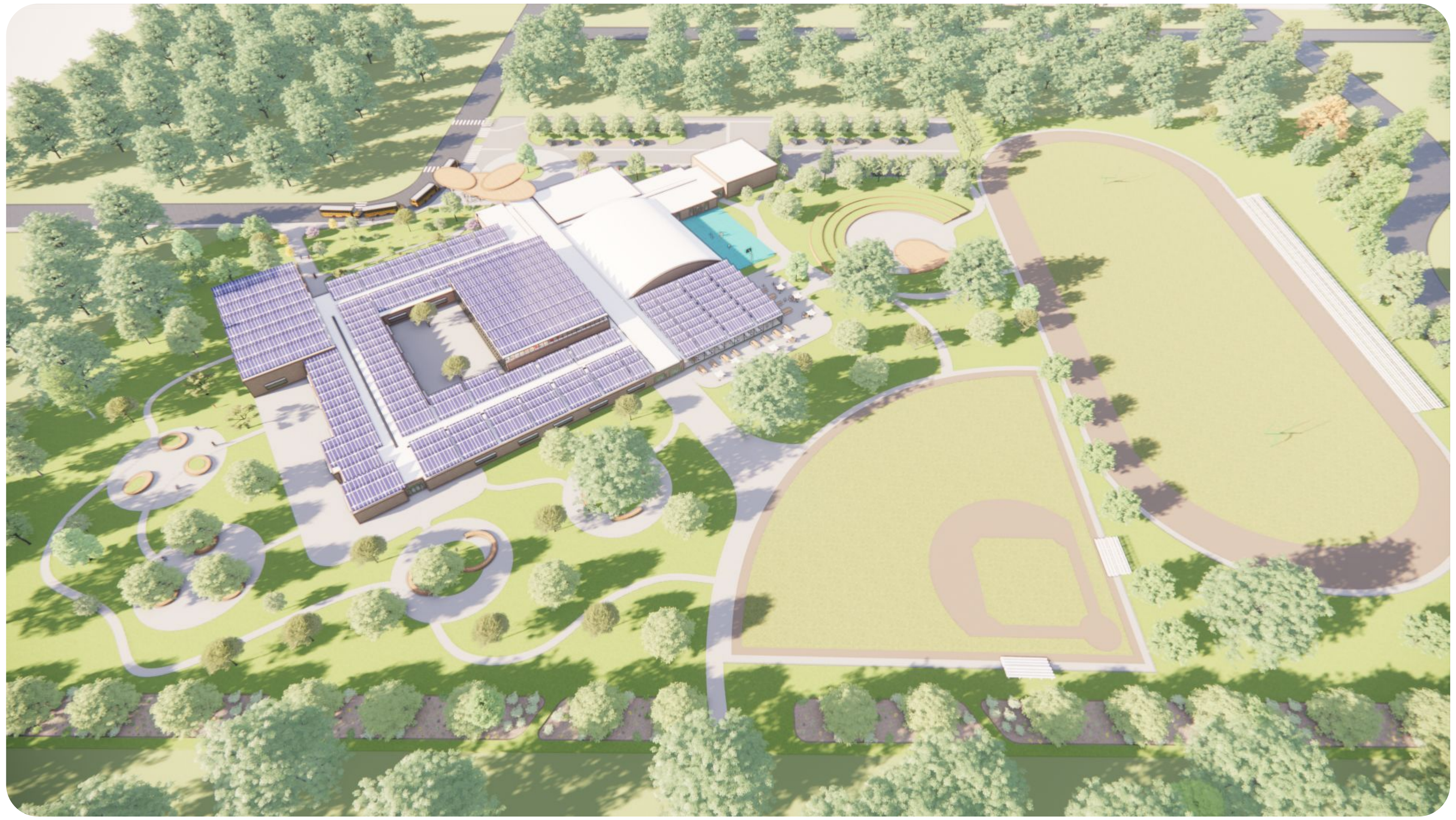
- Advance to airtight envelope
- Incorporate new HVAC system
- Introduce renewable energy generation
- Implement new water management system

APPROACH 2:

ESTABLISH A RESILIENT & SUSTAINABLE CAMPUS

LISLE JUNIOR HIGH SCHOOL

Current — Retrofitting outdated campus → Future

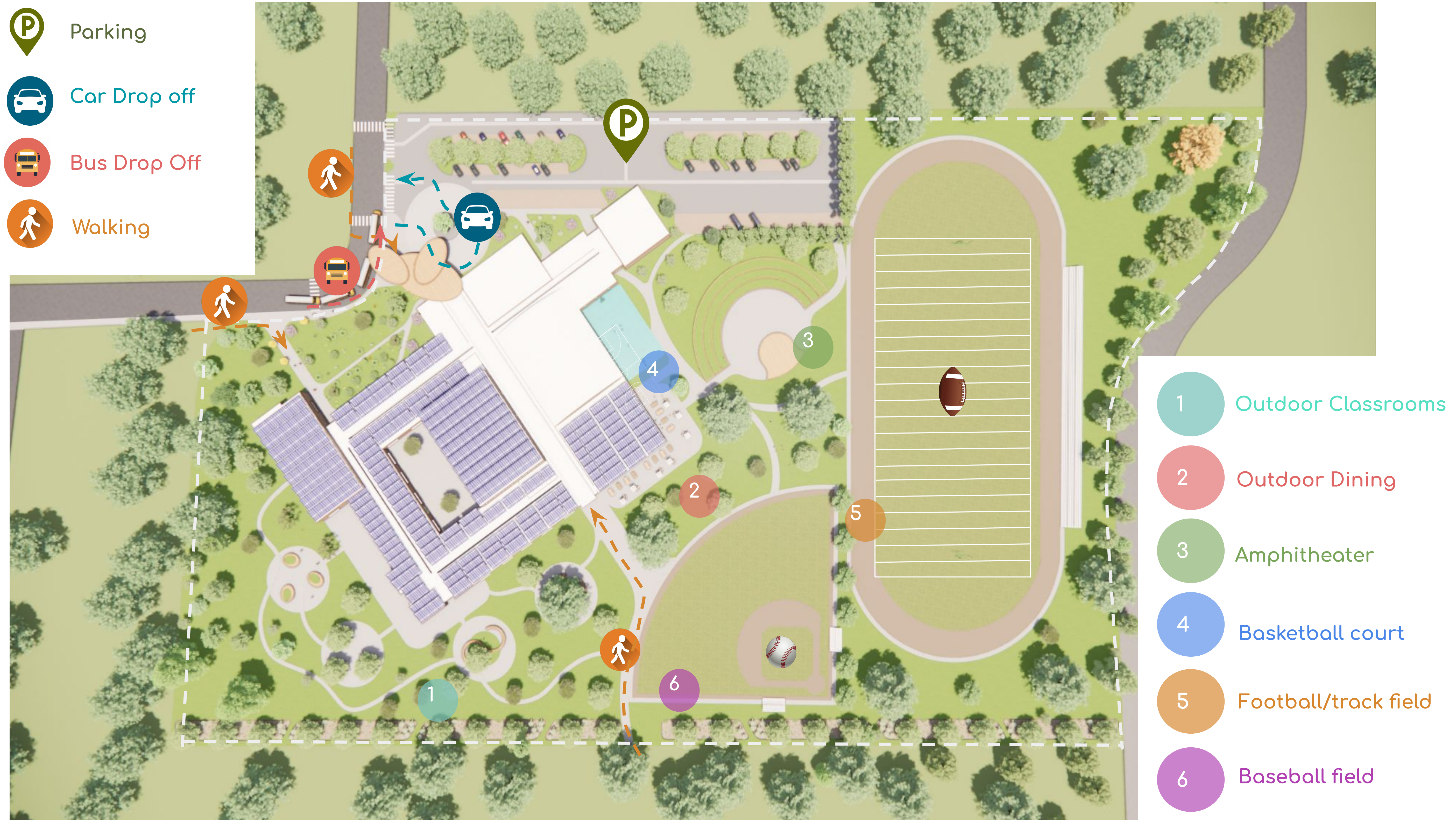


APPROACH 1

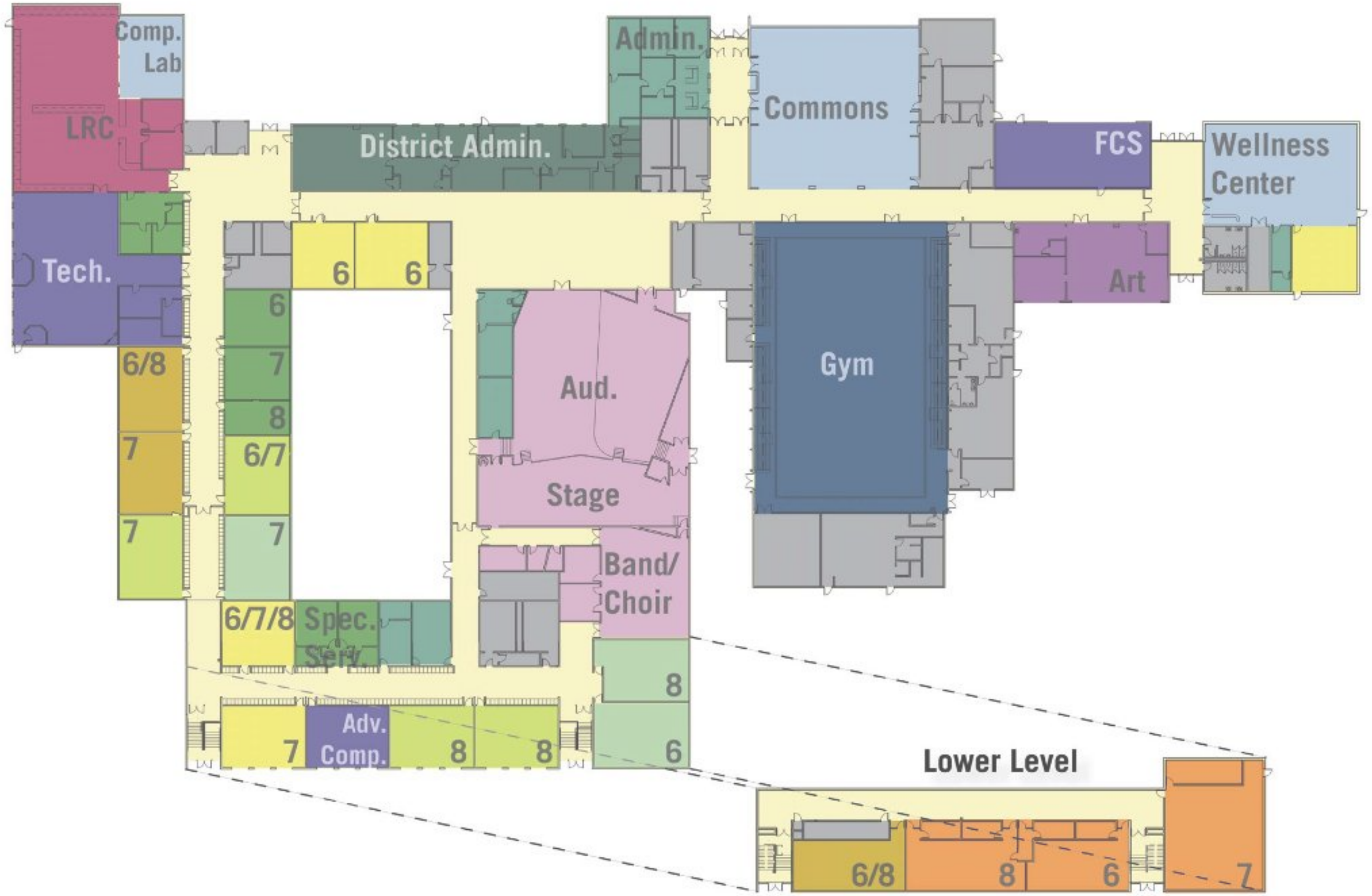
CULTIVATE AN ENGAGING LEARNING ENVIRONMENT

EXISTING SITE PLAN

PROPOSED SITE PLAN



EXISTING PROGRAMMING



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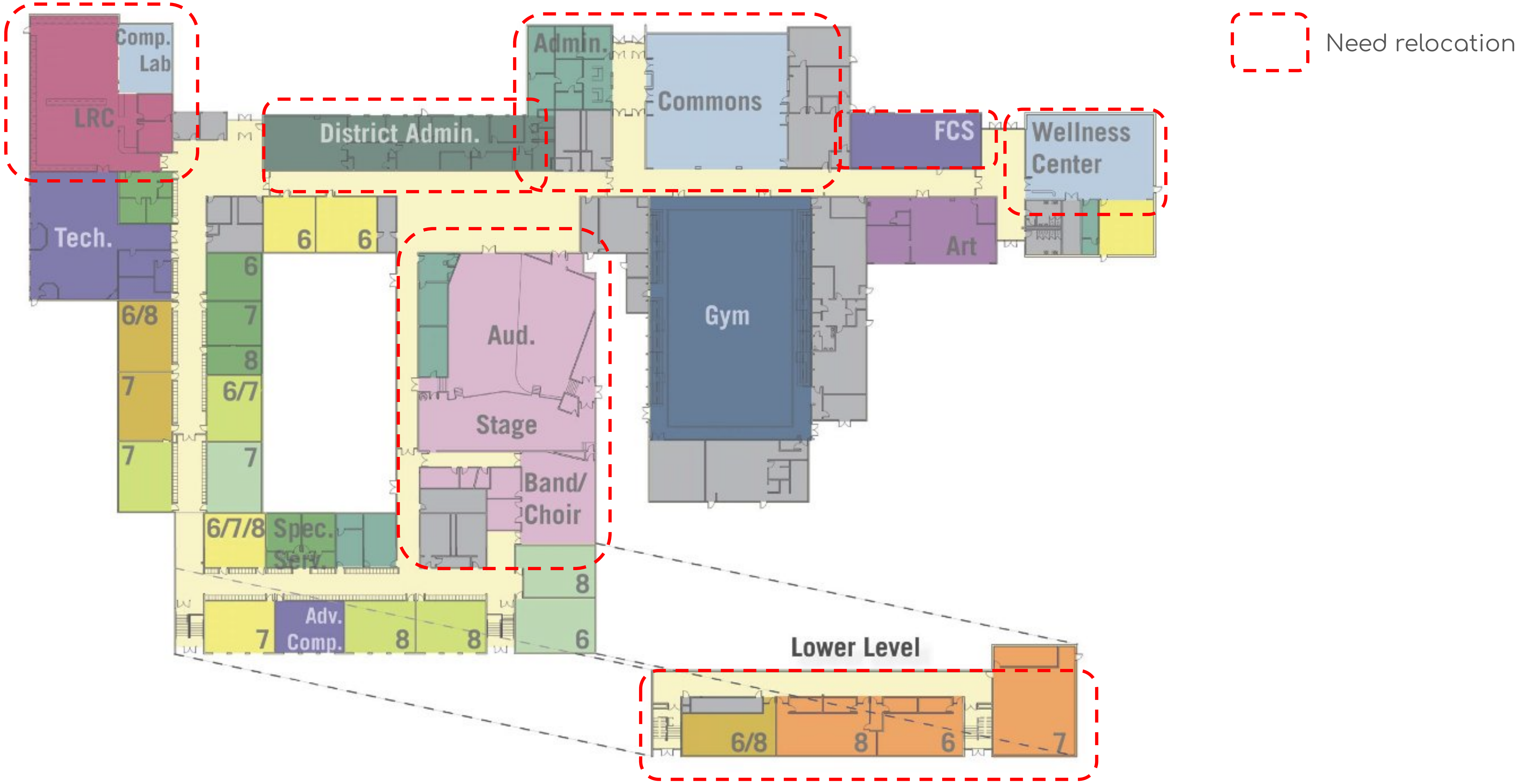
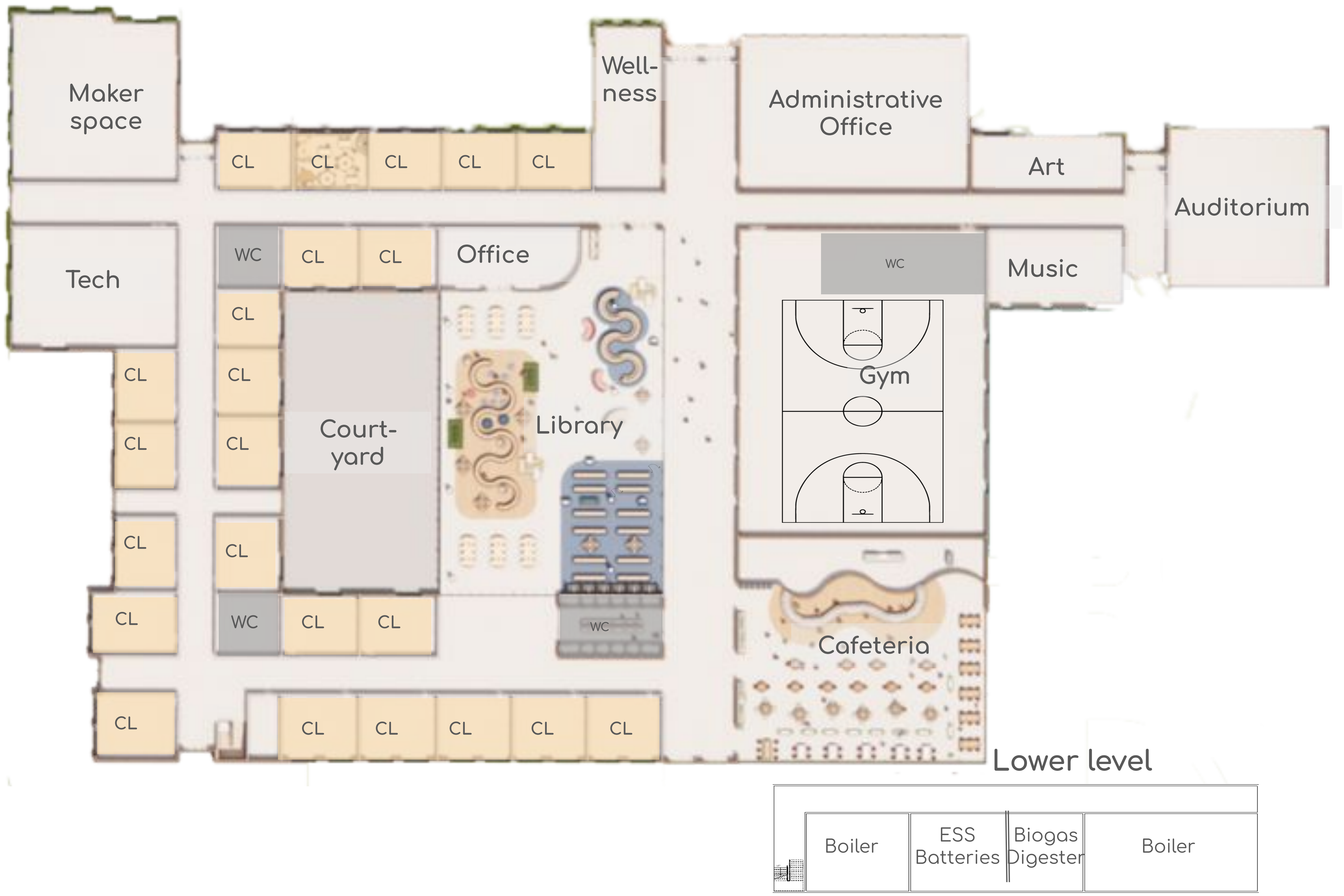


EXISTING PROGRAMMING

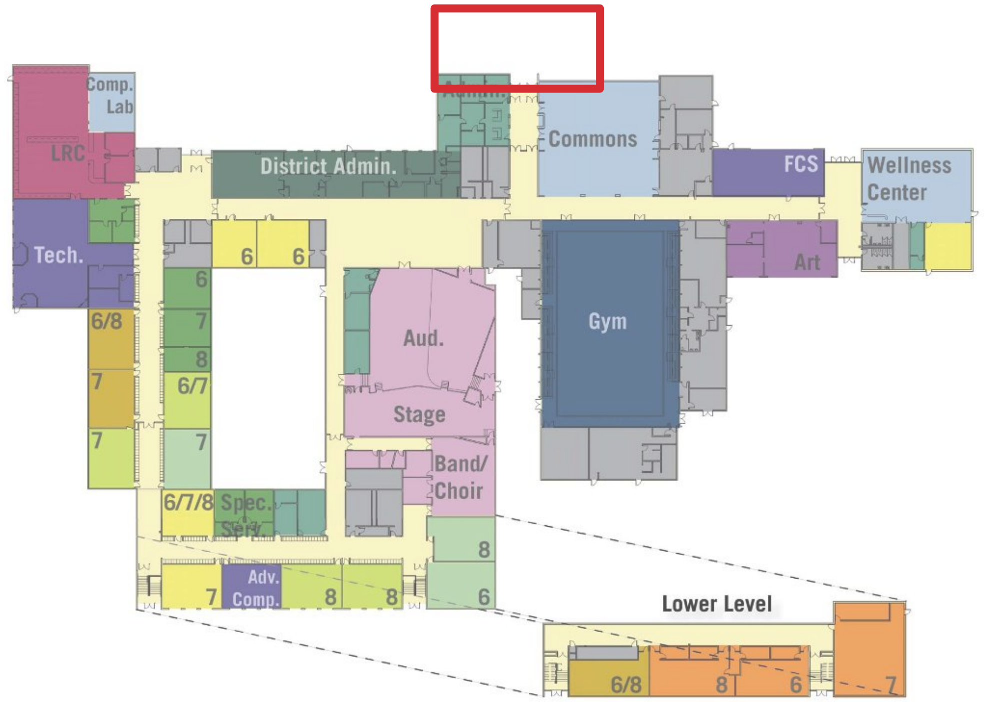
PROPOSED PROGRAMMING

CL Classrooms

WC Gender Neutral Restrooms



PROPOSED ENTRANCE



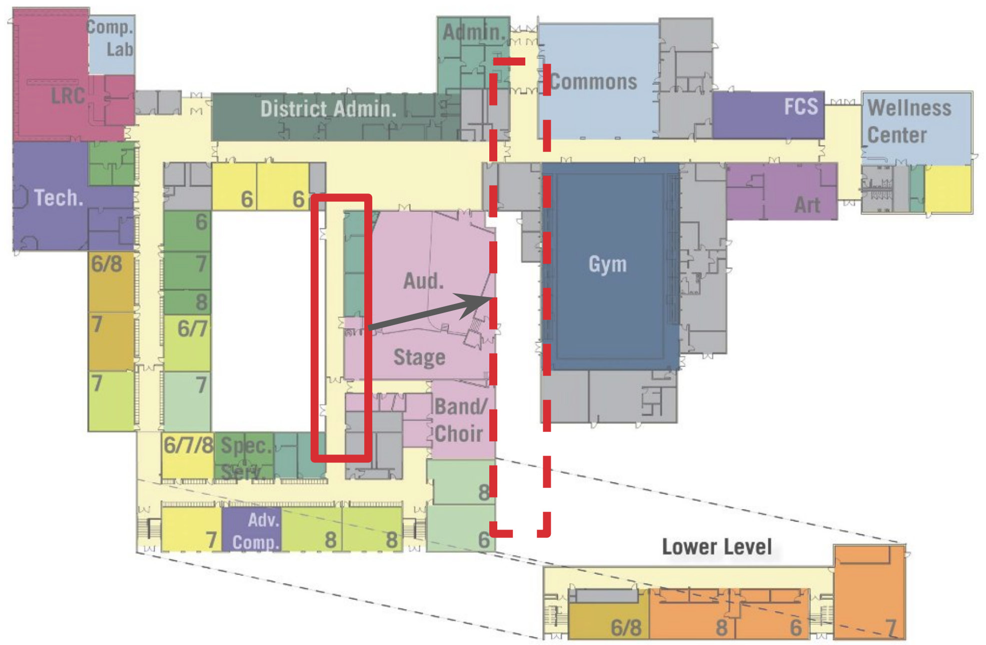
EXISTING

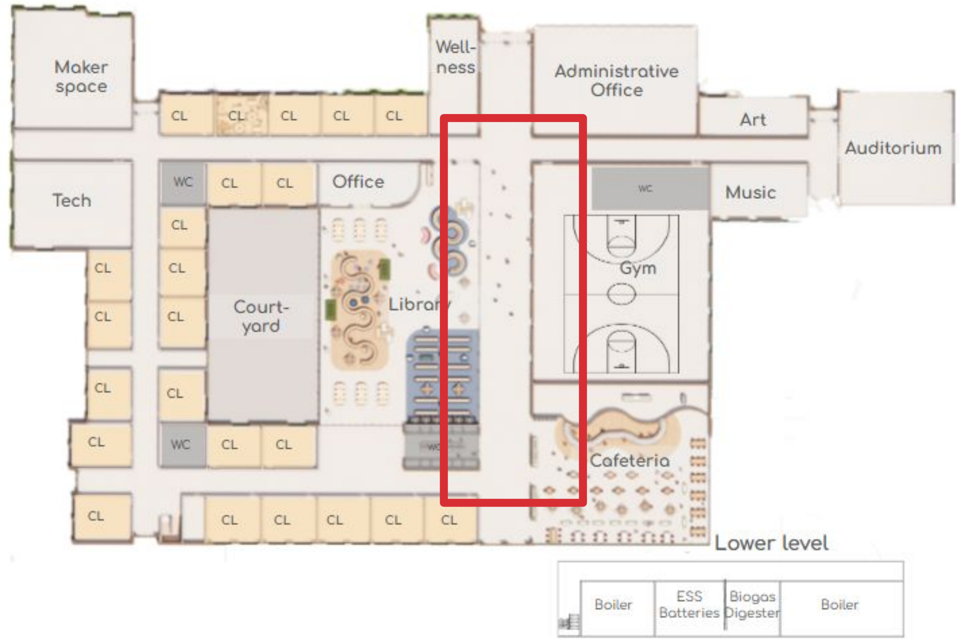
PROPOSED

Unwelcoming for students' drop off;
lackluster entrance

Shaded, interesting canopy to
welcome students and staff

PROPOSED CENTRAL CORRIDOR





EXISTING

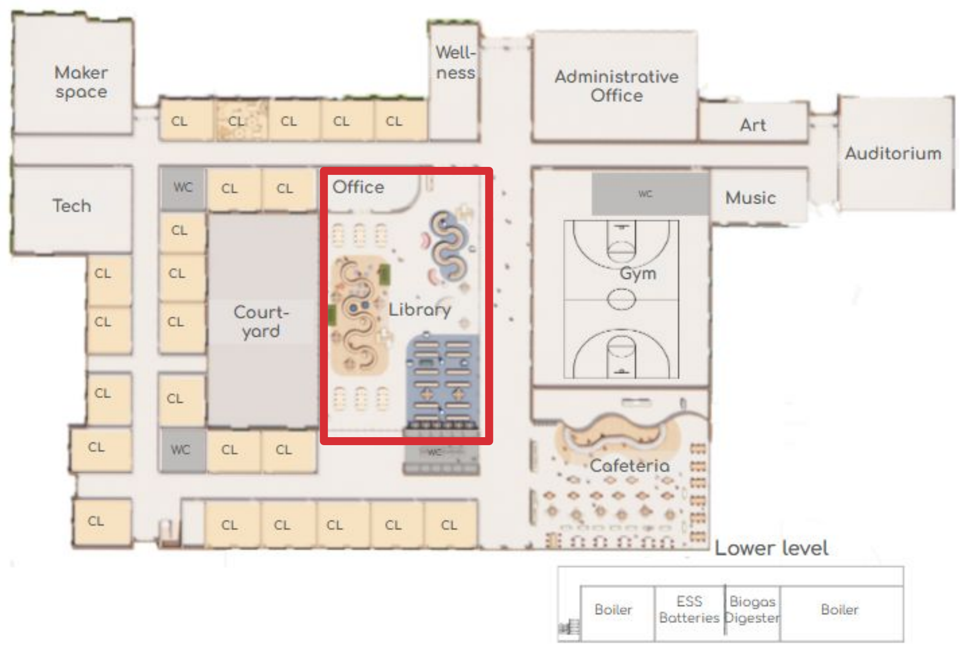
Dark, gloomy hallways that are not centralized

PROPOSED

Natural sunlight and more centralized to ease movement

PROPOSED LIBRARY

EXISTING

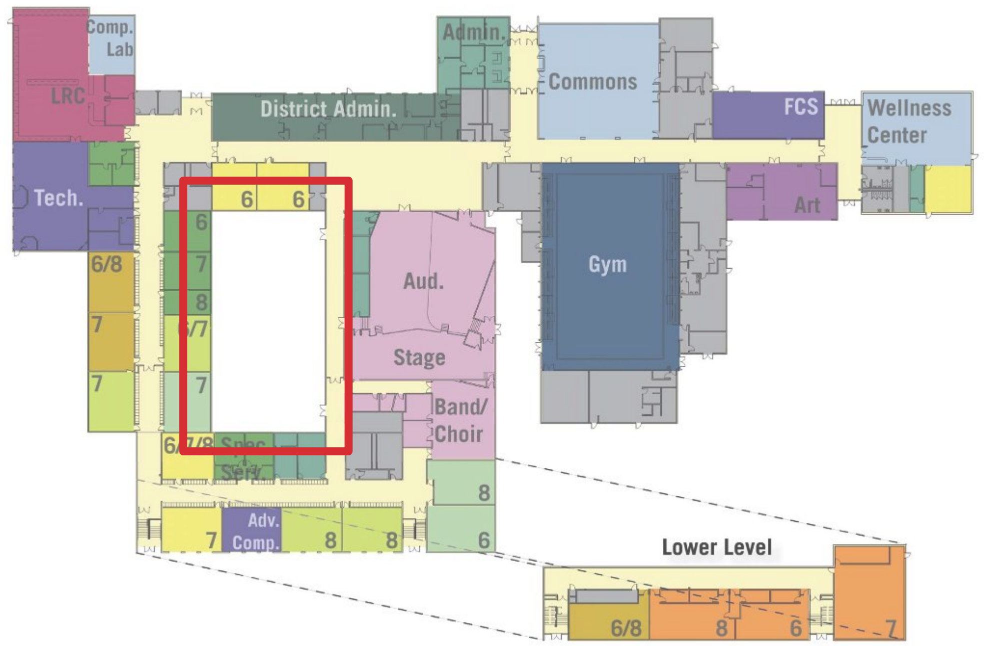


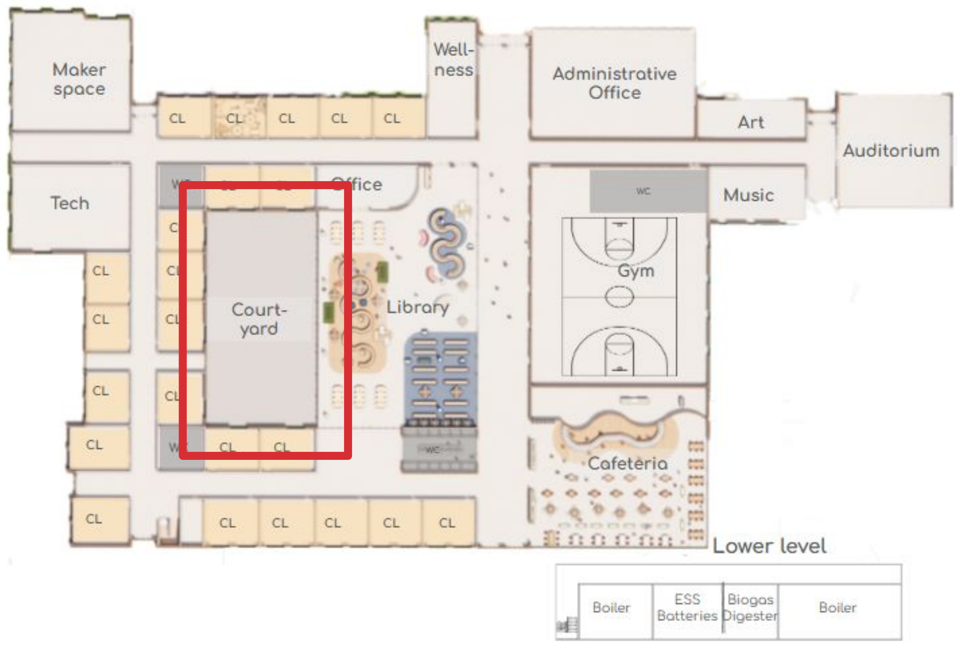
PROPOSED

Small windows that did not permit a view; limited seating options

More natural sunlight, adaptable seating options, and centralize to the school

PROPOSED COURTYARD





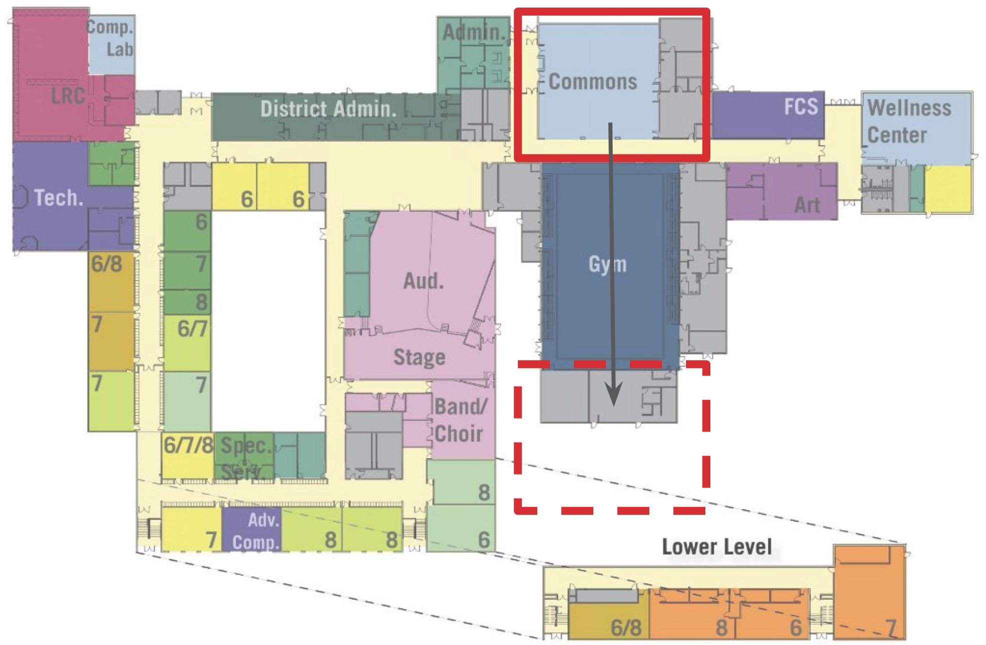
EXISTING

PROPOSED

Underutilized and not interactive

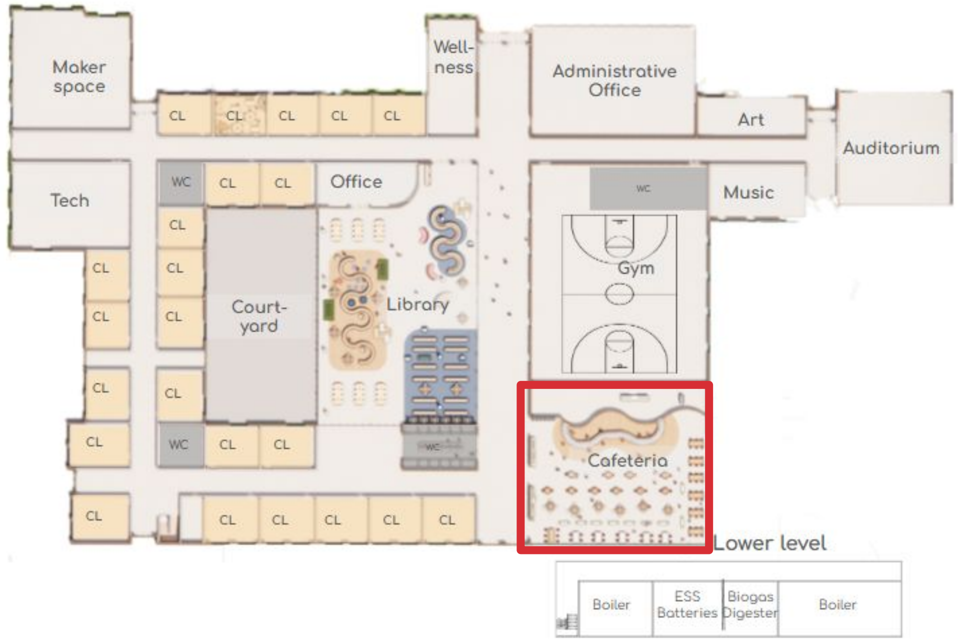
Centralized and accessible place for students and staff during recess and lunch

PROPOSED CAFETERIA



EXISTING

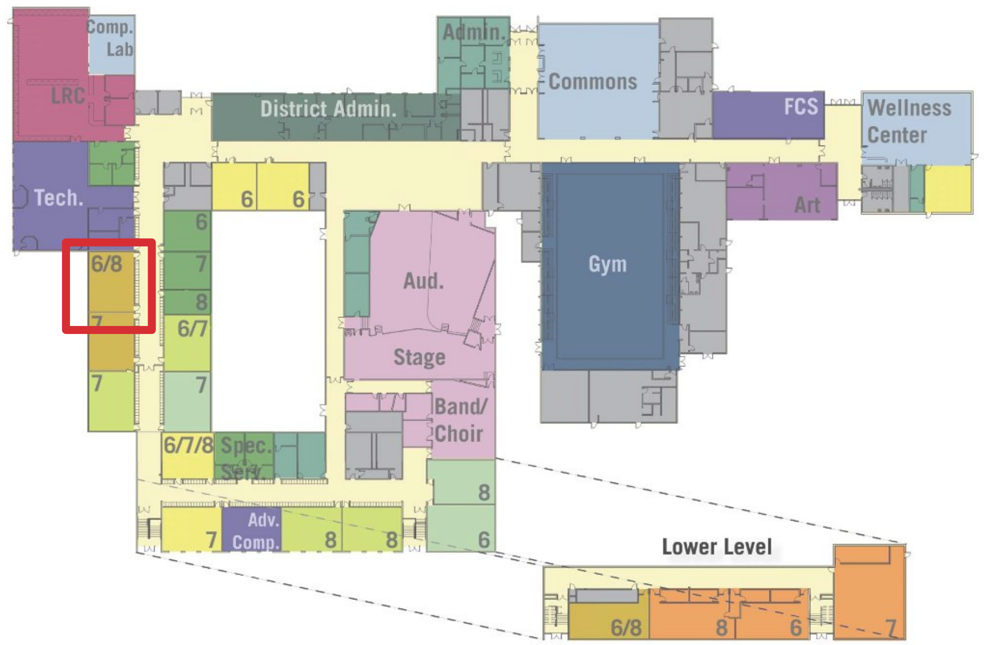
Unattractive location, right in front of the school



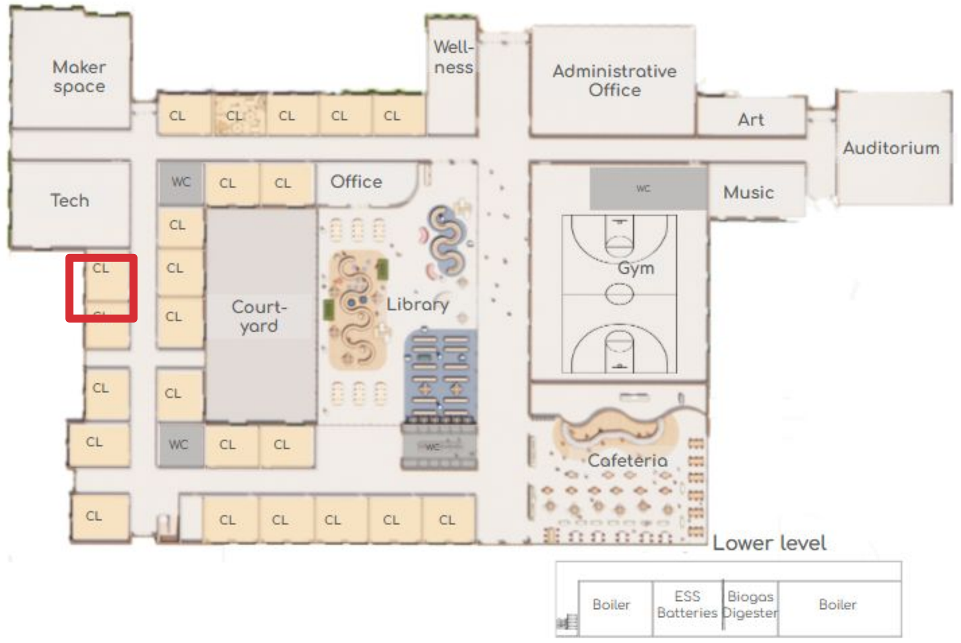
PROPOSED

Attractive, central space to eat healthy foods with view and access to landscape

PROPOSED CLASSROOM



EXISTING



PROPOSED

Small windows with no natural light; uncollaborative seating

More flexible learning environment with natural light

PROPOSED OUTDOOR

Activating outdoor spaces outside the school
to create the feel of a **School in a Park**

EXISTING

Underutilized outdoor space

PROPOSED

Variety of outdoor programming for Lisle community
outside of school hours

PROPOSED OUTDOOR

Activating outdoor spaces outside the school
to create the feel of a **School in a Park**

EXISTING

Underutilized outdoor space

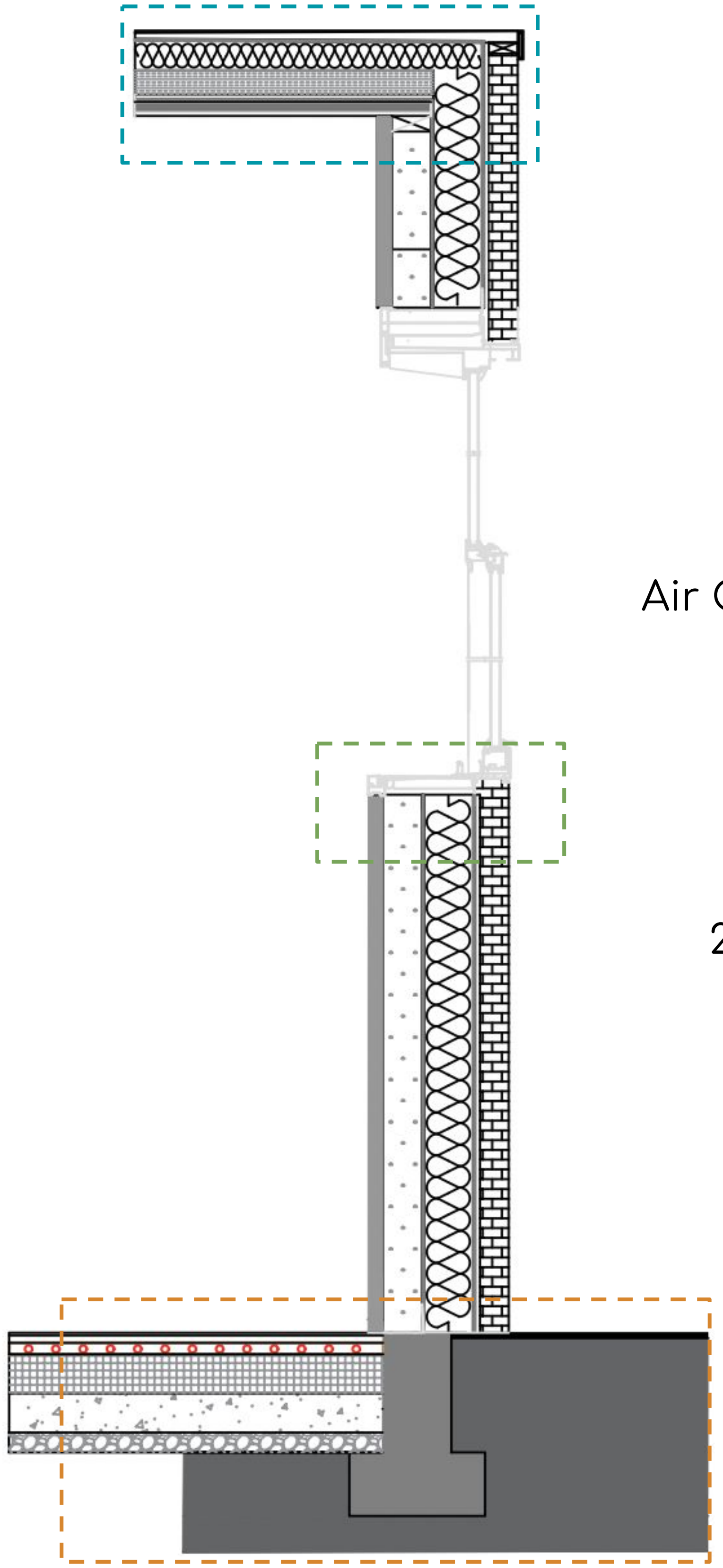
PROPOSED

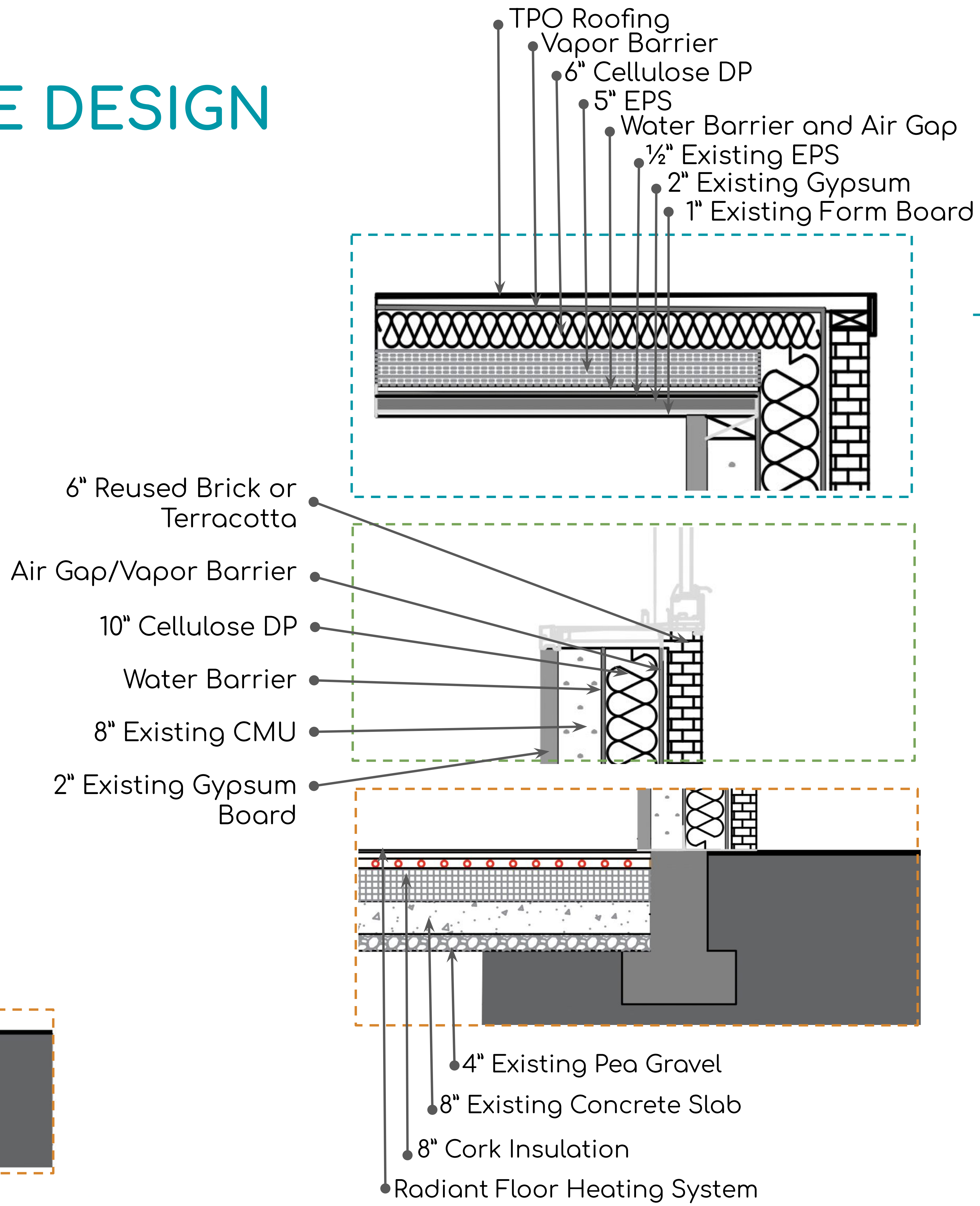
Outdoor learning spaces easily accessible by classroom

APPROACH 2

ESTABLISH A RESILIENT & SUSTAINABLE CAMPUS

ENVELOPE DESIGN

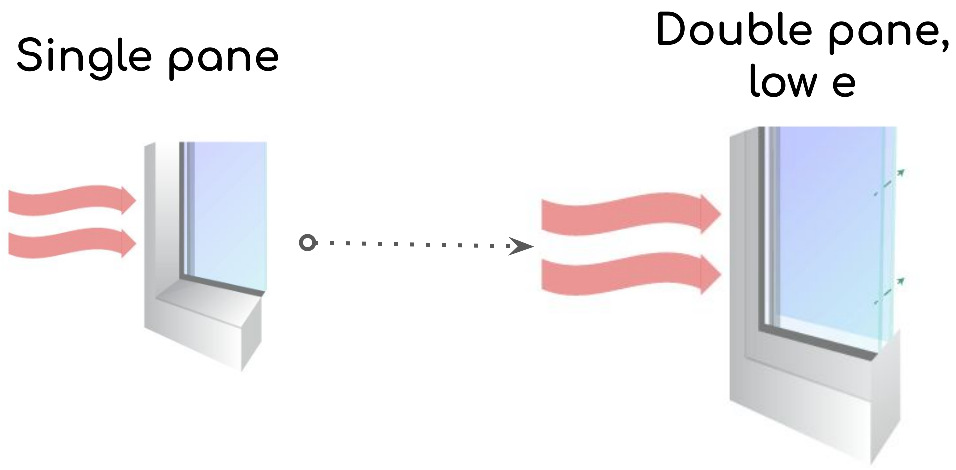




PROPOSED INSULATION VALUES

SECTION	EXISTING VALUE	IECC VALUE	RETROFIT VALUE
Wall Assembly	R-7.5	R-21	R-41
Slab Assembly	R-13	R-10	R-36
Roof Assembly	R-21.4	R-30	R-44

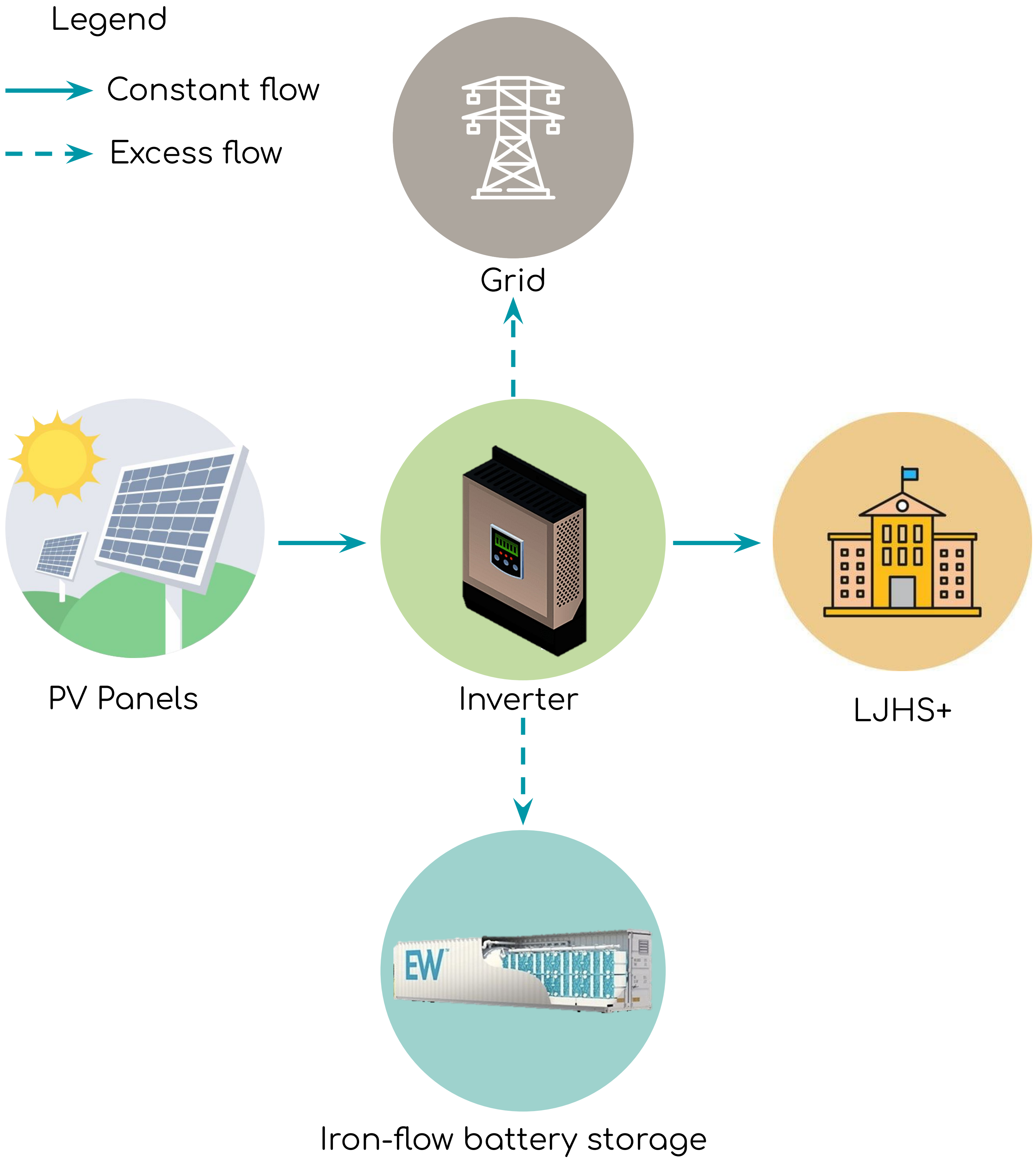
PROPOSED WINDOW GLAZING

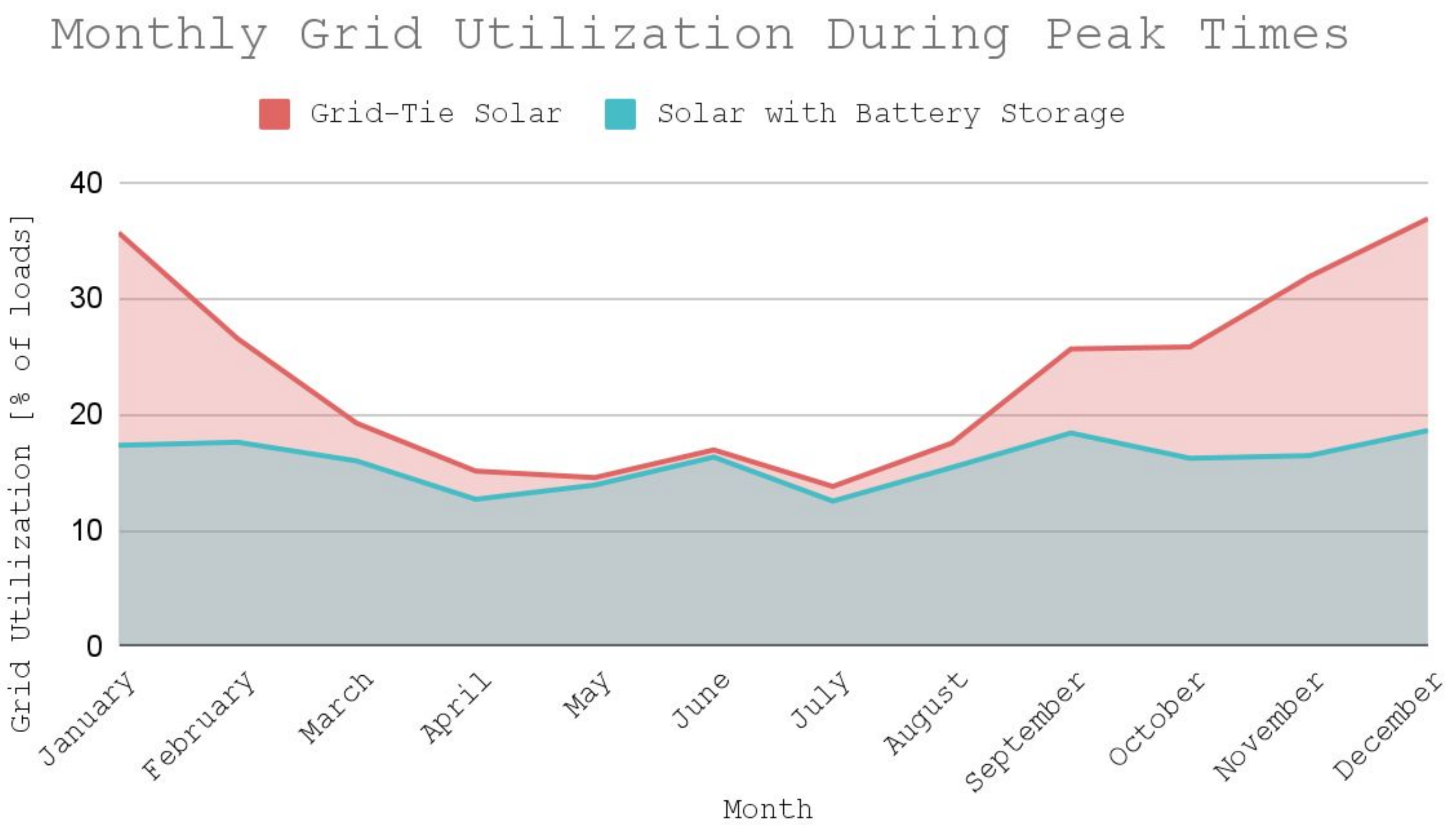


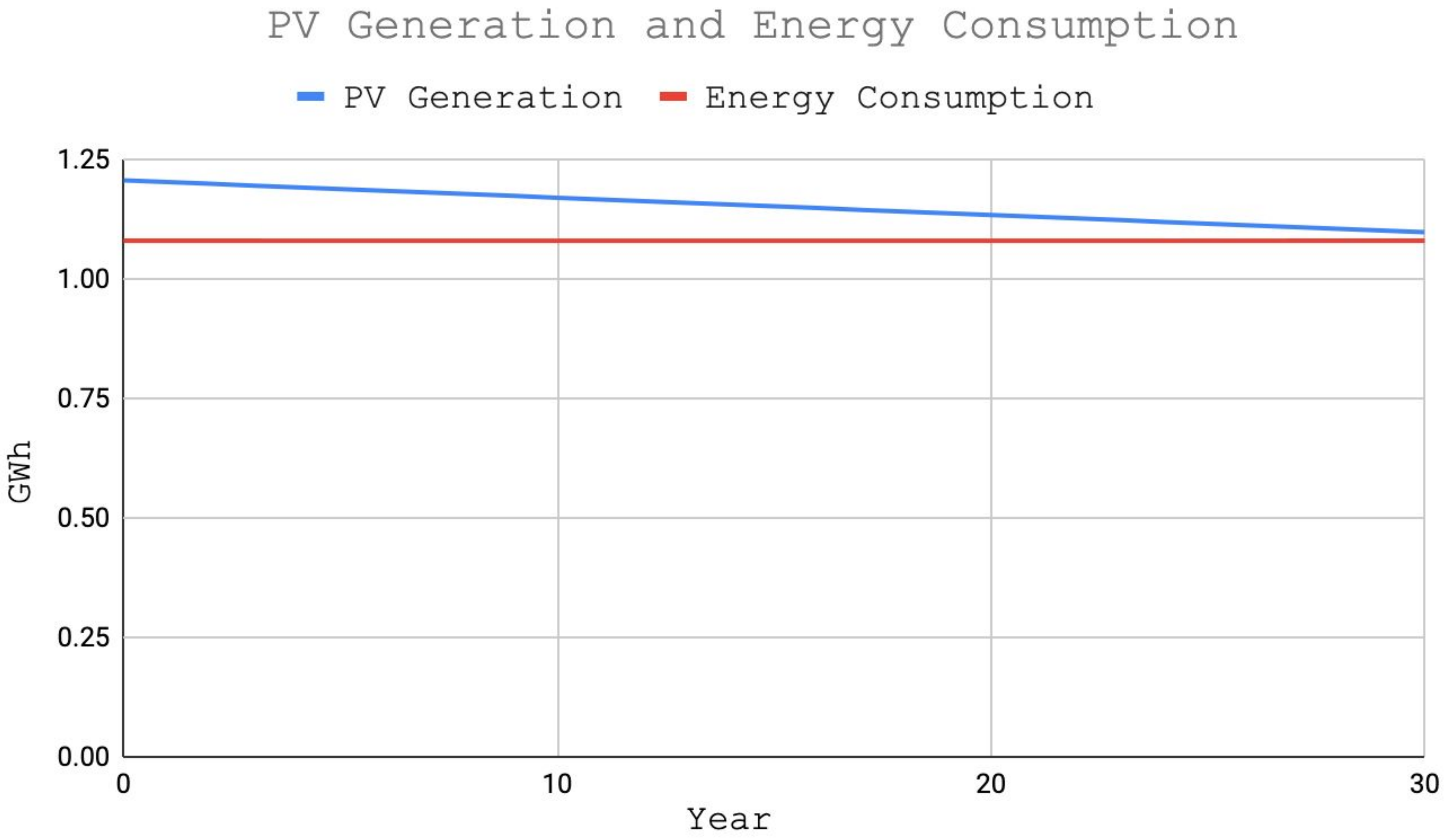
ACTIVE ENERGY SYSTEM

PHOTOVOLTAIC ARRAYS & STORAGE

DURING DAYLIGHT



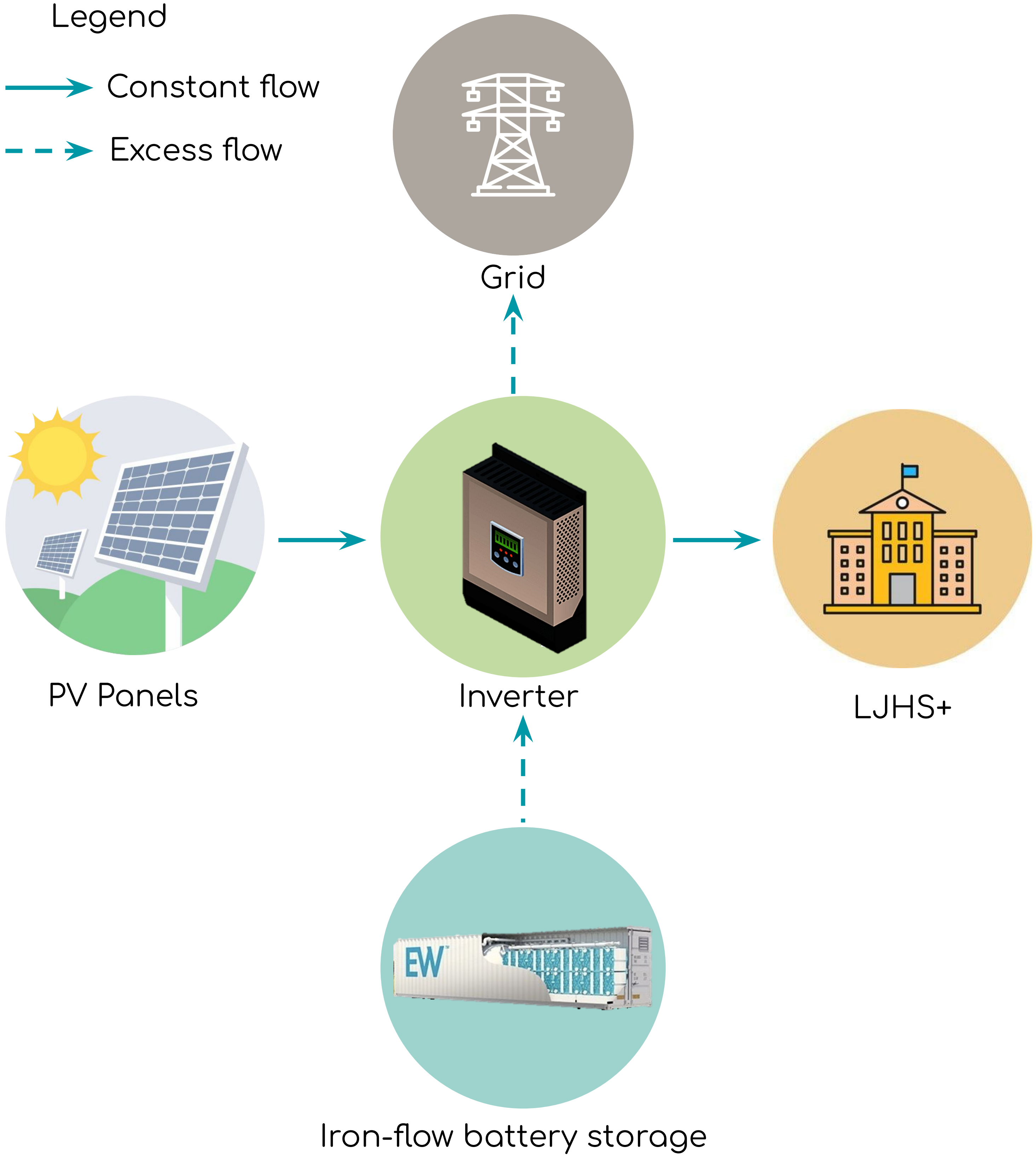


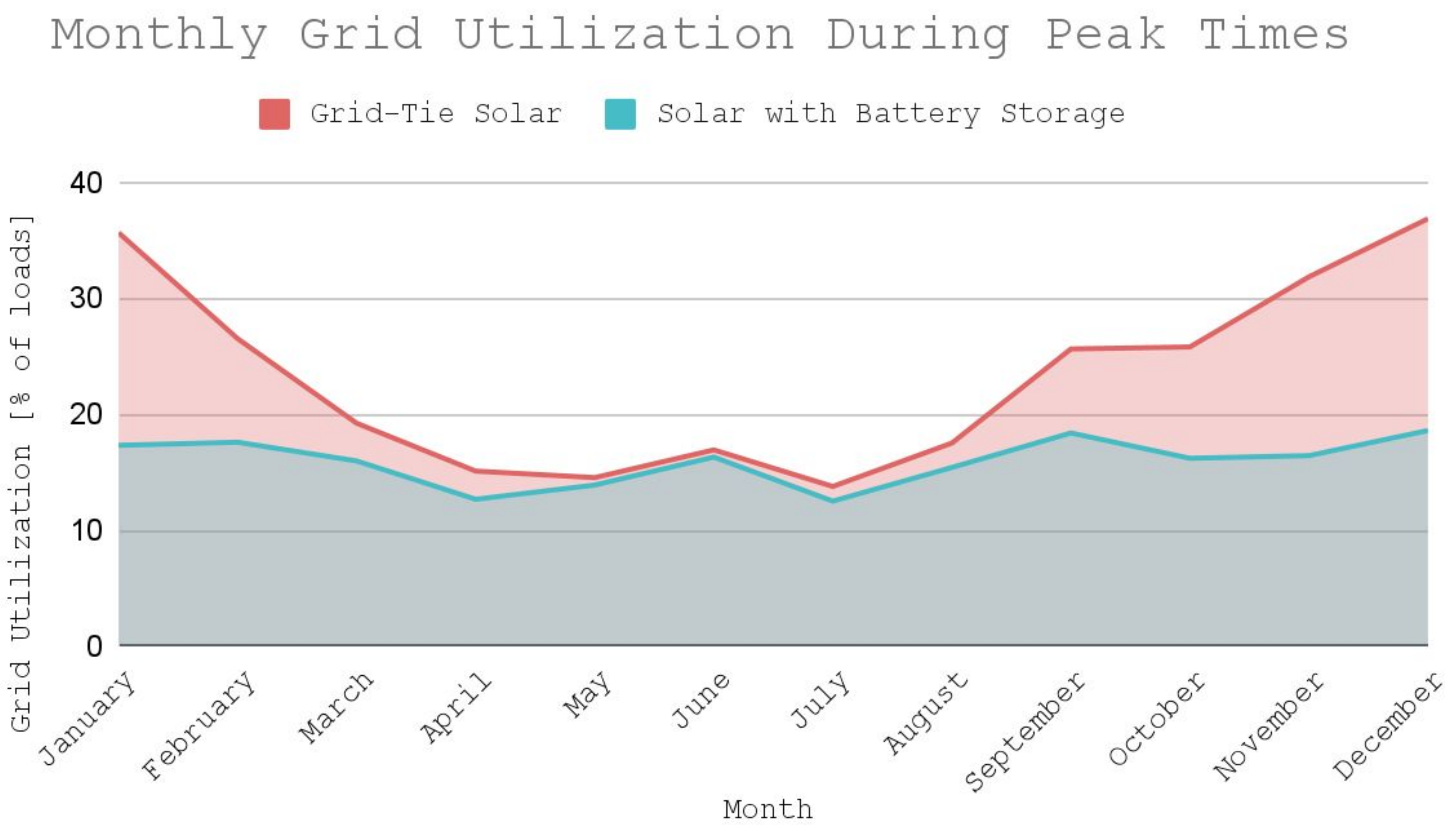


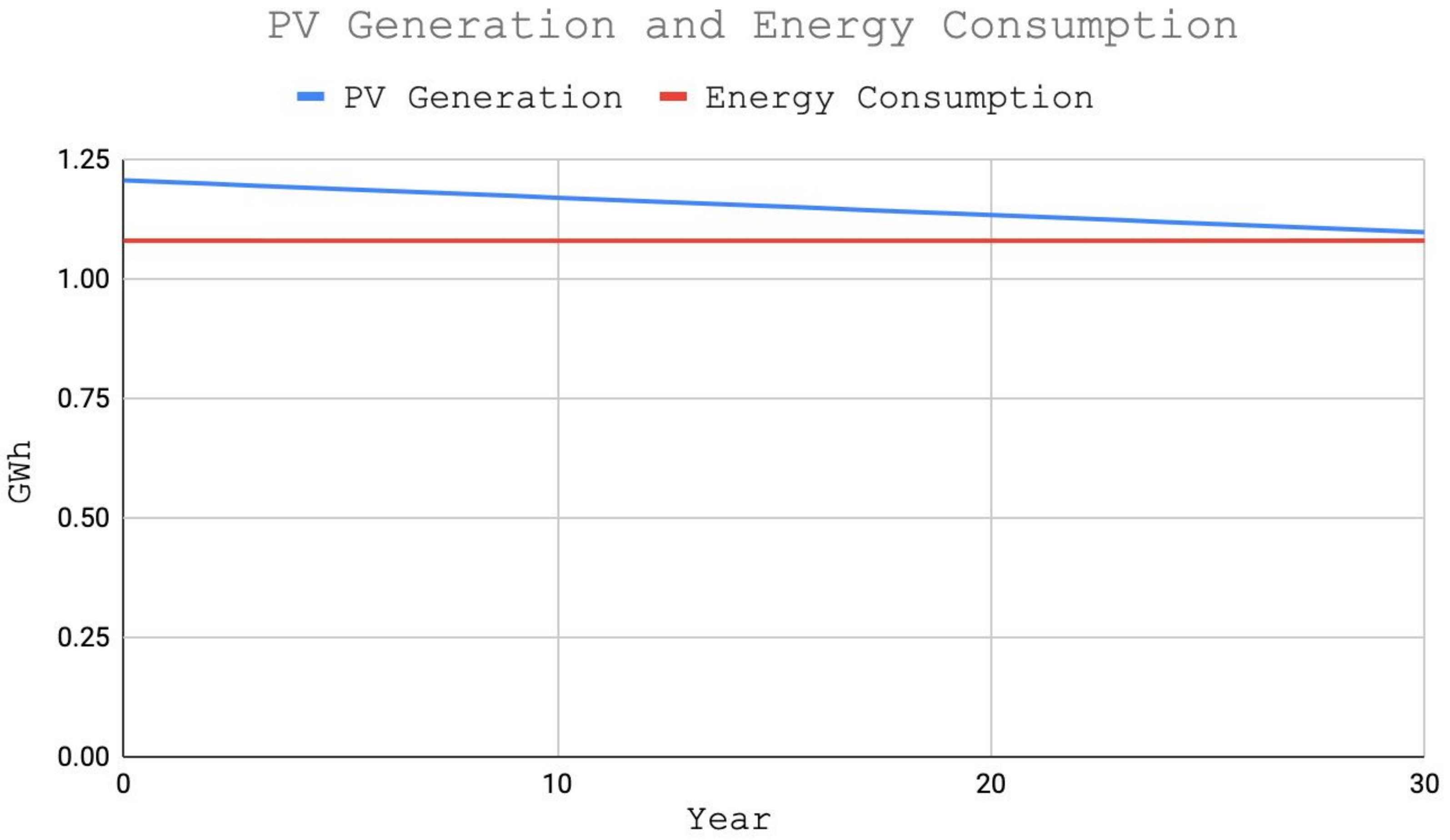
ACTIVE ENERGY SYSTEM

PHOTOVOLTAIC ARRAYS & STORAGE

DURING AFTERNOON PEAK



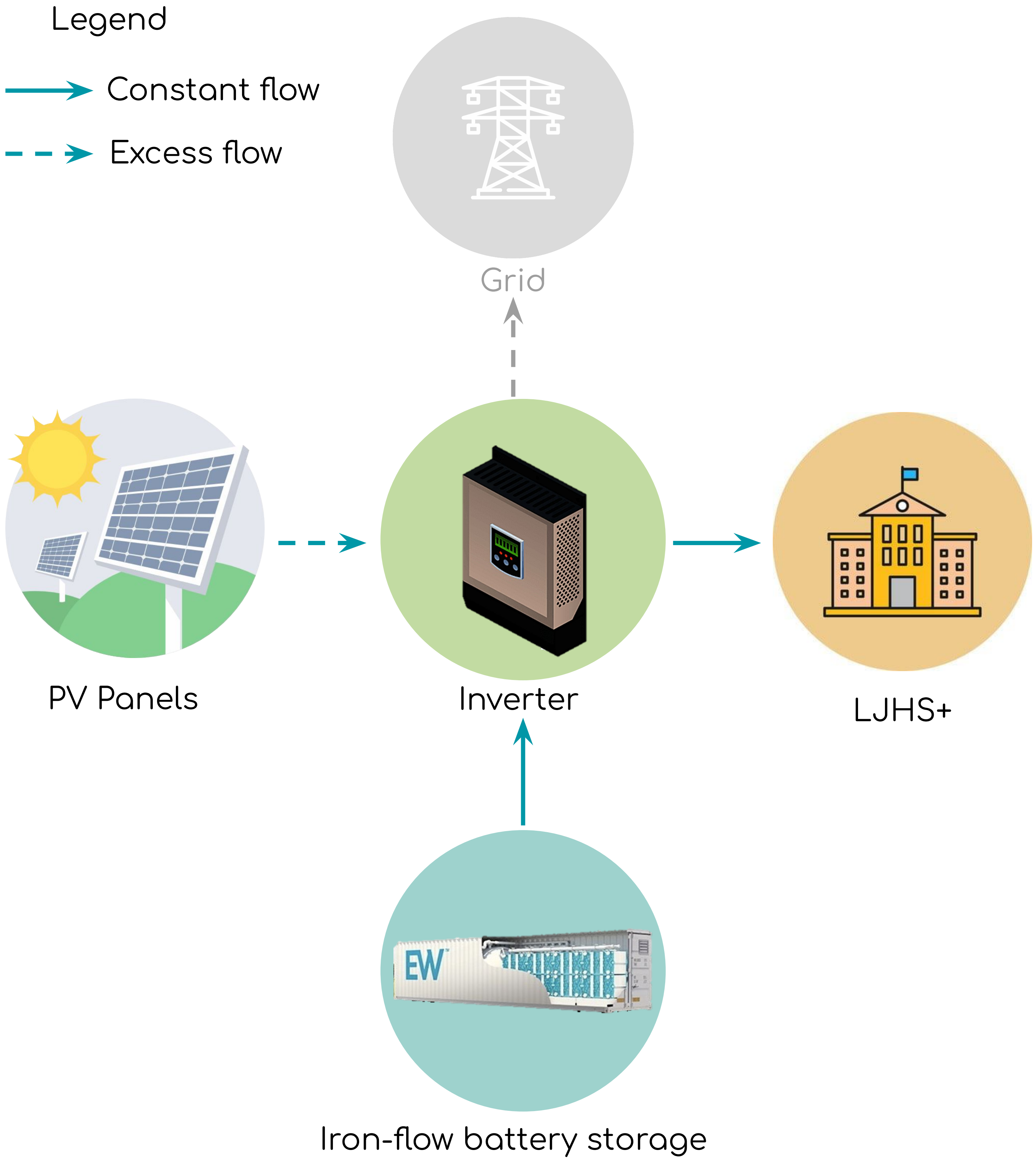


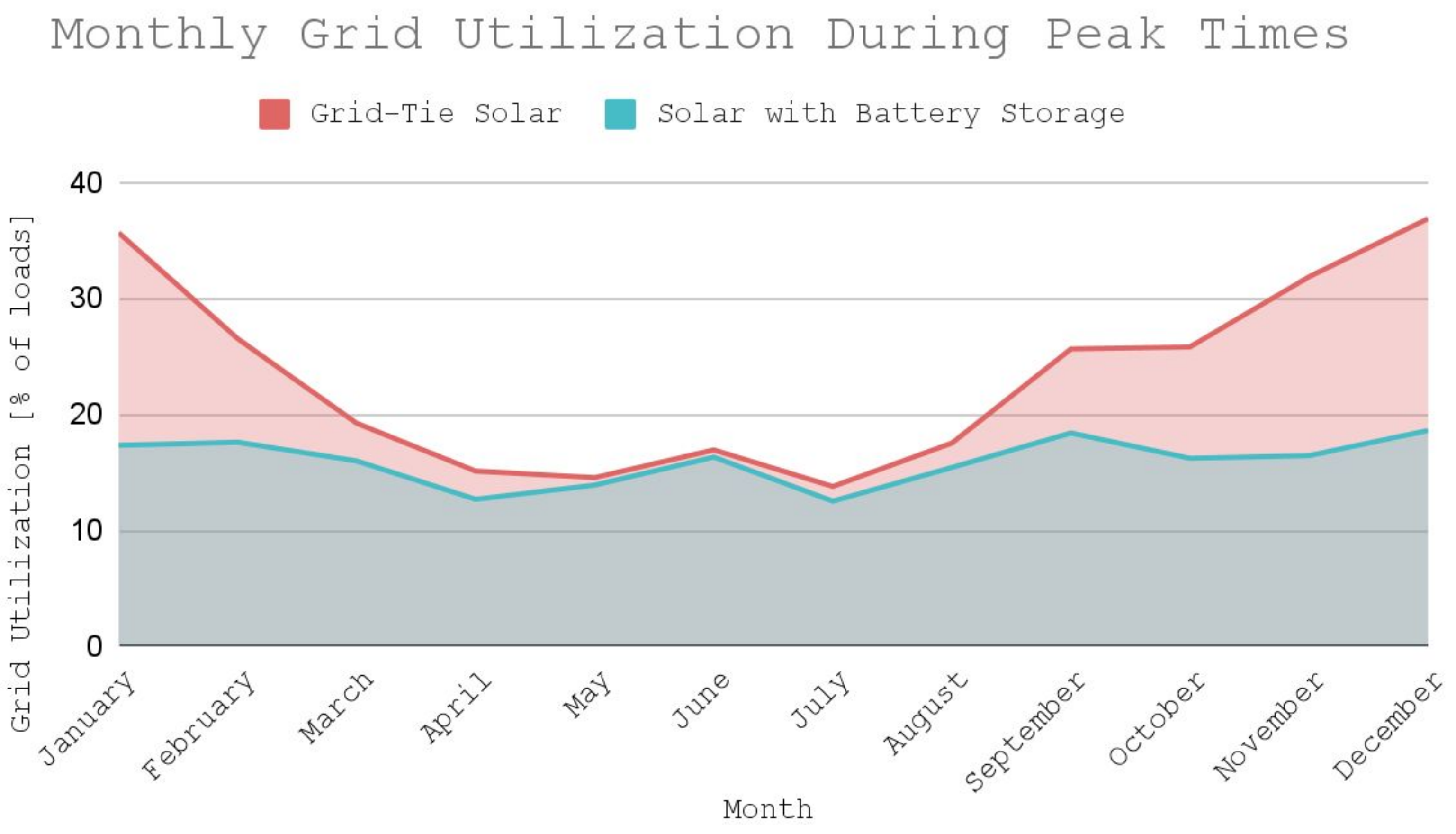


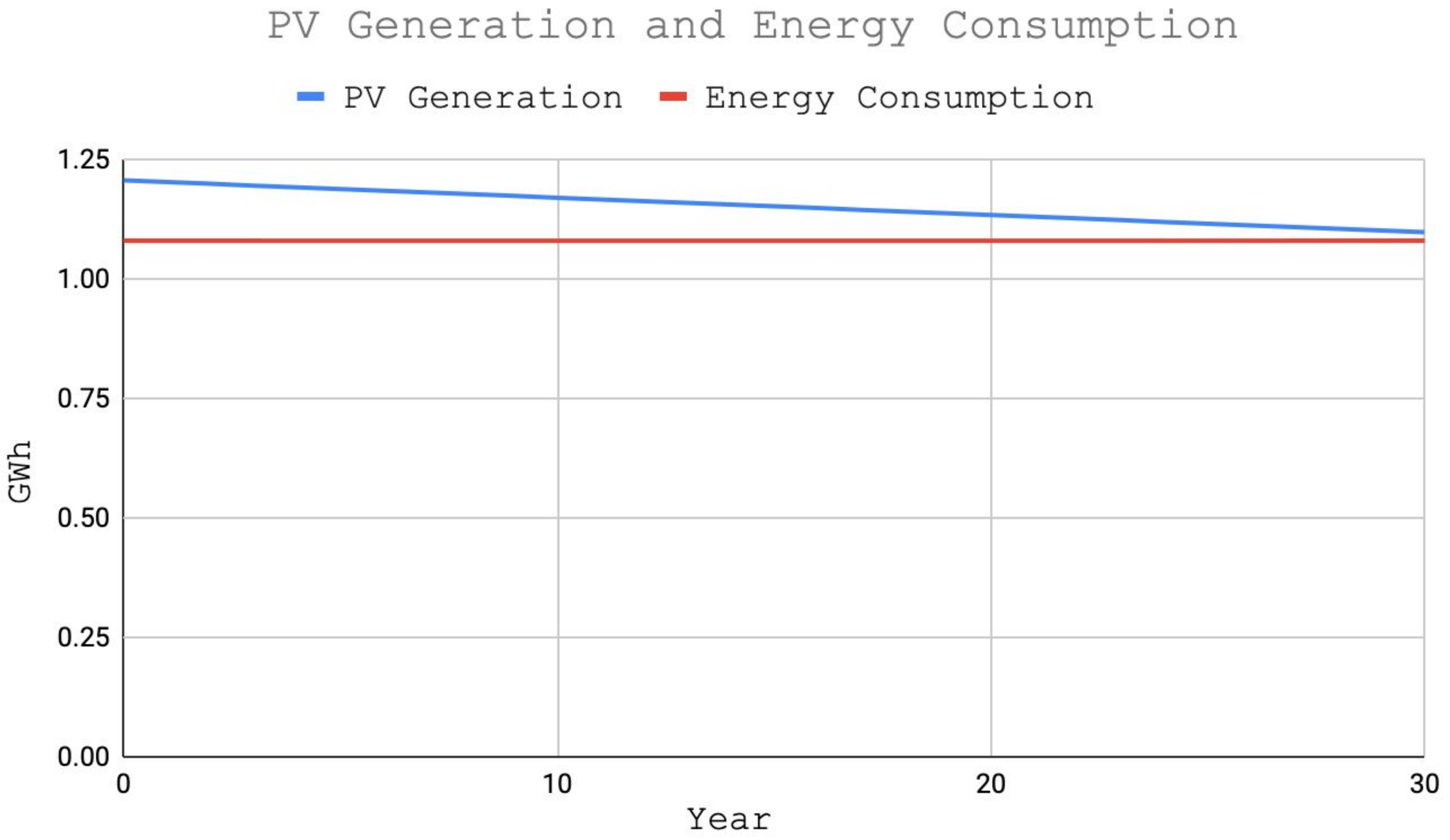
ACTIVE ENERGY SYSTEM

PHOTOVOLTAIC ARRAYS & STORAGE

DURING POWER OUTAGE

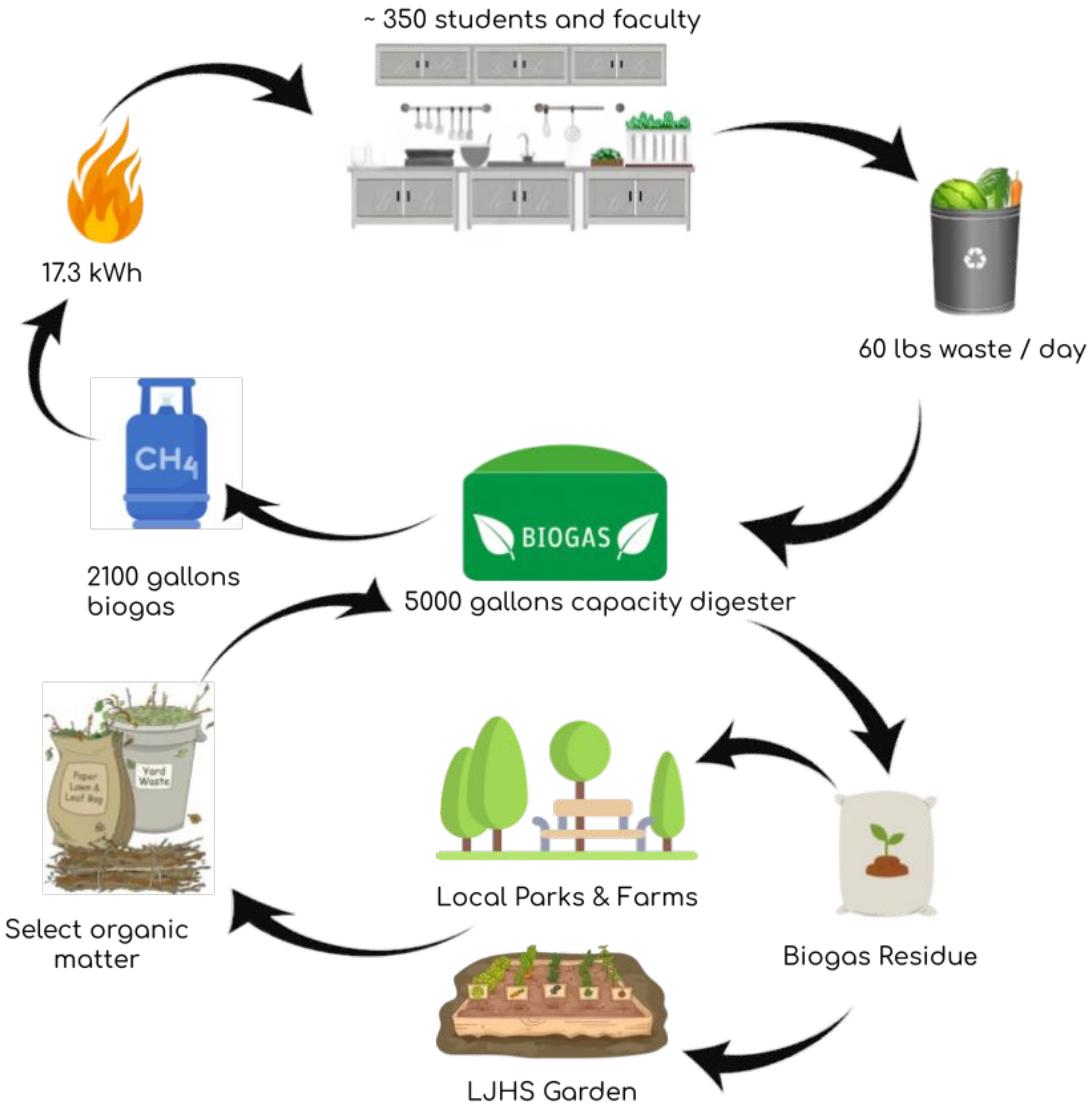


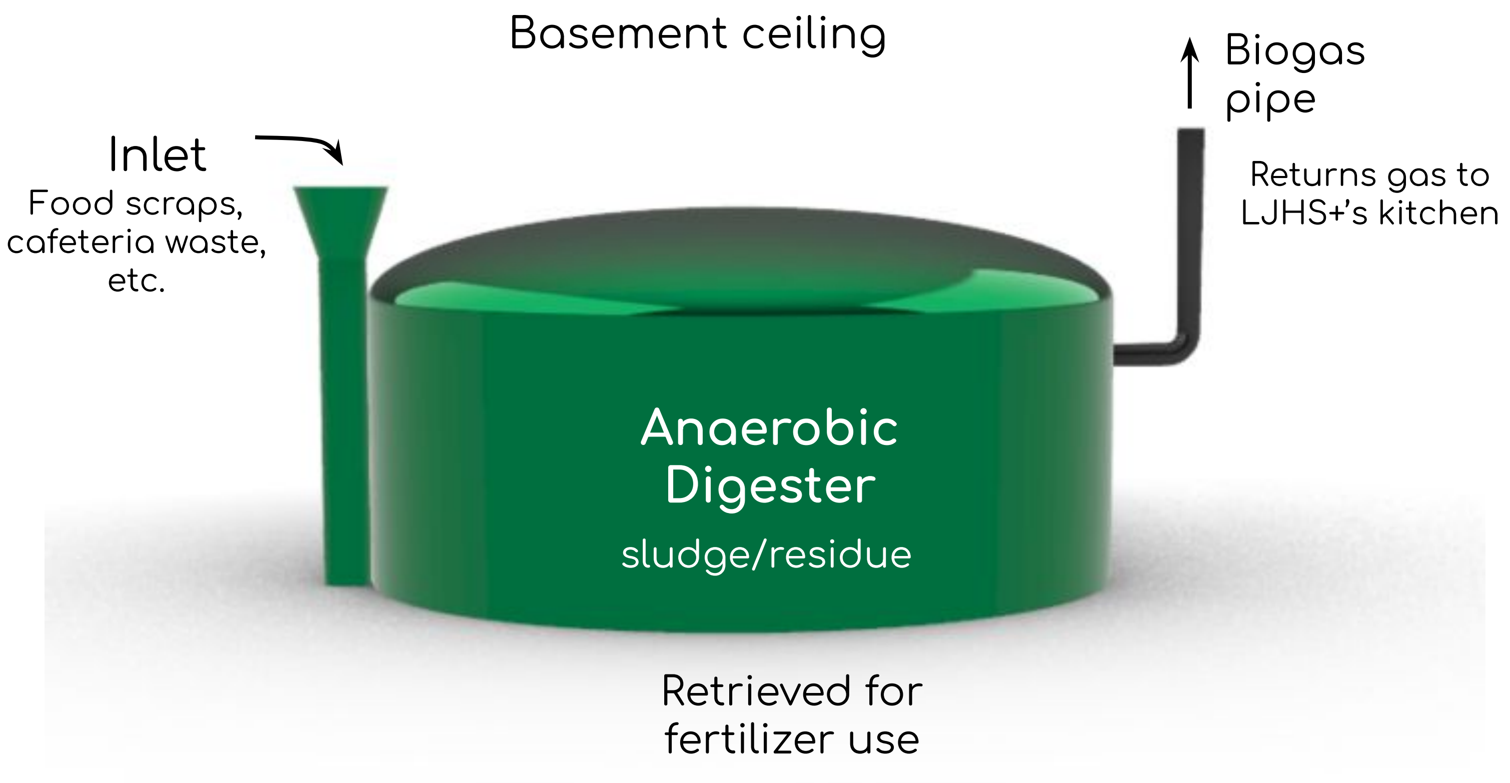




ACTIVE ENERGY SYSTEM

ANAEROBIC DIGESTER





Redirects **1 metric ton** of methane per year from landfills

Equivalent to **25 tons** of CO_2 in terms of global warming potential

Biogas residue reduces the need for energy-intensive fertilizers

ACTIVE ENERGY SYSTEM

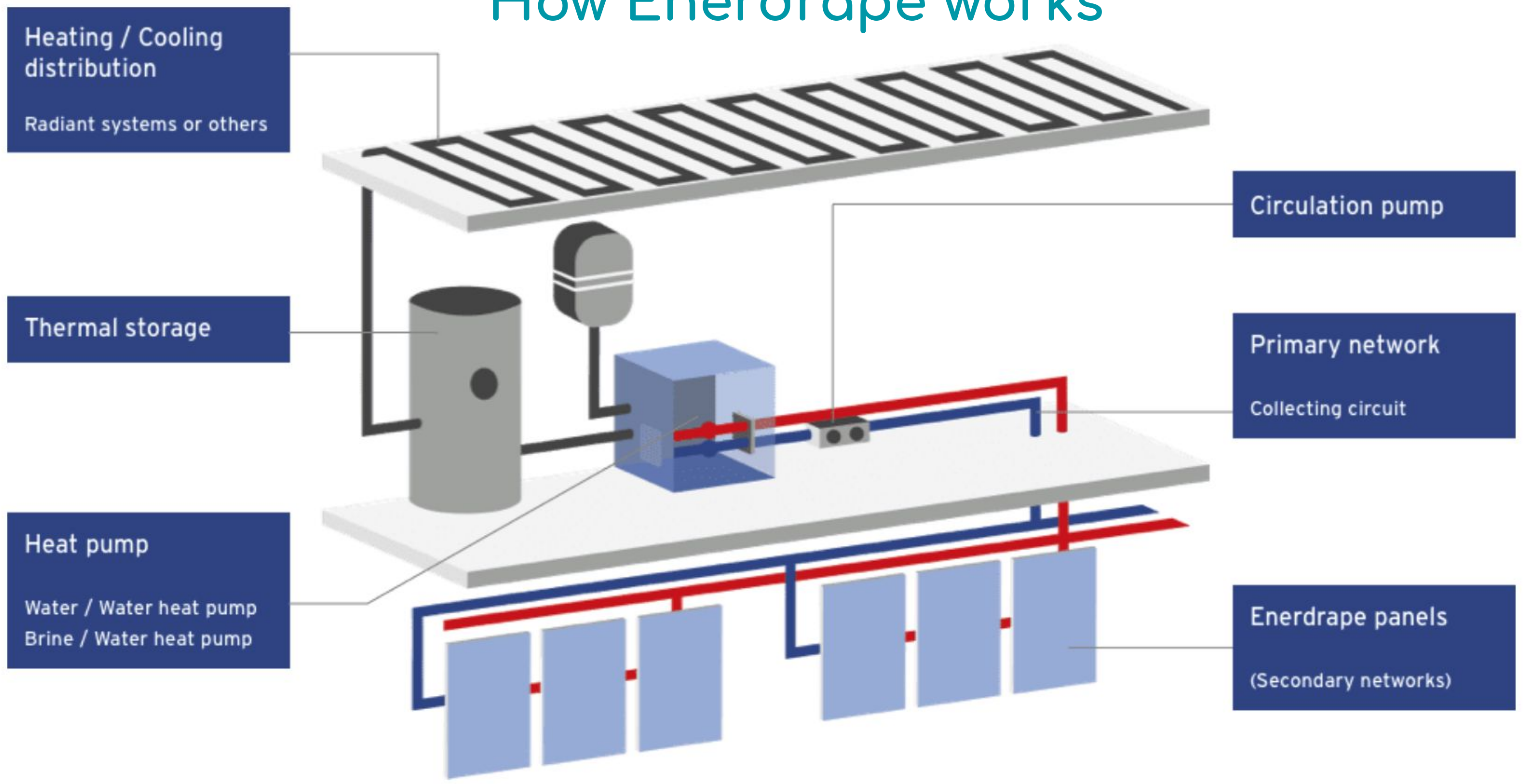
ENERDRAPE (New technology developed by a Northwestern professor)

Dr. Alessandro Rotta Loria
CTO & Co-founder of **Enerdrape**

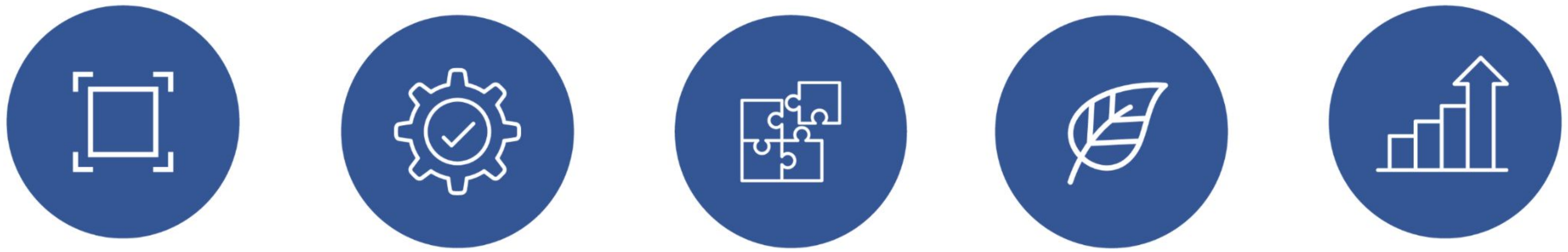
Assistant Professor of Instruction

Northwestern
McCORMICK SCHOOL
OF ENGINEERING

How Enerdrape works



Why Enerdrape?



Retrofit-friendly
Minimal impact on the structure & minimal use of space

Easy to install
Quick installation & quick coupling

Modular
Scalable & Customisable

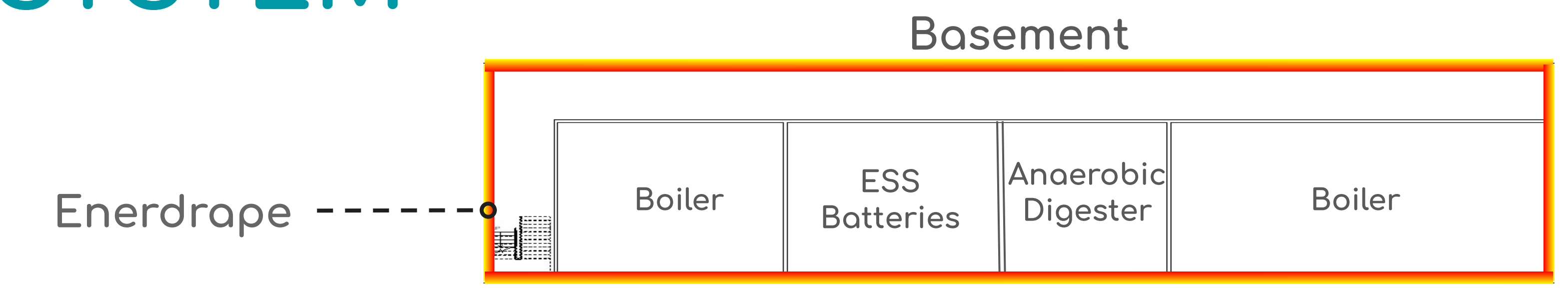
CO2 Savings
On-site renewables & smart use of material

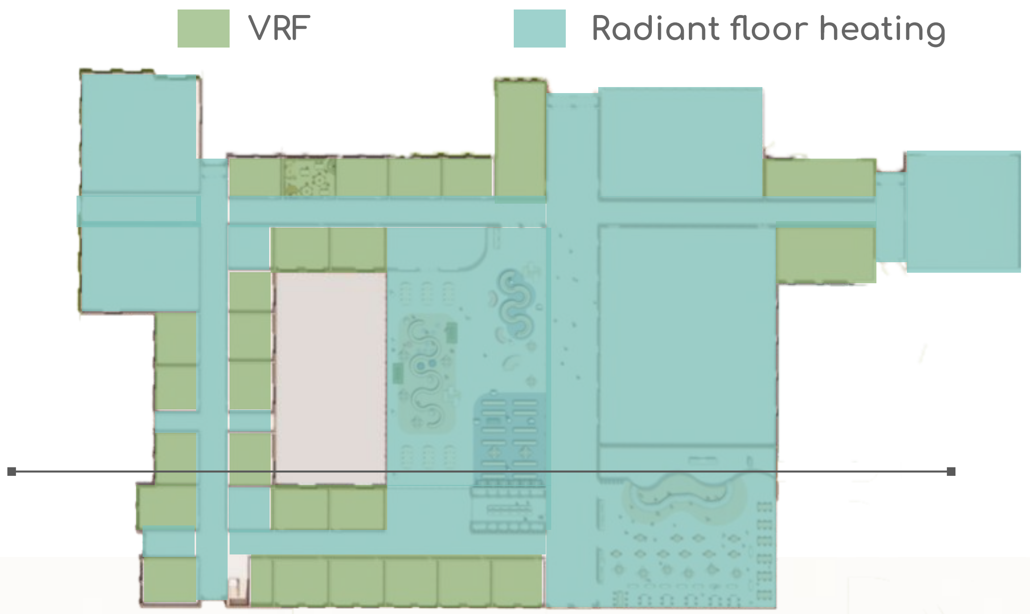
Constant efficiency
Independent of exterior conditions

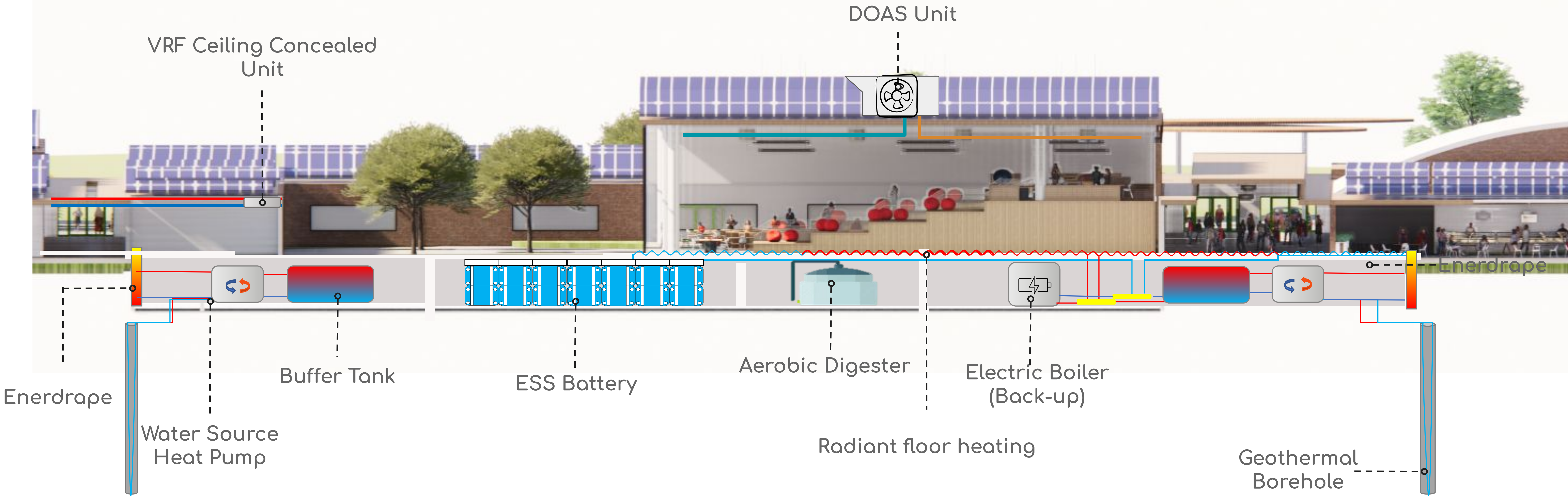
Able to supply **275 KWh** of conditioning annually

https://enerdrape.com/en/solution/

INTEGRATED HVAC SYSTEM







COMFORT AND ENVIRONMENTAL QUALITY

THERMAL COMFORT & AIR QUALITY

- Personalized temperature control
- High efficient radiant floor heating and VRF
- Efficient envelope design

VISUAL COMFORT

- Daylighting and occupancy sensors
- Biophilic design

ACOUSTIC COMFORT

- Separation of learning spaces from active spaces
- Acoustic ceilings and gypsum walls
- Acoustic HVAC system: radiant floor heating and VRF

DAYLIGHTING & SUN EXPOSURE

sDA Analysis

sDA: spaces receiving 300 lux of daylight more than 50% of the occupied hours 8am-6pm throughout the year.

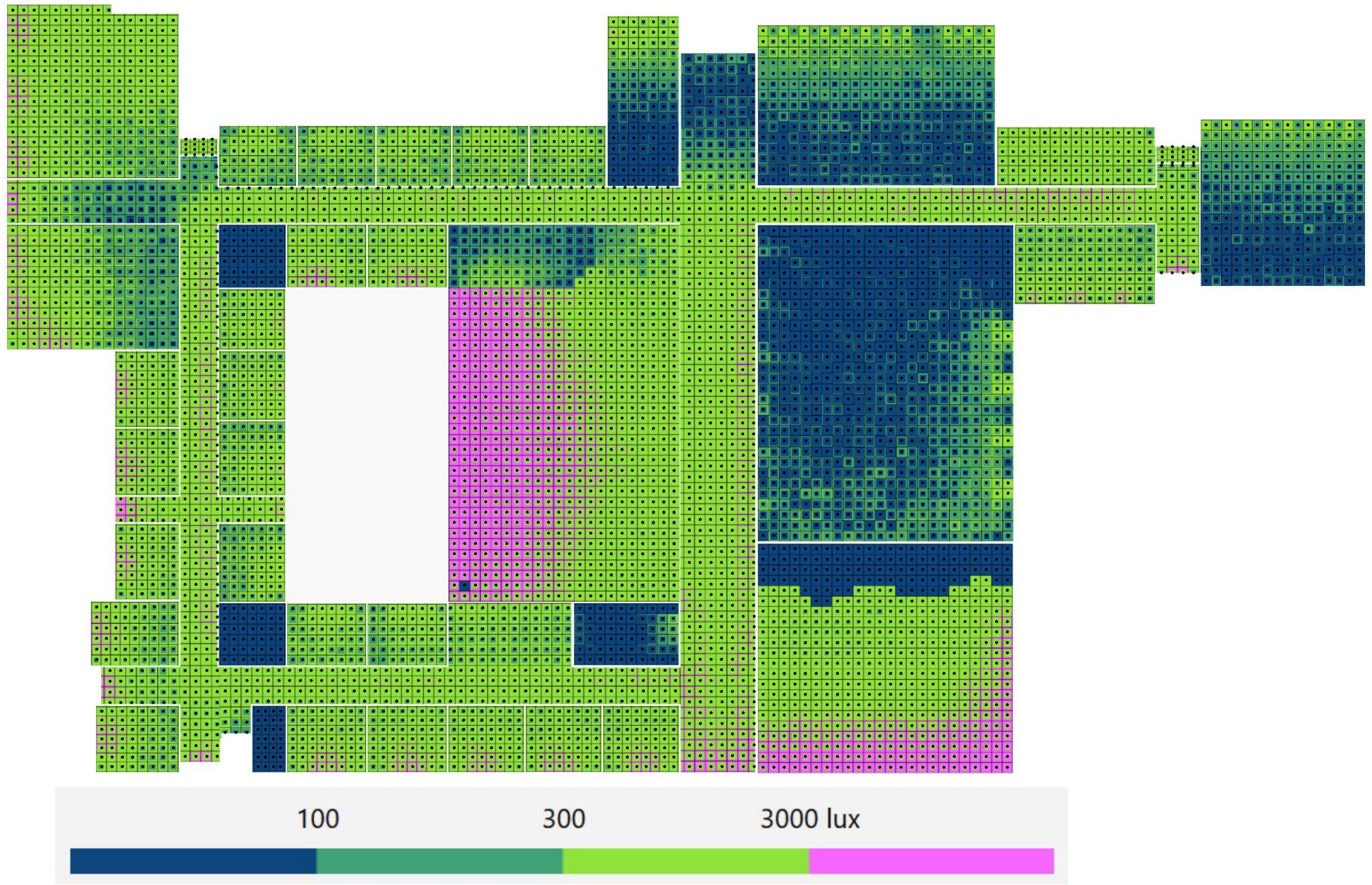
Illuminance

DAYLIGHTING & SUN EXPOSURE

sDA Analysis

sDA: spaces receiving 300 lux of daylight more than 50% of the occupied hours 8am-6pm throughout the year.

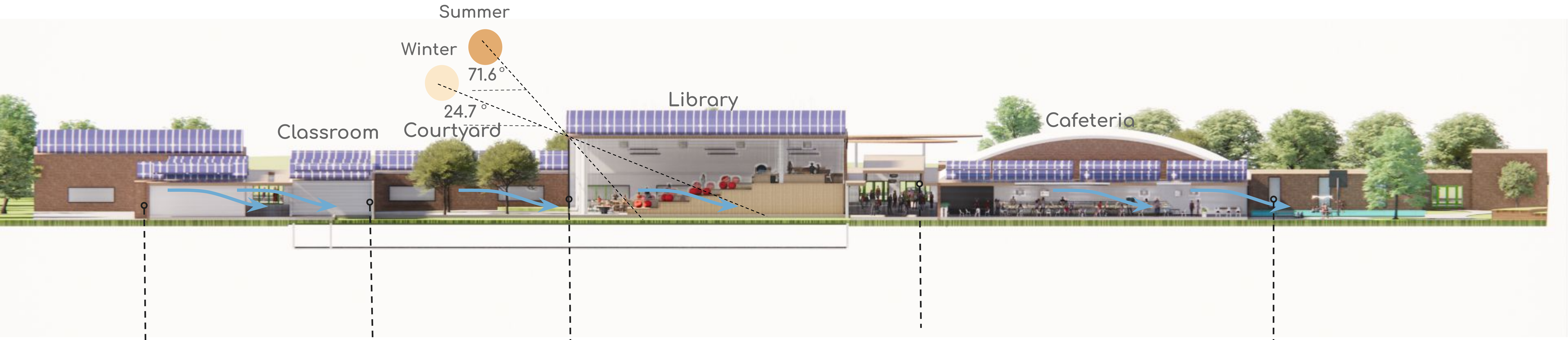
Illuminance



Failing Supplemental Autonomous Excessive

PASSIVE STRATEGIES

Site Section
Looking from south-east



Light Shelves
Allows diffused daylight to penetrate deep into a building.

Operable Windows
Opens access to natural ventilation during nice weather

Window Shades
Block direct sunlight to reduce glaring when needed.

Hallway Skylight
Allow sunlight into dark hallways to reduce artificial light

Double-glazed windows
Improve thermal performance

BUILDING AUTOMATION

SMART TECHNOLOGIES

Occupancy sensor

Daylighting sensor

Energy Star Appliances

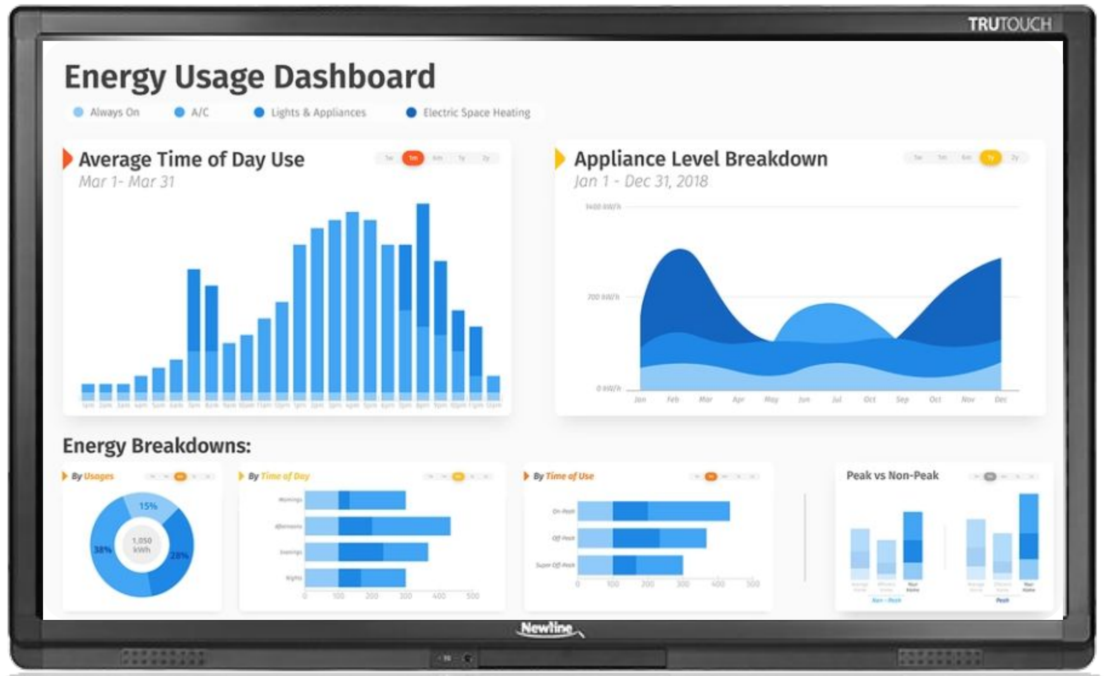
Energy efficient LED fixtures

Plug load manager

Smart thermostat

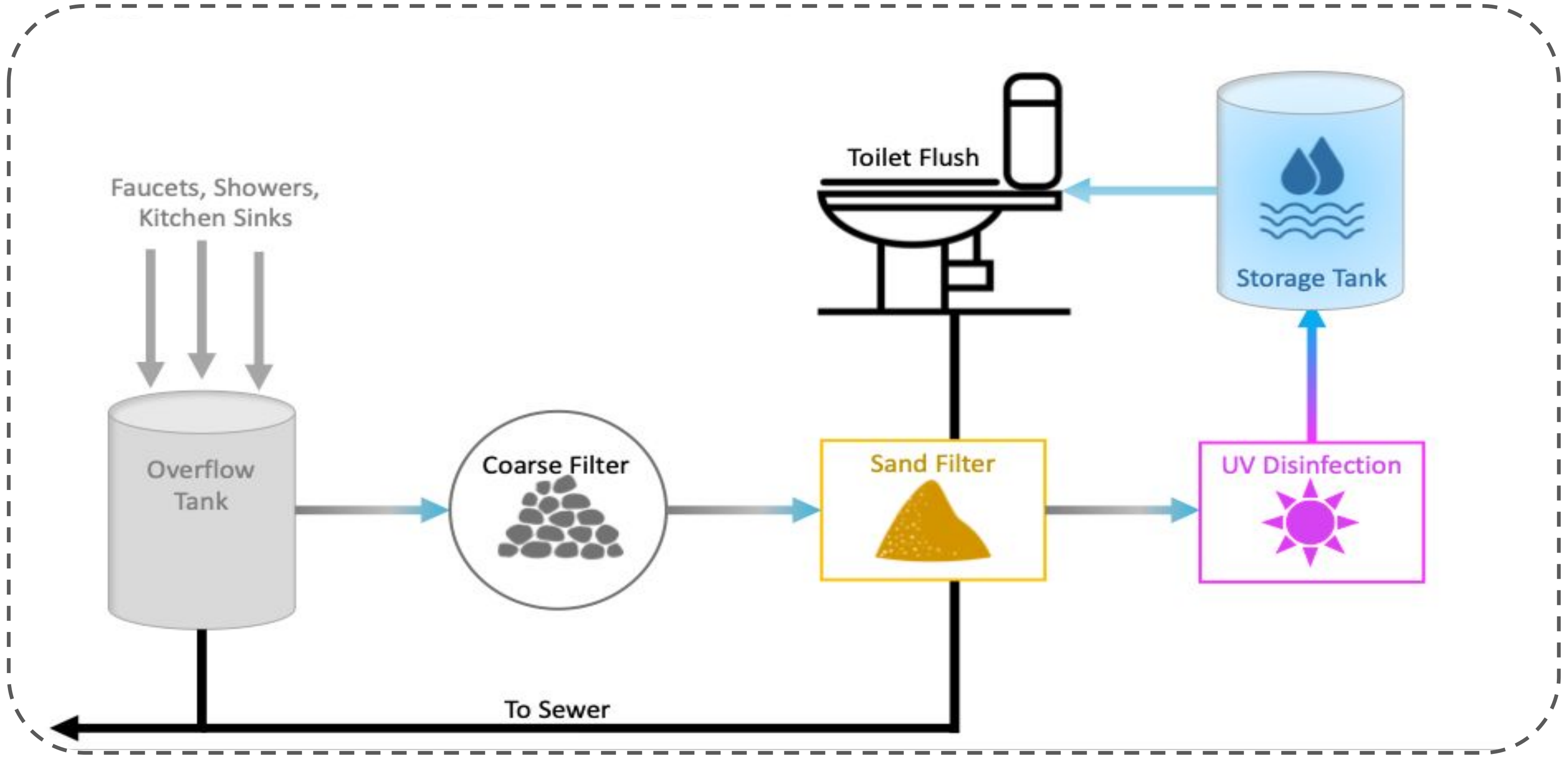
Security camera

EDUCATIONAL DASHBOARD



WATER MANAGEMENT SYSTEM

GREYWATER REUSE SYSTEM

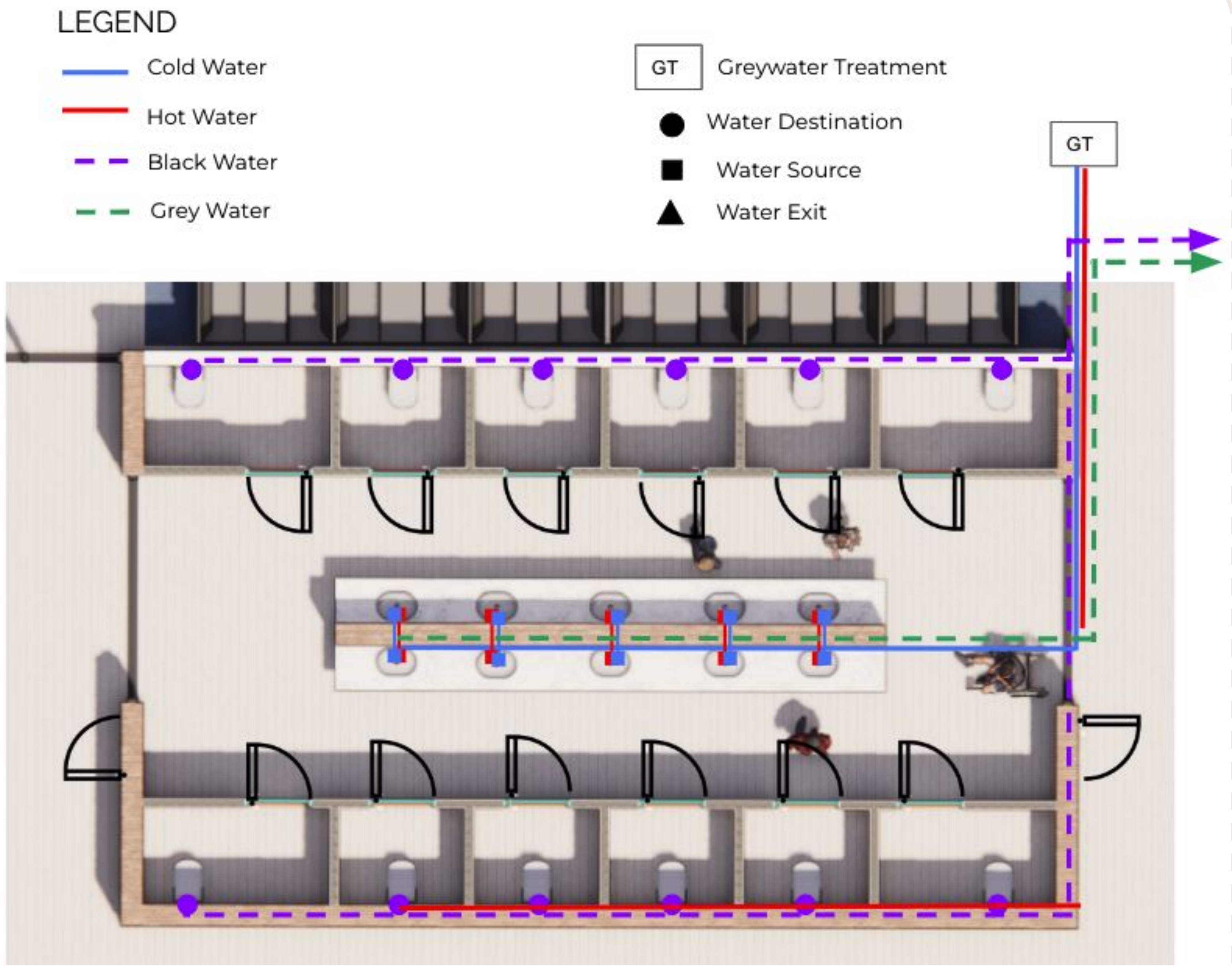


WATER EFFICIENT FIXTURES

33.5%

Water Savings

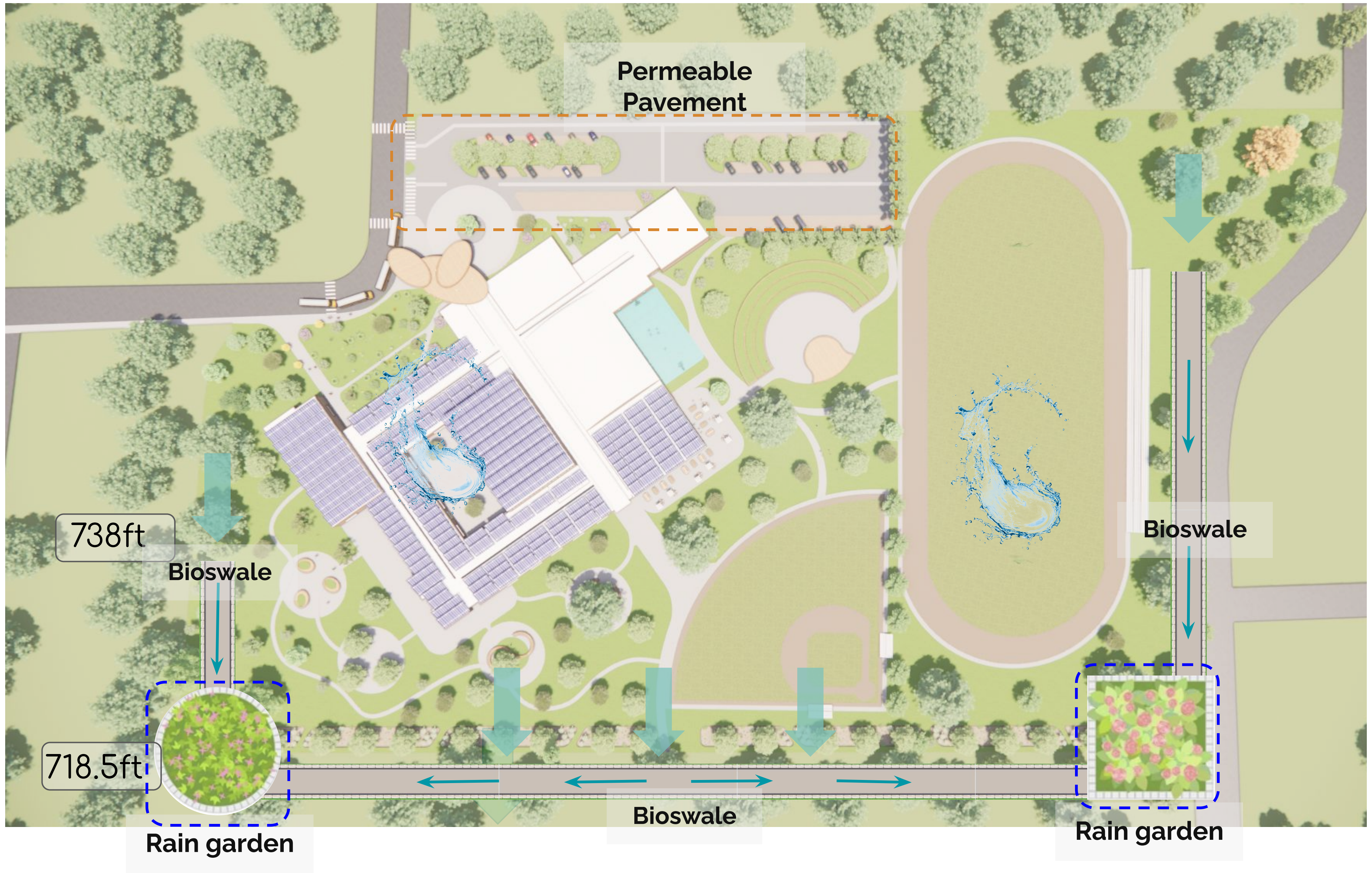
PLUMBING SCHEMATIC DIAGRAM



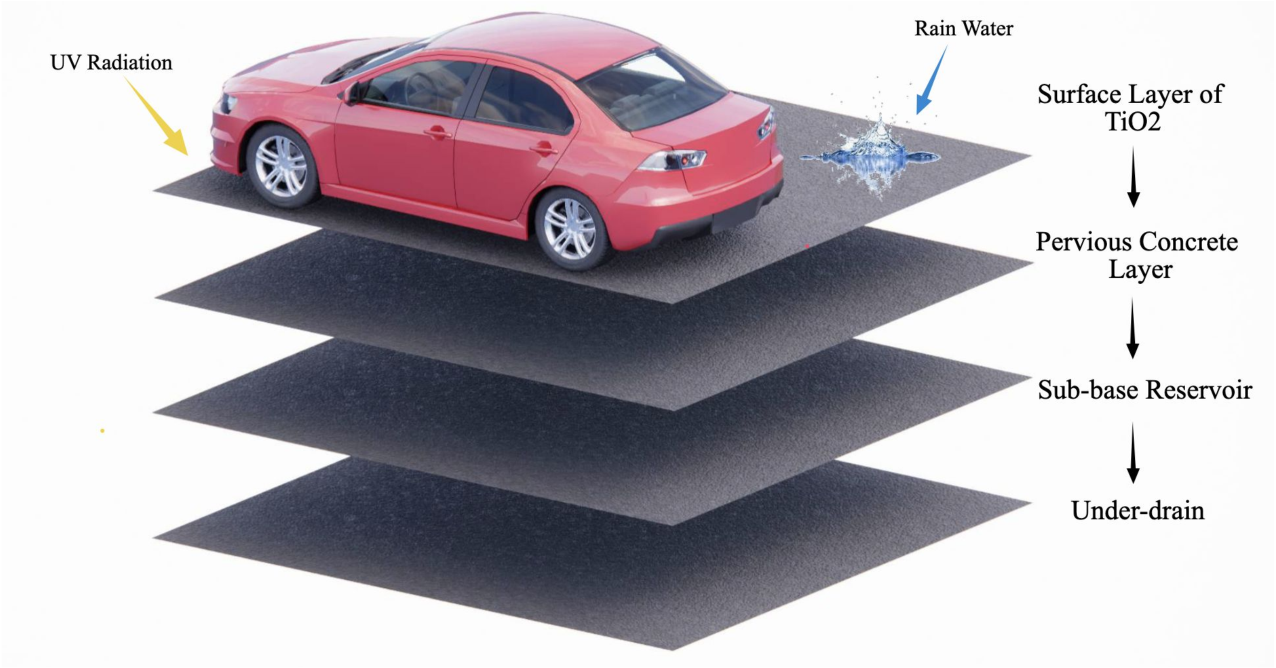
All-Gender Restroom

WATER MANAGEMENT SYSTEM

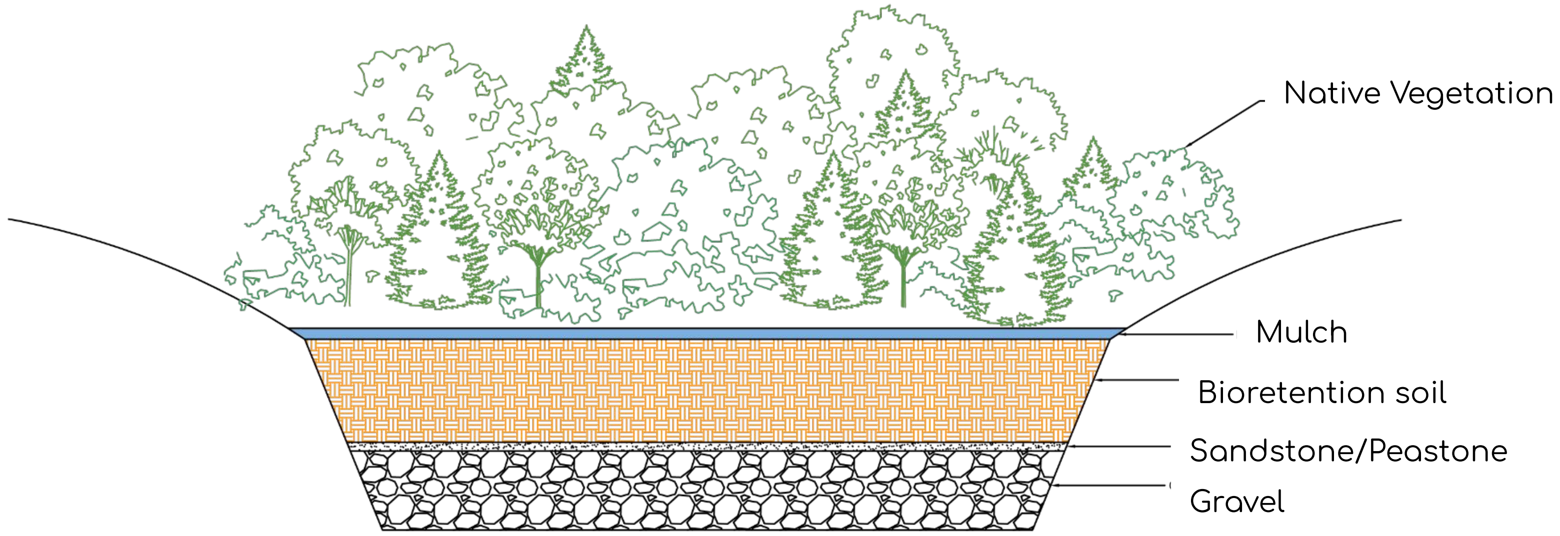
STORMWATER SYSTEM



PERMEABLE PAVEMENT

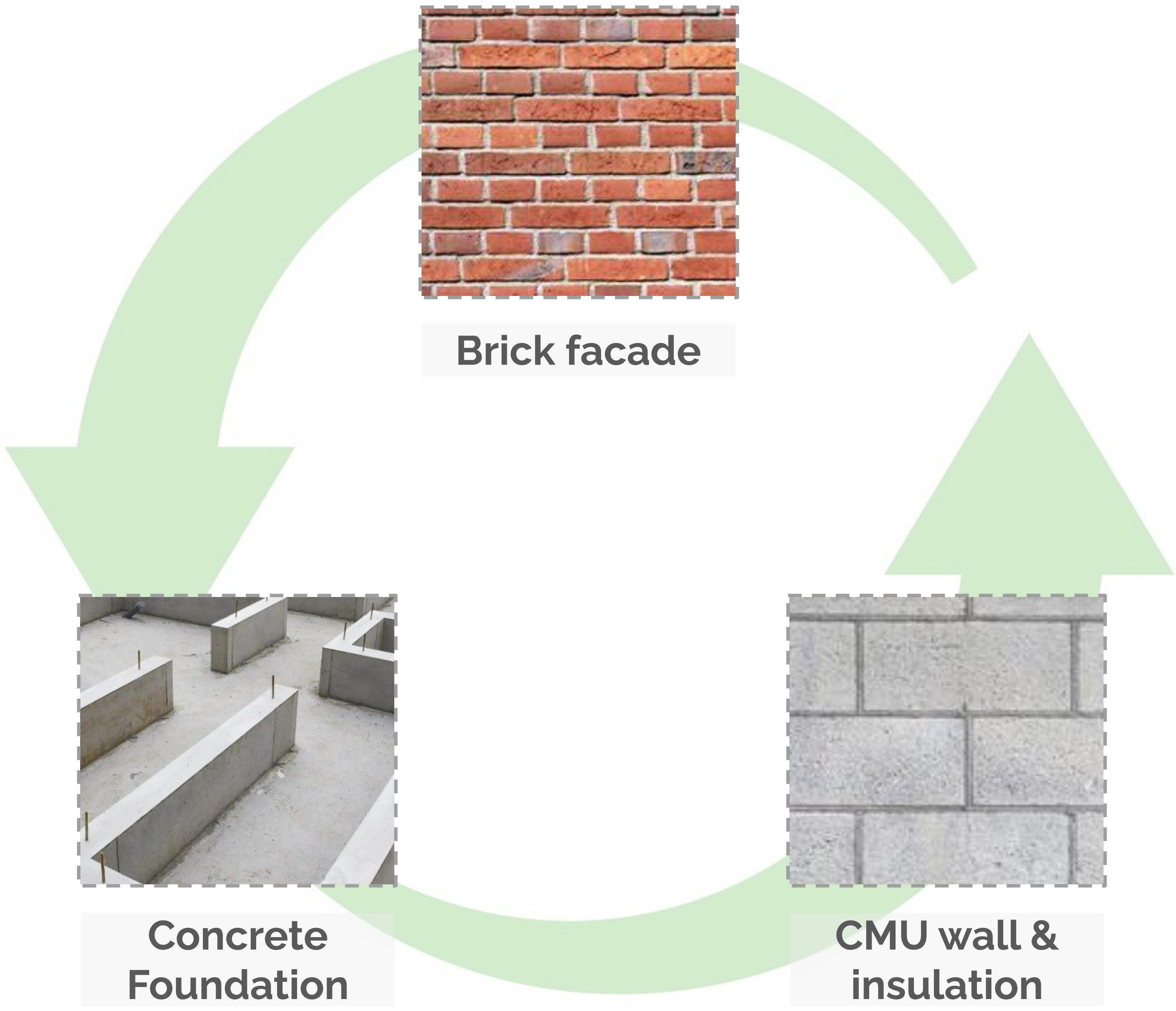


RAIN GARDEN



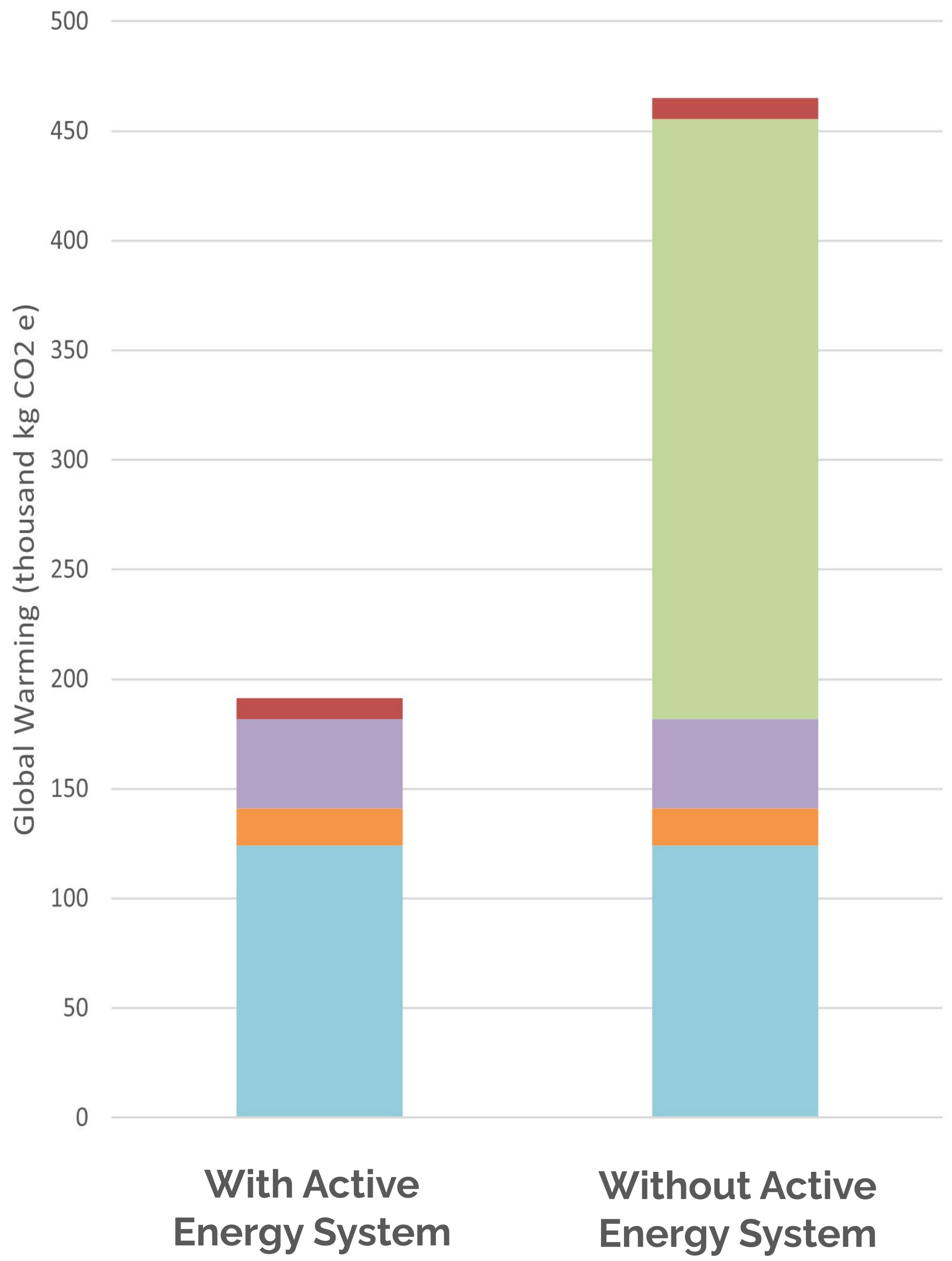
EMBODIED ENVIRONMENTAL IMPACT

REUSE OF MATERIALS

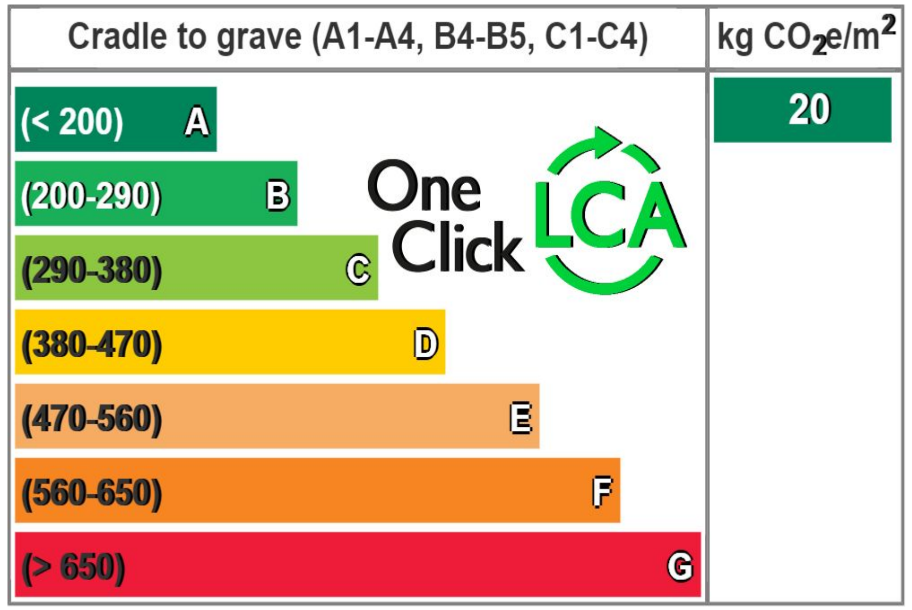


LCA "CRADLE TO GRAVE"

Global Warming by life stage ($kg\ CO_2$)



Carbon Benchmark



A1-A3 Materials
A4 Transport
B6 Energy
C1-C4 End of Life

Active System :

PV + Geothermal Heat pump + Enerdrape

ENERGY PERFORMANCE

Current Building

EUI
48.6

Retrofit Building

EUI
29.4

Retrofit with Onsite PV

EUI
-2.8

HVAC Upgrades

Natural Gas Boilers → GSHP

Fan Coil Units → Hydronic floor heating VRF & DOAS

Envelope Improvements

Air gap Insulation → Cellulose Insulation

Residential Grade Windows → Double-glazed Windows

Sensors & Automation

Fixed lighting levels → Occupancy and Daylighting Sensors

Fixed ventilation rates → CO_2 sensors and Room-controlled VRF

Net Zero

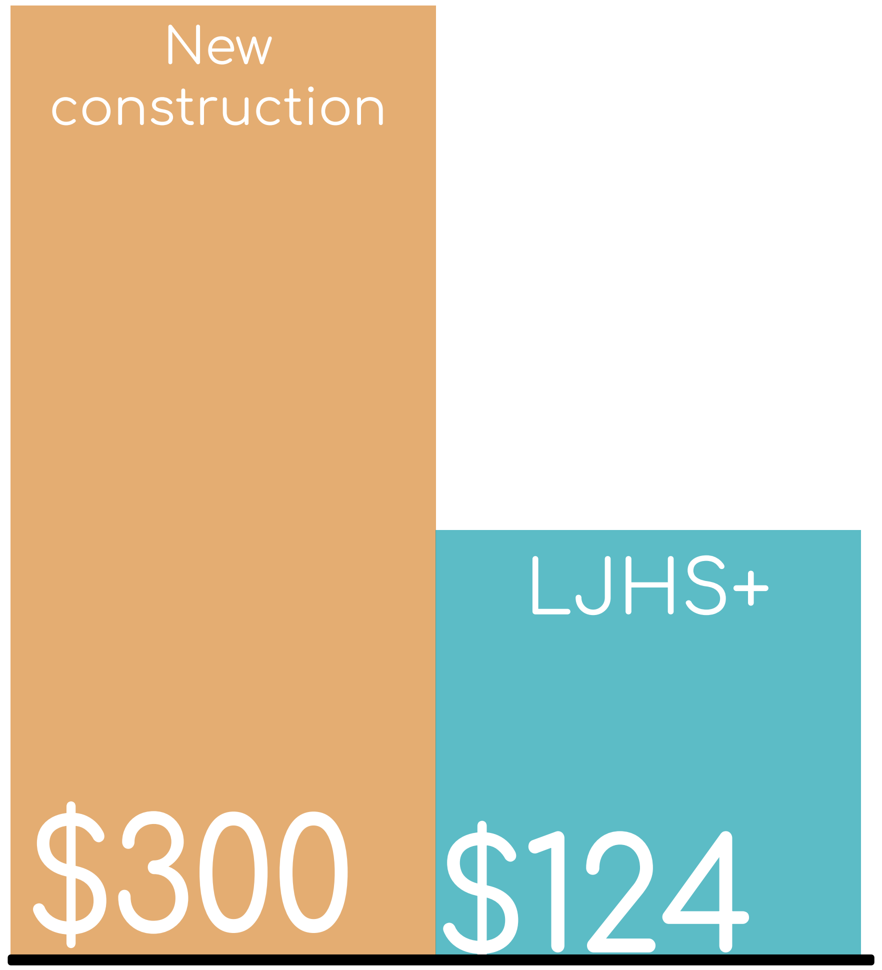
Onsite PV Generation

CONCLUSION

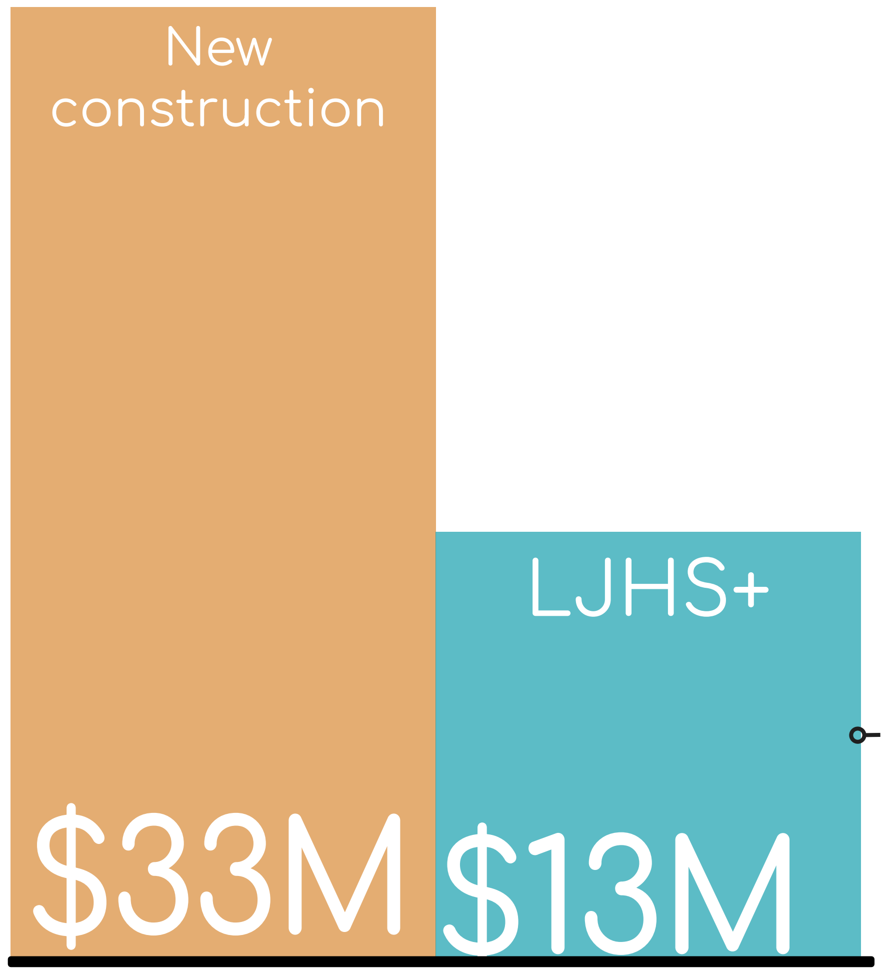
MARKET ANALYSIS

FINANCIAL FEASIBILITY

Cost Per Square Foot



Total Costs



COST BREAKDOWN

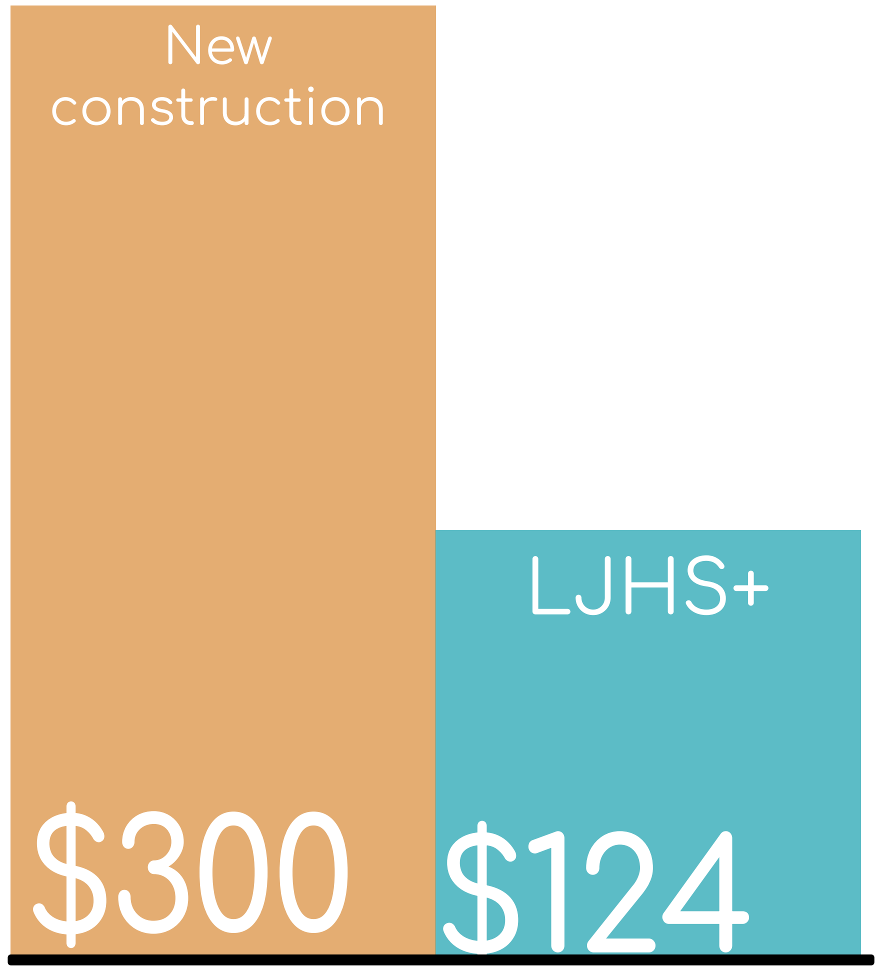
CONSTRUCTION = $3.1M
Materials cost, construction cost, retrofit cost, and labor

MEP = $7.1M
Mechanical, electrical, renewables, sensors, HVAC, water

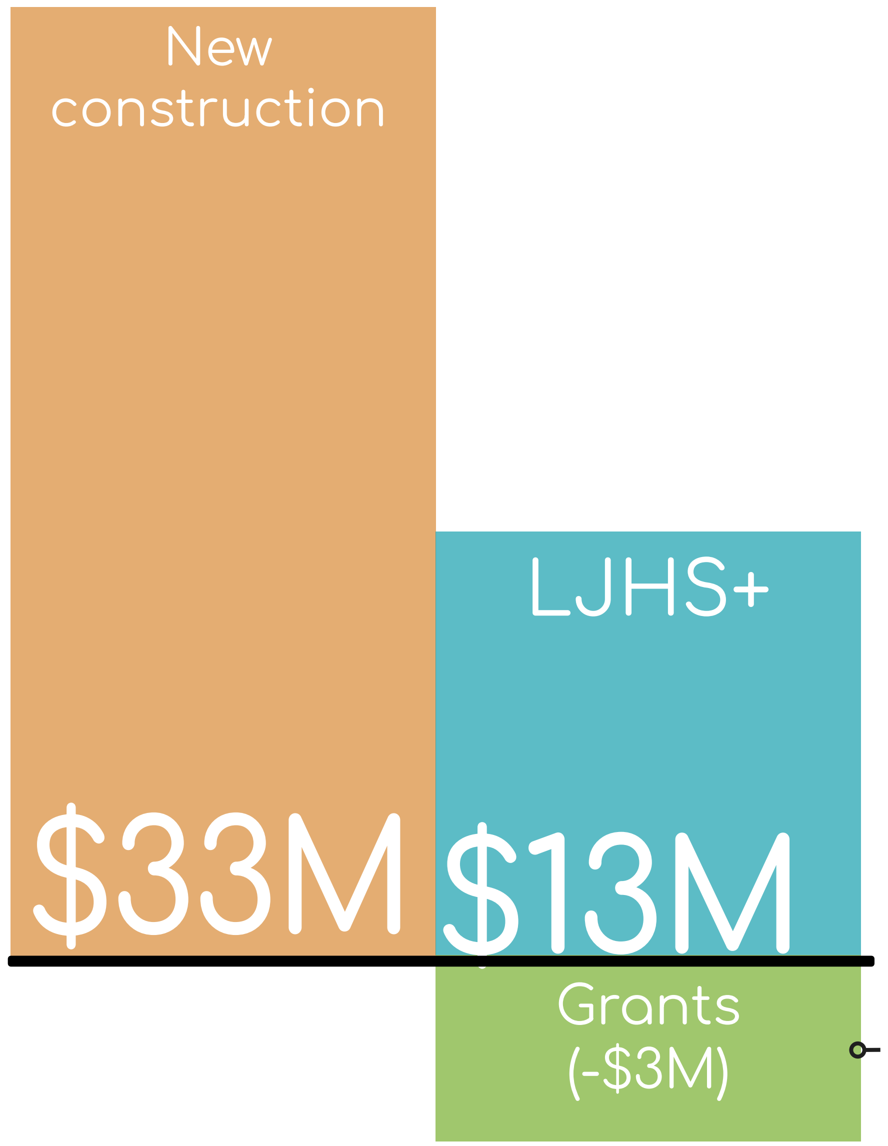
OVERHEAD = 10%
General contractors and miscellaneous costs

FINANCIAL FEASIBILITY

Cost Per Square Foot



Total Costs



AVAILABLE TAX CREDITS AND REBATES

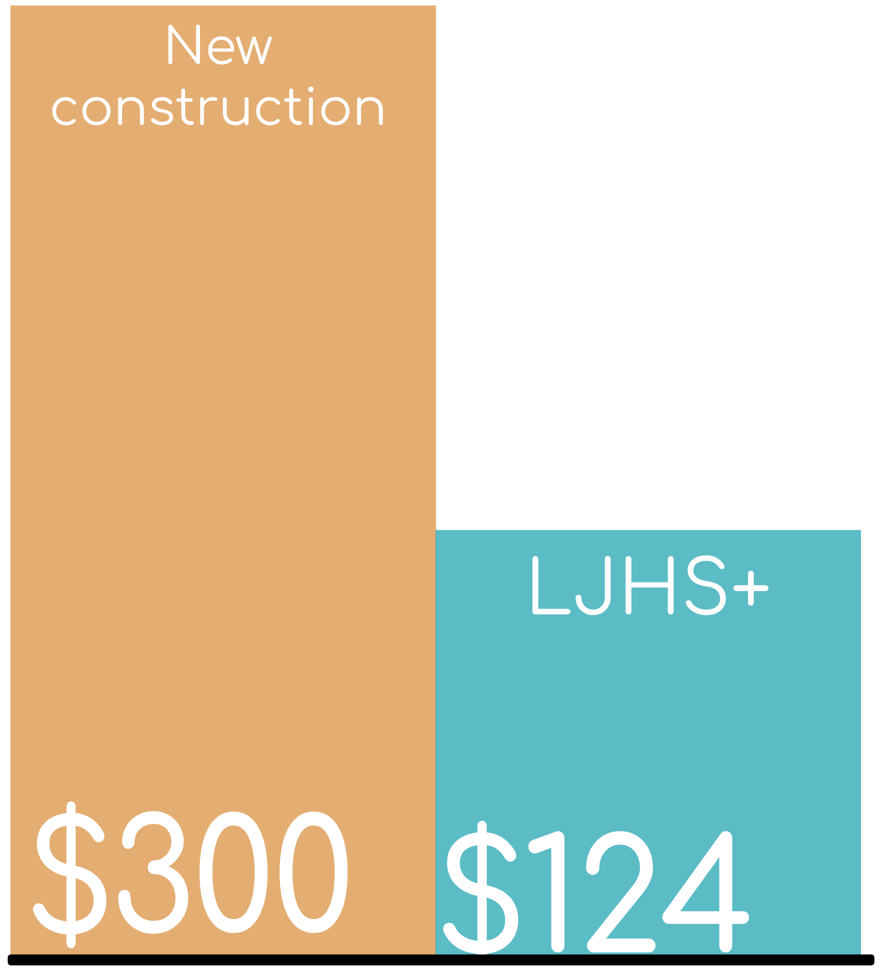
DE-FOA-00002756
Energy innovation initiatives being implemented in K-12

DE-FOA-00002632
Implementation of geothermal energy

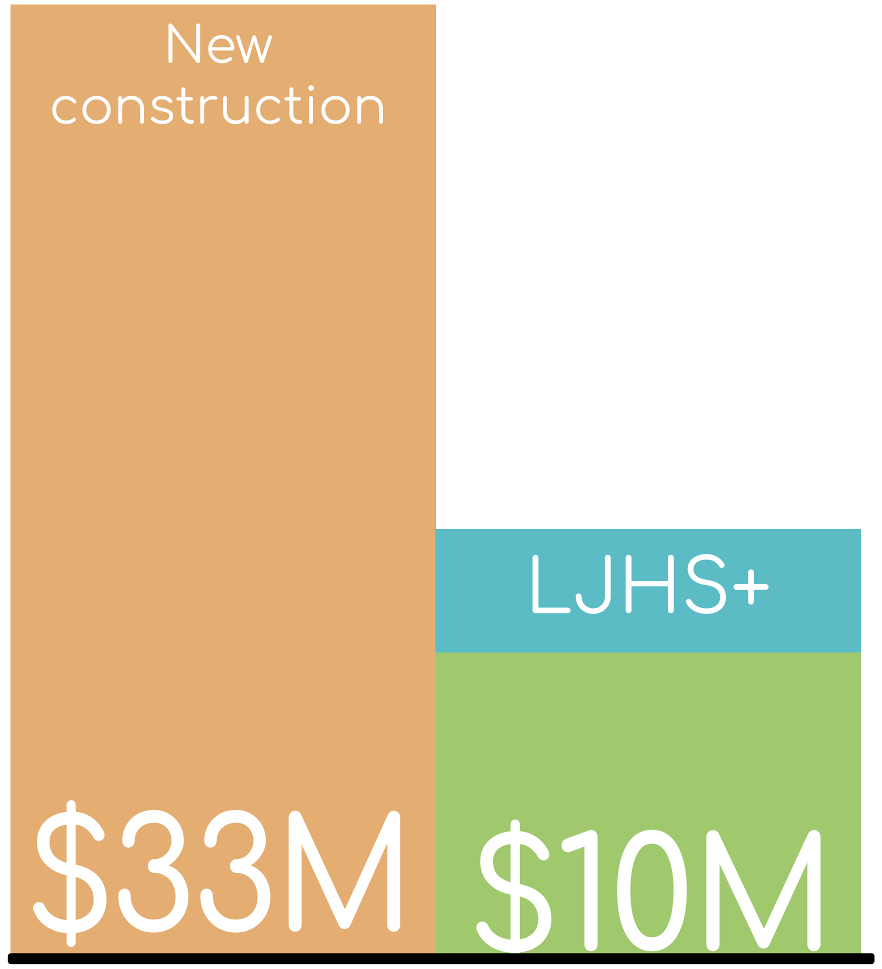
DE-FOA-00002788
Implementation of renewable energy strategies

FINANCIAL FEASIBILITY

Cost Per Square Foot



Total Costs



AVAILABLE TAX CREDITS AND REBATES

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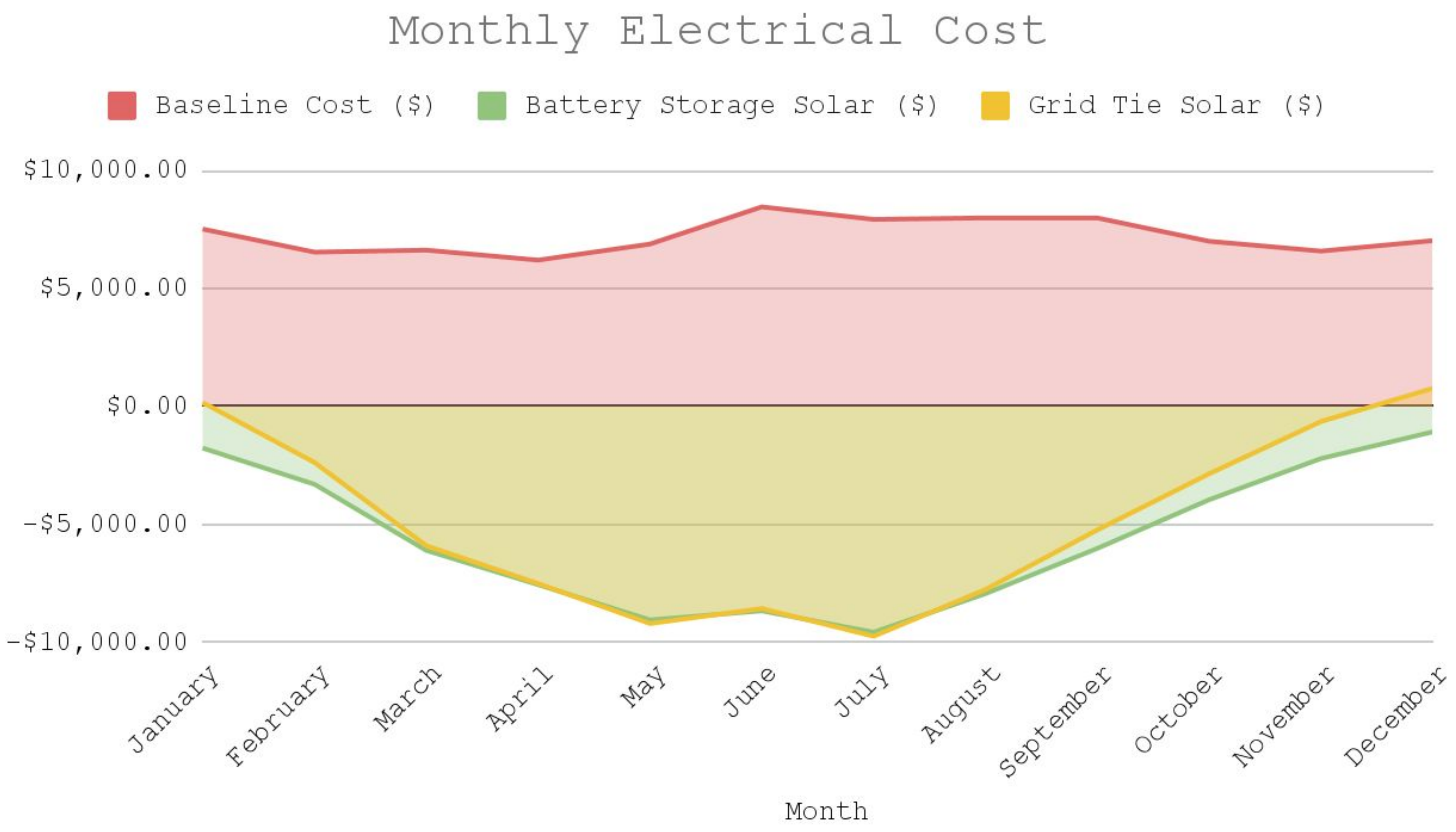
SOLAR RETURN ON INVESTMENT



Initial Investment

Net Cost

$1.2M

8 Years

Breakeven

$0

25 Years

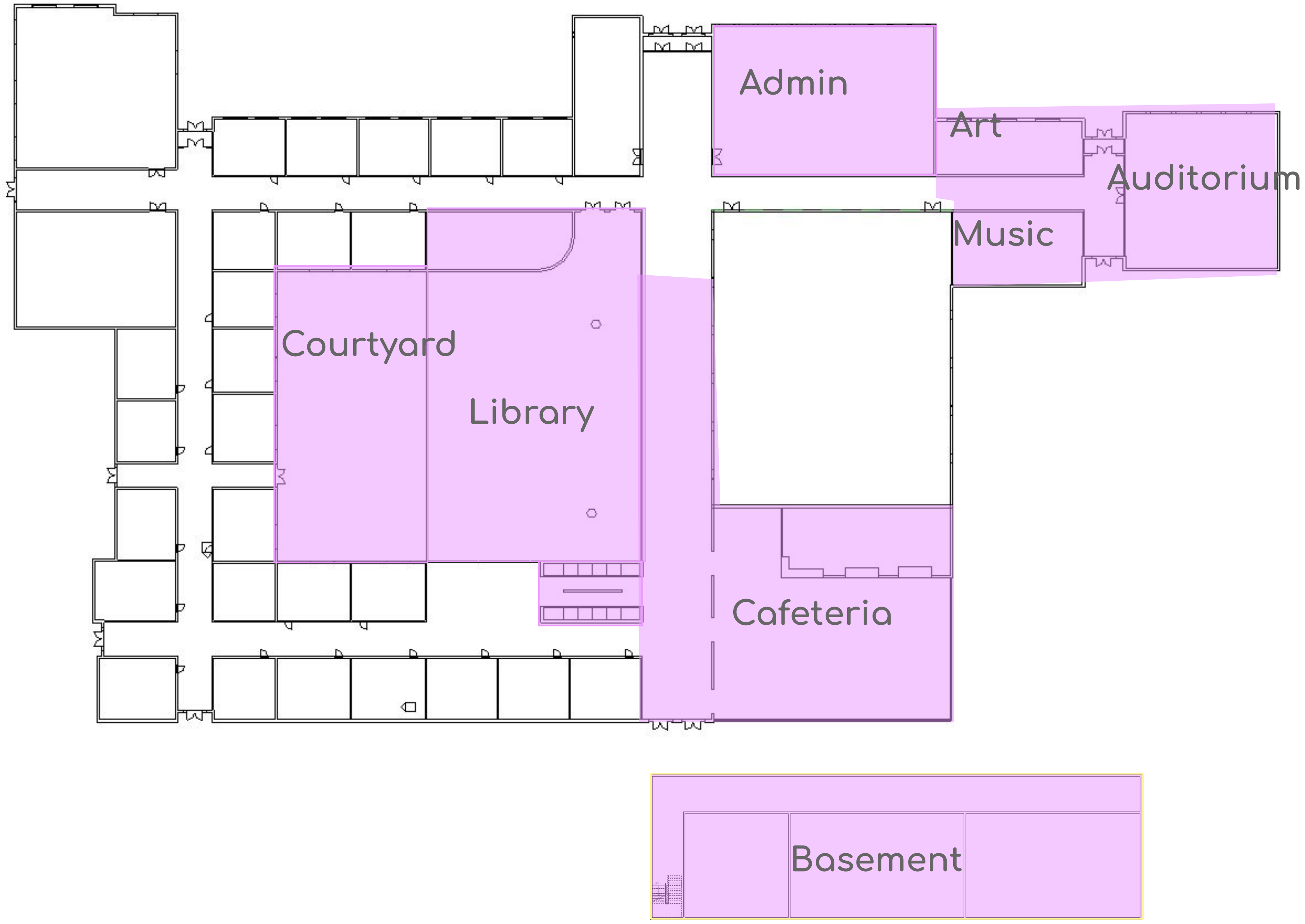
Excess

$3.5M

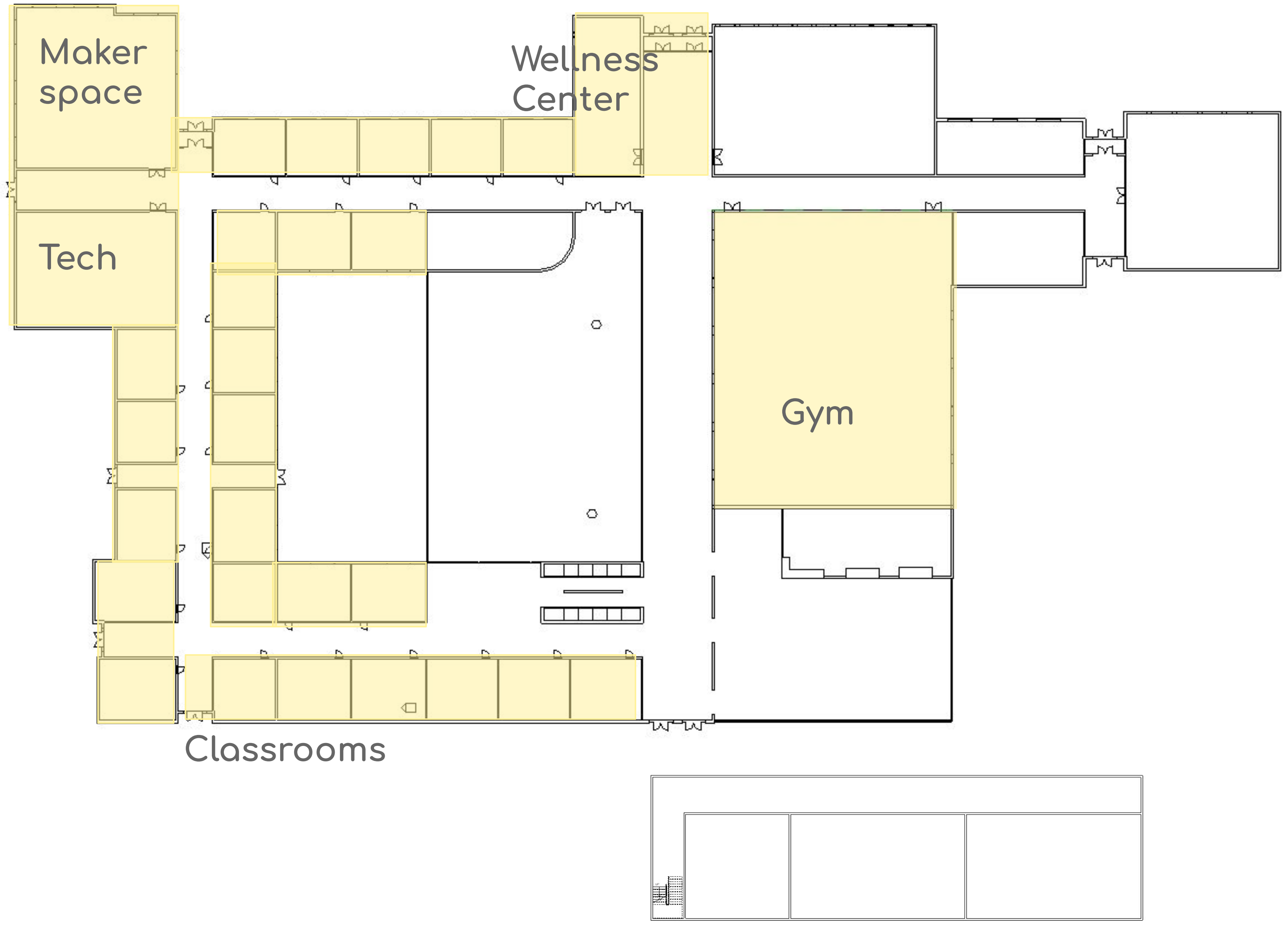
WHY RETROFIT MAKES SENSE

PHASE CONSTRUCTION

Retrofitted Immediately

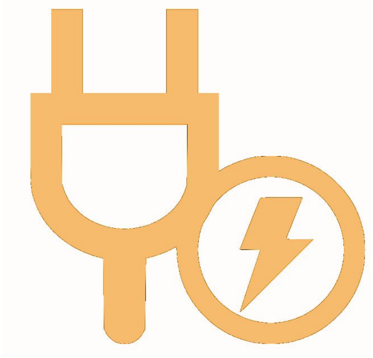


Retrofitted Over Summer



DEFINE SOLUTIONS

Environmental Impacts of retroffing LJHS

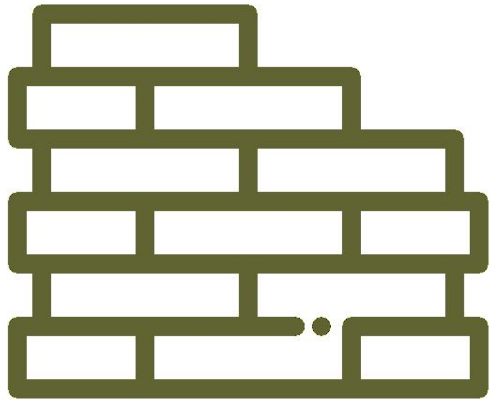


Produce green energy on site

Minimize embodied and operational carbon with refurbishment

Save water usage through greywater system and efficient fixtures

Social benefit of retroffing LJHS



Refurbish aging School Infrastructures

Increase lifespan of public schools in the US

Save **$110 billions** every year on maintenance, operation, and capital construction in PK-12 public school facilities

THE BIGGER PICTURE

ACCESSIBILITY AND INCLUSIVITY
Accessible spaces and gender neutral restrooms

COMMUNITY OUTDOOR
Interior courtyard, outside basketball court, and amphitheatre for a variety of outdoor experiences

FLEXIBLE LEARNING
Classrooms and library support different learning modes

NATURAL LIGHT
Skylights, passive strategies, and classrooms relocated to maximize natural light

RESILIENT INFRASTRUCTURE
Design prioritizes disaster mitigation, security and protection against moisture degradation

SMART TECHNOLOGY
Occupancy sensors to personalize comfort and save energy

AIRTIGHT ENVELOPE -
Efficient building science control layers

CLEAN ENERGY GENERATION
Solar, biogas, and geothermal energy generated on-site

WATER MANAGEMENT
Stormwater management and greywater from sinks reused in toilets

FINANCIALLY FEASIBLE
Structurally preserved, and generate revenue from PVs

INTEGRATED SYSTEM
Efficient, decoupled HVAC, and DOAS units

THE ARCHITECTURE & ENGINEERING WORK TOGETHER