Regenerative Design:
A Bridge between Sustainability and Resilience

Weeks after Tesla founder Elon Musk and Gov. Ricardo Rossello spoke about the tech company aiding Puerto Rico, Tesla says it has restored electricity to a children's hospital, using solar energy and batteries.

Tesla

CSBR Center for Sustainable Building Research

COLLEGE OF DESIGN
UNIVERSITY OF MINNESOTA

Liz Kutschke, Center for Sustainable Building Research

In accordance with the Department of Labor and Industry’s statute 326.0981, Subd. 11,

“This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward **Building Officials** continuing education requirements.”

For additional continuing education approvals, please see your credit tracking card.

Outline:

Introduction
- B3 / SB2030
- Saint Paul Ford Site Speculative Development
- Building Prototyping

Resilient Adaptation of Sustainable Buildings
- Precedents and Context
- Historic Weather
- Future Weather
- Multi Family Resilience – Shelter In Place
- Library Resilience – Disaster Hub
- Future Research and Next Steps

Questions and Discussion

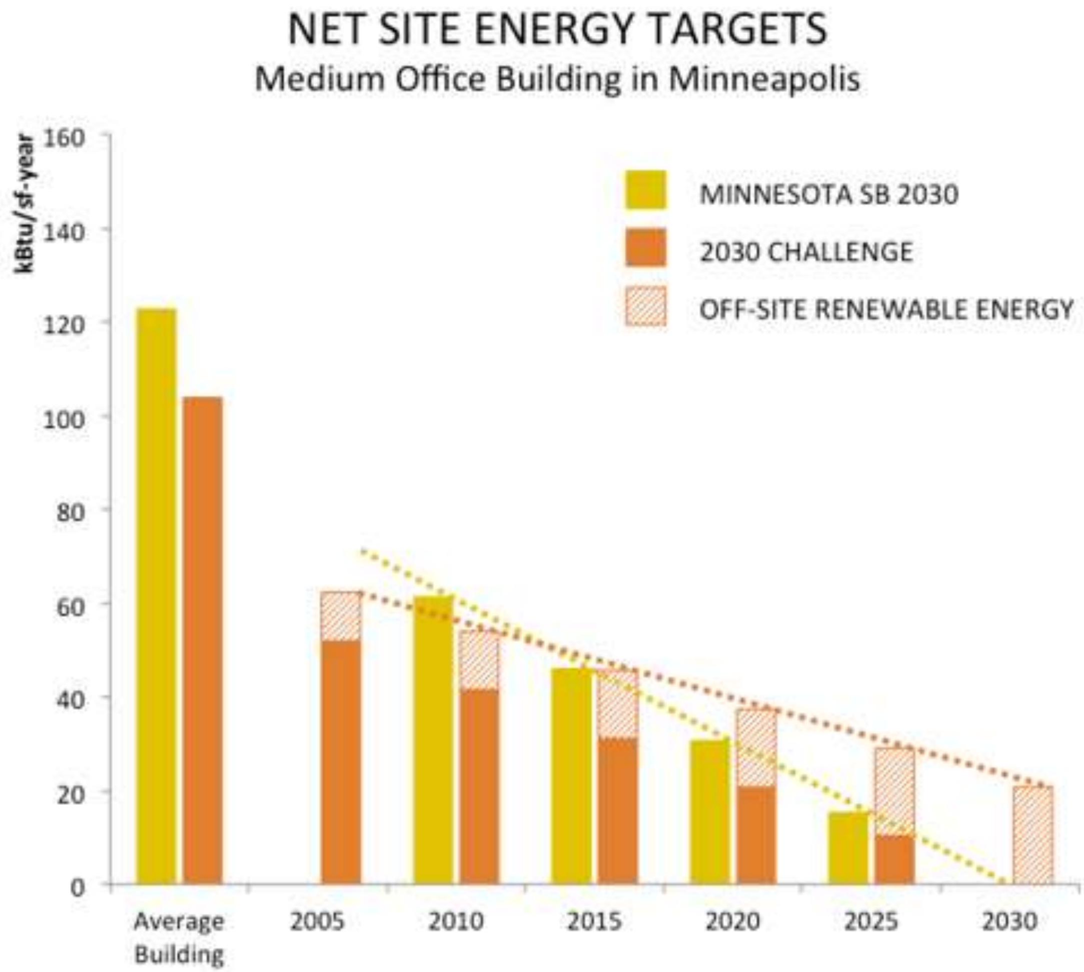
SUSTAINABLE BUILDING 2030

MINNESOTA SB 2030

Goal of net-zero energy
Average building:
- Based on the ASHRAE 1989 90.1 Energy Code
- Calculated with the SB 2030 Energy Standard Tool

2030 CHALLENGE

Goal of carbon neutrality
Average building:
- Based on existing building energy use (CBECS 2003 data)
- Calculated with the EPA Target Finder



MINNESOTA SUSTAINABLE BUILDING 2030

CASE STUDY METRICS – www.casestudies.b3mn.org


Bear Head Lake State Park


Hennepin County 911 Facility


BSU Decker Hall Renovation


MnSCU Mankato Clinical Sciences Building


Hamline Station


Tettegouche Visitor Center and Rest Area


Western U Plaza


Kendall's Payne Avenue Hardware


Big Bog State Recreation Area


Minnesota National Guard Winona Armory Renovation


MSU Science Education Building


NHCC Biosciences and Health Careers Center


NCC Academic Partnership Center


SCC Classroom Renovation and Addition


UMM Green Living and Learning Community


BSU Memorial Hall Renovation


Camp Ripley COE Training Facility


Duluth Armory


Maplewood Mall Parking Structure


PTC Entrepreneurship Center and Business Incubator

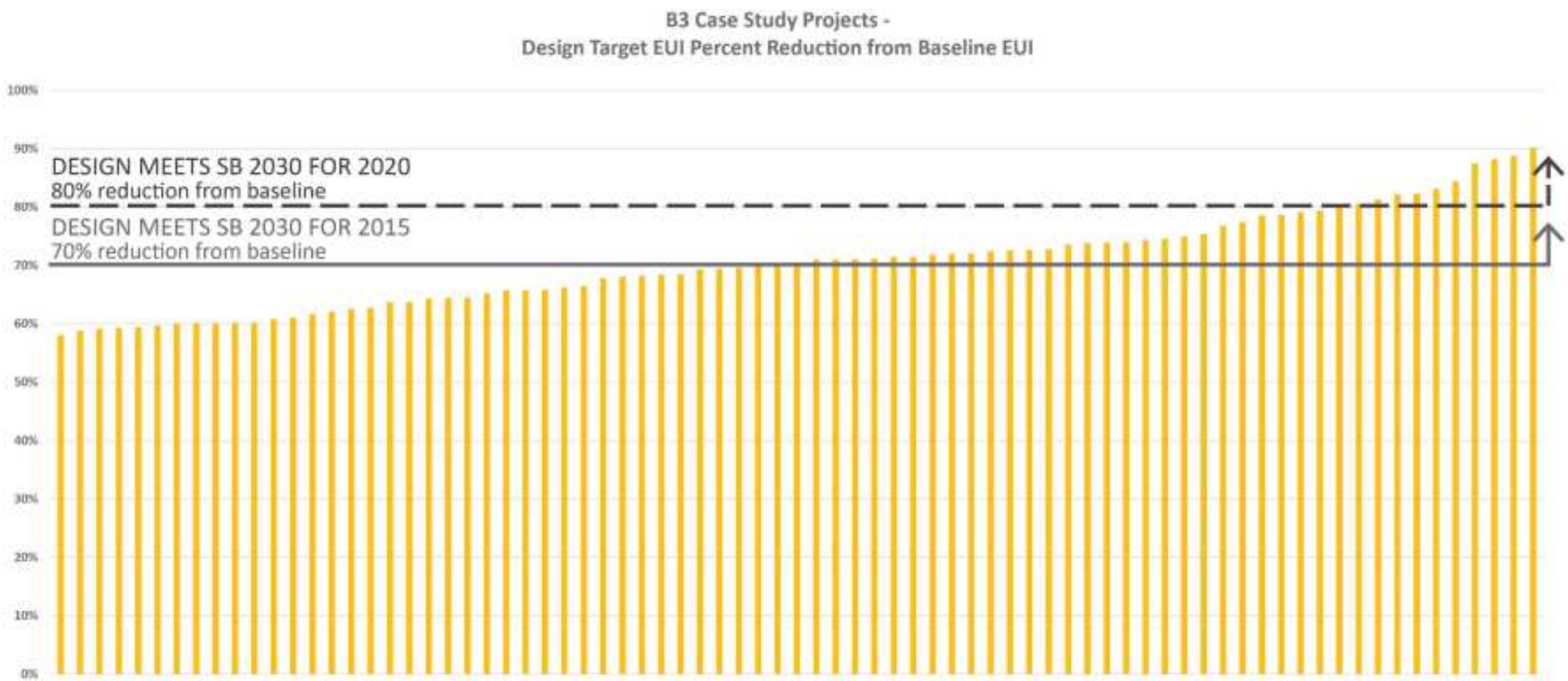

Washburn Center for Children


STCC Medium Heavy Truck and Auto Body


Duluth Entertainment and Convention Center


Silver Creek Corner

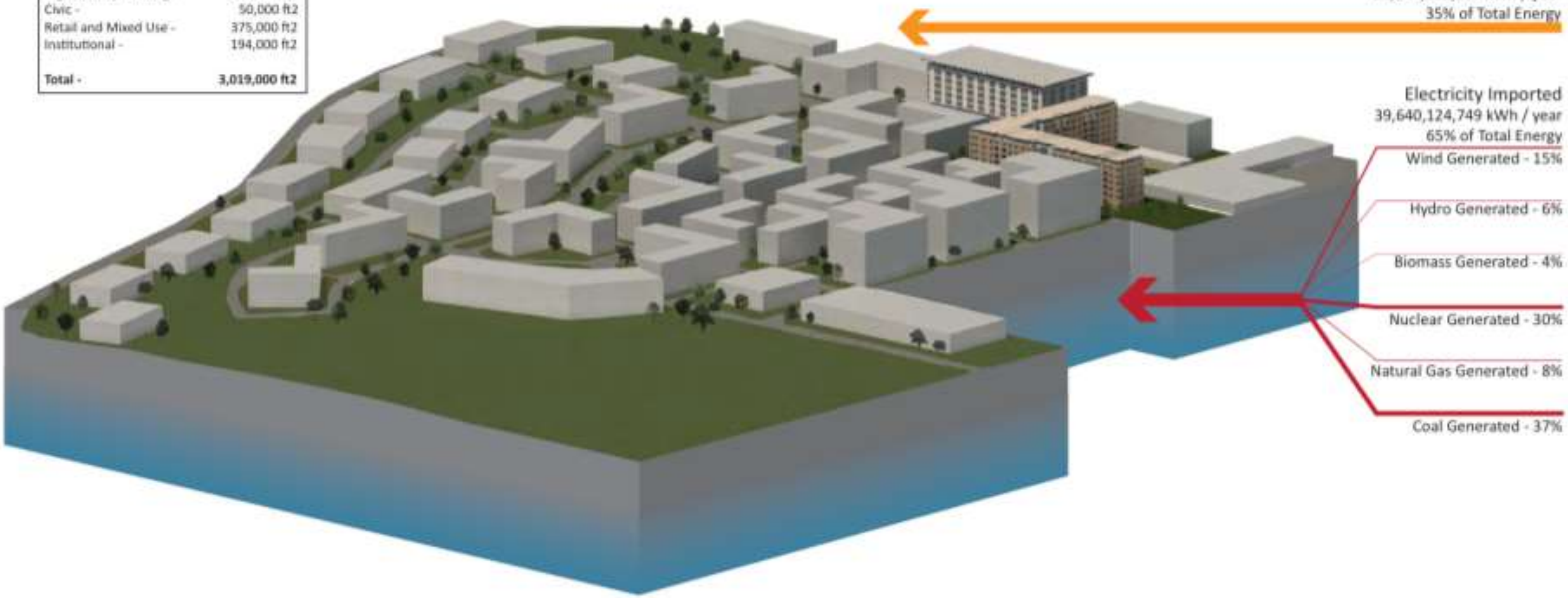
RESULTS – ENERGY (DESIGN/SB 2030 STANDARD)



Code-Based Buildings - ASHRAE 90.1 2010
2015 Energy Grid

Total Energy Use: 60,984 MWh / year

Built Up Area:	
Low Density Housing -	534,000 ft2
Med Density Housing -	1,296,000 ft2
High Density Housing -	570,000 ft2
Civic -	50,000 ft2
Retail and Mixed Use -	375,000 ft2
Institutional -	194,000 ft2
Total -	**3,019,000 ft2**



Code-Based Buildings - ASHRAE 90.1 2010
2030 Energy Grid

Total Energy Use:
60,984 MWh / year

Built Up Area:	
Low Density Housing -	534,000 ft2
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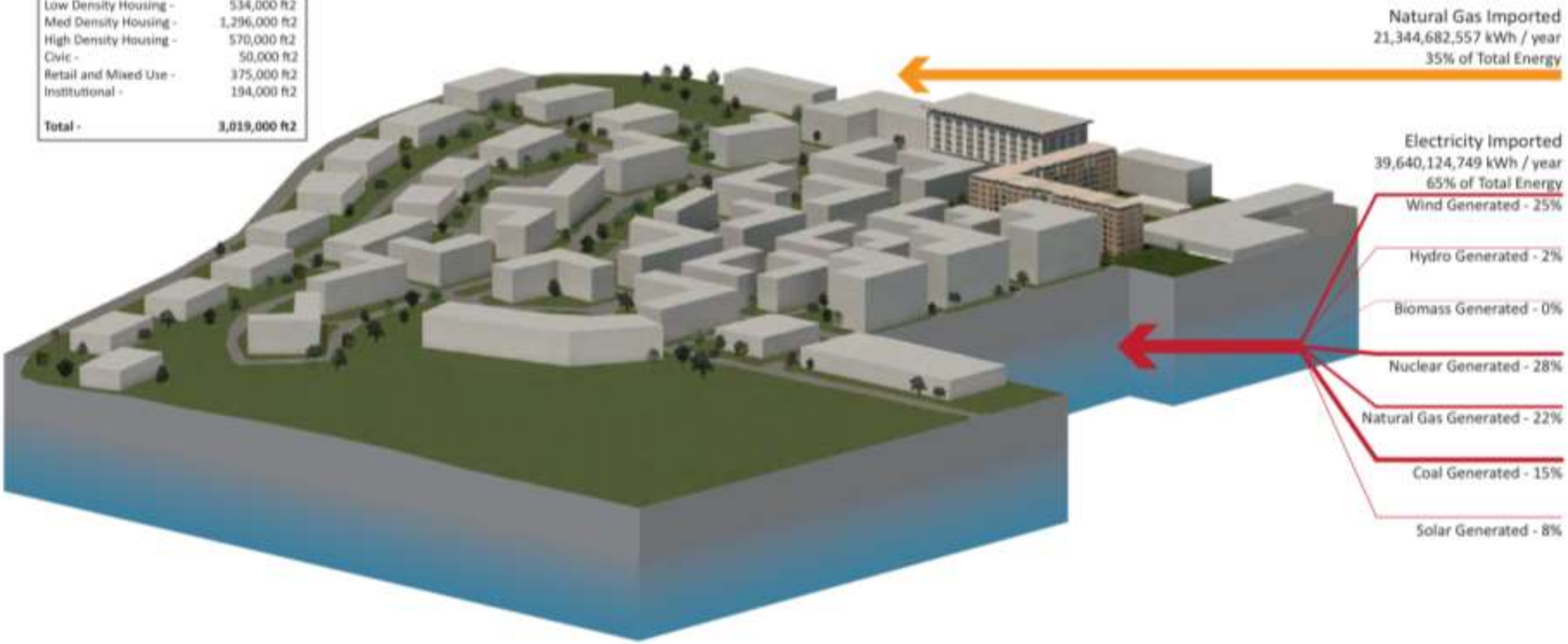
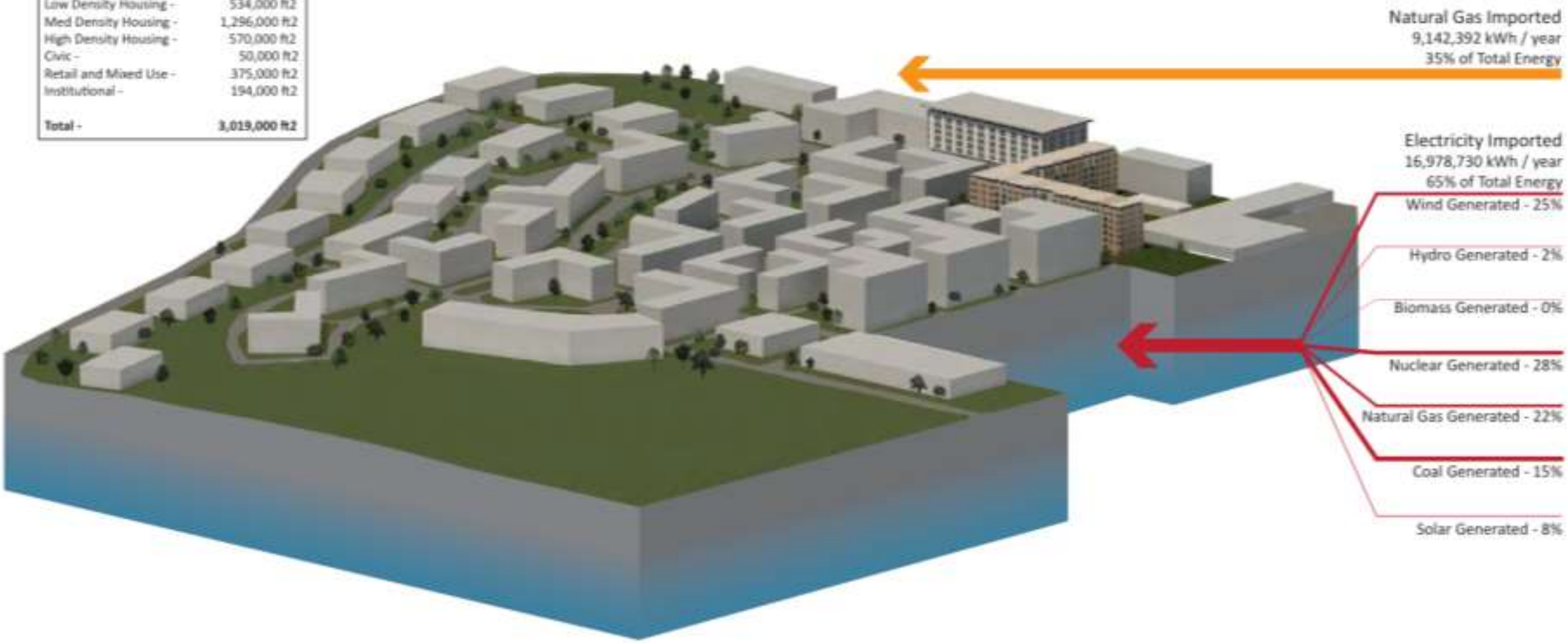


SB2030 80% Better Buildings
2030 Energy Grid

Built Up Area:	
Low Density Housing -	534,000 ft2
Med Density Housing -	1,296,000 ft2
High Density Housing -	570,000 ft2
Civic -	50,000 ft2
Retail and Mixed Use -	375,000 ft2
Institutional -	194,000 ft2
Total -	**3,019,000 ft2**

Total Energy Use:
26,121 MWh / year
57% Reduction



SB2030 80% Better Buildings
2030 Energy Grid + PV Roofs

Built Up Area:	
Low Density Housing -	534,000 ft2
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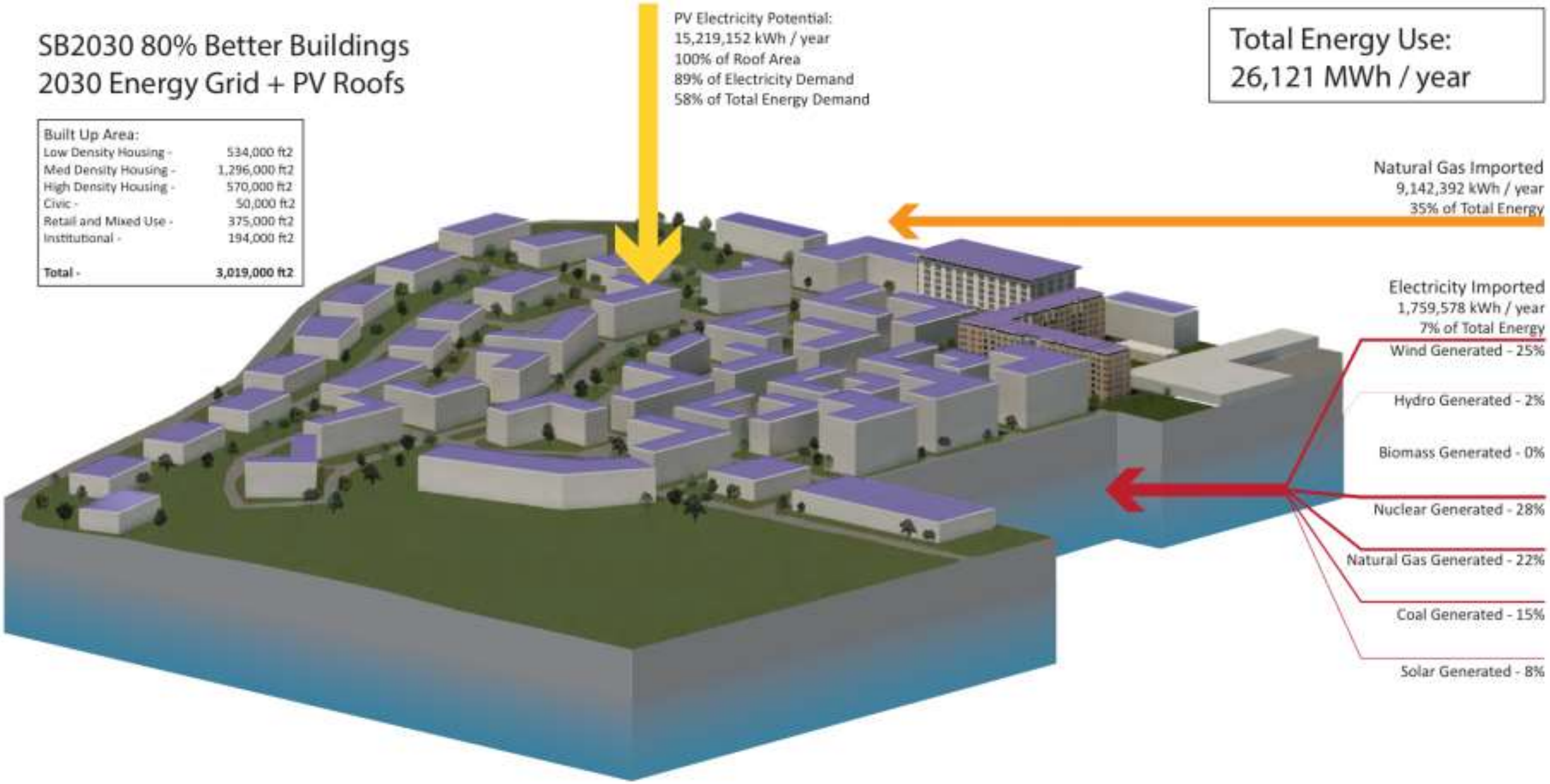
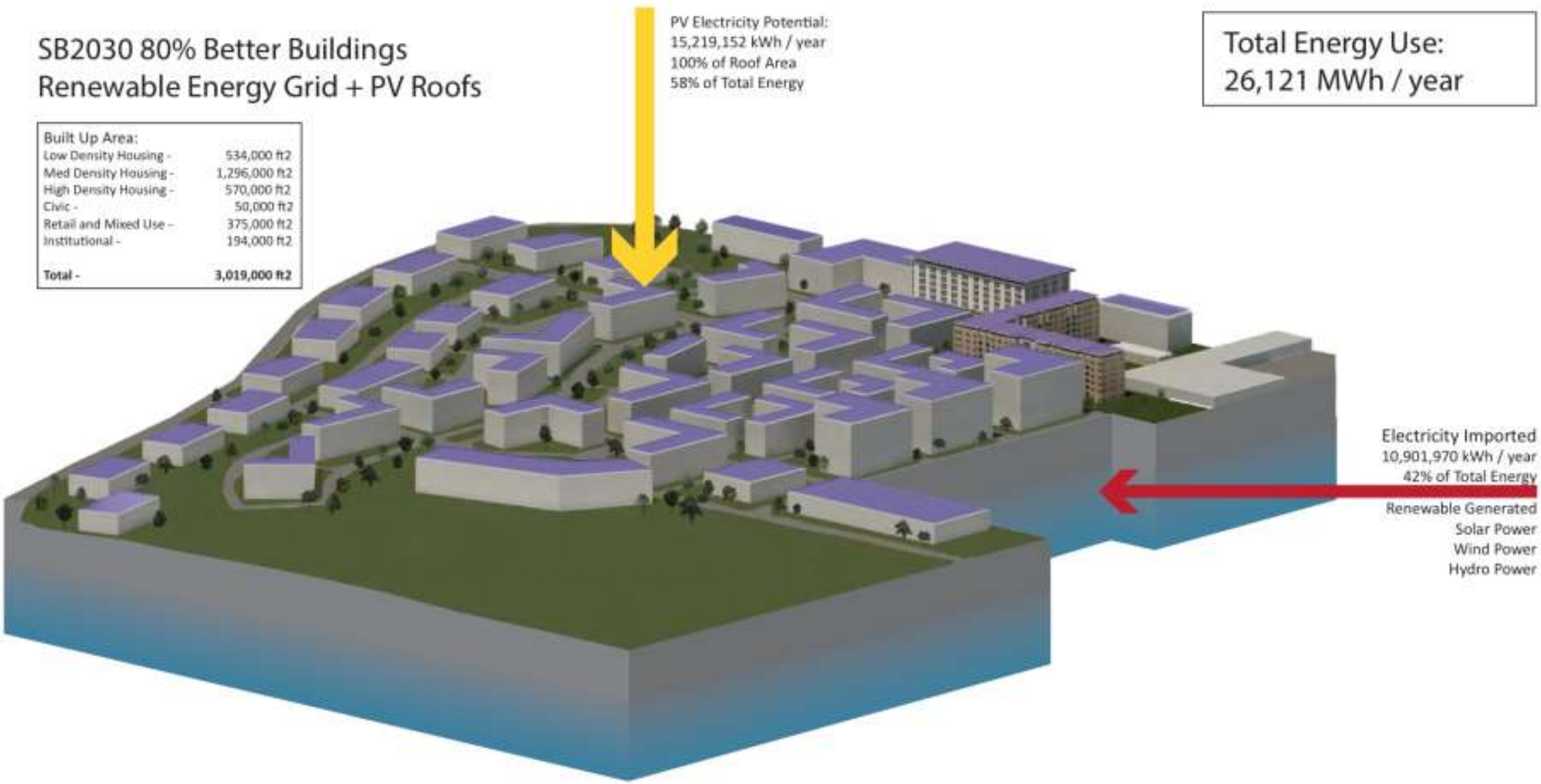
High Density Housing -	570,000 ft2
Civic -	50,000 ft2
Retail and Mixed Use -	375,000 ft2
Institutional -	194,000 ft2
Total -	**3,019,000 ft2**

Total Energy Use:
26,121 MWh / year

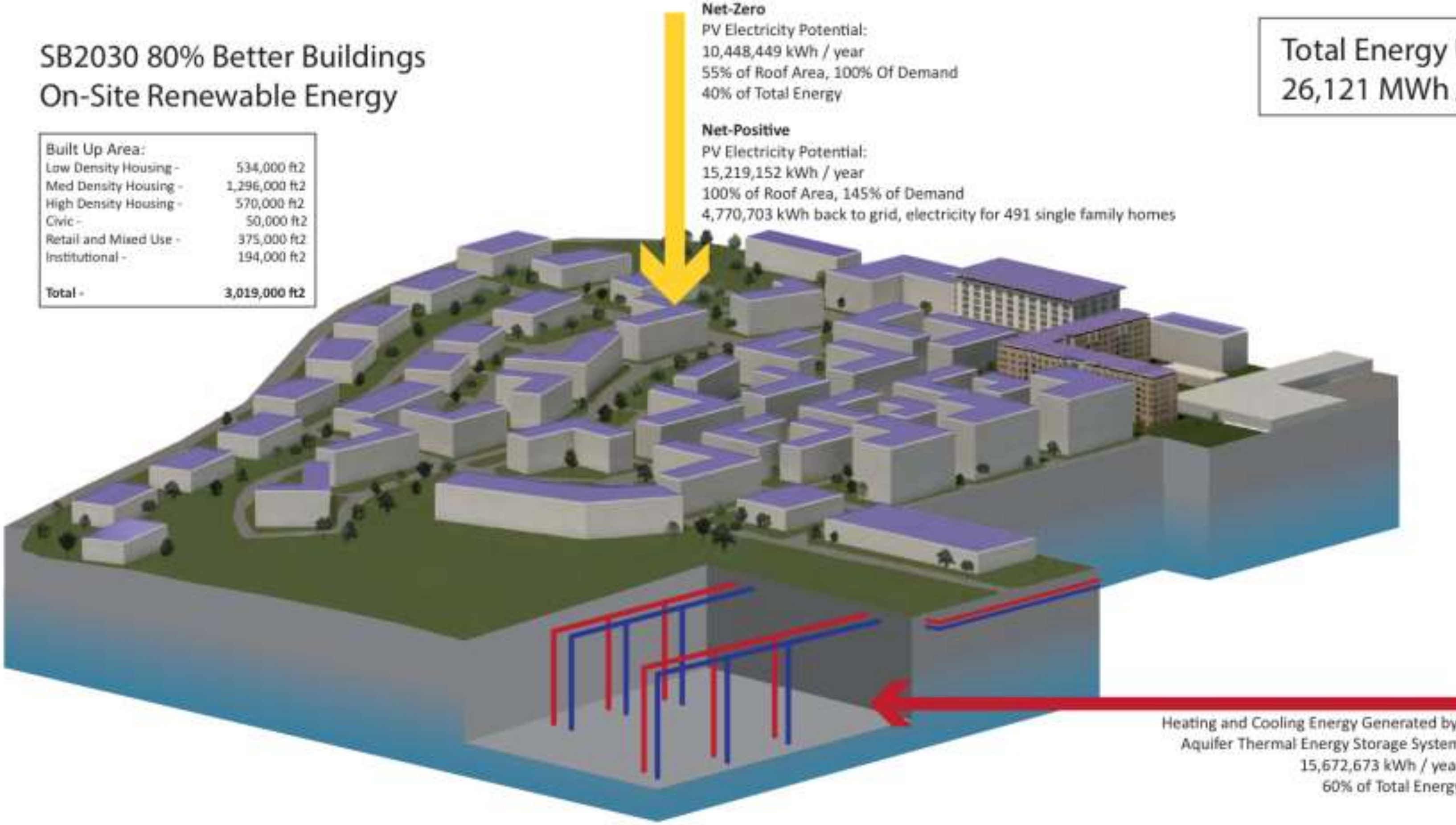




SB2030 80% Better Buildings
Renewable Energy Grid + PV Roofs
Built Up Area:
Low Density Housing - 534,000 ft2
Med Density Housing - 1,296,000 ft2
High Density Housing - 570,000 ft2
Civic - 50,000 ft2
Retail and Mixed Use - 375,000 ft2
Institutional - 194,000 ft2
Total - 3,019,000 ft2
PV Electricity Potential:
15,219,152 kWh / year
100% of Roof Area
58% of Total Energy
Total Energy Use:
26,121 MWh / year
Electricity Imported
10,901,970 kWh / year
42% of Total Energy
Renewable Generated
Solar Power
Wind Power
Hydro Power

SB2030 80% Better Buildings
On-Site Renewable Energy

Built Up Area:	
Low Density Housing -	534,000 ft2
Med Density Housing -	1,296,000 ft2
High Density Housing -	570,000 ft2
Civic -	50,000 ft2
Retail and Mixed Use -	375,000 ft2
Institutional -	194,000 ft2
Total -	**3,019,000 ft2**



OFFICE PROTOTYPE

IMPROVED CASE - BY THE NUMBERS

Office and Retail

BUILDING DETAILS

176,865 Total SF
26,865 Retail SF on 1st Floor
30,000 Office SF on 2nd-6th Floor
30,000 Roof SF

ENERGY PERFORMANCE

22.5 kBtu/sf/yr EUI
610,837 kW Photovoltaic Array

WATER USE

72% of Potable Water Demand met by Rainfall
6.3 Gallon Demand per Person per Day

VALUE

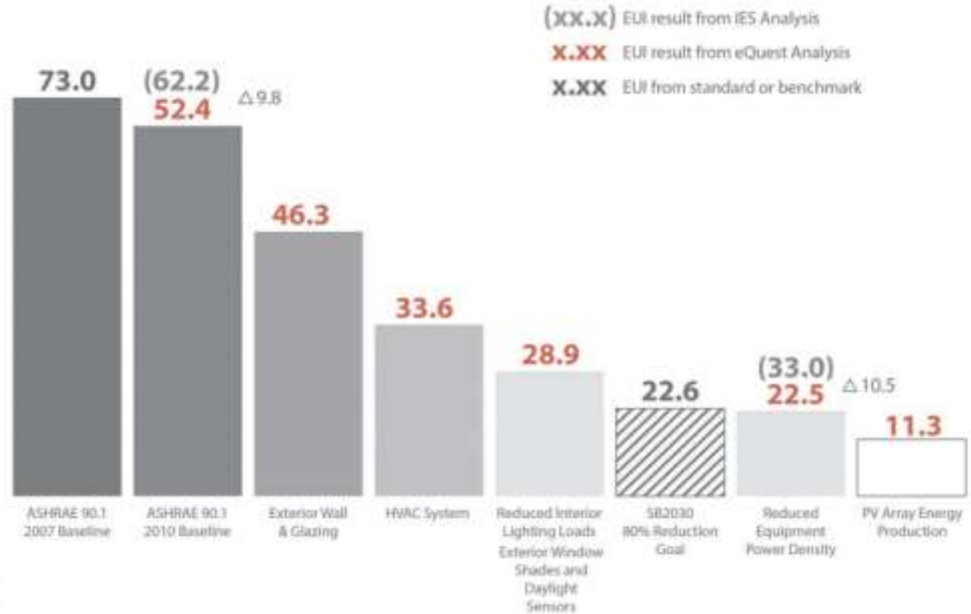
$000 / SF Baseline
$000 / SF Net Zero Energy
$000 / SF Net Zero Water
$000 / SF Living Building Challenge

MAJOR DESIGN STRATEGIES

88% Potable Water Demand Reduction
Rainwater capture & Greywater reuse
Increased R Values for Walls & Roof
Improved Glazing Performance
Improved HVAC system and efficiency
Lighting Power Densities reduced 50%
Equipment Power Density Reduced 40%

IMPROVED CASE - ENERGY USE

Office And Retail

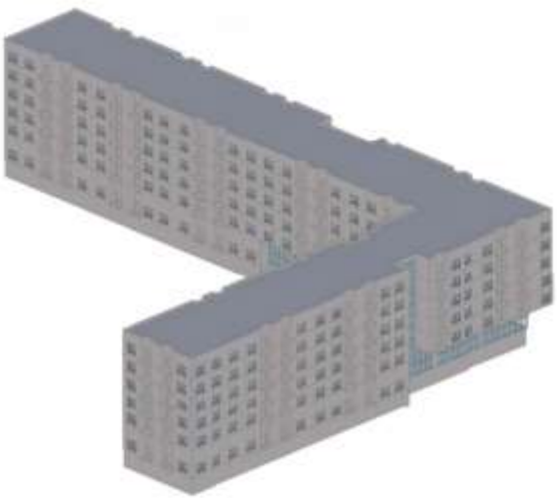


EUI = Energy Use Intensity measured in kBtu/sf/yr

RESIDENTIAL PROTOTYPE

IMPROVED CASE - BY THE NUMBERS

Multi Family and Retail



BUILDING DETAILS

219,096 Total SF
7,658 Retail SF on 1st Floor
187 Units on 1st-6th Floor
37,073 Roof SF

ENERGY PERFORMANCE

38.2 kBtu/sf/yr EUI
511,870 kW Photovoltaic Array

WATER USE

35% of Potable Water Demand met by Rainfall
18.13 Gallon Demand per Person per Day

VALUE

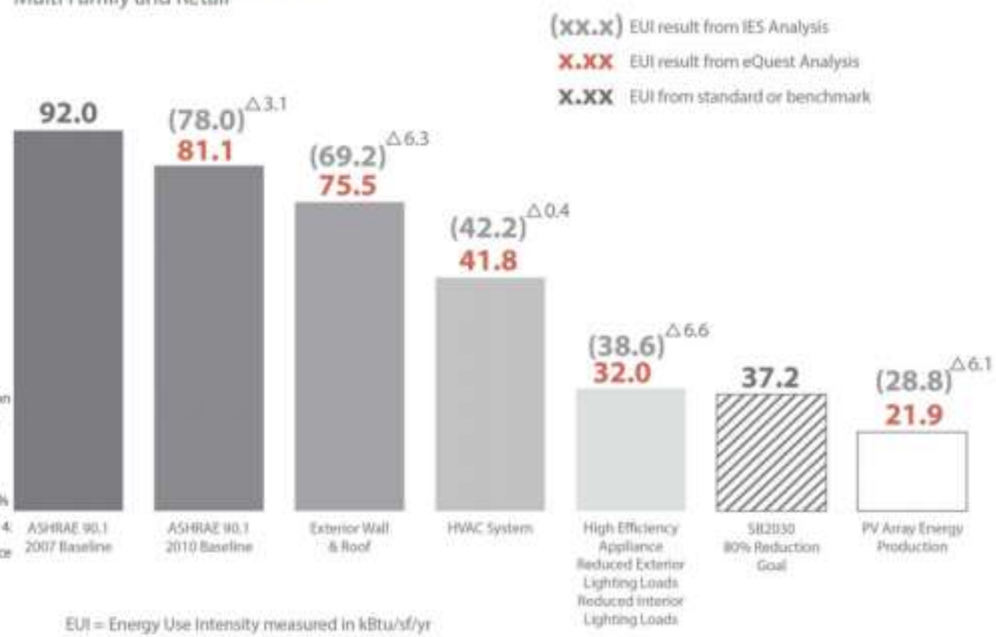
$000 / SF Baseline
$000 / SF Net Zero Energy
$000 / SF Net Zero Water
$000 / SF Living Building Challenge

MAJOR DESIGN STRATEGIES

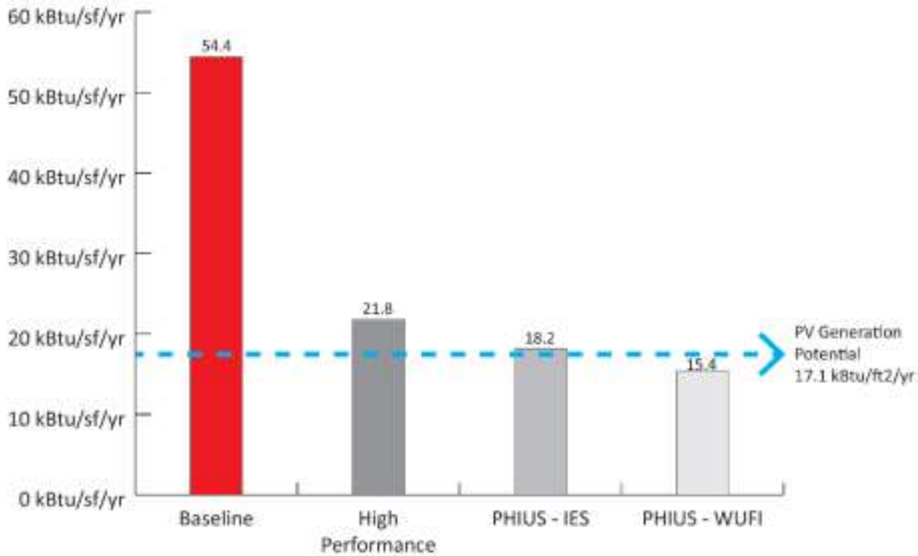
53% Potable Water Demand Reduction
Rainwater capture & Greywater reuse
Increased R Values for Walls & Roof
Improved Glazing Performance
Lighting Power Densities reduced 20%
Lights dim when daylighting reaches 4:
Orientation optimized for performance

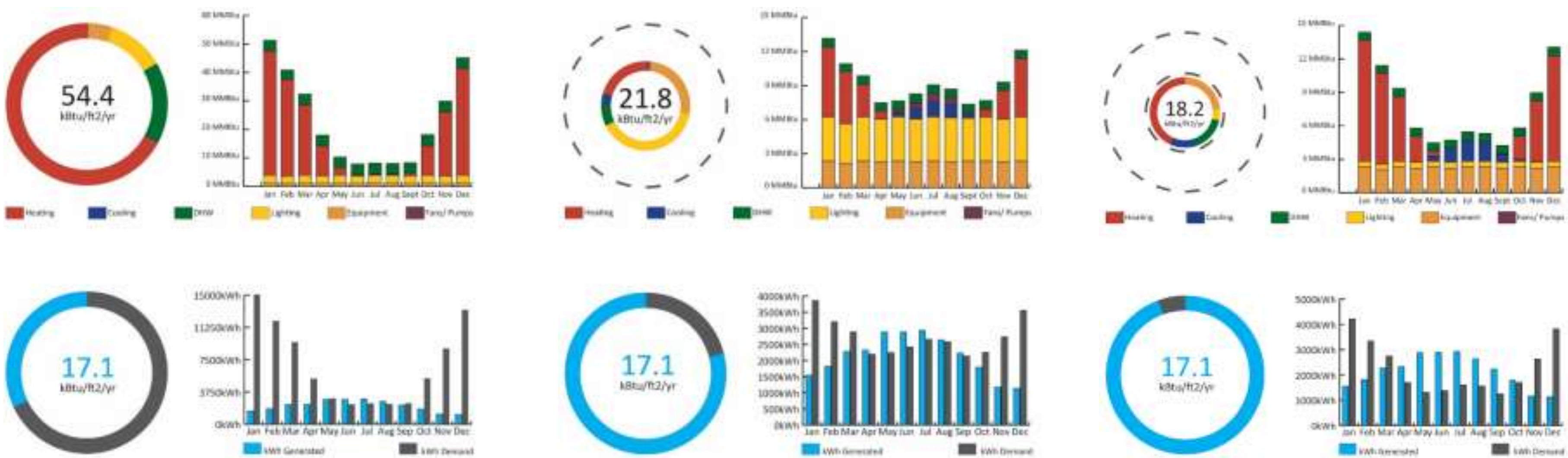
IMPROVED CASE - ENERGY USE

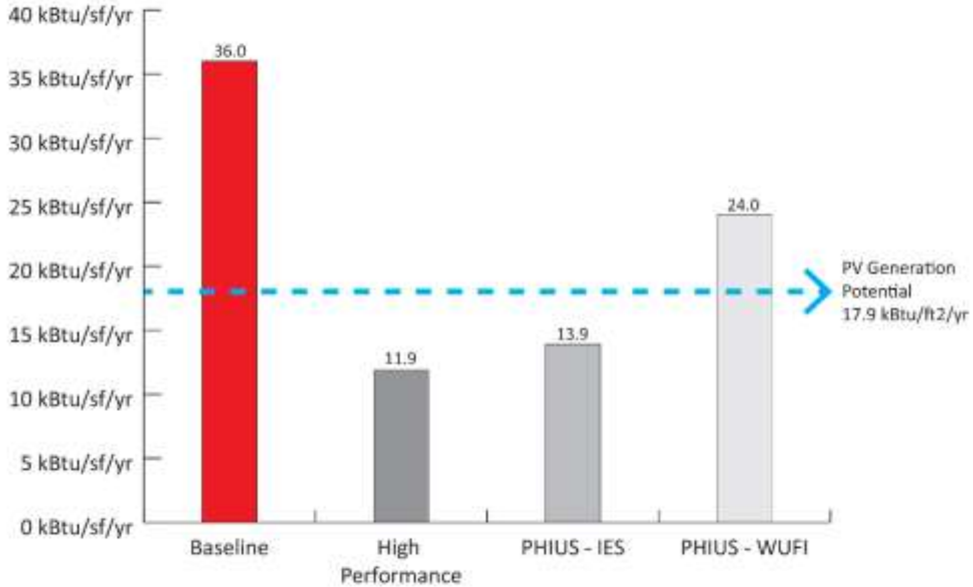
Multi Family and Retail



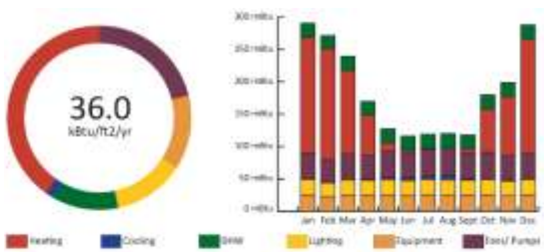
Townhome Prototype
4 Units, 12 Residents
2 Stories
5,100 ft2

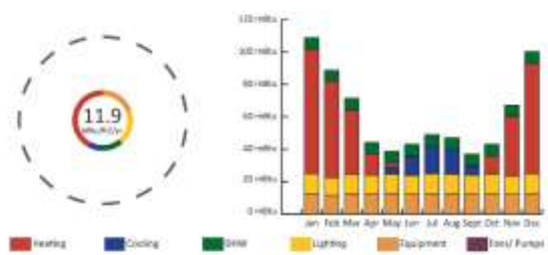


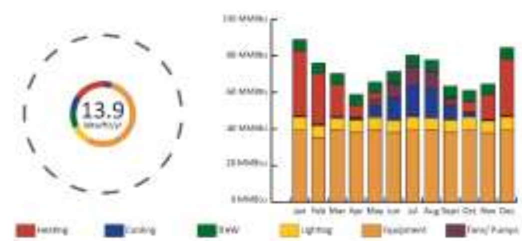


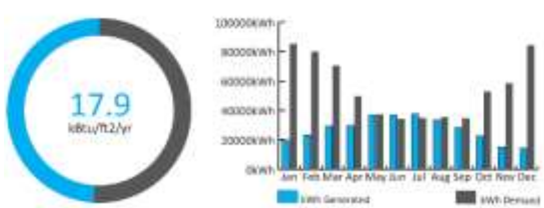


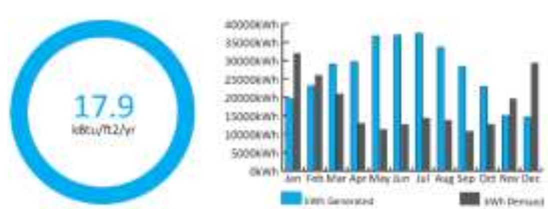
Low Rise Prototype
48 Units, 147 Residents
3 Stories
61,170 ft2

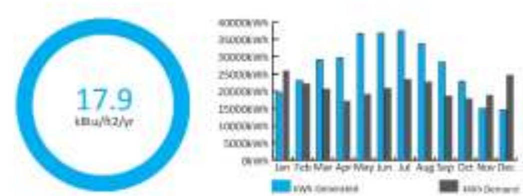






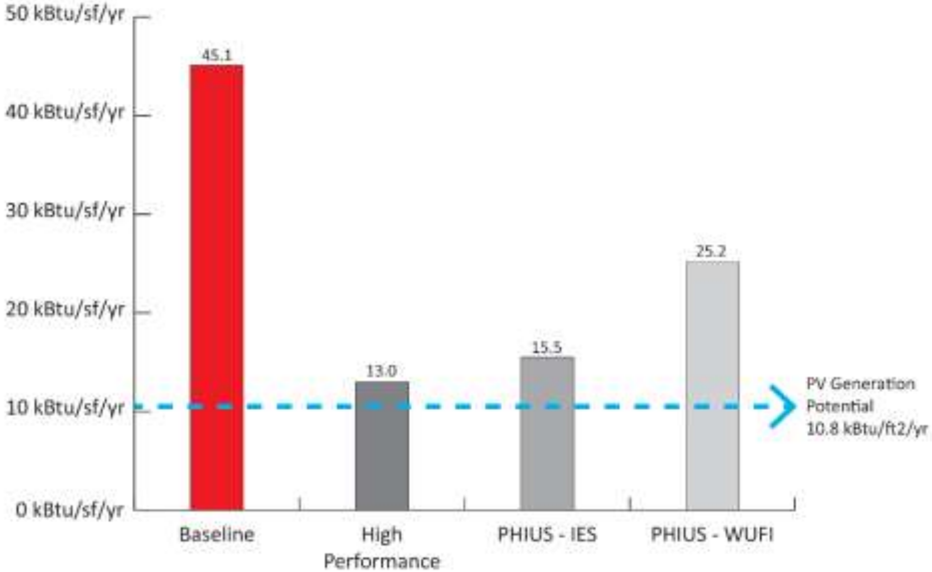


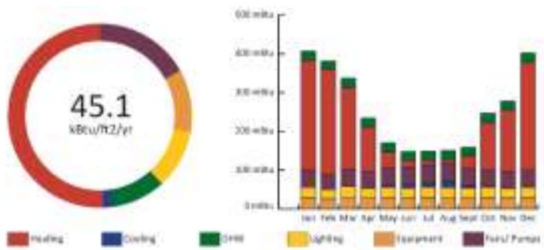


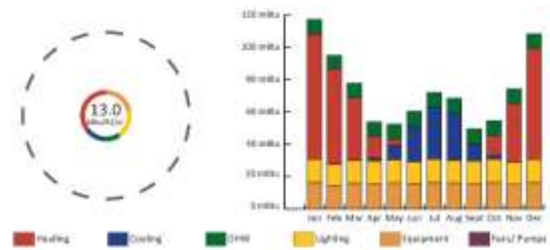


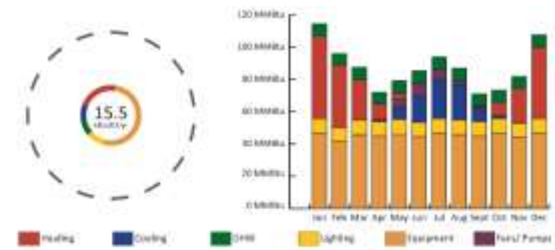
Regenerative Design: A Bridge Between Sustainability and Resilience
February 26, 2019

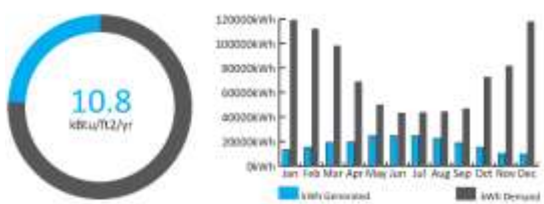
Low Rise Prototype
52 Units, 170 Residents
5 Stories
67,845 ft2

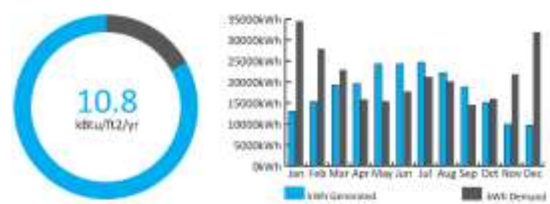


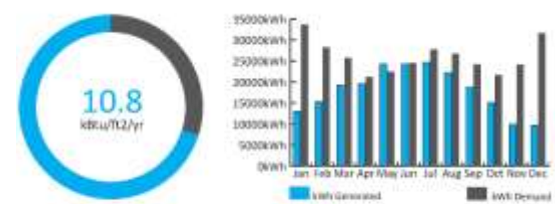




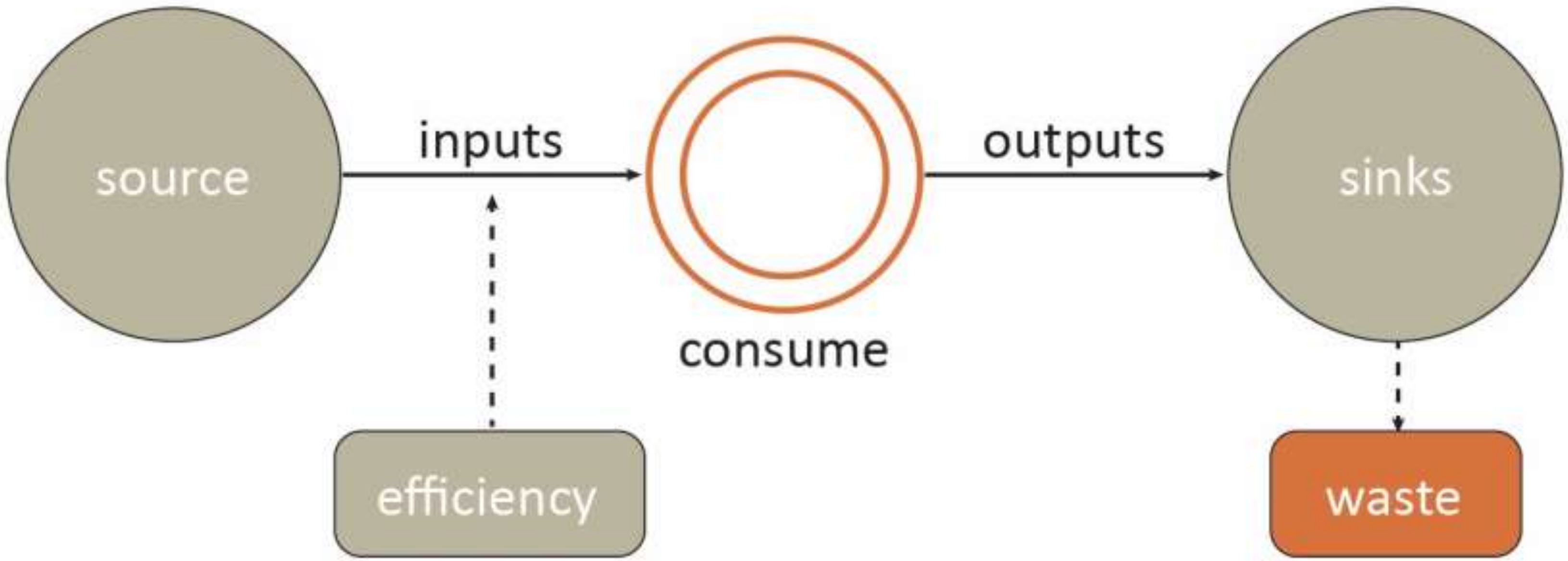








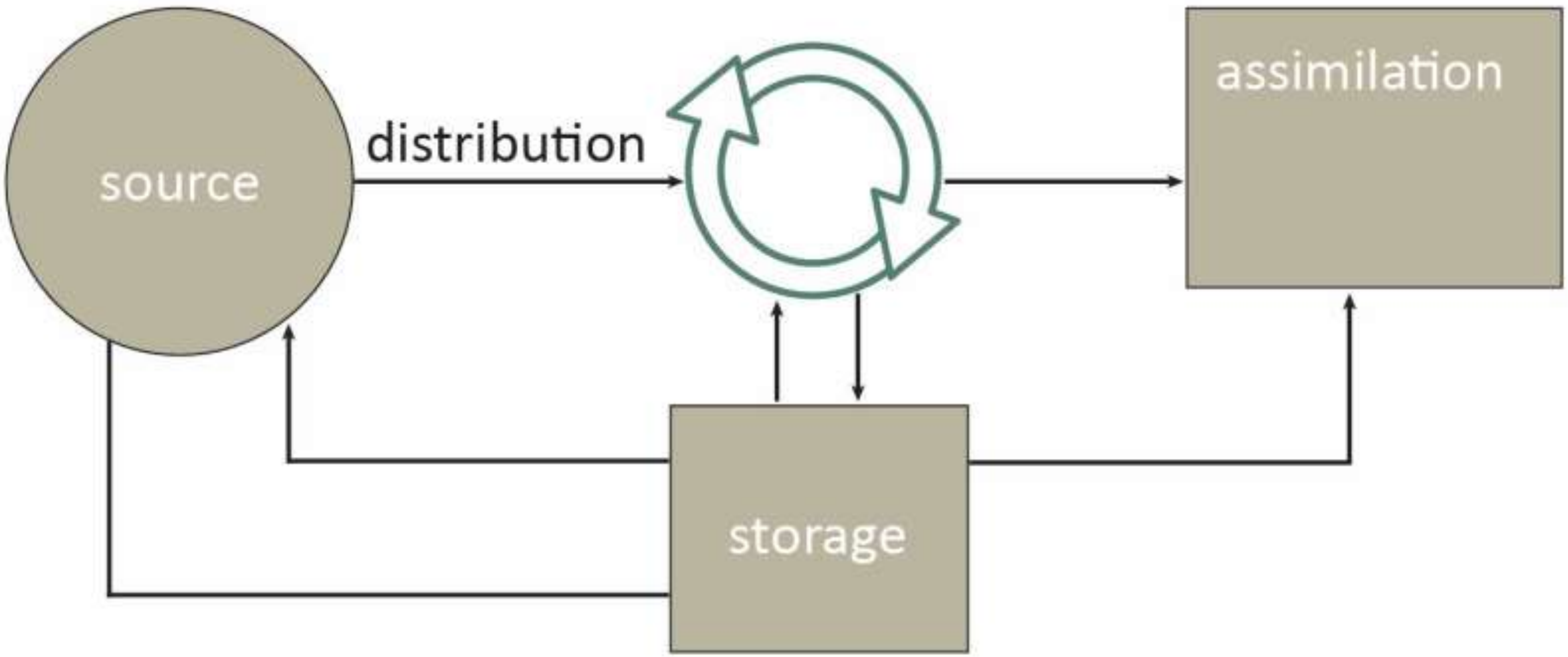
Existing Throughput Systems



- Efficiency as end goal
- Degenerative linear flows

John Tillman Lyle, Regenerative Design for Sustainable Development, 1994

Regenerative Systems



- Effectiveness as end goal
- Within renewal capacity
- Integrate with natural processes
- Symbiosis
- Closed-loop system
- Multiple pathways

John Tillman Lyle, Regenerative Design for Sustainable Development, 1994

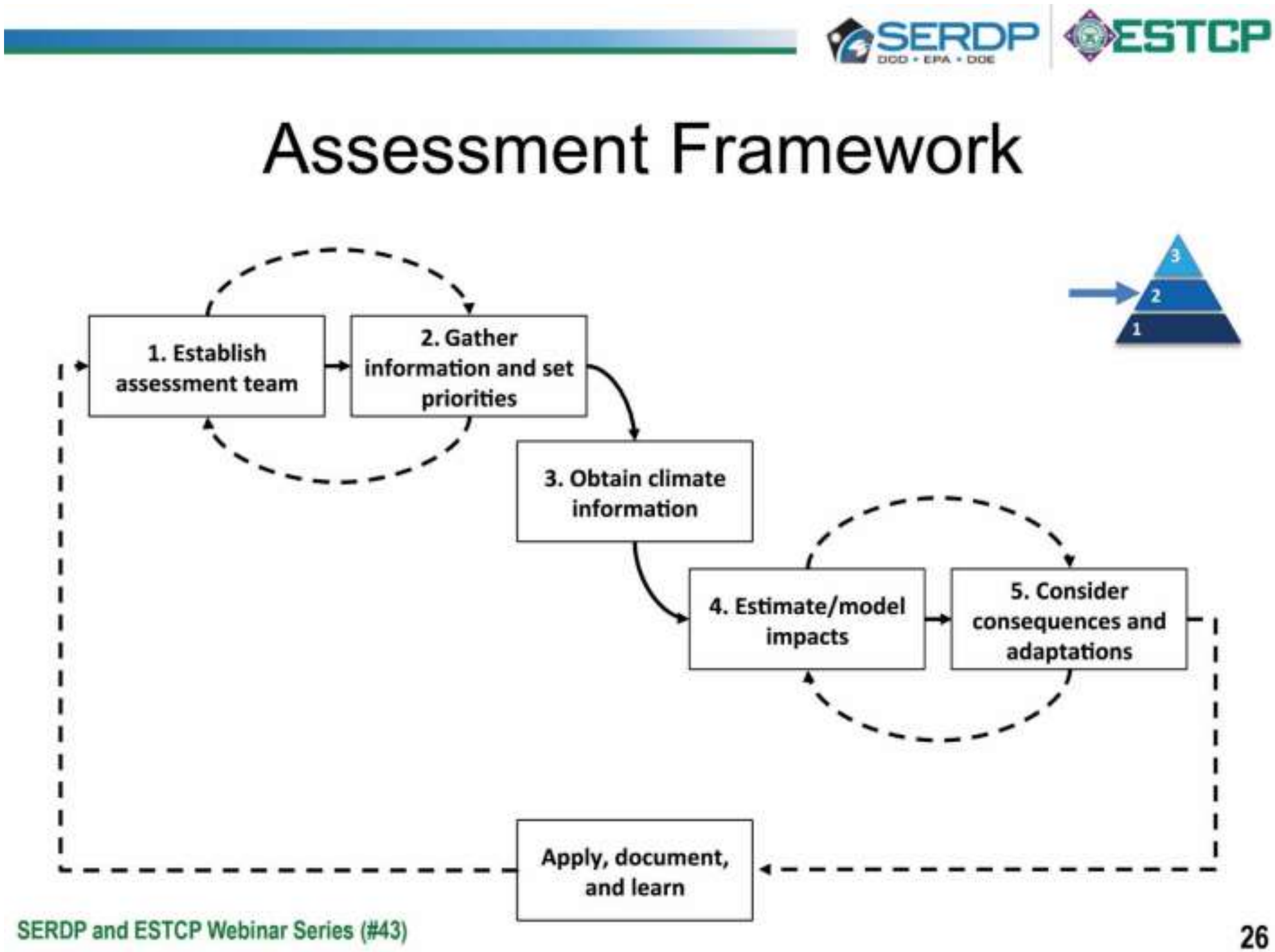
Resilient Adaptation of Sustainable Buildings

Center for Sustainable Building Research

University of Minnesota

May 2018

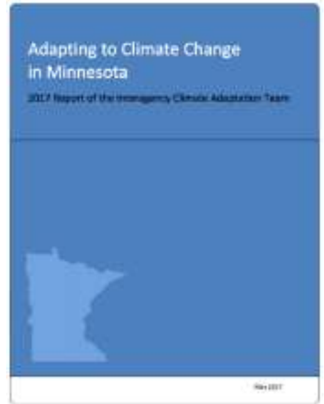
Vulnerability Assessment Framework

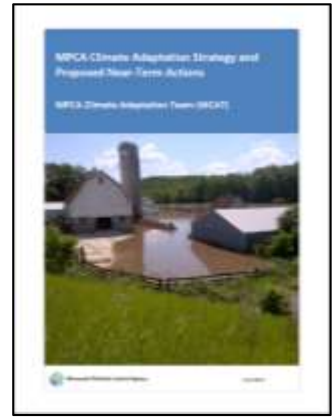


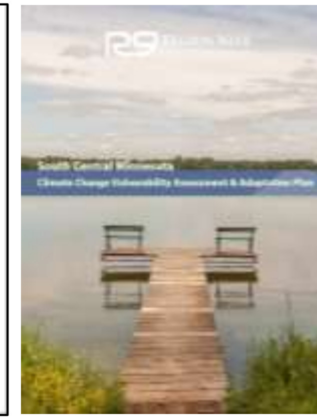
SERDP and ESTCP Webinar Series, Vulnerability Assessments and Resilience Planning at Federal Sites, 2016
Strategic Environmental Research and Development Program (SERDP)
Environmental Security Technology Certification Program (ESTCP)


MINNESOTA CLIMATE CHANGE VULNERABILITY ASSESSMENT 2014
MDH Minnesota Department of Health

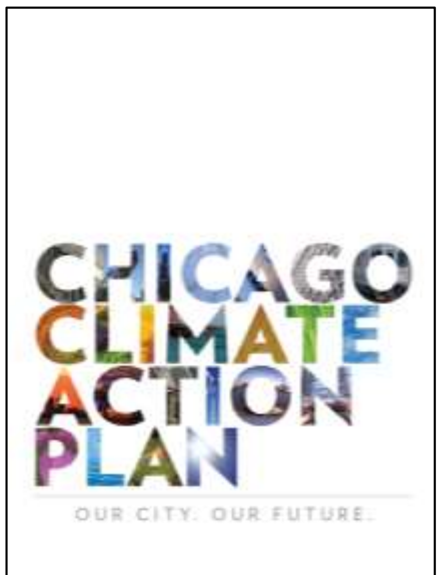

Minnesota State Hazard Mitigation Plan 2014
HSEM

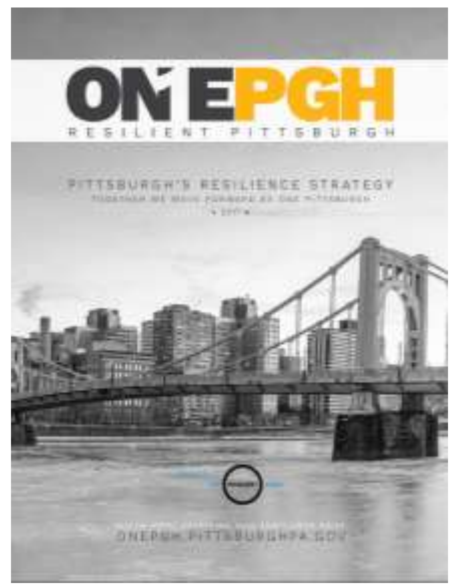

Adapting to Climate Change in Minnesota
2017 Report of the Interagency Climate Adaptation Team


MPCA Climate Adaptation Strategy and Proposed Near-Term Actions


South Central Minnesota
Climate Change Vulnerability Assessment & Adaptation Plan


BUILDING RESILIENCE IN BOSTON
"Best Practices" for Climate Change Adaptation and Resilience for Existing Buildings


CHICAGO CLIMATE ACTION PLAN
OUR CITY. OUR FUTURE.


ONEPGH
RESILIENT PITTSBURGH
PITTSBURGH'S RESILIENCE STRATEGY
ONEPGH.PITTSBURGHPA.GOV


planYC
A STRONGER, MORE RESILIENT NEW YORK

Future Weather Files

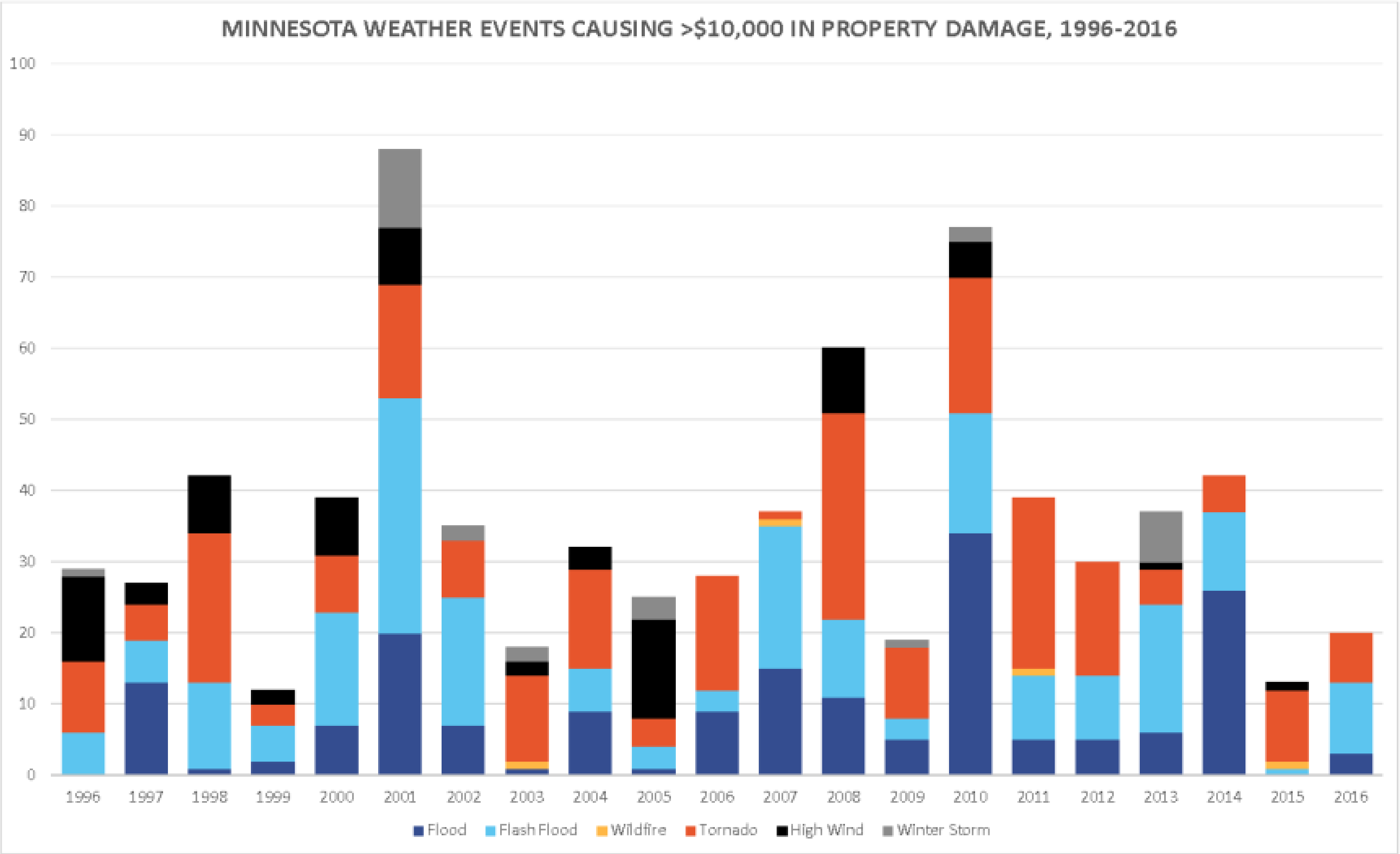


Figure 4: Weather Events Causing Significant Damage in Minnesota

Future Weather Files

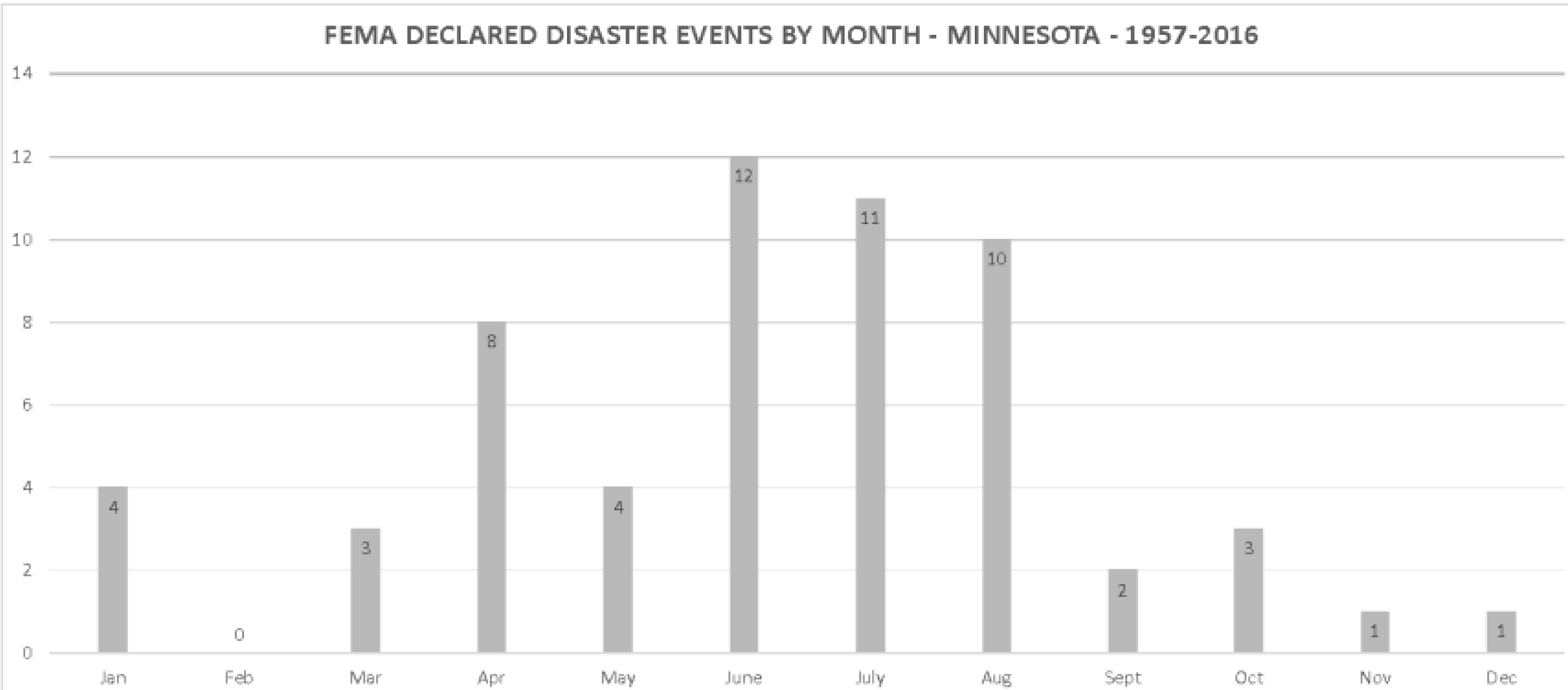
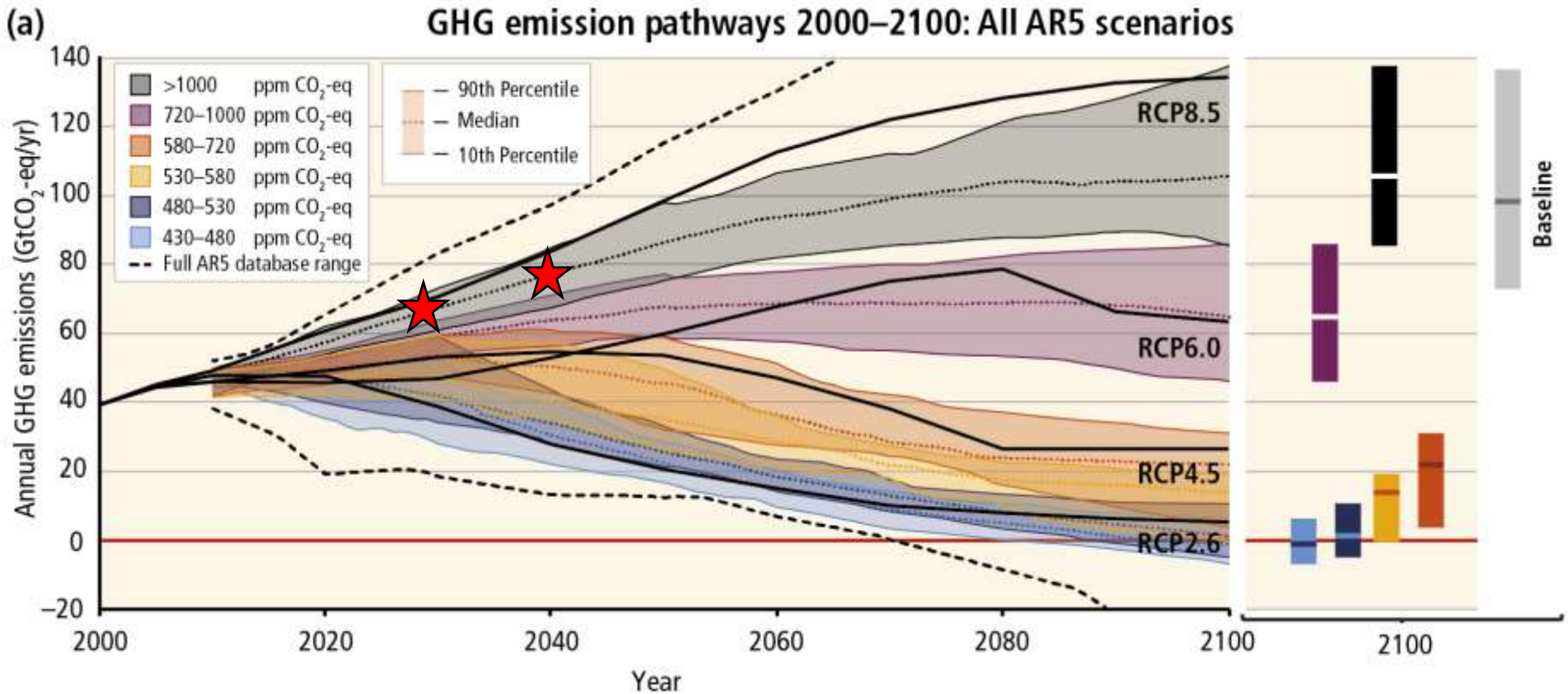


Figure 5: FEMA Disaster Declarations by Month

Future Weather Files



Intergovernmental Panel on Climate Change, Fifth Assessment Report. 2014

- Morphed weather files for the Minneapolis / Saint Paul Area
- Future performance analyzed using RCP 8.5, 50th percentile

Future Weather Files

Strategy	Hours: Actual and Percentage					
	Now		2030		2040	
Comfort	942	11%	885	10%	936	11%
Sun Shading of Windows	586	7%	778	9%	817	9%
High Thermal Mass	154	2%	217	2%	240	3%
High Thermal Mass Night Flushed	154	2%	228	3%	256	3%
Direct Evaporative Cooling	109	1%	179	2%	198	2%
Two-Stage Evaporative Cooling	111	1%	192	2%	216	2%
Natural Ventilation Cooling	104	1%	162	2%	170	2%
Fan-Forced Ventilation Cooling	72	1%	104	1%	106	1%
Internal Heat Gain	1589	18%	1353	15%	1361	16%
Passive Solar Direct Gain Low Mass	899	10%	826	9%	796	9%
Passive Solar Direct Gain High Mass	624	7%	559	6%	539	6%
Wind Protection of Outdoor Spaces	259	3%	254	3%	249	3%
Humidification Only	0	0%	0	0%	0	0%
Dehumidification Only	491	6%	659	8%	692	8%
Cooling, add dehumidification if needed	305	3%	549	6%	604	7%
Heating, add humidification if needed	4791	55%	4545	52%	4436	51%

Predicted Effectiveness of Comfort Strategies for Minneapolis / Saint Paul – Climate Consultant, UCLA Energy Design Tools Group

Future Weather Files

Strategy	Hours: Actual and Percentage					
	Now		2030		2040	
Comfort	942	11%	885	10%	936	11%
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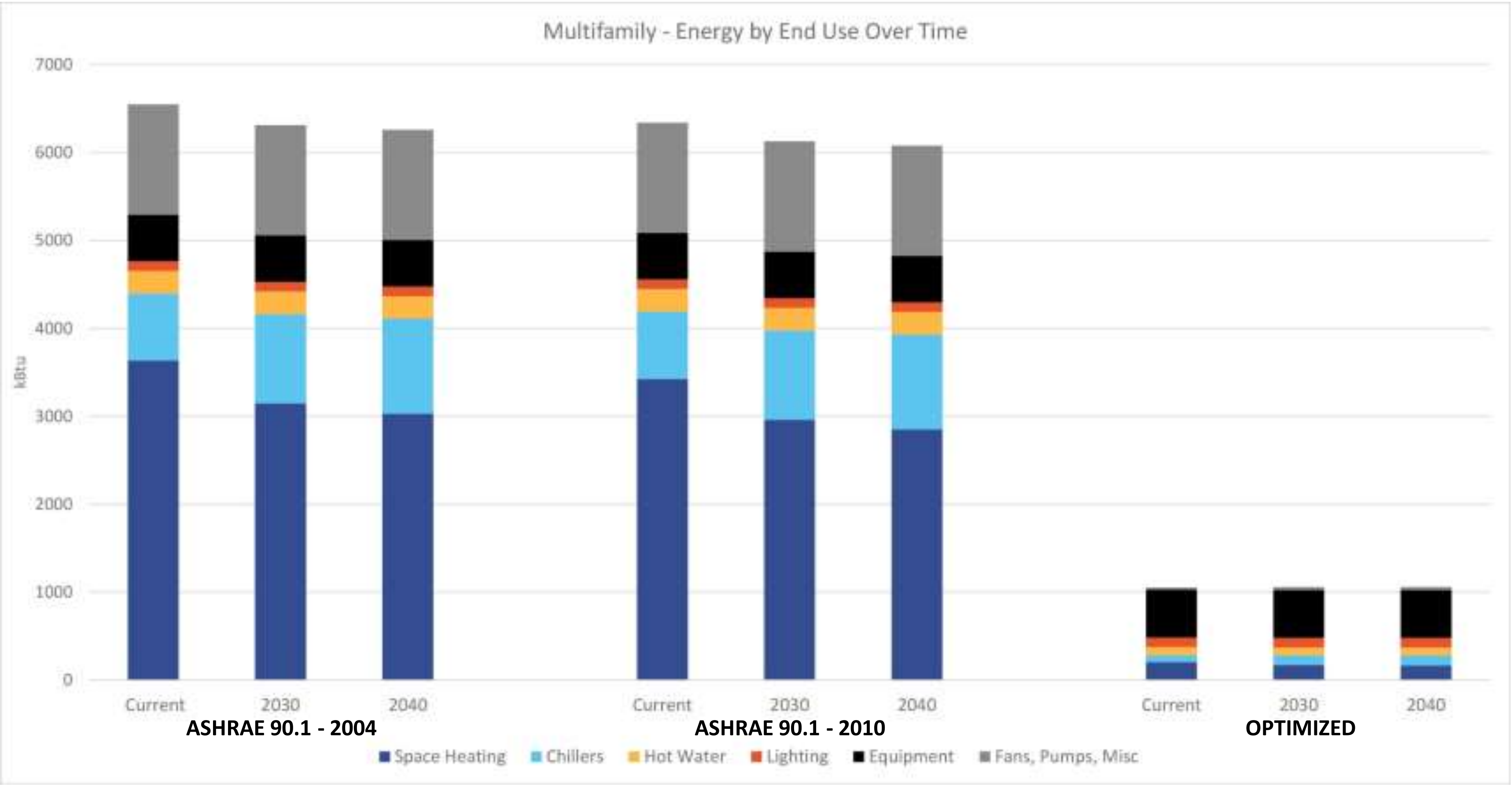
Predicted Effectiveness of Comfort Strategies for Minneapolis / Saint Paul – Climate Consultant, UCLA Energy Design Tools Group

Future Weather Files

- Energy use in code buildings decreases over time
- Increase in cooling load is outweighed by decrease in heating loads
- Energy use in high performing buildings stable over time



Future Weather Files

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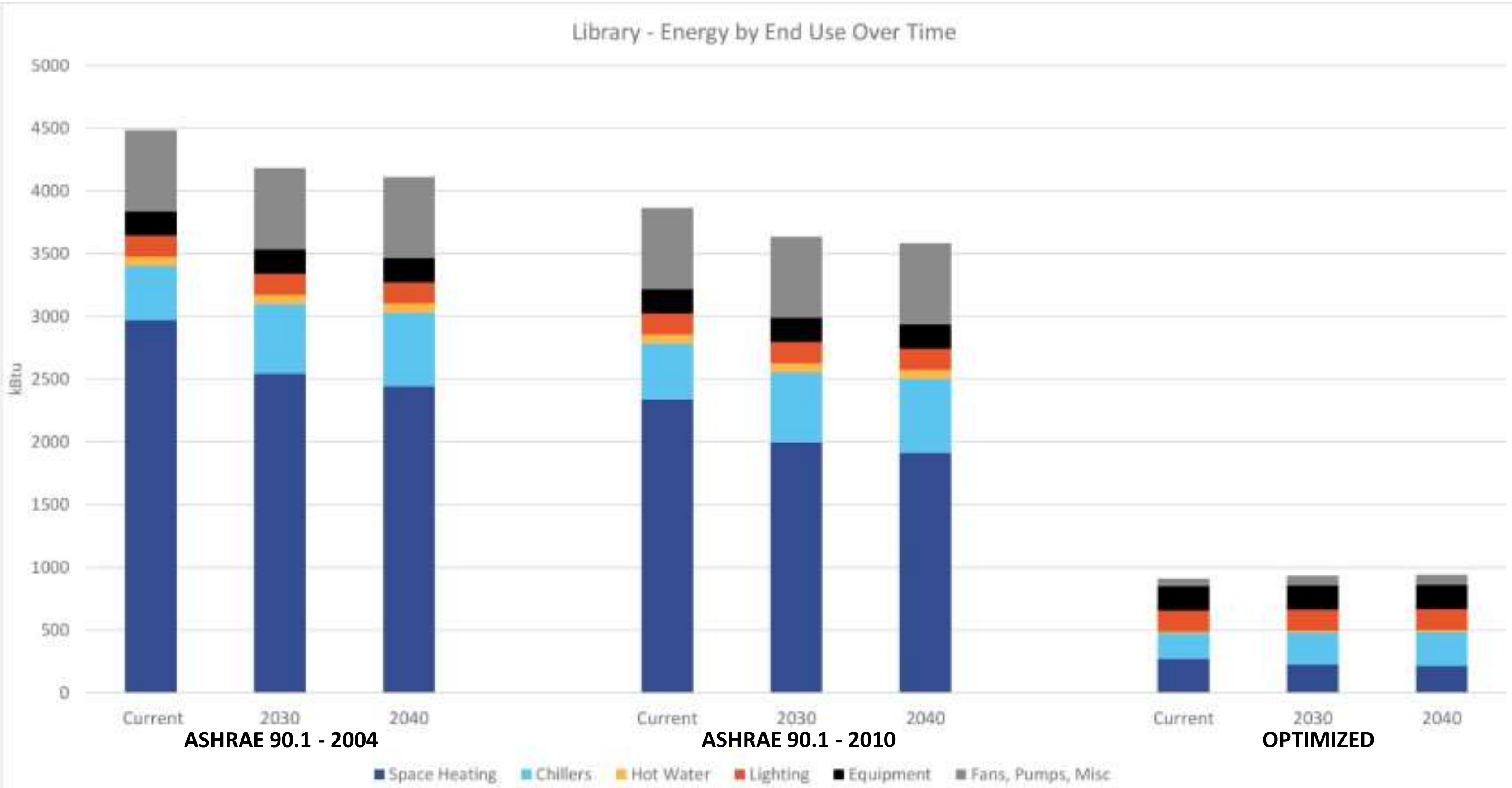


Future Weather Files

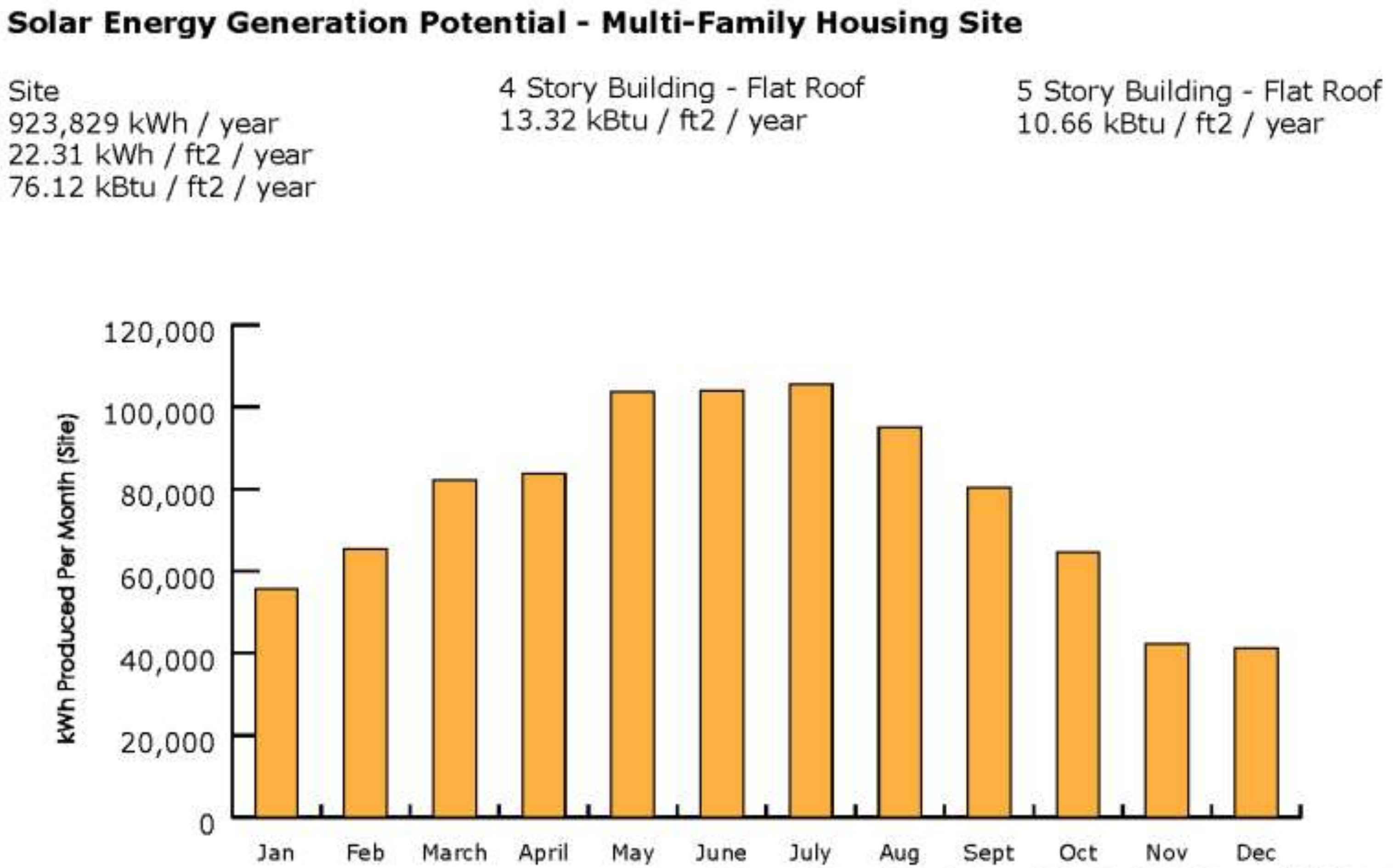


Figure 17: Potential Annual Production of Solar Panels in Minneapolis / Saint Paul

Future Weather Files

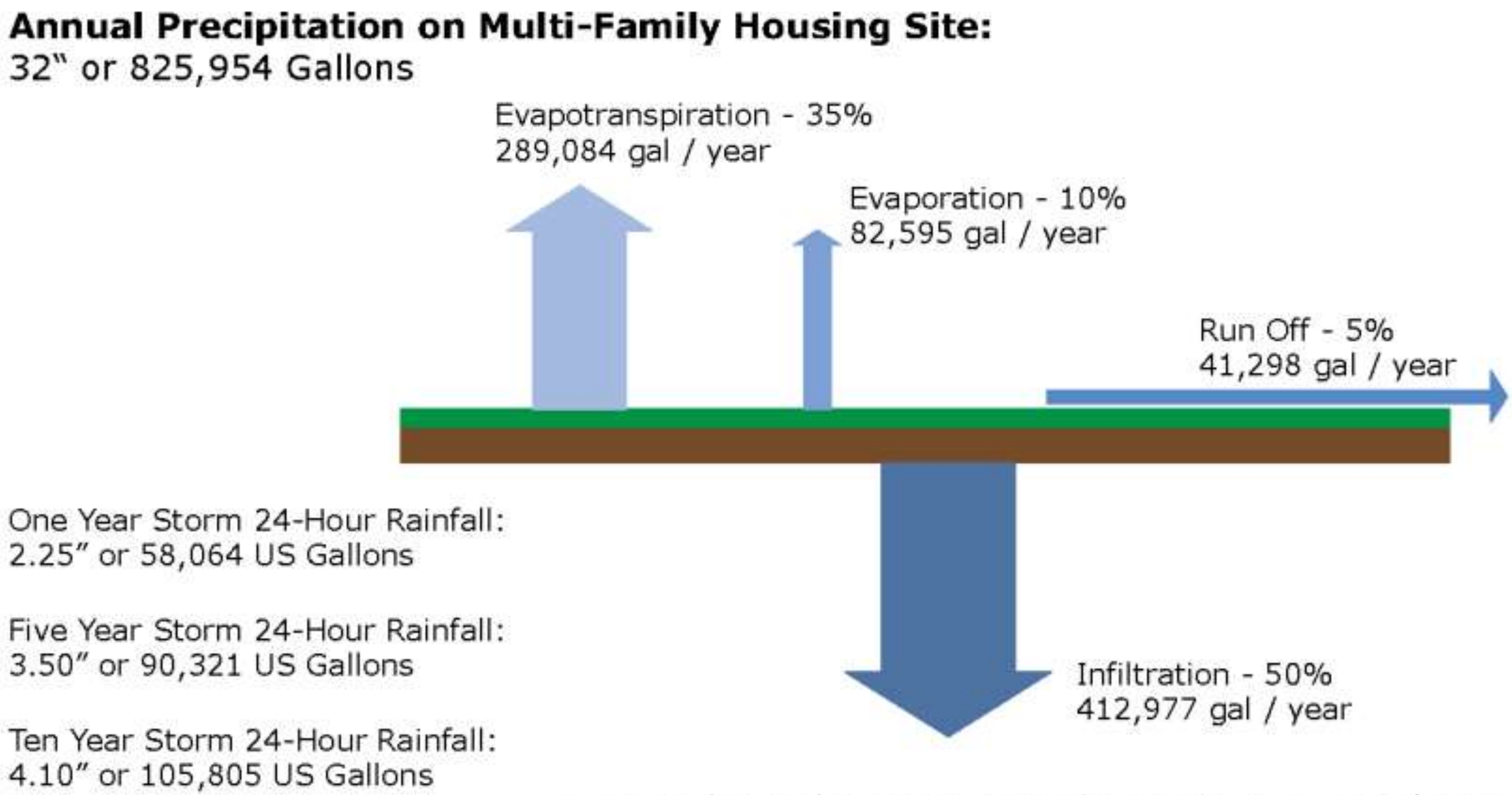
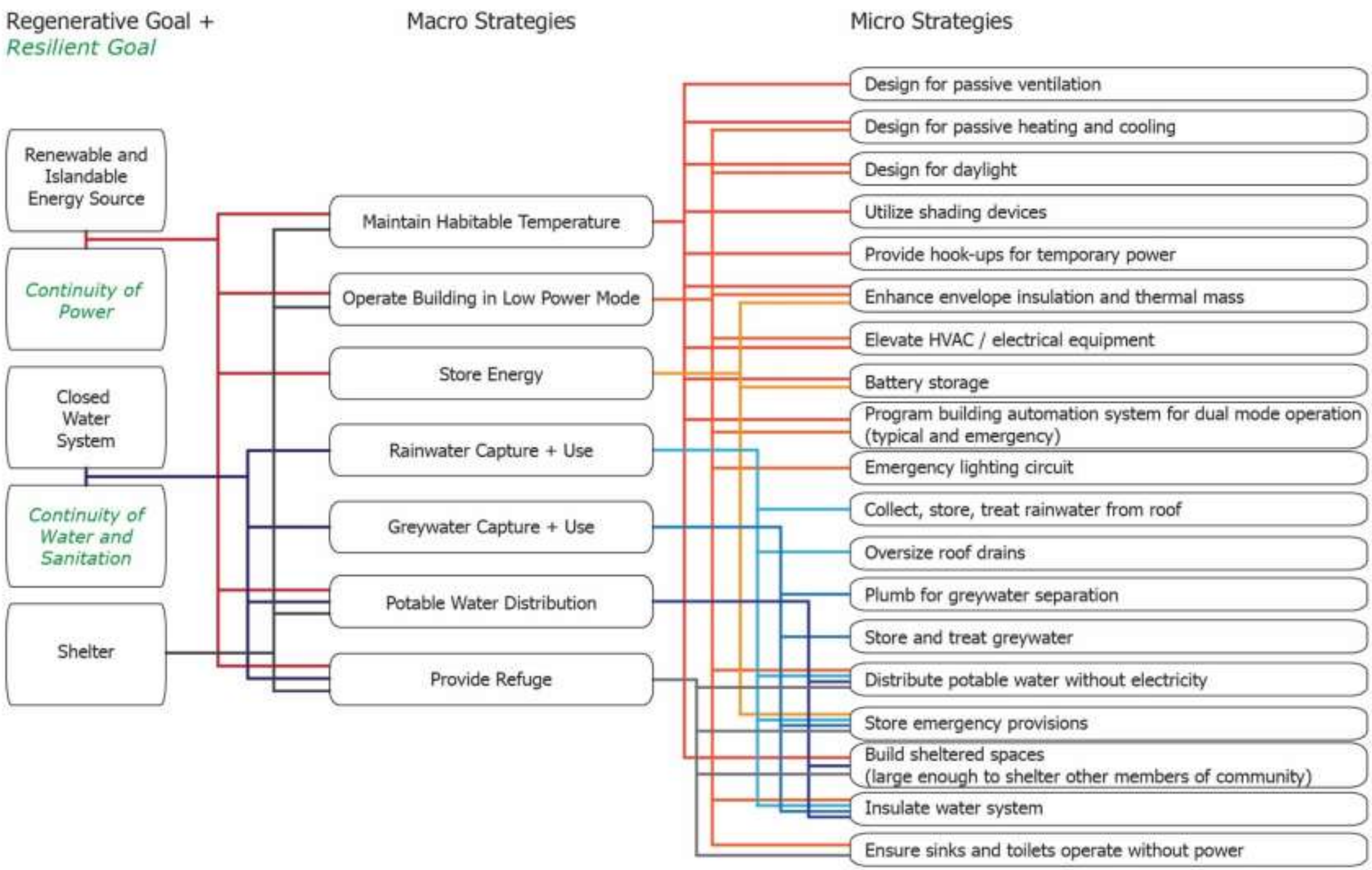


Figure 18: Annual Pre-Development Precipitation and Rain Distribution Minneapolis / Saint Paul

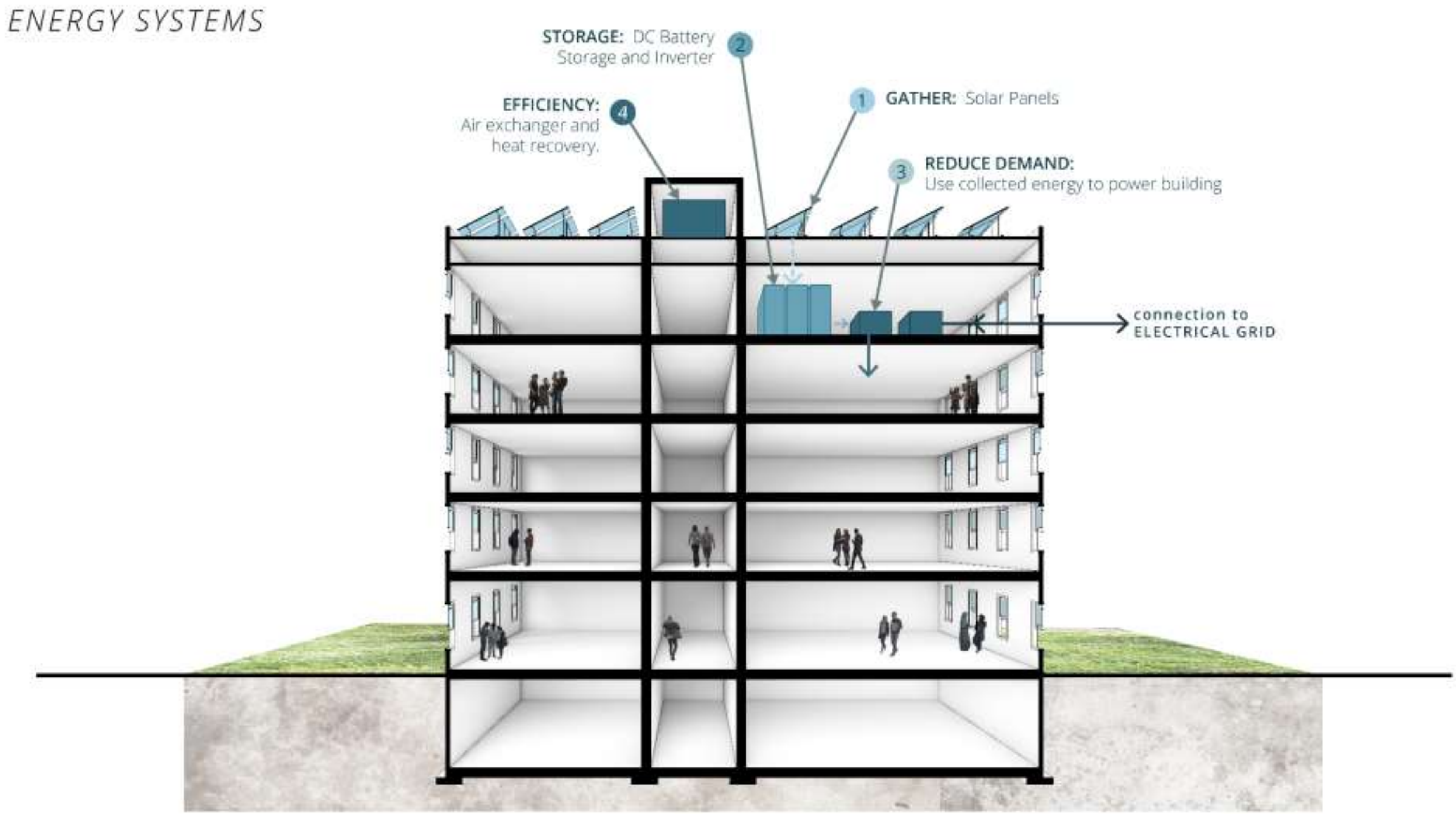
Resilience Adaptation of Sustainable Buildings

27

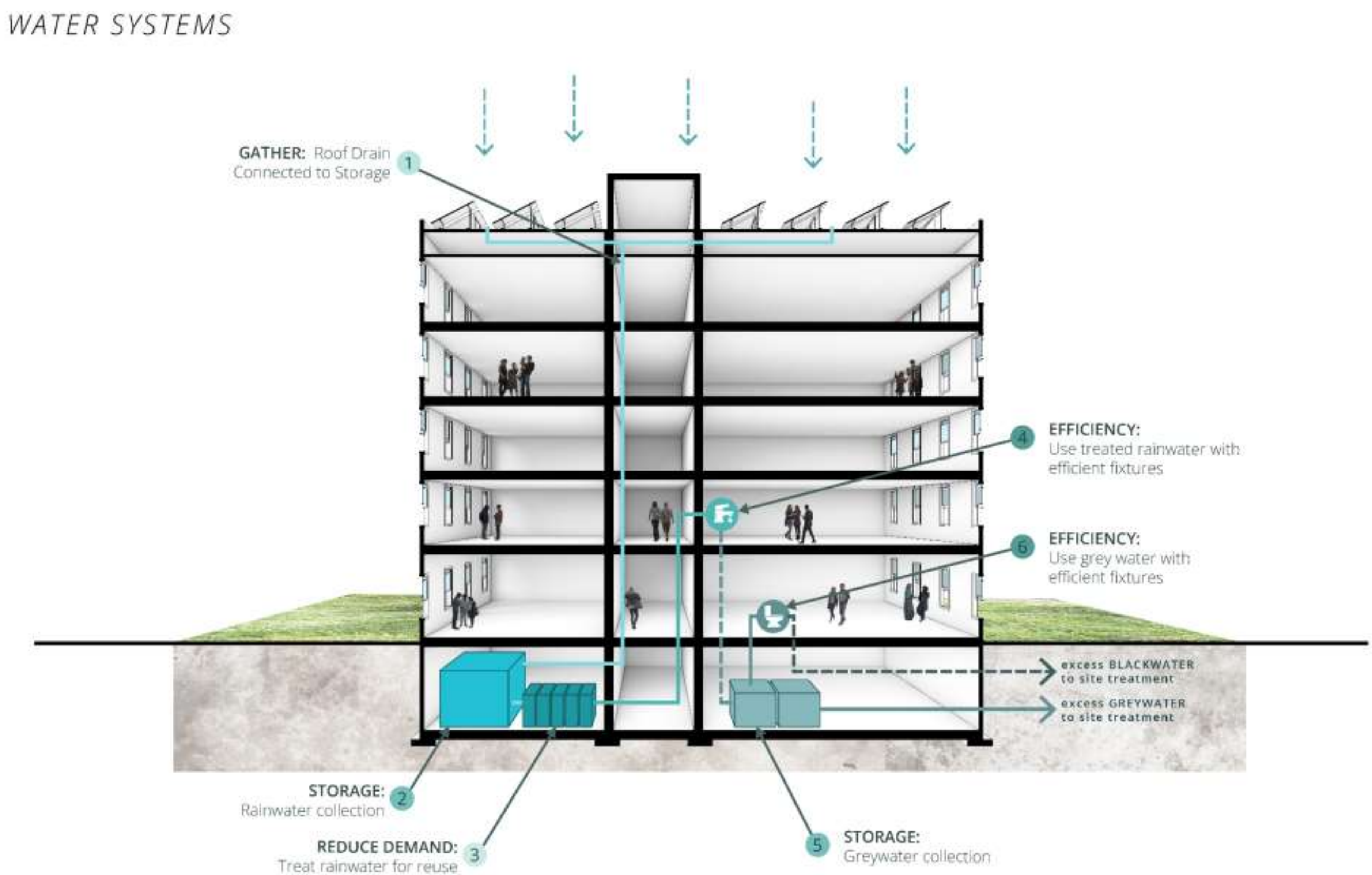
Regenerative and Resilient Design Strategies



Prototype: Multi-Family Residential

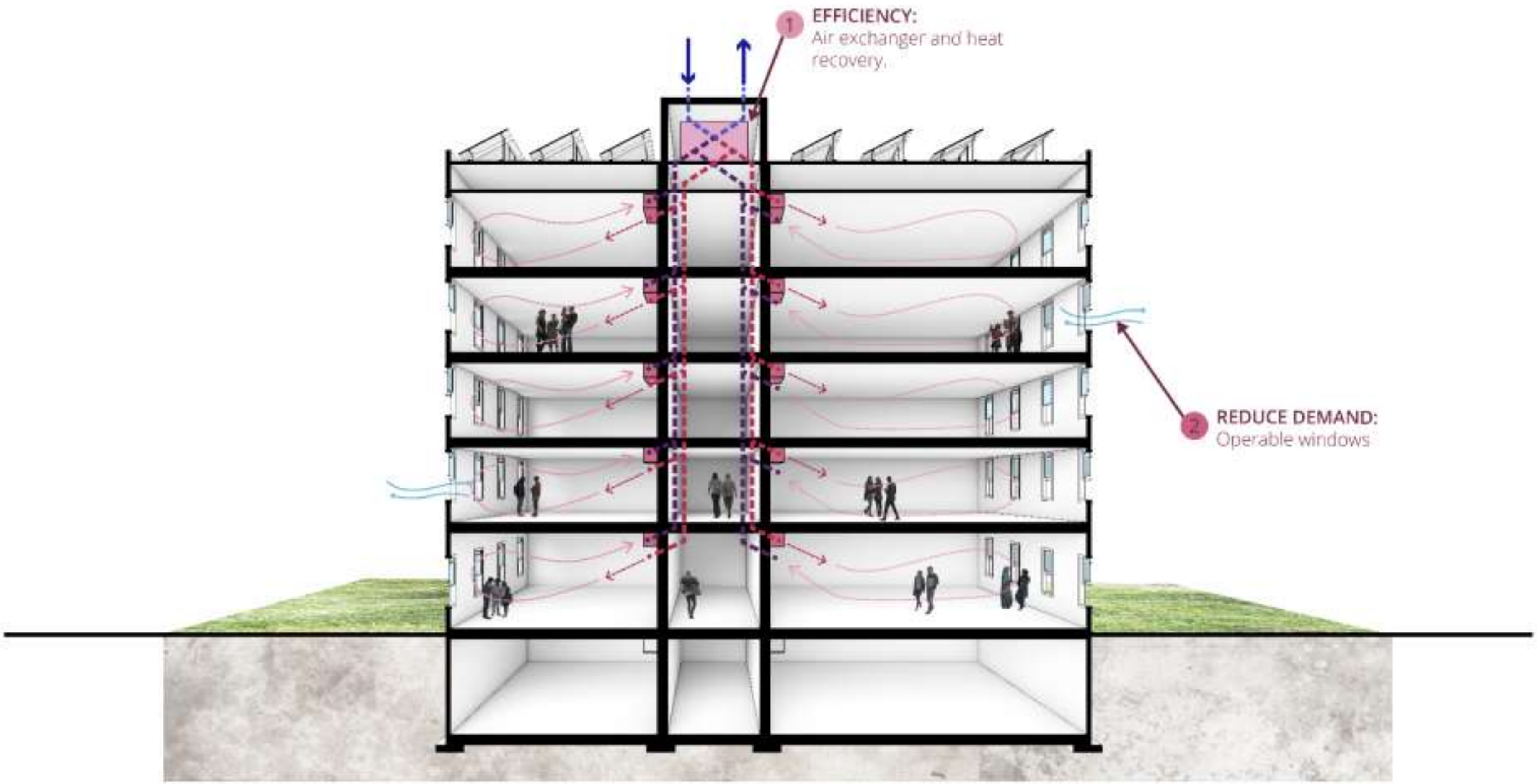


Prototype: Multi-Family Residential



Prototype: Multi-Family Residential

VENTILATION SYSTEMS



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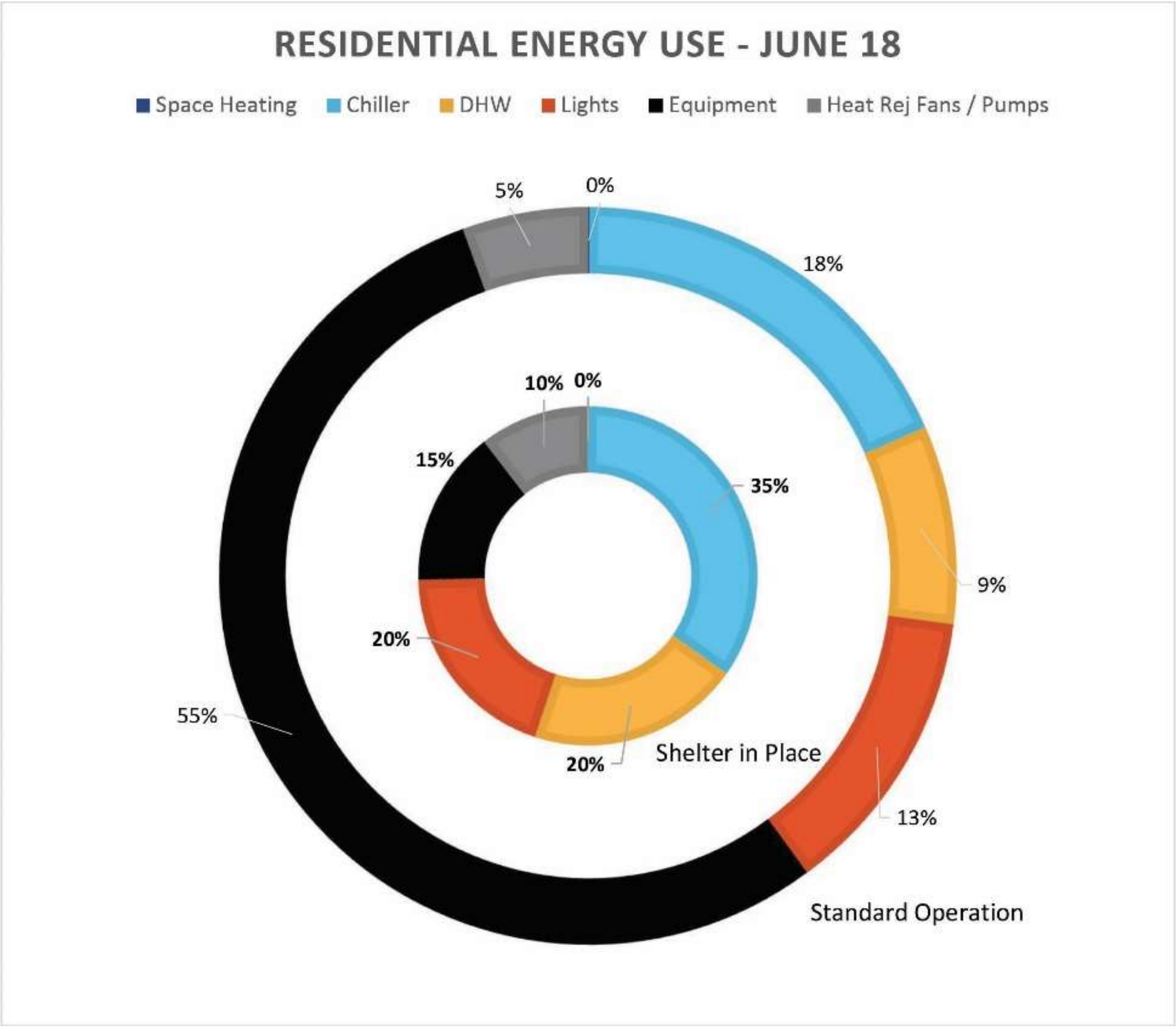
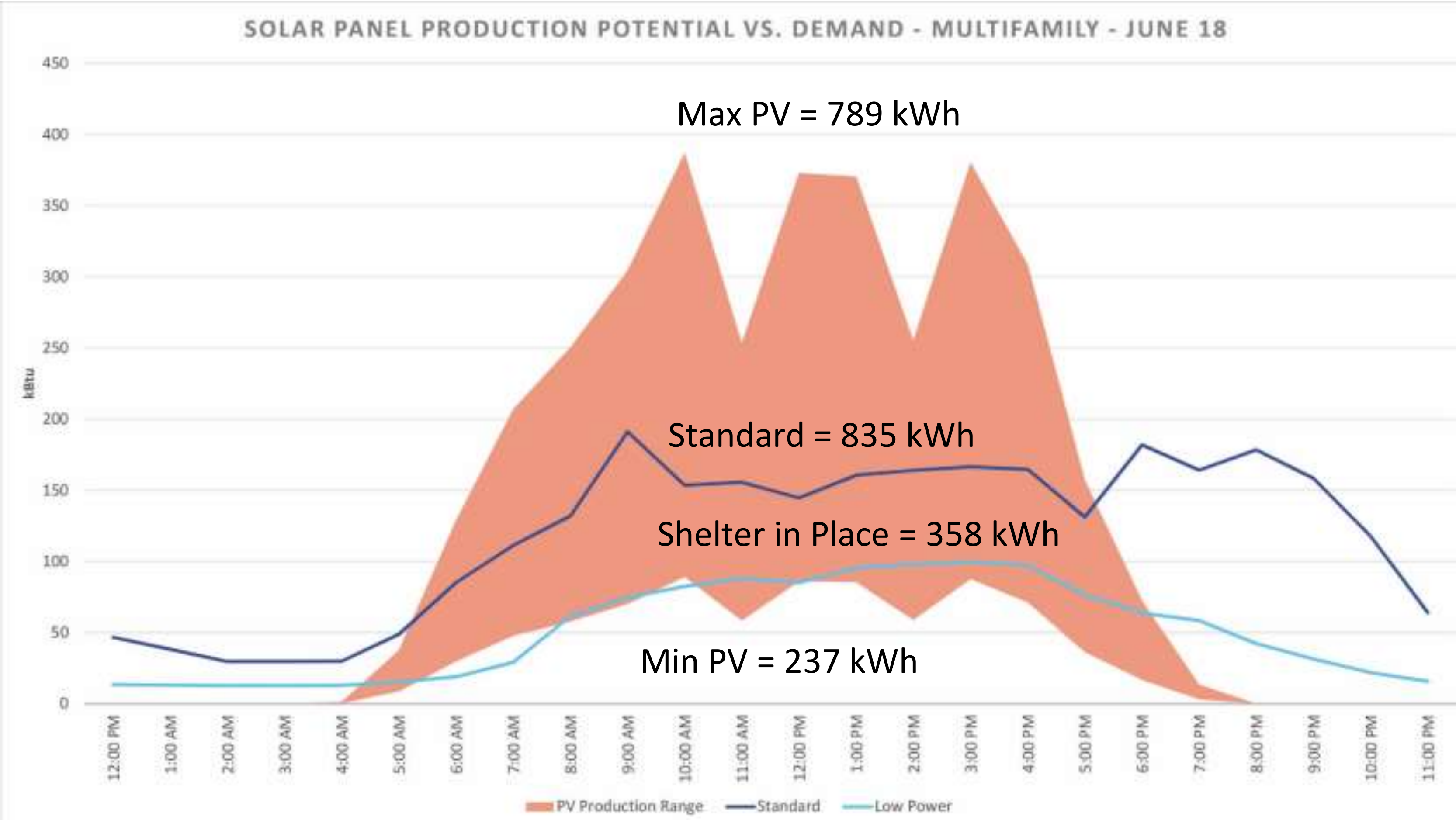
February 26, 2019

Prototype: Multi-Family Residential



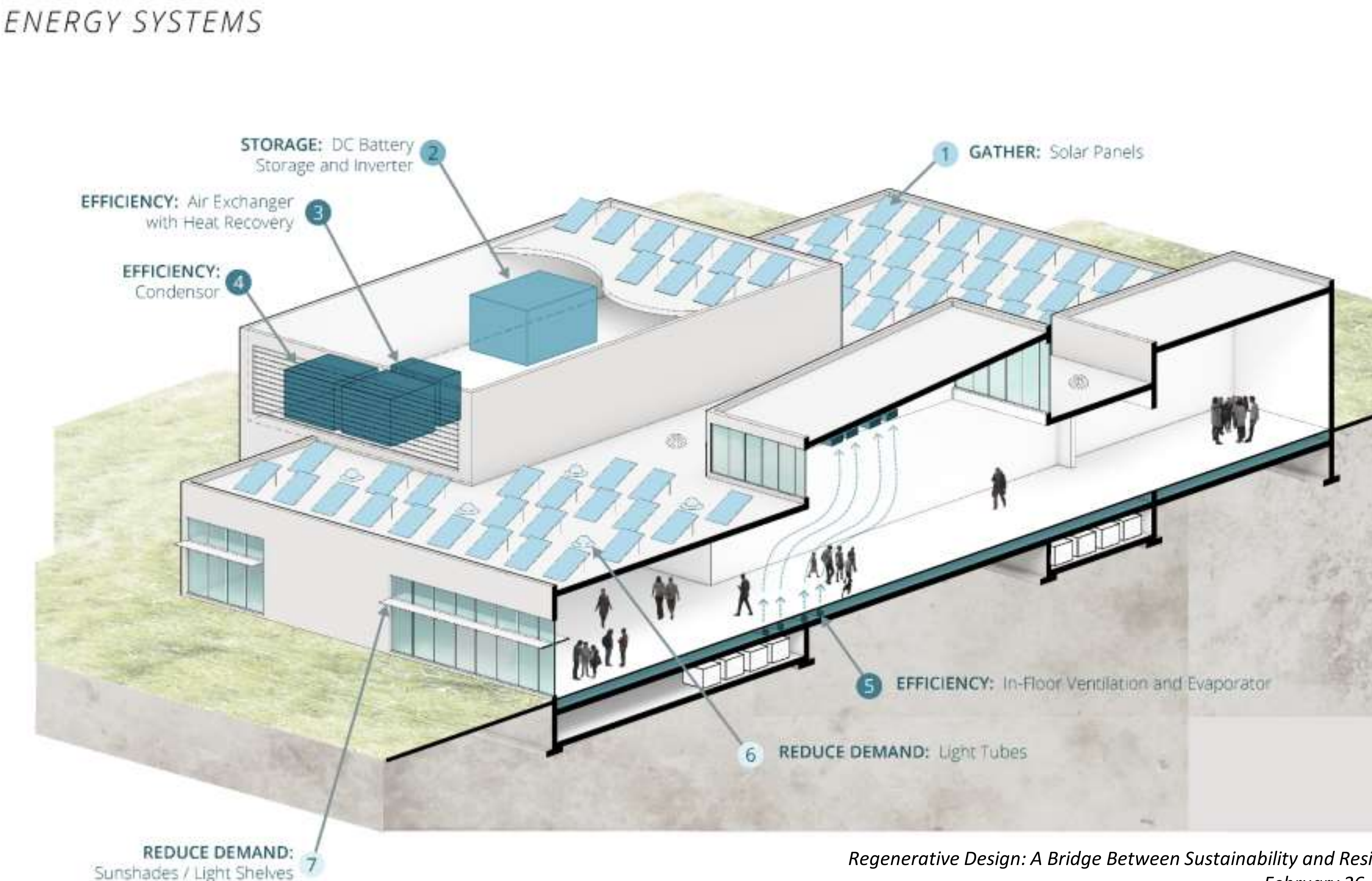
Simulated Energy Use during Standard Operation and Shelter in Place Operation. Energy Modeled in IES-VE 2015

Prototype: Multi-Family Residential



Predicted PV Production and Predicted Energy Use. Energy Modeled in IES-VE 2015, PV data from NREL PVWatts

Prototype: Library



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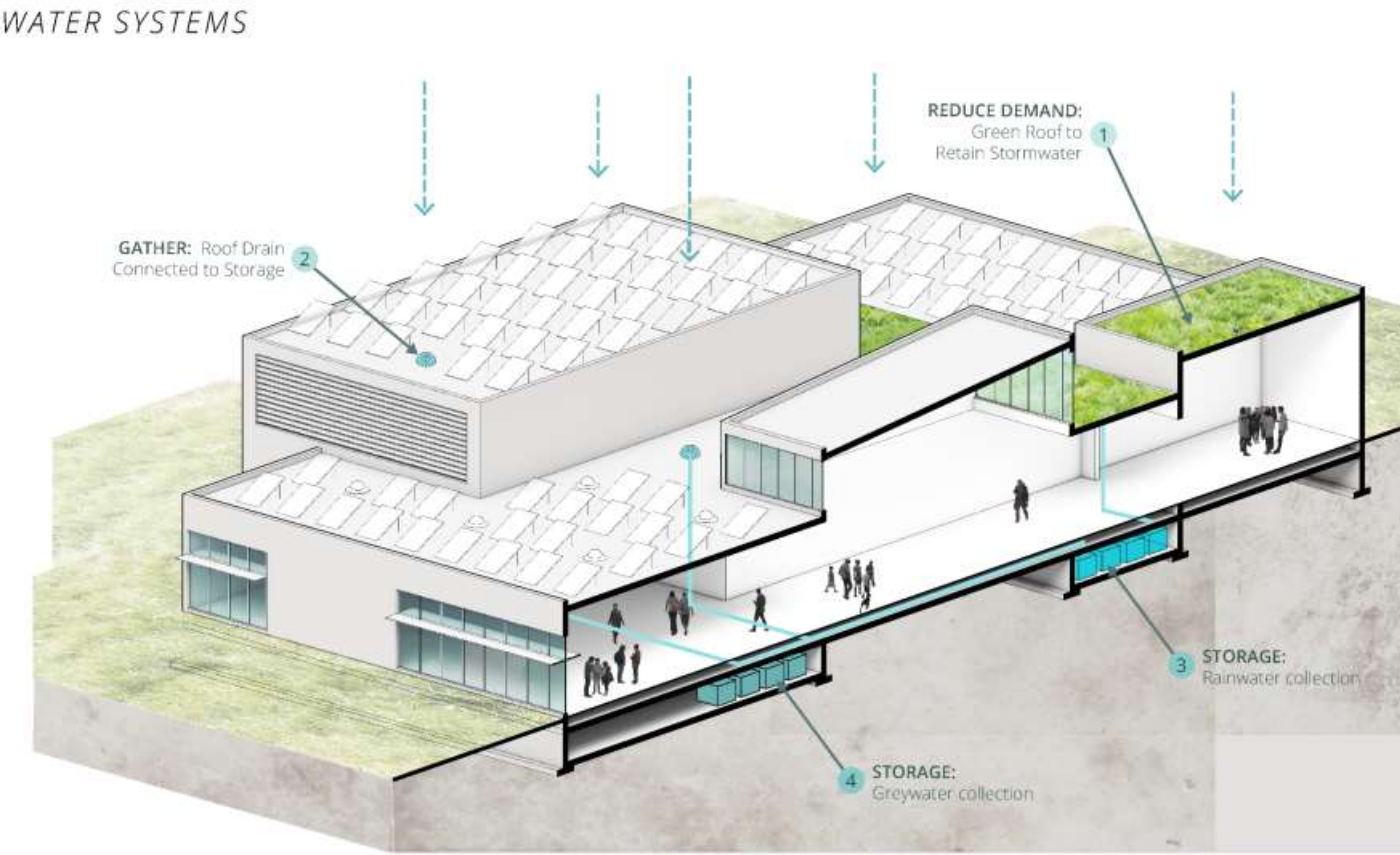
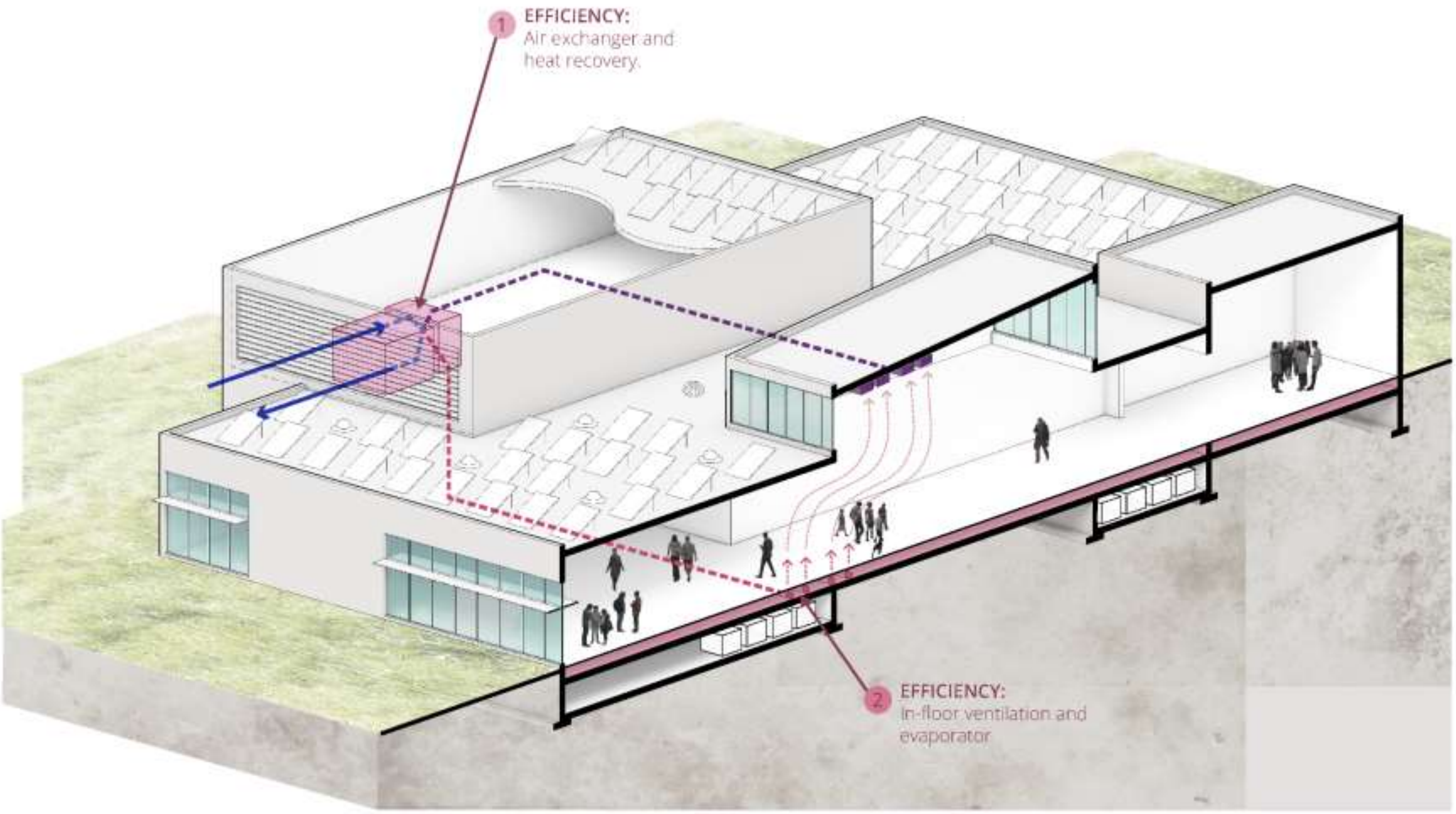
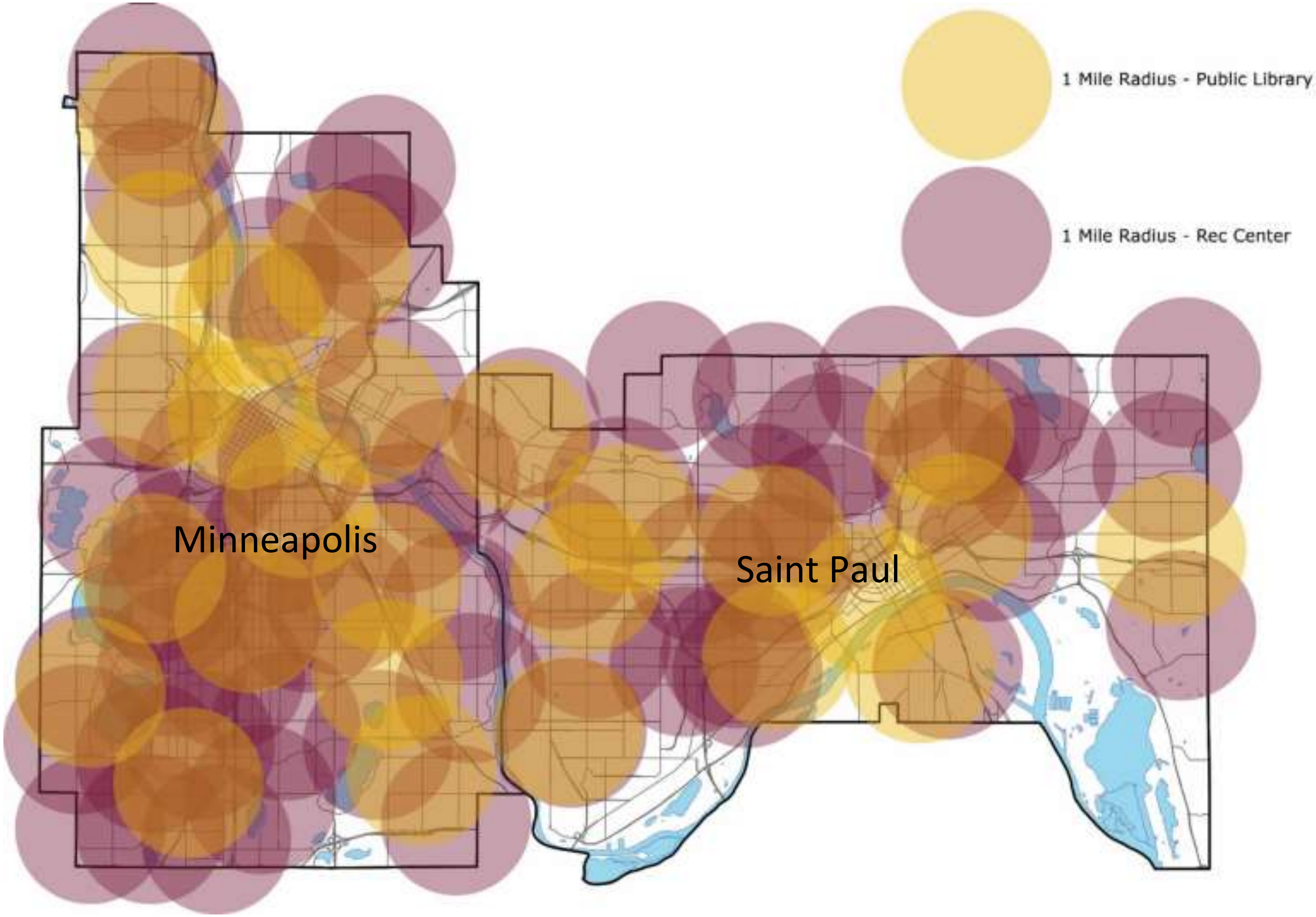


Prototype: Library

VENTILATION SYSTEMS



Prototype: Library



Potential Areas Served by Disaster Hubs

Regenerative Design: A Bridge Between Sustainability and Resilience
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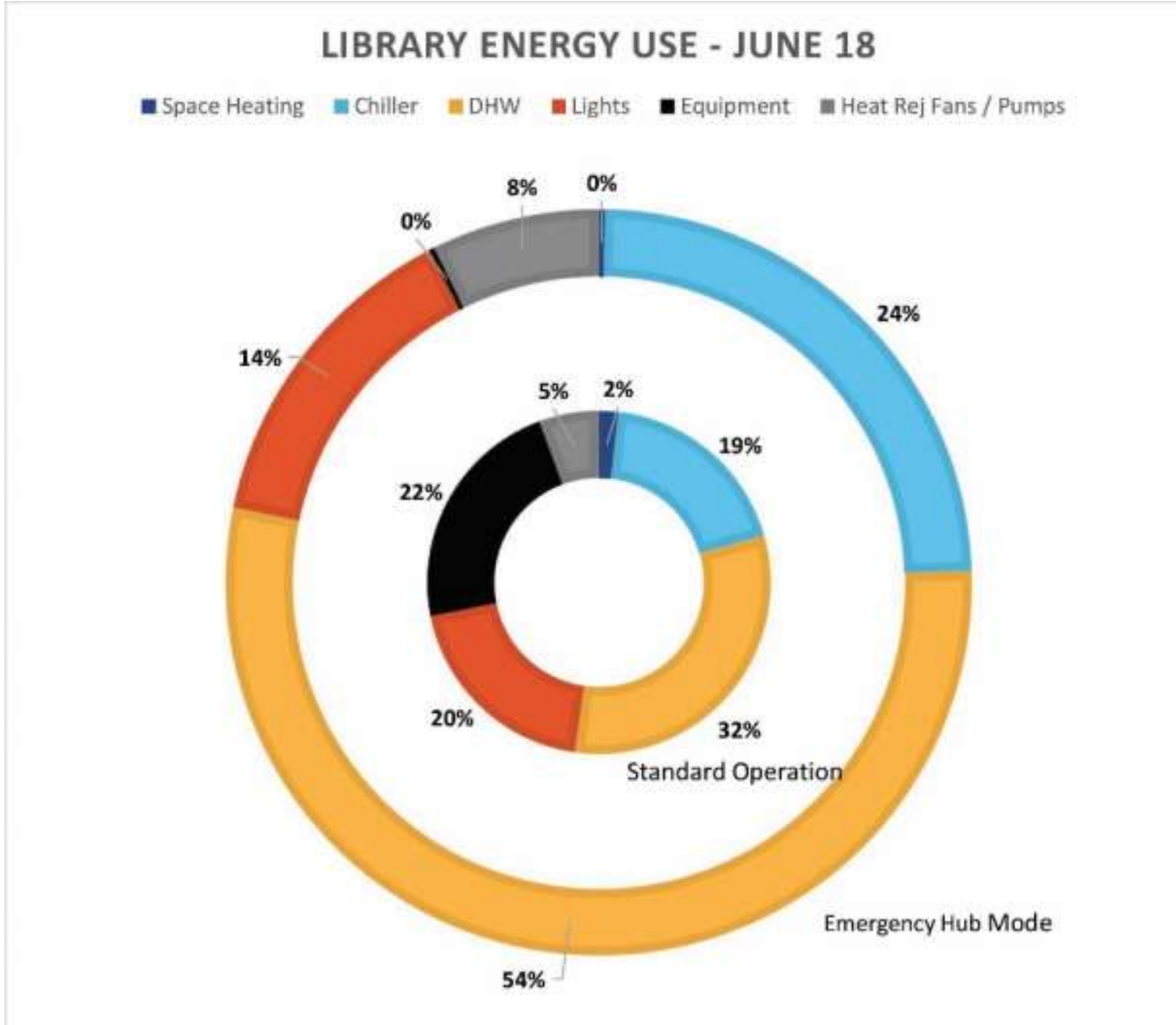
Prototype: Library

Library can support approximately 550 people in 'hub mode'

- Roughly 10% of population living within ½ mile
- Statistically will include:
    - 64 people with a disability
    - 125 people living within 150% of poverty line
    - 42 children under age 5
    - 52 people over age 65

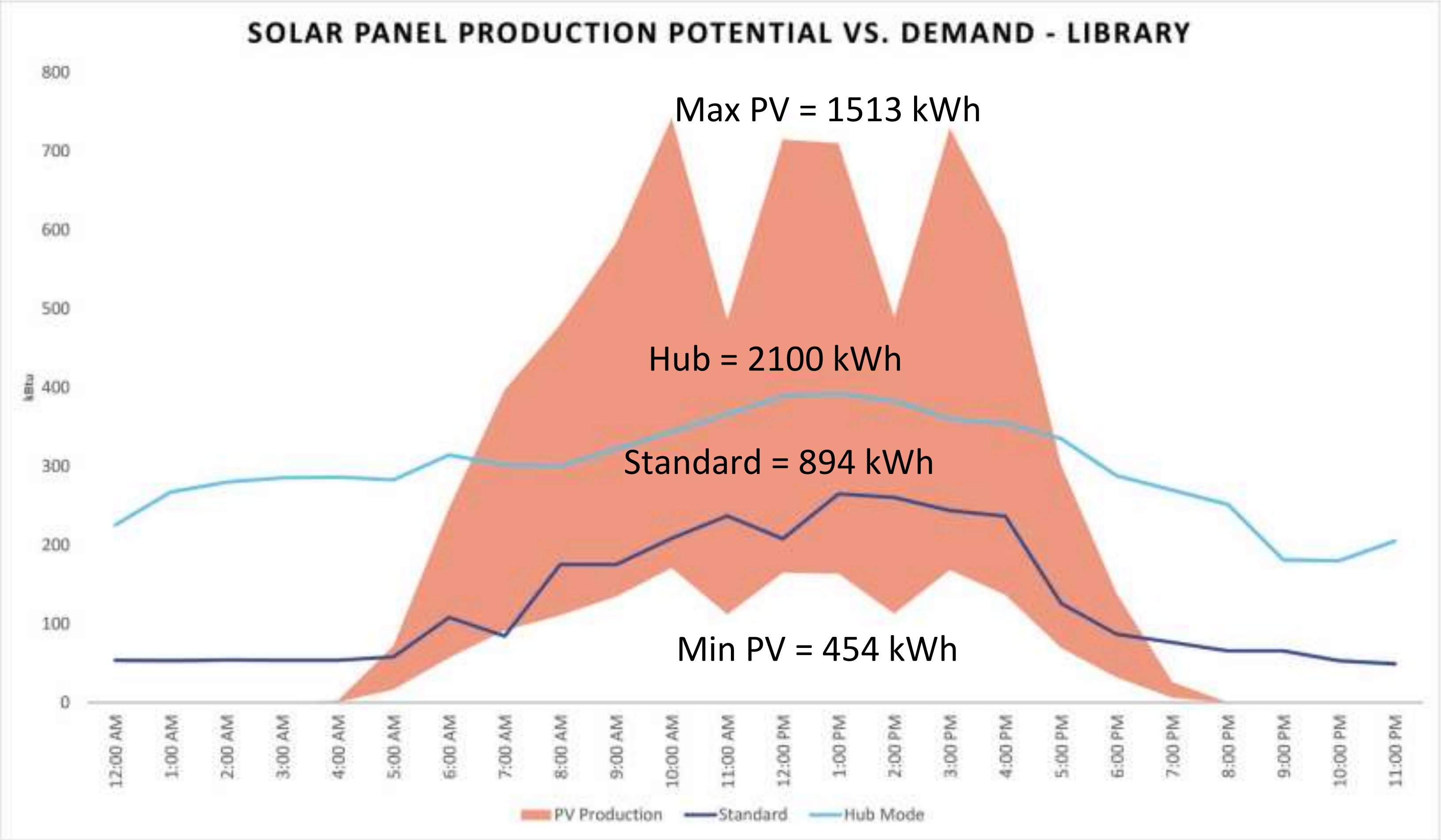
Potential Population Served by Disaster Hubs
American Community Survey, 2015

Prototype: Library



Simulated Energy Use during Standard Operation and Disaster Hub Operation. Energy Modeled in IES-VE 2015

Prototype: Library



Predicted PV Production and Predicted Energy Use. Energy Modeled in IES-VE 2015, PV data from NREL PVWatts

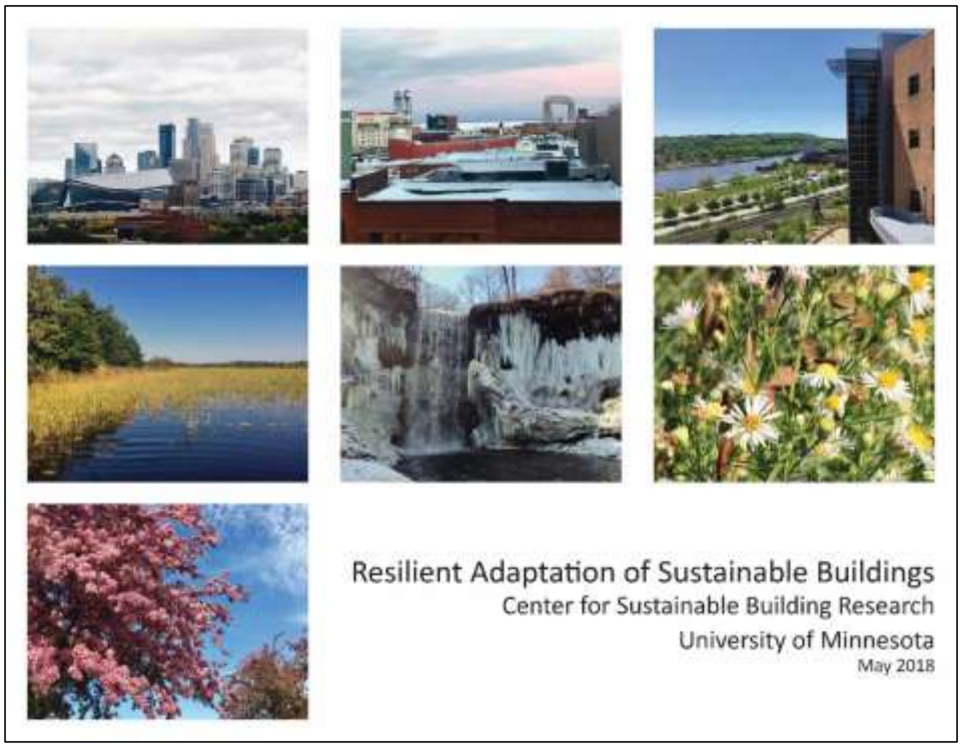
Future Research

- Specific sizing and capacity for electricity and water systems
- Code and regulatory barriers to implementing resilient strategies
- Financial implications and possible paybacks
- Additional assessment and modeling of critical loads
- Equitable and just access to resilient buildings
- Resilient models of other building and program types
- Real life design and implementation!

Next Steps

BUILDINGS, BENCHMARKS & BEYOND

Tools and Programs for Sustainable Buildings in Minnesota



View the full report at www.CSBR.umn

CSBR

Center for Sustainable Building Research

COLLEGE OF DESIGN

UNIVERSITY OF MINNESOTA

Thank you!