

A modern building with a blue glass facade and a rooftop garden. The building has a grid-like pattern of windows and is surrounded by lush greenery. The sky is a clear blue.

EMPOWERING DESIGN FOR RESEARCH ENVIRONMENTS:

Strategies for Climate Resilience

AGENDA

1

WHAT IS CLIMATE RESILIENCE?

2

FACES OF RESILIENCE

3

CASE STUDY; VIRGINIA TECH

4

NAVIGATING BARRIERS

5

Q&A

INTRODUCTION



KURT CUNNINGHAM, P.E
PRINCIPAL
SMITHGROUP
kurt.cunningham@smithgroup.com



VICTORIA BRINEMUGHA
SENIOR MECHANICAL ENGINEER
SMITHGROUP
victoria.brinemugha@smithgroup.com

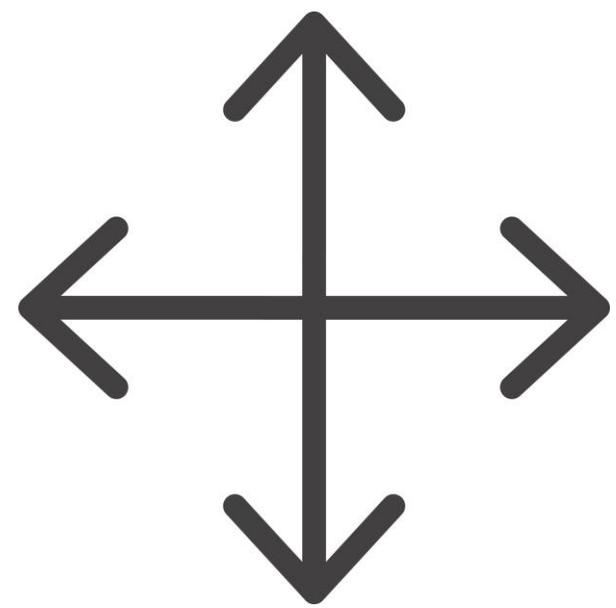


Defining Climate RESILIENCE

FACES OF RESILIENCE

**OPERATIONAL
IMPERATIVES**

**EXTERNAL
THREATS**

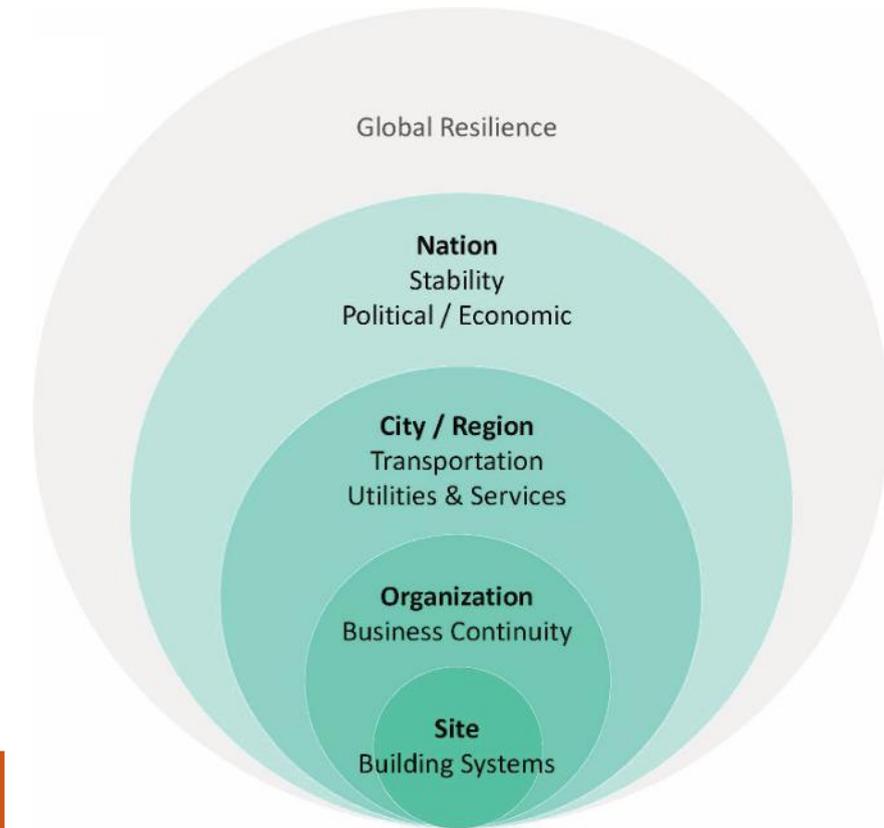


**INTERNAL
THREATS**

**BEHAVIORAL
IMPERATIVES**

EXTERNAL THREATS AND SYSTEM IMPACTS

Building System Impacts	From immediate threat >> to long term concern							
	Activist, terrorist	Earthquake	Fire in or outside	Tornado, hurricane	Storm, flood	Pandemic	Climate change	Obsolescence
Structure	D	D	D	D	D			D
Envelope / Exterior	D	D	D	D	D	I		
Interior / Finishes	D	D	D	D	D	D		D
Domestic Water	D	D	R	R	D	I	D	
Sewer / Lab Waste	R	D	R	R	R	I		
Storm Drainage	R	D	R	R	R		D	
Heating / Cooling	D	D	D	D	D	D	D	D
Ventilation / Exhaust	D	I	D	D		D	D	D
Normal Power	D	D	D	D	D		I	
Standby Power	D	I	I	I	D			
Data / Communic.	D	D	R	R	R			D
Service / Supplies	D	I	D	I	D	D		



D = Direct threat to building
 I = Indirect threat via disruption of supply
 R = Regional threat from infrastructure failure

EXTERNAL THREATS - FLOOD RESILIENCE



With protected risers, a Penthouse might suit substations, generators, other primary MEP infrastructure.

Main levels tend to best suit full and consistent lab floor plates, but infrastructure *may* need to intrude.

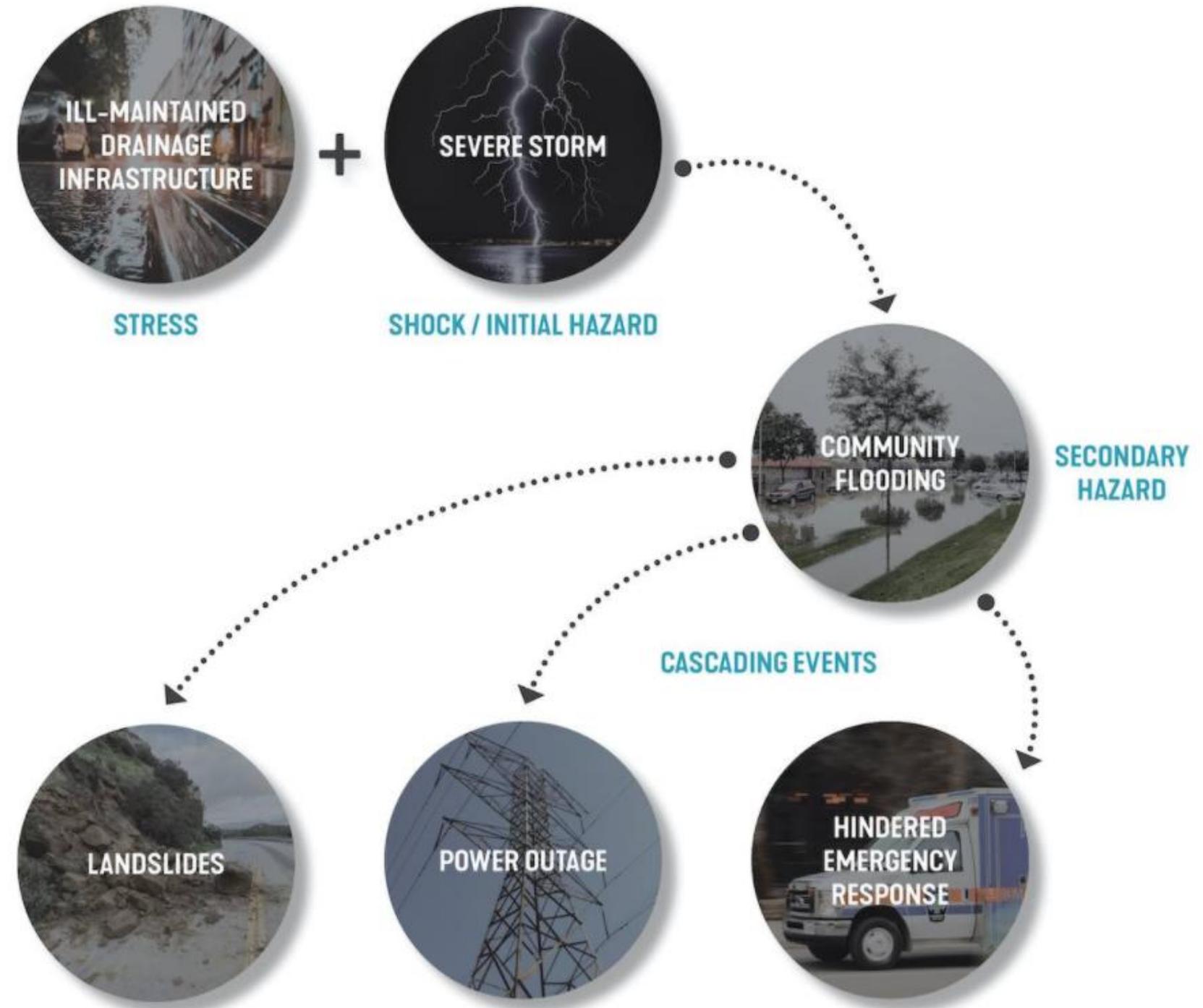
Raised or Mezzanine levels may suit fire pumps with outside access. And one may need a raised main elevator lobby, with a shuttle/ramps to egress.

Grade level space is at a premium. Yet flooding may obviate main elevators from this level.

Traditional basement levels may be obsolete for infrastructure—as Hurricane Sandy informed NYC.

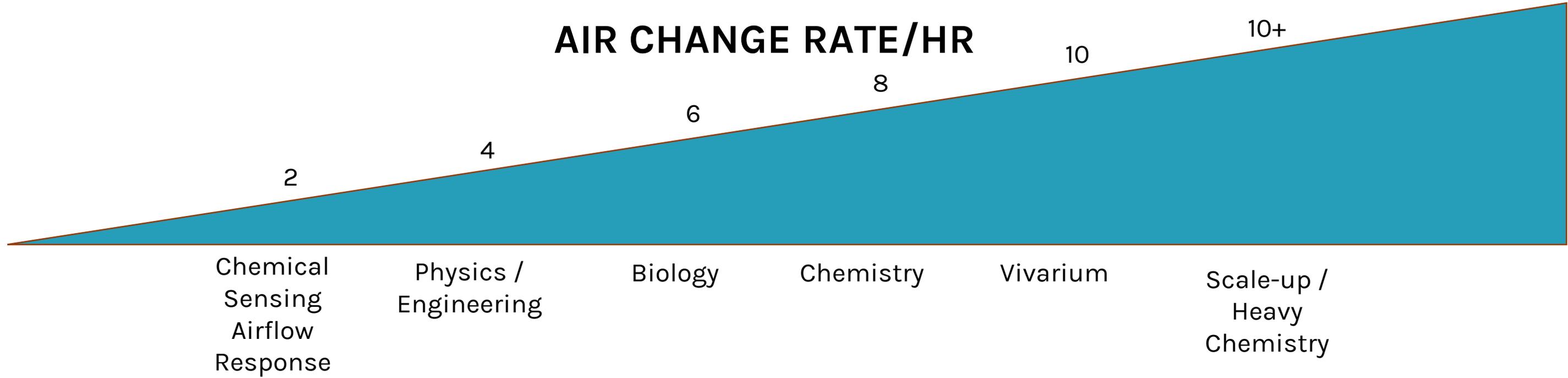
EXTERNAL THREATS - CASCADING EVENTS

- An external or internal threat that seems moot to a lab can cascade into events that cripple it
- System O&M stress—in or out of the lab—is often a contributor
- Deferred maintenance may let an “N+1” system yield to a shock



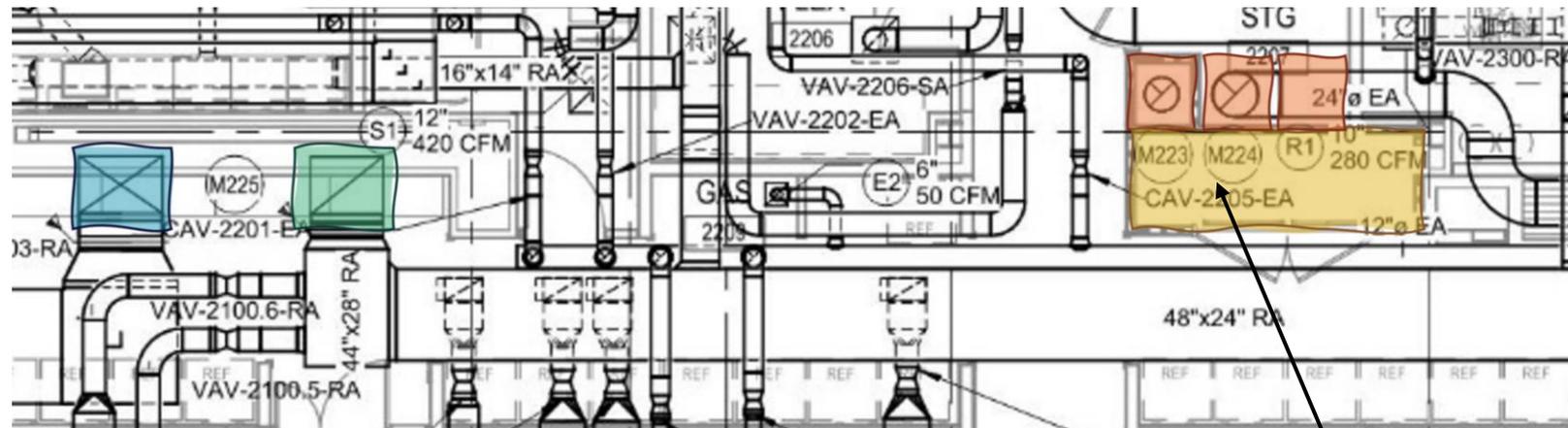
INTERNAL THREATS - SYSTEM CAPACITY

BASELINE Air Change Rate (OCCUPIED)

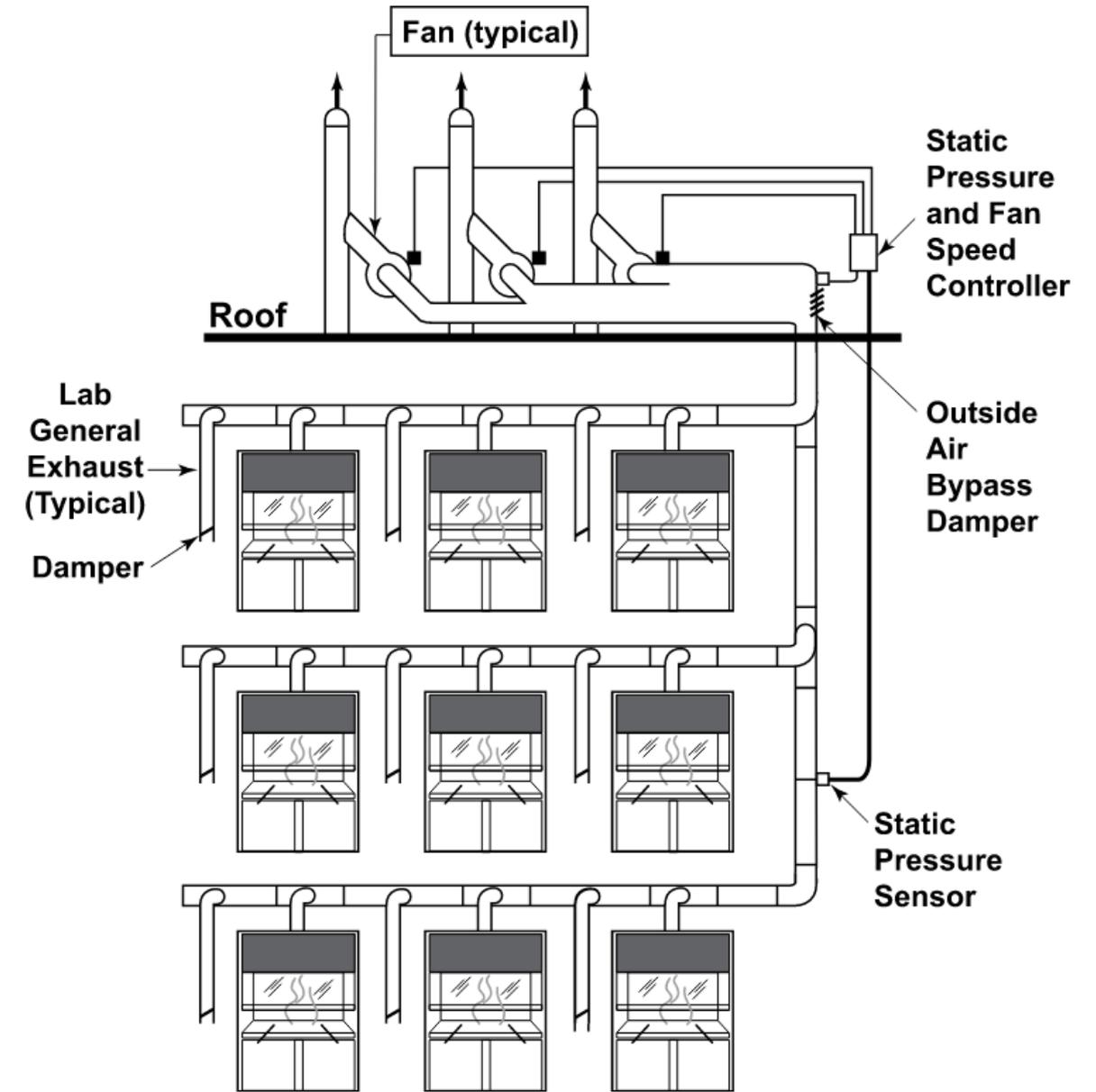


INTERNAL THREATS – VERTICAL PATHWAYS

- Manifolded Exhausts
 - Energy and flexibility advantages
- Independent Exhausts
 - Perchloric, radioisotope, bio-safety cab. exhaust
- Consider
 - Dust-Laden Exhaust
 - Chemical Compatibility
 - Duct Material Compatibility



ACCESSIBLE SHAFTS WITH SPACE FOR FUTURE NEEDS



I2SL Best Practice Guide
Manifolding Laboratory Exhaust Systems
April 2007

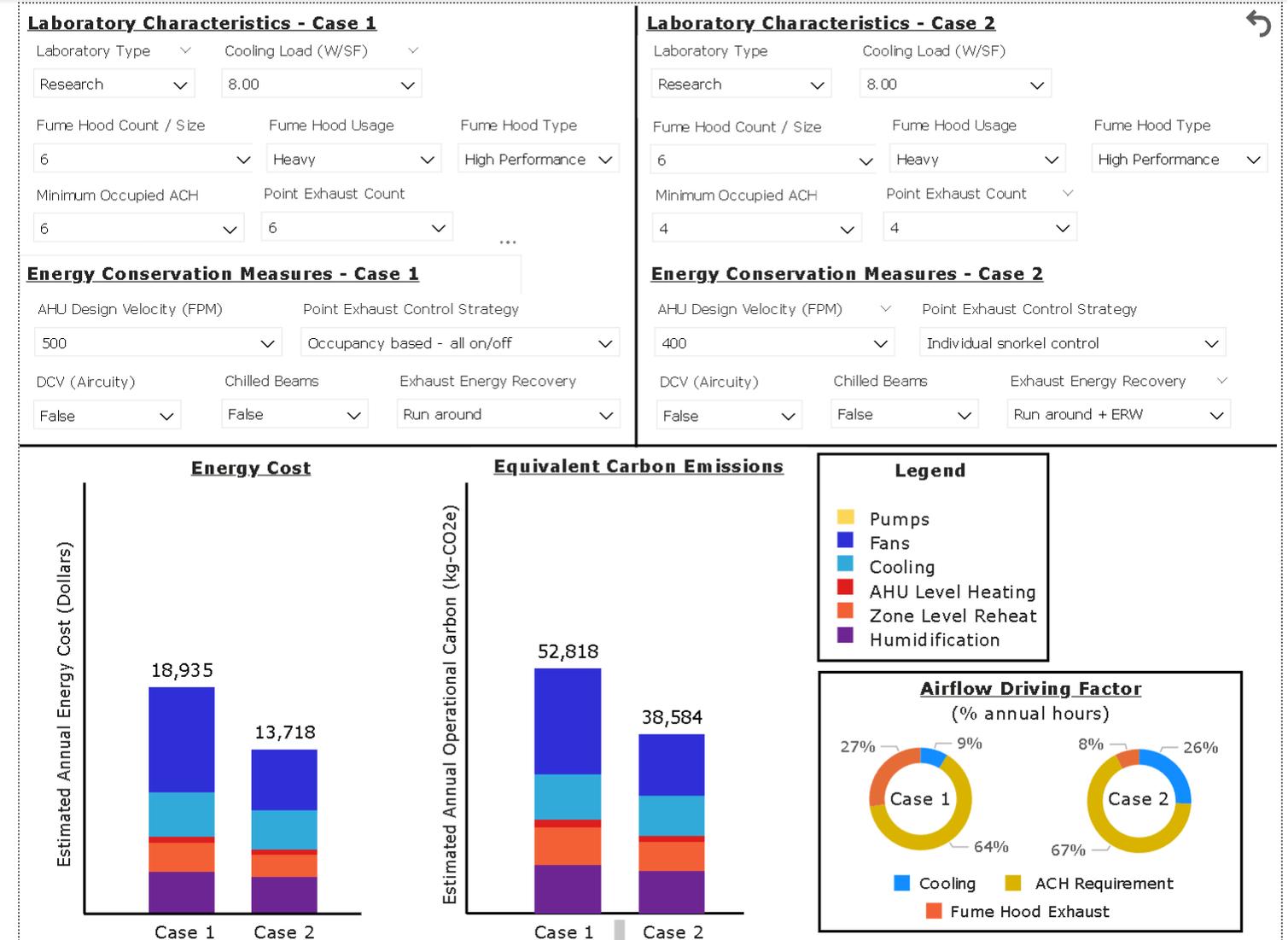
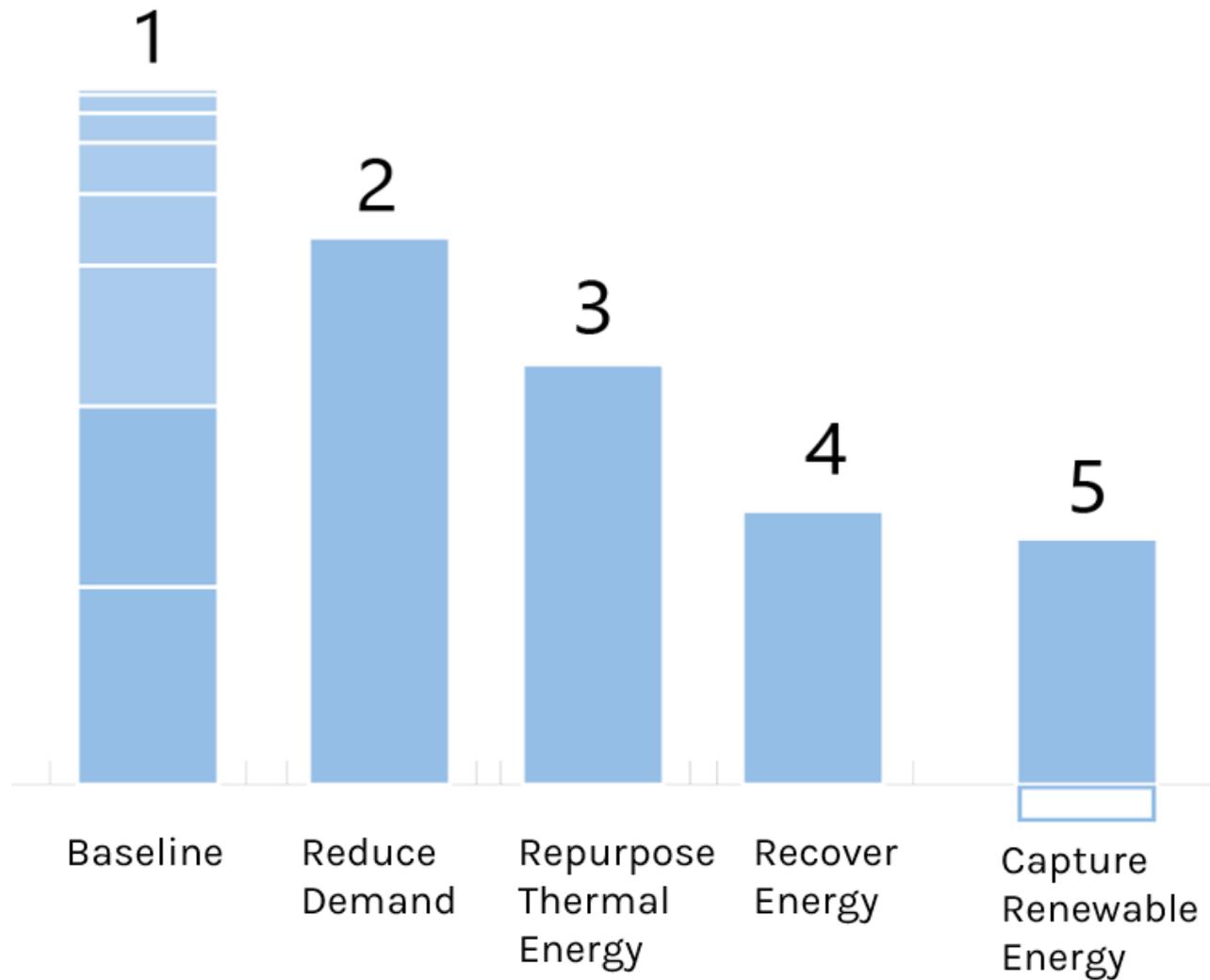
OPERATIONAL RESILIENCY

Systems Resilience		Options From conventional backup >> to resilient and sustainable planning		
Structure	Hardening	Low vibration		
Envelope / Exterior	Air barriers	Hardening	Force set-backs	Design for fire
Interior / Finishes	Hardening	Raised lobby/MEP	Vestibule traps	UVGI
Domestic Water	Flow-through storage	On-site fire storage	Use prioritization	Dry coolers ILO towers
Sewer / Lab Waste		Holding tanks	Living machine recycling	Composting toilets
Storm Drainage	Site hold/pump	Flood mitigation design	Bioswale	Green roof
Heating / Cooling	Alt. campus sources	Geothermal	Low-entropy campus	Fuel cells on green H2
Ventilation / Exh.	Alt. equipment/flows	Filtration	UVGI	Air purification options
Normal Power	Dual feeds	Utility collab. on subs	Microgrids	PV ± Wind
Standby Power	UPS	Dual feeds	N+1 generators	PV + Battery / Rotary
Data / Communic.	Prioritization	Alt. 2N connectivity	Multiple feeds	
Service / Supplies	Stockpiles	Contracted alt. sources	Triage-mode resuse plans	

Systems resiliency options, from conventional to resilient/sustainable.

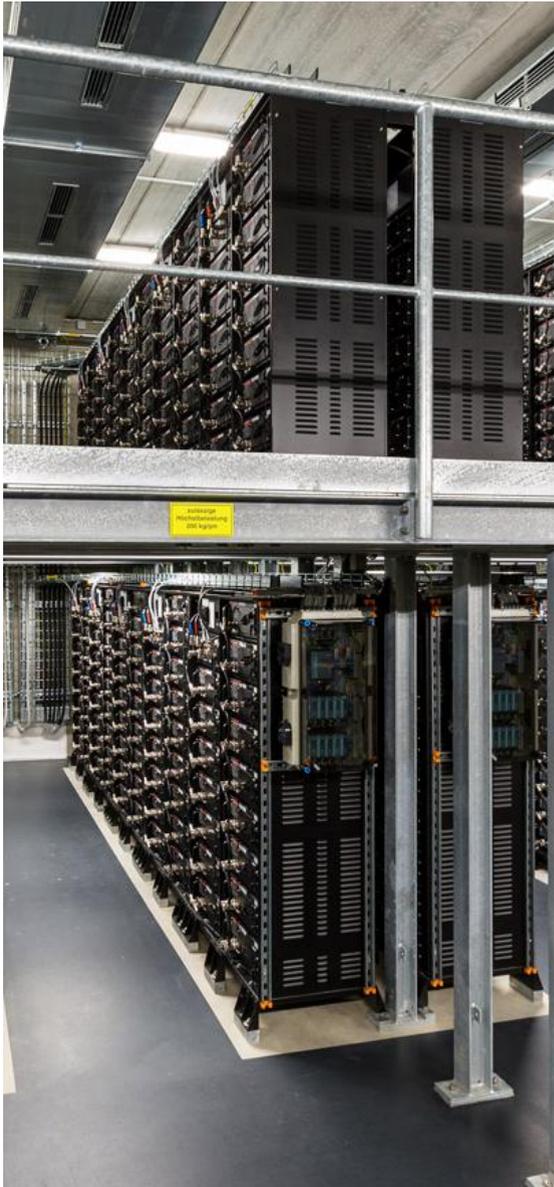
OPERATIONAL RESILIENCY

Pathway to Performance



OPERATIONAL RESILIENCY

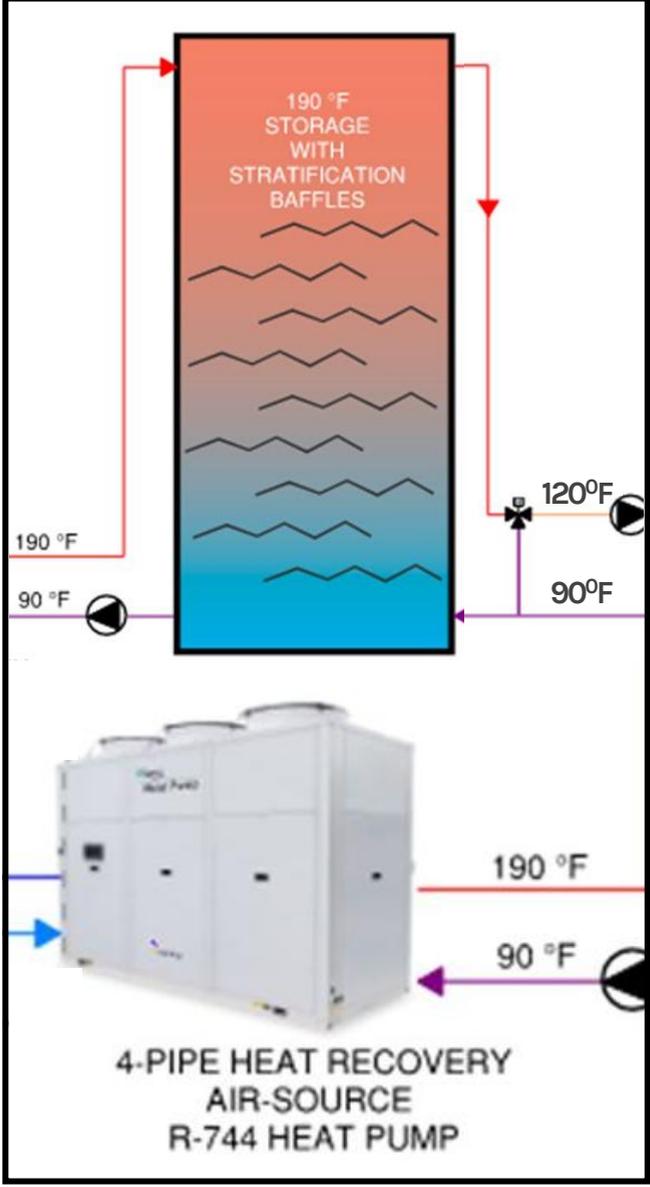
Shifting to off-peak generation to slash carbon and reduce cost



LITHIUM-ION BATTERIES



ICE/CHW STORAGE



190°F WATER STORAGE



GREEN HYDROGEN STORAGE



DEEP GRID STORAGE

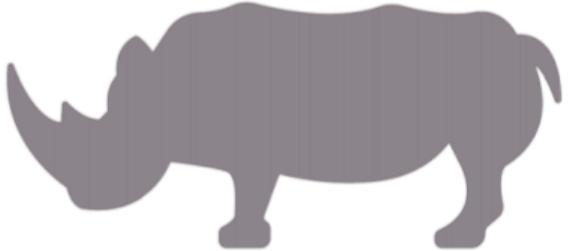
BEHAVIORAL RESILIENCY

THREE ASPECTS OF RESILIENCE AND HUMAN BEHAVIOR

BLACK & GREEN SWAN

A diagram showing two swans: one black and one green, representing the Black & Green Swan concept.

GRAY RHINO

A diagram showing a gray rhino, representing the Gray Rhino concept.

OSTRICH PARADOX

A diagram showing an orange ostrich, representing the Ostrich Paradox concept.

- Myopia
- Amnesia
- Optimism
- Inertia
- Simplification
- Herding

BEHAVIORAL RESILIENCY



MEP 2040
Committing to Zero



**The AIA 2030
Commitment**

CASE STUDY: VIRGINIA TECH ICAB



CASE STUDY – VIRGINIA TECH ICAB

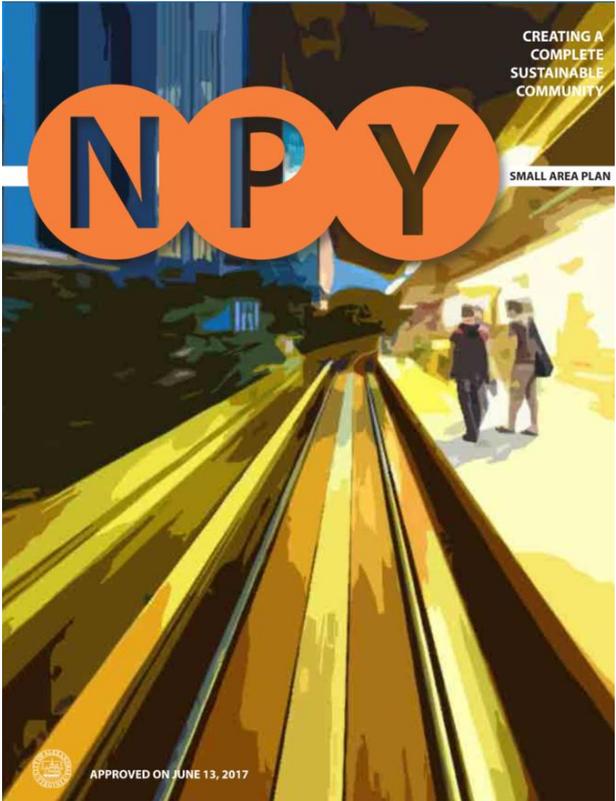
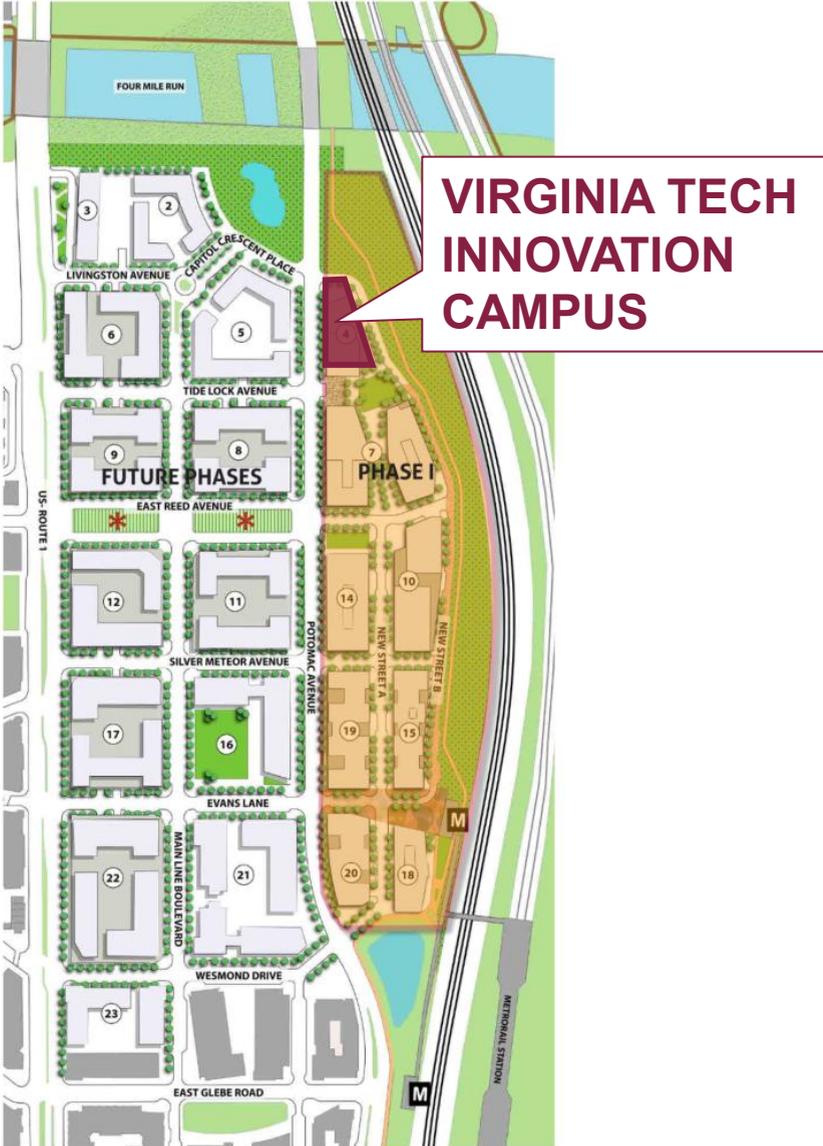
Virginia Tech
Innovation Campus
Academic Building 1

North Potomac Yards
Alexandria, VA

- 285,000 gsf
- 11 Floors
- Computer Science
- Computer Engineering
- Electrical Engineering



CASE STUDY – VIRGINIA TECH ICAB NORTH POTOMOC YARD



The intent of the Plan is to encourage district-wide sustainability measures that will be integrated in a coordinated and comprehensive manner...

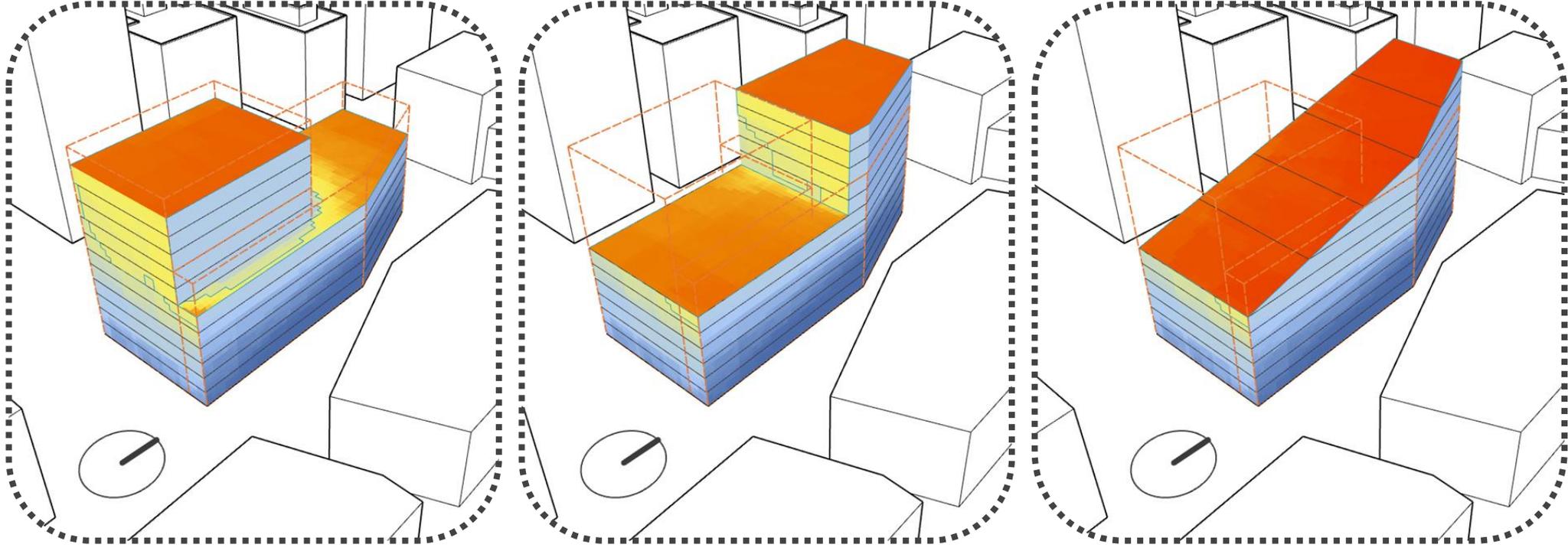
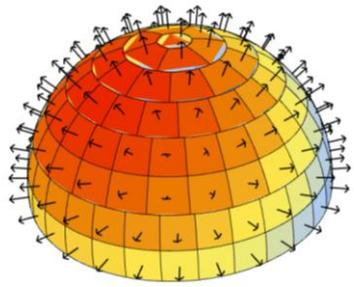
CASE STUDY – VIRGINIA TECH ICAB

VT GUIDING PRINCIPLES

1. The VT Experience and Identity
2. Universal Design
3. East of Movement
4. Health and Wellness
5. Green and Social Spaces
6. Connectivity
7. Flexibility
8. Visual Connectivity and Transparency
9. Integrated Technology
10. **Sustainability and Resilience**

CASE STUDY – VIRGINIA TECH ICAB

BASELINE MODELS



ZONING

VIOLATED ZONING:
MOVE TOWER TO NORTH

VIOLATED ZONING:
SLOPED FACING SOUTH

TOTAL RADIATION

4,455,415 kWh

5,286,726 kWh (+19%)

5,354,319 kWh (+20%)

RADIATION / SF

113 kWh/SF

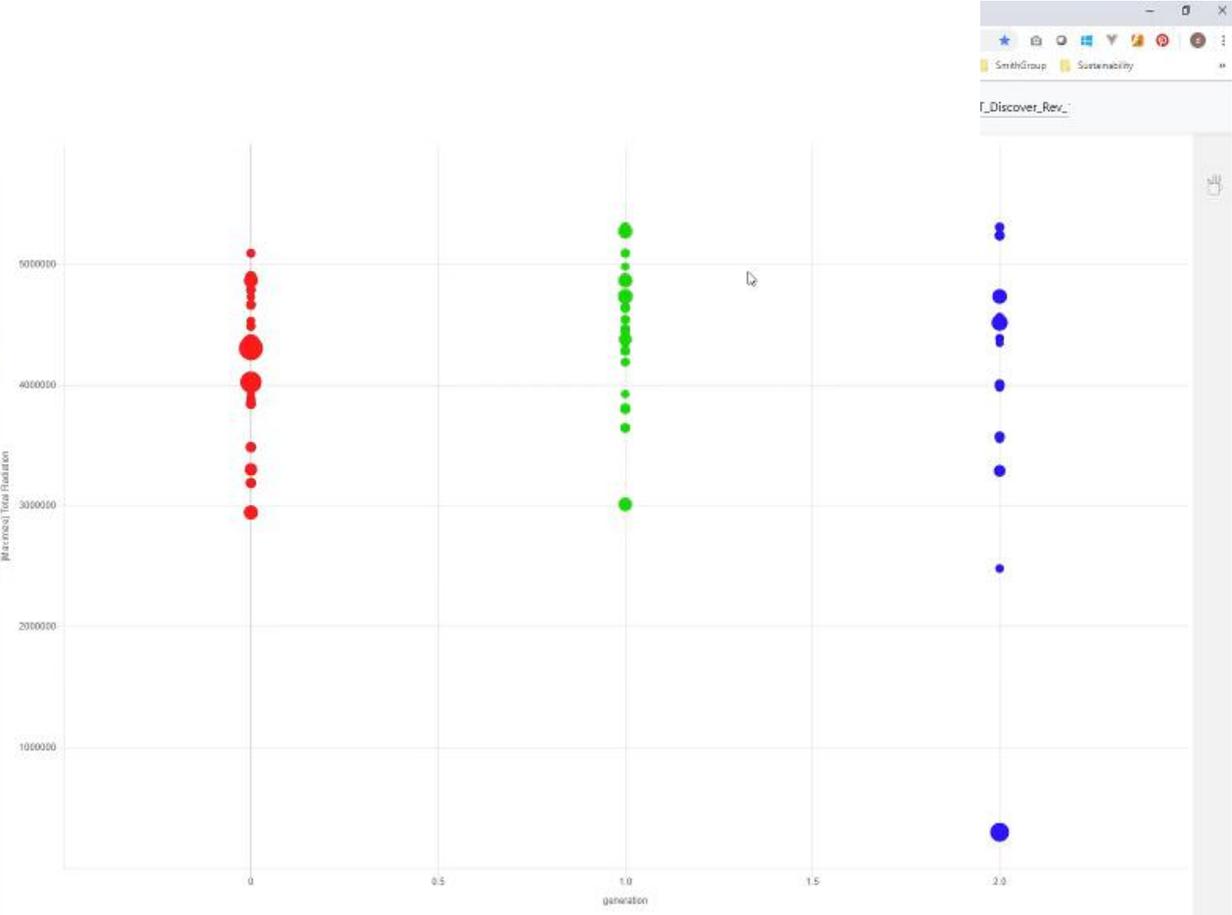
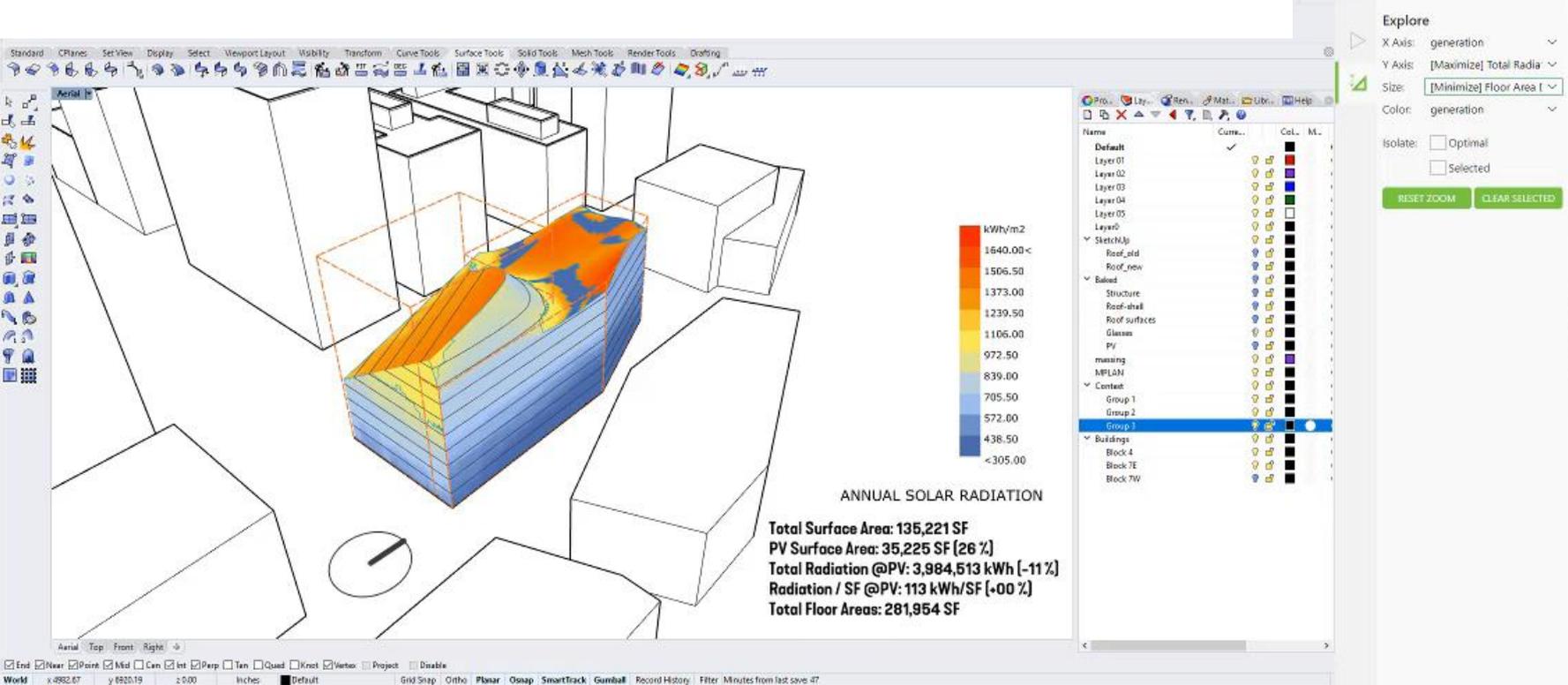
117 kWh/SF (+4%)

139 kWh/SF (+23%)



CASE STUDY – VIRGINIA TECH ICAB MAXIMIZING PV GENERATION

USING COMPUTATION AND AI-ENHANCED METHODS

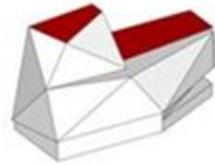
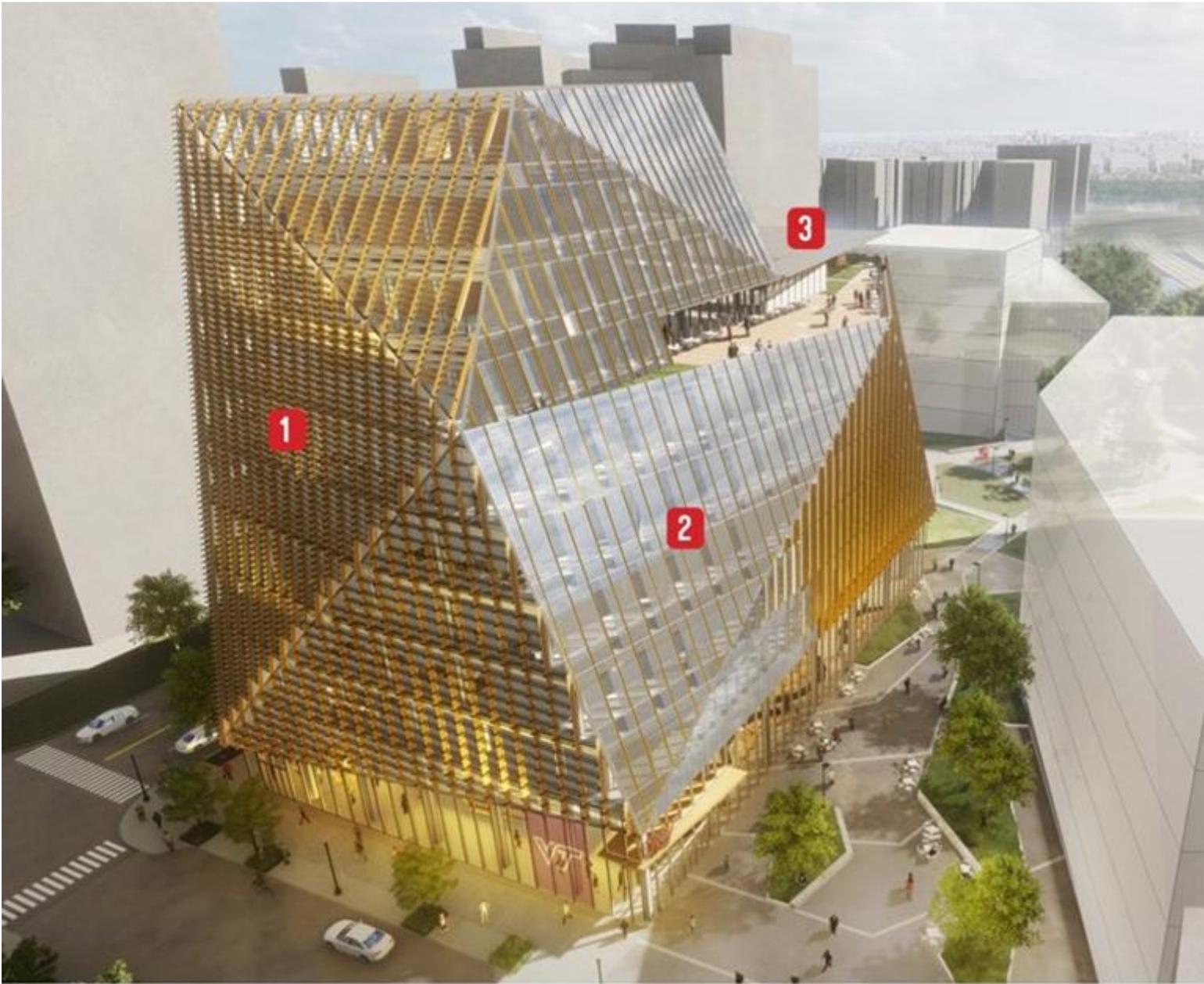


DESIGN + PERFORMANCE METRICS

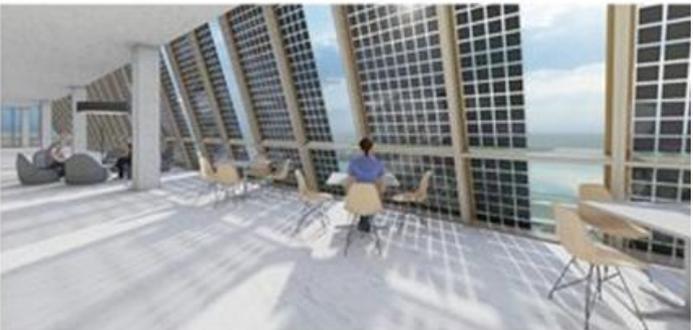
SCATTERPLOT

CASE STUDY – VIRGINIA TECH ICAB A SOLAR POWER PLANT

Total Power Generation: 351,332 kWh/yr



3. Photovoltaic Panel Roof Canopy: 158,019 kWh/yr

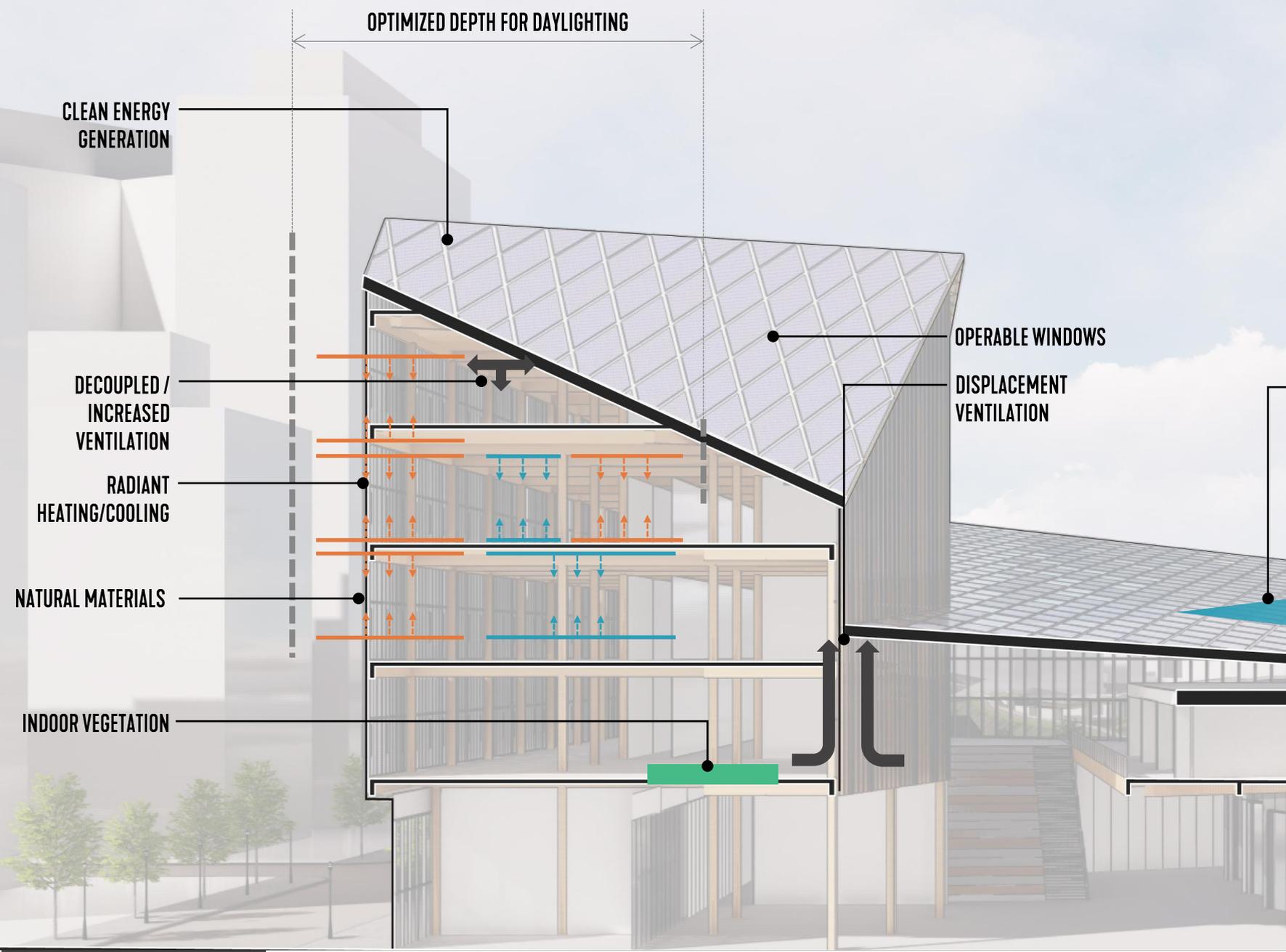


2. Building Integrated Photovoltaic: 119,550 kWh/yr



1. Photovoltaic Glass Fins: 73,763 kWh/yr

CASE STUDY – VIRGINIA TECH ICAB SYSTEM STRATEGIES



Radiant ceilings are used throughout ICAB
Uses water to distribute heat and cooling, much more efficient than moving air
Visual experience is just perforated metal



CASE STUDY – VIRGINIA TECH ICAB

NESTED SYSTEMS

- ① Academic Building 1
- ② Innovation Campus
- ③ Innovation Campus + adjacent natural assets
- ④ District physical and natural assets for synergistic benefits

CHALLENGING SCALE

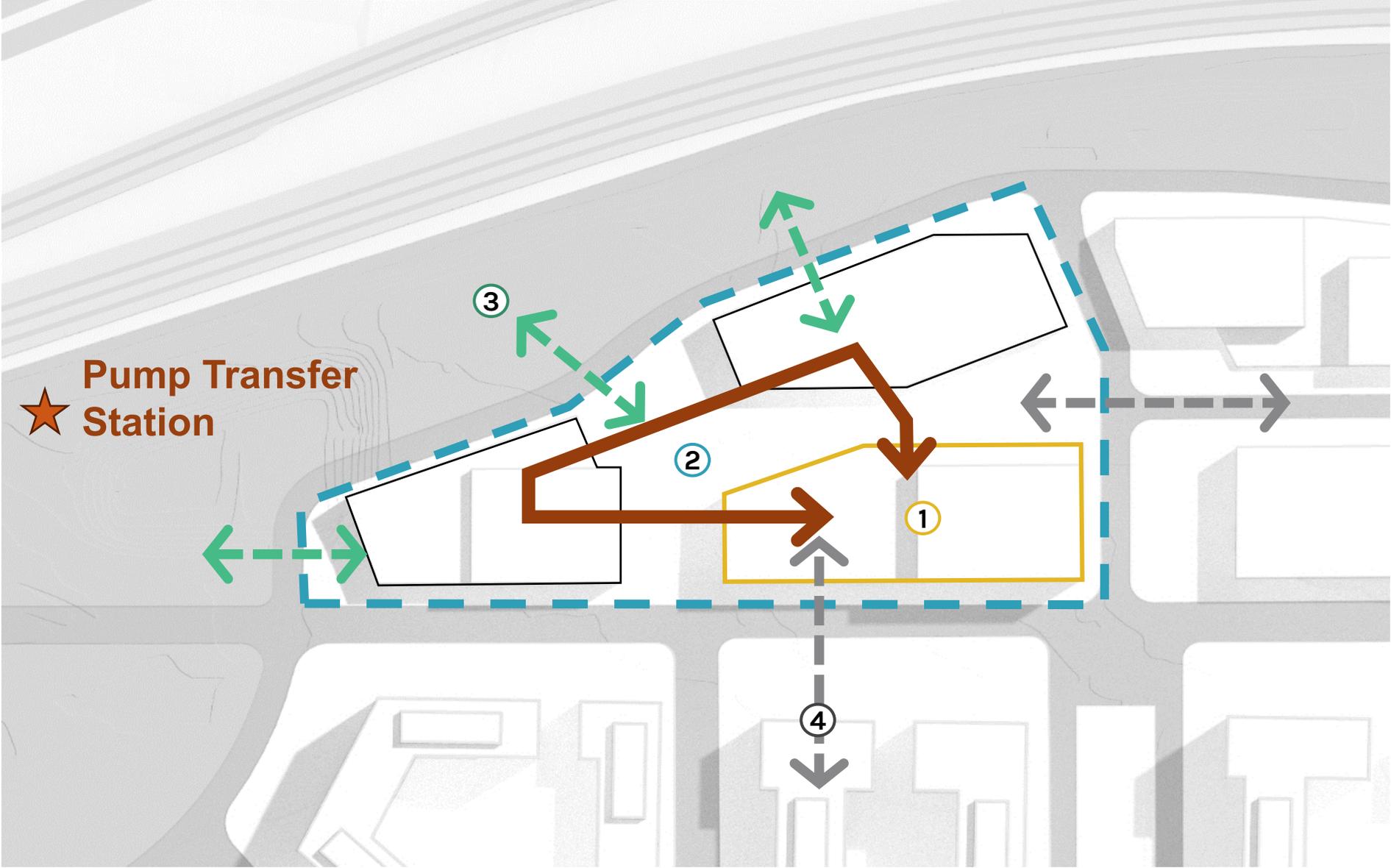
- Phase a campus central plant?

LOAD DIVERSITY

- Campus program too similar?
- Opportunity to leverage the broader development (i.e., district-scale system?)

NATURAL ASSETS

- Use adjacent greenway for GSHE?
- Tap the public sewer main?



CASE STUDY – VIRGINIA TECH ICAB

INFRASTRUCTURE CONCEPT

HIGH-PERFORMANCE BLDG

- ① DOAS w/parallel conditioning (radiant, ACB, chilled box)

PRIME THERMAL GENERATION

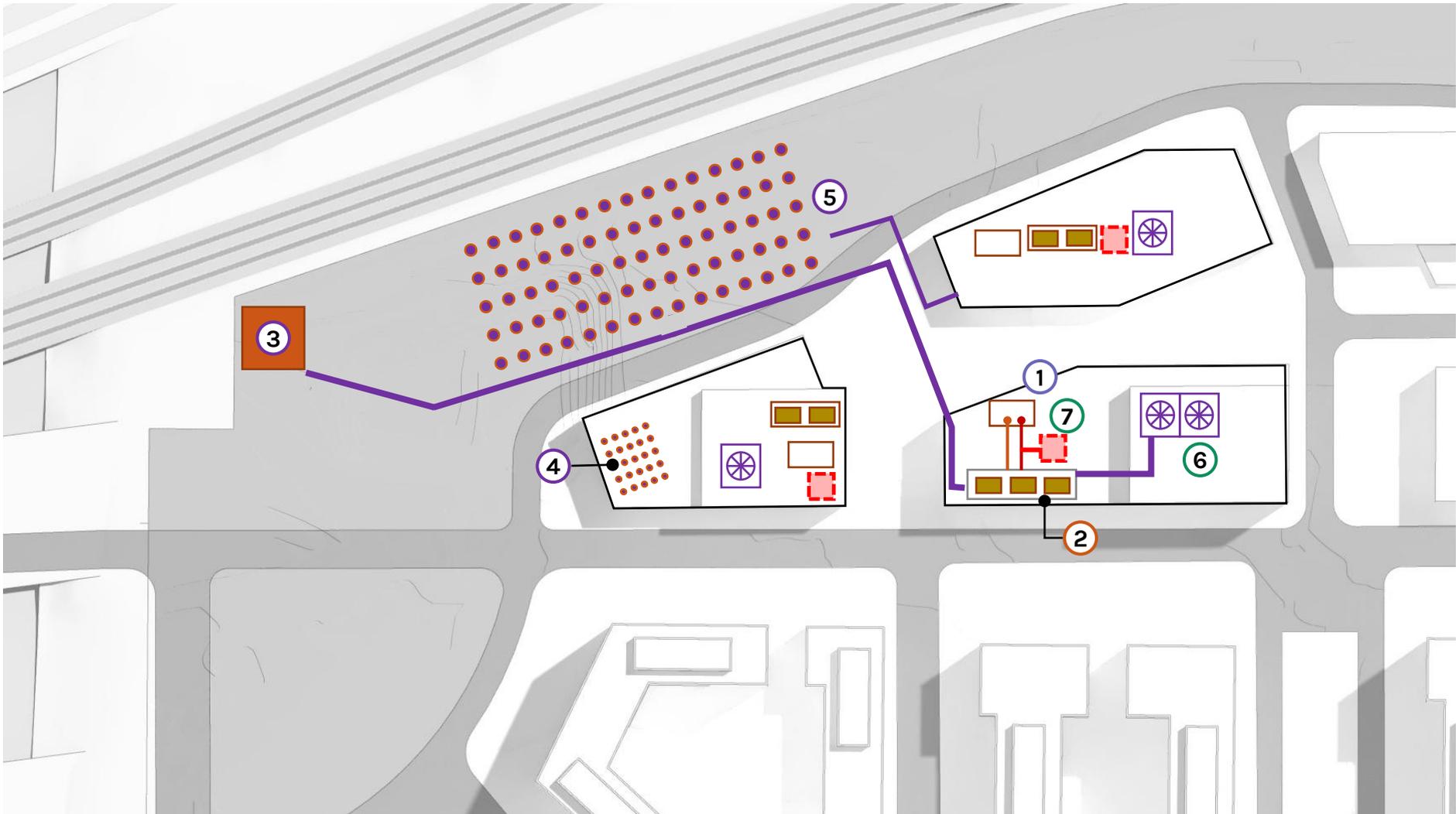
- ② Heat-recovery chillers

MULTI-SOURCE ENERGY EXCHANGE

- ③ Municipal pump station with sewer thermal heat recovery (FUTURE)
- ④ Deep foundation energy piles
- ⑤ Vertical borefield (70-100#) (FUTURE)

AUXILIARY HEATING, COOLING, HEAT REJECTION

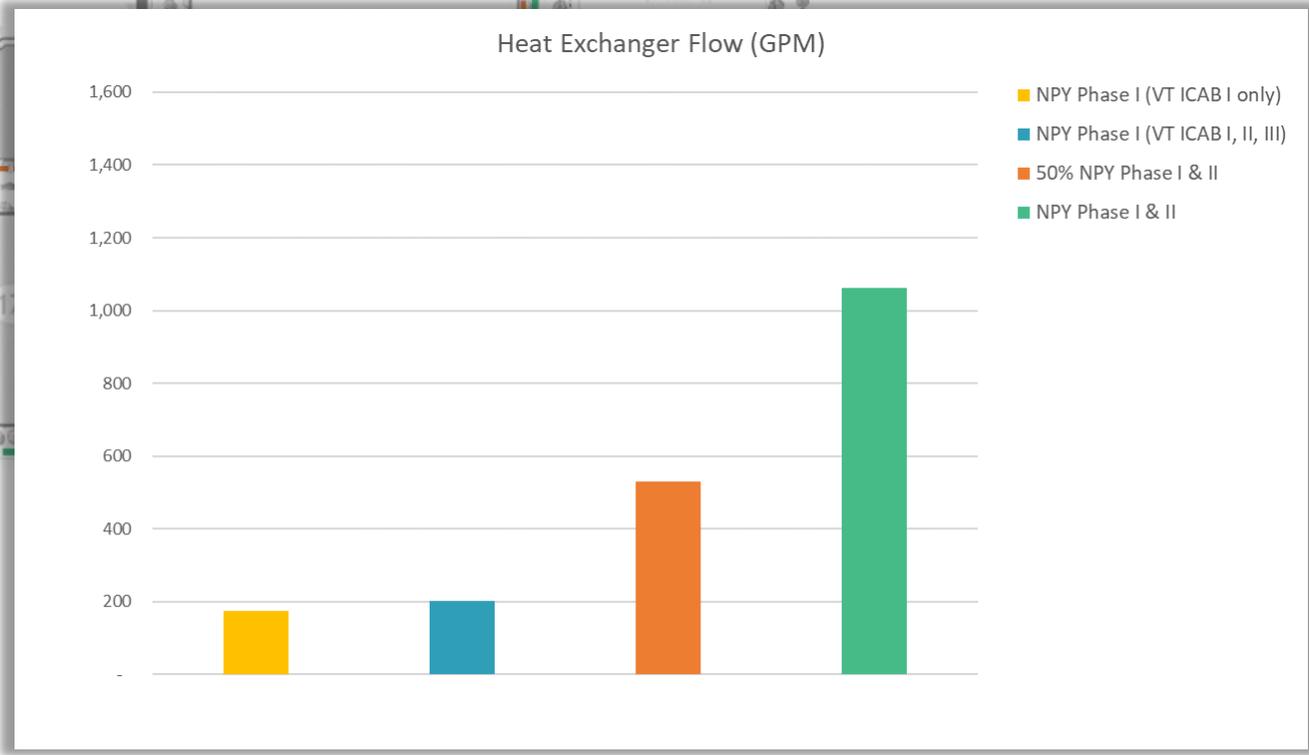
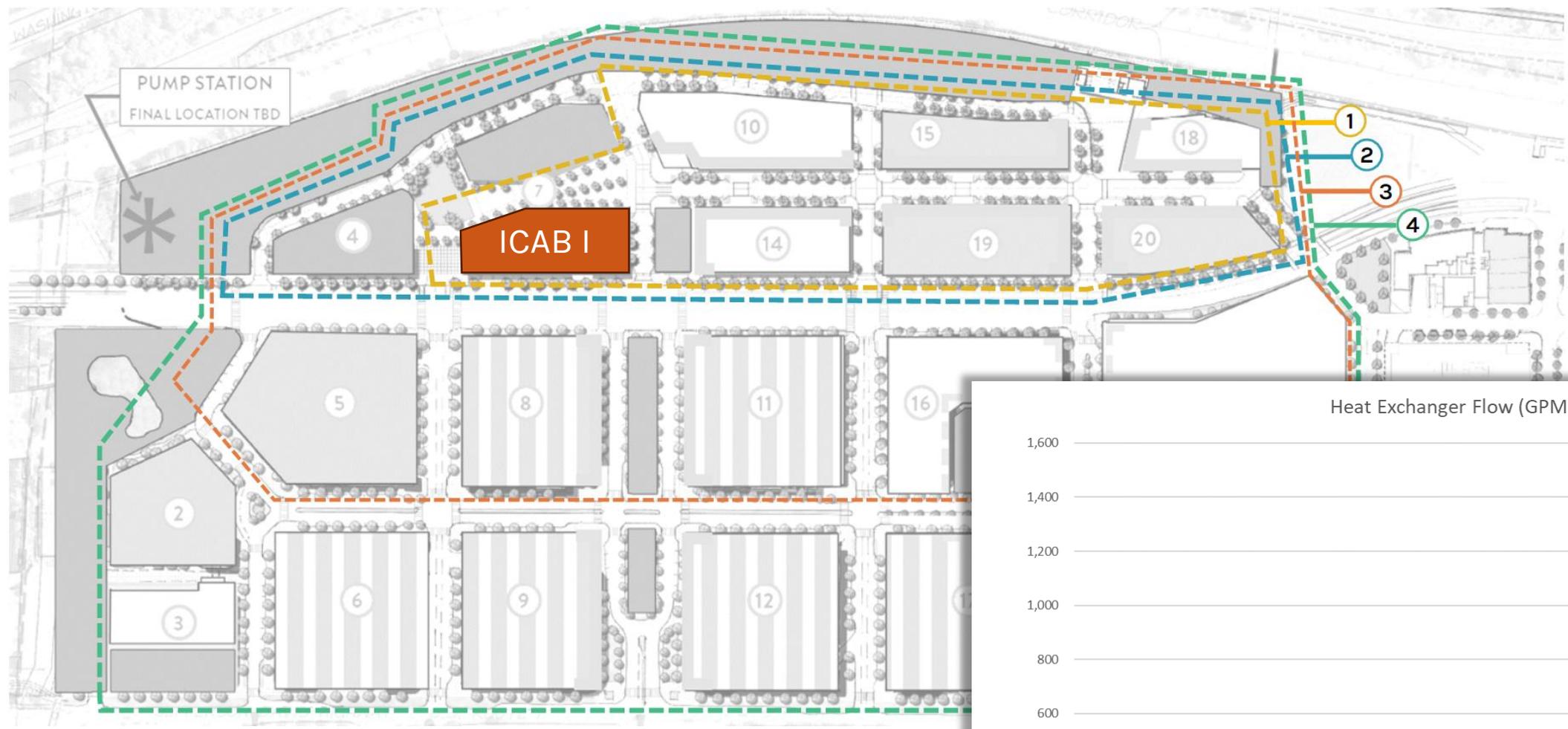
- ⑥ ASHP
- ⑦ Electric boiler



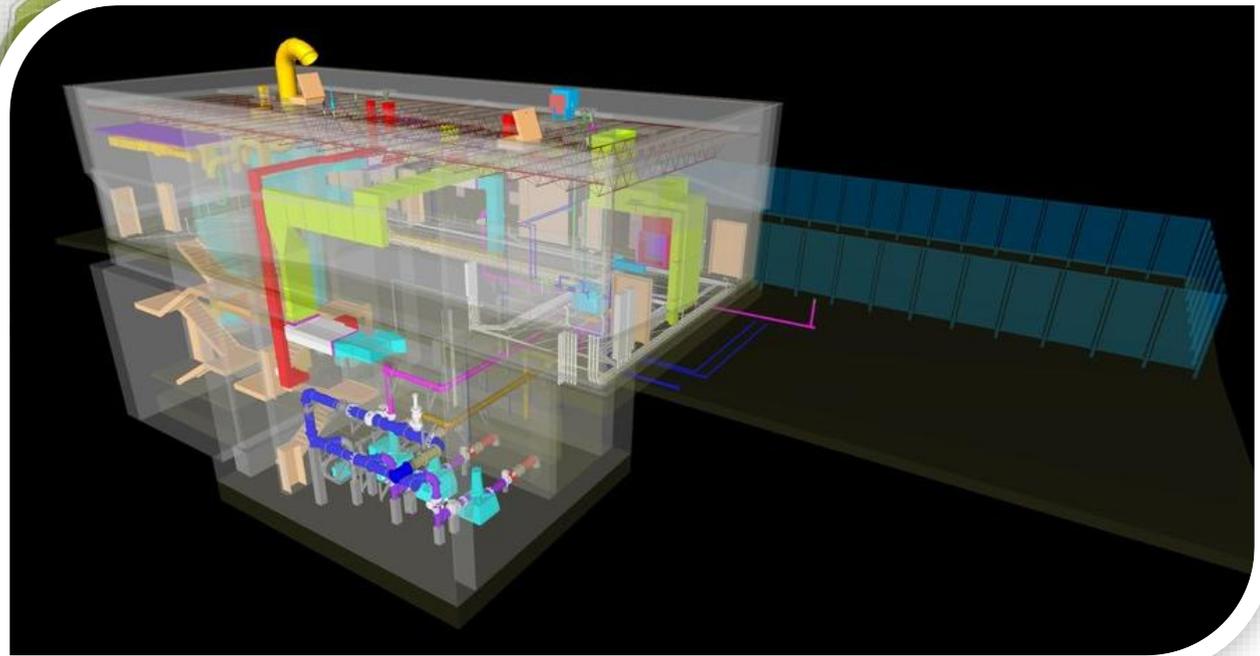
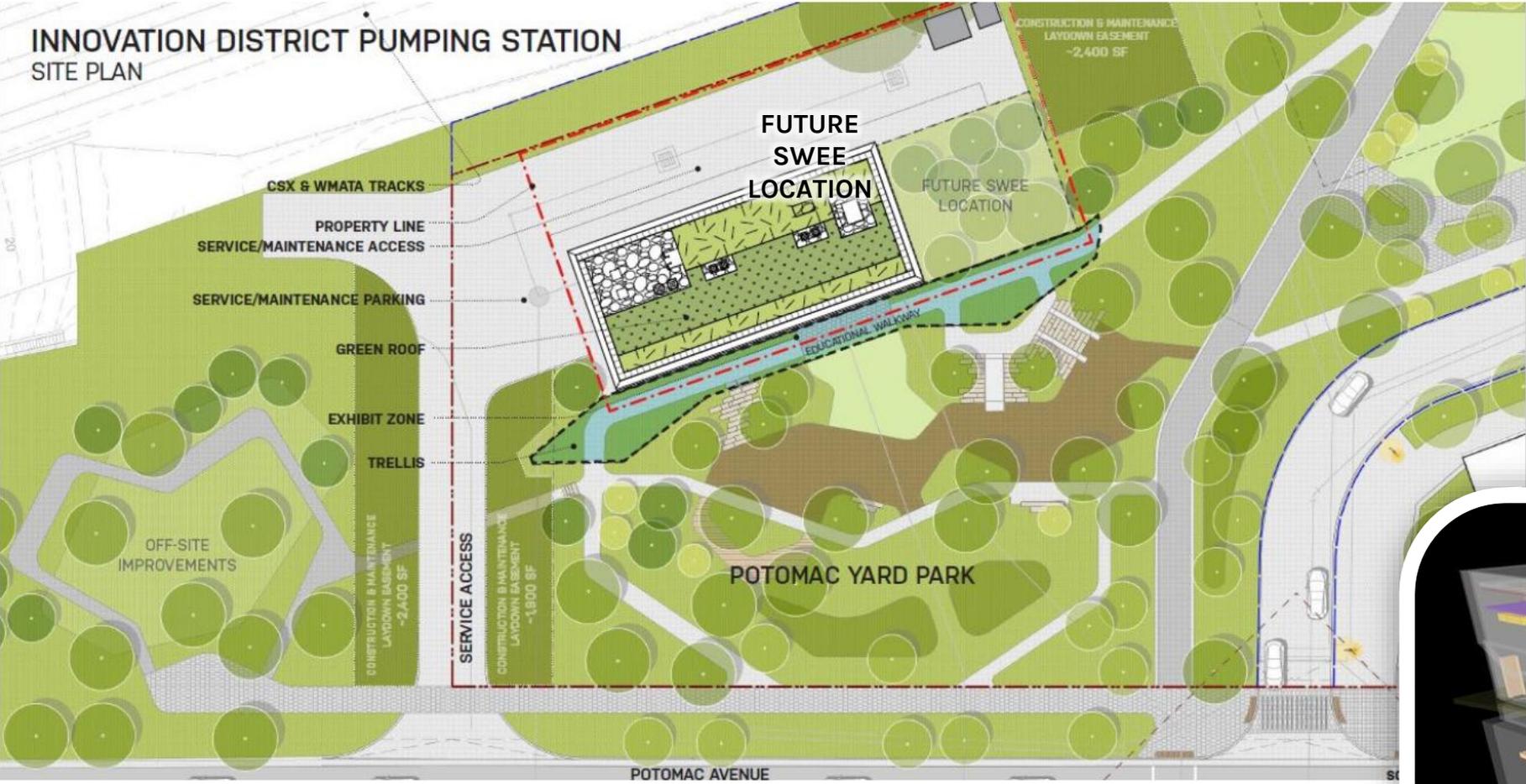
CASE STUDY – VIRGINIA TECH ICAB

SEWER THERMAL EXCHANGE

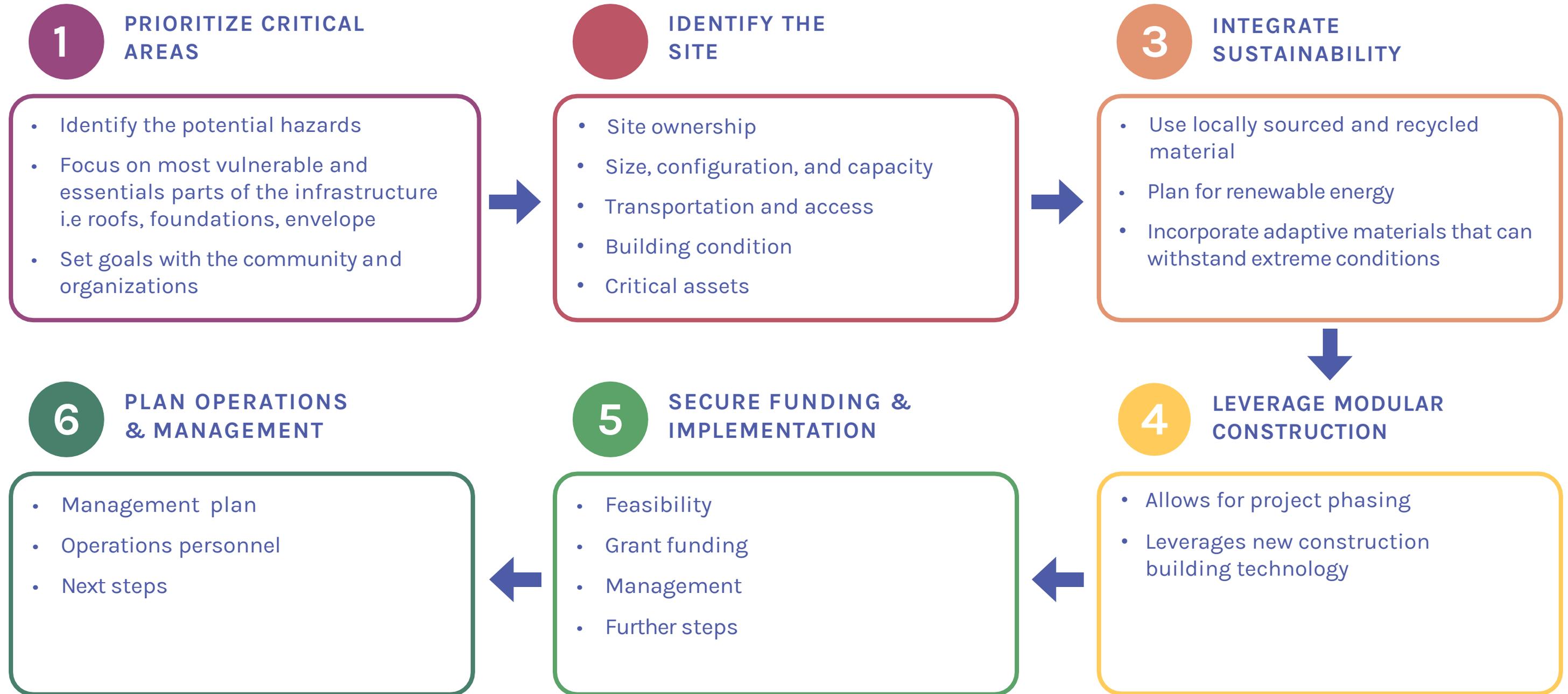
- ① NPY Phase I (ICAB I only)
- ② NPY Phase I (ICAB I, II, III)
- ③ 50% NPY Phase I & II
- ④ NPY Phase I & II



CASE STUDY – VIRGINIA TECH ICAB SEWER THERMAL EXCHANGE



HOW TO IMPLEMENT RESILIENT BUILDING INFRASTRUCTURE..



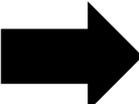
...WITH BUDGET CONSTRAINTS



ENERGY TAX CREDIT



Inflation Reduction Act (IRA)



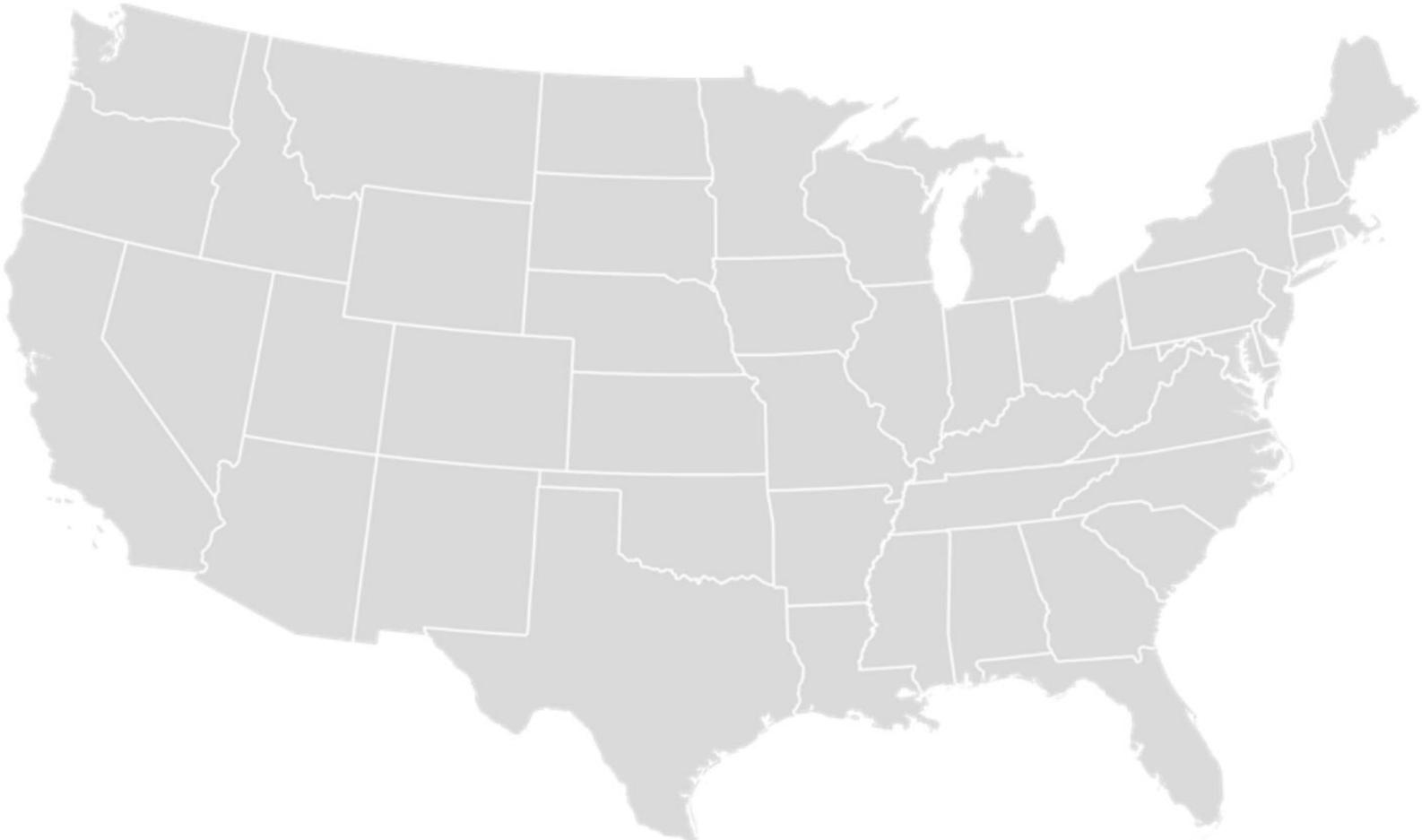
Investment Tax Credit (ITC)



Section 48 Energy Credit



Geothermal Heat Pump Property



WHO IS ELIGIBLE FOR "ENERGY TAX CREDIT"?

For-Profit

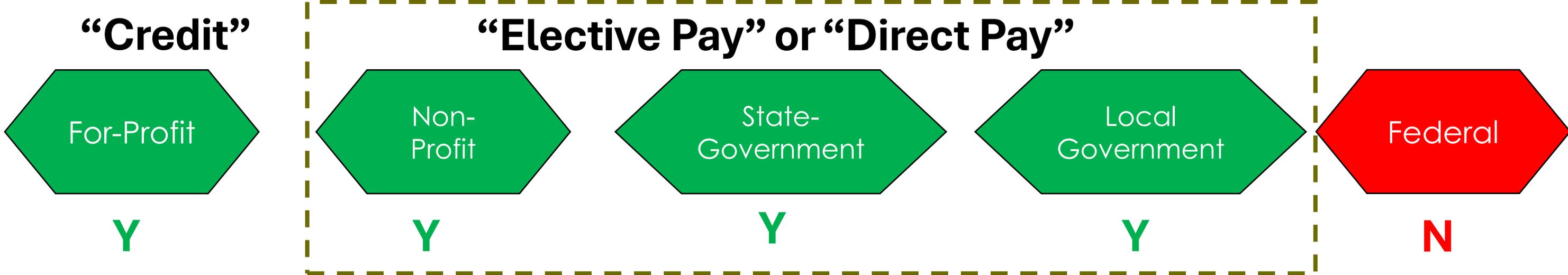
Non-Profit

State-Government

Local Government

Federal

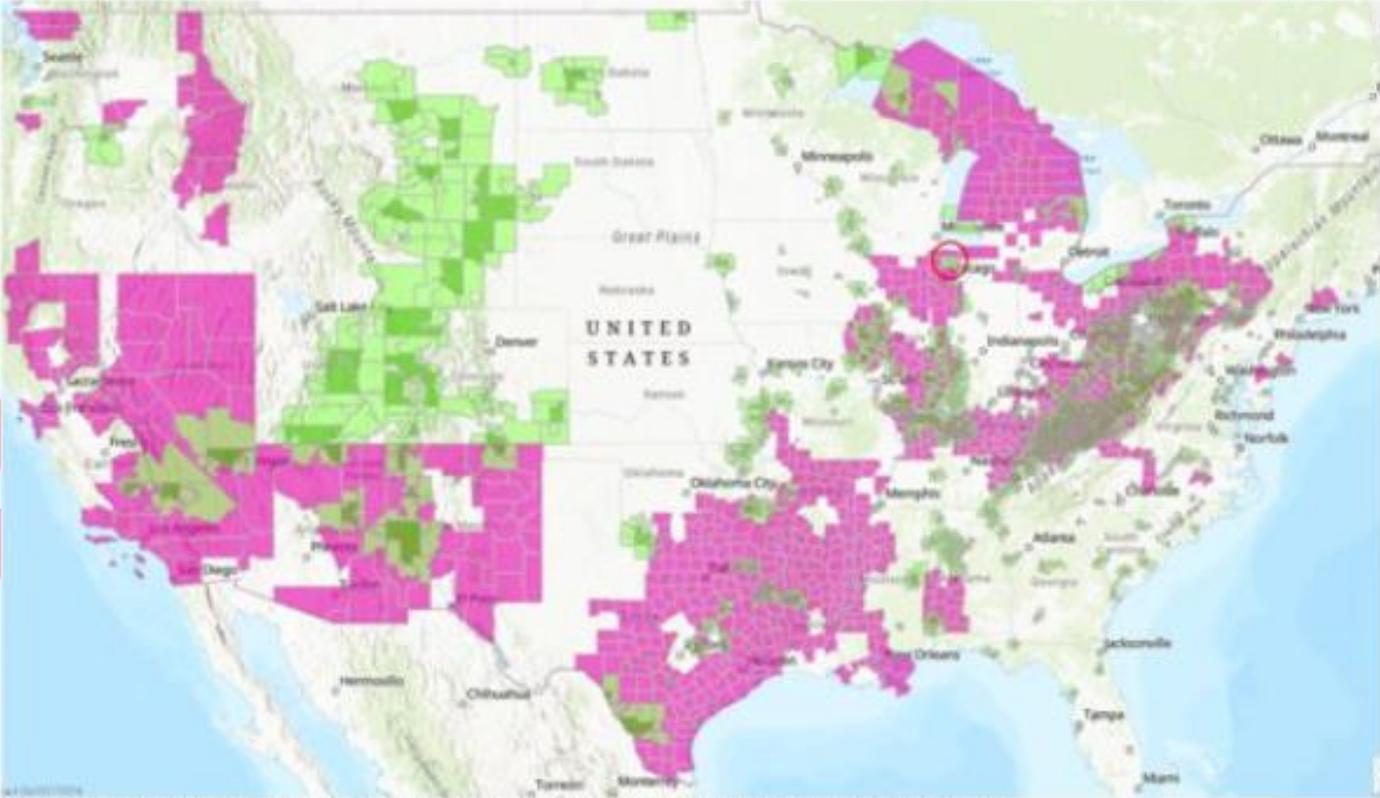
WHO IS ELIGIBLE FOR "ENERGY TAX CREDIT"?



INFLATION REDUCTION ACT FUNDING



Technology	Base Credit	5x Bonus Credit (2022)	Domestic Content (2023)	Energy Community (2023)	Low Income (2023)	Range
Solar Technologies (2022)	6%	30%	2%/10%	2%/10%	10%/20%	6%-70%
Small Wind (2022)	6%	30%	2%/10%	2%/10%	10%/20%	6%-70%
Ground Source Heat Pump (2022)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Microturbine	2%	10%	2%/10%	2%/10%	0%	2%-30%
CHP (2022)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Microgrid Controller (2023)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Standalone Energy Storage Systems (2023)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Thermal Energy Storage Systems (2023)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Fuel Cell (2022)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Geothermal Electricity(2022)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Biogas (2022)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Waste Energy Recovery Electricity (2022)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Interconnection Property (2023)	6%	30%	2%/10%	2%/10%	0%	6%-50%
Electrochromic Glass (2023)	6%	30%	2%/10%	2%/10%	0%	6%-50%



LEGEND

2024 Coal Closure Energy Communities

Tract Status

- Census tract with a coal closure
- Directly adjoins a tract with a coal closure

2024 MSAs/non-MSAs that are Energy Communities

MSAs/non-MSAs that meet both the Fossil Fuel Employment (FFE) threshold and the unemployment rate requirement and are an energy community as of June 7, 2024

TAKEAWAY

A resilient building stands ready to support its community when it matters most. Invest with that purpose in mind because the structures that endure can continue to serve, uplift, and help close social and economic gaps.

But buildings don't exist in isolation. They're part of a broader ecosystem. Whenever possible, advocate for master planning that considers resilience at the neighborhood or district scale. One resilient building is powerful. A network of them? That's transformative. That's regenerative.



QUESTIONS?

CLINICAL SOCIAL WORK
TRABAJO SOCIAL CLÍNICO

REGISTRATION /
REGISTRARSE

PSICOLOGÍA
PSICOLOGIA

SMITHGROUP