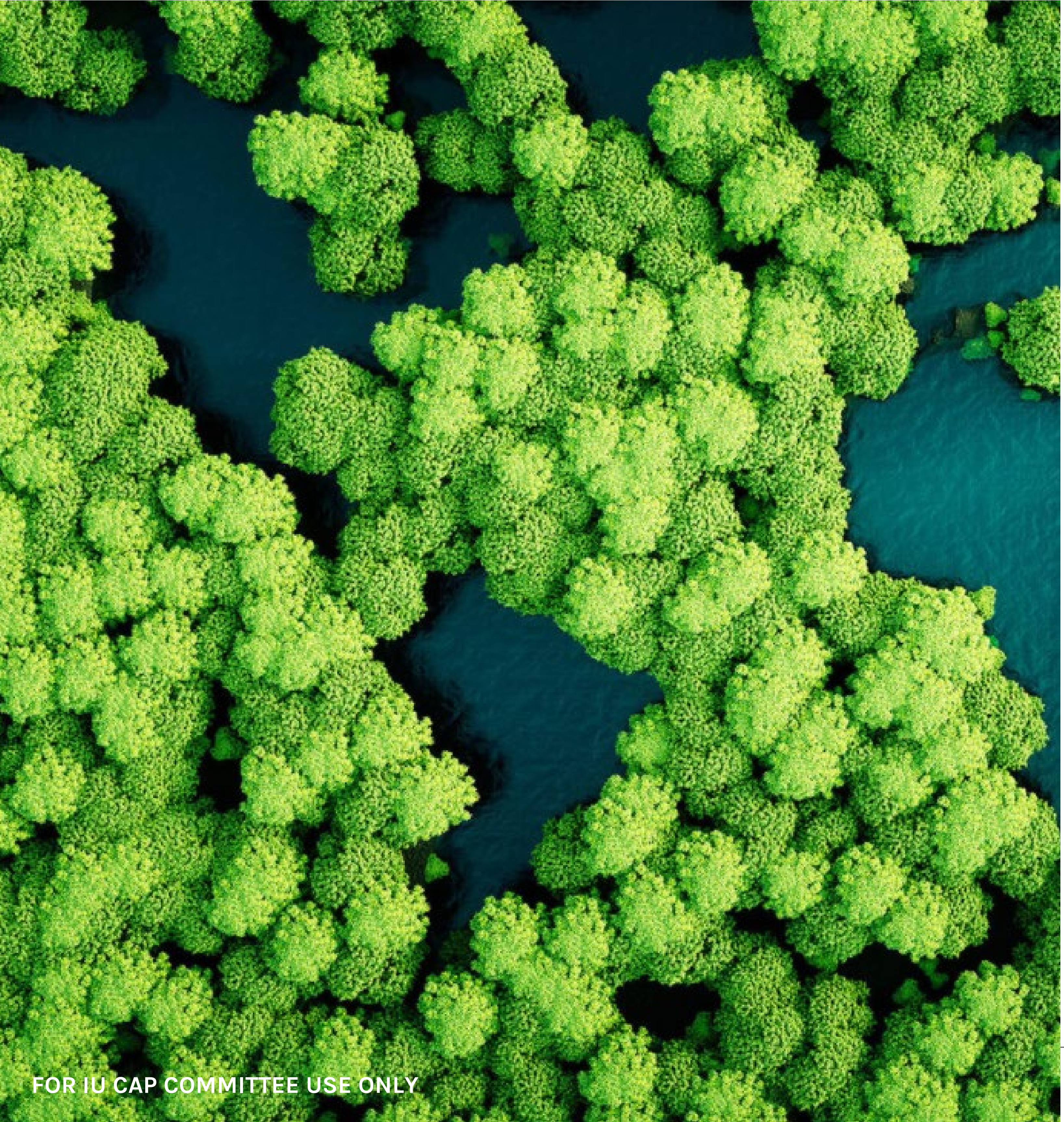
INDIANA UNIVERSITY CLIMATE ACTION PLAN

IU CAP Committee Meeting

December 14, 2022

FOR IU CAP COMMITTEE USE ONLY

SMITHGROUP

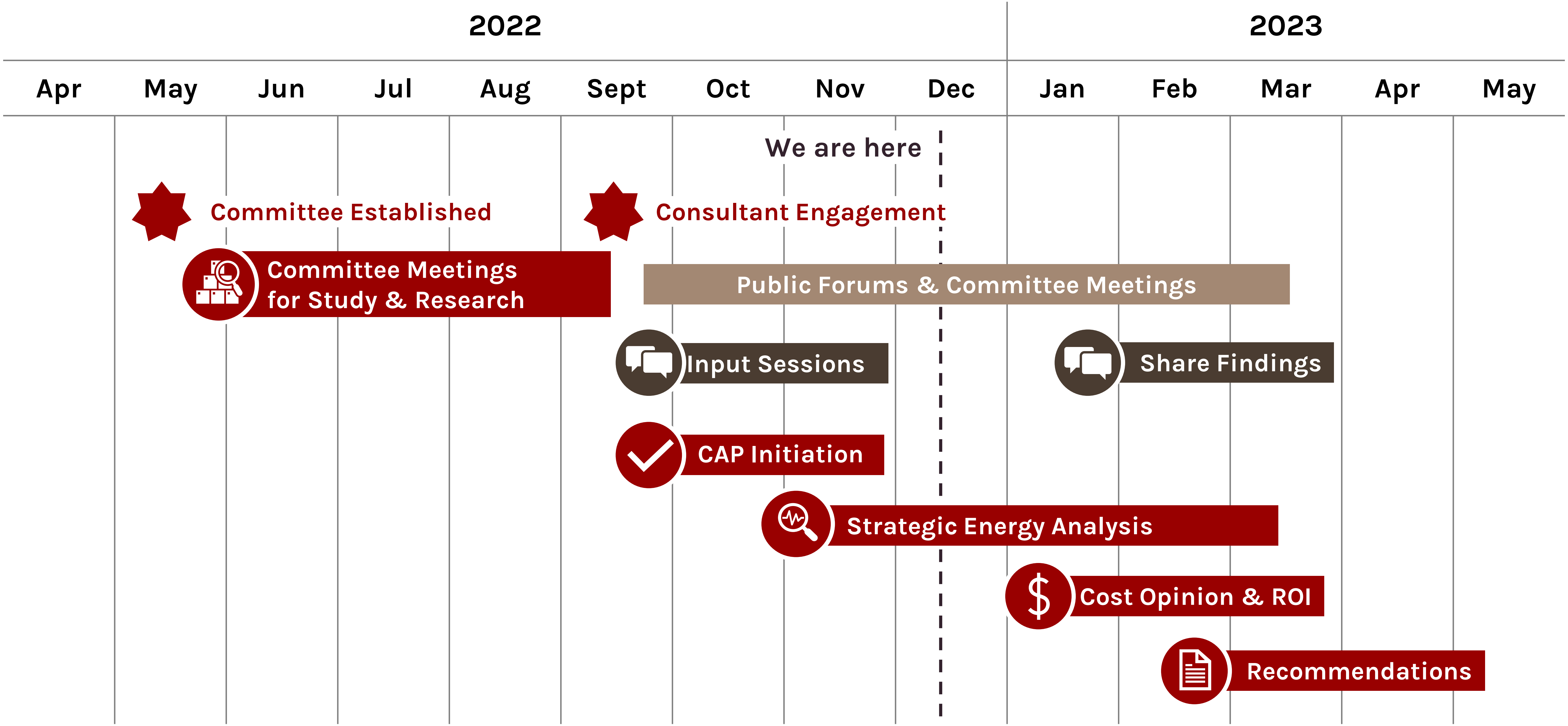


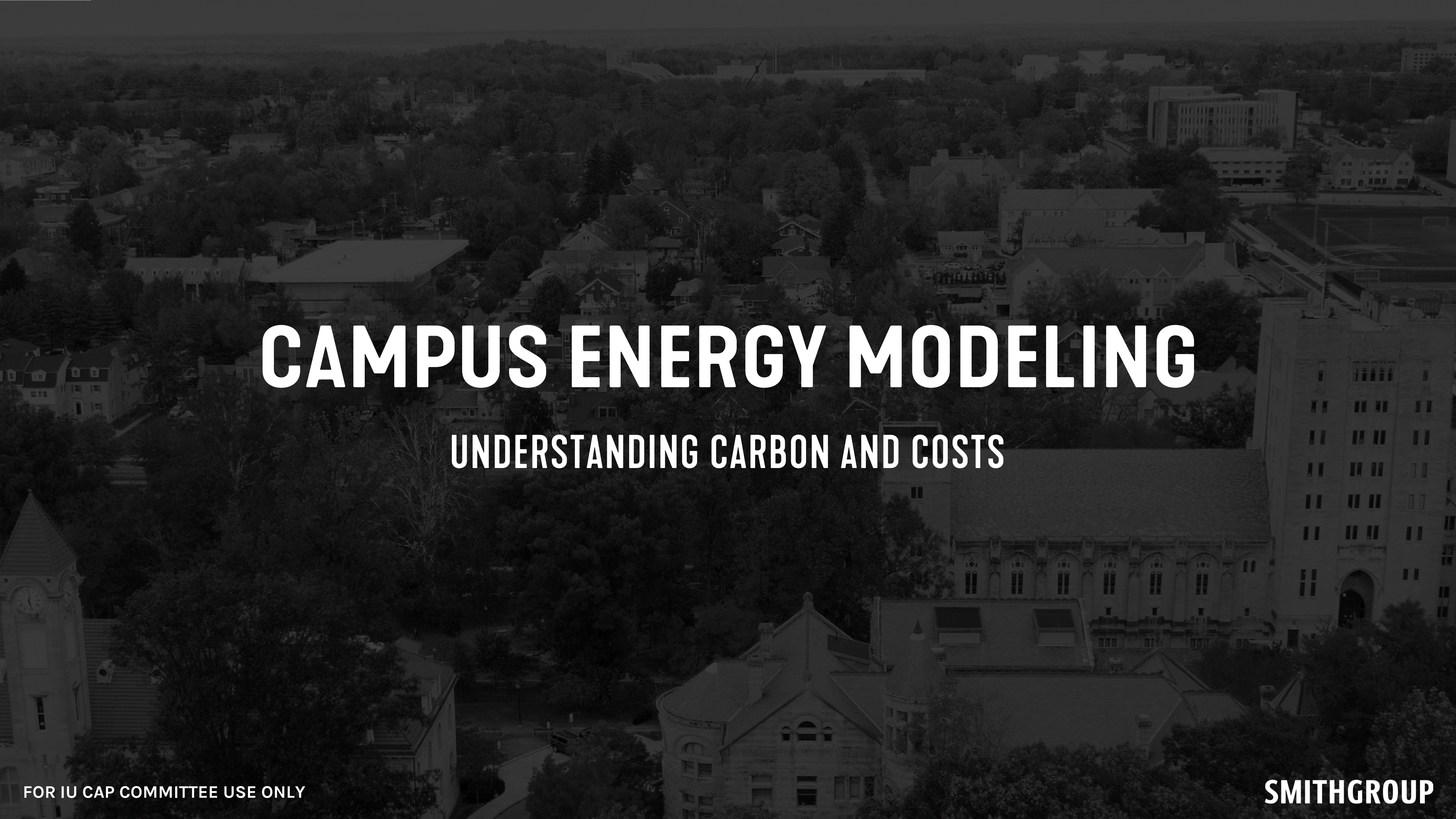
AGENDA

Campus Energy Modeling Process

Initiatives

PROJECT SCHEDULE



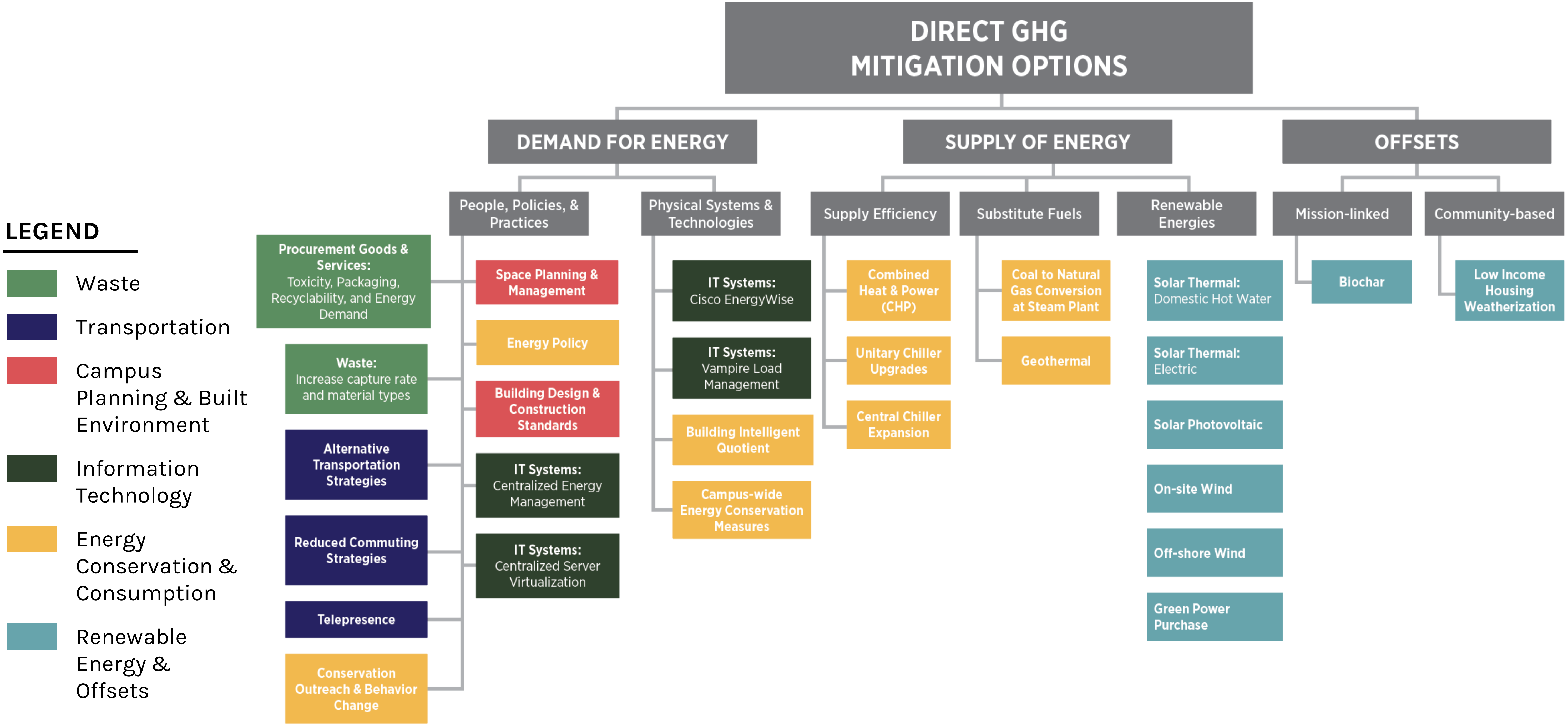


CAMPUS ENERGY MODELING

UNDERSTANDING CARBON AND COSTS

SMITHGROUP

APPROACH & SUMMARY OF METHODS



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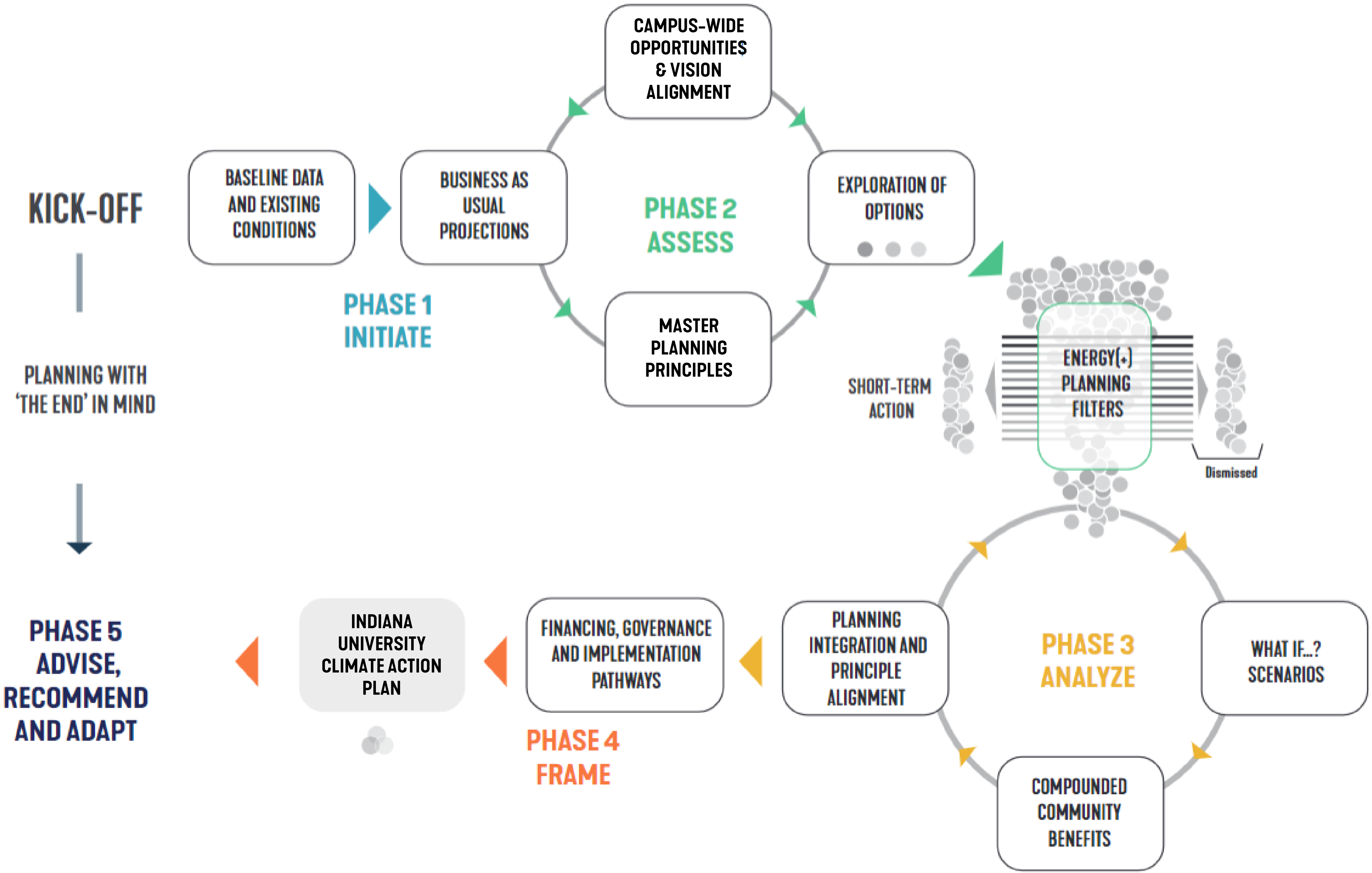


STEP ONE

SUPPLY-SIDE ANALYSIS

STEP ONE: BASELINE DATA & EXISTING CONDITIONS

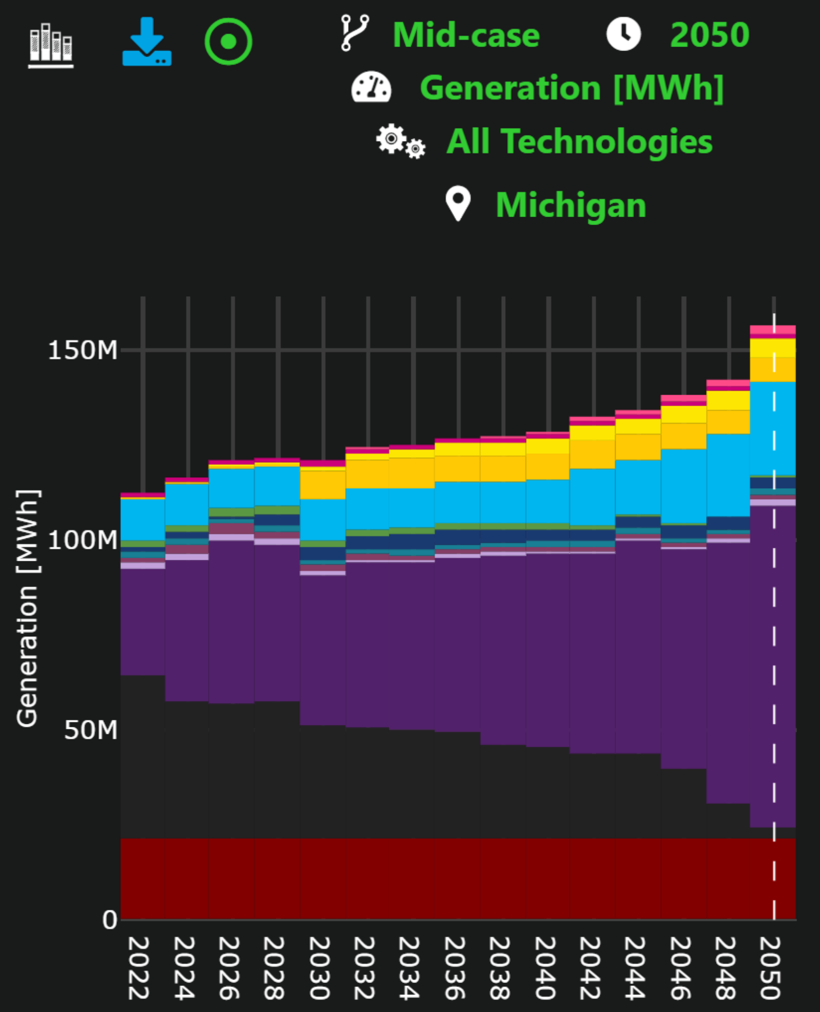
IDENTIFY SUPPLY-SIDE CAMPUS ENERGY

1. What central plants are there on campus? (heating and cooling)
2. What is the grid provision for local electricity?
3. Identify any onsite renewables
4. Quantify any economic agreements- power-purchase of renewables and/or any retail bulk energy agreements; make sure you have the unit cost of energy identified for all supply sources (electricity, gas, coal, hydro etc)
5. Collect any carbon footprint inventory or calculations done to date

CONVERT THESE TOTALS TO TOTAL UNITS OF CARBON

TOOLS TO USE:

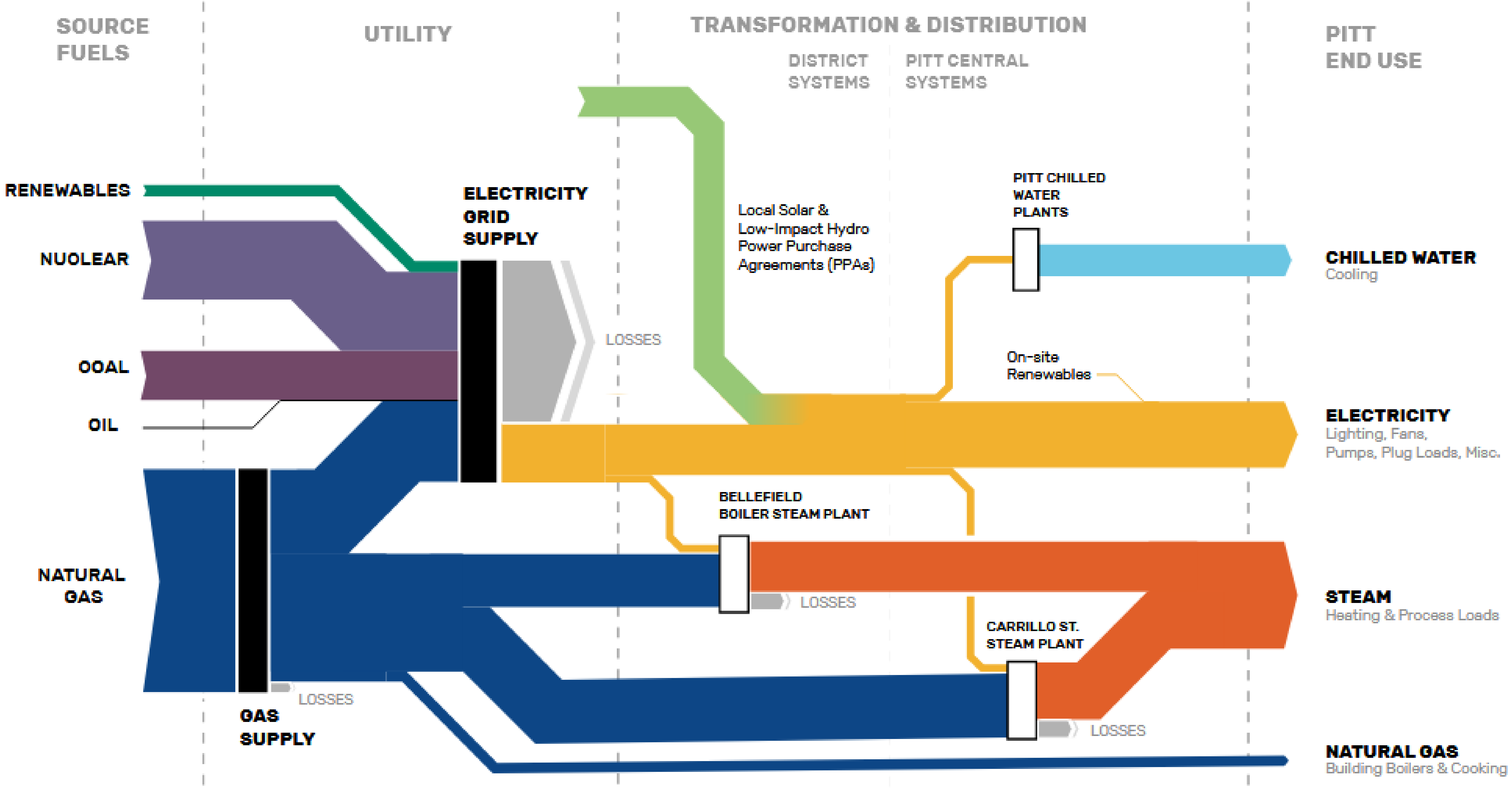
Cambium (NREL) and/or EIA



SUGGESTED OUTPUTS

Pie Charts and Graphs

CAMPUS ENERGY SUPPLY AND DEMAND



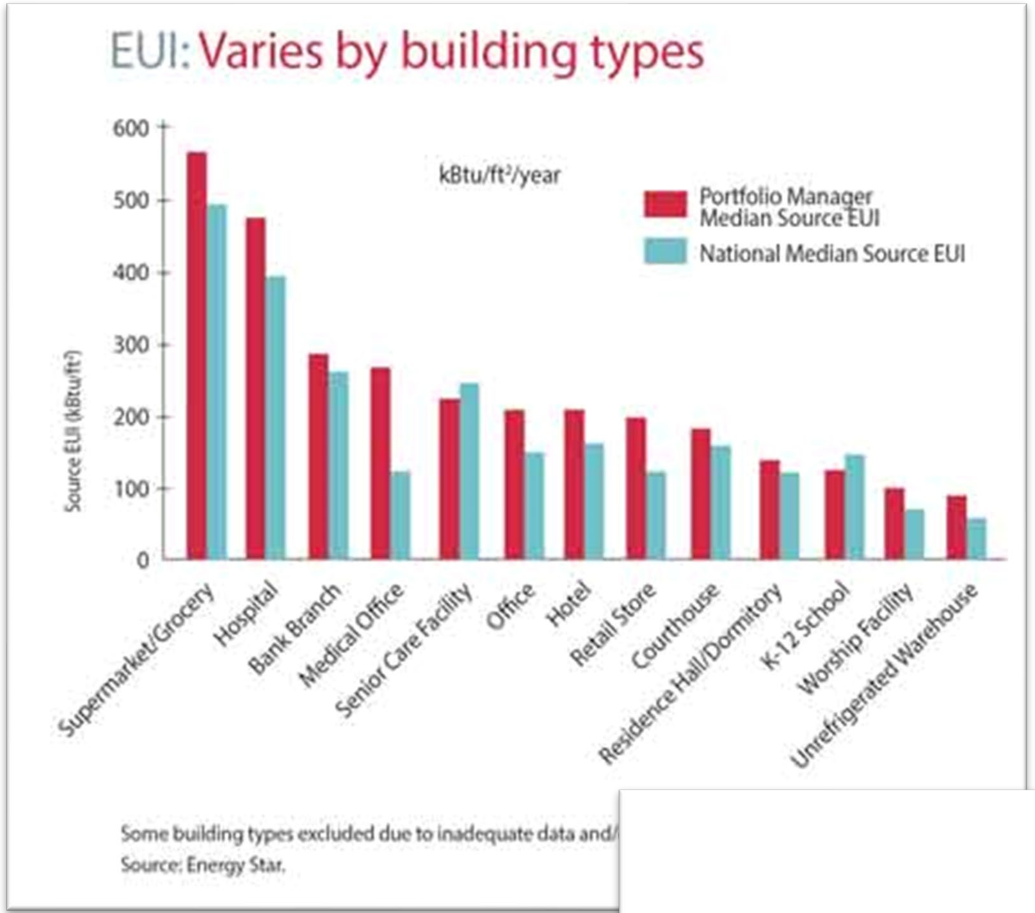
STEP TWO

DEMAND-SIDE SUMMARY

UNDERSTAND HOW BUILDINGS CONSUME ENERGY

Important considerations:

- Break-down of buildings and space by building use and type across campus(es)
- How the existing infrastructure contributes to energy use intensity
- How energy fluctuates across existing building types
- How and where energy clusters may occur
  - Are there groups of buildings that need upgrades around the same time? If so, can we decentralize?



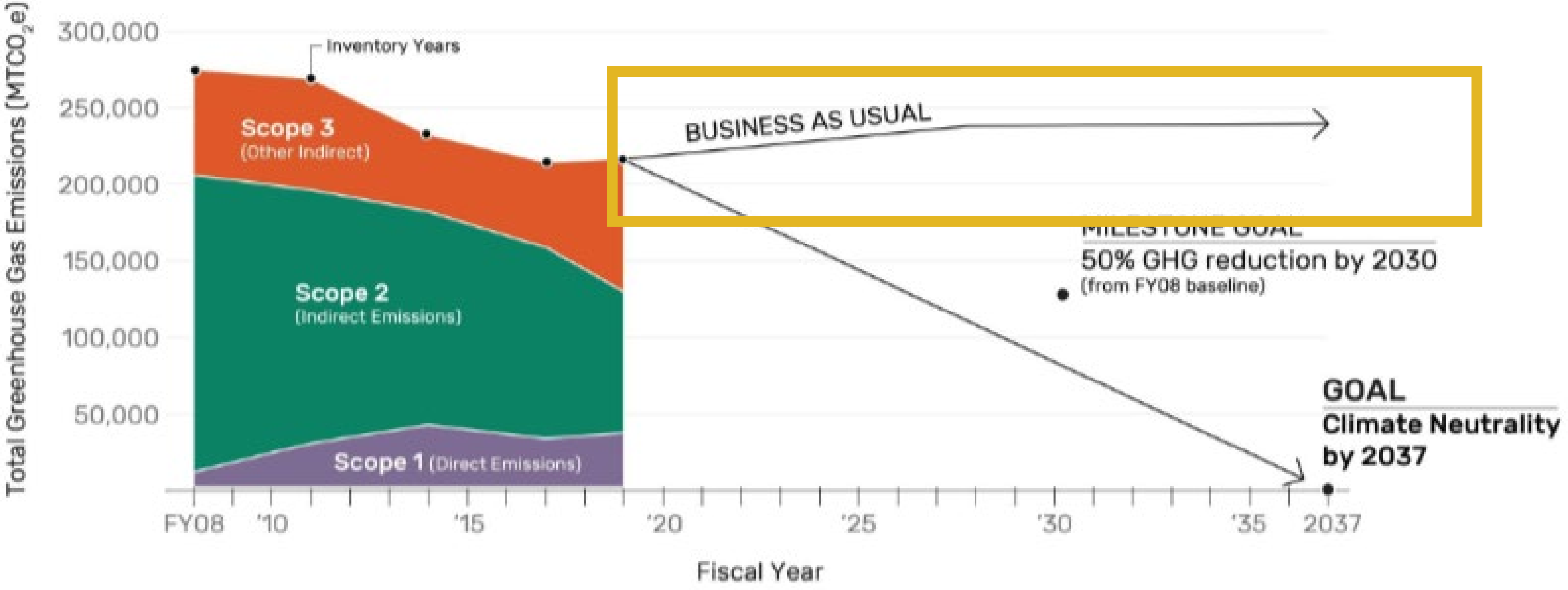
STEP THREE

IDENTIFY FUTURE GROWTH AND IDENTIFIABLE GOALS

ONCE TOTAL SUPPLY AND DEMAND ARE IDENTIFIED, FORECAST WHAT THIS WILL LOOK LIKE IN THE FUTURE

Utilize forecasting tools in Excel and/or Power Bi to understand what future emissions will look like in a business-as-usual scenario.

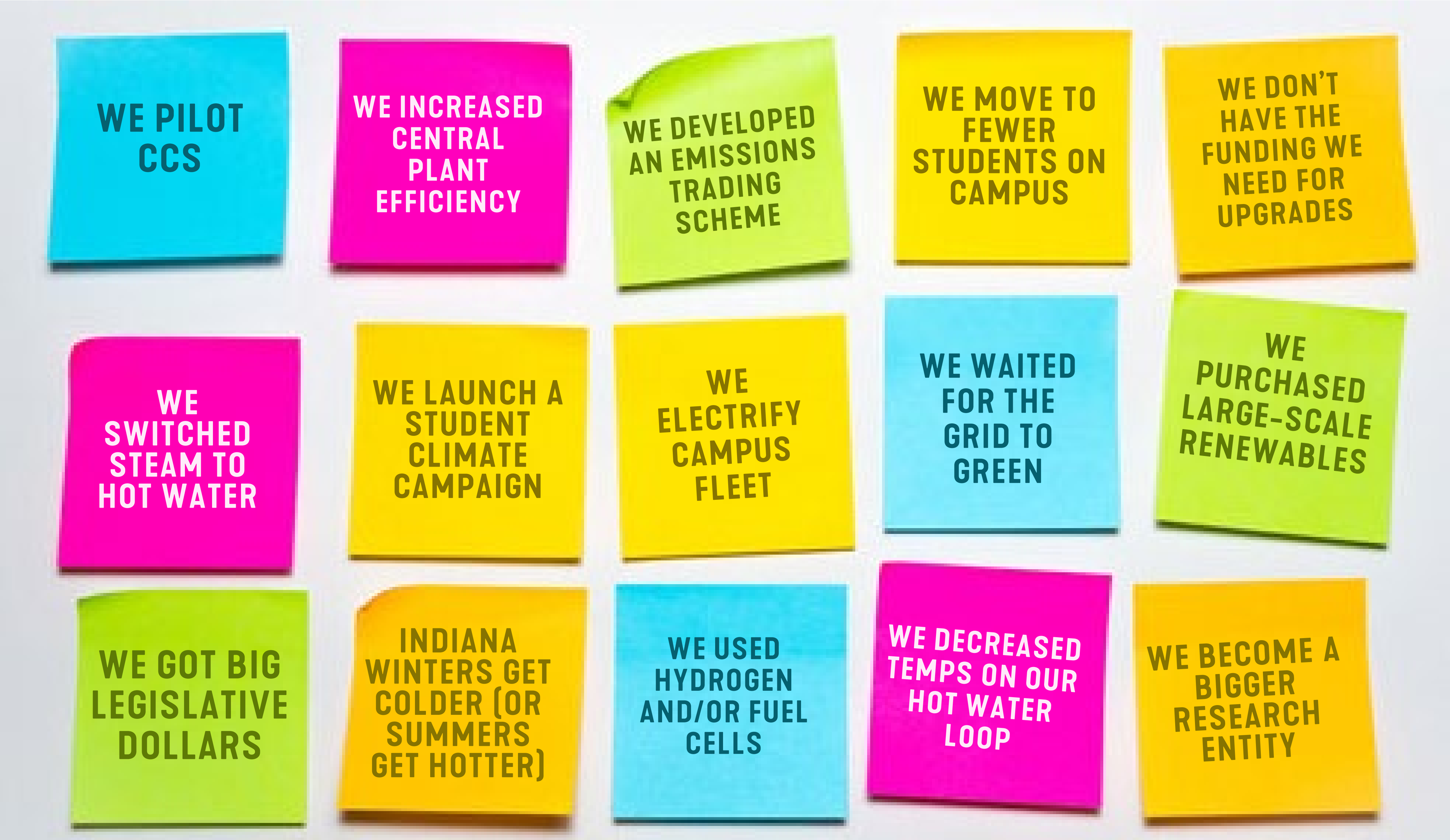
Identify if there is an appropriate rate of decarbonization or forecast out with a % change that is equivalent to population change. When in doubt, you can simply decrease by 2% for normal "efficiency gains"



STEP FOUR

IDENTIFY ALTERNATIVE PATHWAYS

WHAT IF...



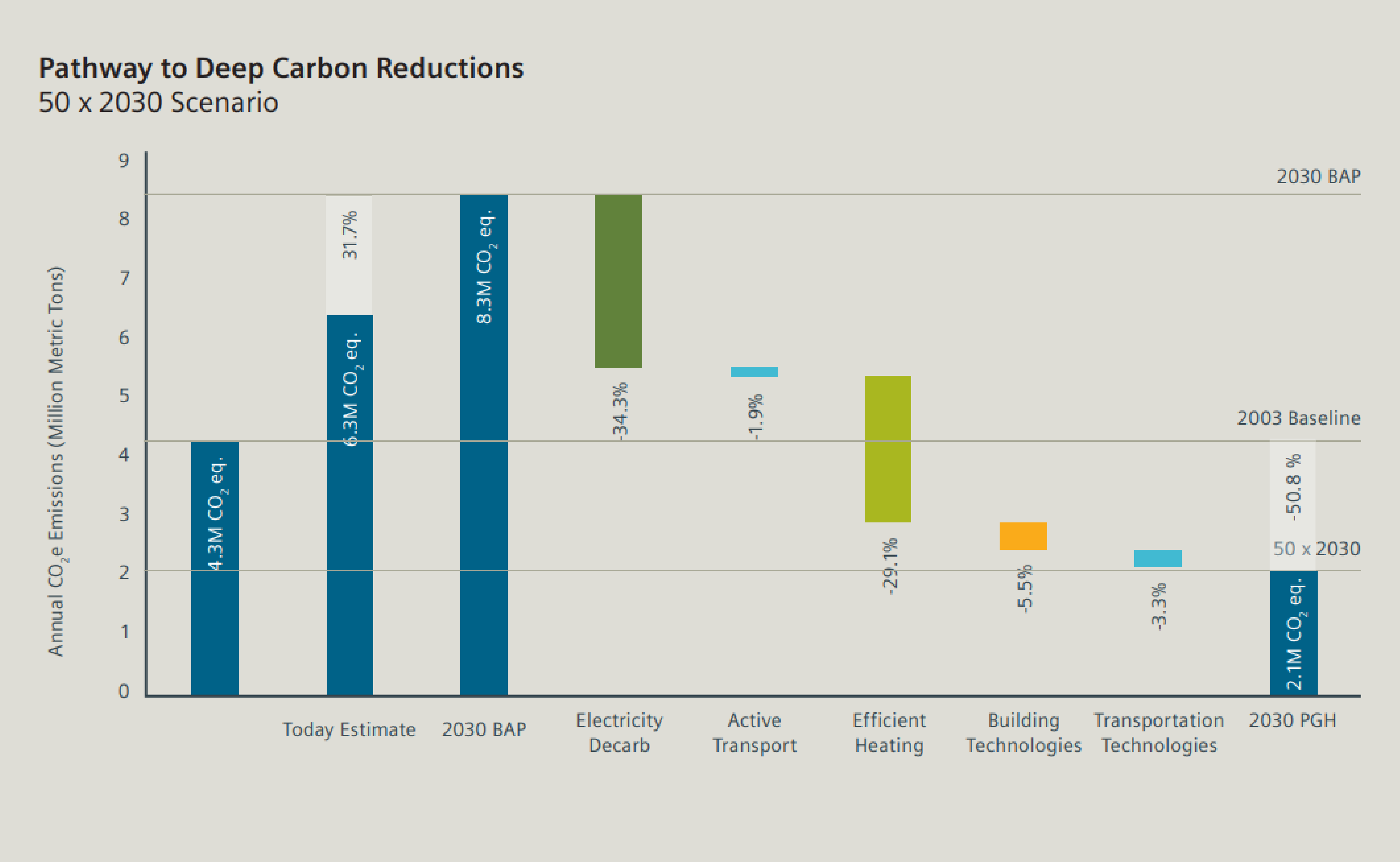
WE PILOT CCS
WE INCREASED CENTRAL PLANT EFFICIENCY
WE DEVELOPED AN EMISSIONS TRADING SCHEME
WE MOVE TO FEWER STUDENTS ON CAMPUS
WE DON'T HAVE THE FUNDING WE NEED FOR UPGRADES
WE SWITCHED STEAM TO HOT WATER
WE LAUNCH A STUDENT CLIMATE CAMPAIGN
WE ELECTRIFY CAMPUS FLEET
WE WAITED FOR THE GRID TO GREEN
WE PURCHASED LARGE-SCALE RENEWABLES
WE GOT BIG LEGISLATIVE DOLLARS
INDIANA WINTERS GET COLDER (OR SUMMERS GET HOTTER)
WE USED HYDROGEN AND/OR FUEL CELLS
WE DECREASED TEMPS ON OUR HOT WATER LOOP
WE BECOME A BIGGER RESEARCH ENTITY

SCENARIO DEVELOPMENT

Here, we need to identify the qualitative changes that could make a big impact, such as:

1. What happens when trying to achieve carbon neutrality or net zero future?
2. What happens if the price of fuel or utility rates increase?
3. Are there any big buildings with planned changes?
4. Big infrastructure projects?

Identify different scenarios and start to develop stories around them.

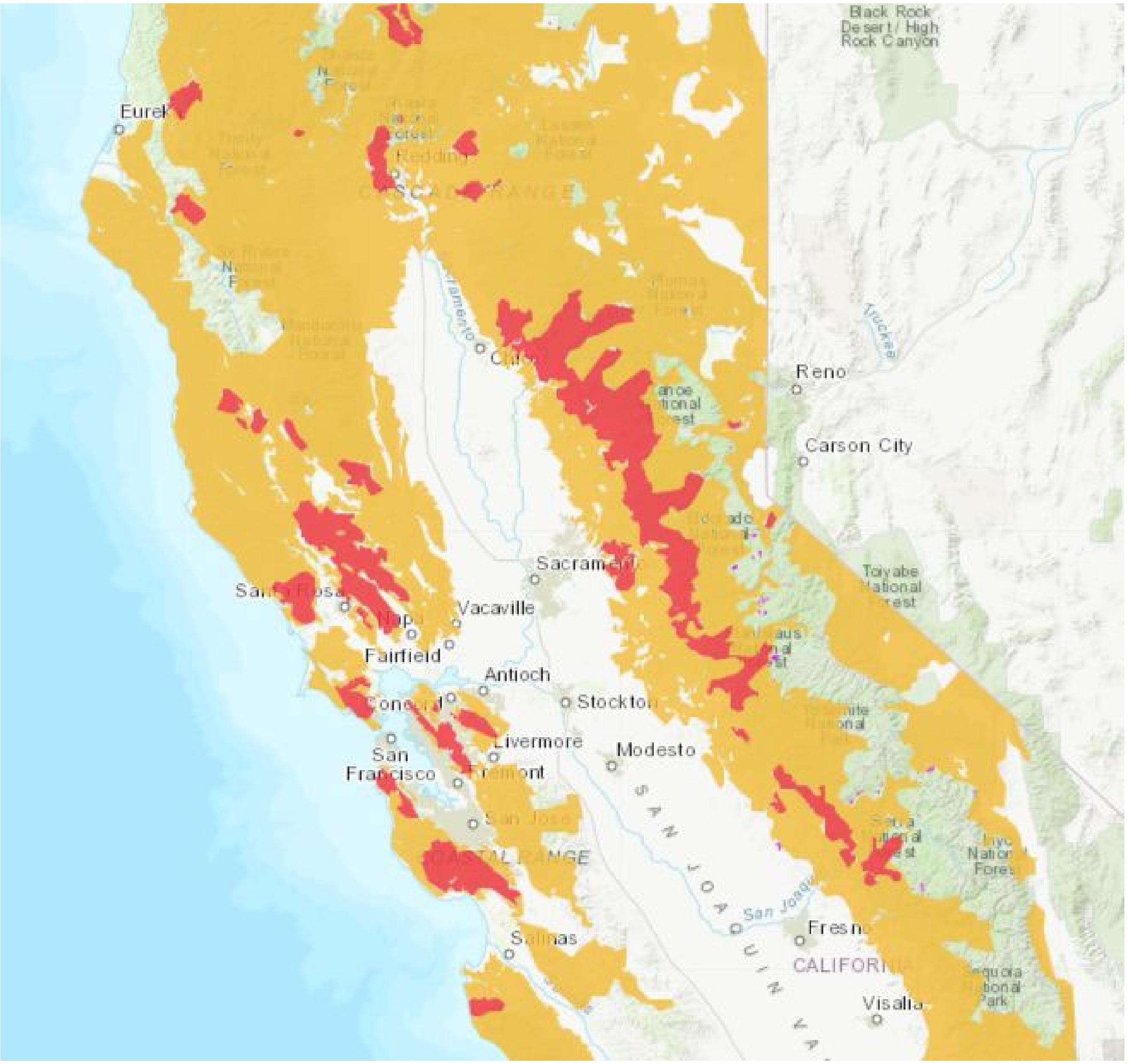


STEP FIVE

DEEP DIVING INTO BUILDINGS

ADMINISTRATIVE BUILDING

RESILIENCE SCENARIOS AND EQUIPMENT OPTIONS



The following is a real-world example of energy resiliency and high-level cost estimation for a project in Southern California. Client, project, and bidder names have been redacted.

0-5 Day
Outage Duration

RENEWABLE ENERGY GENERATION

ENERGY STORAGE

BACK-UP GENERATORS

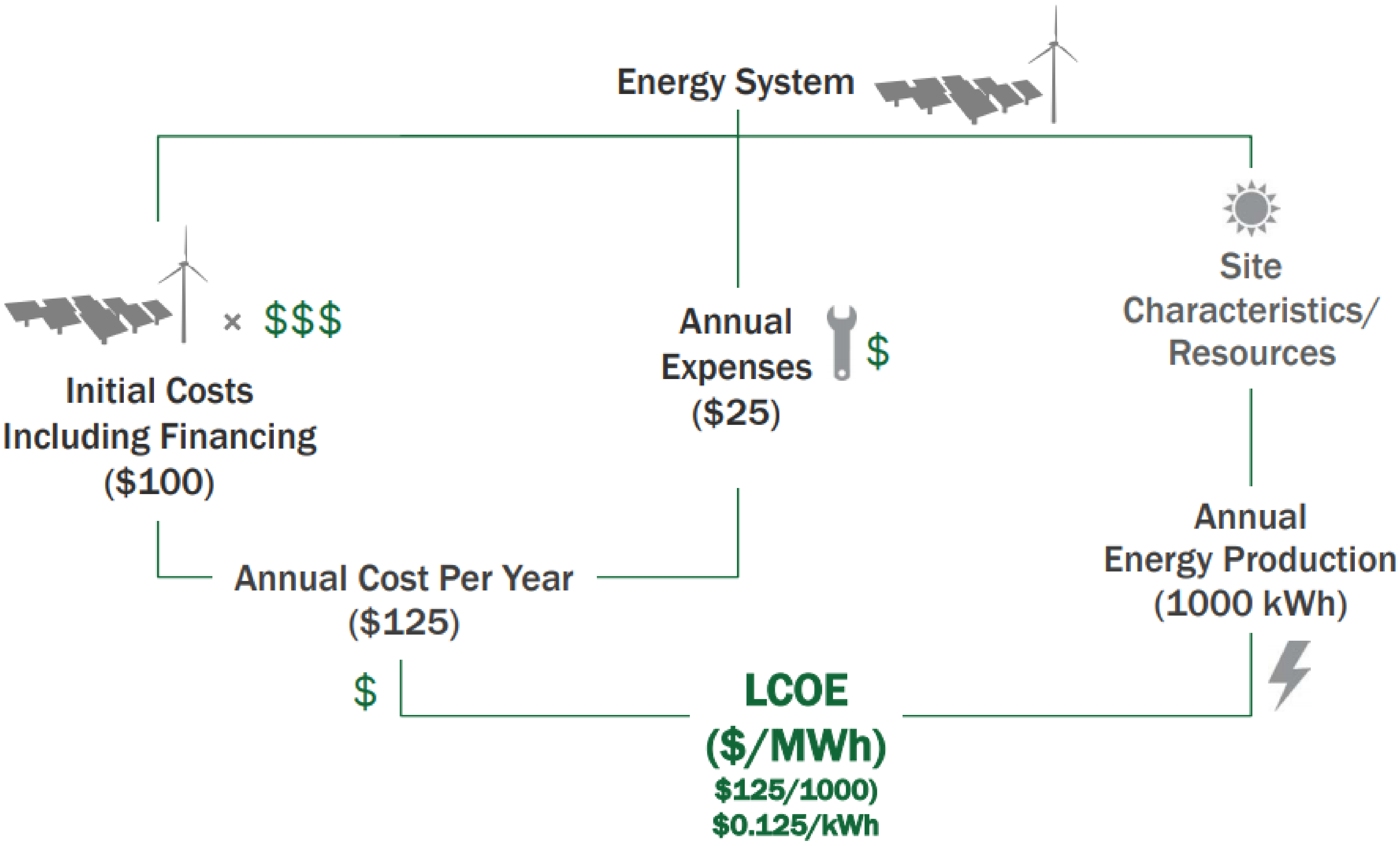
ADMINISTRATIVE BUILDING

EVALUATION CRITERIA

LEVELIZED COST OF ENERGY (LCOE)

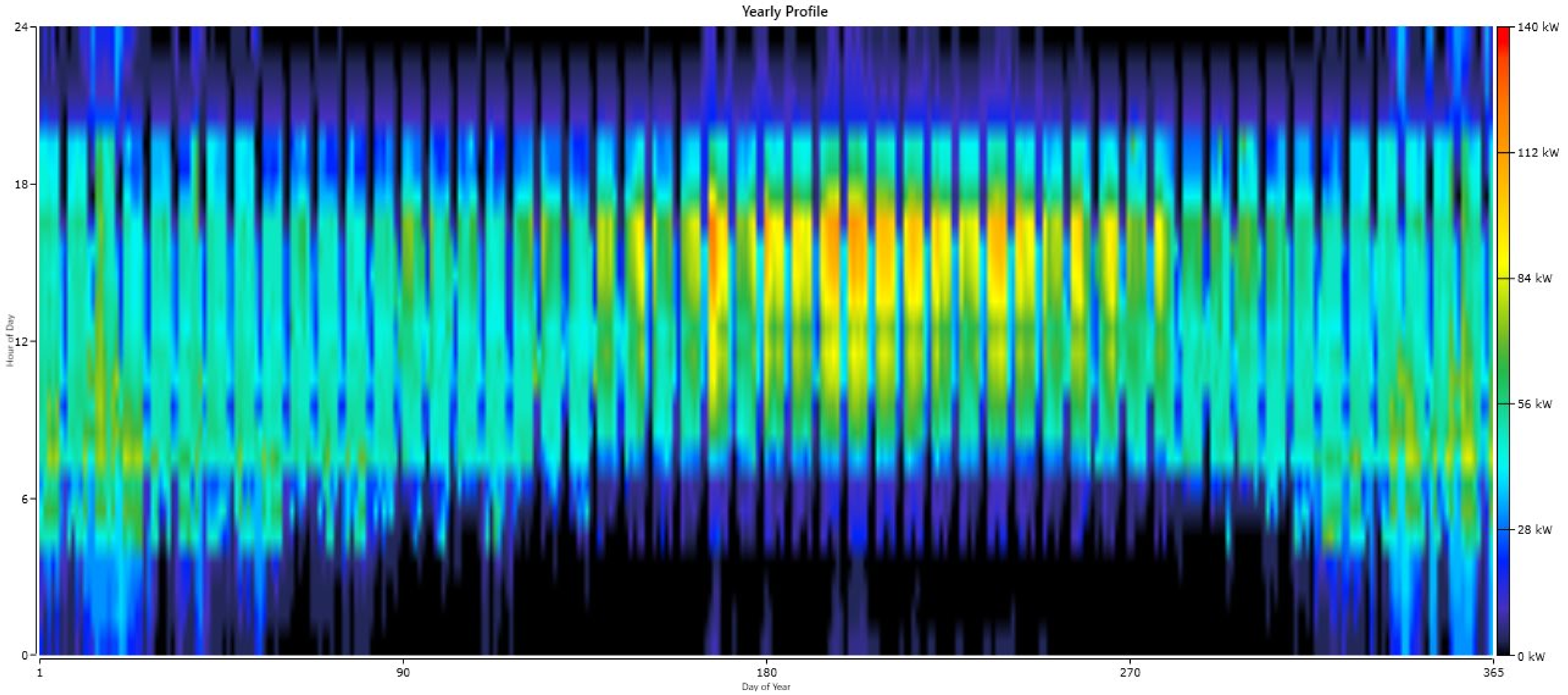
Allows comparison of total cost for assets with different lifespans and O&M costs

- Carbon Emissions
- % Renewable Energy
- Initial Investment
- Simple Payback



ADMINISTRATIVE BUILDING

ENERGY USE PROFILE – CUSTOM TO ADMINISTRATIVE BUILDING



ADMINISTRATIVE BUILDING

SUMMARY: INITIAL OPTIMIZATION VS UPDATED COST FROM COST ESTIMATOR

LIFE CYCLE COST ANALYSIS**

- 2% Escalation
- 8% Discount Rate
- Includes O&M, Battery Cycling Degradation

RESILIENCE: ALL BACKUP SCENARIOS ARE MODELED AGAINST A 130KW GENERATOR

- Assumes 24hr notice of power shutoff
- Assumes outage of noted duration occurs every year.

UPDATE:

- Updated the initial capital cost based on Cost Estimator's $/kw for PV and $/kwh for Batteries.

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ADMINISTRATIVE BUILDING

SUMMARY: INITIAL OPTIMIZATION VS UPDATED COST FROM COST ESTIMATOR

	System Info			HOMER Model				Cost Estimate (From Cost Estimator)			Delta
	Resilience Backup (consecutive days)	PV (kW DC)	Battery (kWh)	Initial Capital Modeled (2020 USD)	Simple Payback (# years)	Levelized Cost of Energy (2020 USD)	Internal Rate of Return (%)	PV Cost (2020 USD)	Battery Cost (2020 USD)	Cost Estimator Total (2020 USD)	Delta (HOMER – Cost Estimate)
Updated Model	**0**	**205**	**0**	**$443,636**	**12**	**$0.0934**	**-**	**$443,620**	**-**	**$443,620**	**$16**
	1	205	59	$517,204	12.3	$0.1240	6.8%	$443,620	$91,450	$535,070	$(17,866)
	2	**352**	**195**	**$1,010,000**	**17**	**$0.1050**	**3.6%**	**$754,688**	**$242,580**	**$997,268**	**$12,732**
	3	311	197	$933,146	20	$0.1270	2.5%	$700,061	$245,068	$945,129	$(11,983)
	4	**393**	**216**	**$1,130,000**	**14**	**$0.0990**	**3.9%**	**$841,806**	**$263,952**	**$1,105,758**	**$24,242**
	5	414	316	$1,300,000	23	$0.1230	1.3%	$872,712	$375,724	$1,248,436	$51,564

SUMMARY

The following options give the lowest **Levelized Cost of Energy**; beating the $0.11/kWh current cost

- 0 – Day Resilience, Net Zero Energy ($0.0934/kWh)
- 2 – Day Resilience, Net Positive Energy ($0.105/kWh)
- 4 – Day Resilience, Net Positive Energy ($0.0990/kWh)

All systems are compared against a 130kw Generator ($135,000).

HOMER is used to assess costs for energy use. IU R&R and references will be used to understand factors such as:

- Operational change impacts
- Sustained reinvestment
- Changes in funding sources
- Changes in efficient

ENERGYCAP

BUILDING ENERGY DATA COLLECTION

Indiana University Enterprise — Summary by Commodity

Cougar Center [KO871]

ACADEMIC Primary Use	5,285 SqFt Floor Area	2725 S Lafountain St Kokomo, IN, US 46904-9003 Address
Building Place Type	01/01/1989 Build Date	

Energy Use Percentage

Cost Percentage

	Commodity Use			Energy Use			Cost	
	Use	Use Per Area	Unit Cost	Use	Use Per Area	Unit Cost	Cost	Cost Per Area
Electric	14,133 kWh	2.674 kWh/SqFt	$0.143 /kWh	48 MMBtu	0.009 MMBtu/SqFt	$42.014 /MMBtu	$2,026	$0.38 /SqFt
Natural Gas	174 DKTHM	0.033 DKTHM/SqFt	$9.424 /DKTHM	174 MMBtu	0.033 MMBtu/SqFt	$9.424 /MMBtu	$1,639	$0.31 /SqFt
Sewer	70 Kgal	0.013 Kgal/SqFt	$6.400 /Kgal	0 MMBtu	0.000 MMBtu/SqFt	$0.000 /MMBtu	$448	$0.08 /SqFt
Water	63 Kgal	0.012 Kgal/SqFt	$8.326 /Kgal	0 MMBtu	0.000 MMBtu/SqFt	$0.000 /MMBtu	$527	$0.10 /SqFt
Fire Protection							$59	$0.01 /SqFt
Storm							$41	$0.01 /SqFt
Total				222 MMBtu	0.042 MMBtu/SqFt		$4,740	$0.89 /SqFt

Indiana University Enterprise — Report-26 - Use and Cost Summary

Use and Cost Summary by Building and Commodity

Commodity	#Days	Use	UOM	Demand	UOM	Cost	Cost/Day	Cost/Unit
Building Total	**3224**	**280,944.26**	**MMBtu**			**$5,927,460**	**$1,838.54**	**$21.098**
1000 N Indiana Ave [BL402N]								
RENTALS (Primary Use); Building (Place Type)	391 SqFt (Floor Area); 01/01/1979 (Build Date)					1000 N Indiana Ave, Bloomington, IN, US 47408 (Address)		
Electric [ELECTRIC]	1004	8,063.00	kWh			$1,502	$1.50	$0.186
Building Total	**1004**	**27.51**	**MMBtu**			**$1,502**	**$1.50**	**$54.598**
1000 WATERWAY BLDG [IN001L]								
ACADEMIC (Primary Use); Building (Place Type)	30,012 SqFt (Floor Area); 01/01/2002 (Build Date)					1000 WATERWAY BLVD, Indianapolis, IN, US 46202 (Address)		
Electric [ELECTRIC]	390	145,920.00	kWh	50.00	kW	$20,643	$52.93	$0.141
Water [WATER]	3459	928.91	Kgal			$5,587	$1.62	$6.014
Sewer [SEWER]	3459	311.23	Kgal			$7,849	$2.27	$25.220
Natural Gas [NATURALGAS]	3651	9,330.91	DKTHM			$40,252	$11.02	$4.314
Building Total	**3651**	**9,828.79**	**MMBtu**			**$74,331**	**$20.36**	**$7.563**
1001 E SR 45 46 BYP [BL605N]								
ACADEMIC (Primary Use); Building (Place Type)	2,618 SqFt (Floor Area); 01/01/1947 (Build Date)					1001 E SR 45 46 BYP, Bloomington, IN, US 47408 (Address)		
Electric [ELECTRIC]	2678	143,668.00	kWh	0.00	kW	$18,203	$6.80	$0.127
Water [WATER]	2190	162.00	Kgal			$1,206	$0.55	$7.443
Natural Gas [NATURALGAS]	2332	718.85	DKTHM			$6,196	$2.66	$8.619
Storm Drainage [STORMDRAIN]	2190					$318	$0.15	
Fire Protection [FIREPROTECTION]	2190					$348	$0.16	

For all campuses:

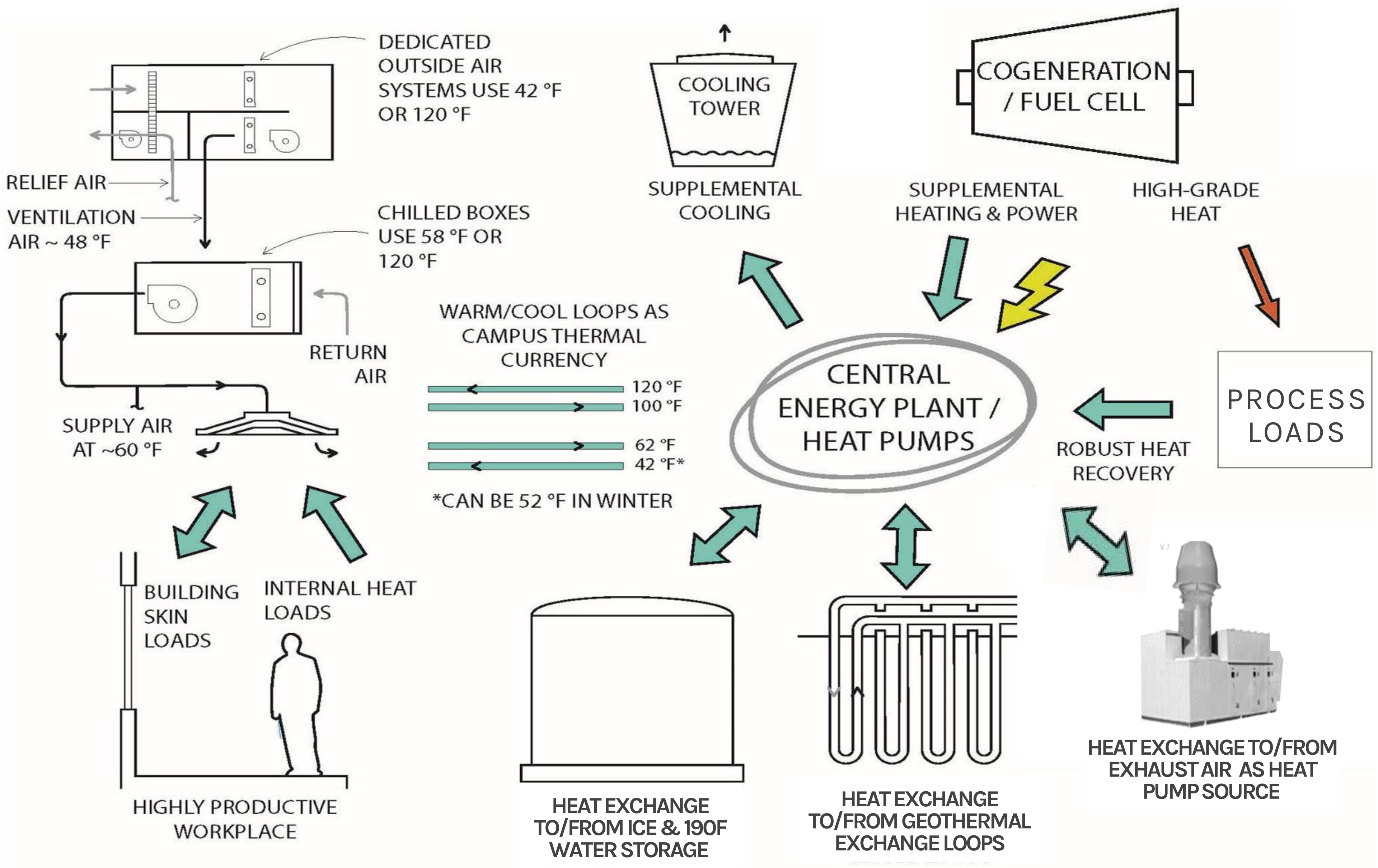
- Building
- Building ID
- Gas
- Steam
- Electricity
- Water
- EUI
- GHG

STEP SIX

INCORPORATE THE POLICY-PLANNING AND FINANCING

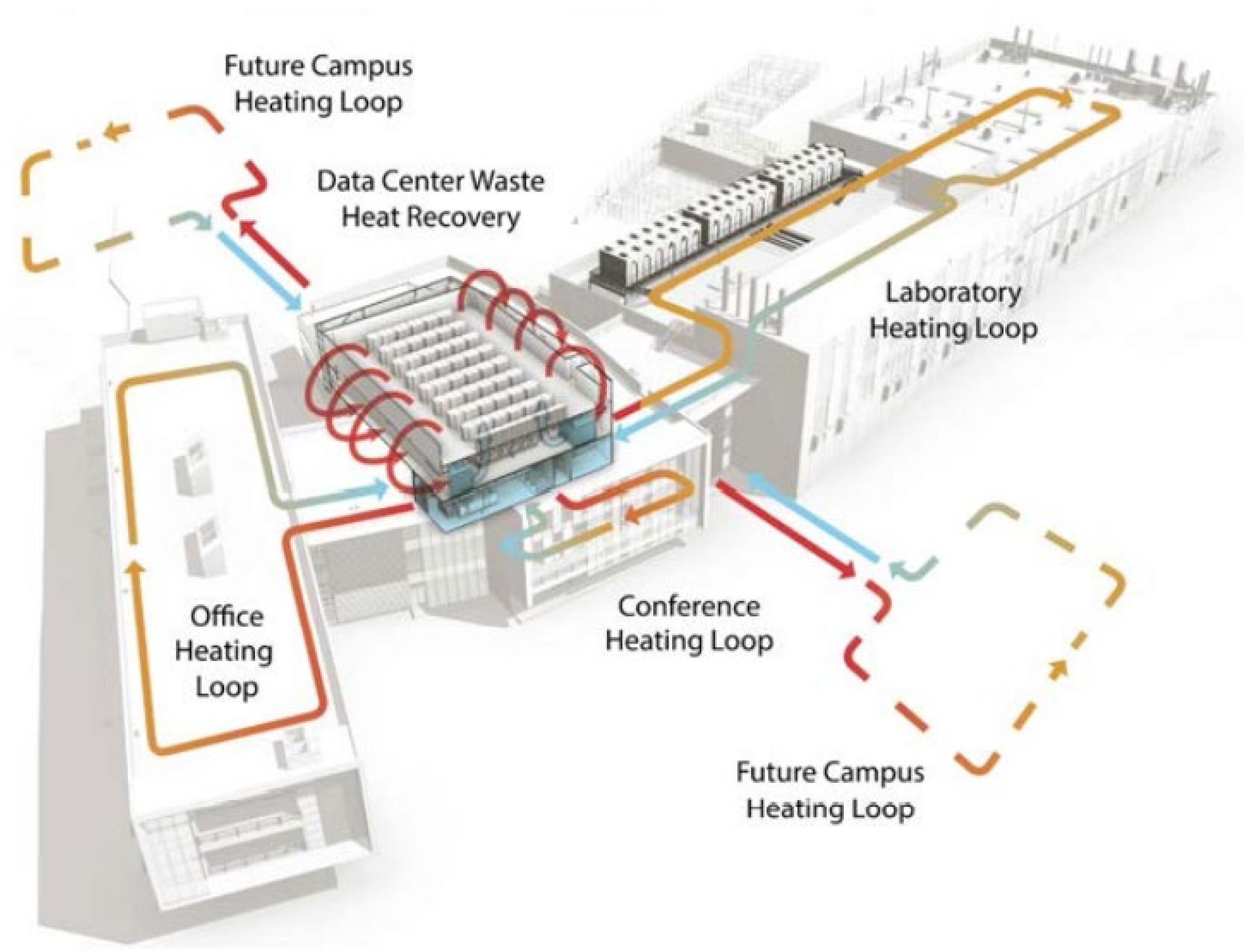
"THERMAL CURRENCY" FOR LARGE CAMPUS

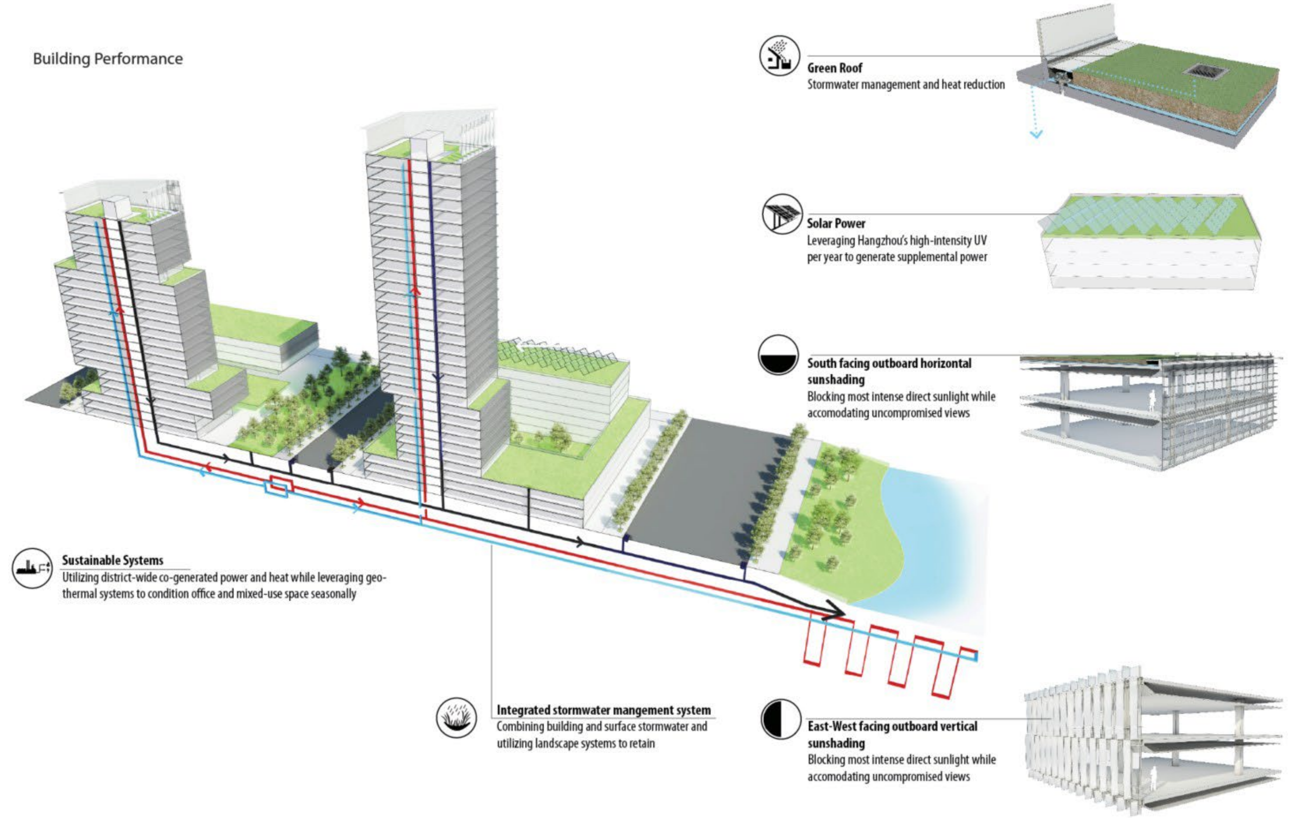
WARM & COOL WATER LOOPS

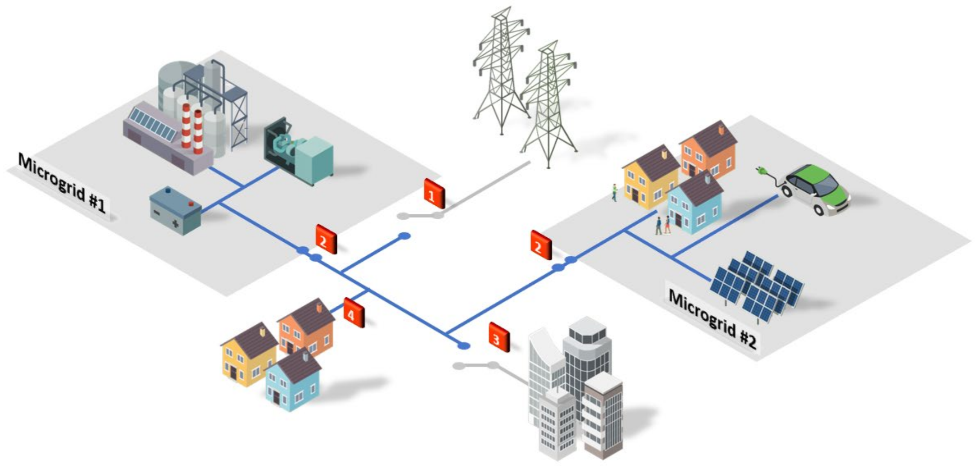


Ford Dearborn Master Plan

DISTRICT OR CAMPUS LOOP-LEVEL CHANGES







Pittsburgh 2030
Climate Action Plan Scenario

2.2M

Potential CO_2eq Reduction (in metric tons) as compared to 2030 BAP

27.9%

Potential CO_2eq Reduction (%) as compared to 2030 BAP

$5B

Capital and Operating Expenditures between Today and 2030

47K

Full-time Equivalents Generated between Today and 2030

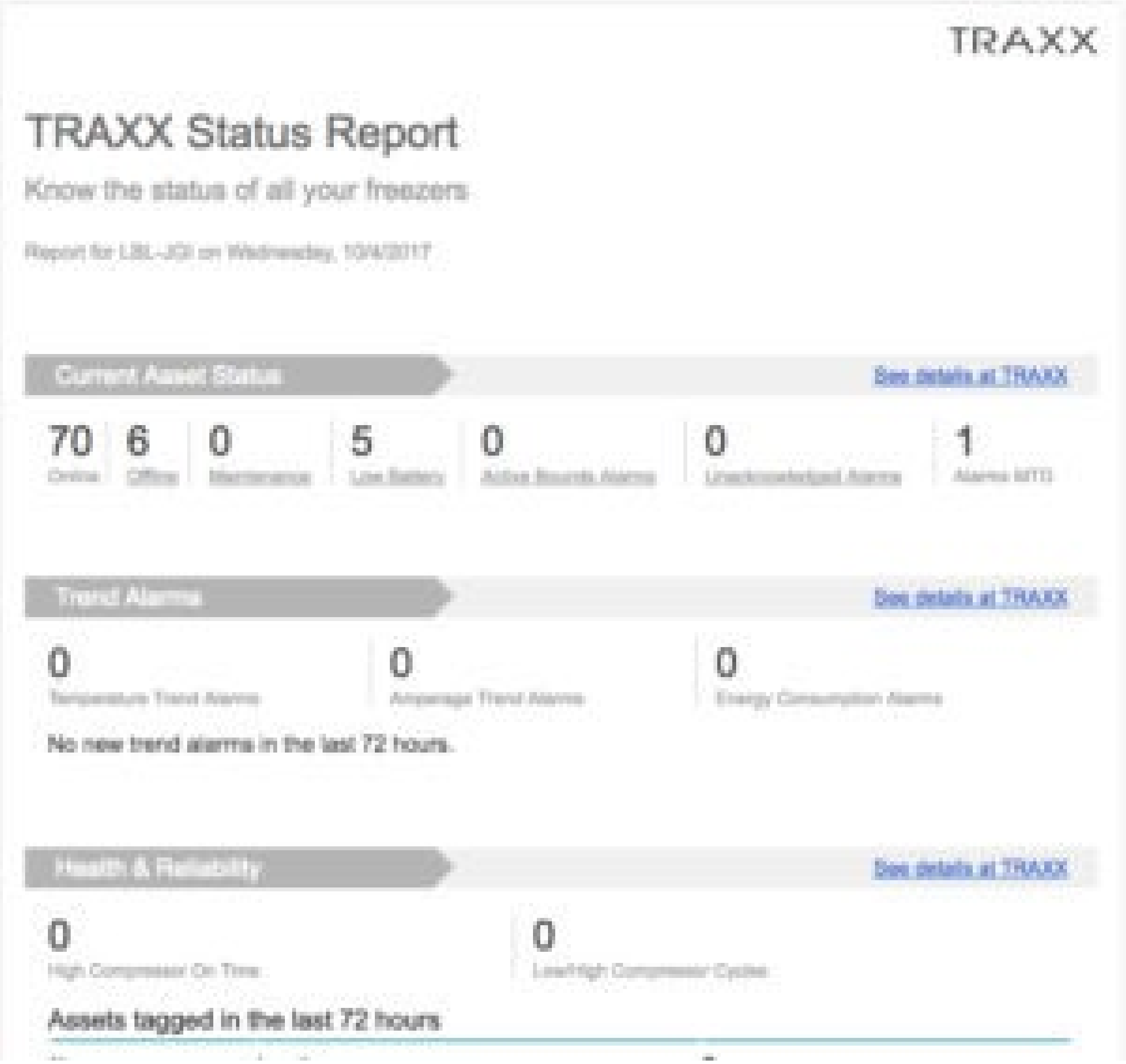
INITIATIVES

FROM PREVIOUS COMMITTEE MEETING DISCUSSIONS

LOW HANGING OPPORTUNITIES – OPERATIONAL & MAINTENANCE

October 26, 2022

- Thermostat Setpoint Adjustments (Cautiously)
- Space Utilization Informed Class Scheduling – Tighter "open hours"
- Student Dorm Shower Head Replacements
- Lavatory Aerator Replacement
- Refrigeration Monitoring
  — (Commercial kitchen and Industrial)
- SmartPlug Strips with Motion Sensors to power Monitors
- Laptops in lieu of Desktops
- Fume Sash Closers



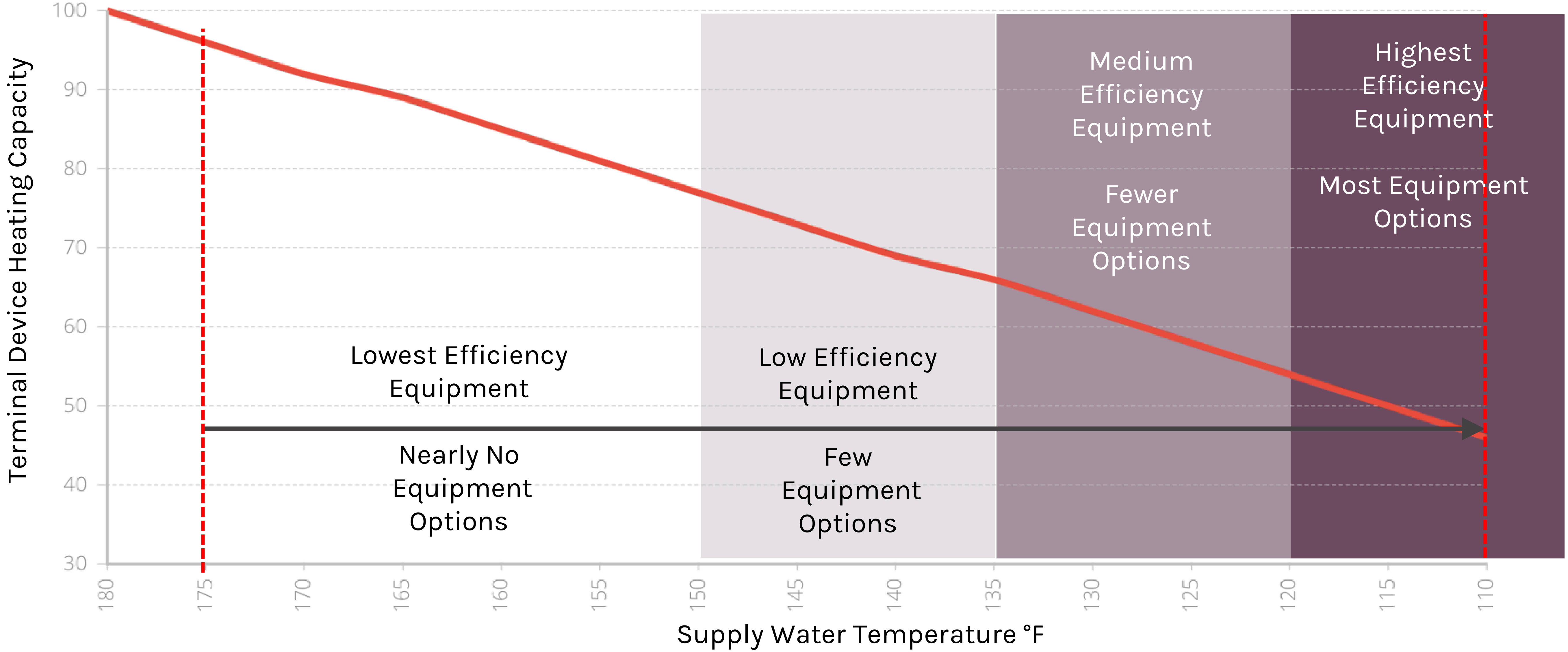
LOW HANGING OPPORTUNITIES – STUDIES AND DEMONSTRATIONS

- Wintertime Heating Hot Water Supply Temperature Stress Test @ sample Bld
  - Enabling Low Entropy Conversions
- Commercial Kitchen Energy Star Equipment Replacement Program
- Commercial Kitchen Heat Pump Water Heater Demonstration
- Investigate Utility Options for Bio-Gas & Renewable Gas

WINTERTIME STRESS TEST

October 26, 2022

HHWS TEMPERATURE REGIME TEST → REDUCING INVESTMENT COSTS



LOW HANGING OPPORTUNITIES – STUDENT ENGAGEMENT

- Establishment of a Student-Run Sustainability Fund for EEM Projects
  - Seed Money; Revolving-funding through savings
- Student Run Energy Audits
  - IR Themography, Blower door Tests, etc.
- Energy Dashboards

- Solar Device Charging Station Design Competition & Fabrication


FINANCIAL TOOLS TO MAKE IT HAPPEN

October 26, 2022

UPCOMING OPPORTUNITIES IN THE IRA TAX BILL – DIRECT GRANT PAYMENTS

		179D Commercial Building Energy Tax Deduction	Modified Accelerated Cost Recovery System	Bonus Depreciation	Business Energy Investment Tax Credit	Renewable Energy Production Tax Credit	Rural Energy for America Program Grants
Basic Project Attributes	Project Type	New Construction	New Construction	New Construction	New Construction	New Construction	New Construction
		Retrofits	Retrofits	Retrofits	Retrofits	Retrofits	Retrofits
	Eligible Technology	Energy Efficiency	Energy Efficiency	Energy Efficiency	Energy Efficiency	Renewables	Energy Efficiency
			Renewables	Renewables	Renewables		Renewables
			Energy Storage	Energy Storage	Energy Storage		
	Eligibility Notes	Envelope, HVAC, Hot Water, Lighting	Equipment or property must largely be used for commercial purposes	Recovery Period for depreciation must be less than 20 years	Technology Dependent	As of 2022, only applicable to wind energy	Only available to Rural Businesses or Agricultural Producers

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	Eligible Technology	Energy Efficiency	Energy Efficiency	Energy Efficiency	Energy Efficiency	Renewables	Energy Efficiency
			Renewables	Renewables	Renewables		
			Energy Storage	Energy Storage	Energy Storage		Renewables
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FOR IU CAP COMMITTEE USE ONLY

INDIANA UNIVERSITY SMITHGROUP

BUILDING A FRAMEWORK

November 15, 2022

Energy Efficiency & Upgrades	Programming & Operations	Campus Systems (Larger Lift)	Vehicle Fleet (Medium Lift)	Learning, Research, Participation, and Innovation	Funding Strategies
Student Dorm Shower Head Replacements Lavatory Aerator Replacement Refrigeration Monitoring (Commercial kitchen and Industrial) SmartPlug Strips with Motion Sensors to power Monitors Laptops in lieu of Desktops Fume Sash Closers	Space Utilization Informed Class Scheduling – Tighter "open hours" Thermostat Setpoint Adjustments (Cautiously)	Heat Recovery Retrofits • Air-to-Air • DHW – CHWR • WasteWater Heat Recovery Heat Pump Conversions (Including Dual-Fuel) District Energy Cluster Conversions Solar-Battery Microgrids – Non-exporting BioGas & Solar Procurement via utilities	Encourage carpooling, transit, biking, and walking Replace eligible internal combustion engine vehicles with electric vehicles (buses, trucks, vehicles, maintenance equipment including landscape services) Electric Vehicle Charging (Fleet)	Establishment of a Student-Run Sustainability Fund for EEM Projects Seed Money; Revolving-funding through savings Student Run Energy Audits IR Themography, Blower door Tests, etc. Energy Dashboards	To Be Discussed in Future Meetings

STARTING INITIATIVES

1. Replacing traditional fixtures with LED lighting
2. Installing motion sensors
3. Installing utilities meters at individual buildings
4. Retro-commissioning
5. Electrifying grounds maintenance equipment
6. Consistent building set points

DISCUSSION

WHAT'S NEXT?