University of Dayton Carbon Neutrality Efforts

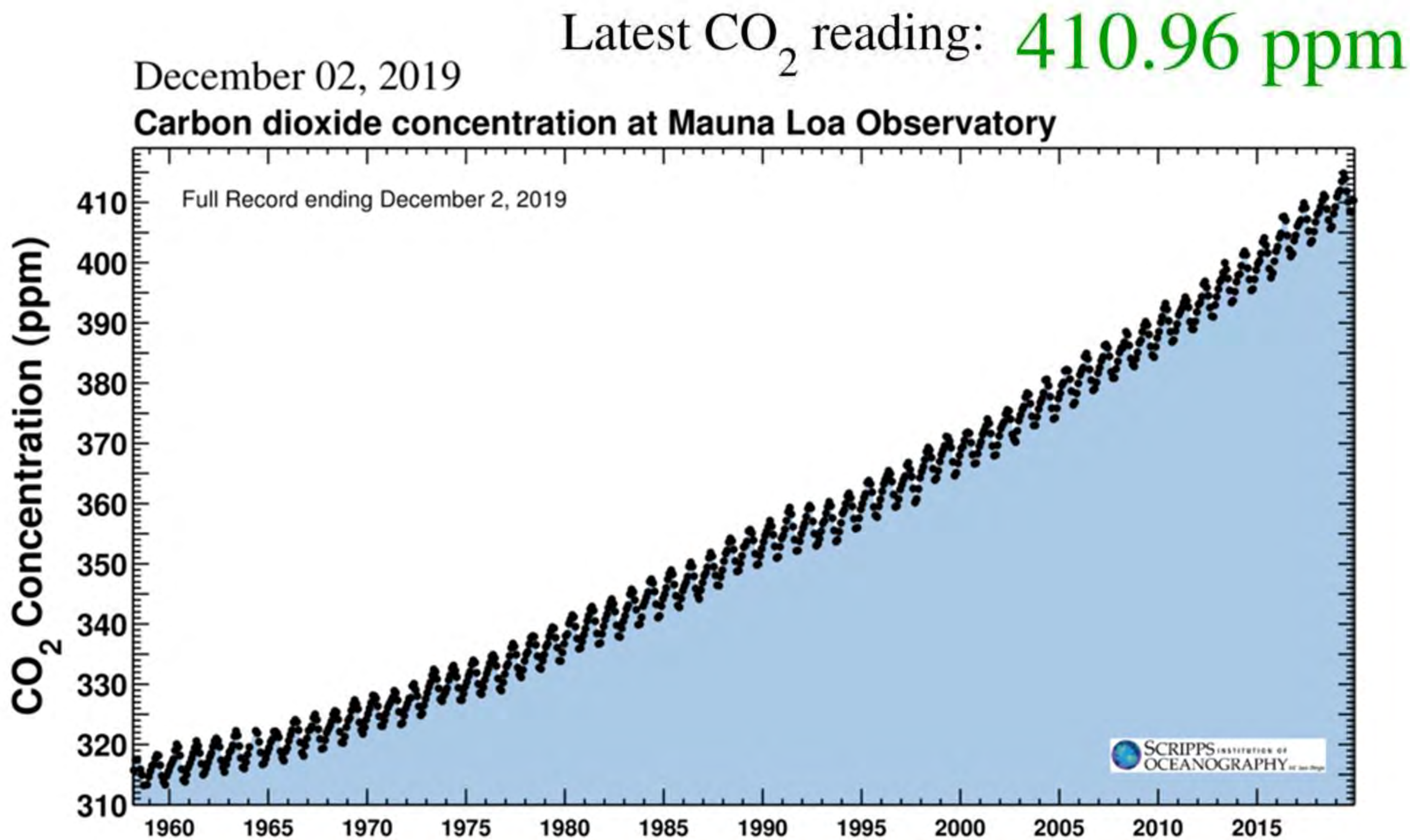
Ben McCall
Matthew Worsham

MVRPC Sustainability Roundtable
December 4, 2019

University of Dayton

Motivation

Why We're Here



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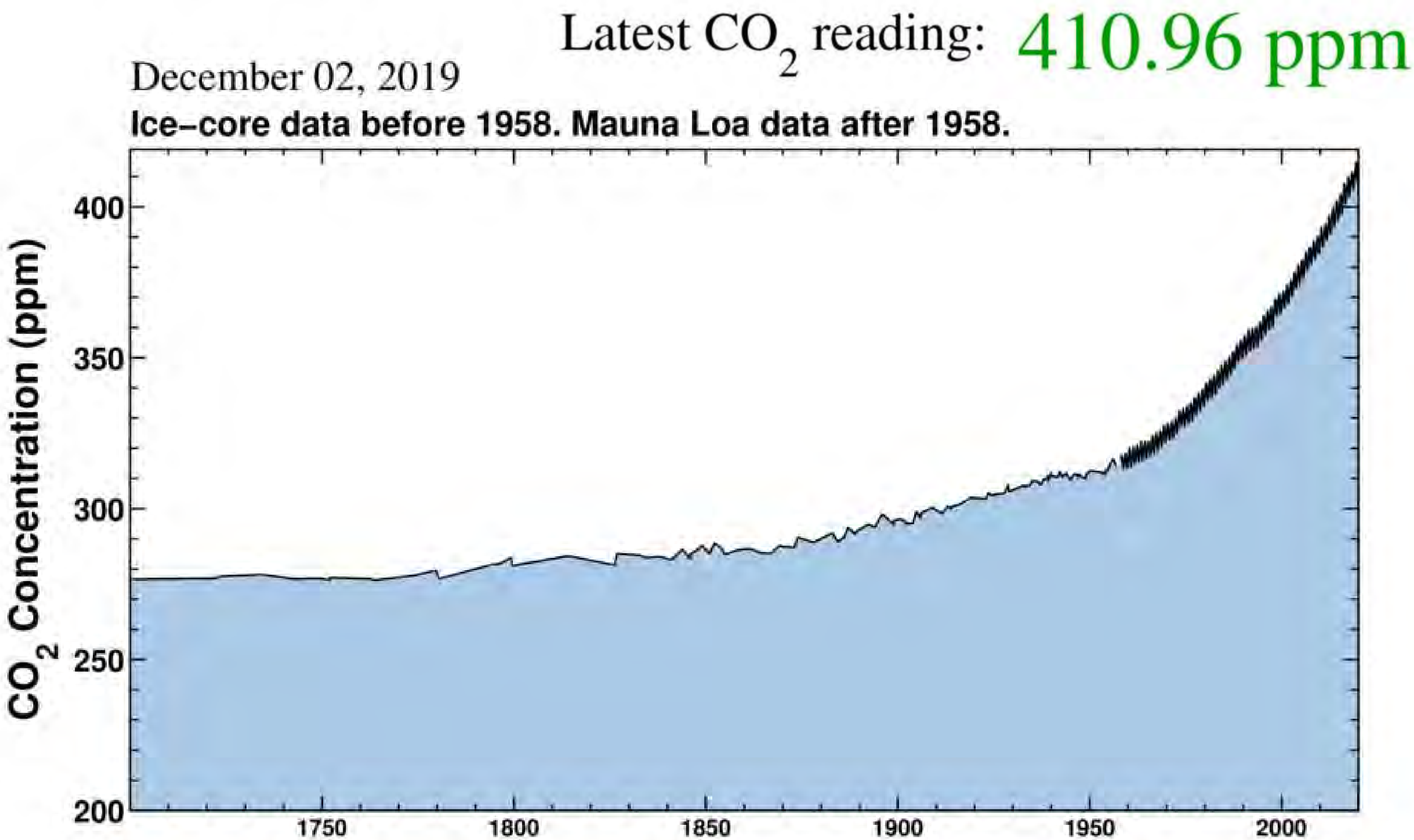

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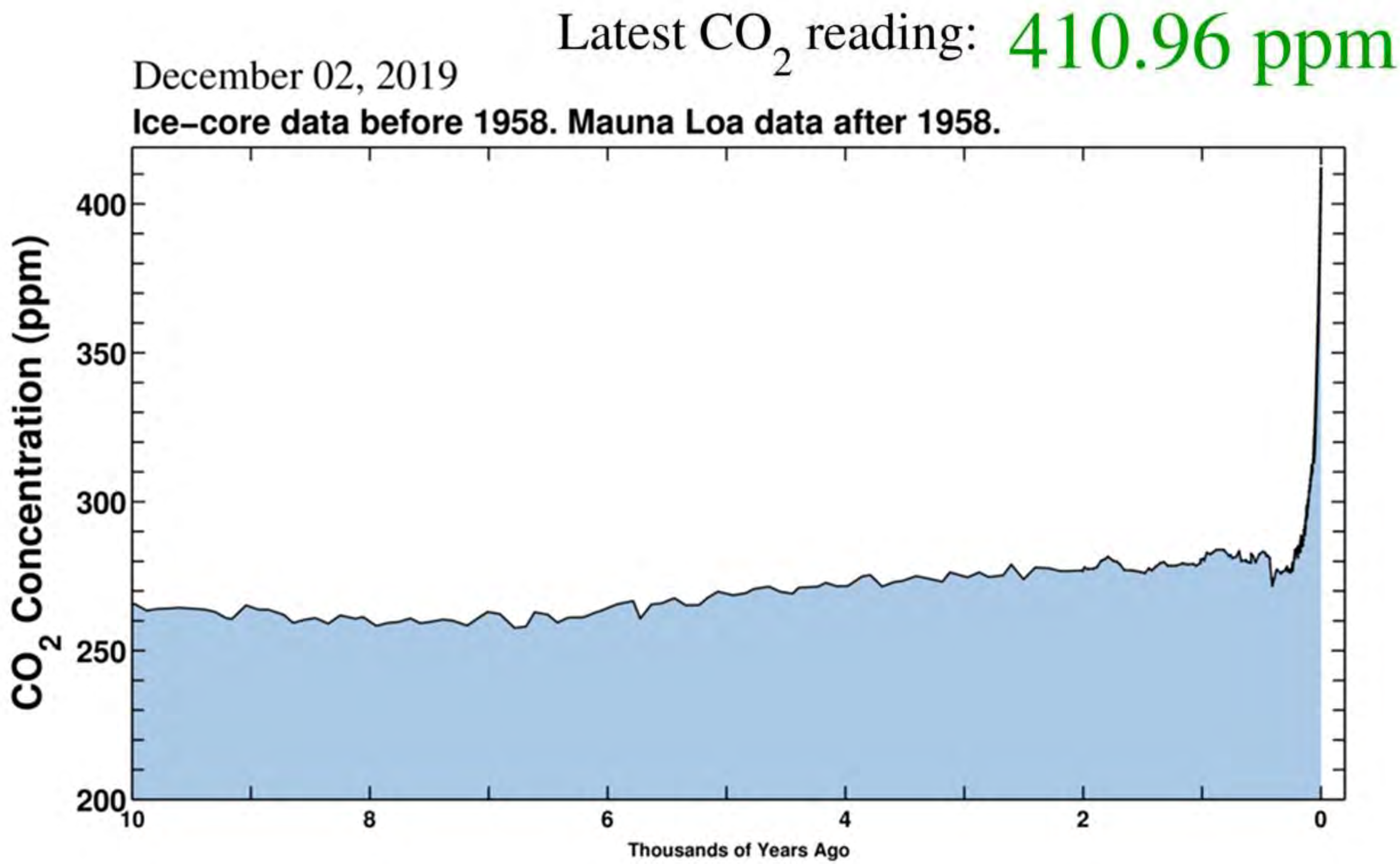

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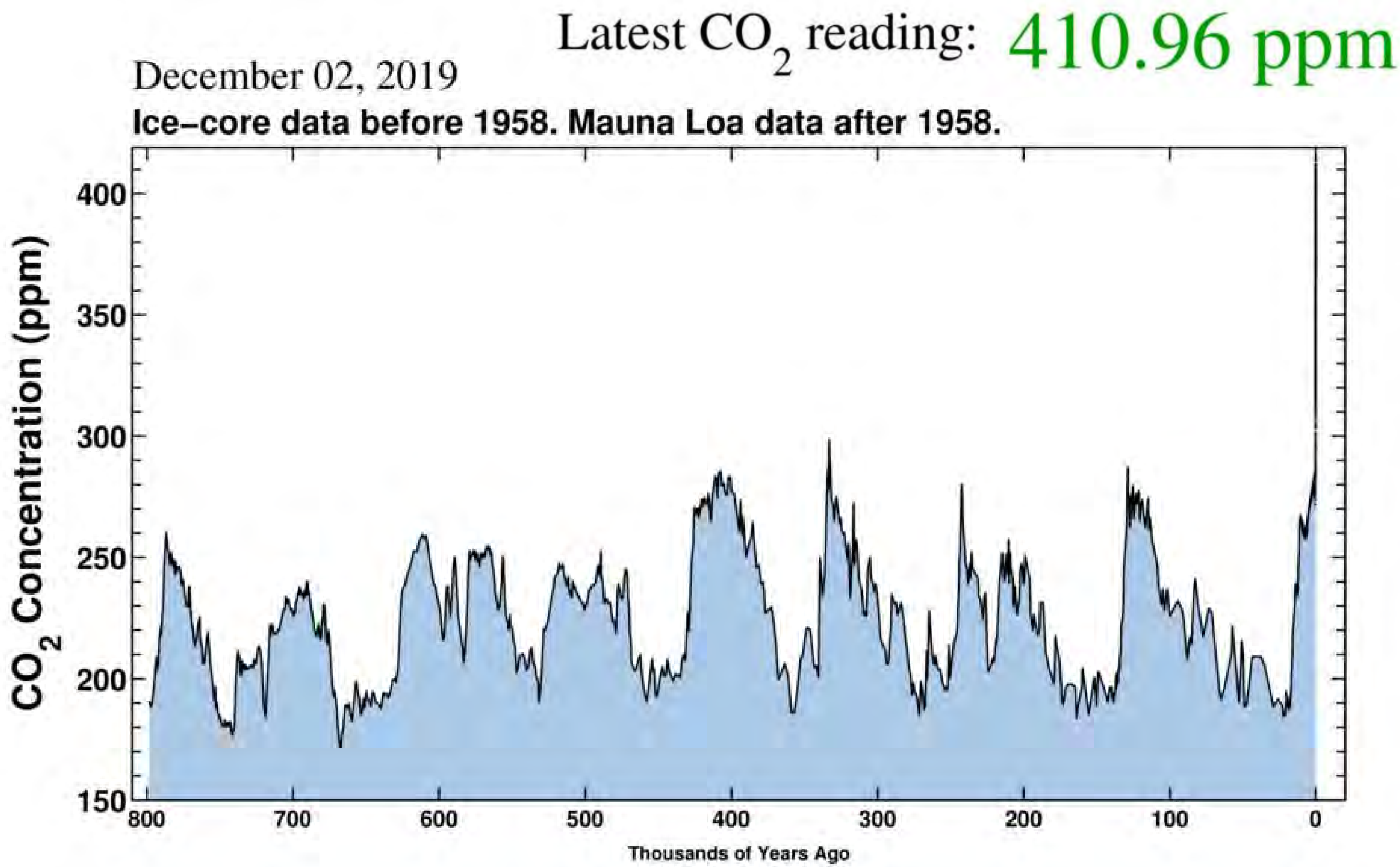
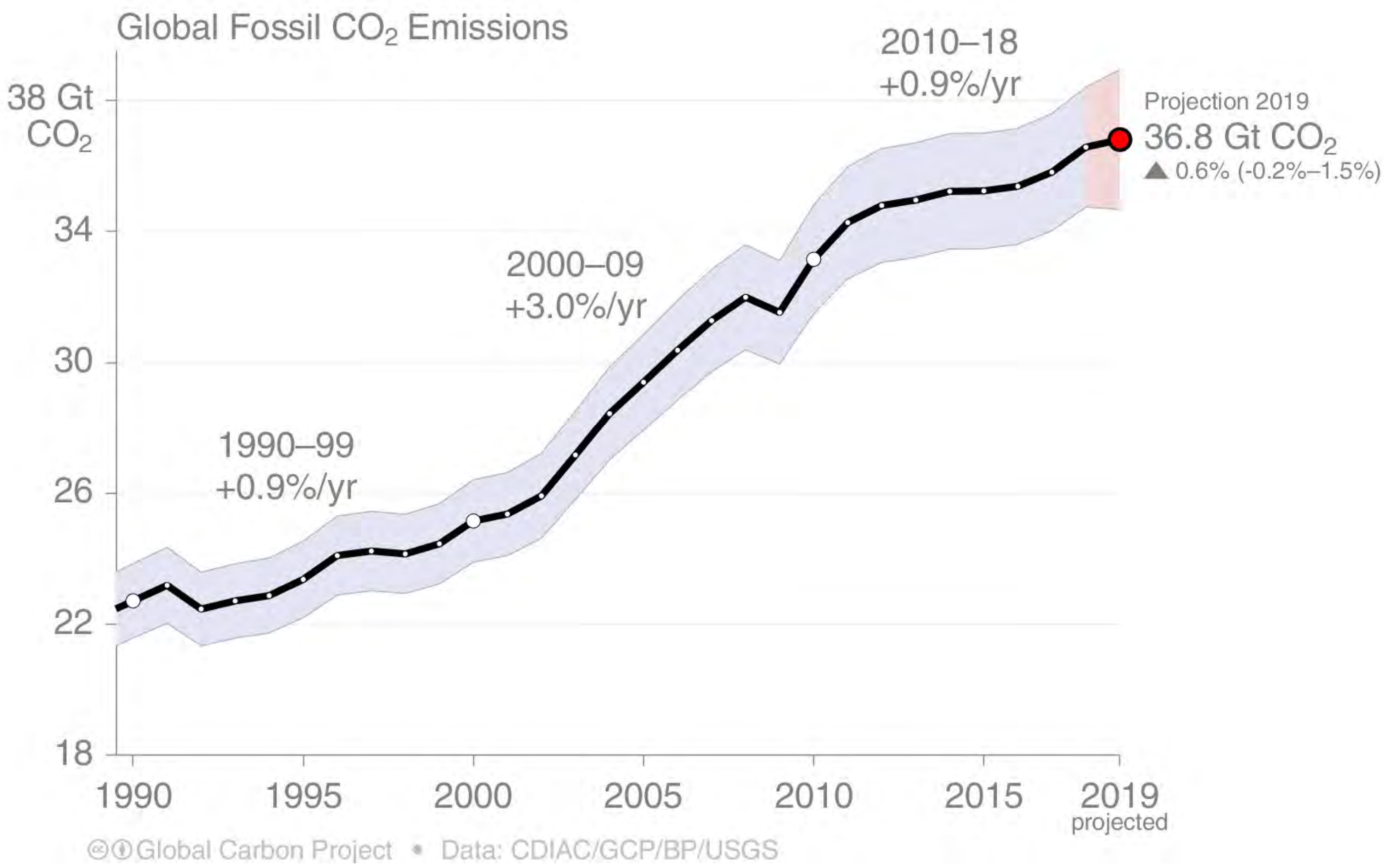


Global Fossil CO_2 Emissions

Global fossil CO_2 emissions: 36.6 ± 2 $GtCO_2$ in 2018, 61% over 1990

● Projection for 2019: 36.8 ± 2 $GtCO_2$, 0.6% higher than 2018 (range -0.2% to 1.5%)

Fossil CO_2 emissions will likely be more than 4% higher in 2019 than the year of the Paris Agreement in 2015

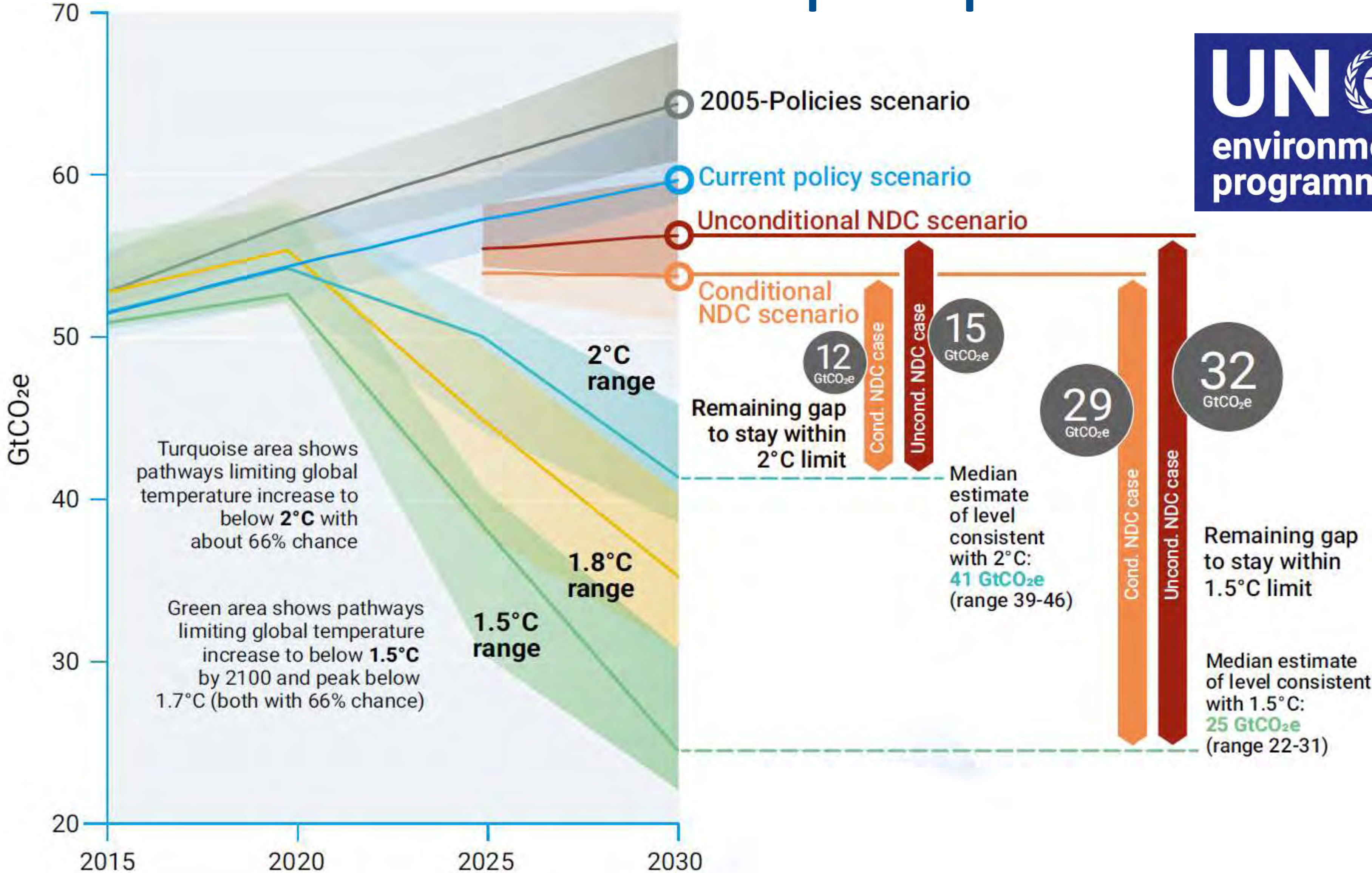


Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

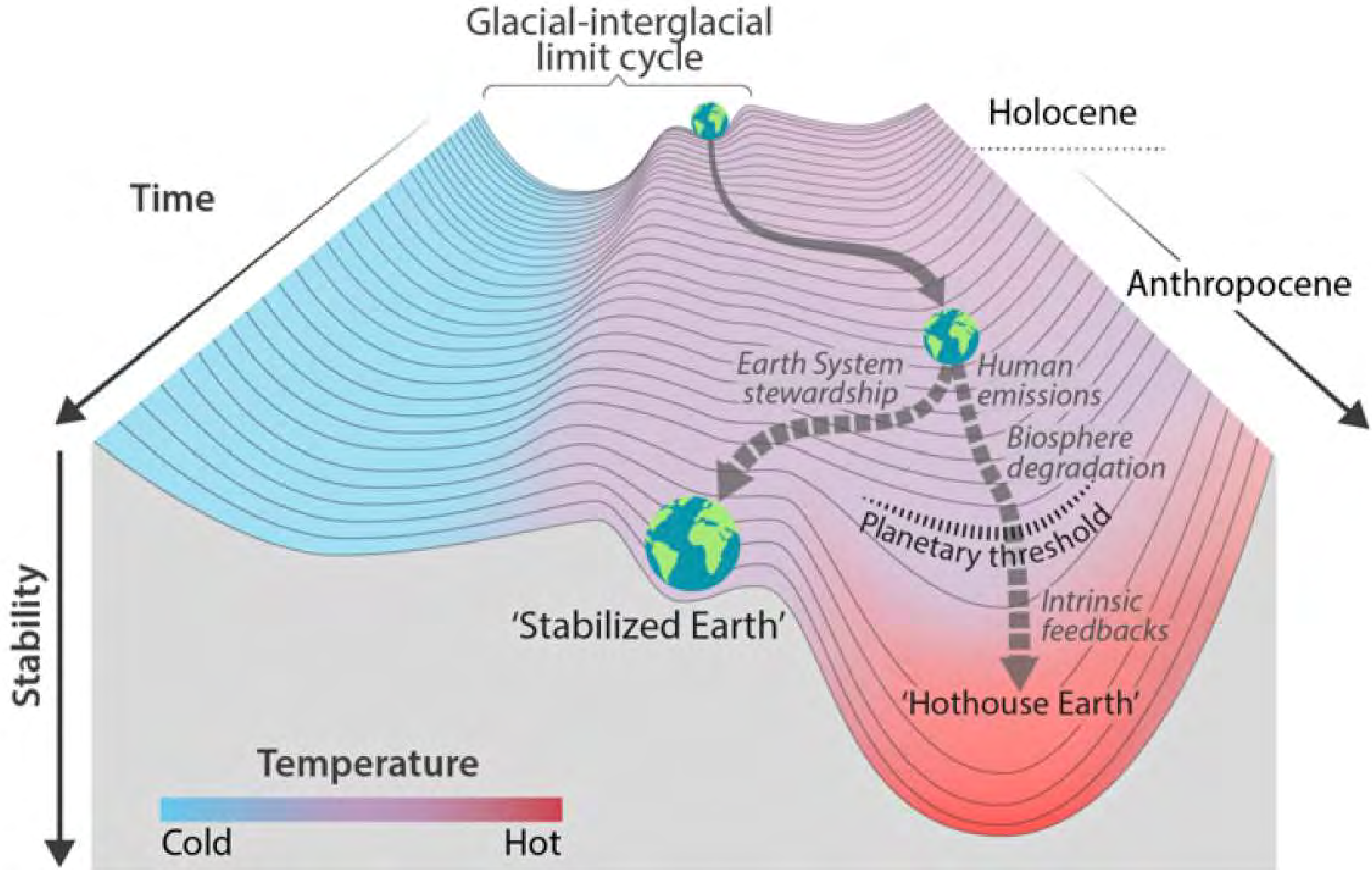
The 2019 projection is based on preliminary data and modelling.

Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

UNEP Emissions Gap Report 2019



Trajectories of the Earth System in the Anthropocene



- UD has committed to carbon neutrality, but has not yet set a timeline.
- Given the urgency of the climate crisis, sooner is much better than later!
- Opportunity to demonstrate leadership in a critical area consistent with our mission and *Laudato Si*

Arguments for Bold and Rapid Action

- Climate crisis is "moral equivalent of war"
  - Existential crisis for UD, and indeed the human project
  - Can we afford <u>not</u> to do this?
- Provide leadership in community
- Dispel the notion that mitigation must be slow
- Mobilizing will engage entire campus community
  - Form student servant leaders on climate crisis & sustainability
  - Build a point of pride for the campus
  - Despair & "learned helplessness" → hope & self-efficacy
  - "Ask not what your planet can do for you…"?

"It is not enough to balance, in the medium term,
the protection of nature with financial gain,
or the preservation of the environment with progress.
Halfway measures simply delay the inevitable disaster."

Taking action

Making a commitment

- Second Nature climate commitment
  - Signed in 2013 (ACUPCC)
  - Committed UD to net-zero emissions by 20XX

MARKS OF
DISTINCTION
2019

Renewed focus

- “We are still in” 2017
- Requested and obtained presidential charge to investigate feasibility of carbon neutrality commitment
- Organized study committee of multidisciplinary contributors

The Charge

- Evaluate in a preliminary fashion the feasibility of two potential target dates for carbon neutrality: 2025 and 2032
- Focus on Scope 1 (on-site) and Scope 2 (purchased electricity) emissions
  - Not focused on Scope 3 (indirect) emissions
- Actions that actually reduce emissions associated with University's activities
  - Not focused on offsets, unbundled RECs

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Finance and Administration

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RCL/HSI

Milena Walwer
Graduate Student
RCL/HSI

Matthew Worsham
Sustainability & Energy Coordinator, Facilities

Team composition highlights

- Hanley Sustainability Institute
- Facilities Management
- Finance officer
- UD Research Institute
- School of Engineering
- Graduate students

Project development and scope

Key first steps

- Commit to action
  - Second Nature, We are Still In, Ready for 100, CDP, etc.
- Conduct a greenhouse gas inventory
  - GHG boundaries will inform your future activities
- Gather experts and administrators who can make positive change

Final deliverables

- Two presentations to university leadership (midterm and final)
- Executive report (10 pages)
- Appendices (133 pages)
  - Detailed methodology and provided additional information on scenarios

Boundaries – Greenhouse Gas Protocol

Sources of campus emissions

Collected carbon emissions at University of Dayton

Scope 1 – Direct GHGs	Scope 2 – Upstream GHGs	Scope 3 – Indirect GHGs
• On-Campus Stationary (Natural Gas) • Vehicle Fleet • Agriculture • Refrigerants	• Purchased Electricity	• Faculty/Staff/Student Commuting • Directly Financed Air Travel • Study Abroad Travel • Solid Waste • Wastewater • Paper Purchases • Transmission & Distribution Losses

Increasingly difficult to control and/or mitigate →

sightlines

Example: electricity

UNIVERSITY of DAYTON

80,000,000 kWh

0.000625 MTCDE

kWh

50,000
MTCDE

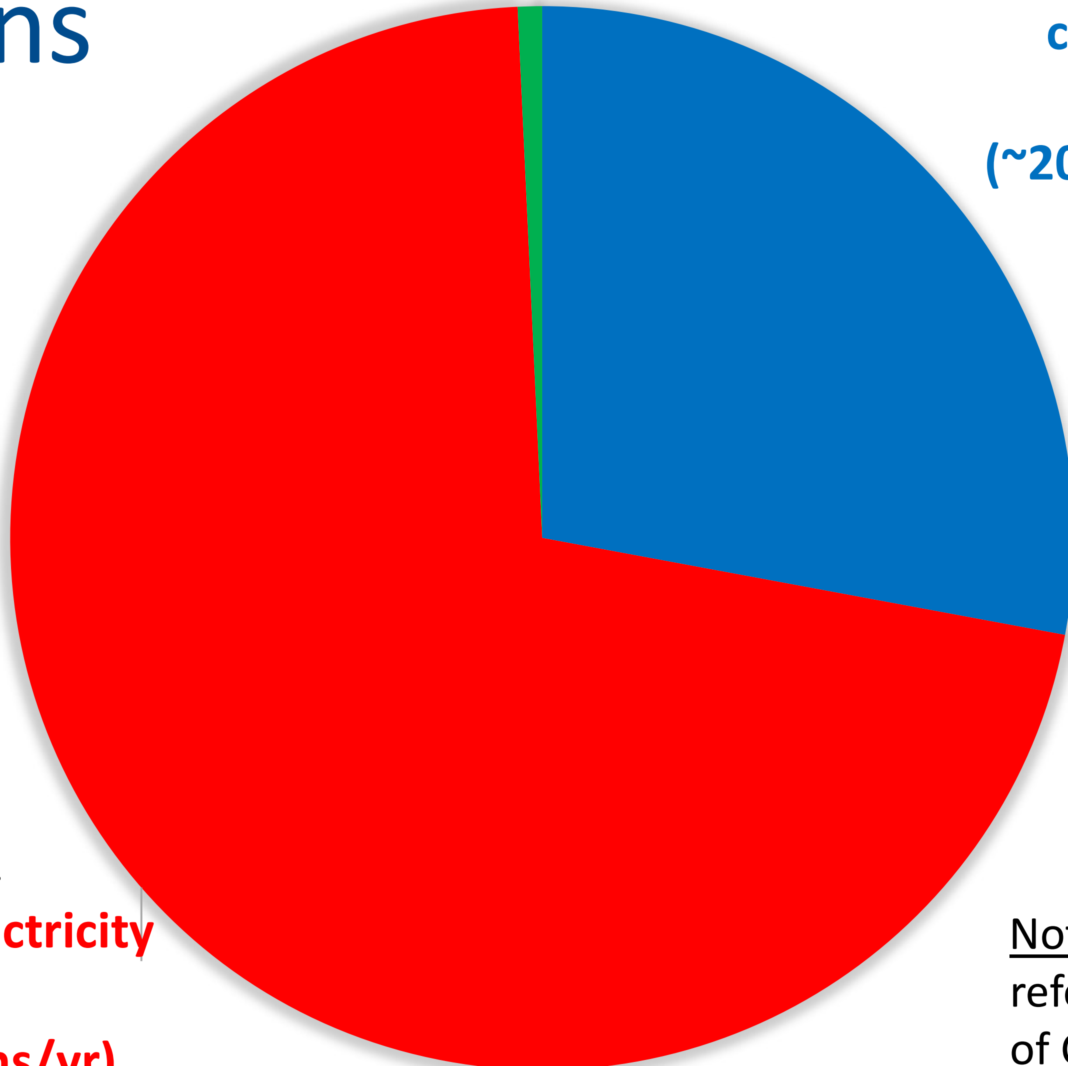
FY2018 Emissions

~2.5% of emissions from Dayton!

Scope 1

Fleet 1% (~500 tons/yr)

On-site combustion 28% (~20,000 tons/yr)



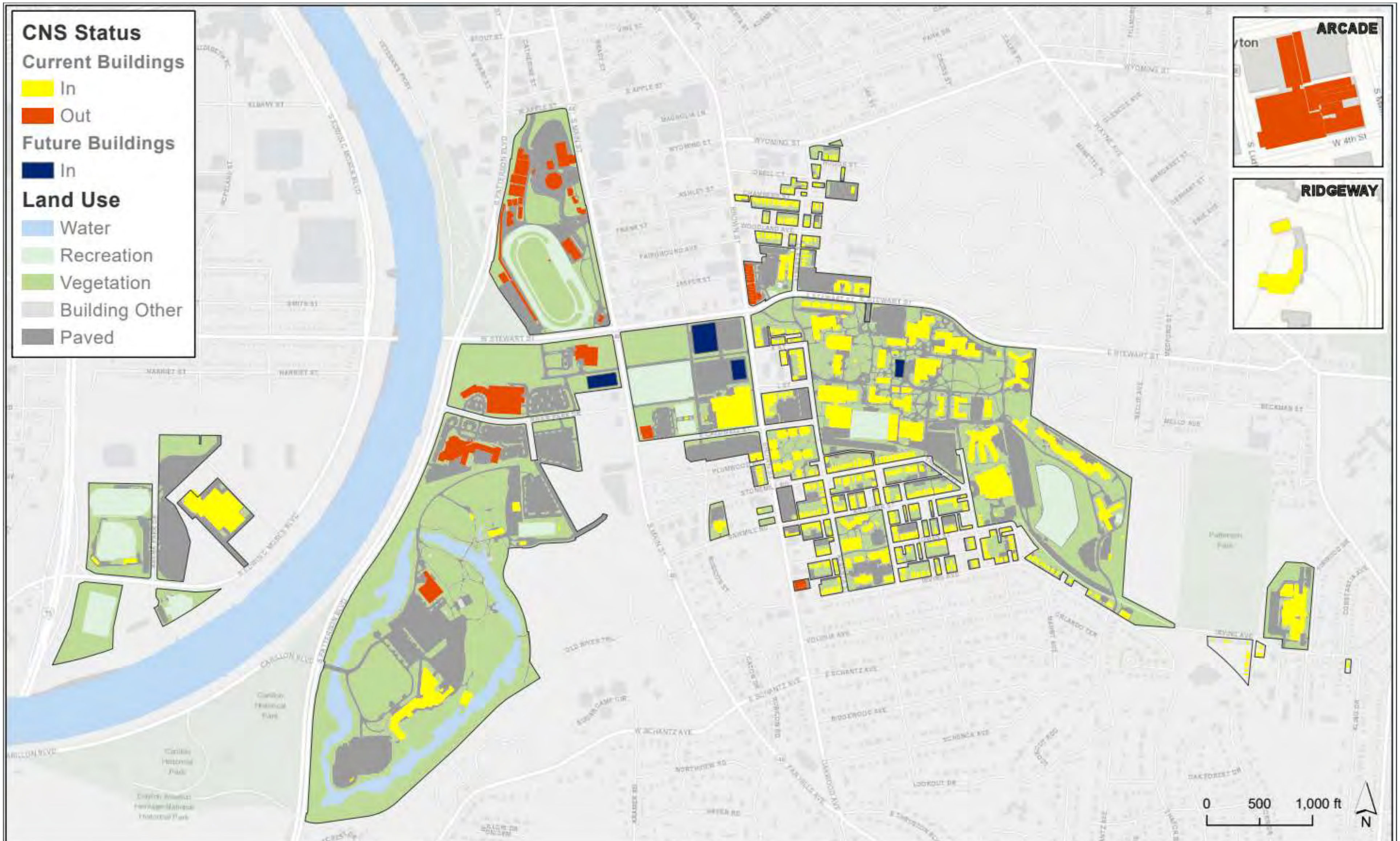
~87,000 MWh/yr

Scope 2

Purchased electricity 71% (~50,000 tons/yr)

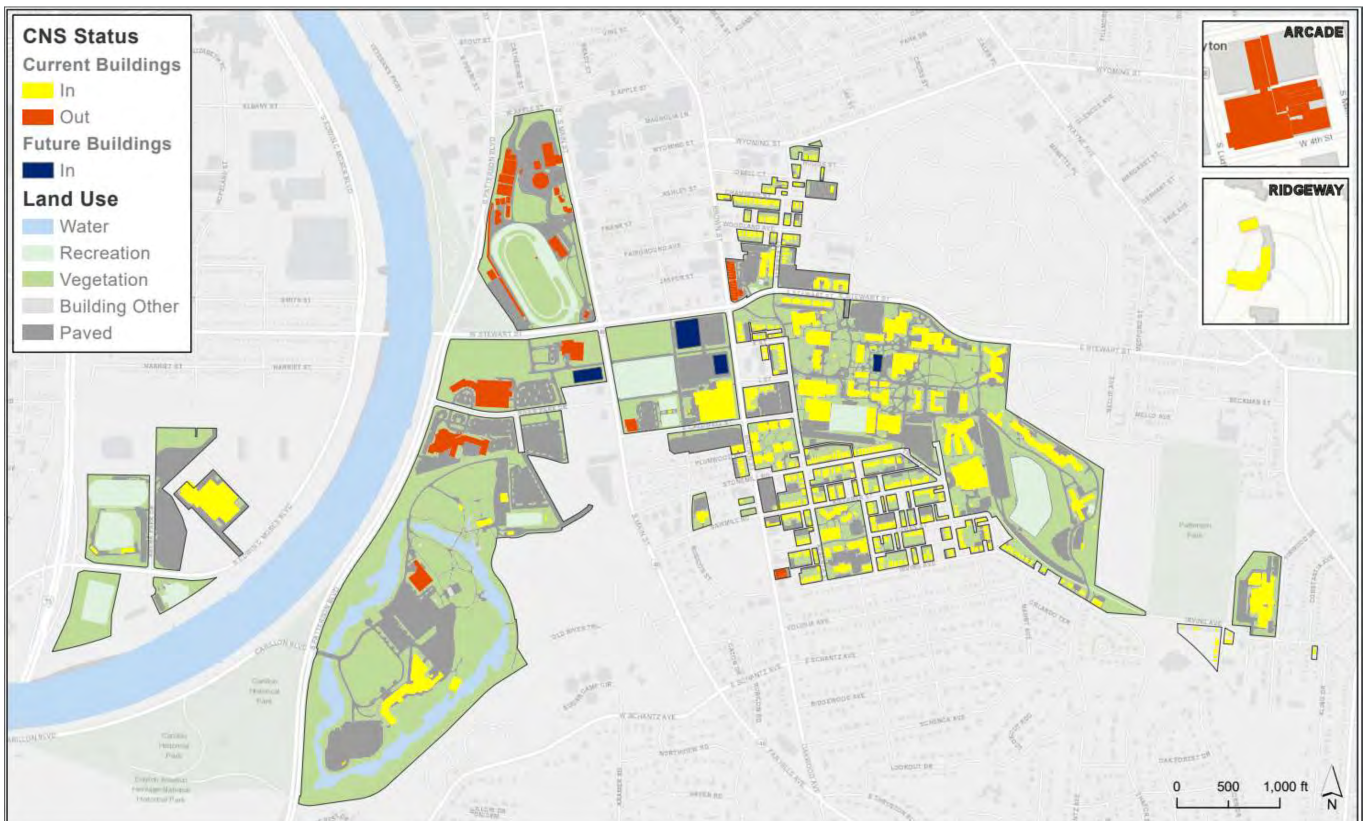
Note: All uses of “ton” refer to metric tonnes of CO_2 equiv.

Boundaries – Campus footprint



Boundaries – Campus footprint

- “Operational control”
  - Who controls utility systems?



Boundaries – energy and financial assumptions

- Key financial parameters like discount rate, energy costs and escalation rates
- Emissions coefficients for fuel types and region
- Social cost of carbon, offset prices, etc.

Project timeline

- Administration provided 12 weeks to produce a report
- Whole team met twice weekly
- Research, analysis, report writing took place outside of normal meeting times

Project timeline example

	Meeting Date	Data and analysis completion (first iteration)	who is responsible	Discussion	who is responsible
Thurs	18-Oct	On-site solar analysis - What are the economics, challenges, and timing of renewable electricity procurement?	Ryan	Eric's model visualization Steam vs Hot Water scenarios: Distribution infrastructure- what level of confidence to dive into HW exploration - What are the economics, challenges, and timing of a hot/cold water conversion?	Eric Ben
Fri	19-Oct	BioMass and Biofuels possibilities	Eric	10am: conversation with Heapy, services for Energy Planning	Steve
Tuesday	23-Oct			MEP and Miami University visit 8:00 AM - 9:00 AM (Meeting at UD, FH665) 9:00 AM - 10:30 AM (Travel Window - UD to Miami) (van) 10:30 AM - 11:45 AM (Miami Tour) 11:45 AM - 1:15 PM (Travel Window - Miami to UD)	Ben
Thurs	25-Oct			Miami, MEP, and Heapy debrief Geothermal options [Kelly, Andrew] - What is the optimum mix, or some different potential combinations, of technologies to produce hot and cold water, given our load profile and the economics, challenges, and timing?	Ben Kelly, Andrew
Fri	26-Oct	Educational value metrics Heat Recovery potential, high level check-in Fleet conversion analysis - What are the economics, challenges, and timing of a fleet conversion, to presumably mostly electric vehicles but maybe some biogas or biodiesel?	Milena Matthew Ryan Matthew	Presentation Draft for Mid-term meeting with Leadership team Draft boundary map	

Division of labor

- Team investigated decarbonizing all Scope I and II sources
- Research topics came from emissions sources, assigned based on subject matter expertise and interest
- Delegates worked independently, together, or consulted students/staff/faculty outside of the study committee
- Delegates provided updates during meetings, wrote appendices

Sample meeting agenda

November 16, 2018

Carbon Neutrality Feasibility Study

9-10:30am

Eric, Ryan, Matthew, Milena, Bro Ron, Andrew, Ben

Check-ins

- Calendar updates (Nov 30, Dec 7)
  - Nov 30: MEP 8:30-10:30am
  - Dec 7: Feast of the Immaculate Conception
- Mapping updates (Ridgeway house)
  - Add as inset; in-bounds for study
- Notes from yesterday available (team drive, Meeting Notes folder)
- Goals for today:
  - fine-tune analysis for Student Neighborhood
  - fine-tune potential for fleet conversion with biogas
  - names to appendix sections

Analysis

- Student Neighborhood passive house retrofit potential [Eric, Mary]
- Student Neighborhood air source heat pump [Andrew]
- Biogas [Kelly]
  - postpone Nov 29th

Discussion

- Appendix, list of topics [first come, first served]

Notes

- Passive House -- Is it possible to get the numbers we need for an analysis?

Student involvement

- This project was a great opportunity for student learning
  - Graduate student research project
  - Undergraduate leadership development
  - Educational projects with facilities

Overall Approach: 4 Pieces

1. Energy Efficiency
   – Reduce building energy use to save costs
2. Carbon Neutral Fleet
   – Convert fleet from gasoline/diesel to electric/biodiesel
3. Renewable Electricity
   – Options for onsite PV generation
   – Virtual Power Purchase Agreement (PPA)
4. Thermal Energy Generation
   – Convert to hot/cold water from geothermal heat pumps
   – Powered by renewable electricity

1. Efficiency
2. Fleet
3. Electricity
4. Thermal E

1. Energy Efficiency

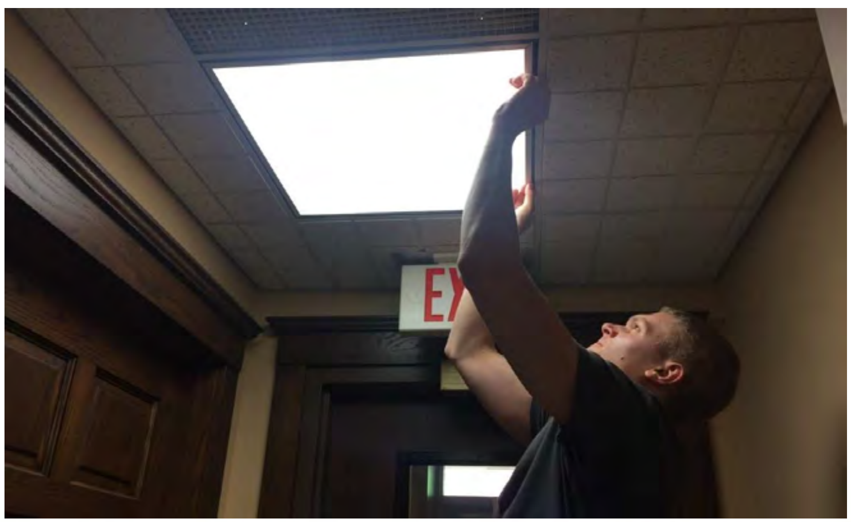
Energy Efficiency Measure	CO_2 Reduction	Status
LEDs & Occupancy Sensors	2,672 tons/yr	**In progress**
AHU scheduling & set point reset	2,752 tons/yr	**In progress**
Heat recovery & economizers	2,750 tons/yr	**In progress**
Residential thermostat controls	639 tons/yr	**Complete**
TOTALS	8,814 tons/yr	

- Energy efficiency saves money and carbon; we should do all of this
- More efficiency savings anticipated in the future

1. Energy Efficiency

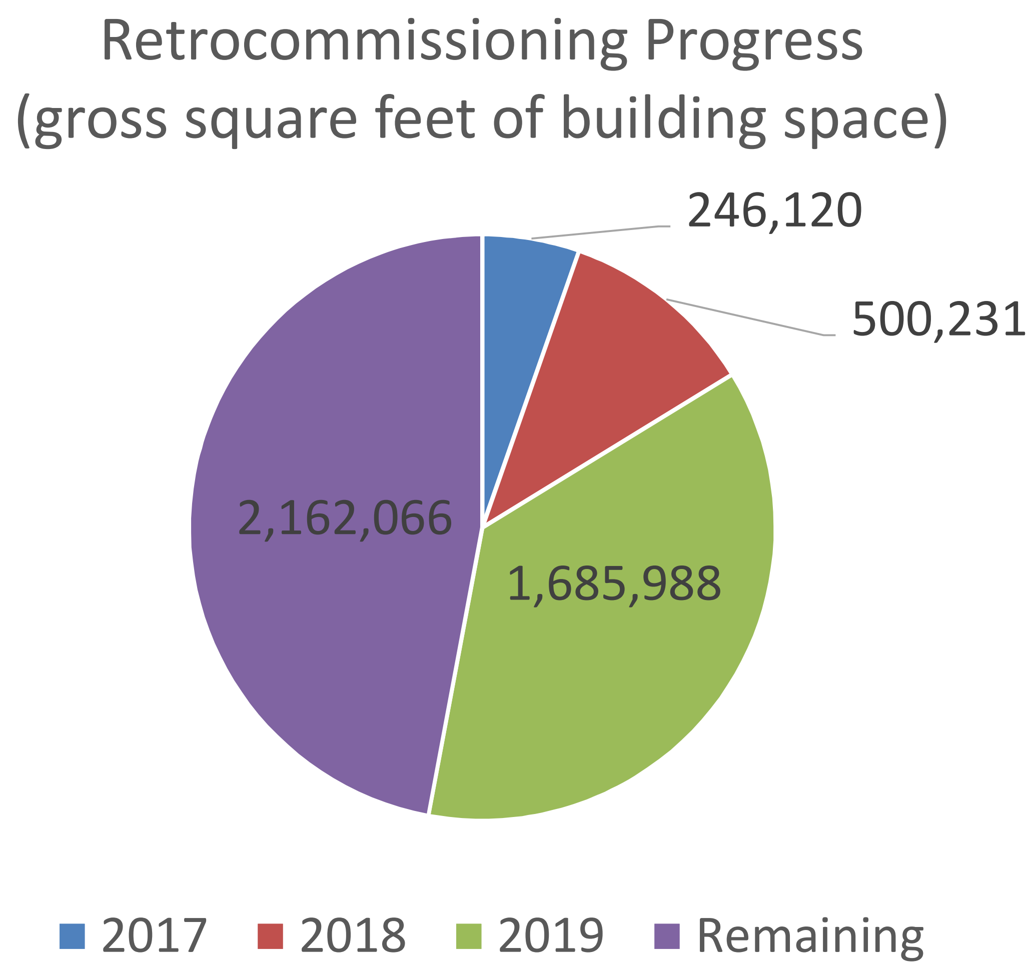
Revolving Loan Fund

1. Energy Efficiency



1. Energy Efficiency

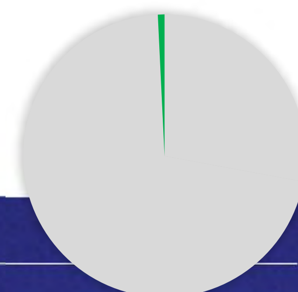
- 2017
  - Science Center
  - Sherman Hall
  - Wollheben Hall
- 2018
  - Fitz Hall
- 2019
  - Kettering Labs
  - Humanities Center
  - Kennedy Union
  - Miriam Hall
  - St. Mary's Hall
  - Anderson Center
  - Keller Hall
  - RecPlex
  - Shroyer Park Center
  - Bombeck Center
  - Curran Place



1. Efficiency
2. Fleet
3. Electricity
4. Thermal E

2. Carbon Neutral Fleet

- Current fleet
  - Golf carts, personal vehicles, trucks, etc.
  - 27 electric, 21 diesel, 179 gasoline
- Method
  - Use fuel consumption, mileage data to identify low efficiency, low mileage vehicles
  - Categorized vehicles as “oversized” and “right-sized”
  - Proposed a suitable electric alternative



1. Efficiency
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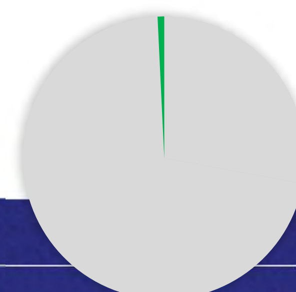
2. Carbon Neutral Fleet

- Low-speed electric vehicles

GEM: $15-25K, depending on battery choice (range 10-60 miles), 1400 lb. payload capacity



1. Efficiency
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2. Carbon Neutral Fleet

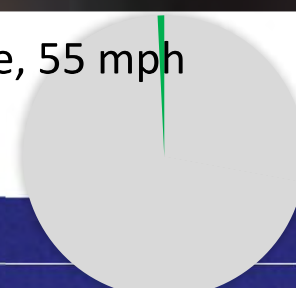
- High-speed electric vehicles (“right-sized”)

Jaguar I-PACE
0-60 mph in 4.5 s
234 mi range

3000 lb payload, 80 mile range, 55 mph

Chevy Bolt:
0-60 mph in 6.3 s
range 140-240 miles

Seats 16, 80 mile range, 55 mph



1. Efficiency
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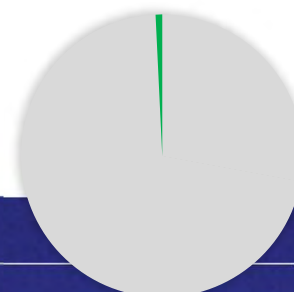
2. Carbon Neutral Fleet

- Logistical challenge
  - Need to site charging infrastructure
- Economic feasibility
  - 30-yr LCC savings ~$2M

- Currently exploring phased conversion to electric vehicles



1. Efficiency
2. Fleet
3. Electricity
4. Thermal E

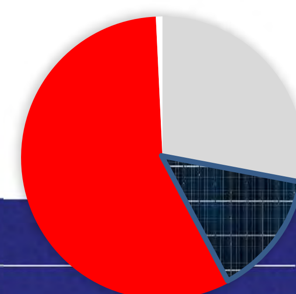
3. Renewable Electricity: on-site

Options for on-site PV production:

- Limit to existing PV installations (Fitz/Curran/Adele)
  - Estimated production: 1,300 MWh/yr (1.6% of electricity)
- Rooftop solar on large buildings
  - 8,100 MWh/yr (10.1%) ; ~$2M net present cost (+0.8¢/kWh; IRR=2.7%)
- Parking canopies
  - 10,600 MWh/yr (13.2%) ; ~$13M net present cost (+4.1¢/kWh; IRR=-0.3%)
- Neighborhood rooftop solar
  - 900 MWh/yr (1.1%) ; ~$0.8M net present cost (+3.0¢/kWh; IRR=2.1%)

We do not include additional on-site solar in our scenario

- Higher net present costs than off-site PPA
- But, high visibility & educational value
- Also, hedge against electricity price increases



1. Efficiency
2. Fleet
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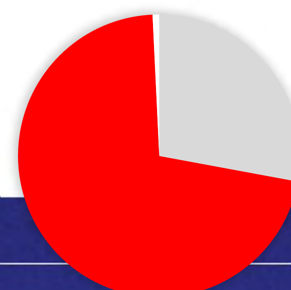
4. Thermal E

3. Renewable Electricity: PPA

- Physical vs. Virtual PPA
  - We analyzed only virtual PPA for simplicity
    - No interference with contracts or actual electricity delivery
    - Easier to get information about
- Regional vs. Distant PPA
  - In our scenario, we include a regional PPA
    - Optimal hedge against electricity purchases (market correlation)
    - Optimal hedge against future regulation (e.g., price on carbon)
    - Reduces pollution (non-CO_2) in local region
    - Local economic and workforce development
    - Accelerates clean energy transition in our region
    - Improves resilience of our region
    - Increased educational/research opportunities
    - More directly connects UD to its impacts
    - (Might be more expensive than a distant PPA)



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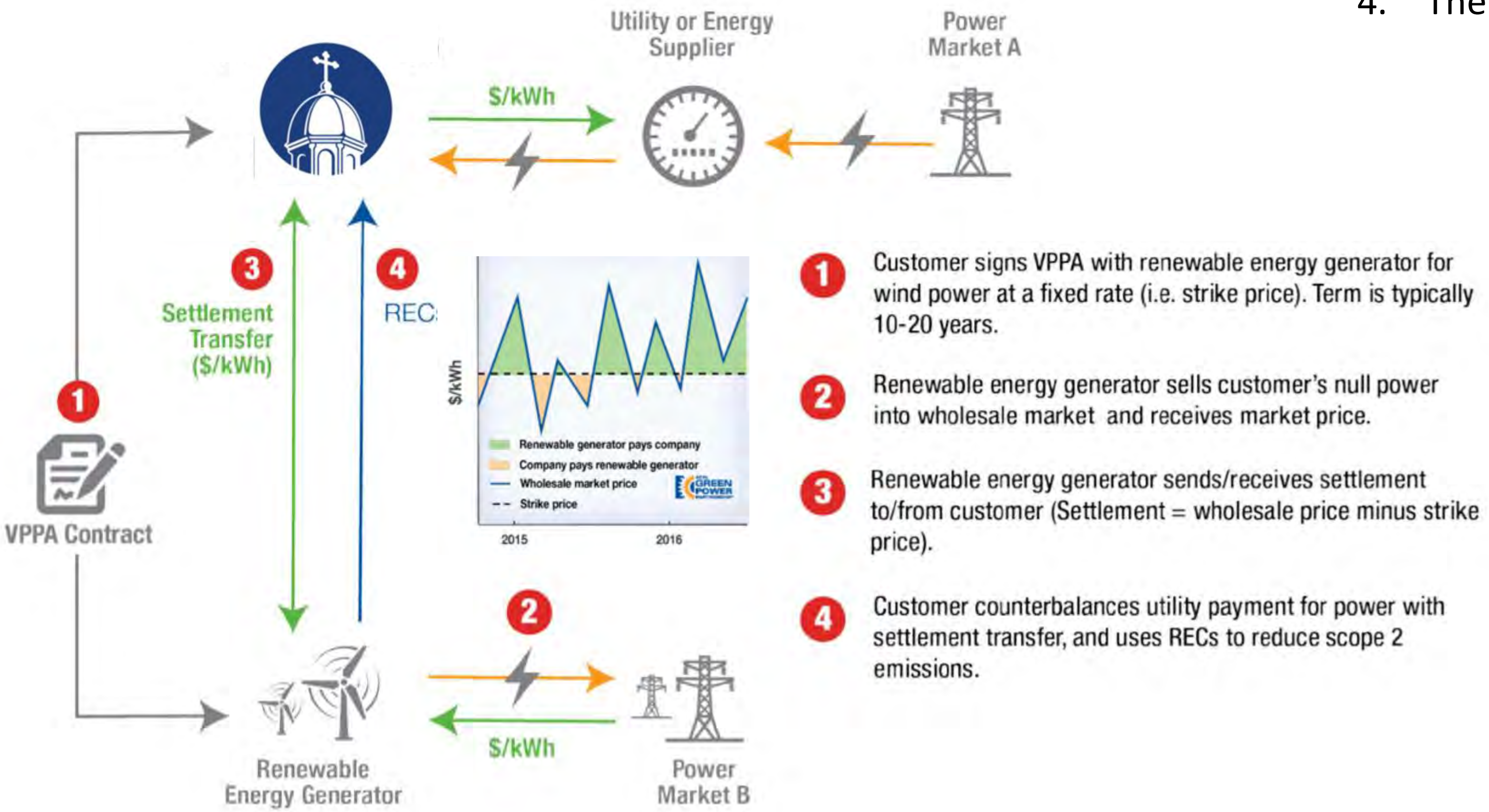
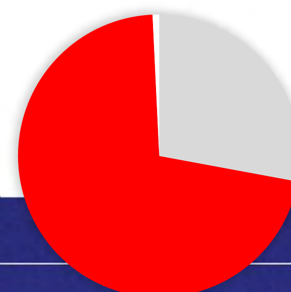
Virtual PPA



- "Contract for differences"
- Can contract with a different grid region
- Provides hedge to extent markets are correlated



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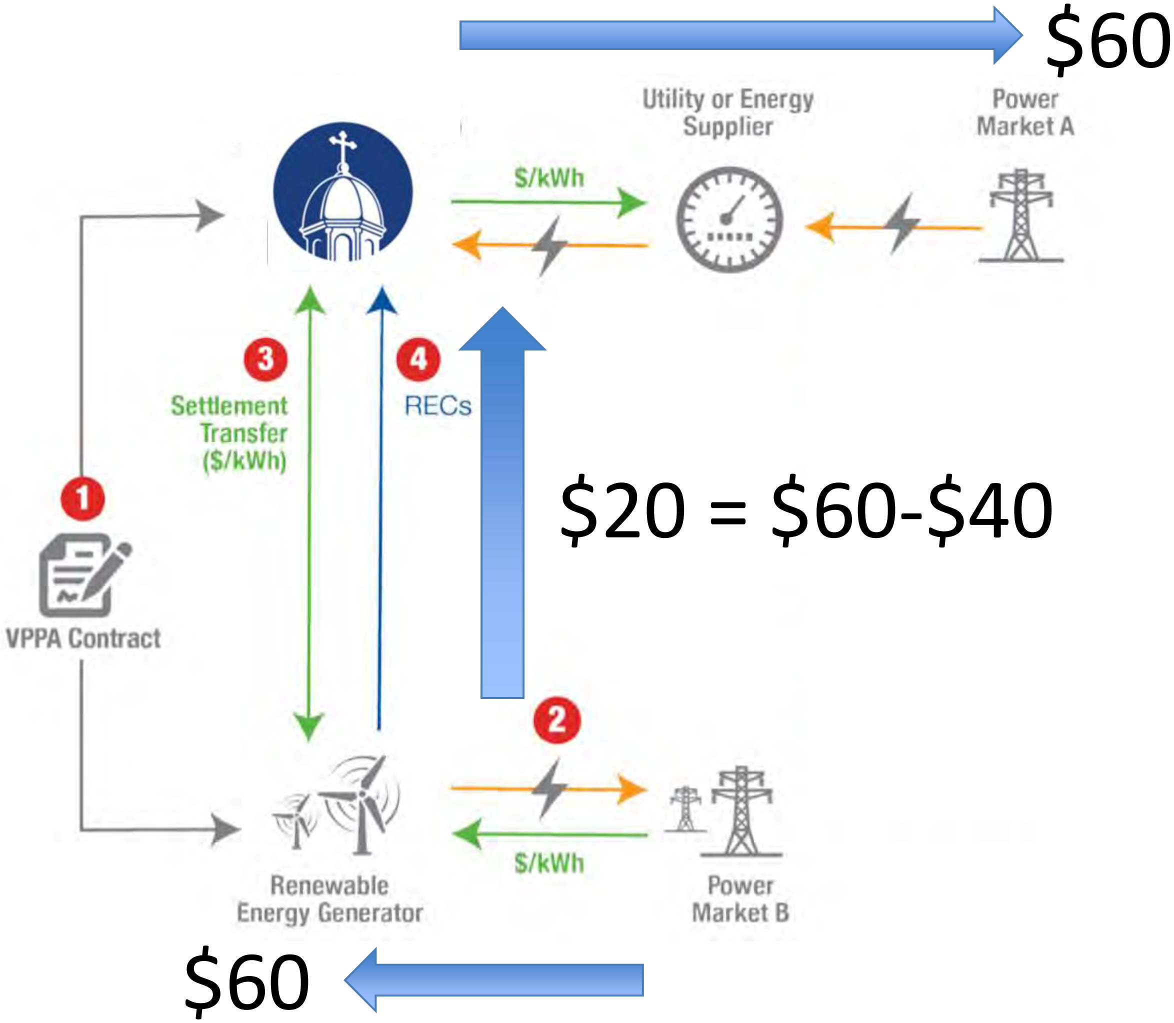
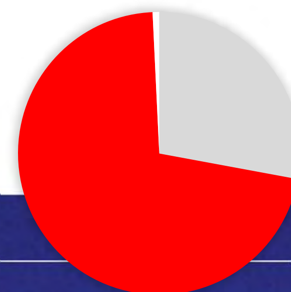
Example: Virtual PPA as Hedge



Strike price $40



Renewable Energy Certificates

1. Efficiency
2. Fleet
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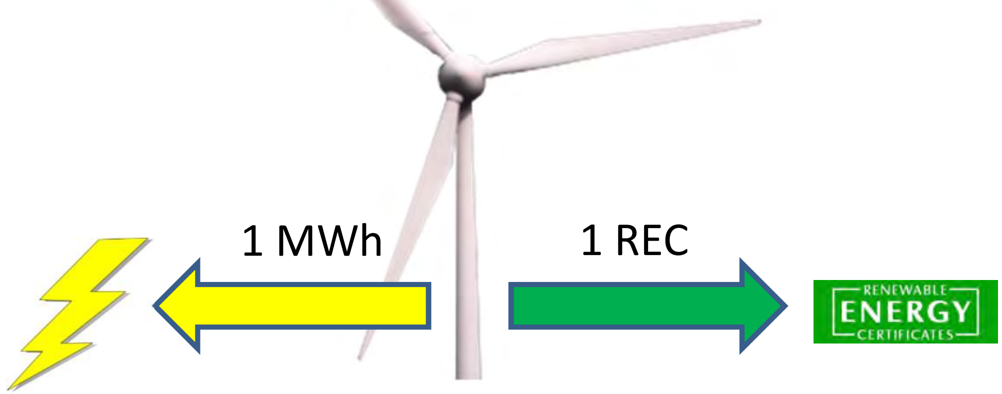
4. Thermal E



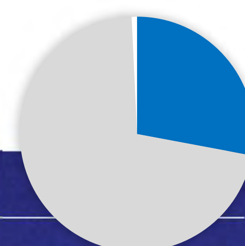
- If we buy a REC, we can claim we used 1 MWh of renewable electricity
- Ideal: buy RECs bundled with energy from new build
- Some PPA contracts arbitrage project RECs for national RECs to reduce strike price
  - Disadvantage: We would be unable to claim climate additionality benefits of PPA, since we couldn’t claim to be using electricity from that generator
  - Would we want to consider this? Need to study carefully.

4. Thermal Energy Generation

- Currently all heat is from natural gas combustion
  - Humanities steam plant serves central campus (55%)
  - Separate boilers in Fitz Hall (10%) & Curran Place (12%)
  - Stuart (5%), Shroyer Park (4%), Bombeck/Caldwell (1% ea)
  - Furnaces and hot water heaters in houses (10%)

A. Stick with steam
  - Switch to burning biomass
  - Promising option, based on initial exploration
  - Potential for carbon sequestration (biochar)
  - Definitely worth exploring further

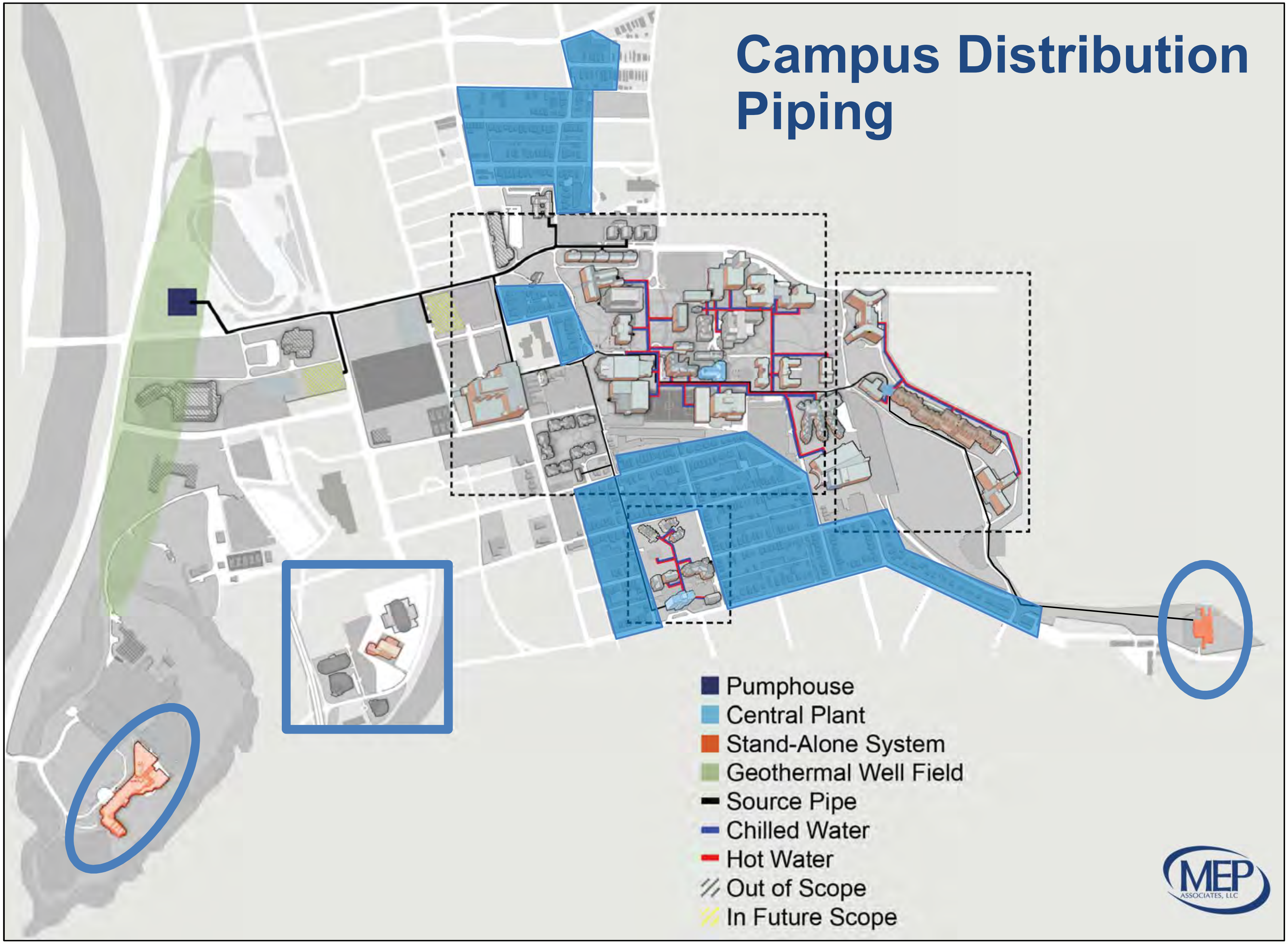
B. Convert to hot water (130 °F)
  - Heat pumps with open-loop geothermal exchange
  - Topic of MEP Associates study
  - This is the option we include in our scenario



4. Hot Water Conversion

- Heat pumps:
  - Used alone to meet simultaneous heating and cooling load (e.g., reheat in summer)
  - Extract or reject heat to/from groundwater, then return water to river
  - Efficiencies ~300-700% (vs. ~60% for steam)
  - Powered by renewable electricity (through PPA)
- Improved safety, reduced labor
- District chilled water system improves redundancy
- Need to run new water distribution pipes to every building on campus – lots of digging

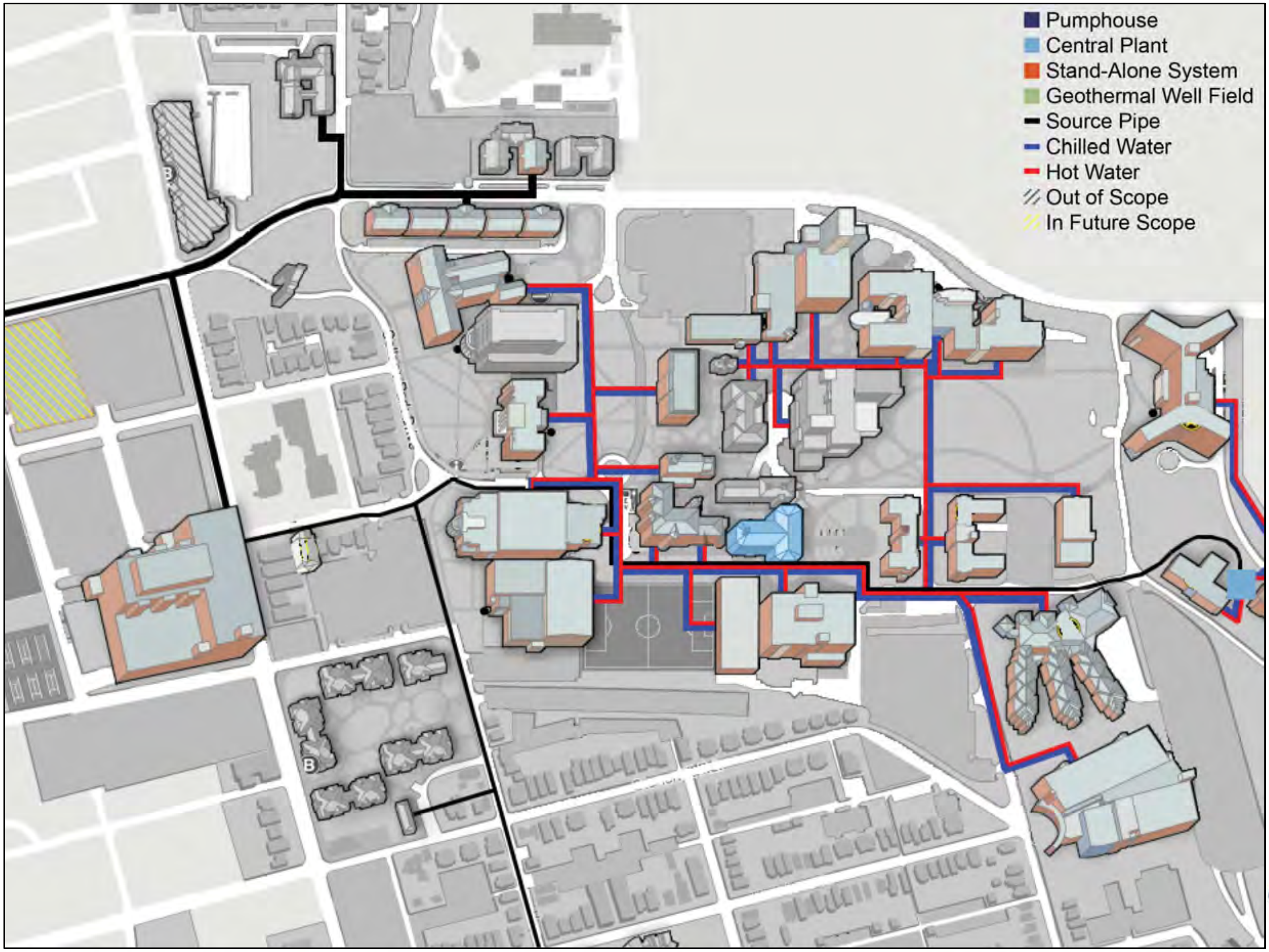
Campus Distribution Piping



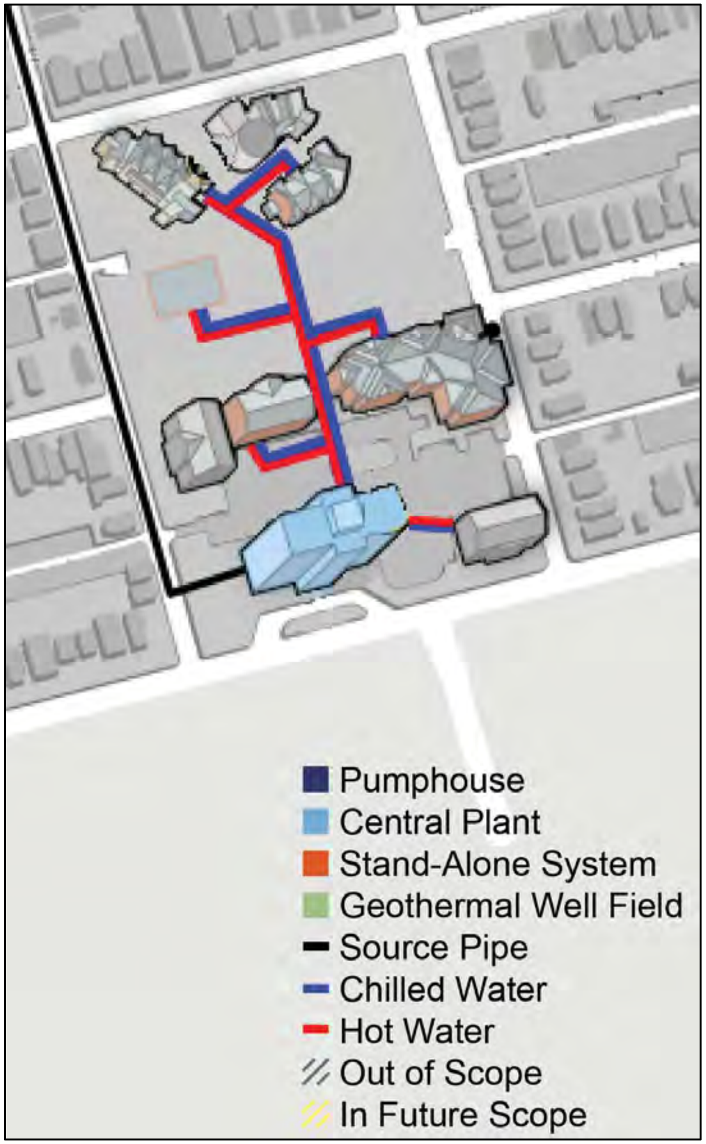
4. Notes on Neighborhood

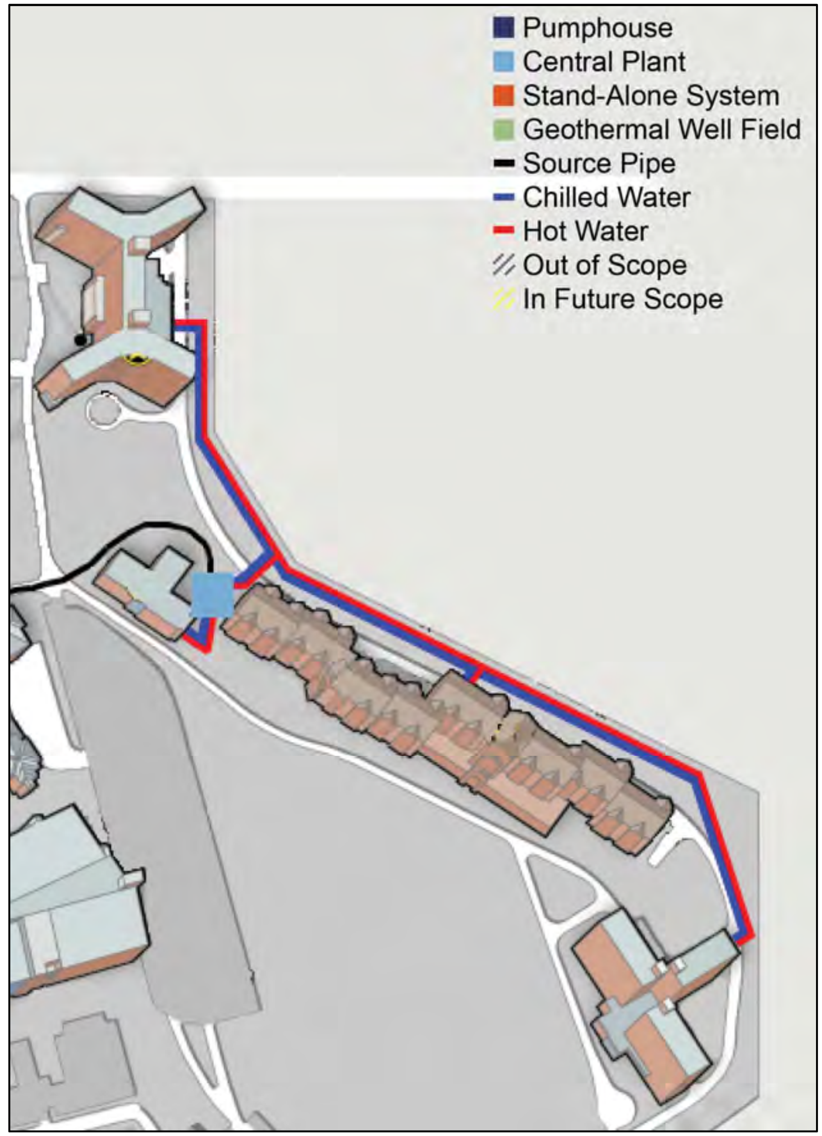
- Alternative approach is air source heat pumps
  - May have lower LCC, but higher operating costs
  - Financial analysis needs refinement
- Opportunity to be an example and leader of neighborhood conversion in the Midwest
- Judged too expensive to do deep retrofits
- Recommend net zero standards for new houses

Campus Distribution Piping: North



Campus Distribution Piping: South & East

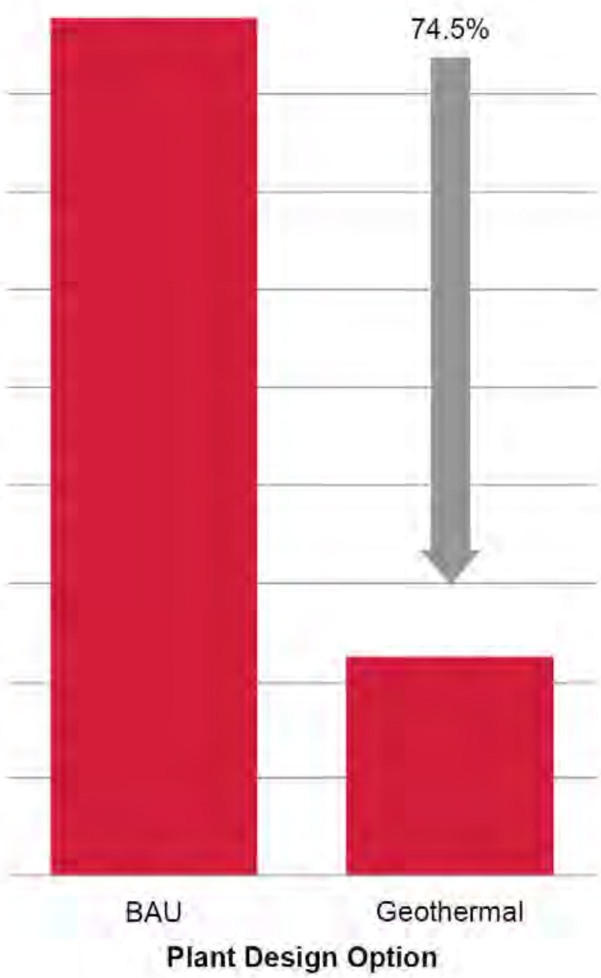




MEP ASSOCIATES, LLC

Energy Savings: Main Campus and Curran Place

Main Campus

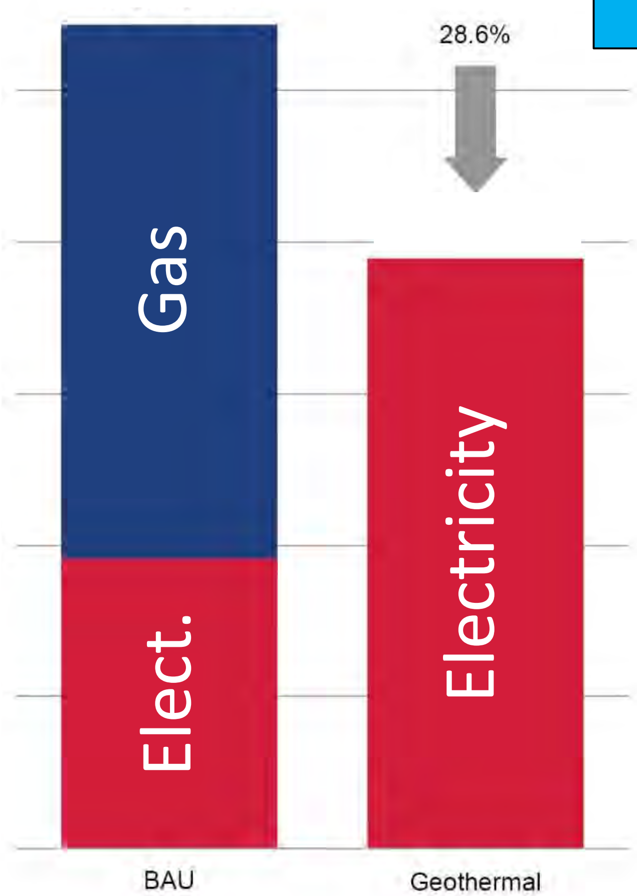


Curran Place

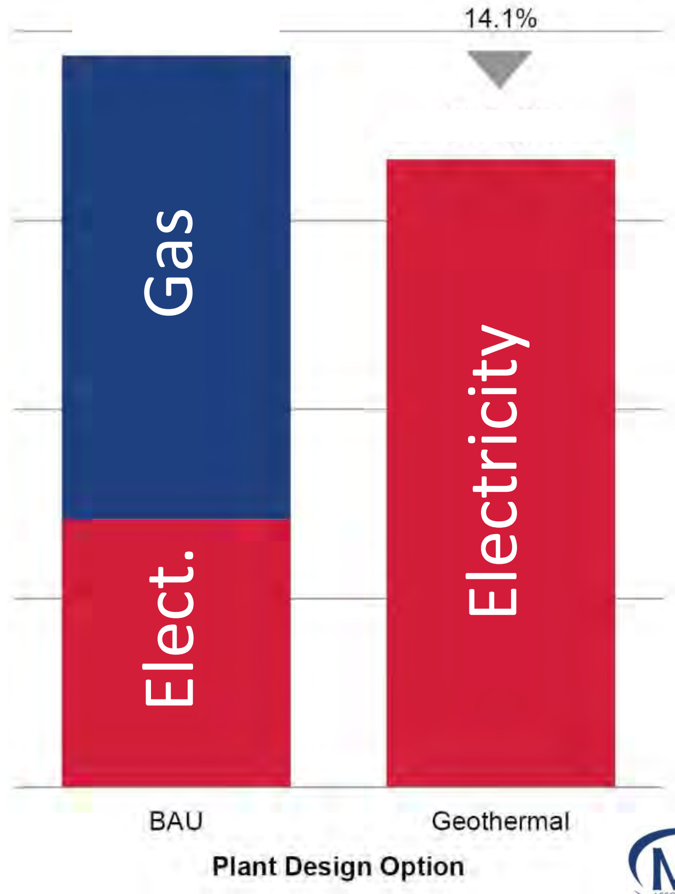
Cost Savings: Main Campus and Curran Place

Note: Based on current (low) gas prices.

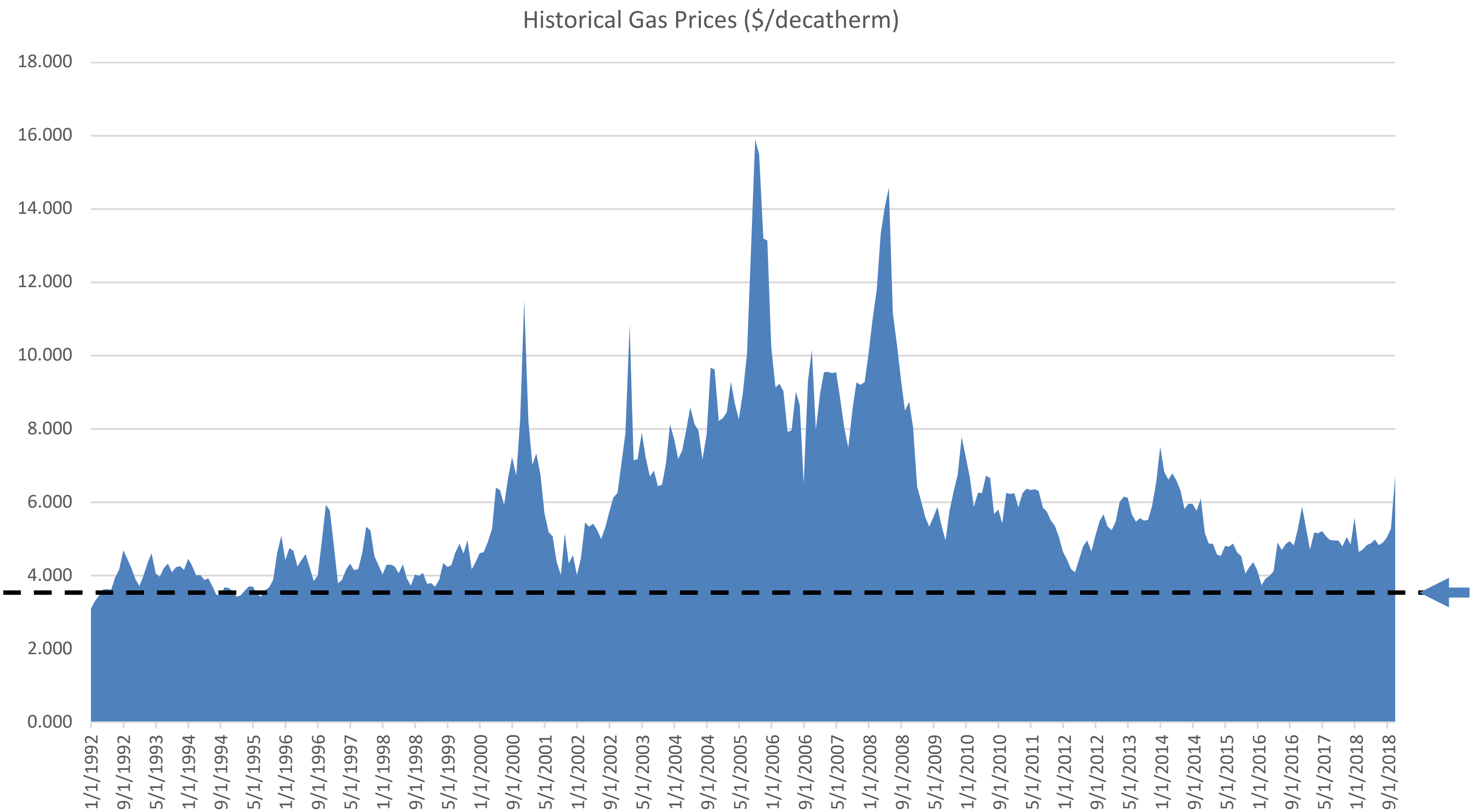
Main Campus



Curran Place

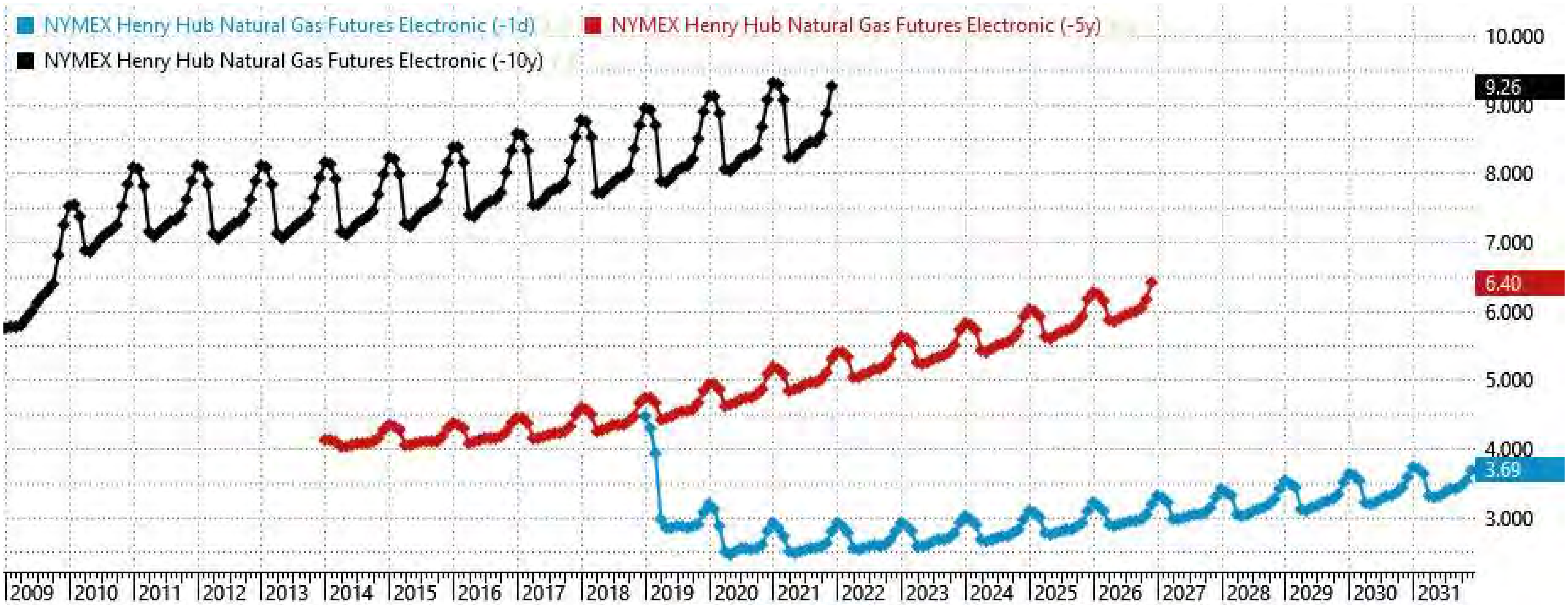


Natural Gas Historical Prices



From Chris Wettle

Past & Present Natural Gas Futures

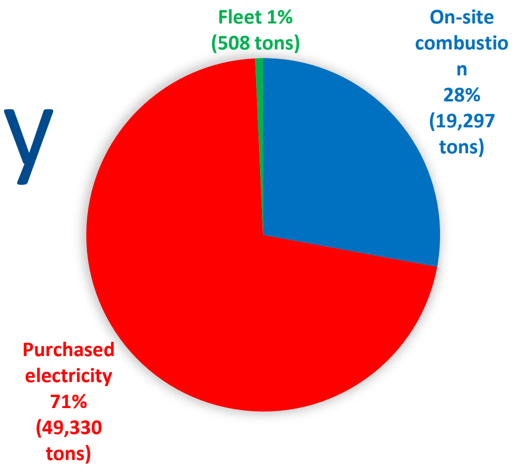


From Chris Wettle

4. Geothermal Feasibility

- Technical feasibility
  - No technical obstacles for either 2025 or 2032
- Logistical feasibility
  - Depends on campus' tolerance to disruption, in the form of trenching pipes and building conversions
  - Other campuses have done in ~4-15 years
  - 2032 should be no problem at all
  - Might need more detailed study of staging to confirm how feasible 2025 is?
- Financial feasibility
  - Appears to depend largely on availability of capital

Scenario Summary

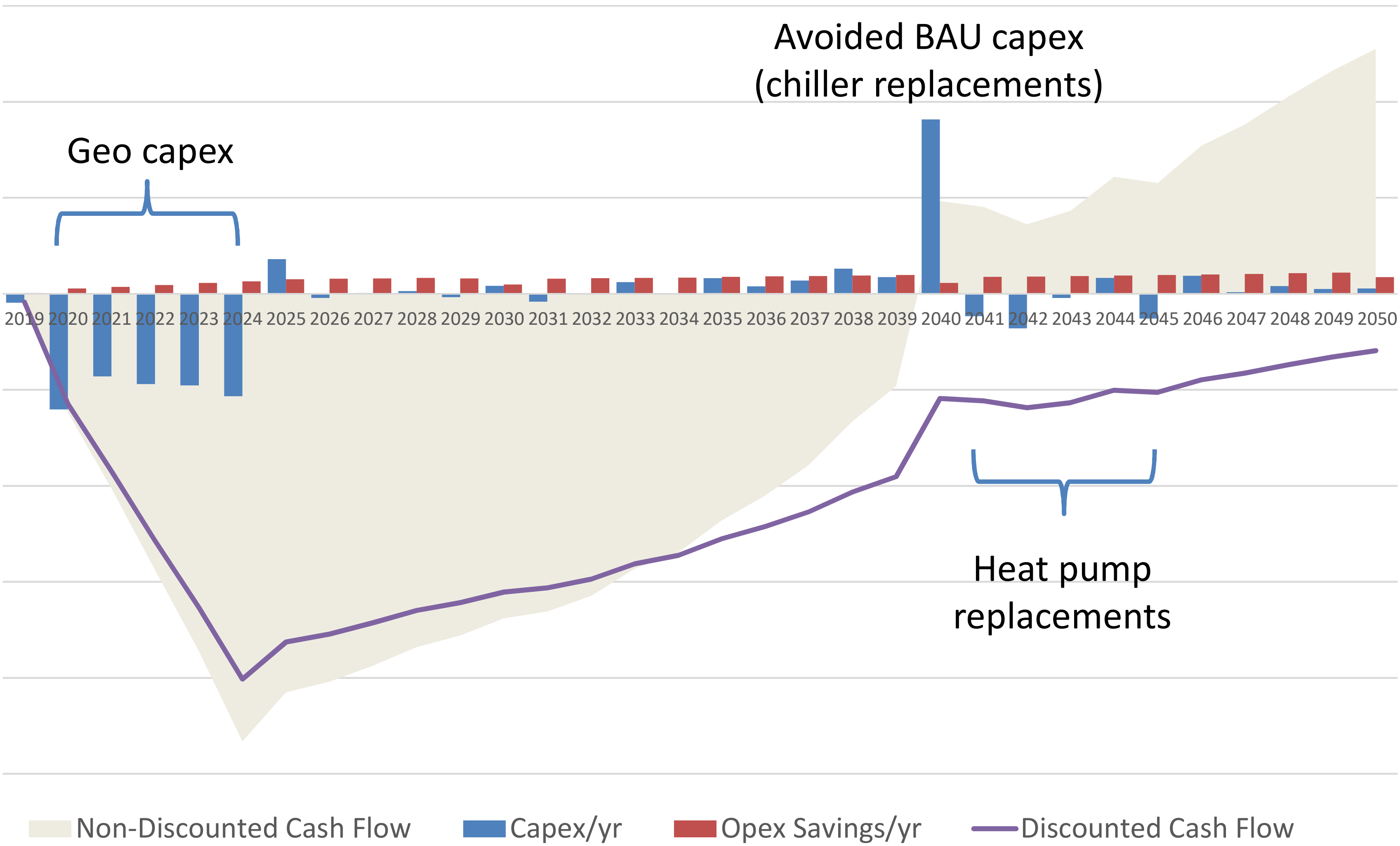


1. Energy Efficiency
   – Total of ~$10M in LCC savings vs. BAU
2. Carbon Neutral Fleet
   – Electric/biodiesel conversions
   – Feasible and ~$2M in LCC savings vs. BAU
3. Renewable Electricity
   – PPA can be achieved quickly, and cut 71% of emissions
   – Roughly neutral cost
4. Thermal Energy Generation
   – Need to further investigate biomass option
   – This scenario assumes all geothermal
   – Net cost vs. BAU, assuming cheap gas

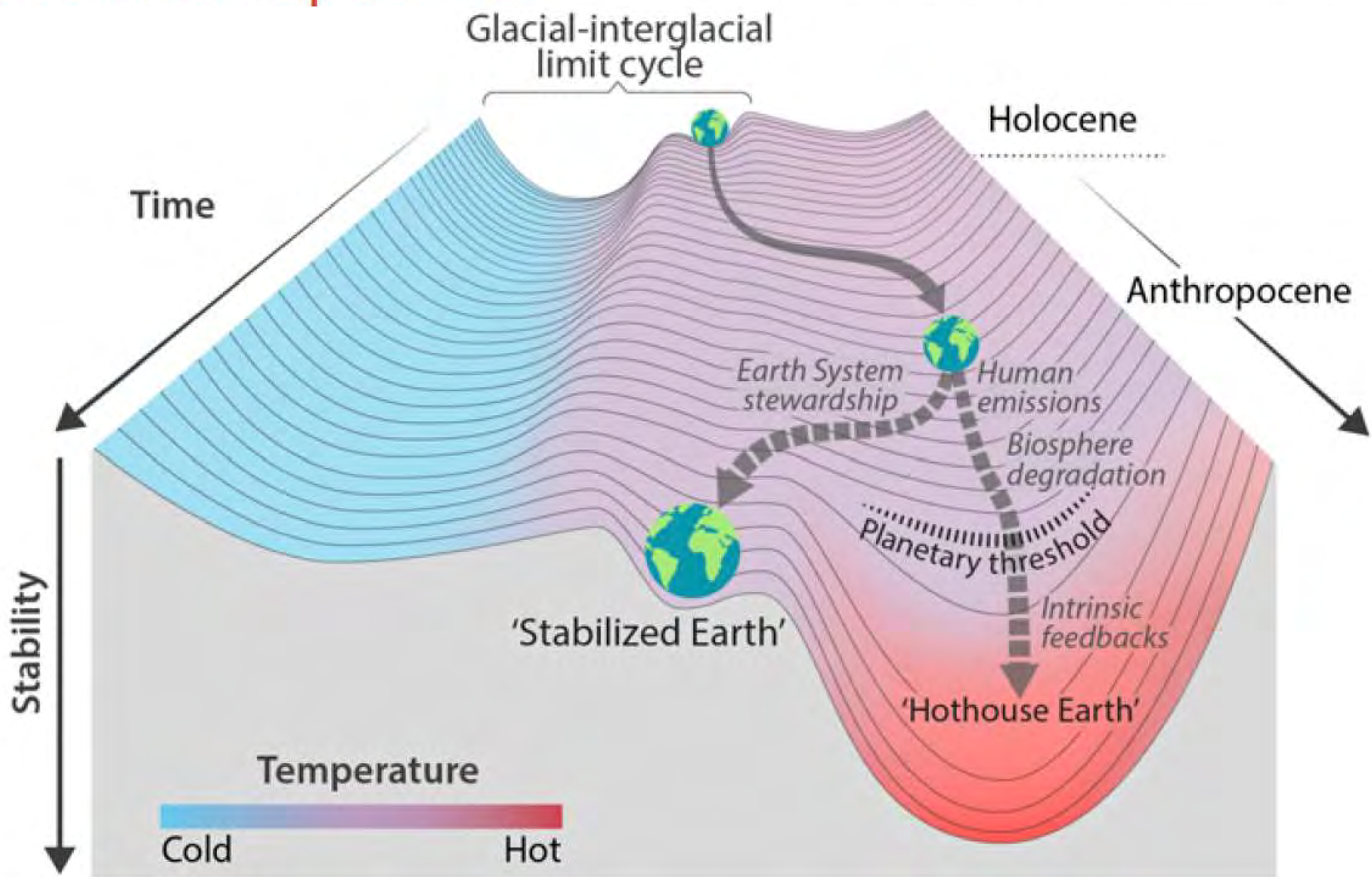
Uncertainties & Risks

- 30-year life cycle costs are very sensitive to assumptions
  - Discount rate
  - Future natural gas pricing
  - Future electricity pricing
- Proposed measures hedge future risks
  - Reducing energy imports
  - Moving away from natural gas
  - Hedging electricity prices
  - Avoiding future carbon taxes
- This scenario could be viewed as a conservative approach

Δ(Cash Flow) Projection ($M)



Trajectories of the Earth System in the Anthropocene



Social Cost of Carbon

- “Climate change is…the greatest market failure the world has ever seen.” – Nicholas Stern, former chief economist of the World Bank
- One approach to internalizing the externalities of GHG emissions is to put a price on carbon
- Three values we consider:
  - Carbon Cycle Interagency Working Group
    - Actively used by U.S. government for planning regulations
    - Generally thought to be too low
  - Institute for Policy Integrity
    - “Expert consensus” of economists publishing in top journals on climate
  - Intergovernmental Panel on Climate Change
    - Different methodology
    - In context of avoiding temperature rise >1.5°C (“dangerous” climate change)
- Currently an externalized cost but we could be forced to internalize it
  - British Columbia: current carbon tax of $35/ton
  - Canada: carbon tax $50/ton in 2022

Adopted Social Cost of Carbon Prices			
	Interagency Working Group	Institute for Policy Integrity	Intergovernmental Panel on Climate Change
Scenario	3% average	Expert consensus	<1.5°C
Year/Unit	2007$/ton	2015$/ton	2010$/ton
2020	$42	$128	N/A
2030	$50	$175	$862
2050	$69	$324	$1,785

NPC of BAU	$56M	$205M	$1,006M

>> NPC of carbon neutrality scenario (~$6M)

Carbon neutrality is a hedge against future carbon pricing!

2025 Conclusions on Feasibility 2032

- Carbon neutrality *is* technically feasible, even by 2025
- Energy efficiency is feasible and yields cost savings
- Fleet conversion is feasible and yields cost savings
- Off-site PPA could be done by 2020-21, eliminating 71% of our GHG emissions, and nearly cost neutral
- Thermal energy conversion is key
  - Highest capex, most logistically complex
  - If capex is at all viable, consider target date of 2025
    - Conduct more detailed study, also including biomass option
    - Then re-evaluate timeline and commit to a neutrality date

Tasks for Study/Planning Teams

- Renewable electricity
  - Select a PPA market advisor firm
  - Develop criteria for RFP
  - Conduct preliminary review of responses & bring to leadership
  - Further evaluate opportunities for on-campus solar
- Thermal energy
  - Examine potential staging of geothermal by 2025
  - Commission detailed study of biomass option (costs & logistics)
  - Evaluate pros/cons of conducting a full utilities master plan
- Energy efficiency
  - Identify ways to accelerate energy efficiency implementation
  - Develop standards for new buildings/houses & major renovations
- Fleet
  - Flesh out conversion pathway & logistics

QUESTIONS/DISCUSSION?