Paying for Carbon Reduction: Stationary Fuel Combustion and Grid-Supplied Electricity

Presenter:

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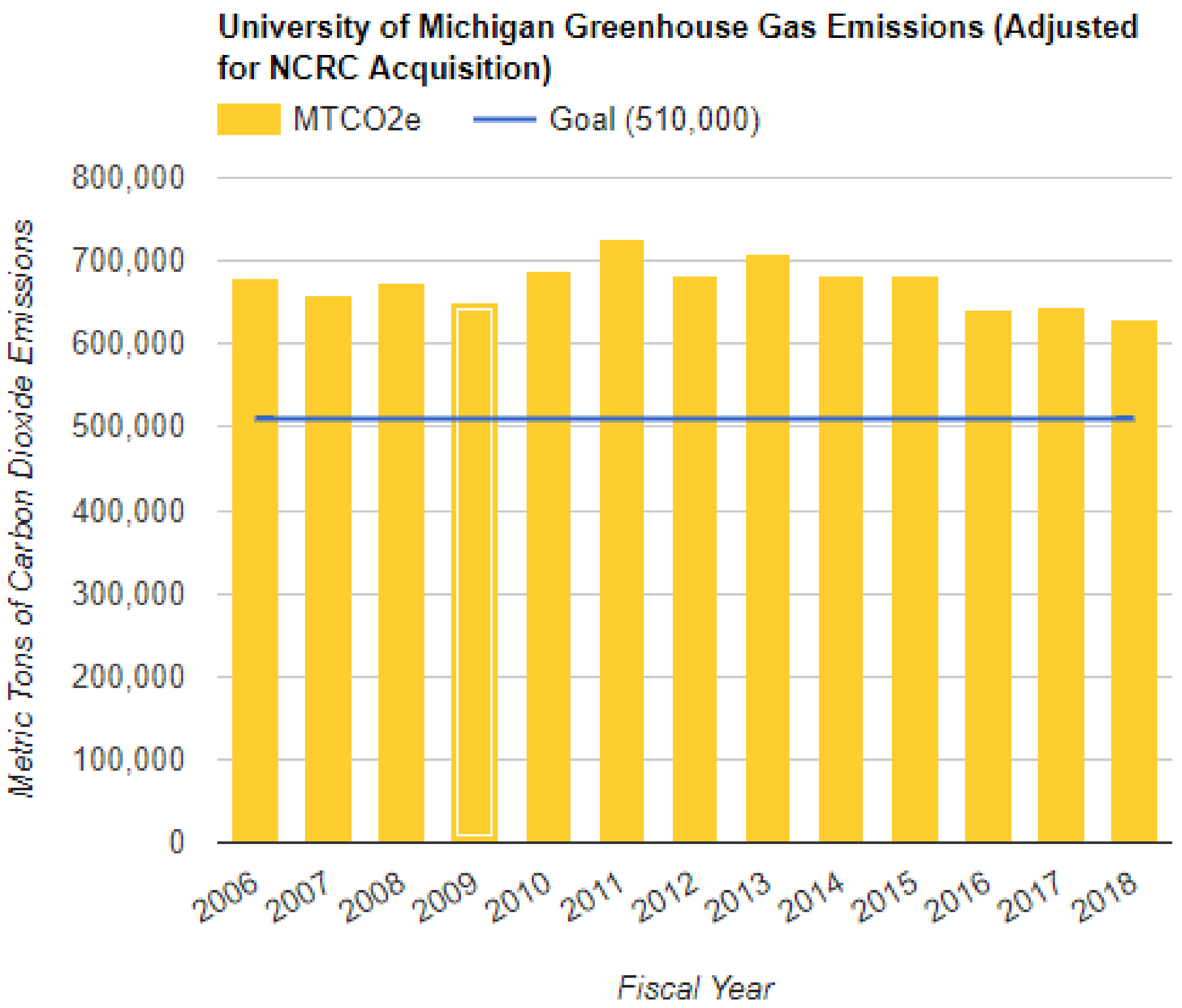
45 Years of Experience in Sustainable District Energy Systems

Agenda

1. **Presentation**
   - Aggressive carbon reduction goals
   - Scoping emissions
   - Planning for capital requirements
   - Financial viability
   - Pricing carbon
   - Key Considerations

2. **Q&A**

Aggressive Carbon Reduction Goals



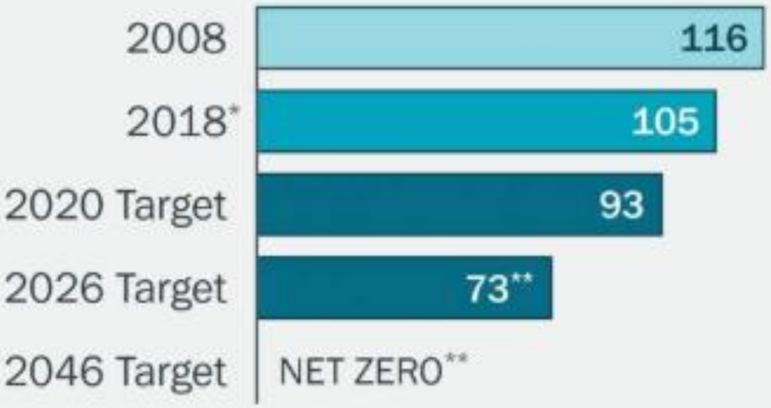
Aggressive Carbon Reduction Goals

OBJECTIVE

Accounting for campus growth, achieve carbon neutrality by 2046 — Princeton's 300th anniversary — through the use of repeatable, scalable and innovative solutions.

Targets

Campus emissions (metric tons CO_2 x 1000)

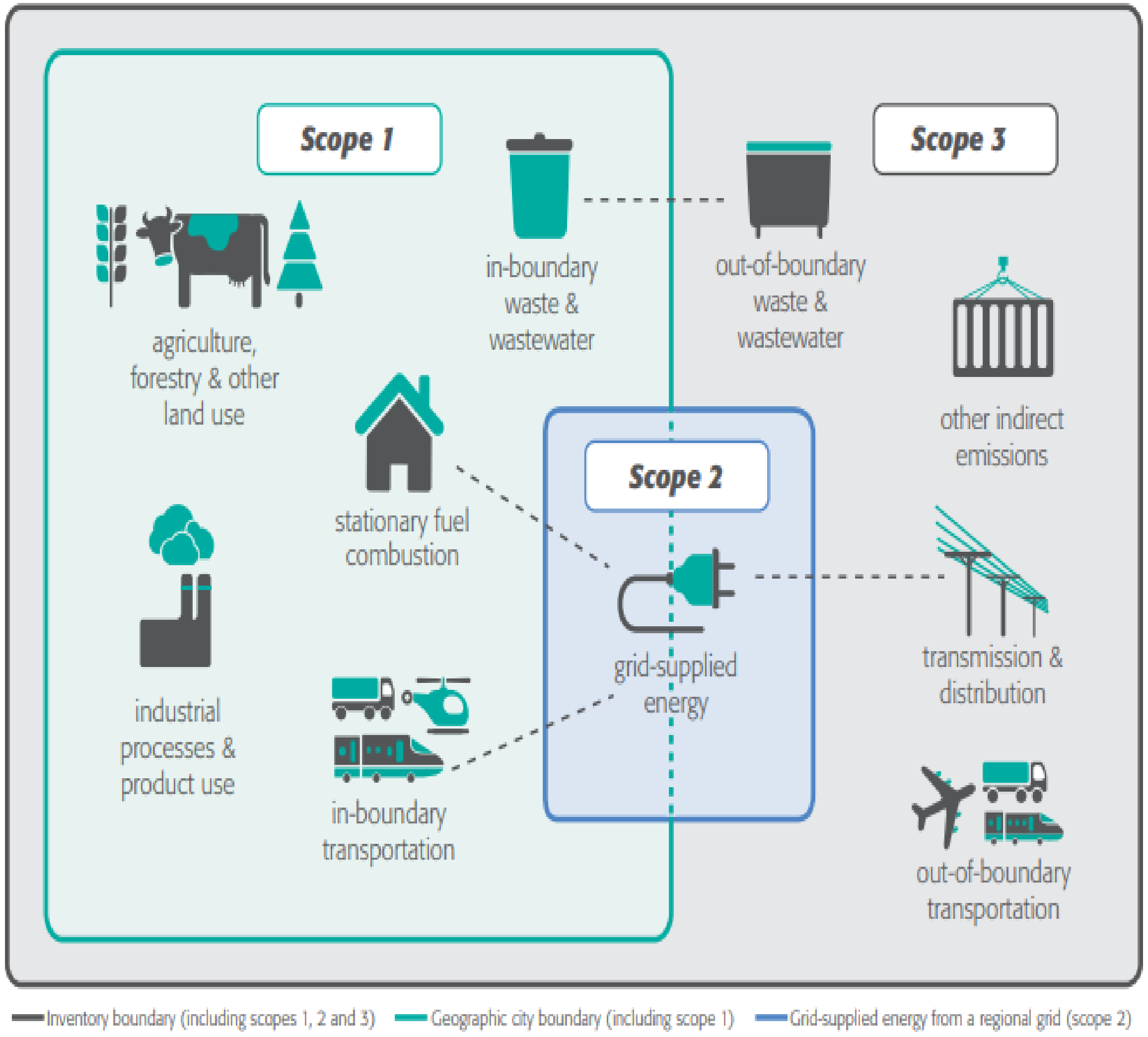


*2018 represents an average of 2017 and 2018 performance data.
**Targets reflect CO_2 equivalence (CO_2e)

PRINCETON UNIVERSITY SUSTAINABILITY ACTION PLAN: TOWARD 2026 AND BEYOND

Scoping Emissions

1. Stationary fuel combustion
2. Grid-supplied energy



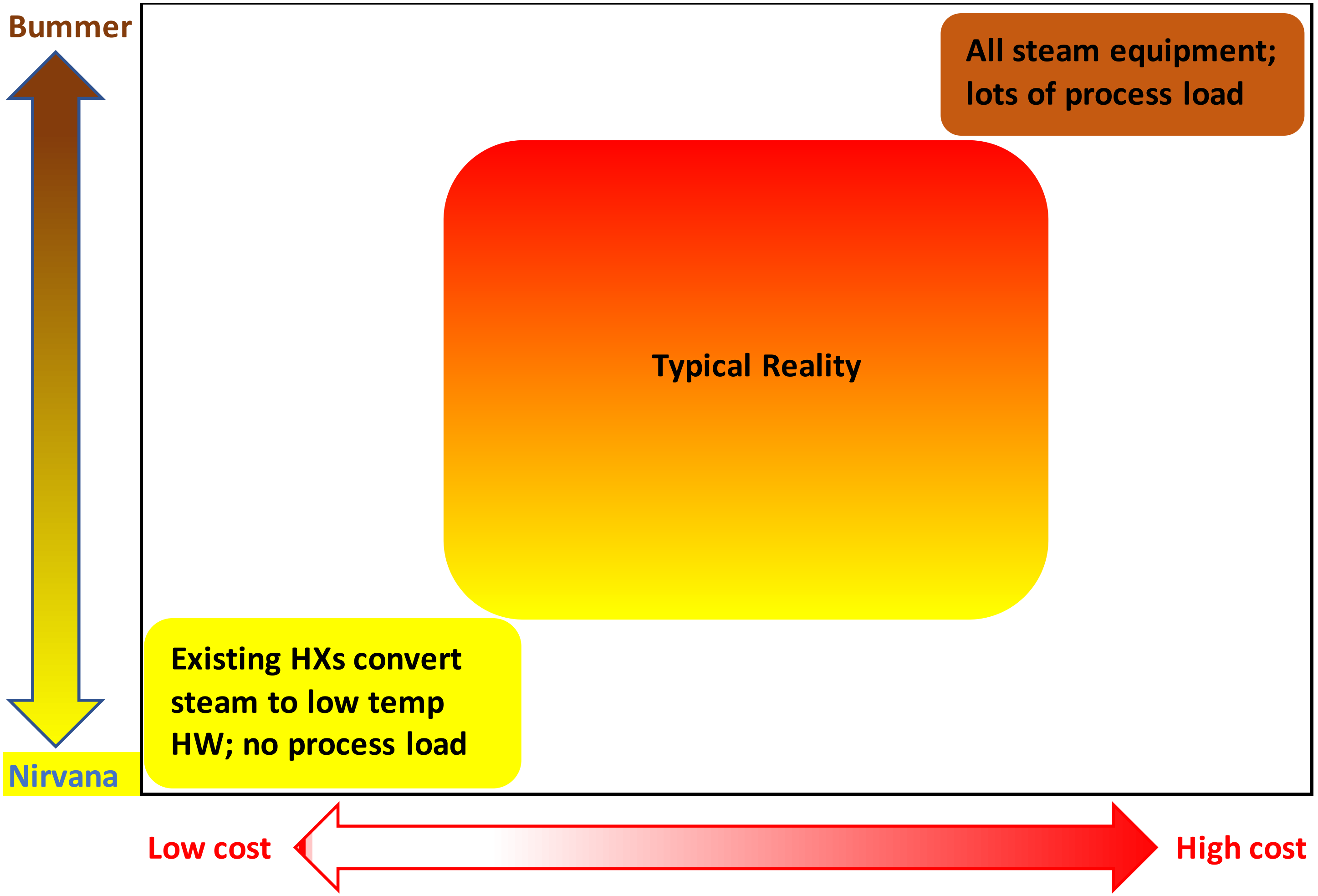
Planning for Capital Requirements

- **Key thoughts:**
  1. **Existing building stock mix and characteristics**
  2. **Temperature requirements**

- **Budgeting at the University of Michigan**

What is the mix of new vs. existing building space?

What are the characteristics of the existing HVAC systems?



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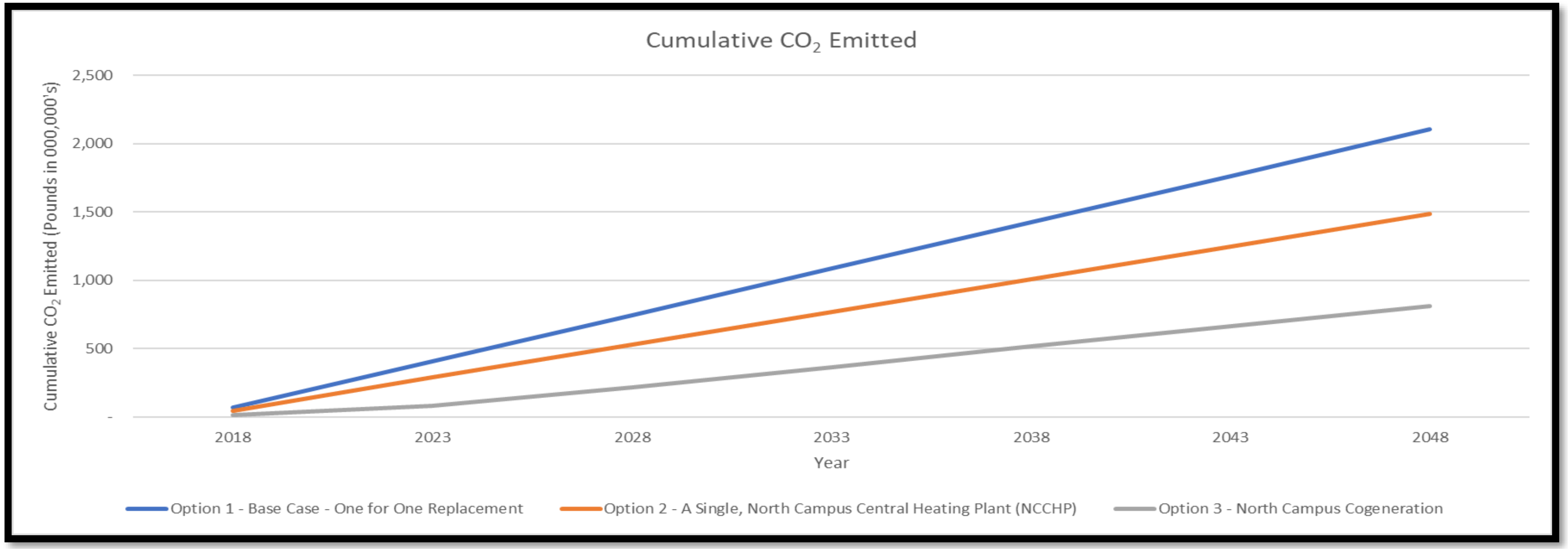
What temperatures are required for hot water thermal service?

	Option A - Building Peak Supply of 180 °F	Option B - Building Peak Supply of 140 °F
HWDH Distribution System	Higher Delta T, smaller pipe sizes	Lower Delta T, larger pipe sizes
Building System Conversion	Non-invasive retrofit of AHUs likely	Mandatory replacement of AHUs & coils
	Reuse of hot water piping on building side of steam/HW heat exchangers	Mandatory replacement of perimeter radiation. Potential Replacement of hot water piping in the building.
Operating Costs	Higher energy costs for temperature boost during peak conditions	Increased use of low temperature resources
	Higher distribution heat loss. Lower pumping costs.	Lower distribution heat loss. Higher pumping costs.

Capital Requirements: U-M Preliminary Study

Option | Description Present Value in 2018 (USD in millions)	2018 $ Totals
Option 1 – Base Case – One for one boiler replacement	$21
Option 2 – Central Heating Plant	$58
Option 3 – Central Heating Plant + Cogeneration	$78



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Financial Viability: Metrics

- **Simple payback**
- **Net Present Value (NPV):**
  - **The difference between the present value of the benefits of a project and its costs.**
  - **Executing a project with a positive NPV is equivalent to avoiding its NPV in cash today**

Financial Viability: U-M Preliminary Study Outcomes without Carbon Cost

- **Key thoughts:**
  1. Viable in the long term
  2. 30-Yr study window influences NPV

30-Yr Net Present Value **Present Value in 2018 (USD in millions)**	Option 1 Localized Heating	Option 2 New Boiler Plant	Option 3 CHP Plant Addition
Natural Gas	$49	$29	$48
O&M	$35	$28	$44
Carbon Cost	$0	$0	$0
Electricity Offsets	$0	$0	($84)
Subtotal Operating Costs	$84	$57	$8
Subtotal Capital Costs	$19	$56	$76
Net Incremental Capital Costs		$37	$57
Total Life Cycle Costs	$103	$112	$84
NPV Cost Savings vs. Base		***($9)***	***$19***
Option Selection	2	3	1
Payback (years)		26	18

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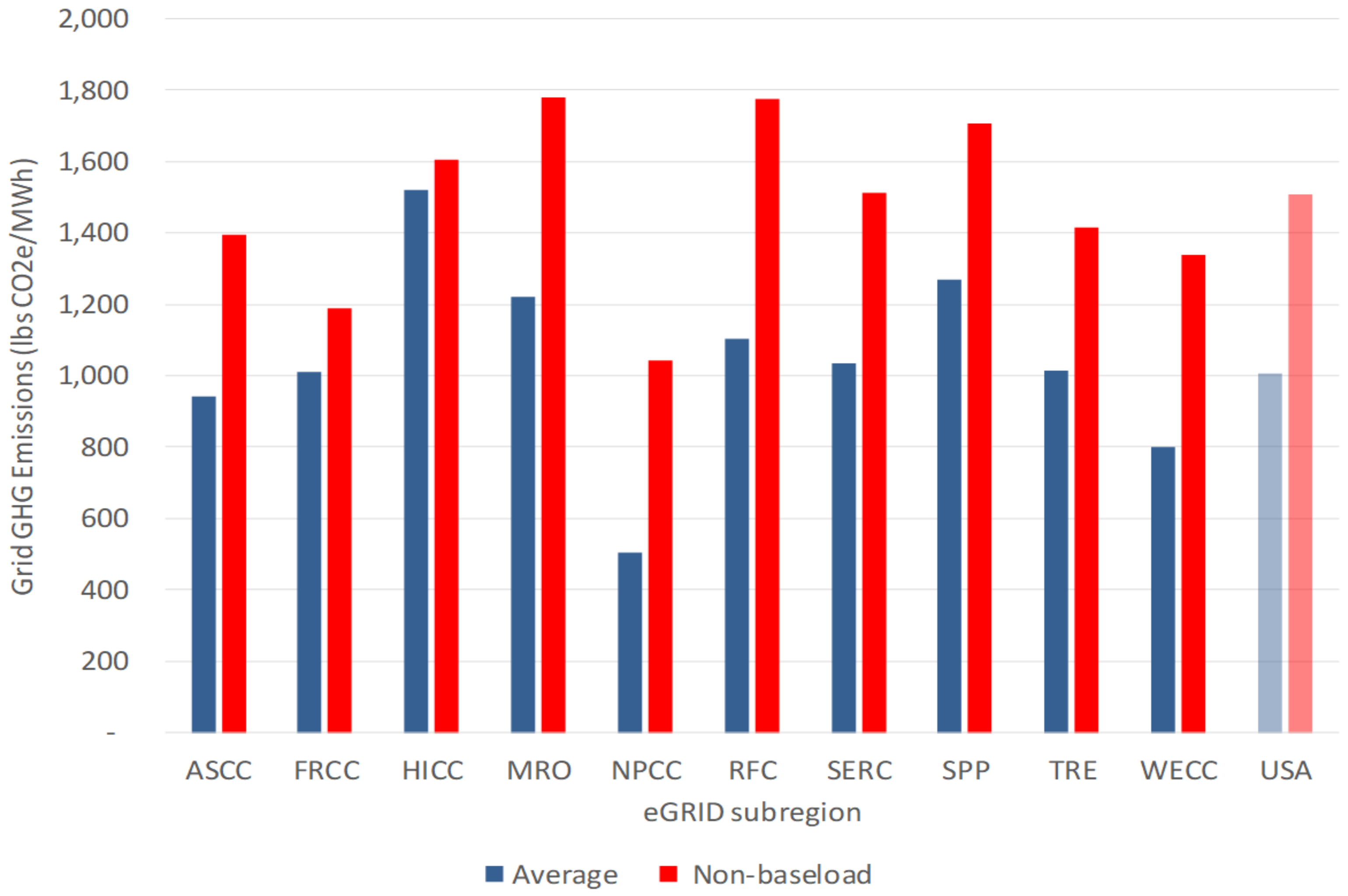
Pricing Carbon

- **Key thoughts:**
  1. **$27.27/Ton is equivalent to a cost of 1.5 cents per kWh when electrical service is provided by DTE Energy**
  2. **Implementing a carbon cost increases financial viability of district energy options**

	Option 1	Option 2	Option 3
30-Yr Net Present Value Present Value in 2018 (USD in millions)	Localized Heating	New Boiler Plant	CHP Plant Addition
With a $27.27/Ton Carbon Tax			
Total Life Cycle Costs	$ 123	$ 127	$ 97
NPV Cost Savings vs. Base		***($5)***	***$26***
With a $60/Ton Carbon Tax			
Total Life Cycle Costs	$ 146	$ 145	$ 112
NPV Cost Savings vs. Base		***$1***	***$35***
With No Carbon Tax			
Total Life Cycle Costs	$ 103	$ 112	$ 84
NPV Cost Savings vs. Base		***($10)***	***$19***

Where will your electricity consumption come from?
What is the carbon footprint of that power?



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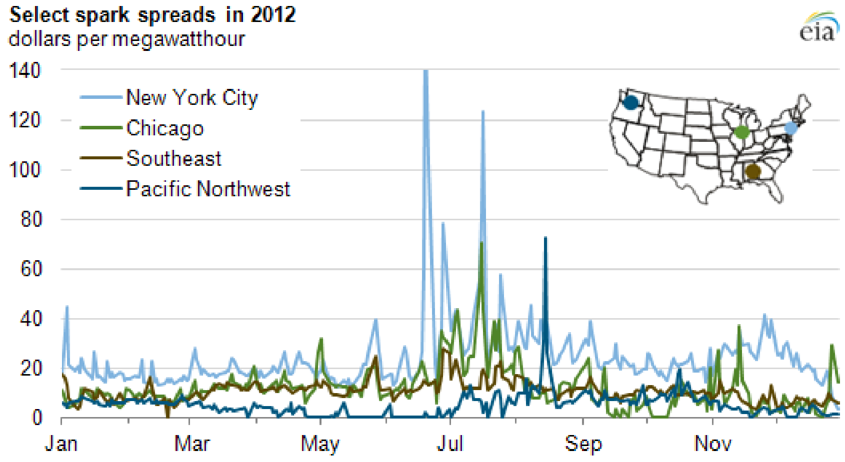
Key Considerations

Distribution piping system (DPS) lifespan

- EN-certified piping systems are expected to last at least 50 years
- Difficult to capture the residual value of the DPS over a shorter study period

The spark spread

- Infamously difficult to predict changing natural gas prices over time
- Variation by region and utility mix



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Key Considerations

Seasonal boiler efficiency

- Small variations in efficiency can have large effects
- An in-depth study presented in the 1994 ASHRAE journal postulated 42.5% to 76.6% should be used when actual performance is not available

Thanks for your attention!

Questions?

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