Towards a Fossil Free Campus: Sharing Plans, Accomplishments, and Challenges Moving Forward

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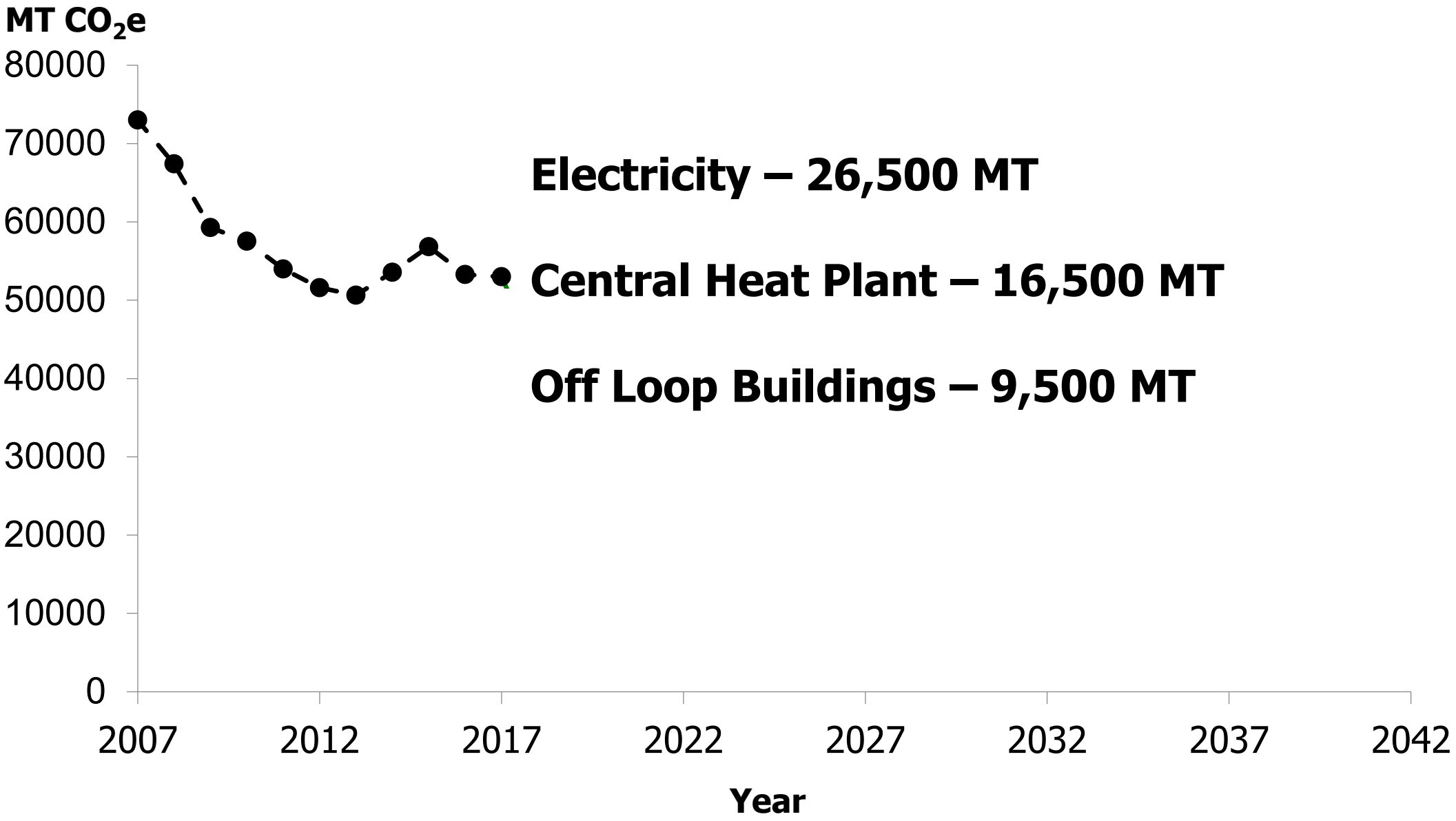
Brown University – Quick Facts

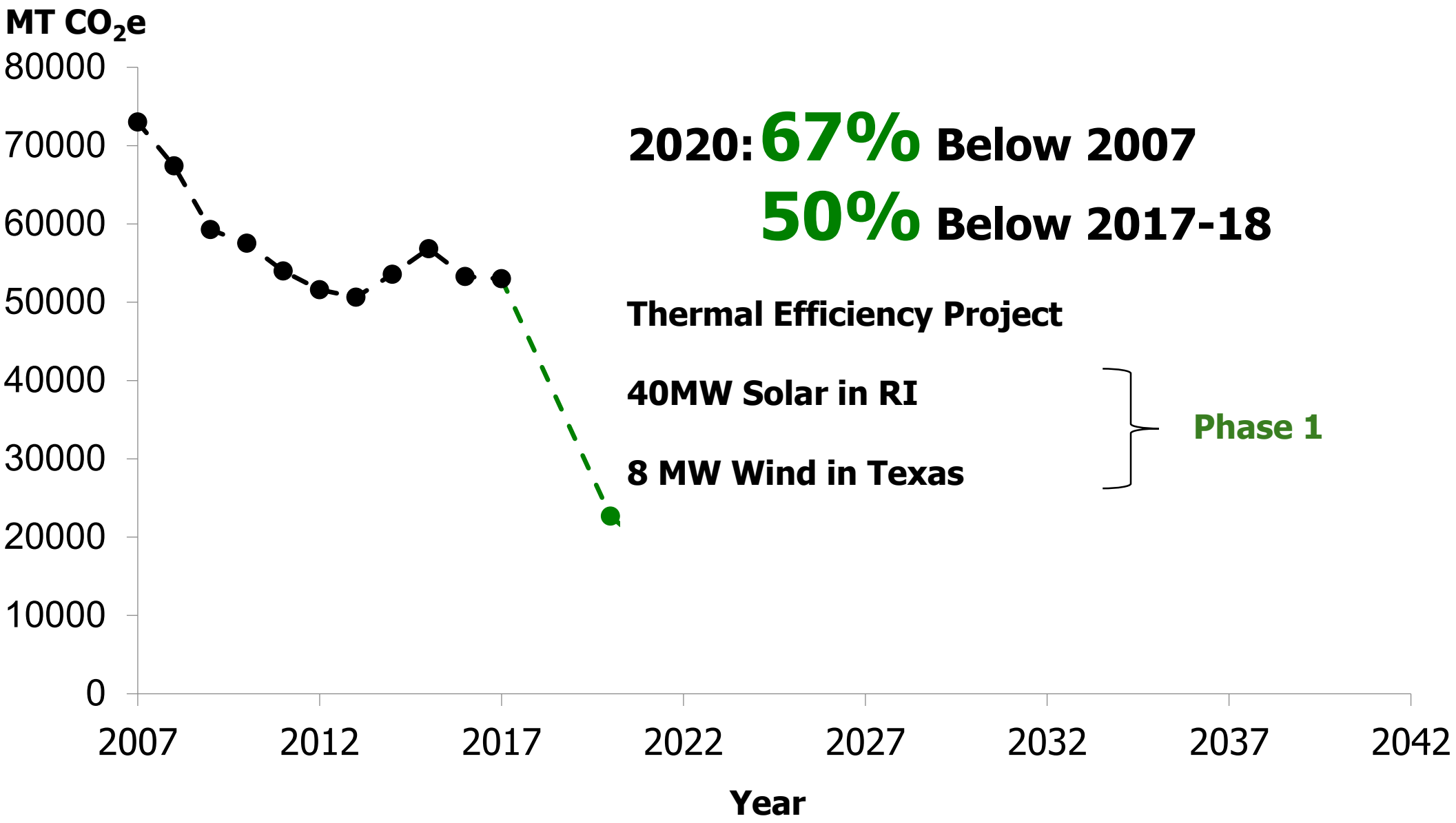
Founded	1764
# of Buildings	~240
Gross Sq Ft.	6.5 Million
# of Students	~9000 (all undergrad)
% Residential	<50%
Heating Mix	70 % sq ft heating by nat gas central plant. Other buildings individually heated/cooled. Electricity purchased.
Energy Intensity (kBtu/sq. ft)	115 (FY17)
GHG Intensity ($kg\ CO_2e/sq.\ ft$)	8.2 (FY17)
GHG Emissions Goals	Net zero by 2040
GHG Emissions Scopes	1 & 2 plus T&D losses

Built: 1770 – 2018
Biggest: ~200,000 sq ft Smallest: 2,500 sq ft

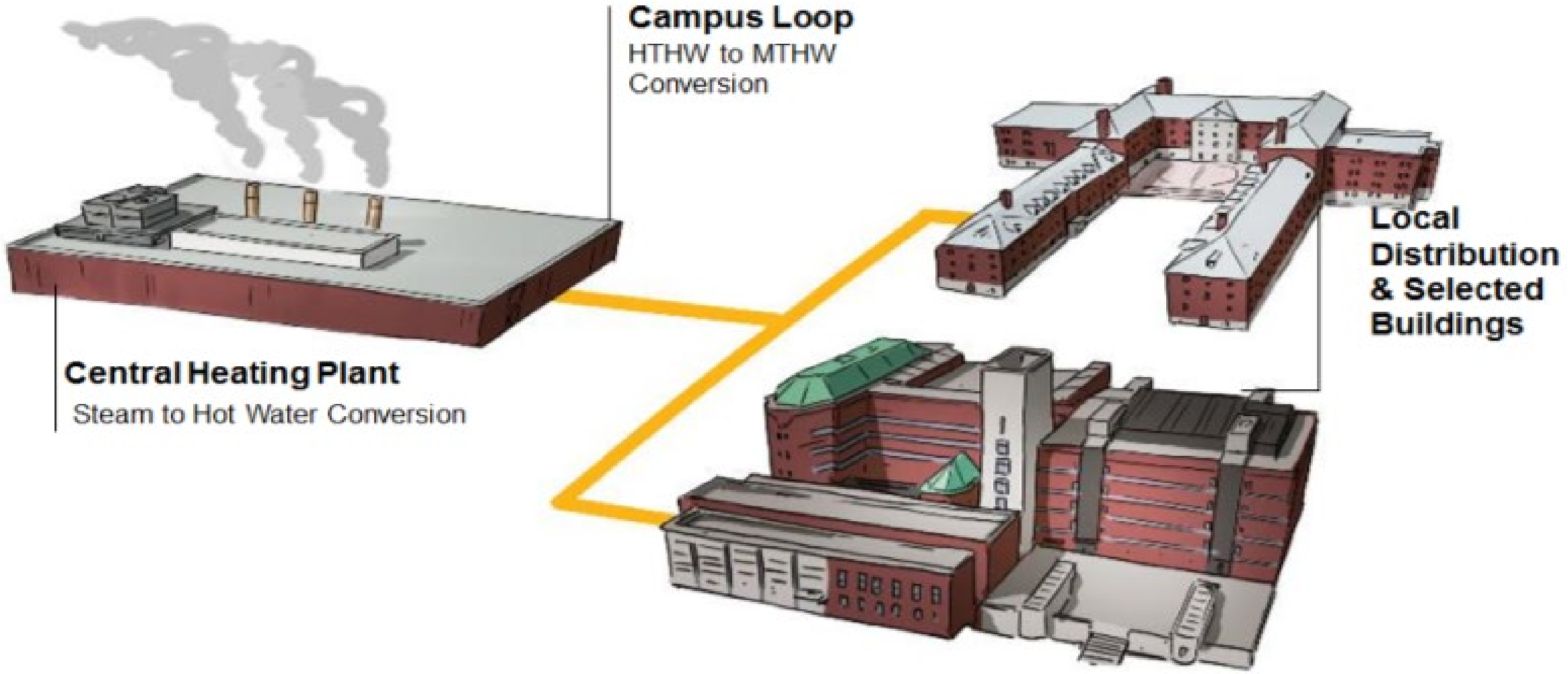
Brown's Campus Emissions Path



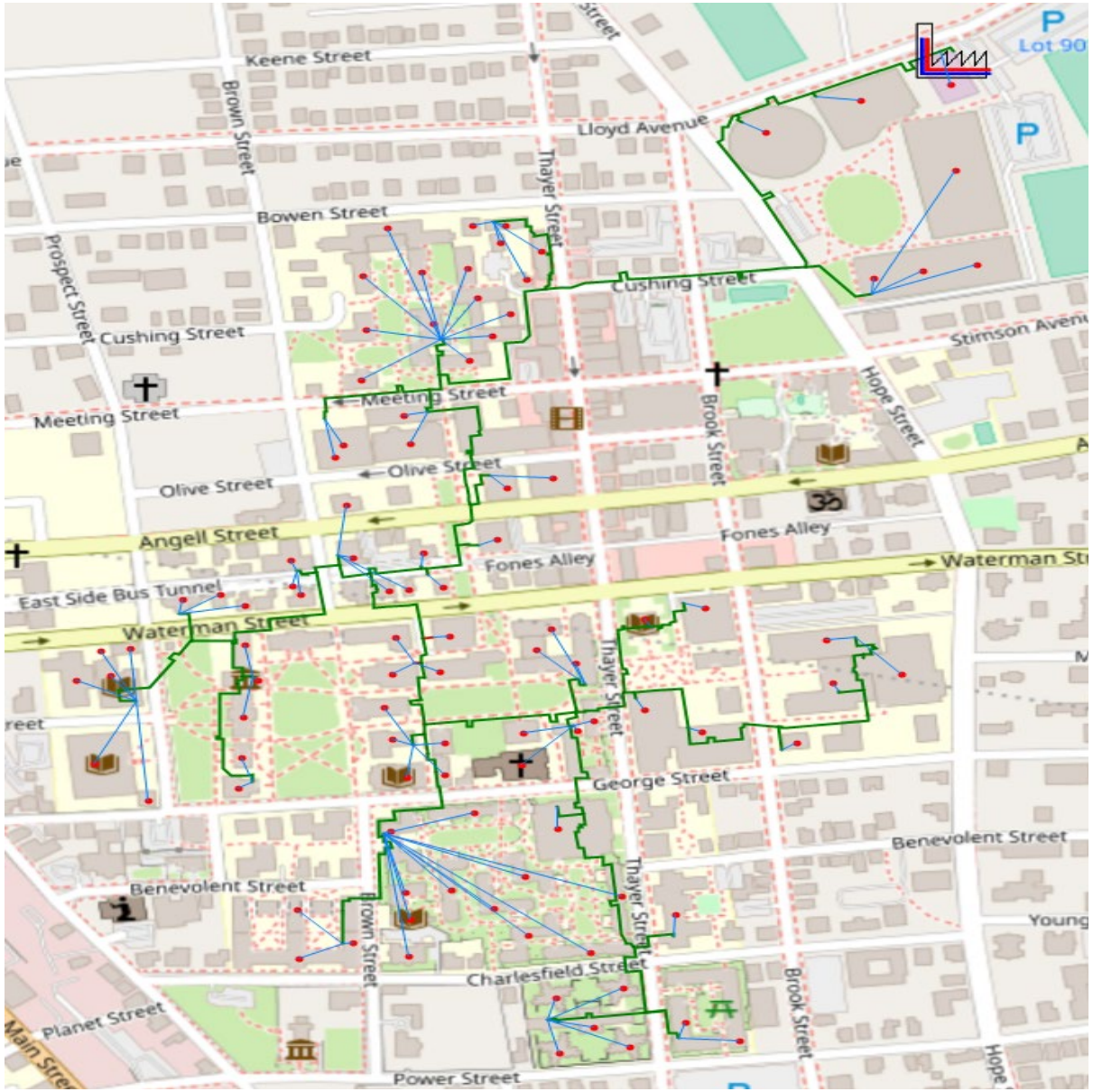
Brown's Campus Emissions Path



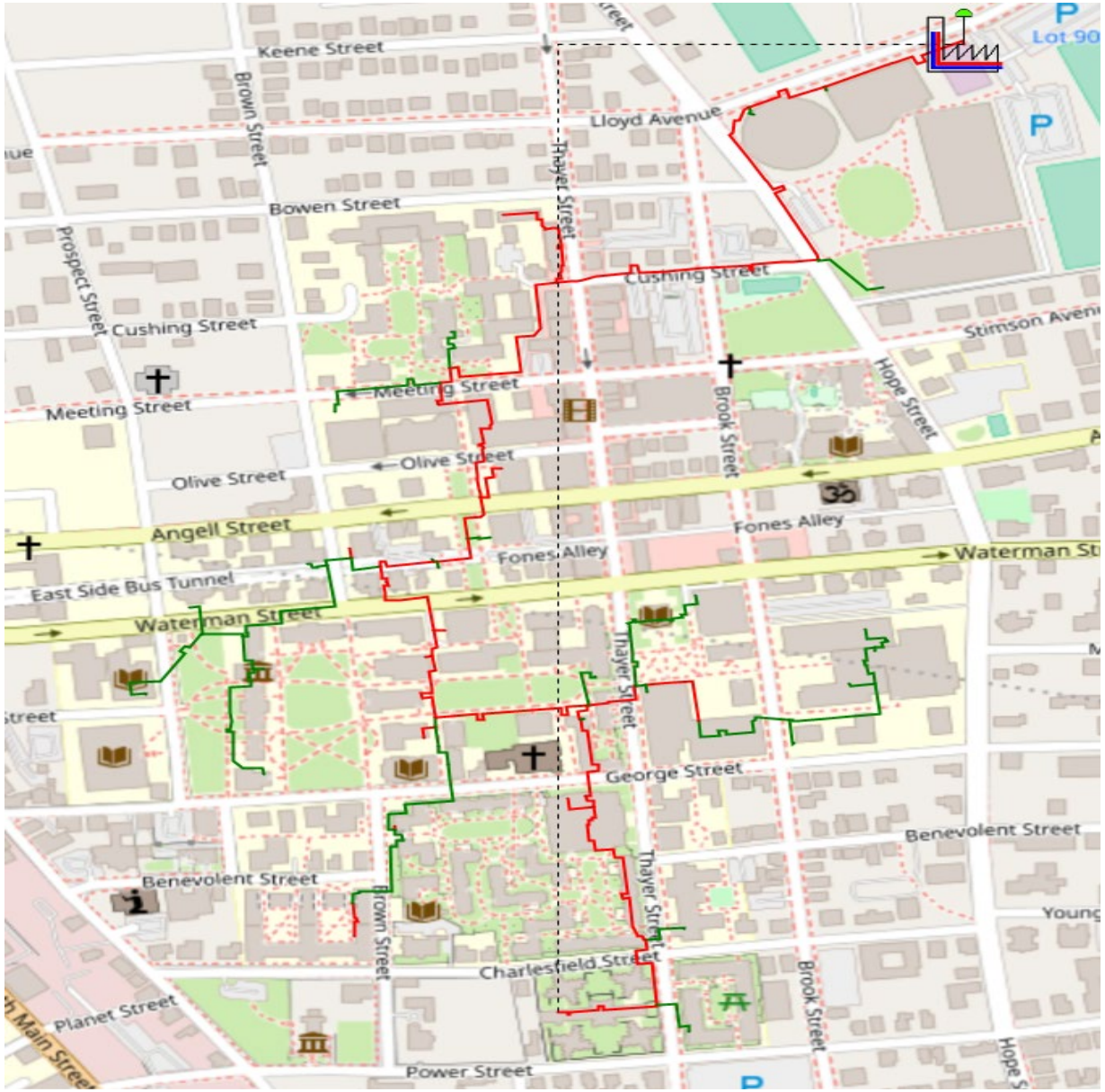
Central heating loop serves 70% of campus



Current water temp 350°F



Goal is to lower the loop temp to 185°F

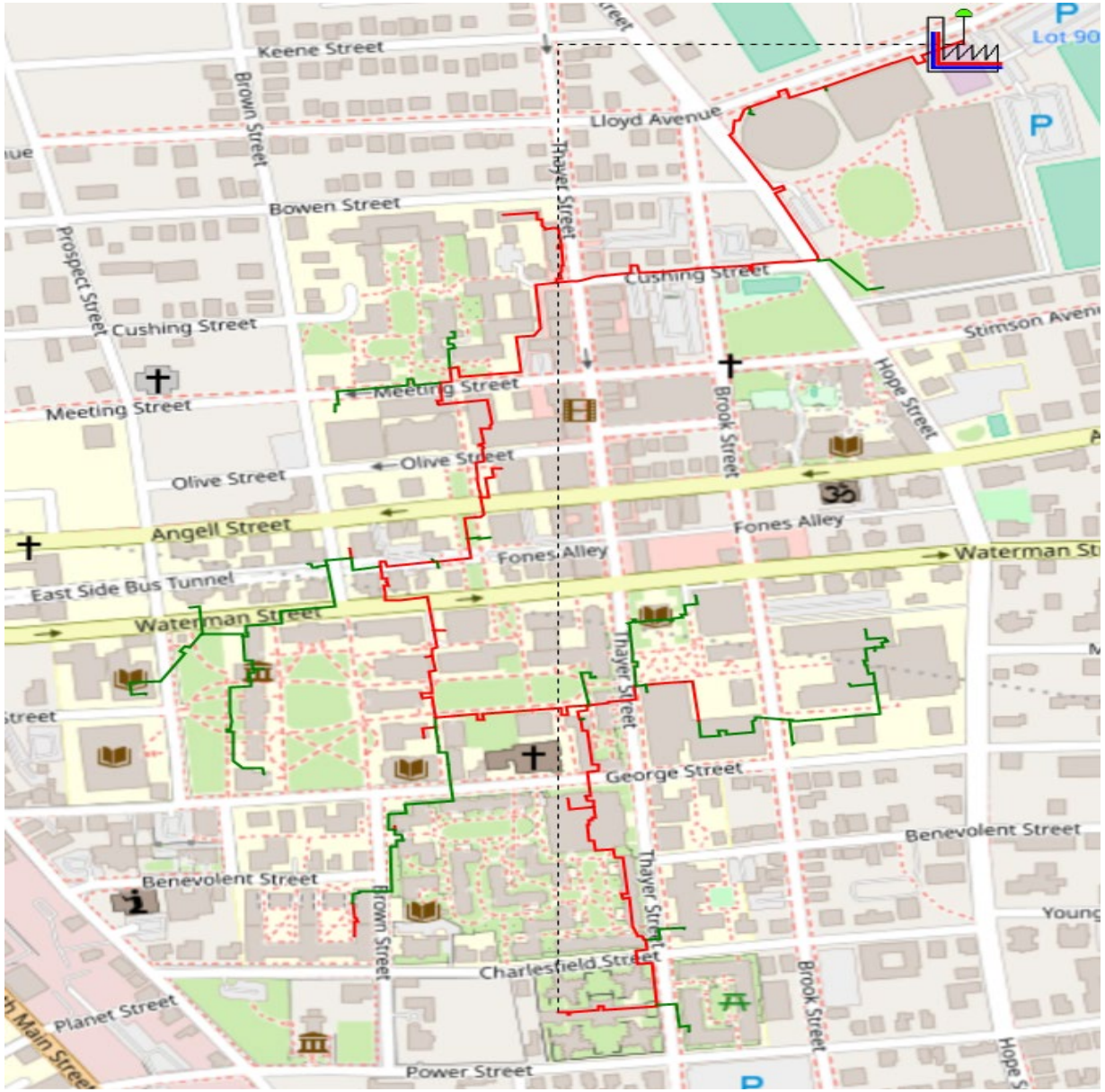


Lower water temperatures increase efficiency

185°F water opens up more heat source options

But requires building modifications

It will take >10 years and >$100M to get buildings ready



Grad Center A-E

(radiators, fan coils, air handlers)

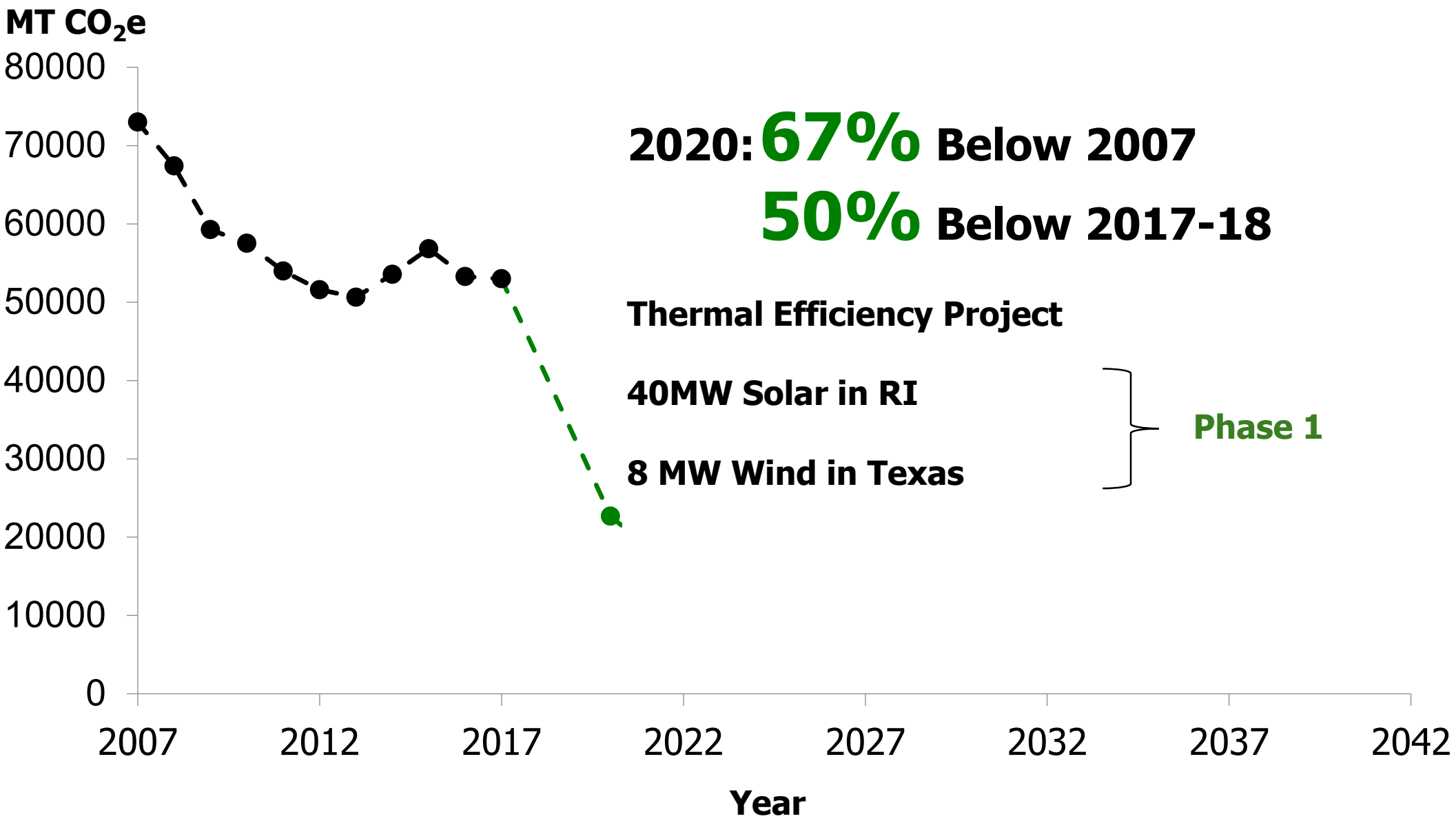
Sharpe Refectory

(radiators, pipe system, pumps, controls)

Wriston Quad

(radiators, some air handlers)

Brown's Campus Emissions Path

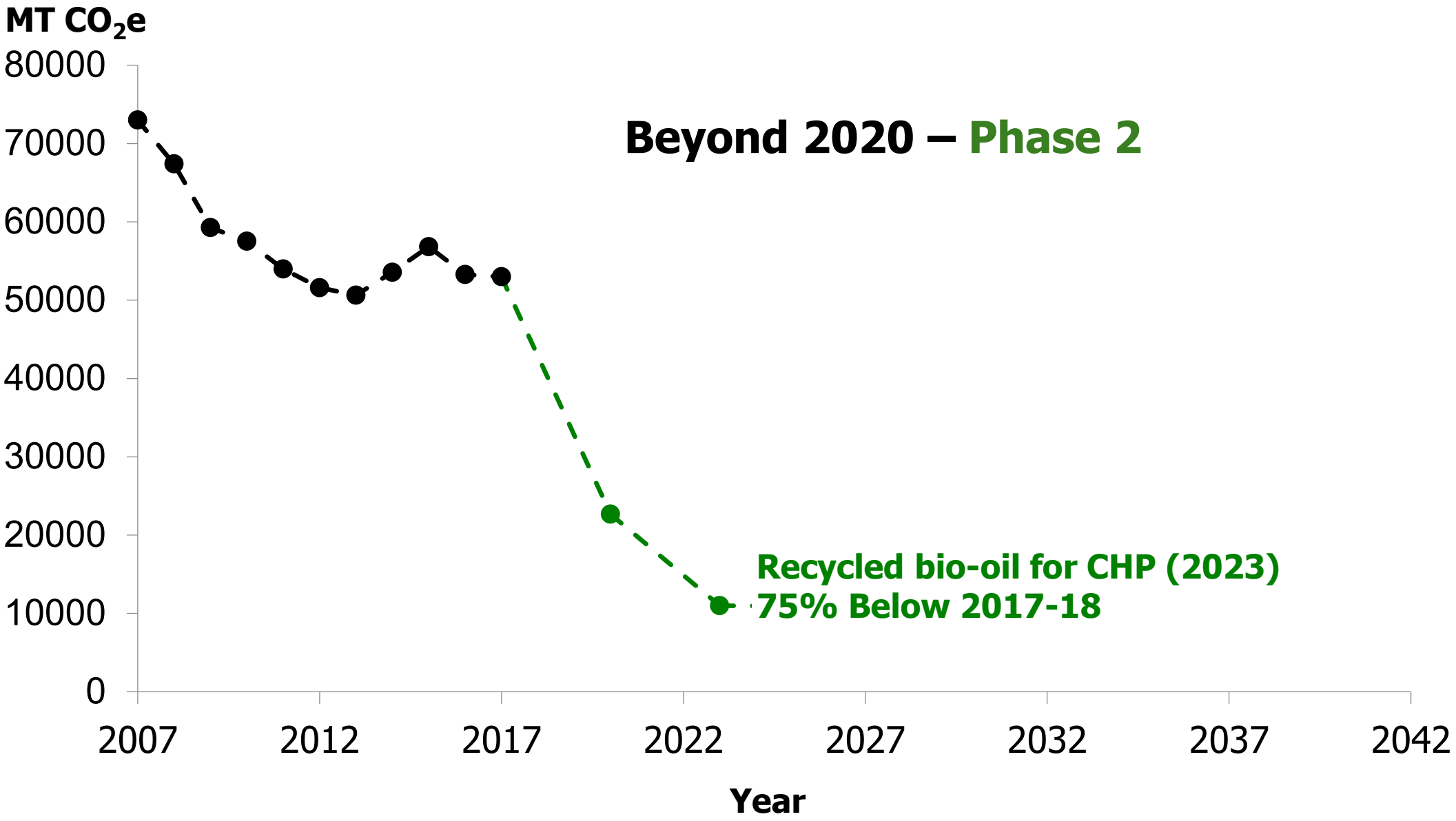


Recycled bio-oil:

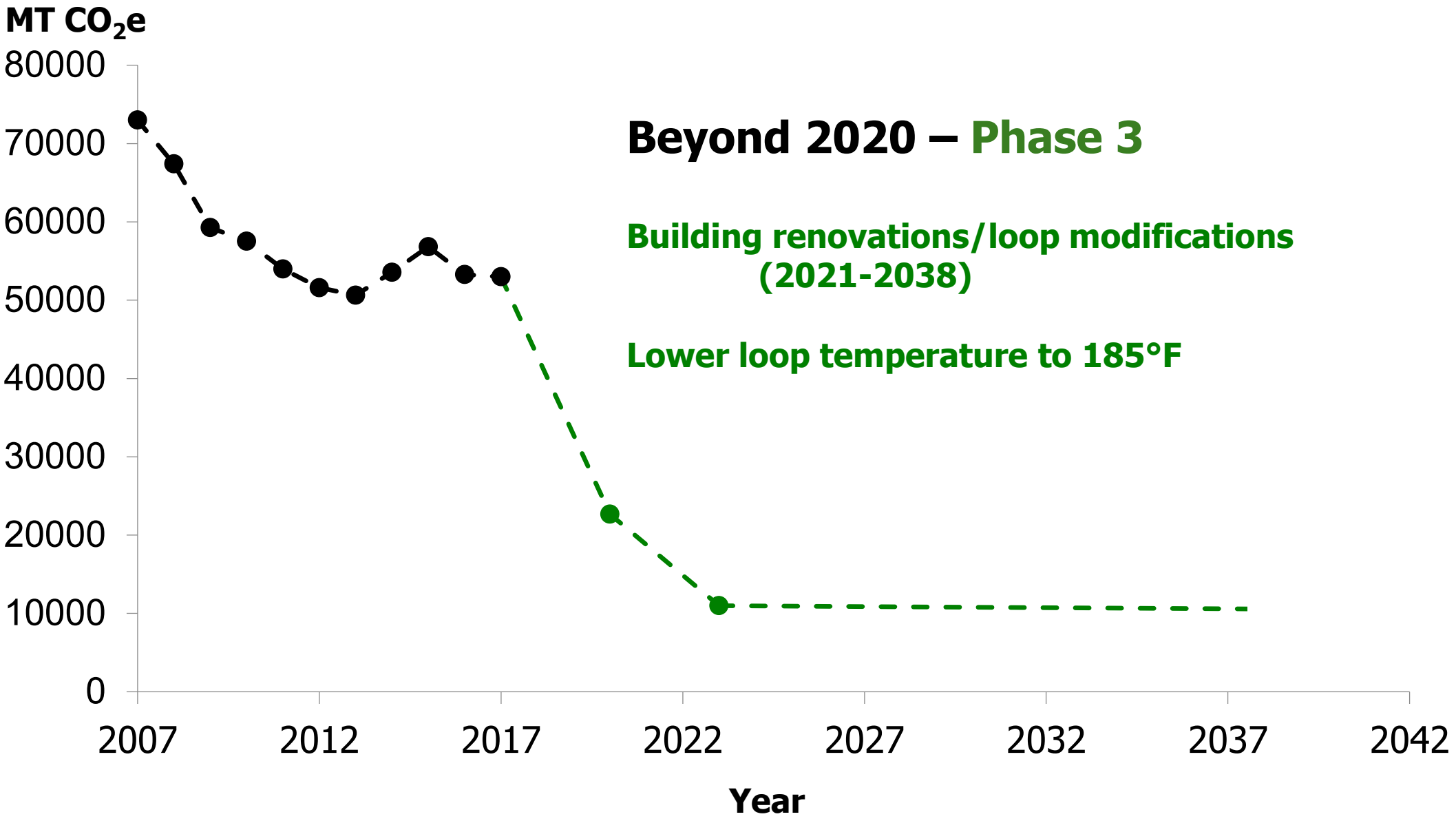
"Drop in" conversion
Low-carbon
Dual fuel capacity

Excellent transitional solution

Brown's Campus Emissions Path



Brown's Campus Emissions Path



Low temp water can come from heat pumps + storage run on renewable electricity.

Low temp water can come from heat pumps + storage run on renewable electricity.

RAMBØLL

Off loop buildings

Gradually transition 140 buildings off fossil fuels

- Maintain campus operations
- Incorporate into ongoing building and boiler renewal
- Prioritize larger and higher value buildings
- Explore connecting additional buildings to the loop
- Leverage other renovations

Free standing houses are “easy” but expensive

(2-3x cost per unit CO_2 reduction)

Free standing houses are “easy” but expensive

Renovation summer 2018

Initial plan to replace part of two-zone heating

(and not update window air conditioners)

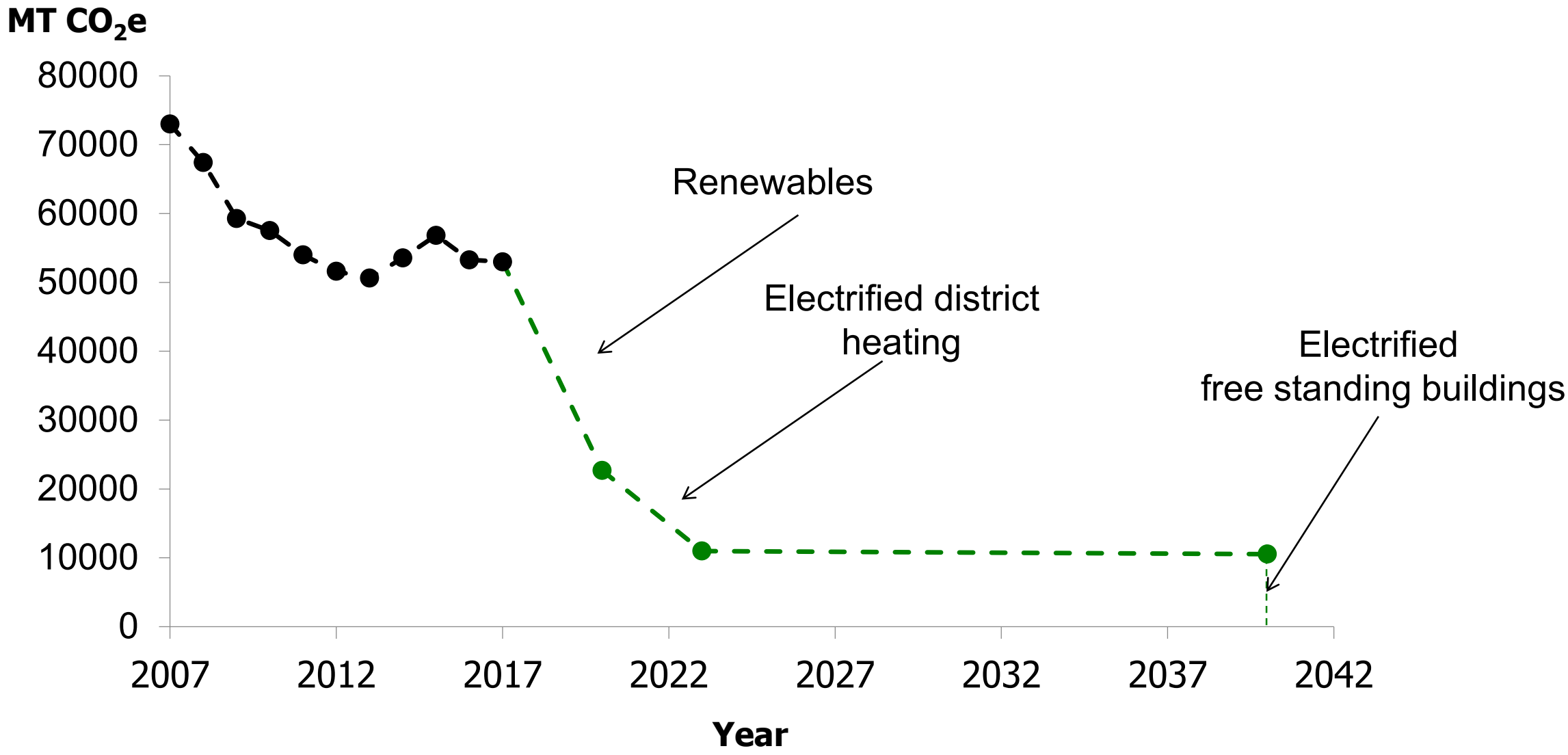
Added $140K for air source heat pumps to provide single heating and cooling system

Greater comfort

Easier maintenance

Net zero after renewable electricity

Net zero by 2040:
Technologically, financially and logistically challenging



Net zero by 2040:
Technologically, financially and logistically feasible