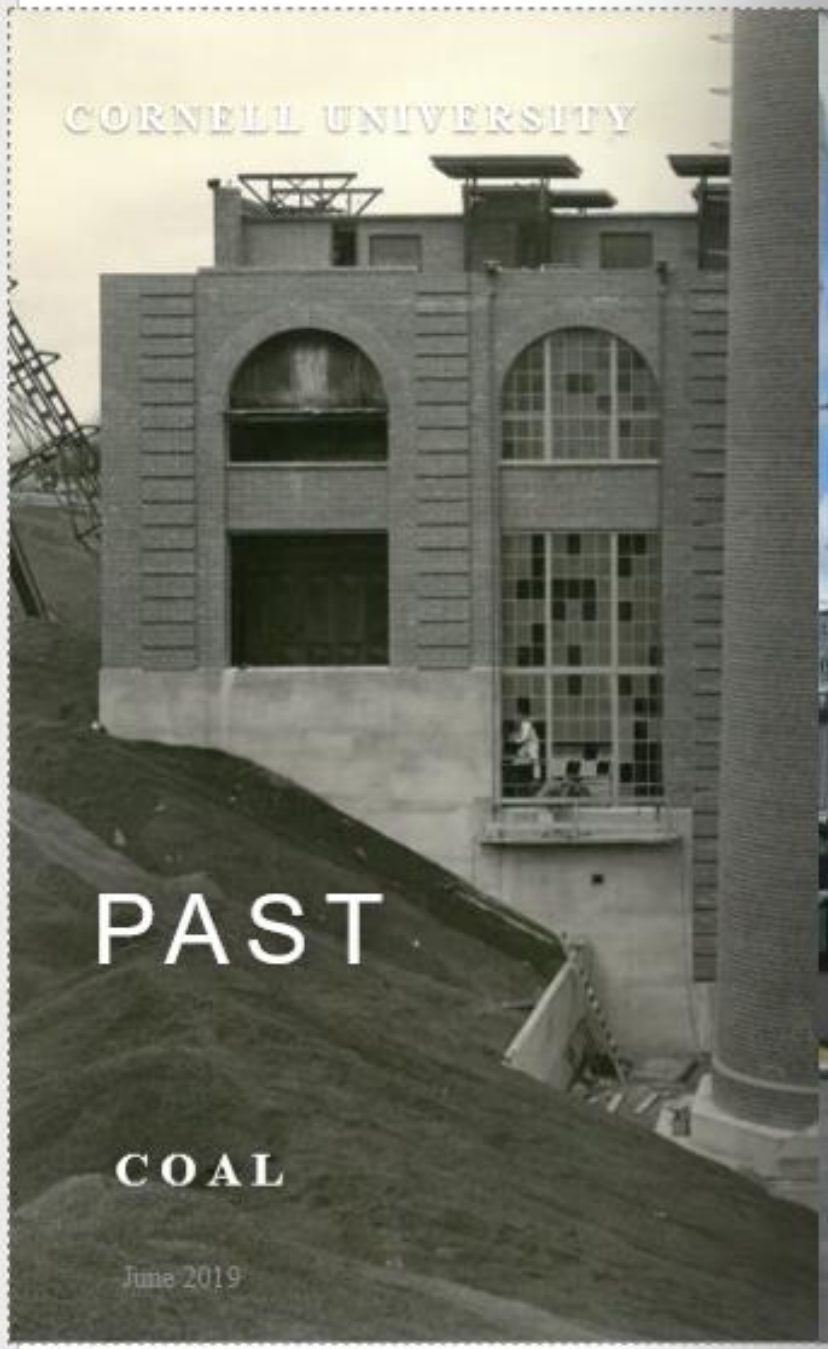
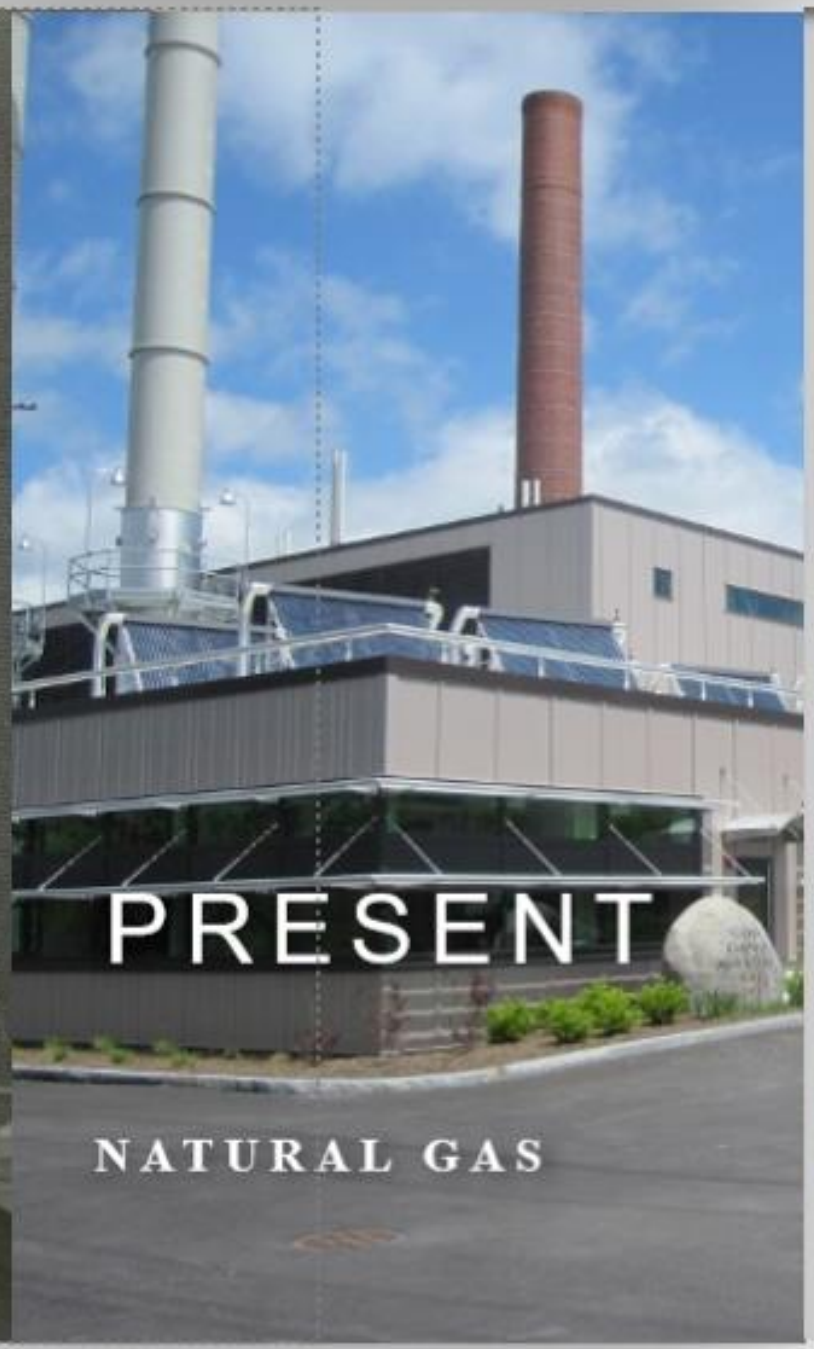

CORNELL UNIVERSITY
PAST
COAL
June 2019


PRESENT
NATURAL GAS


FUTURE
CARBON NEUTRAL
RENEWABLES

Climate Action Plan
Cornell University
BIG RED District Energy Transition

Goal for the Presentation

Introduce first phase of **District Energy Transition Master Plan** for discussion

Presenters

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Cornell Utilities--by the Numbers

Ithaca Campus

- 2,300 acres
- 150 campus buildings
- 15,873,205 gross square feet
- 2.9 trillion BTU Energy Consumption in 2023
- Electricity supplied to 14M gsf
  - 80% fossil fuel, 20% renewables
- Potable water supplied to 13.3M gsf
- Steam/hot water supplied to 13.1M gsf
  - ~95% byproduct of electrical production
- Chilled water supplied to 11M gsf
  - 97% via super efficient (COP 29) Lake Source Cooling

Energy Fast Facts:

Provide a 1-page snapshot of the present energy production, consumption, emissions associated with the central energy plants (this term includes heating, electricity, and chilled water).

https://fcs.cornell.edu/departments/energy-sustainability/energy-management-overview/energy-fast-facts

Climate Action Plan (CAP) Drivers

Internal: carbon neutrality goal

- Net zero combustion emissions from **campus energy use,** commuting, and air travel
- Integrate climate literacy into curriculum and educational experience
- Expand research necessary to achieve carbon neutrality

Reduce Ithaca campus carbon emissions to net zero by 2035

BIG RED Energy Transition

Create a living laboratory for low-impact behaviors, climate education, and research

External: state and local goals/mandates

- NYS climate law and scoping plan
- Ithaca Energy Code Supplement (IECS)
- Lake Source Cooling restrictions

Lead by example on campus and exercise climate leadership beyond campus

External Drivers

New York State Climate Leadership & Community Protection Act (CLCPA)

Buildings:

- New → no fossil fuel by 2025 (small), 2028 (large buildings)
- Existing → no replacement of fossil fuel equipment by 2030/2035

Transportation:

- 2030 100% zero emissions vehicles (ZEV) light duty and 40% medium/heavy duty sales; **ubiquitous EV charging**

Electricity: 70% renewable by 2030, 100% clean by 2040

- >100% demand growth by 2050 → TBD 10GW dispatchable supply to meet new winter peak
- Facilitate/accelerate wind and solar → agrivoltaics and community choice aggregation (CCA); consider advanced nuclear

External Drivers

Ithaca Energy Code Supplement (IECS)

- Local supplement to the NYS Energy Conservation Code
  - Applies to new construction, significant renovations, and additions
  - Must comply for Building Permit or Certificate of Occupancy
- Promotes electrification of building heating and cooling and renewable energy
- By 2026 projects must comply with “Zero” Code
  - Intense energy performance requirements
  - 100% renewable energy offsets for 15 years post construction

District Energy System Transformation

Building an **I**nnovative **G**rid for **R**eliability, **E**fficiency and **D**ecarbonization

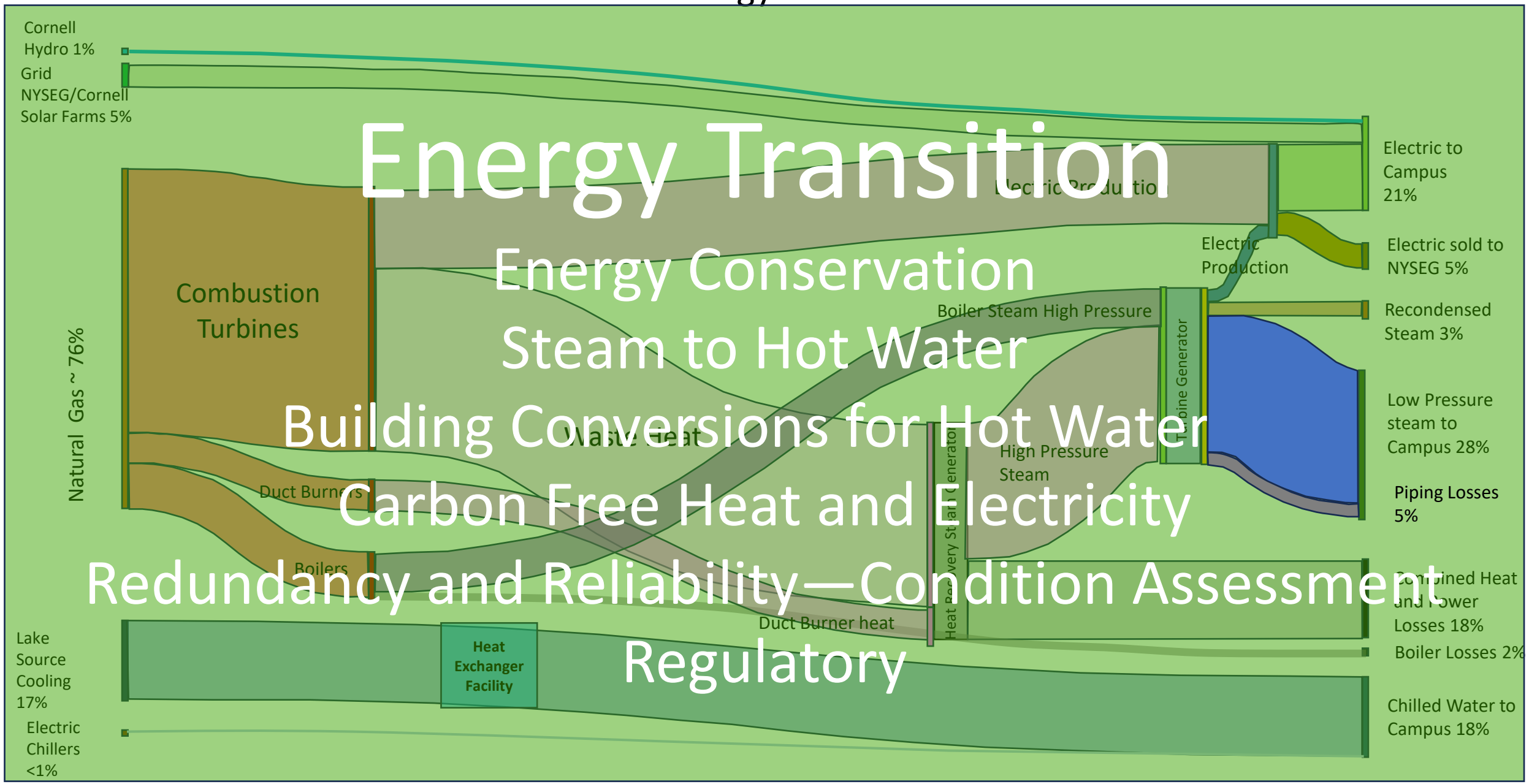
"BIG RED Energy Transition"

Cornell's "fossil fuel free" district energy system will comprise:

- Solar Power (today 20% of annual load, 80% under contract)
- Electricity from the New York State grid—assumed to be zero emissions by 2040
- Hot Water Distribution System instead of Steam Distribution
- Electric heat (Geoexchange)
- Back up power (grid outages)—source TBD
- Cooling provided by mix of Lake Source Cooling, chillers, heat pumps

Addresses the utilities infrastructure portion of the 2035 President's Climate Commitment -- excludes buildings outside district energy, campus process gas, university vehicles, commuting, and air travel.

District Energy Flows



Energy Transition

Energy Conservation

Steam to Hot Water

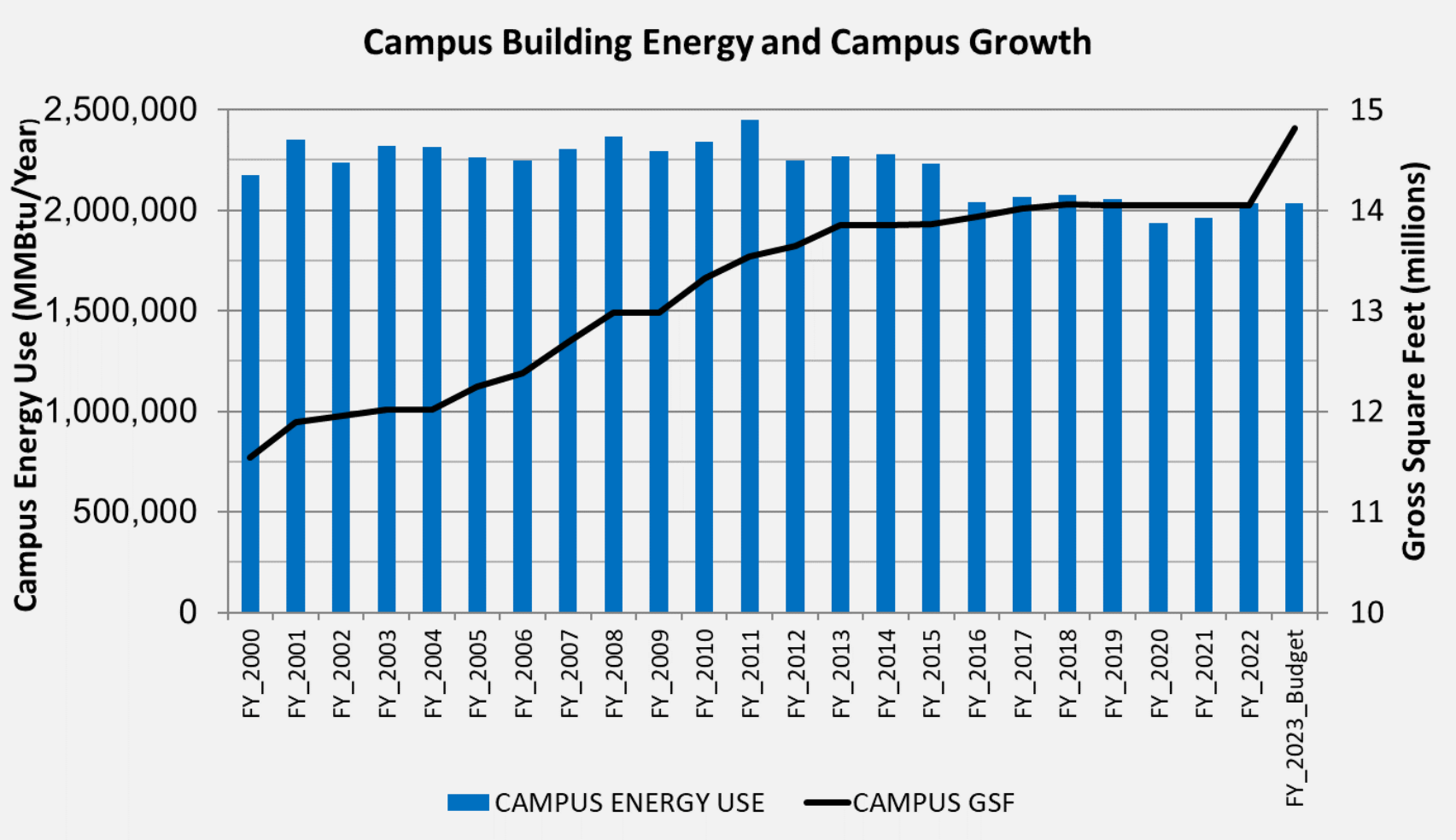
Building Conversions for Hot Water

Carbon Free Heat and Electricity

Redundancy and Reliability—Condition Assessment

Regulatory

Campus Growth and Energy: 2000 – 2022



Energy Conservation Initiative (ECI) …by the numbers

Key Financial Metrics

Invested and Saved

Invested: $ 48,036,886

Saved: $ 77,315,143

Summary

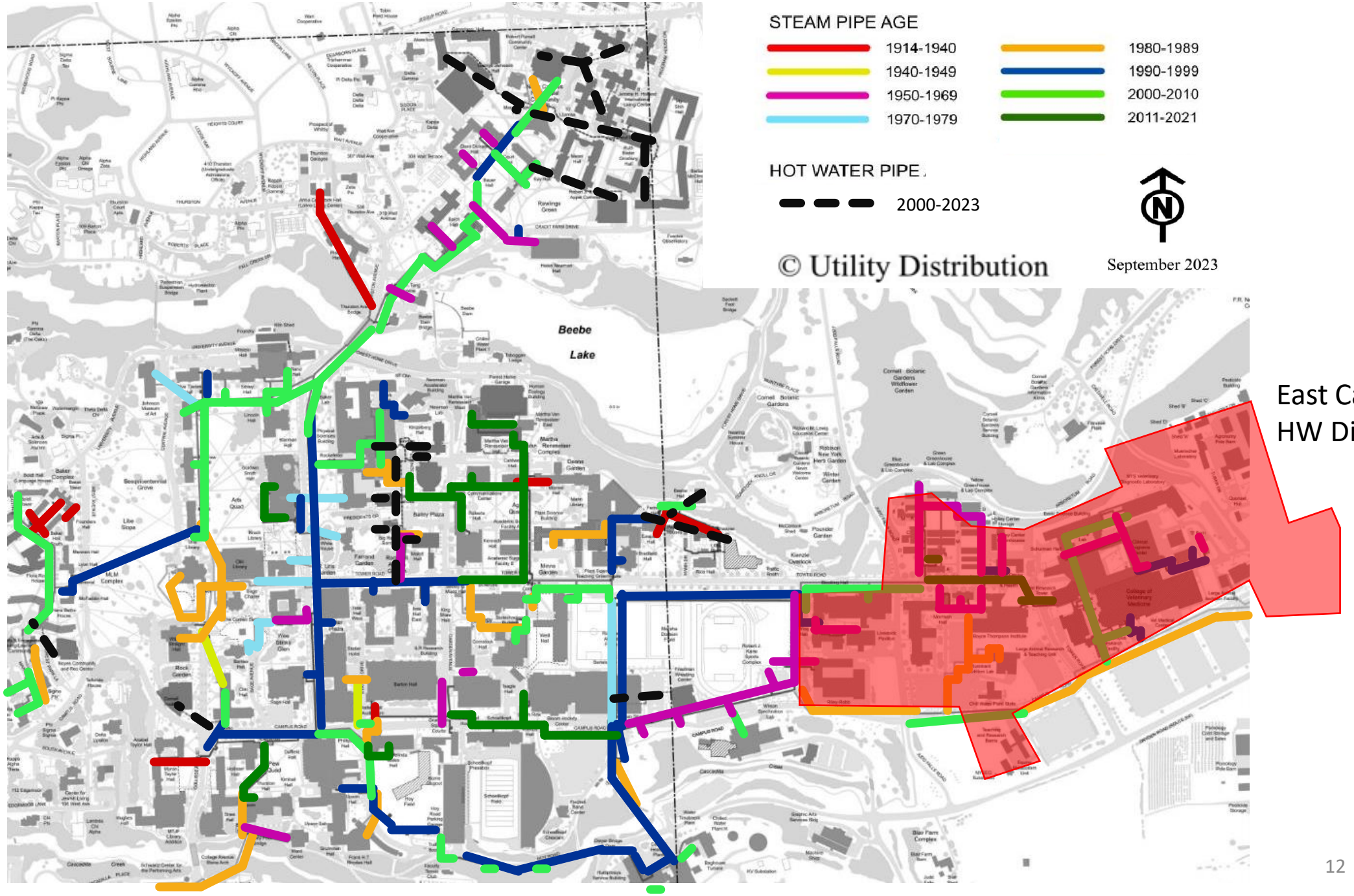
- ECI has been the workhorse of decarb efforts
- Looking to increase annual ECI investment
- Seek projects with <10 year payback AND payback < useful life

Project Portfolio

NUMBER OF PROJECTS FUNDED TO DATE	MEDIAN ANNUAL ROI	MEDIAN PAYBACK PERIOD (YEARS)	MEDIAN UNIT COST PER $MTCO_2E$ ABATED	WATER REDUCED TO DATE (GAL)	ABATED CARBON EQUIVALENT EMISSIONS ($MTCO_2E$) TO DATE	ENERGY REDUCED TO DATE (MMBTU)
68 / 2	13.34%	5.03	$ 97.19	0	229,629	3,652,629

Steam to Hot Water Conversion …needed for carbon free heat

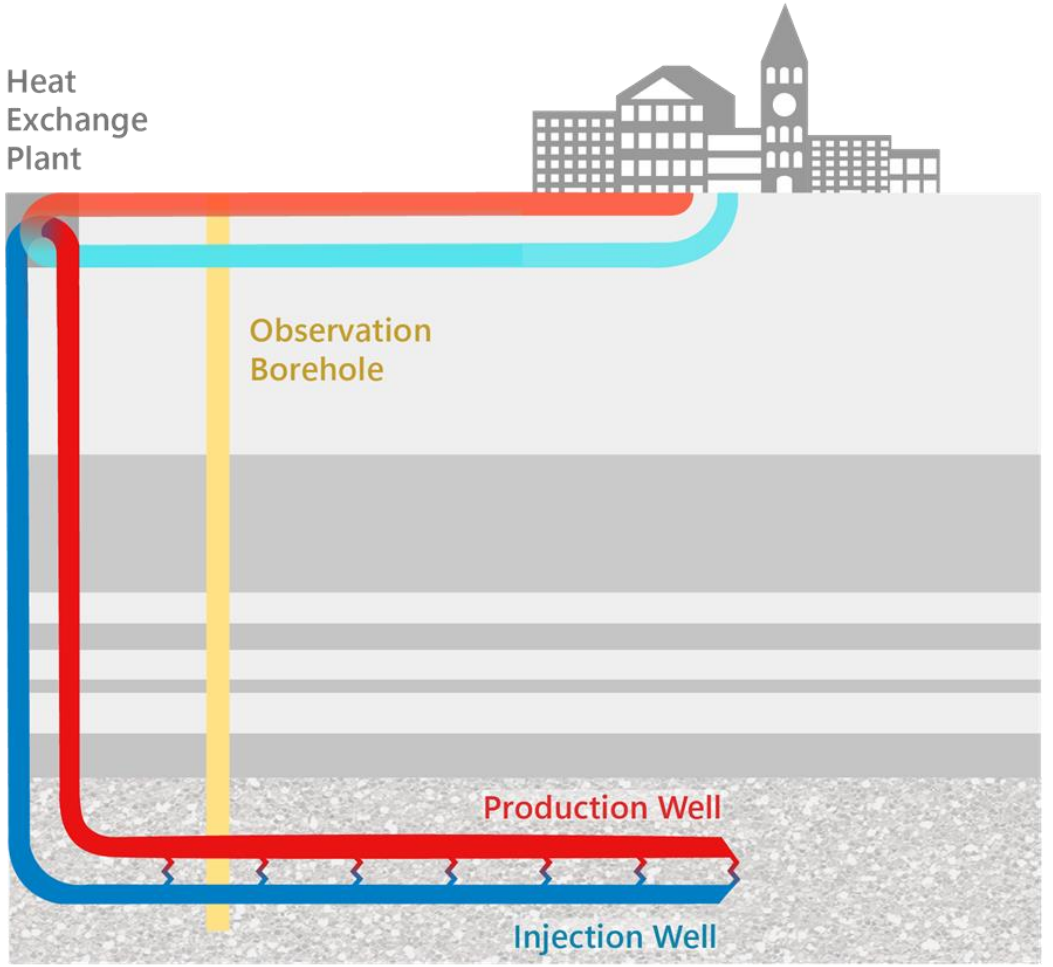
- First hot water district installed 25 years ago
- Pursuing steam to hot water when replace EOL steam lines and new buildings
- Reduces system energy losses and inherently safer
- Begin at the outskirts of campus and work back towards the CEP
- Majority of buildings require upgrades in addition to distribution
- Planning looks at campus growth and densification to ensure inground piping is correctly sized for possible future growth


STEAM PIPE AGE
1914-1940
1940-1949
1950-1969
1970-1979
1980-1989
1990-1999
2000-2010
2011-2021
HOT WATER PIPE
2000-2023
© Utility Distribution
September 2023
Beebe
Lake
East Campus
HW District

Carbon Free: Geoexchange Heating Options

Deep Geothermal: Earth Source Heat (ESH)

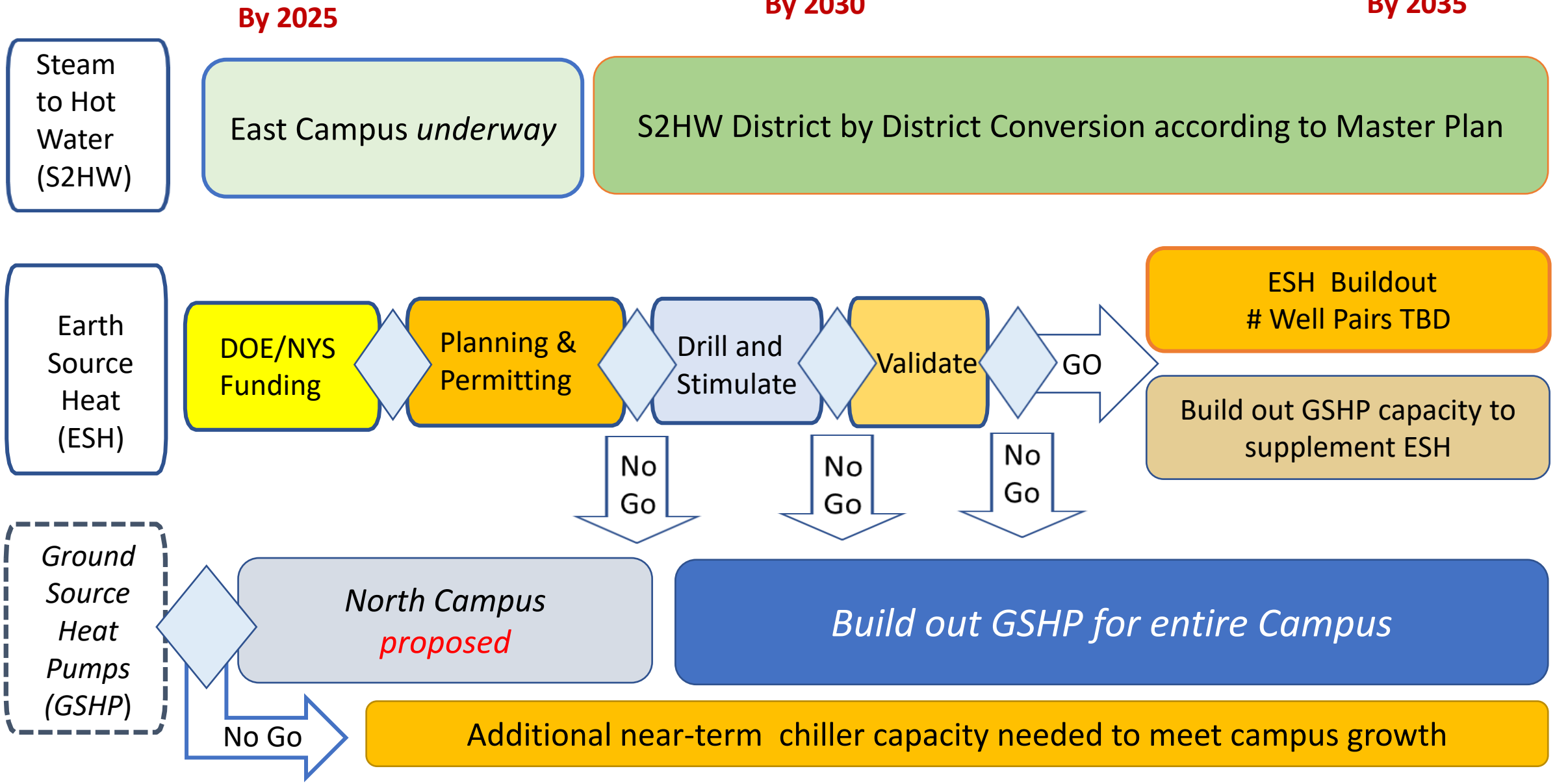
- 10,000ft deep well pairs
- Reliance on unproven Enhanced Geothermal System (EGS) technology
- Low electric demand
- No refrigerants
- Pairs with Lake Source Cooling



Shallow Geothermal + Ground Source Heat Pumps

- Conventional technology used by many campuses
- Doubles electric demand over ESH
- Approximately 10,000 wells each 500 feet deep

Heating/Cooling Transition



CUBO (ESH) Test Bore – What did we find?

- Safe drilling environment
- Ideal temperature for connecting to district energy
- Insights into deep geology and new technology make working at depth more attractive

NEXT

- Demonstration well pair? Funding being pursued

Condition Assessments

- Uncertainty over the future of the Cornell Central Energy Plant
- Expected phase out may look like this?
  - Step 1 - reduction in loads
  - Step 2 - use only for peaking
  - Step 3 – use only for emergency backup (or possibly another technology)

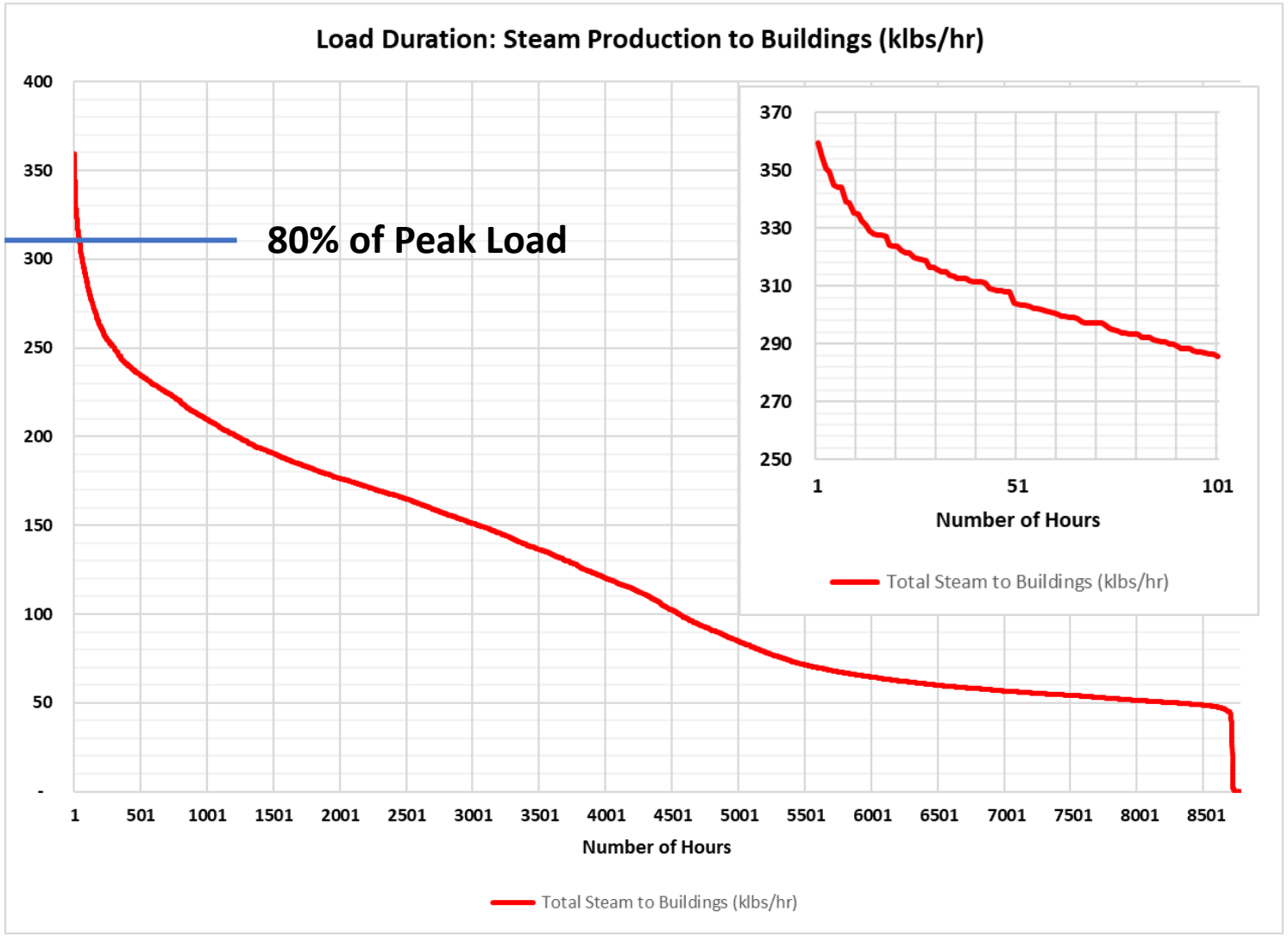
Considering the expected phase out, we anticipate minimized capital investment in the existing plants.

Condition Assessment Study

- Assess current deficiencies
- Compare to the University's current needs (ECI versus building growth)
- Phased capital renewal plan: immediate needs, 1-3 years, >3 years
- Repeat as the future becomes clearer

How will other CIBO Member's plants be utilized in the future?

Challenges--Peaking Load Duration



- There are less than 100 hours in the year where we exceed 80% of the peak. However, such weather conditions also mean low availability of renewables (no wind / no solar)
- Reliability/Redundancy
- Critical loads
- Avoid, Reduce, Replace

Reliability & Resiliency

- The Central Heating Plant may still be needed to provide **peaking capability** for heating demand (energy storage may help) and **backup** heating and electricity for critical loads

- Backup heating, cooling, and electric capacity will most likely not be sufficient to serve all campus loads, and load shedding may be necessary

Strategic Load Shed

- Phase 1: Load shed in an emergency when a production asset is down
- Phase 2: Load shed to avoid capital expenditures on rarely used equipment that will have a limited life?
- Phase 3: Load shed to reduce operating expenses (electrical peak costs)?

Take Aways

- Shifting from voluntary to mandatory climate goals
- BIG RED Energy Transition multifaceted:
  - Currently transitioning from Steam to Hot Water
  - Accelerate Energy Conservation
  - Transition heating technology
- Our Central Energy Plant is a valuable, well-maintained asset
  - Options exist to keep it for back-up and/or peaking consistent with fossil-fuel free goals
- How do you minimize capital investment in existing plants?
- How to meet peak demand?
- How to ensure Reliability and Resiliency?