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CampusEnergy2022

Feb. 15-18 | Westin Boston Seaport District Hotel | Boston, Mass.

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Wesleyan University’s Logical Progression Toward Carbon Neutrality

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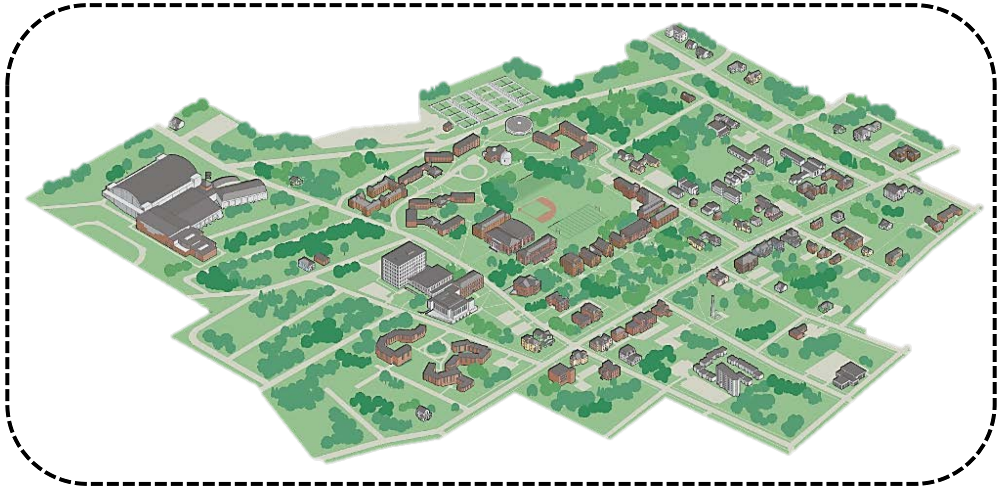
VANZELM ENGINEERS

Wesleyan University

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

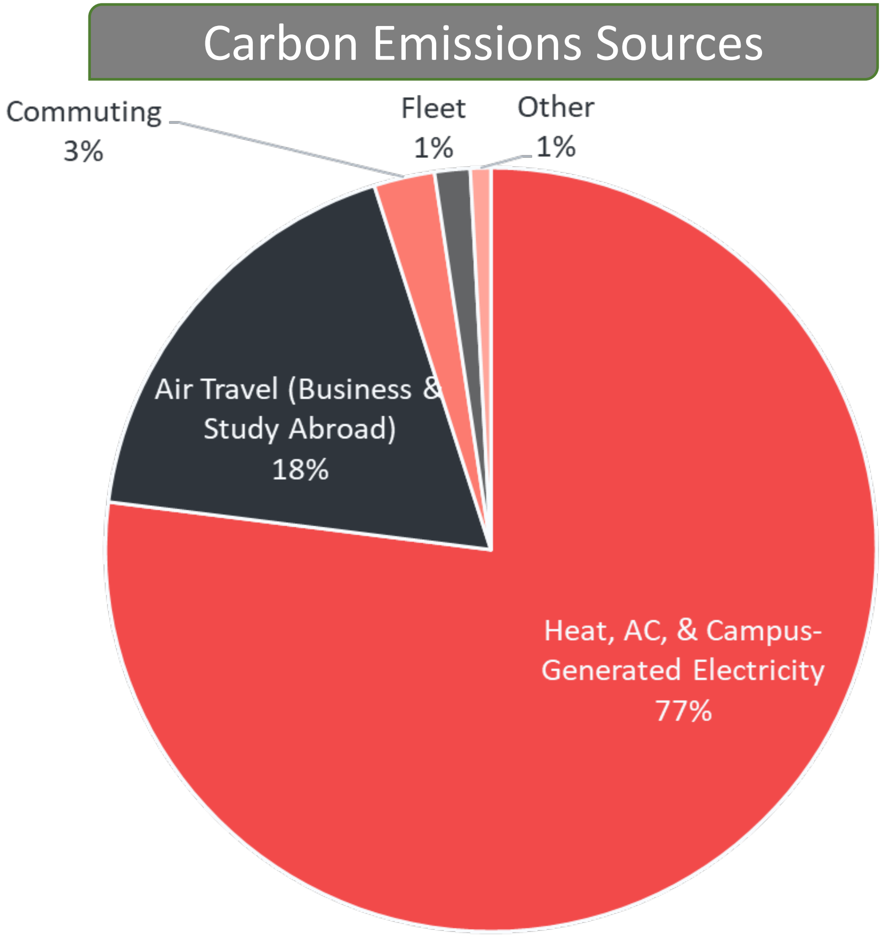
The Wesleyan University Campus

- Located in Middletown, CT – Established 1831
- Total of 300+ buildings, totaling 3.2M sf owned by the University on 360 acres
- "Core Campus" comprises 39 buildings with a total area of approximately 1.6M sf
- All core campus facilities fed by campus steam (60 psi) and medium voltage (13.2 kV) distribution system
- Approximately 60% of core campus buildings served by campus chilled water plant
- All facilities outside of core campus served by a variety of local systems

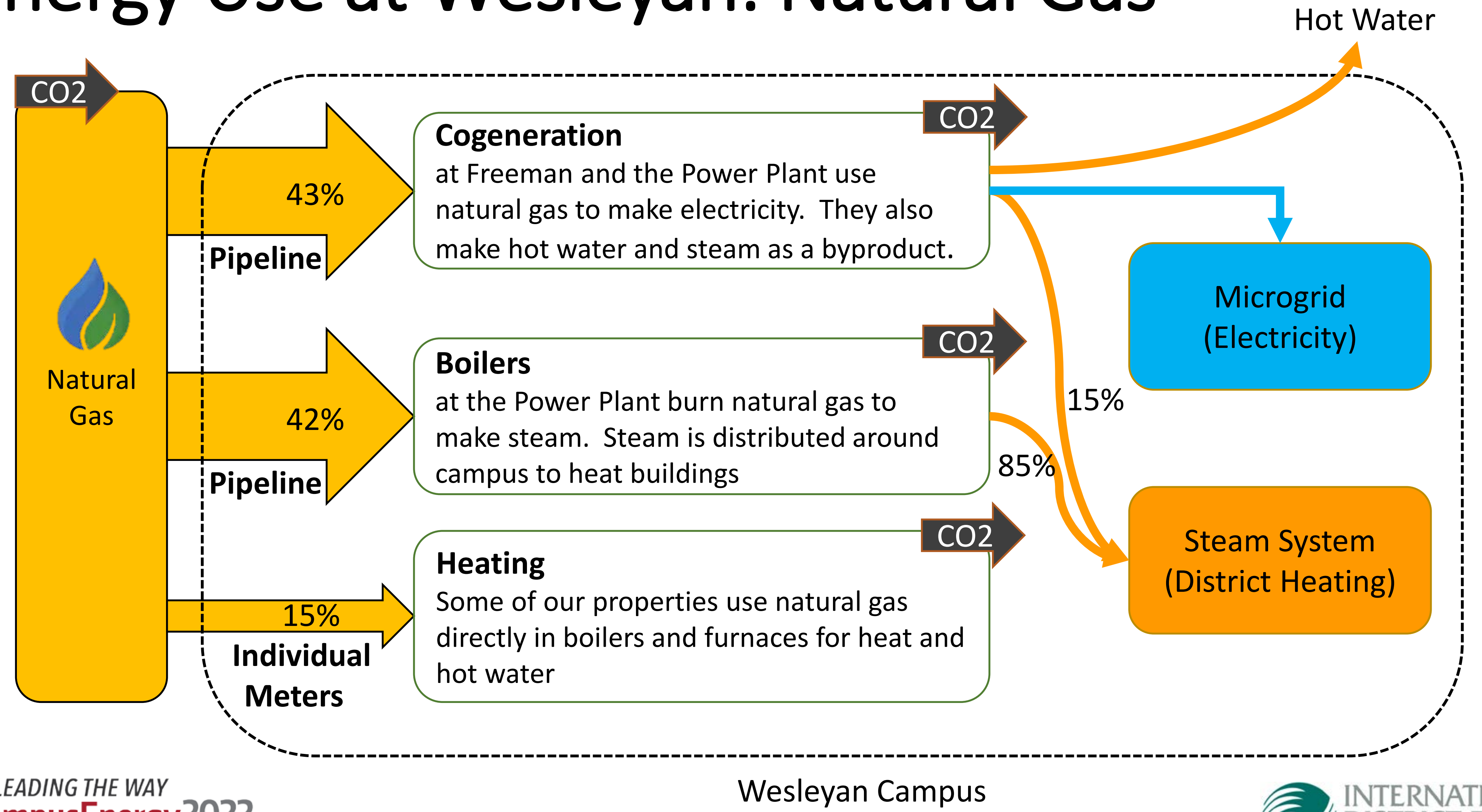


Wesleyan University Carbon Emissions

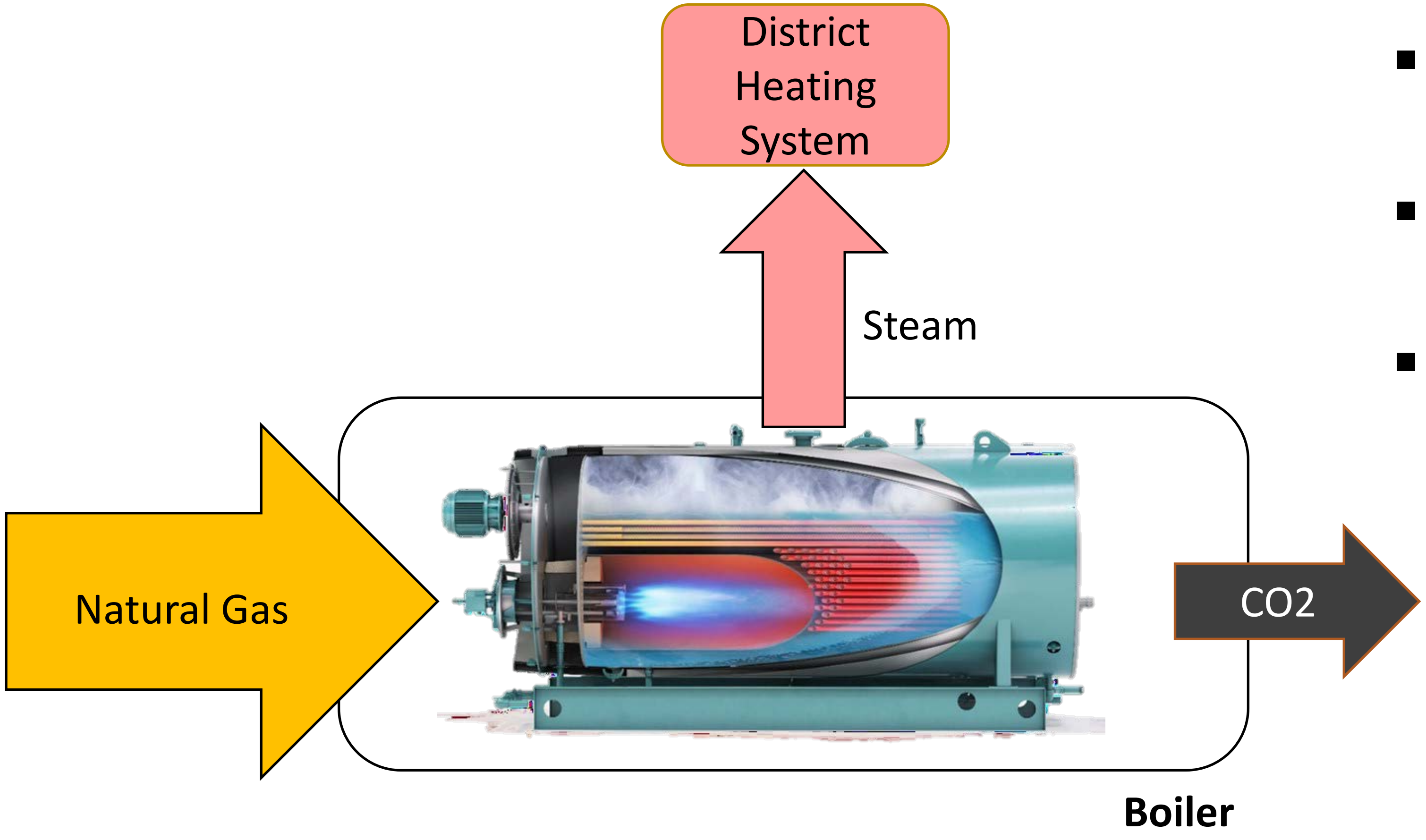
- Our total Carbon Footprint is 26,690 MTCDE
- By far, the largest source of Carbon Emissions on Campus comes from Energy
- Energy accounts for ~77% of our Carbon Emissions
- Electricity (22%)
- Heating (55%)
- Energy includes electricity, heating, and cooling
- There are two major categories of Energy use on campus: centralized and decentralized



Energy Use at Wesleyan: Natural Gas



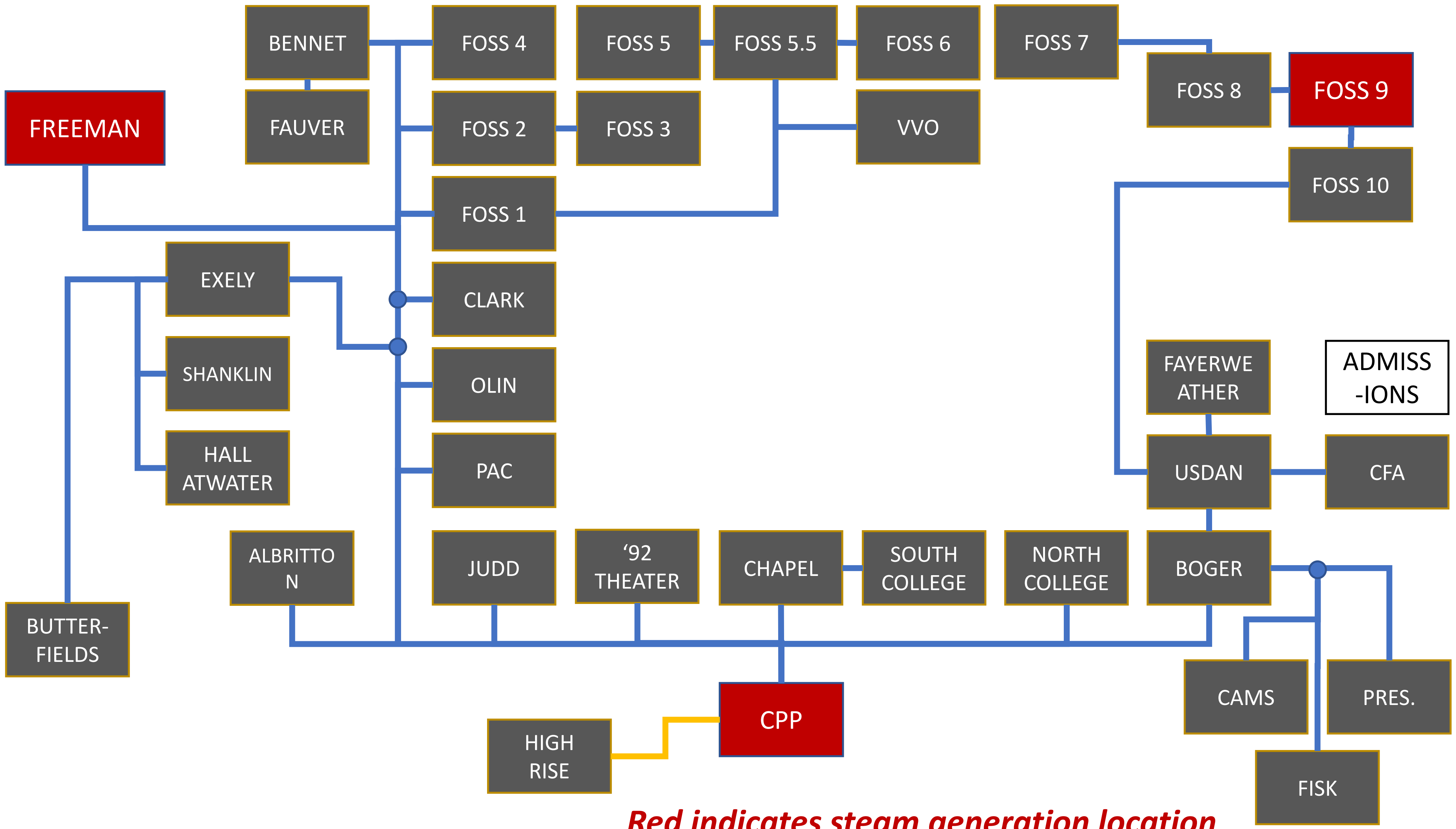
Generation (Heat): Boilers



Campus Boiler Plant

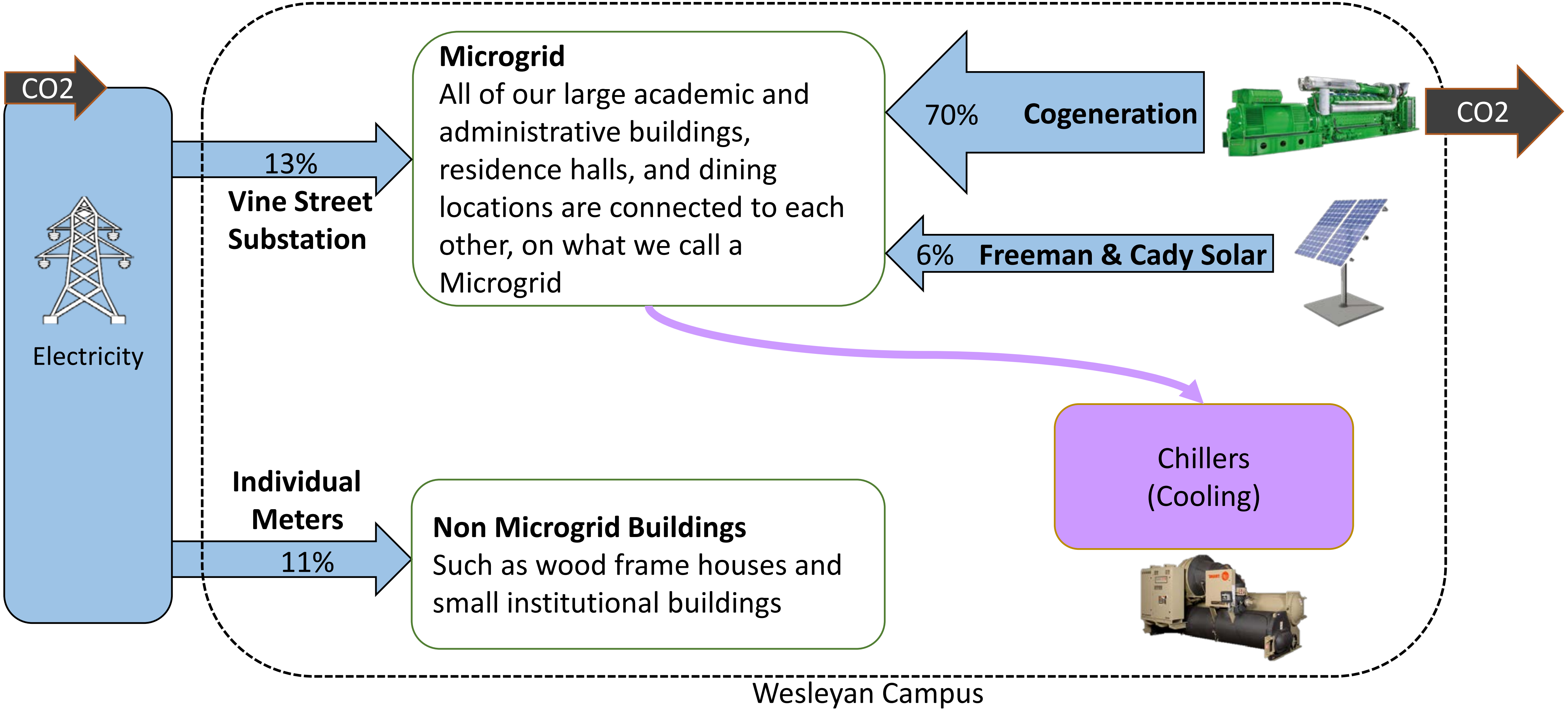
- Constructed 1974
- Two B&W Fire-Tube Boilers, 50,000 lbs/hr each
- One CB Water Tube Boiler, 25,000 lbs/hr
- Peak Campus Load Approx. 50,000 lbs/hr

Heat Distribution (District Steam System)

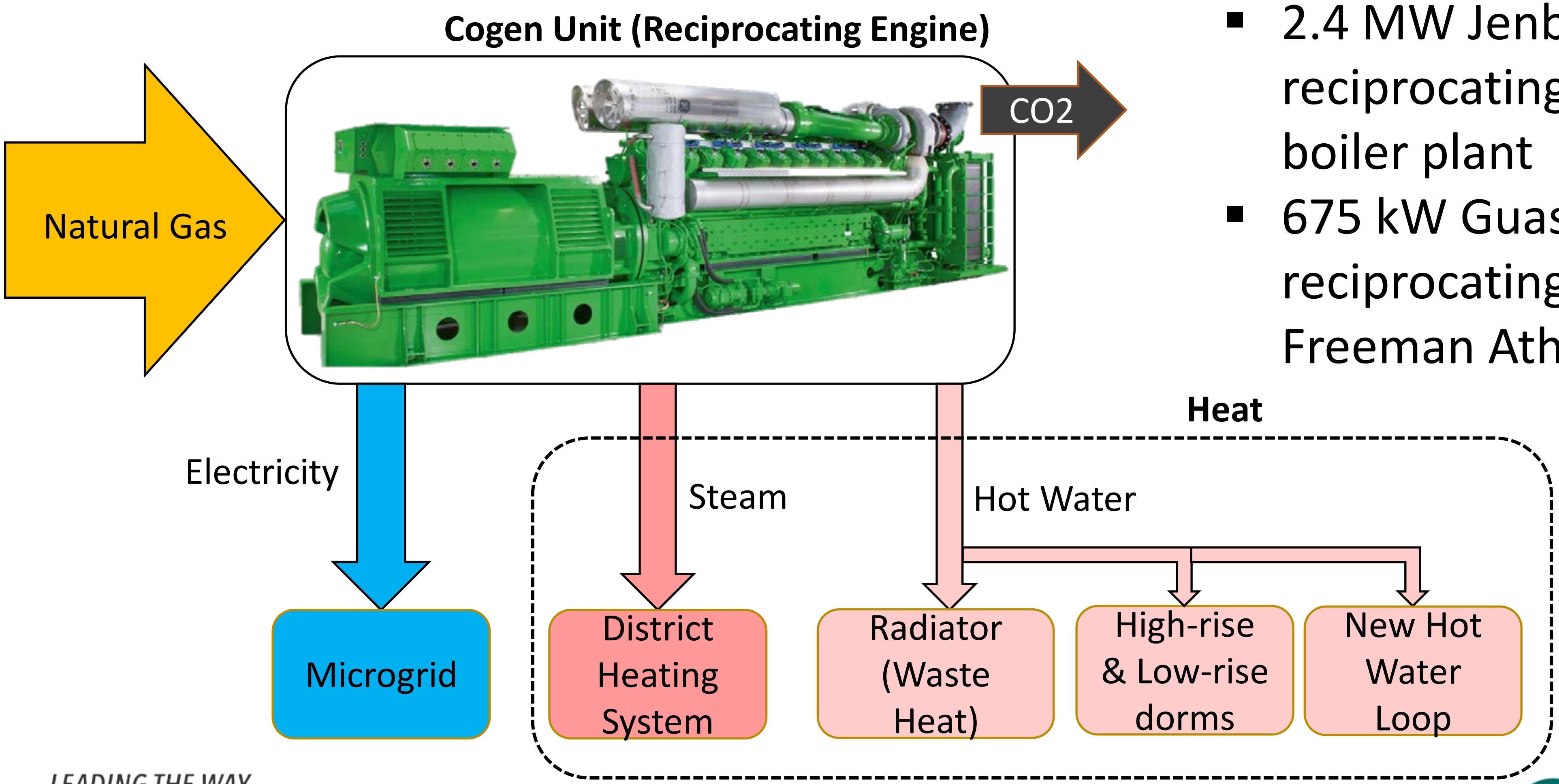


Red indicates steam generation location

Energy Use at Wesleyan: Electricity



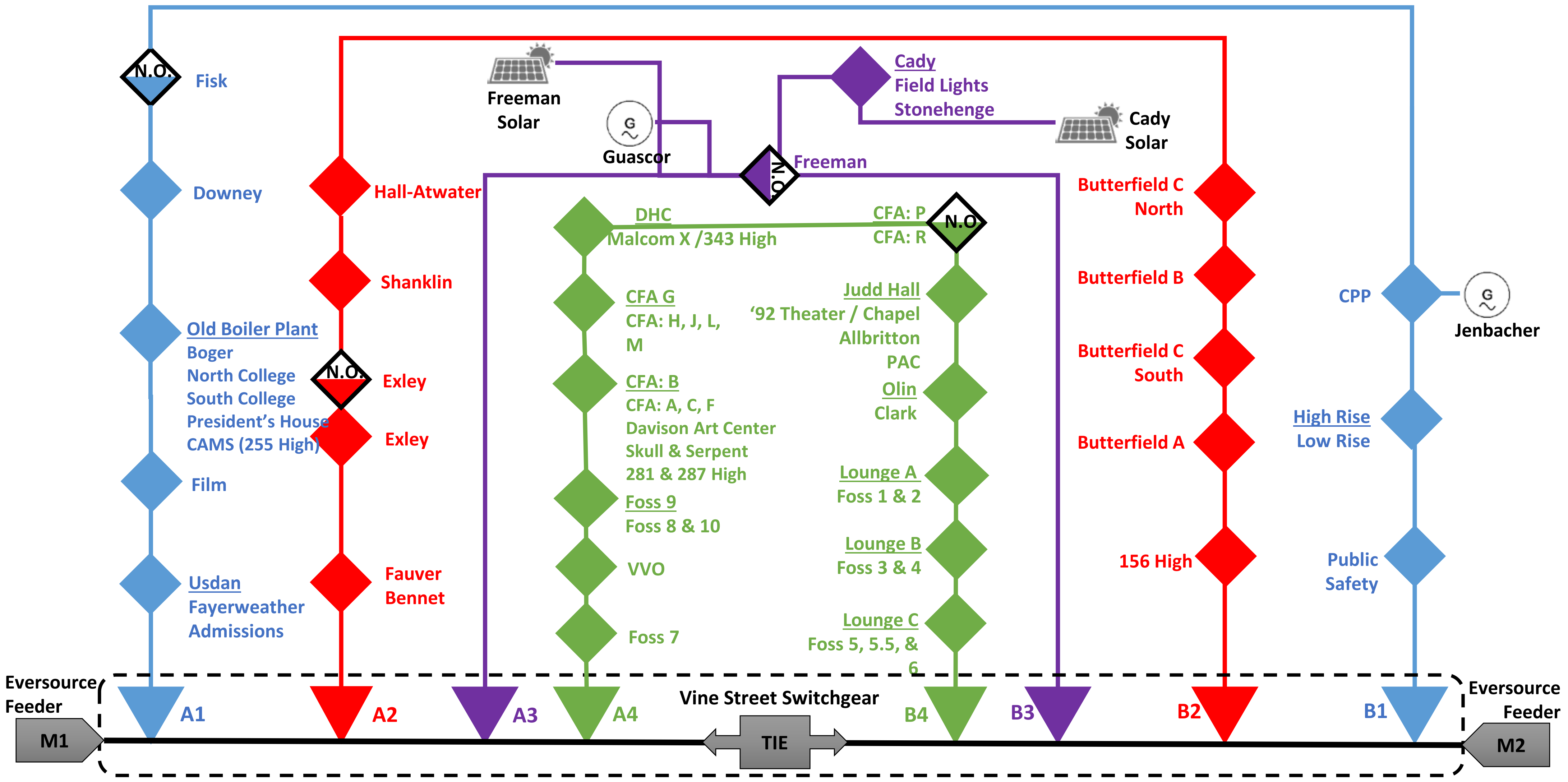
Generation (Heat & Electricity): Cogen



Campus Cogeneration Systems

- 2.4 MW Jenbacher reciprocating engine in boiler plant
- 675 kW Guascor reciprocating engine in Freeman Athletic Facility

Electricity Distribution (Microgrid)

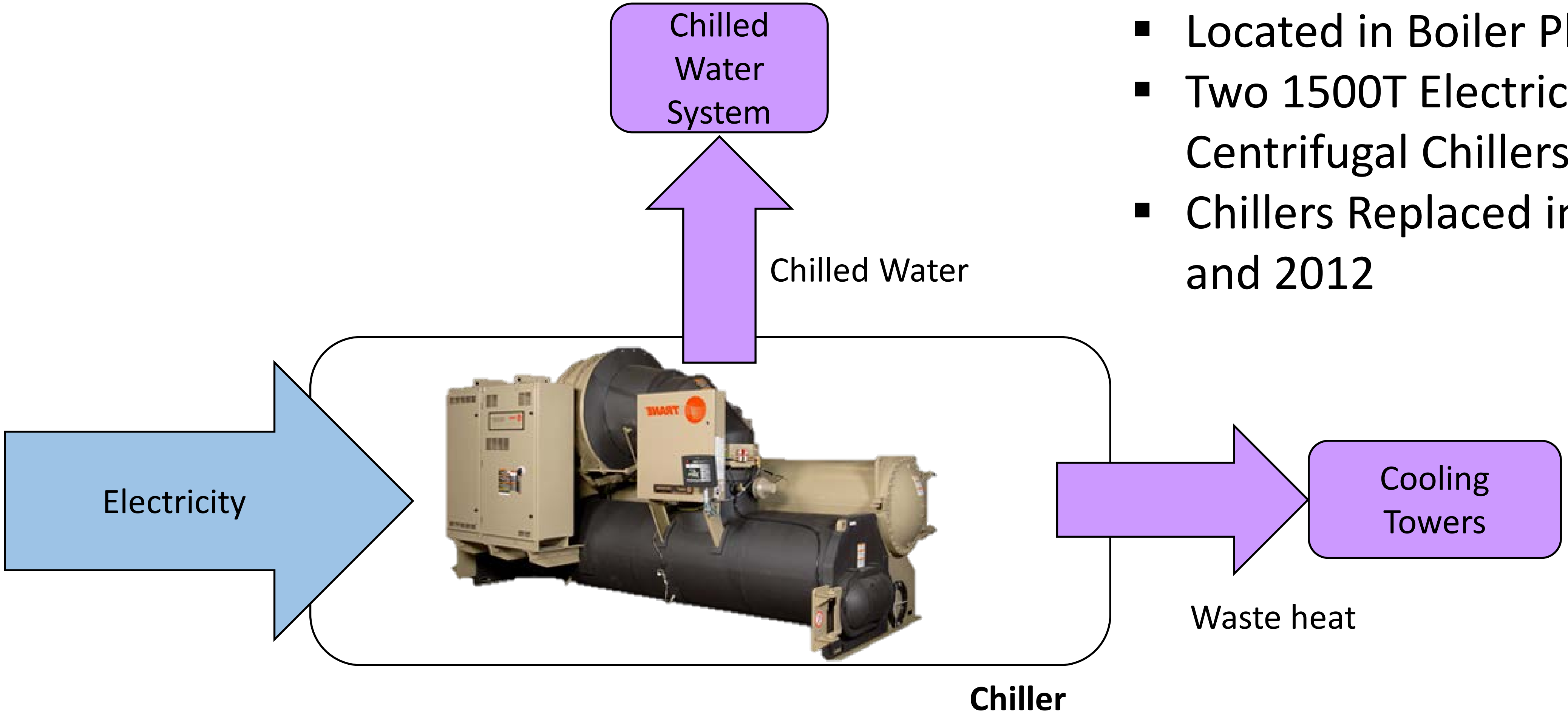


13.2 kV Service and Distribution

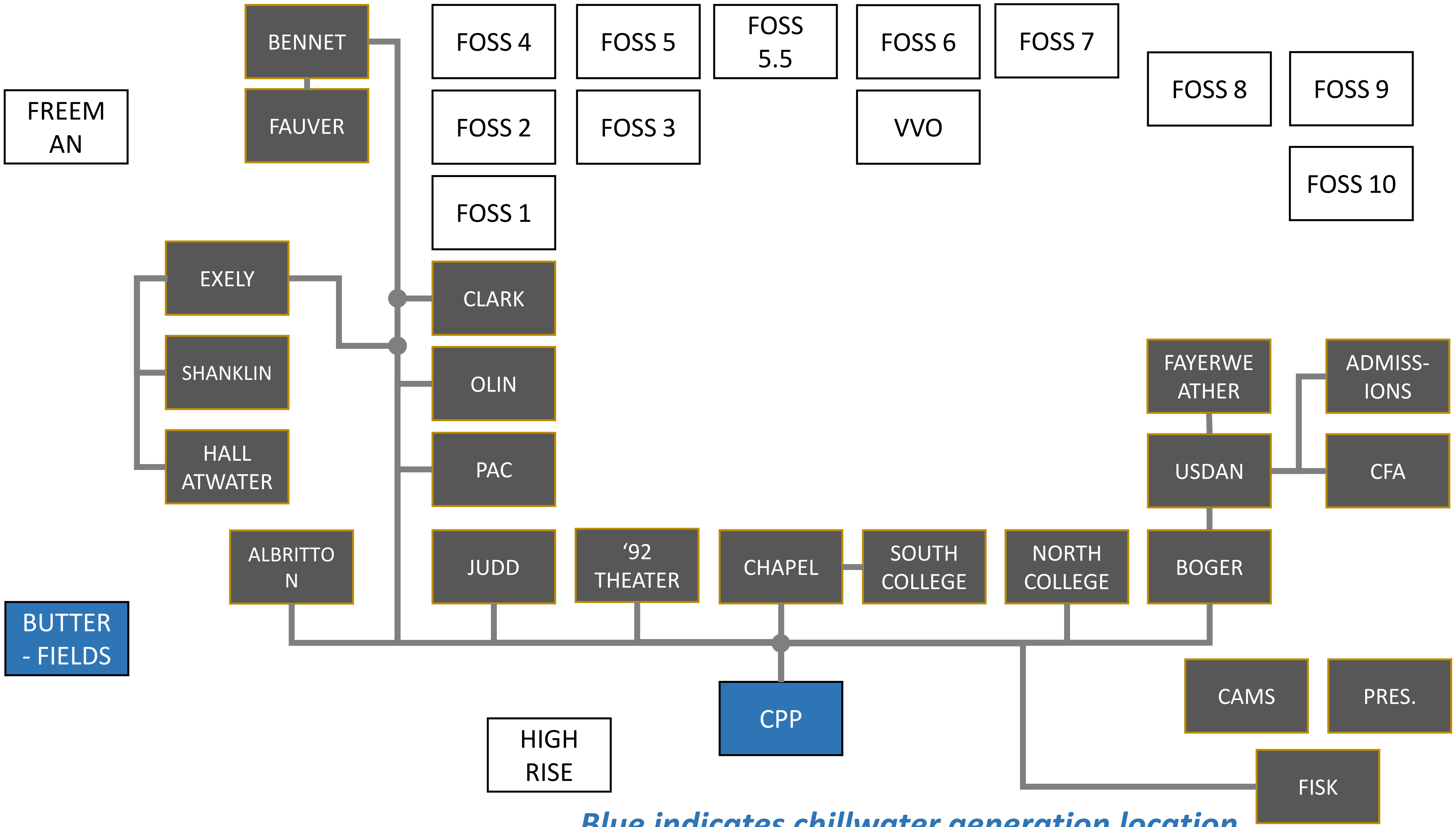
Generation (Cooling): Chillers

<u>Campus Chiller Plant</u>

- Located in Boiler Plant
- Two 1500T Electric Centrifugal Chillers
- Chillers Replaced in 2020 and 2012

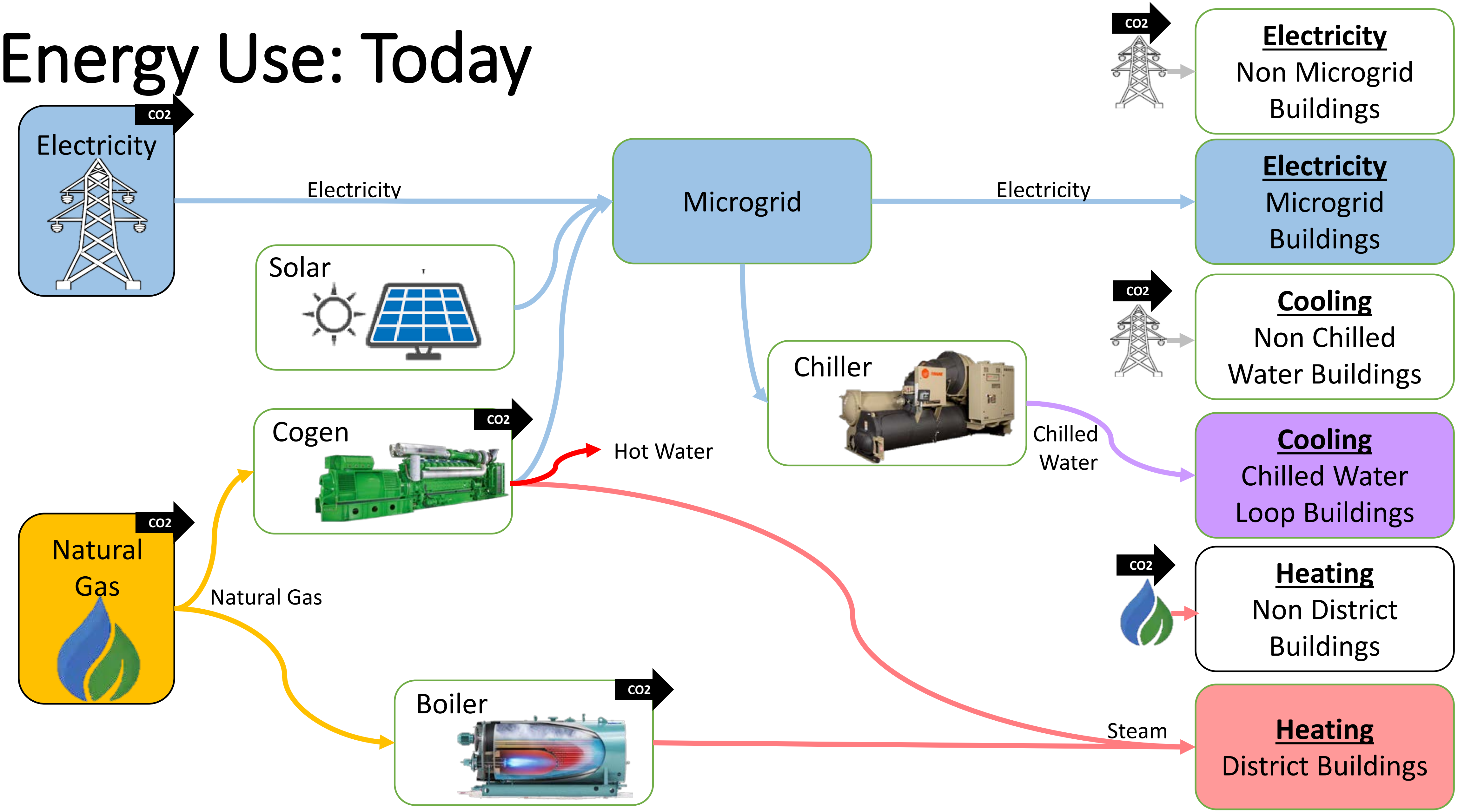


Chilled Water Distribution



Blue indicates chillwater generation location

Energy Use: Today



Carbon Reduction Goals

- Wesleyan shall achieve carbon neutrality for all greenhouse gas emissions before 2035
- Eliminate fossil fuel usage from all campus buildings by 2050
- Offset emissions from all Wesleyan employee business and study abroad air travel by 2022
- Reduce employee business air travel by 25% from FY 2019 by 2025
- Increase use of shared and energy efficient vehicles while decreasing use of fossil-fuel-powered and single-occupancy vehicles
- Divest from fossil fuels by 2030
- Offset all remaining greenhouse gas emissions before 2035

How Do We Reduce our Energy Carbon Emissions?

Conservation

- Comprehensive Energy Projects
- Building Projects
- Deep Energy Retrofits
- Community Education

Infrastructure Modernization

- Steam to Hot Water Conversion
- Ground Source (Geothermal) Heat Pumps
- Renewable Energy Installation (Solar PV with Storage)

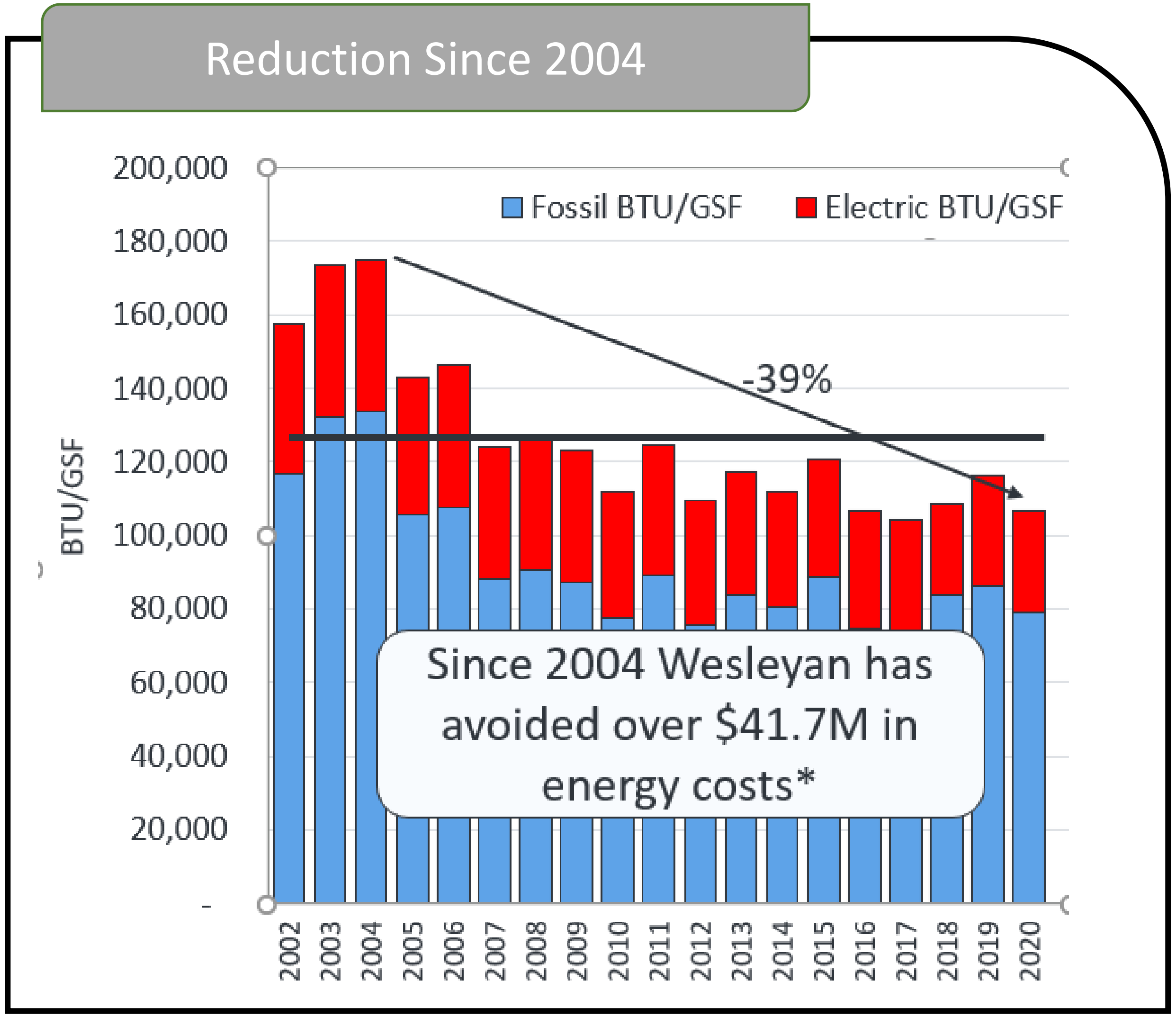
Offsets

- Renewable Energy Credits
- Carbon Offsets

Conservation

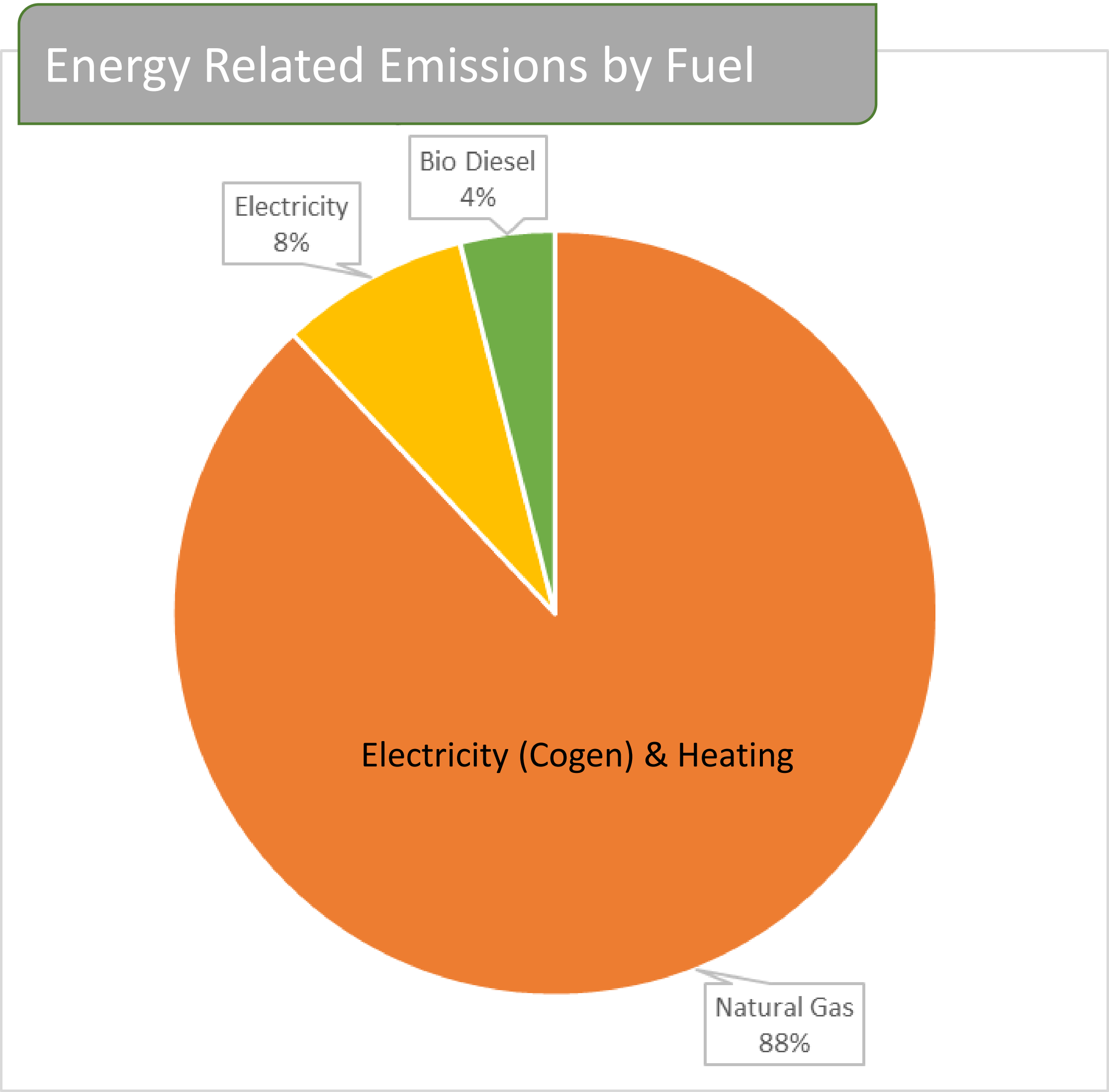
Conservation
Infrastructure Modernization
Offsets

- Comprehensive Energy Projects are Wesleyan's main source of energy conservation and reduction on campus
- Fourteen phases of comprehensive energy reductions projects performed
- Offset $2.6M in energy costs annually
  - 11,500 MWh of electricity annually
  - 83,500 therms of natural gas annually
- Reduced our carbon emissions by 8,567 MTCDE annually



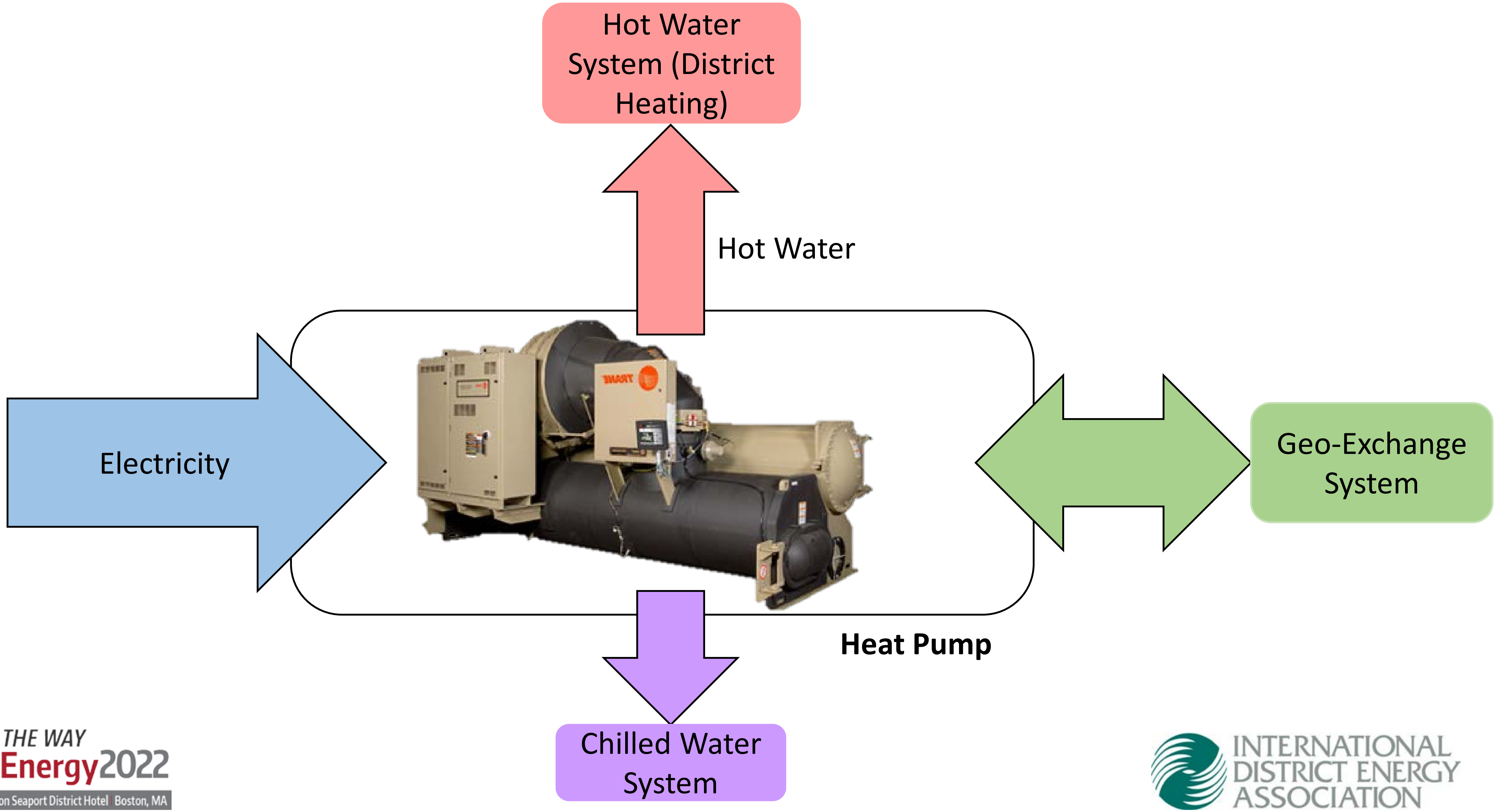
Carbon Neutrality

- To be carbon neutral, we need to stop burning fossil fuels.
- Electricity can be generated from renewable sources (or RECs can be purchased)
- **It is essential to heat our buildings without burning fossil fuels (we can do that by using electricity)**



Conservation
Infrastructure Modernization
Offsets

Generation (Heating): Heat Pump



Steam Loop Connected Buildings

Step 1

Steam to Hot Water Conversion

- Replacement of aging infrastructure
- Significant efficiency increases
- Flexibility for future renewables
- Increased utilization of existing cogen assets
- Foundation of all future work

Step 2

Ground Source Heat Pumps (Geothermal)

- Electrification of campus (space heating & domestic hot water)
- Eliminates burning of fuel for heat (3-5x more efficient)
- Can use cogen to power heat pumps and supplement hot water system until solar is installed
- Allows energy sharing between buildings

Step 3

Solar PV w/ Storage

- Renewable energy for electricity, heating, and cooling
- Opportunity for offsite solar projects
- Storage provides microgrid resiliency after cogen is retired

The Case for Hot Water Conversion

Conservation → Infrastructure Modernization → Offsets → CARBON NEUTRAL

Steam to Hot Water Conversion → Ground Source Heat Pumps (Geothermal) → Solar PV w/ Storage

Replacement of aging infrastructure

- Over 10,000 feet of steam pipe on campus
- Eliminates steam manholes
- Steam Pipe from Boger to Fisk was installed in 1928
- Boilers at CPP are nearly 50 years old

Significantly more efficient

- Steam generation efficiency is approx. 80% (hot water is >90%)
- Steam system standby losses are estimated at 20-30% (hot water is <2%)
- Steam systems experience higher thermal losses than hot water

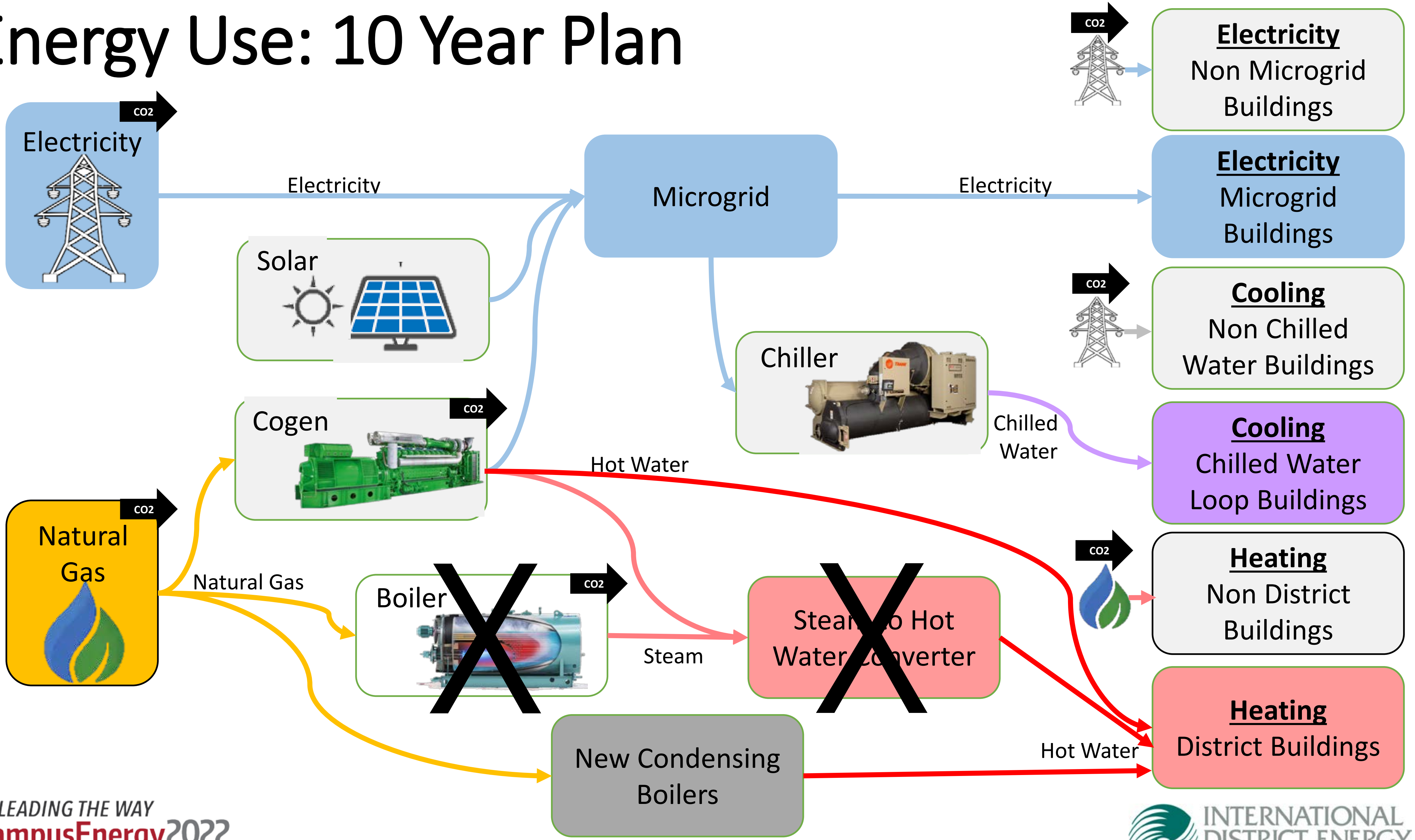
Increased utilization of existing cogen assets

- Currently can't utilize nearly 50% of the thermal energy produced from cogens
- Cogens would meet 100% of our summer heat load

Integration of future renewables

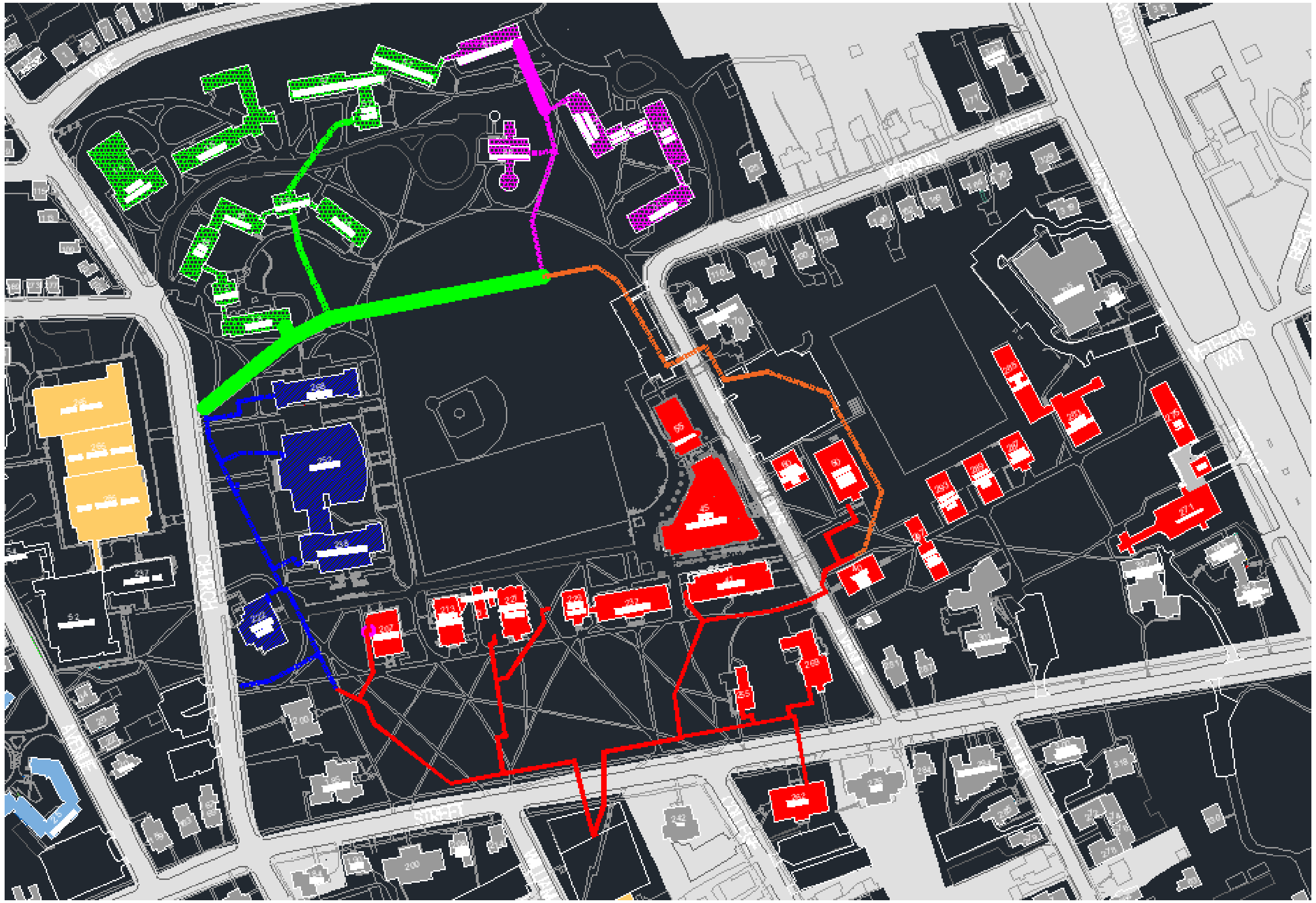
- Nearly all renewable thermal technologies produce low temp hot water (not steam)
- Opens possibilities of heat pumps, solar thermal, fuel cells, and future renewable technologies

Energy Use: 10 Year Plan

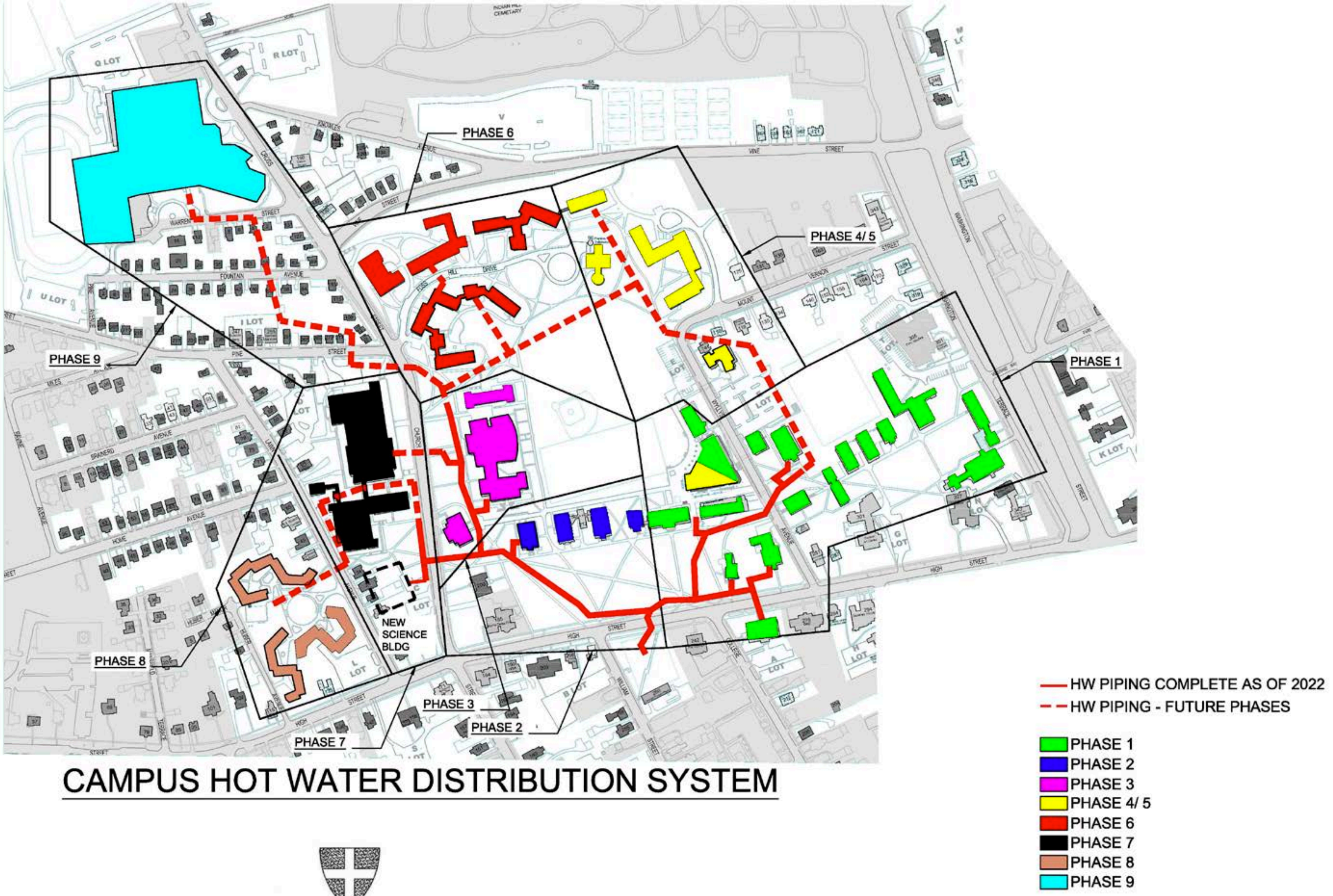


Hot Water Loop

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → **Solar PV w/ Storage**



- Ten phases to convert existing steam loop to hot water New hot water distribution pipe (underground, in tunnels, and mechanical rooms) around campus
- Two Phases (shown in Red) completed
- Loop design provides flexibility and redundancy
- Combination of new and reuse of existing equipment in all mechanical rooms
- New Condensing Hot Water Boilers are Installed at CPP for Peak Load and Backup Heating



CAMPUS HOT WATER DISTRIBUTION SYSTEM

WESLEYAN UNIVERSITY
MIDDLETOWN, CONNECTICUT

Hot Water Loop

Conservation
Infrastructure Modernization
Offsets

Steam to Hot Water Conversion → Ground Source Heat Pumps (Geothermal) → Solar PV w/ Storage

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Conservation
Infrastructure Modernization
Offsets

Ground Source Heat Pumps

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → Solar PV w/ Storage

Converting to Heat Pumps

- Install ground source heat pumps in phases throughout campus.
- As more ground source heat pumps are installed, our electric load will increase, but our natural gas usage will decrease.
- As we continue to add ground source heat pumps, eventually we will be able to retire our boilers and cogens and stop burning natural gas on campus

Eliminates burning of fuel for heat

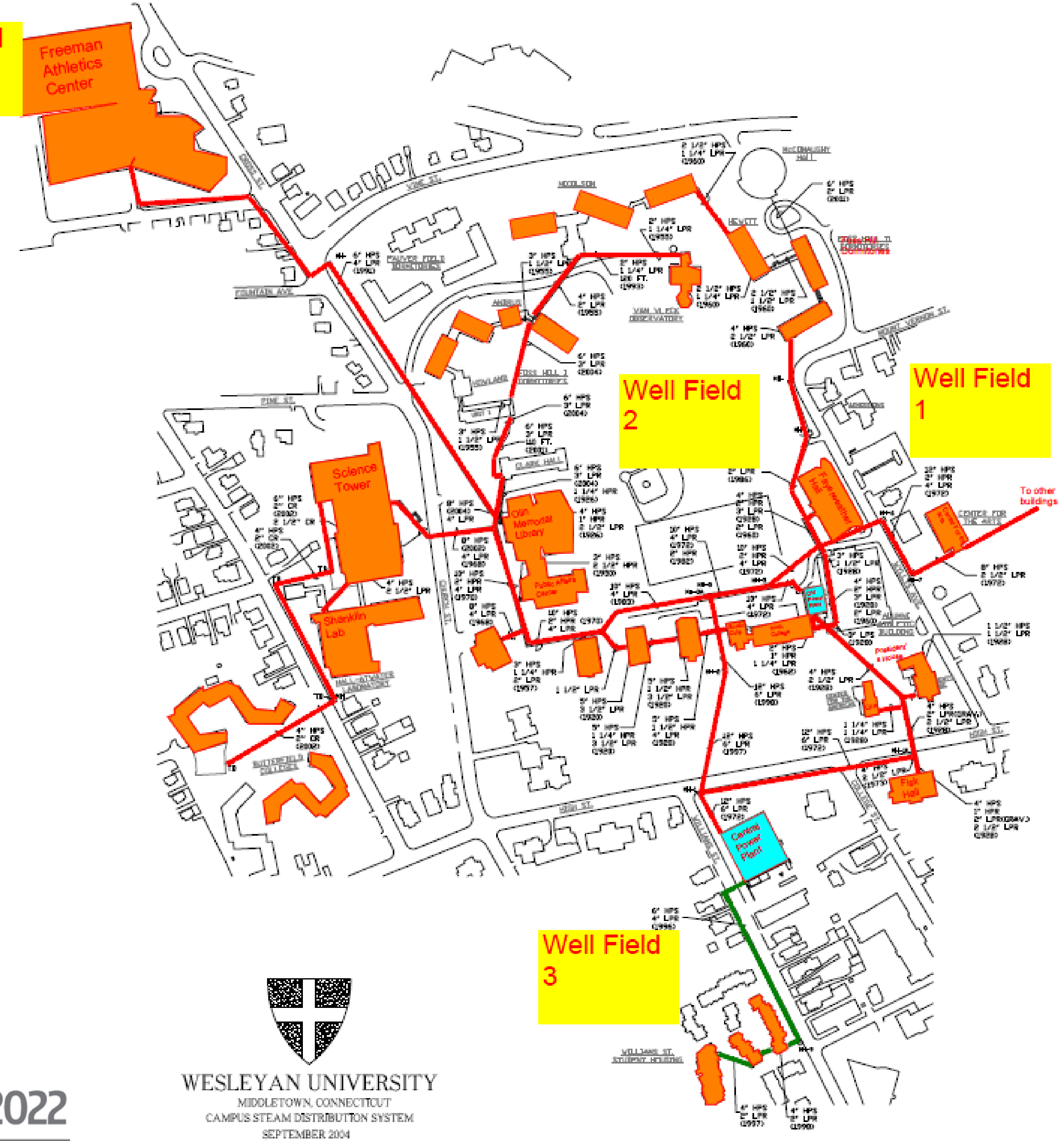
- Ground source heat pumps are 5 times more efficient than using combustion for heat and hot water
- Electricity is significantly easier to produce using renewable energy than thermal energy for heating and hot water

Increased Cogen Utilization

- Allows us to more efficiently use our existing cogeneration assets during the transition period

Other Benefits

- Allows energy sharing between simultaneous heating and cooling loads



WESLEYAN UNIVERSITY
MIDDLETOWN, CONNECTICUT
CAMPUS STEAM DISTRIBUTION SYSTEM
SEPTEMBER 2004

Existing Steam Piping

Major Bldgs on heating loop

Existing Hot Water Piping

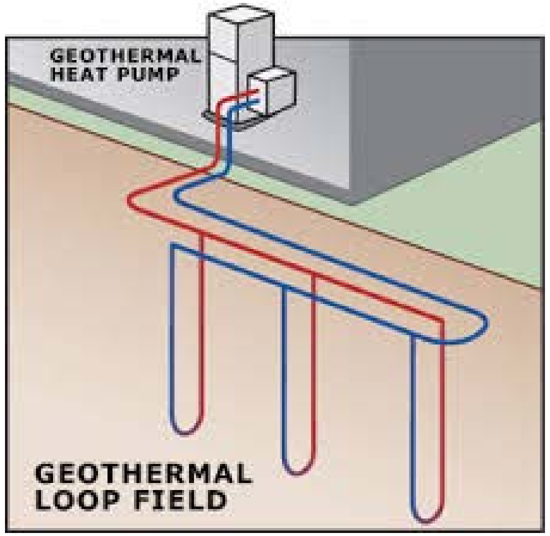
Geo-Exchange Capacity

Conservation
Infrastructure Modernization
Offsets

Steam to Hot Water Conversion → **Ground Source Heat Pumps (Geothermal)** → Solar PV w/ Storage

How Much Geothermal Do We Need?

- Our peak campus heating and domestic hot water load is ~4,200 tonnes (50 MMBTU/hr)
- This equates to roughly ~20 acres of well field to meet our heating load or 5% of campus footprint
- Gas Hot Water Boilers at CPP provide backup heating and for peaking on extremely cold days
- In order to reduce well field area
  - Continue conservation efforts
  - Size well field to balance campus heating and cooling loads
  - Provide supplemental heat via air source heat pumps or boilers (renewable fuel?)



Conservation
Infrastructure Modernization
Offsets

Solar PV with Storage

Steam to Hot Water Conversion → Ground Source Heat Pumps (Geothermal) → **Solar PV w/ Storage**

Renewable energy for electricity, heating, and cooling

- On site PV installation will provide a portion of our electricity, purchased electricity will provide the balance
- Grid purchased electricity is increasingly green and this trend will continue
- Battery storage will allow redundancy in case of a utility outage
- Storage will allow capacity payment reductions

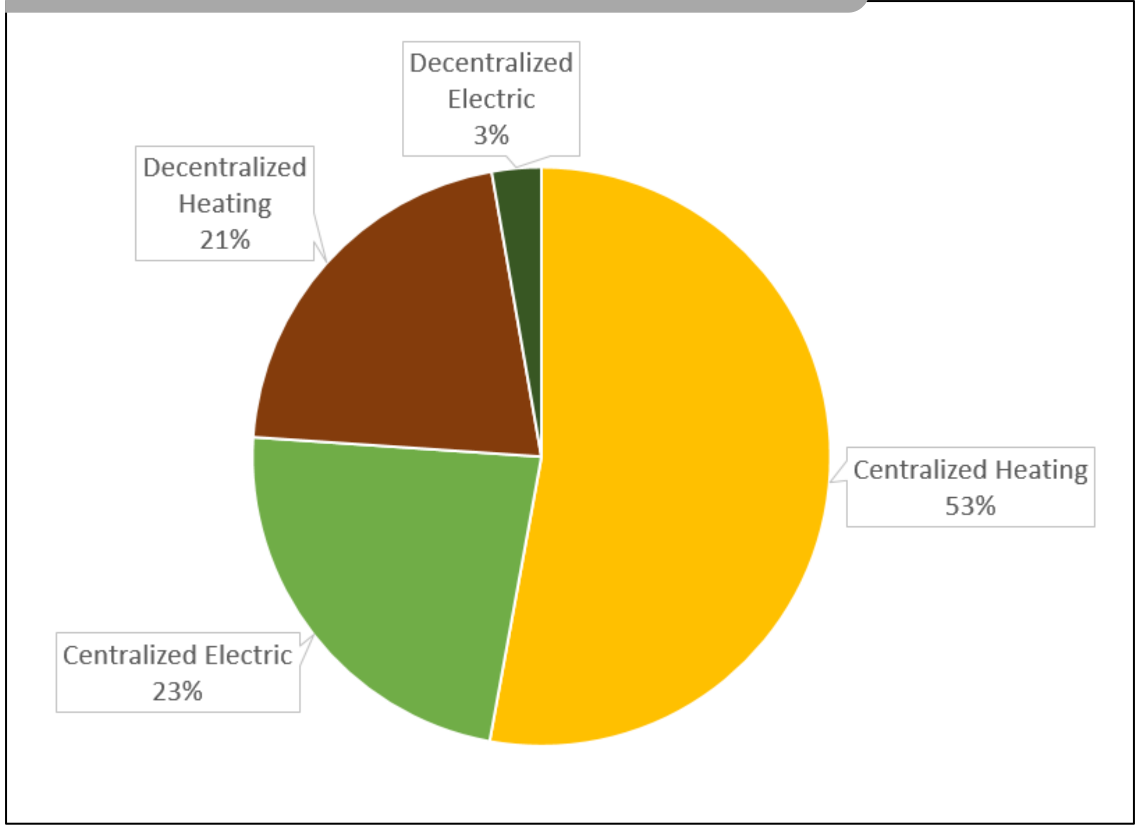
How Much PV Would We Need?

- On average, it would take about 16 solar arrays the size of the one at Long Lane to meet our campus electric load today.
- All else being equal, it would take another 5 solar arrays to heat our campus with heat pumps (that's 21 total to meet our electric + heating needs).
- That would mean covering about 20-25% of our campus with solar panels (70-80 acres)

Decentralized Energy

- Many buildings are not on the central district steam or electric loops, but represent only a portion of campus energy use:
  - ~24% of our energy usage (mainly wood frame houses, small institutional buildings, and rental properties)
- There are several options for these properties:
  - Connection to the new hot water loop and microgrid
  - Conversion to stand-alone heat pumps / electric heating and purchase RECs
  - Divestment
  - Purchasing carbon offsets

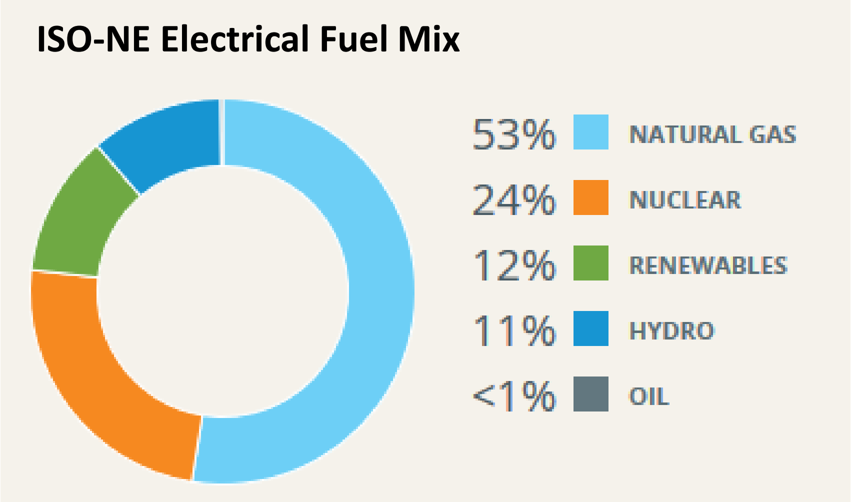
Energy Related Emissions by Use*



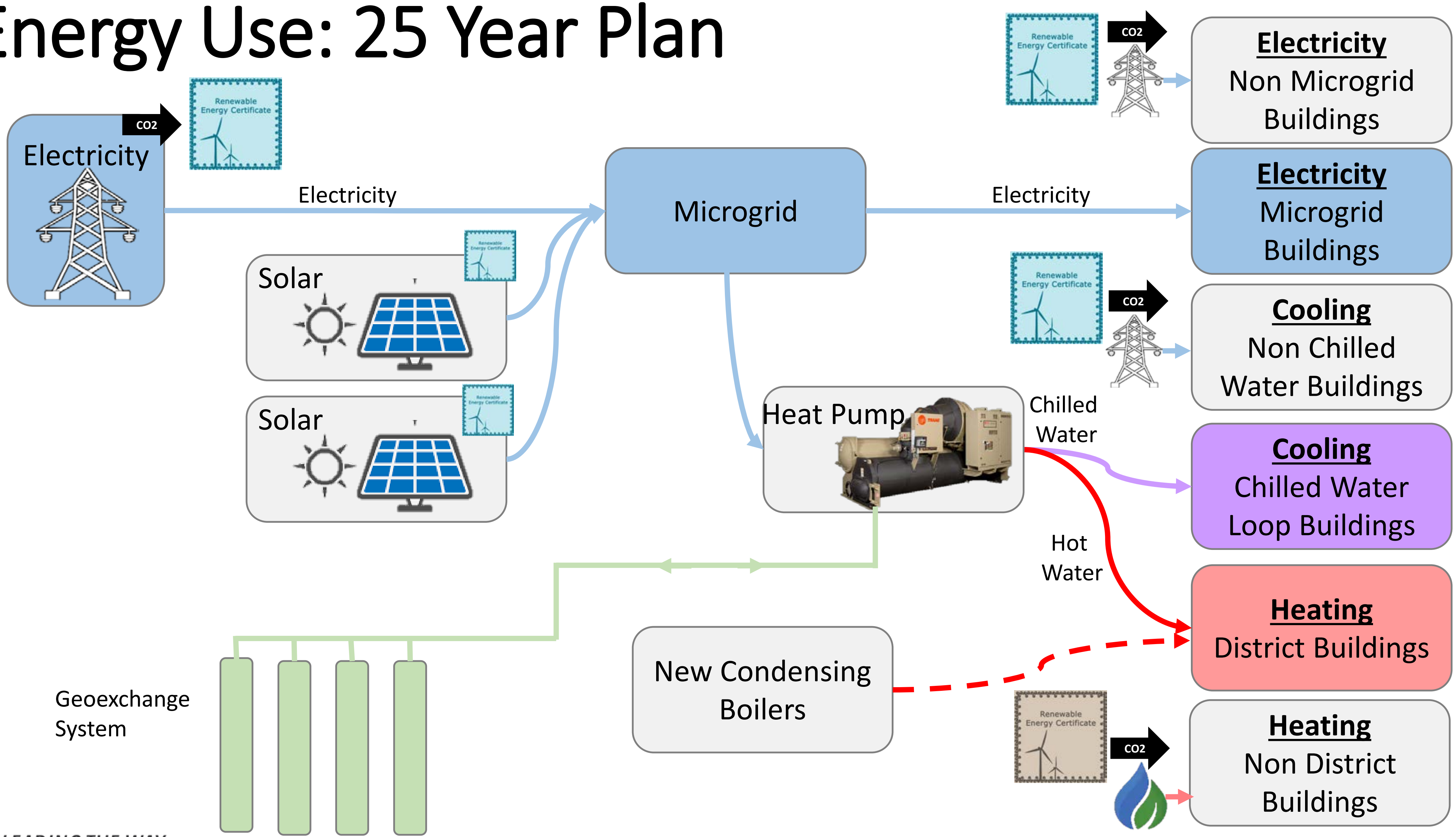
Offsets

- Our electricity demand will increase as we heat our campus with heat pumps, meaning our purchased electricity will increase
  - The grid itself will continue to become greener
  - The amount of Renewable Energy Certificates (RECs) purchased will increase

- Burning fuels will still have a minor role in our energy needs on campus:
  - On very cold days, burning of fuel may be needed to supplement heat pumps for heating
  - Emergency and life safety generators will still burn fuels
  - This carbon footprint can be eliminated by buying carbon offsets



Energy Use: 25 Year Plan



Achieving Carbon Neutrality at Wesleyan

- Challenges:
  - Ongoing energy conservation efforts
  - Reducing hot water operating temperatures in buildings
  - Heating/Cooling load imbalance on campus
  - Available heat pump technology to meet higher operating temperature applications
  - Capital cost / payback of ground source heat pump systems
  - Available campus area to satisfy space requirements for geo-exchange and solar PV Systems

Questions?

Thank you!

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