Integrating Solar Thermal and Biogas into an Innovative District Energy System Replacement

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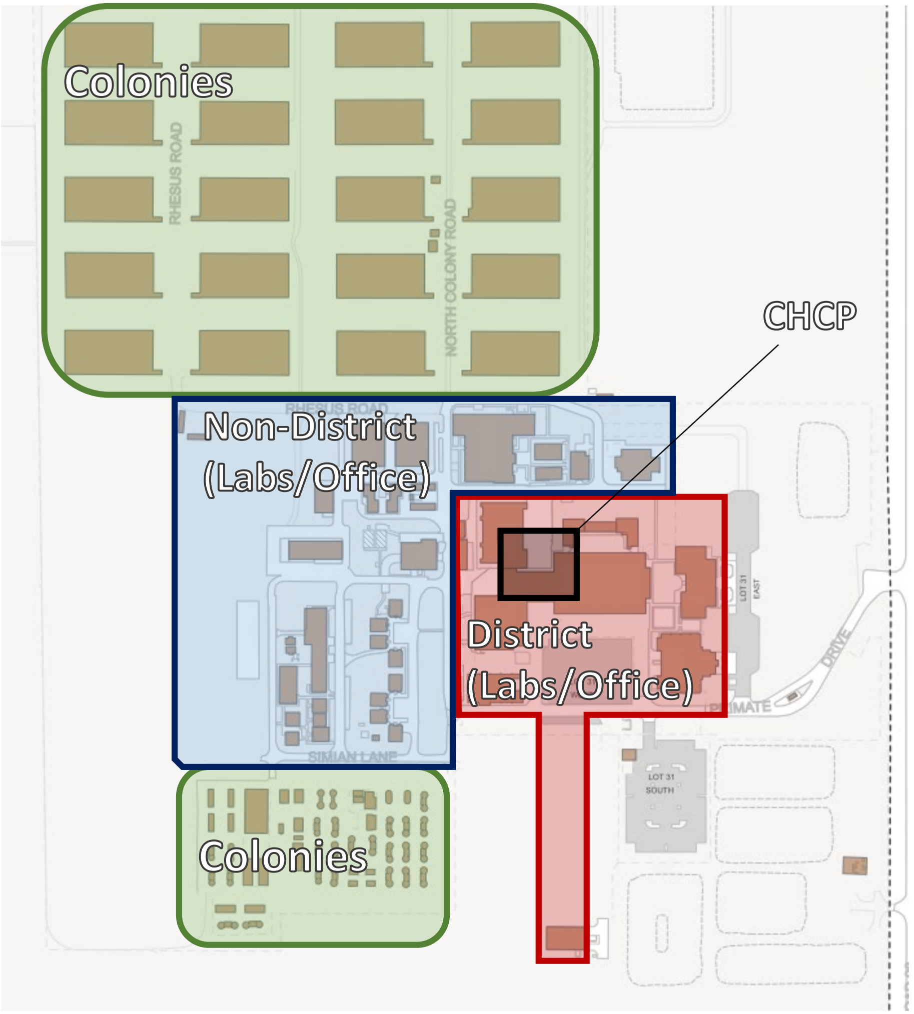
California National Primate Research Center



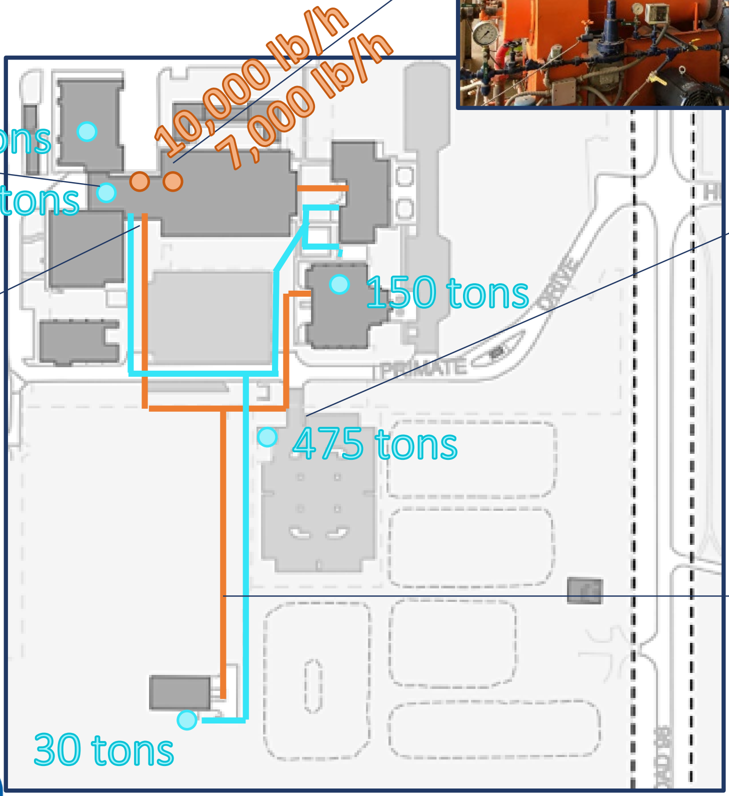
District Energy System

Abs. Chiller

Over 30 yrs old

Boilers

23 yrs old



"New" Chiller and Tower

Repurposed from campus

Cooling Tower

Poor condition

Steam Piping

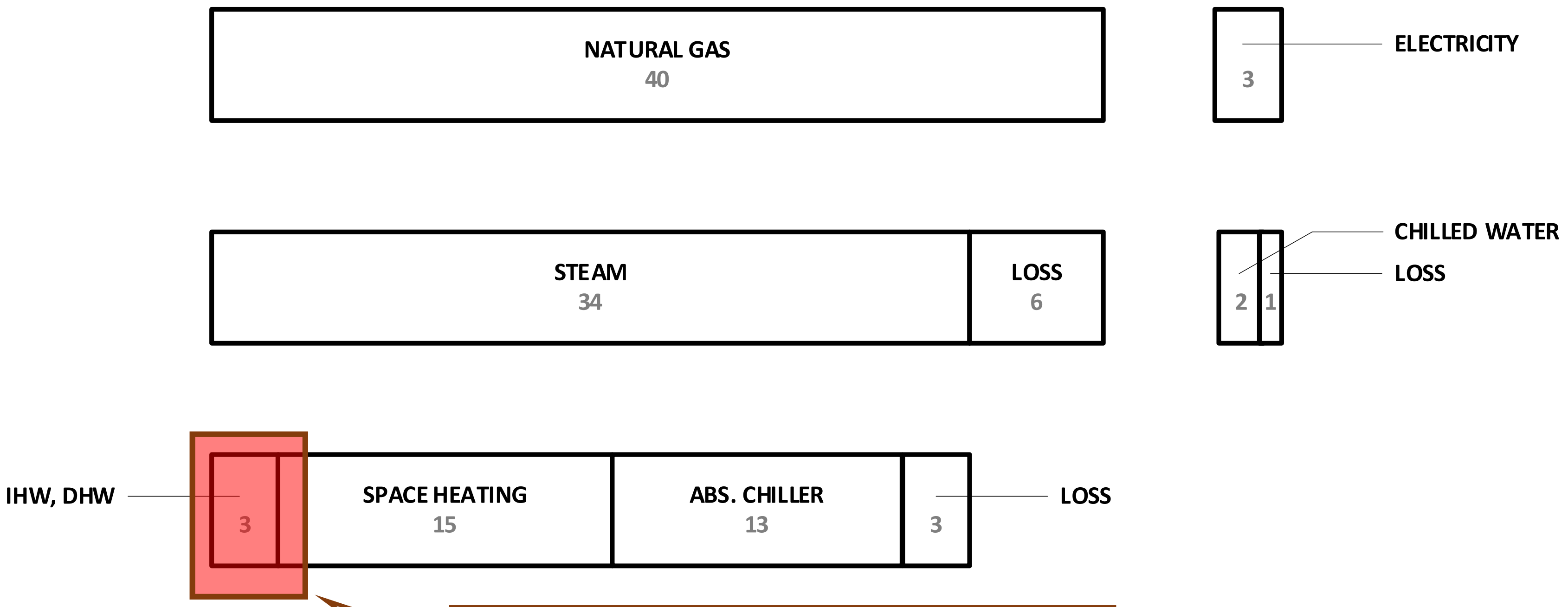
Needs renewal within 10 yrs

Problems with District Energy System

- District energy infrastructure is aged
- Insufficient redundancy
- Energy supply is not aligned with UC initiatives
- High operating costs

Current Energy Supply and Use

Primate District Annual Energy Use Breakdown (Thousands of MMBtu)



- Cage washing
- Autoclaves
- Lab, bathroom sinks

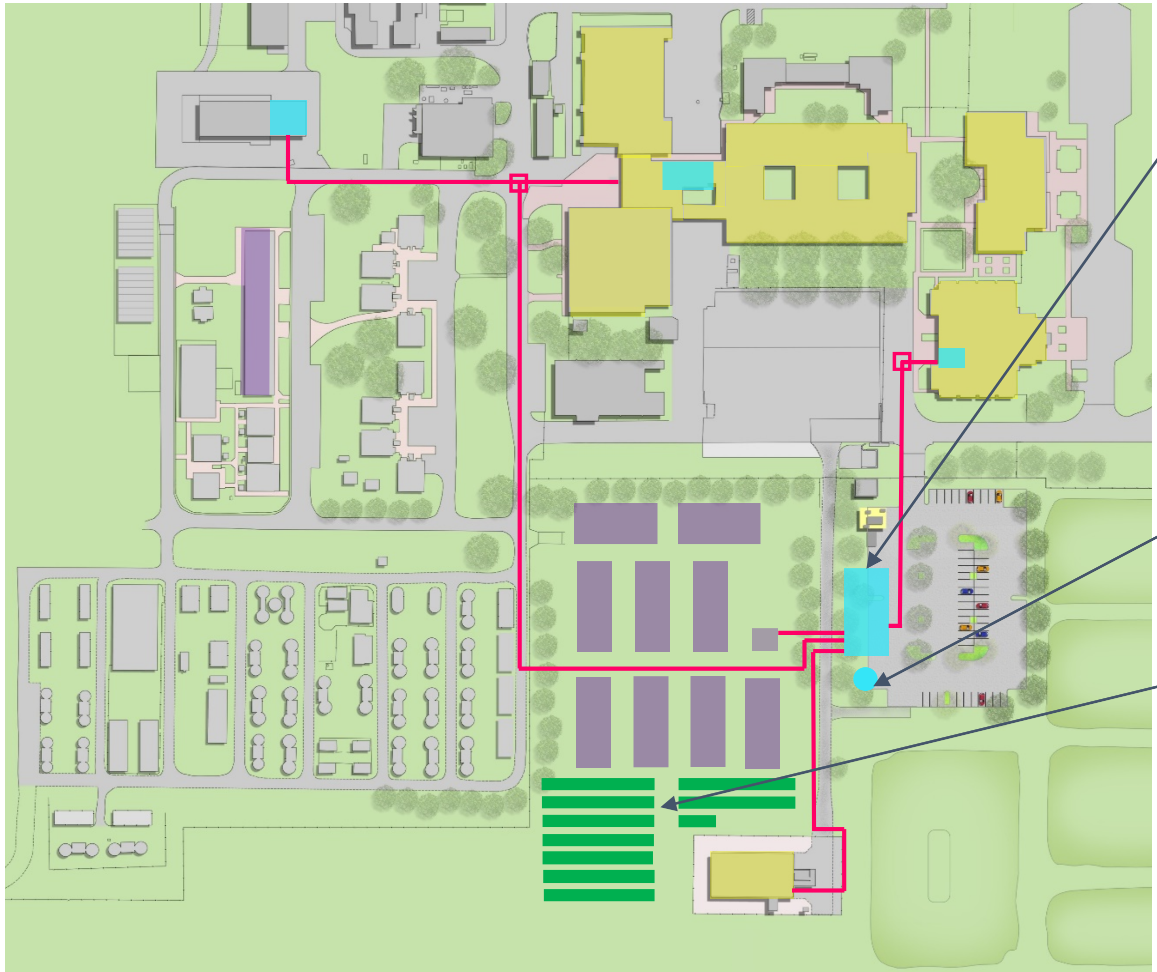
Opportunities

- Donated solar thermal panels
- Extension of Cal Solar Initiative (rebate)
- Plenty of open land area
- Nearby UC-owned biogas production
- Elimination of 24/7 boiler watch
- Main campus steam-HW conversion knowledge

Solution

- Cost analysis indicated best solution (IDEA 2019 presentation)
- Steam to hot water conversion
  - Space heating and most IHW/DW load
- Solar thermal hot water production
  - Heat pumps and TES
- Biogas capable hot water boilers
- Small, local steam generation for process loads

System Configuration – Central Heating & Cooling



New CHCP Building:

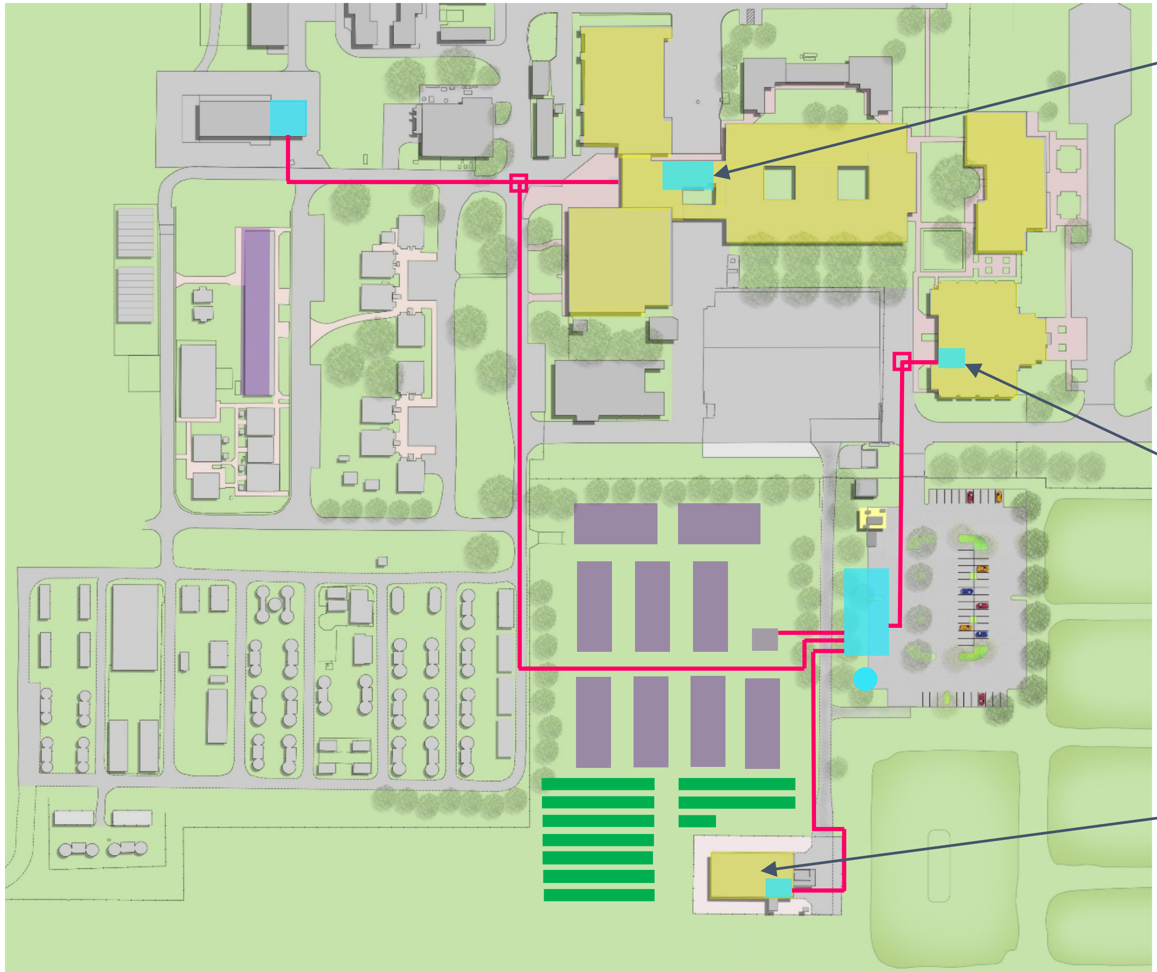
- Electric chillers
- HHW Boilers – NG, Biogas, Propane
- Water source solar thermal heat pumps

25,000 MBtu HW Thermal Energy Storage Tank

Solar Thermal Collector Field:

- 300 total collectors at 40 Deg. incline
- Faces due south for maximum annual production

System Configuration – Building Conversions

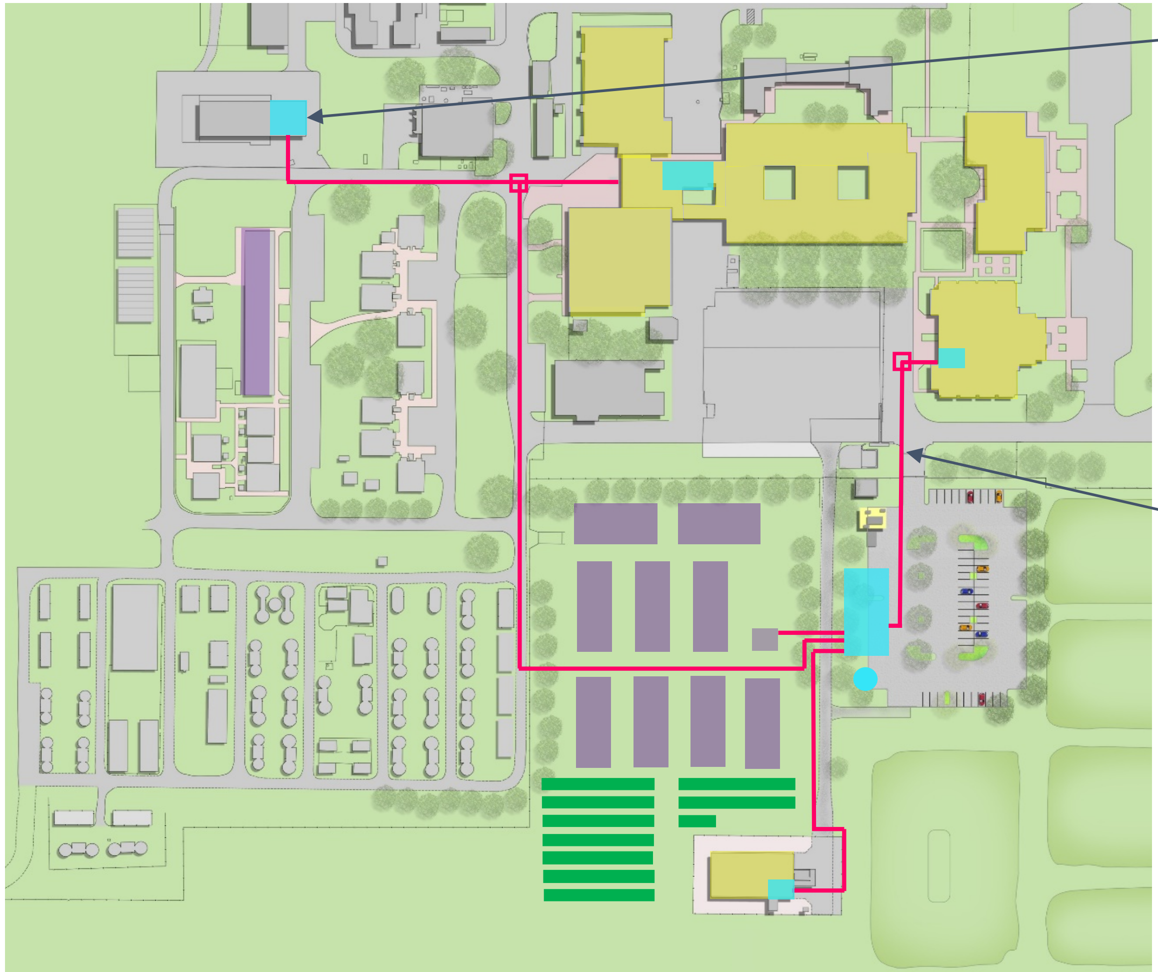


Main Lab/Animal Building:
- Demo existing steam plant
- Steam to HW conversion
- Convert 2 cage washers to hot water operation
- New indirect heater for IHW

CCM Lab Building:
- Electric process steam boilers
- Remove existing heating HW boiler

Quarantine Building:
- Steam to HW conversion
- Electric Process Steam Boilers

System Configuration – Distribution and IHW

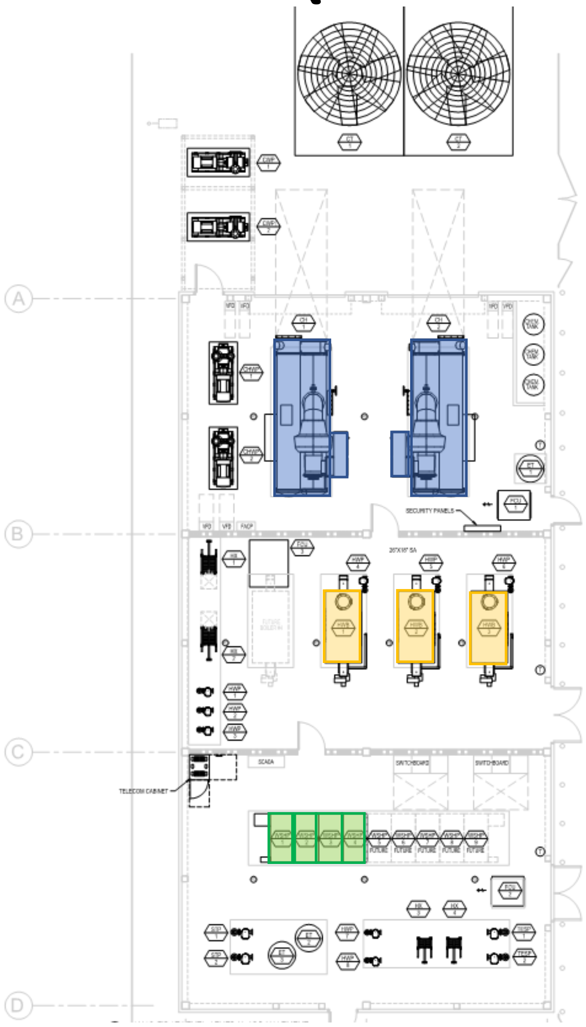


Primate Shop Building Plant:
- Electric process steam boilers
- 135 ºF Industrial HW
- 195 ºF Industrial HW
- Convert 1 cage washer to Hot Water operation

HHW Distribution Piping:
- Direct buried PEX construction
- Primarily a manifold & “home run” configuration limiting field joints and valve boxes

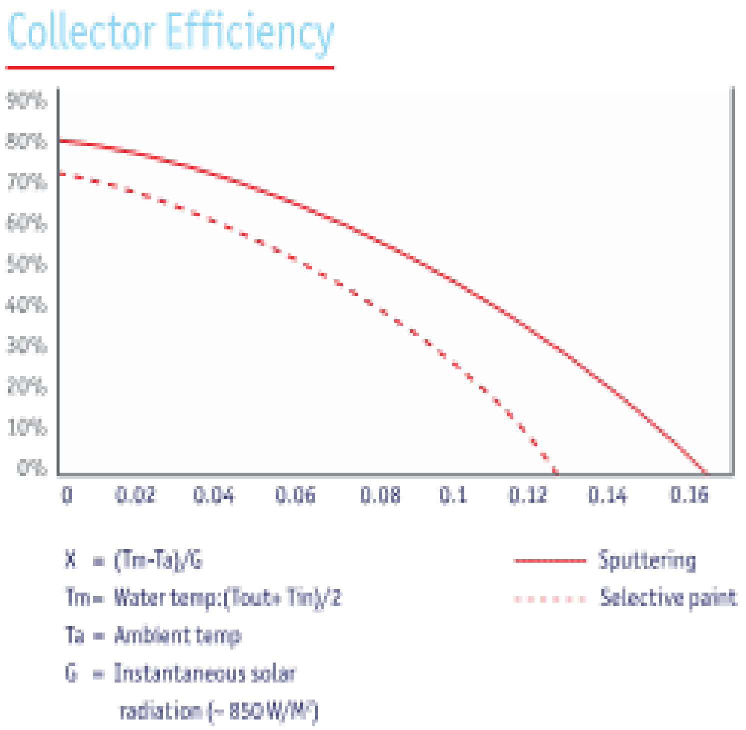
New Central Heating and Cooling Plant (CHCP)

- New 3,250 Sq. Ft. Building Housing:
  - Two 585 Ton Electric Chillers (blue)
  - Three 3,980 MBH Flexible Watertube Boilers (yellow)
  - Four 680 MBH Water Source Heat Pumps for solar thermal system (green)
- Estimated 47% of annual heating load satisfied by solar thermal + heat pump output.
- Modular expandable system with potential geothermal and/or HR chiller integration.
- Need for 24/7 boiler attendance eliminated.

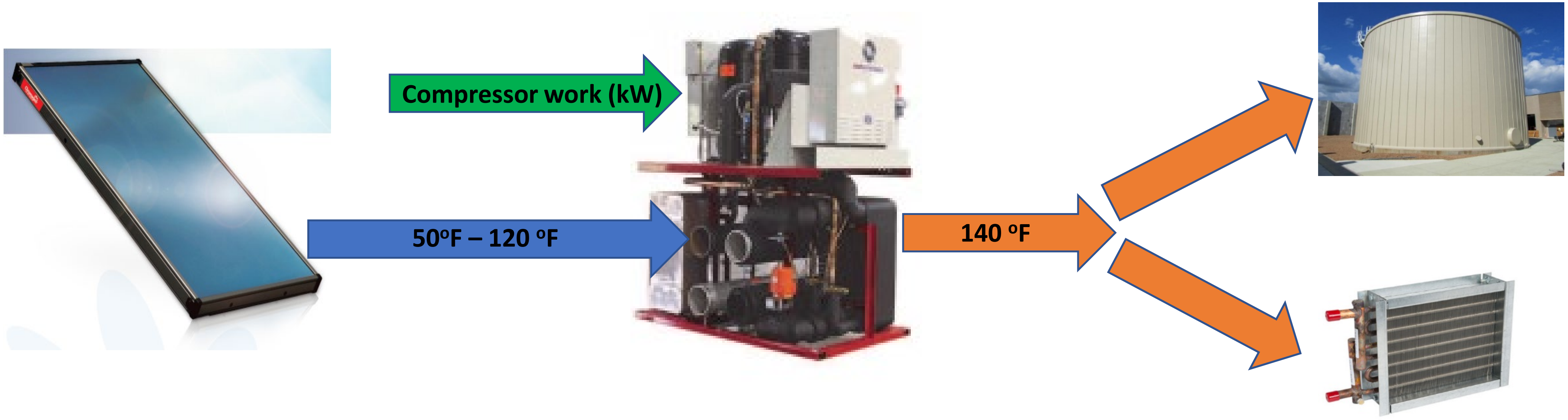


Solar Thermal Collectors

- Solar Thermal Collector Conversion Efficiency Depends on Several Factors:
  - ISO Efficiency = 0.736-0.68438(P/G) – 0.00132(P^2/G)
    - P=Entering Water Temp (Deg. F.) – Ambient Temp (Deg. F)
    - G = Global Radiation
  - By passing through heat pump, collector entering water temperature can be controlled relative to ambient (P)

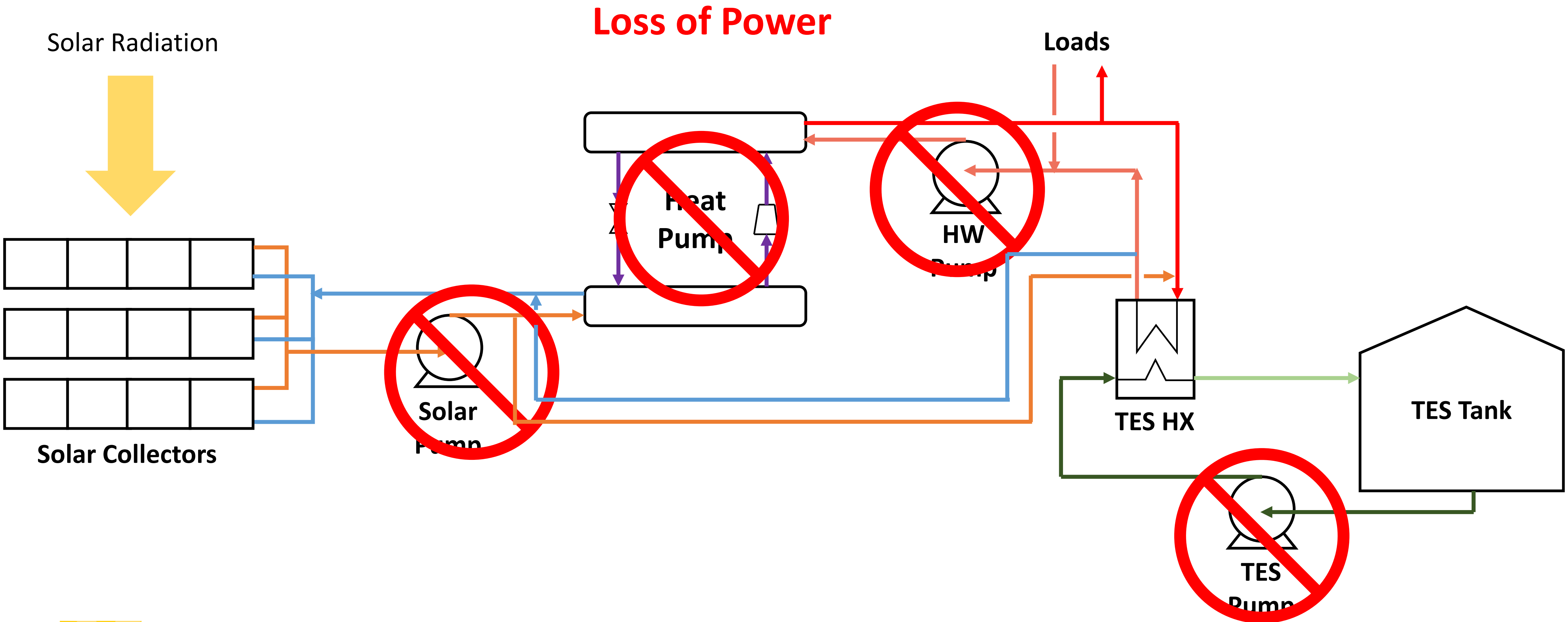


Solar Thermal Heat Pump System



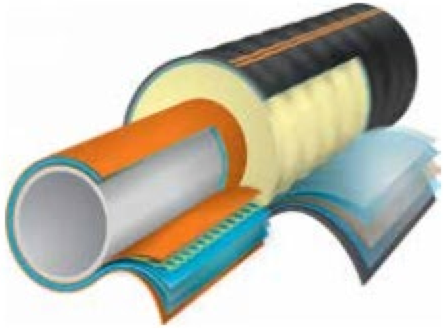
- Heat Pumps function to amplify the temperature of the solar thermal collector output using electric compressor work.
- Output limited to about 140 Deg. F. Therefore the high end of hot water reset curve is satisfied by hot water boilers as required.

Solar Thermal: Stagnation



Underground HW Distribution System

- PEX Flexible Piping System
  - Magnitude of CNPRC heating loads allows relatively small pipe sizes of 6” and smaller.
  - PEX piping available pre-insulated (up to 4”) and field insulated in larger sizes.
  - Flexibility to route around existing utilities rather than relocate.
  - Manifold & home-run design eliminates most field joints, tees, and valve boxes.
  - Valve boxes only for future system expansion.



Energy Use Comparison

Comparison of Existing and Selected Option Energy Use

Parameter	Units	Existing	Selected Option
Gas	MMBtu/yr	40,000	14,000
Electrical Power	MMBtu/yr	2,500	15,000
Solar thermal	MMBtu/yr	0	5,000
Total	**MMBtu/yr**	**42,500**	**34,000**

Summary

- CNPRC district energy system needed substantial improvements:
  - Redundancy, reliability, sustainability, efficiency
- Multi-faceted solution to satisfy diverse district needs
  - Integrated solar, heat pump, and HW TES
  - Biogas-ready
  - Electrical steam and high-temp HW production
- Load sizes and site layout suitable for PEX
- Alignment with UC initiatives
  - Significant carbon reduction
  - Designed to fully electrify in the future

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