UC Davis Carbon Neutrality Initiative for 2025: Modeling campus sustainability alternatives using EnergyPro

Manuel Bugueno, Anindito Wibowoputro, John Martin De Guzman
Client: Josh Morejohn from Energy Conservation Office

Introduction

UC Davis has launched a Carbon Neutrality Initiative (CNI) to achieve a net zero carbon footprint from onsite combustion emission systems and indirect purchased electricity emissions by 2025. From 2016 data, there is an estimated total carbon emission of 107,000 ton [1], corresponding to 46% from natural gas combustion for heating system and 53% from imported electric supply.

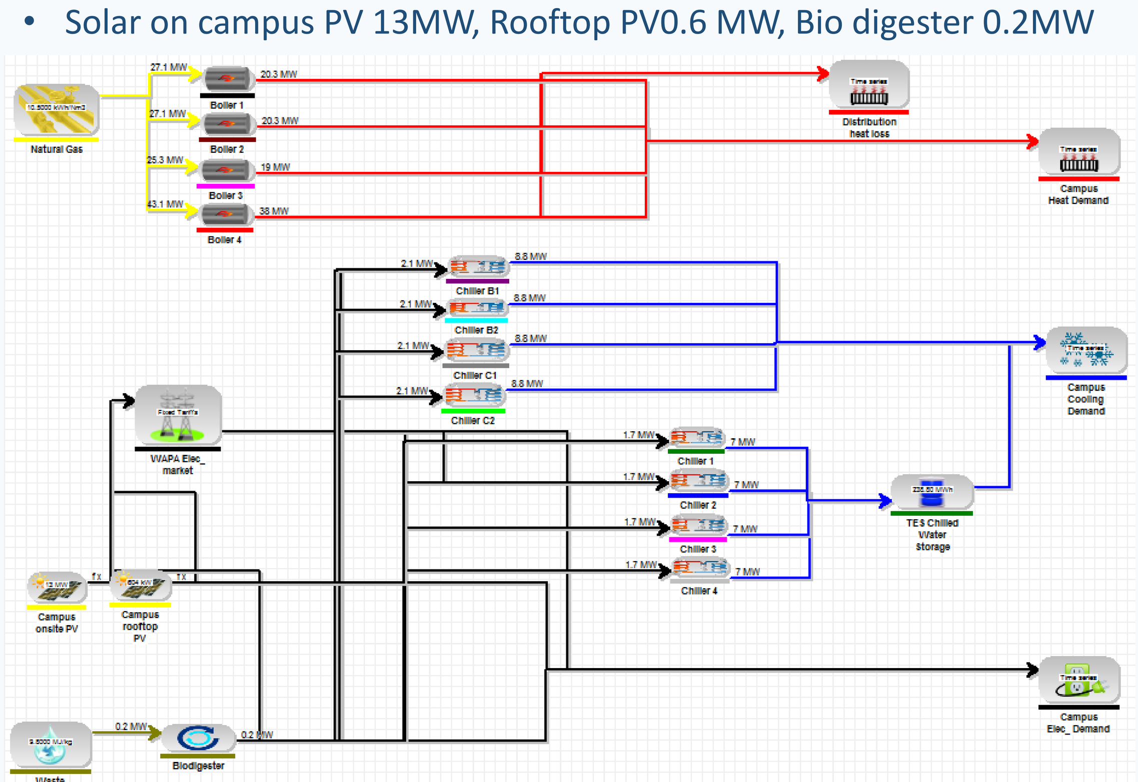
By far the greatest challenge to achieving this feat for the Davis campus will be to reduce or eliminate the dependence on natural gas for heating and change the source of indirect purchased electricity through more renewable alternatives such as more solar PV, solar thermal, or solar PV-driven heat pumps; and also reduce the heat loss that currently reach 50% in energy.

To evaluate possible alternatives to reach CNI, we created models on EnergyPRO based on the energy and equipment alternatives for on/off-campus and operating systems. Our alternatives include SPVF, Solar Thermal and storage, Heat Recovery Chillers and Biomass, and will consider a reduction of 25% of the actual heat loss. We combined these alternatives and came up with three scenarios for UC Davis. Our models suggest that Solar Thermal and Biomass could play a key role to reduce UC Davis carbon footprint significantly by 54% -89%. In addition, Alternative 2 just reduced carbon emission by 5%, suggesting that it is not the best choice to reduce carbon emission.

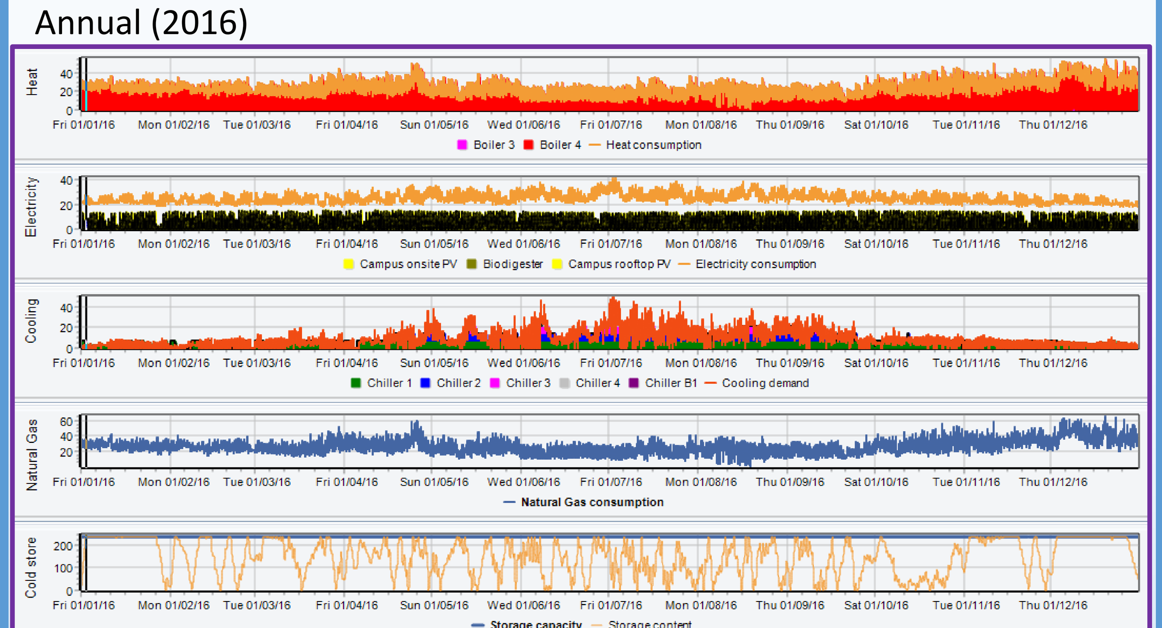
Status Quo Model:

Description:

- Heat system consisting of 2 Boilers of 19 and 38 MW with 2 back up of 20.3 MW heat production each.
- Cooler system consisted of 8 chillers (4 of 8.8 MW and 4 of 7 MW each)
- Chiller water storage 18927 m^3, temperatures 15° on top and 3.89 in the bottom, 239 MWh energy capacity.
- Solar on campus PV 13MW, Rooftop PV0.6 MW, Bio digester 0.2MW



Annual (2016)



Emissions/Year	2016
CO2 [ton]	
CO2, Natural Gas	49,378
CO2, Waste	251
CO2, Elec. imported	56,893
CO2 Total	106,522

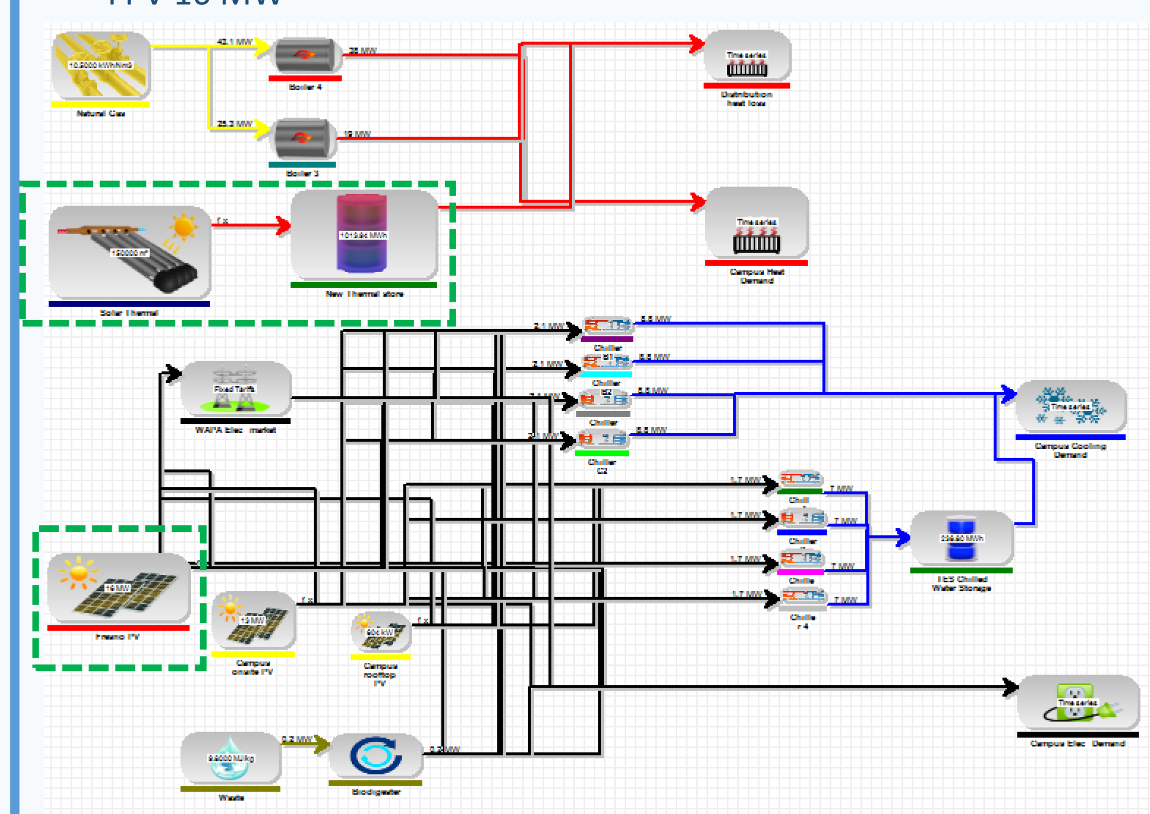
Model Alternative 1

Description

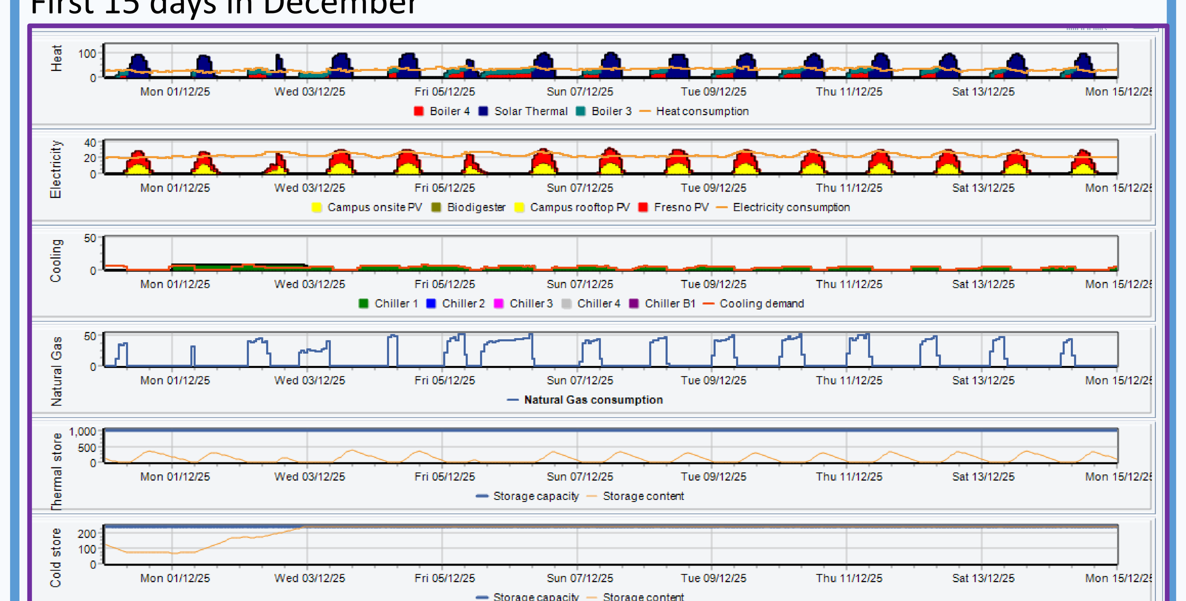
We used the Status Quo model and removed the two non-op boilers (1&2), added Solar Thermal (ST) which provides hot water for Solar Storage (SS). A new source of energy is also added from Fresno PV (FPV). This model assumes 25% heat loss.

Specifications:

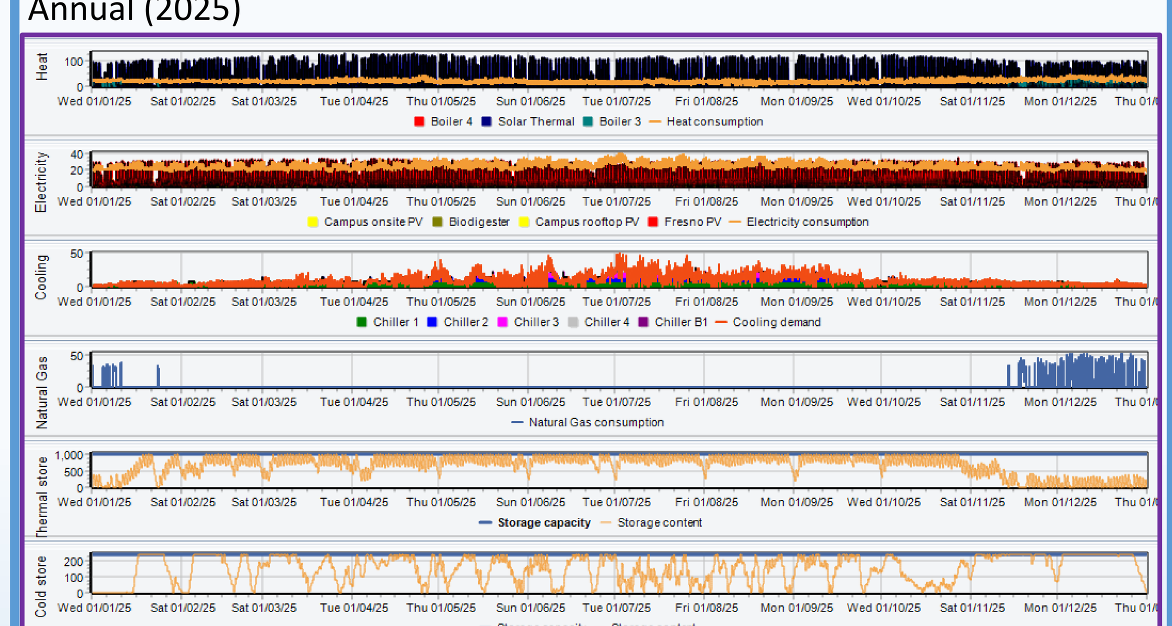
- ST surface of 150,000 m^2
- SS tank volume of 25,000 m^3
- Heat conversion of 90° C out collector and 45° to collector
- Storage at 5°C in the top and 50° C bottom
- 1014 MWh energy capacity
- Consider heat loss from the collector of 5° C
  FPV 16 MW



First 15 days in December



Annual (2025)



Emissions/Year	2025
CO2 [ton]	
CO2, Natural Gas	3,051
CO2, Waste	250
CO2, Elec. imported	45,178
CO2 Total	48,478
%CO2 Reduction	54%

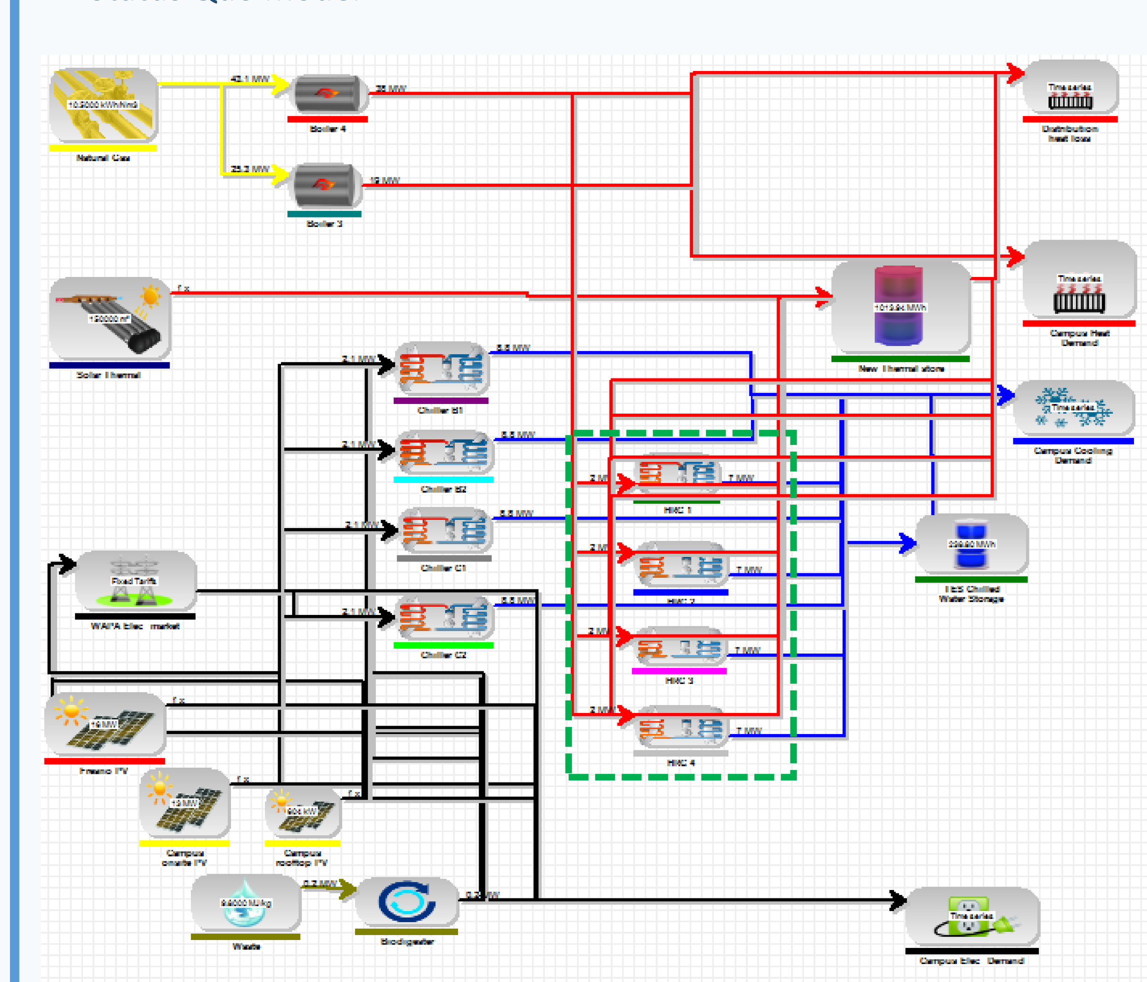
Model Alternative 2

Description

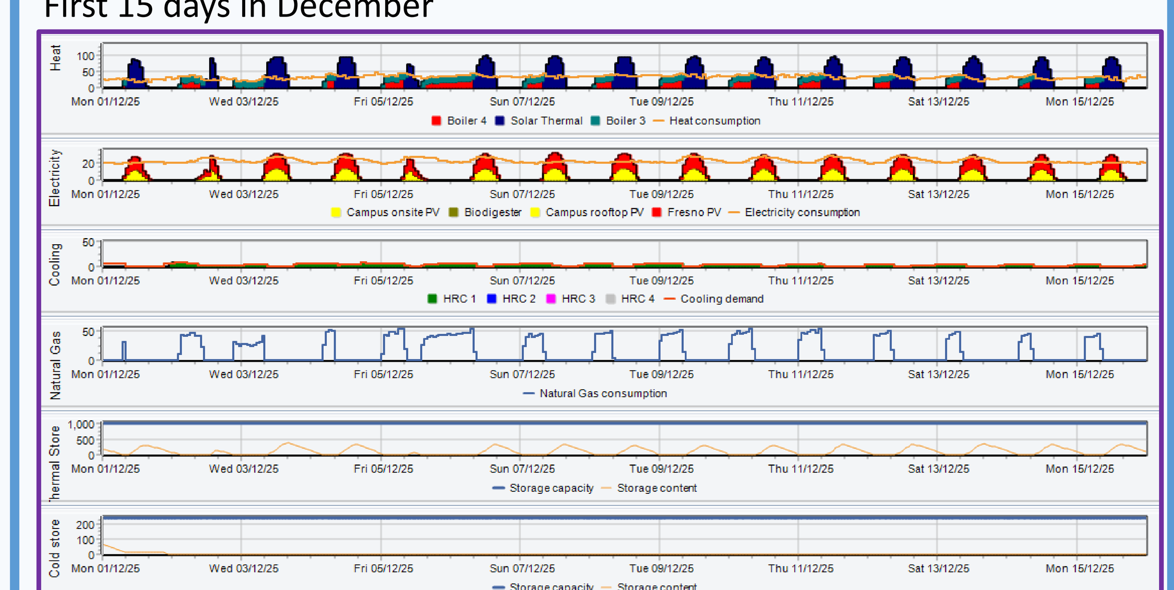
Alternative 1 with added Heat Recovery Chiller (HRC). We replaced conventional electric chillers with more efficient HRC to reduce wasted energy.

Specifications:

- Chiller 1, 2, 3 and 4 was replaced by four HRC in series with the same chilling capacity (7 MW) and with the same operation criteria in the Status Quo model



First 15 days in December



Annual (2025)

Emissions/Year	2025
CO2 [ton]	
CO2, Natural Gas	3,454
CO2, Waste	250
CO2, Elec. imported	39,876
CO2 Total	43,580
%CO2 Reduction	59%

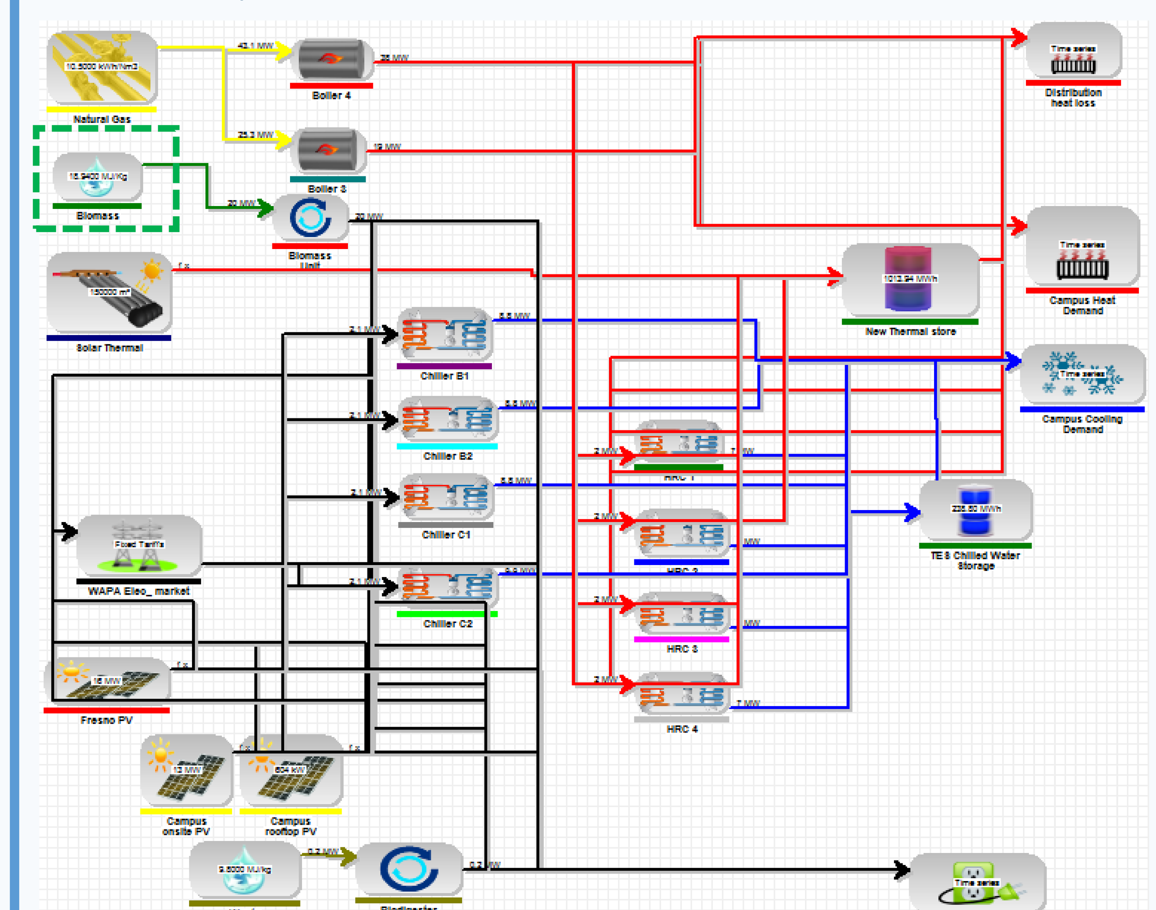
Model Alternative 3

Description

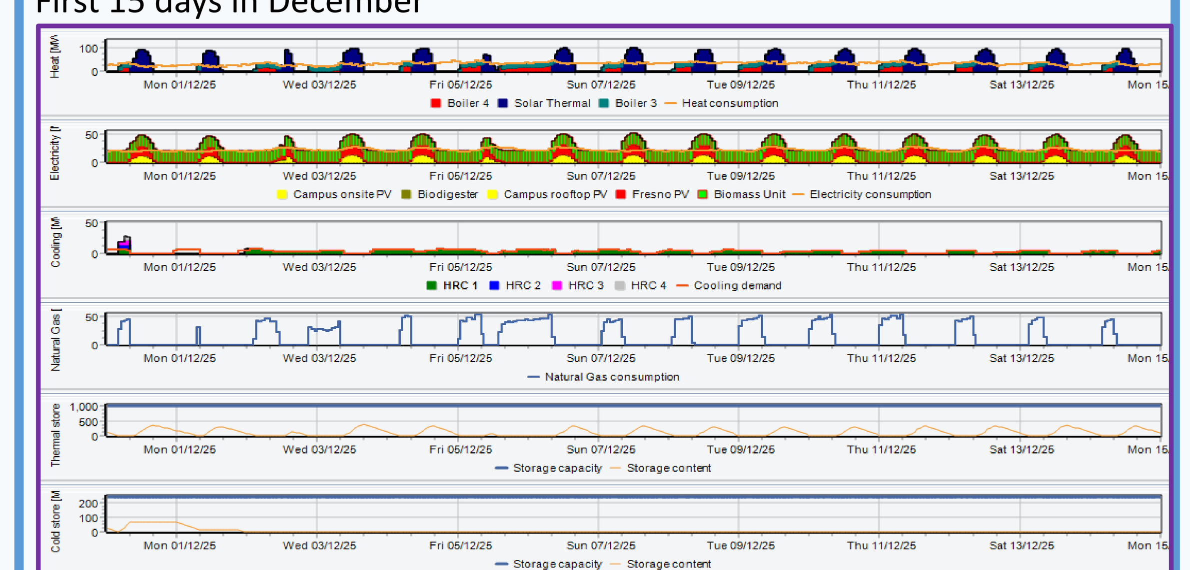
Alternative 2 with added 20 MW Biomass boiler off Campus.

Specifications:

- Heat value of biomass 18.94 MJ/Kg, Value (18.94 MJ/Kg) correspond of the average of low heat value of California biomass [2], 20 MW electrical production.



First 15 days in December



Annual (2025)

Emissions/Year	2025
CO2 [ton]	
CO2, Natural Gas	3,501
CO2, Waste	250
CO2, Elec. imported	2,221
CO2 Total	5,972
%CO2 Reduction	94%

Conclusion

Our models suggest that ST and Biomass could play a key role to reduce UC Davis carbon footprint significantly by 54% -89% and are great alternatives

References

[1] Agerfeld. 2016. Energy Planning at UC Davis. An analysis of benefits of converting steam district heating to hot water.
[2] Jenkins & Ebeling. 1985. Thermochemical properties of biomass fuels. CALIFORNIA AGRICULTURE.