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



	rint trom onsite combustion omission sus	
indirect nurchased ele	print from onsite combustion emission sys	
·	ectricity emissions by 2025. From 2016 da	· ·
	carbon emission of 107,000 ton [1], corres	
	gas combustion for heating system and 53	% from
imported electric sup	• /	
	allenge to achieving this feat for the Davis	
	liminate the dependence on natural gas f	
0	he source of indirect purchased electricity	
	rnatives such as more solar PV, solar therr	· ·
	oumps; and also reduce the heat loss that	:
currently reach 50% i		
•	alternatives to reach CNI, we created mod	
	the energy and equipment alternatives for	
	g systems. Our alternatives include SPVF,	
C ·	Heat Recovery Chillers and Biomass, and	
	of 25% of the actual heat loss. We combin	
	e up with three scenarios for UC Davis. Οι	
	ermal and Biomass could play a key role to	
	print significantly by 54% -89%. In additio	· ·
-	uced carbon emission by 5%, suggesting t	hat it is
not the best choice to	o reduce carbon emission.	
	Status Quo Model:	
Description:		
,	ting of 2 Boilers of 19 and 38 MW with 2	back up
of 20.3 MW heat p		
	sisted of 8 chillers (4 of 8.8 MW and 4 of 7	/ IVI VV
each)		
	ge 18927 m ³ , temperatures 15° on top an	d 3.89 in
	Wh energy capacity.	
• Solar on campus P	V 13MW, Rooftop PV0.6 MW, Bio digester	0.21/1/
20.3 MW 10.5000 KW N10+2 27.1 MW Boller 1		
Natural Gas 25.3 MW Boller 2	Distribution heat loss	
19 MW		
43.1 MW Boller 3 38 MW		2222
43 1 MW Boller 3	21 MW	Campus
43.1 MW	21 MW 21 MW Chiller B1 88 MW 21 MW	Campus
43.1 MW	21 MW Chiller B1 21 MW Chiller B2 2.1 MW Chiller B2 8.8 MW	Campus
43.1 MW	21 MW Chiller B1 21 MW Chiller B2 88 MW Chiller B2 88 MW	Campus Heat Demand
43.1 MW Boller 3 Boller 4	21 MW Chiller B1 21 MW Chiller B2 21 MW Chiller C1 S3 MW Chiller C2 1.7 MW Chiller 1 7 MW	Campus Heat Demand
43.1 MW Boller 3 38 MW Boller 4	21 MW Chiller B1 21 MW Chiller B2 21 MW Chiller C1 S8 MW Chiller C1 S8 MW Chiller C2 1.7 MW Chiller 1 7 MW Chiller 1 7 MW Chiller 2	Campus Heat Demand
43.1 MW Boller 3 Boller 4	21 MW Chiller B1 21 MW Chiller B2 21 MW Chiller C1 S8 MW Chiller C2 1.7 MW Chiller C2 1.7 MW Chiller C2 1.7 MW Chiller C2 7 MW Chiller C2 7 MW Chiller C2 7 MW Chiller C2 7 MW Chiller C2 7 MW Chiller C2 7 MW	Campus Heat Demand
43.1 MW Boller 3 Boller 4 Boller 4	21 MW Chiller B1 21 MW Chiller B2 21 MW Chiller C2 Chiller C2 Chiller C2 Chiller C2 1.7 MW Chiller C3 1.7 MW	Campus Heat Demand
43.1 MW Boller 3 38 MW Boller 4	21 MW Chiller B1 21 MW Chiller B2 38 MW Chiller C1 S8 MW Chiller C2 1.7 MW	Campus Heat Demand
A3.1 MW Boller 3 Boller 4 Boller 4 Boller 4	21 MW Chiller B1 21 MW Chiller B2 38 MW Chiller C1 S8 MW Chiller C2 1.7 MW	Campus Heat Demand
A3.1 MW Boller 3 Boller 4 Boller 4	21 MW Chiller B1 21 MW Chiller B2 38 MW Chiller C1 S8 MW Chiller C2 1.7 MW	Campus Heat Demand
Boller 3 33 MW Boller 4 Boller 4 Boller 4	21 MW Chiller B1 21 MW Chiller B2 38 MW Chiller C1 S8 MW Chiller C2 1.7 MW	Campus Heat Demand
Bolier 3 33 MV Bolier 4 Bolier	21 MW Chiller B1 21 MW Chiller B2 38 MW Chiller C1 S8 MW Chiller C2 1.7 MW	Campus Heat Demand
Boller 3 33 MV Boller 4 Boller 4 Boller 4 Boller 4	21 MW Chiller B1 21 MW Chiller C1 2.1 MW Chiller C2 1.7 MW Chiller 2 1.7 MW Chiller 3 7 MW Chiller 4 1.7 MW Chille	Campus Heat Demand
Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Figure Boller 4 Boller 4 Figure Boller 4 Figure Boll	21 MW Chiller B1 21 MW Chiller C1 2.1 MW Chiller C2 1.7 MW Chiller 2 1.7 MW Chiller 3 7 MW Chiller 4 1.7 MW Chille	Campus Heat Demand
Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Boller 4 Figure Boller 4 Boller 4 Figure Boller 4 Figure Boll	21 MW Chiller B1 88 MW Chiller B1 88 MW Chiller C1 88 MW Chiller C1 88 MW Chiller C1 88 MW Chiller C1 17 MV Chiller T 7 MV Chil	Campus Heat Demand
Bolier 3 3 MW Bolier 4 Bolier 4 B	21 MM 21 MM Chiller B1 33 MW 21 MM Chiller C1 38 MW Chiller C2 17 MW Chiller C2 17 MW Chiller C2 17 MW Chiller C3 17 MW Chiller C3 17 MW Chiller C3 17 MW Chiller C4 17 MW C4 17 MW	Campus Heat Demand
Boller 4 Boller 4 Bol	21 MM Chiller B1 35 MW 21 MM Chiller B2 35 MW 21 MM Chiller B2 35 MW 21 MM Chiller B2 35 MW 21 MM Chiller C1 55 MW 21 MM Chiller C2 17 MW Chiller 7 MW Chiller C2 17 MW Chiller 7 MW Chiller C3 17 MW Chiller 7 MW Chiller C3 7 MW Chiller C4 7 MW C5 MW C6 MW	Campus Heat Demand
Boller 4 Boller 4 Bol	21 MV 21 MV 21 MV Chiller E1 38 MV 21 MV Chiller E3 38 MV 21 MV Chiller E3 38 MV 21 MV Chiller E3 38 MV Chiller E3 17 MV Chiller E3 7 MV Chiller E3 8 MV C	Campus Heat Demand
Boler 4 51 MV Boler 4 50 MV Campus	21 MV 21	Campus Heat Demand
Image: Section of the sectio	21 MV 21 MV 21 MV Chiller E1 38 MV 21 MV Chiller E3 38 MV 21 MV Chiller E3 38 MV 21 MV Chiller E3 38 MV Chiller E3 17 MV Chiller E3 7 MV Chiller E3 8 MV C	Campus Heat Demand
Image: Single	21100 21100 21100 Chiller B 21100 Chiller C 21100 Chiller C	Campus Heat Demand
Image: Single	21 MAY 21 MAY 21 MAY CITIER EB 21 MAY CITIER E	Campus Heat Demand
Boiler 3 35 MV Boiler 4 35 MV Boiler 4 55 MV Boiler 4 56 MV Boiler 4 50 MV Campus 12 Campus 02 MV Diodigester 02 MV Biodigester 02 MV Mon 01/02/16 Tue 01/03/16 Fri 01/01/16 Mon 01/02/16 Tue 01/03/16	21 Mm 58 AW 21 Mm 71 Mm 21 Mm <td>Campus Heat Demand Campus Cooling Demand Campus Cooling Demand Campus <</td>	Campus Heat Demand Campus Cooling Demand Campus Cooling Demand Campus <
Image: Space of the s	11 Min 12 Min 13 Min 11 Min 14 Min 14 Min 14 Min 11 Min 14 Min 17 Min 17 Min 17 Min 11 Min 14 Min 17 Min 17 Min 17 Min 17 Min 12 Min 17	Campus Heat Demand Campus Cooling Demand Campus Cooling Demand Campus <

Introduction

UC Davis has launched a Carbon Neutrality Initiative (CNI) to achieve a

CO2 CO2 [ton] 49,378 CO2, Natural Gas CO2, Waste 251 **CO2**⁻ 56,893 CO2, Elec. imported %CO2 CO2 Total 106,522

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

Model Alternative 1

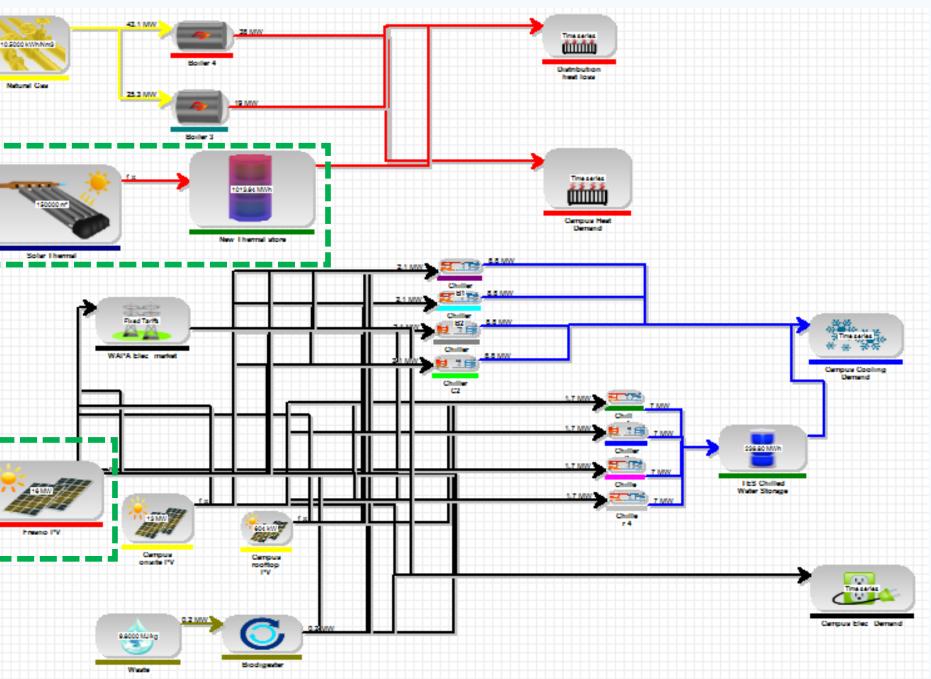
Description

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:

Natural Case

- ST surface of 150,000 m²
- SS tank volume of 25,000 m³
- 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

Mon 01/12/25	Wed 03/12/25	Fri 05/12/25 Boiler 4 Sola	Sun 07/12/25 ar Thermal Boiler 3	Tue 09/12/25 Heat consumption	Thu 11/12/25	Sat 13/12/25	Mon 15/12/2
Mon 01/12/25	Wed 03/12/25 Campus or	Fri 05/12/25 nsite PV Biodigester	Sun 07/12/25 Campus rooftop PV	Tue 09/12/25 Fresno PV — Electricity	Thu 11/12/25 r consumption	Sat 13/12/25	Mon 15/12/2
Mon 01/12/25	Wed 03/12/25	Fri 05/12/25 hiller 1 📕 Chiller 2 📕 0	Sun 07/12/25 Chiller 3 📄 Chiller 4 🔳	Tue 09/12/25 Chiller B1 — Cooling der	Thu 11/12/25 nand	Sat 13/12/25	Mon 15/12/2
Mon 01/12/25	Wed 03/12/25	Fri 05/12/25	Sun 07/12/25 Natural Gas consumpt	Tue 09/12/25	Thu 11/12/25	Sat 13/12/25	Mon 15/12/2
Mon 01/12/25	Wed 03/12/25	Fri 05/12/25	Sun 07/12/25 age capacity — Storage	Tue 09/12/25 content	Thu 11/12/25	Sat 13/12/25	Mon 15/12/2
Mon 01/12/25	Wed 03/12/25	Fri 05/12/25	Sun 07/12/25 age capacity — Storage	Tue 09/12/25 content	Thu 11/12/25	Sat 13/12/25	Mon 15/12/2

Annual (2025)

Emissi

CO2

CO2

CO2

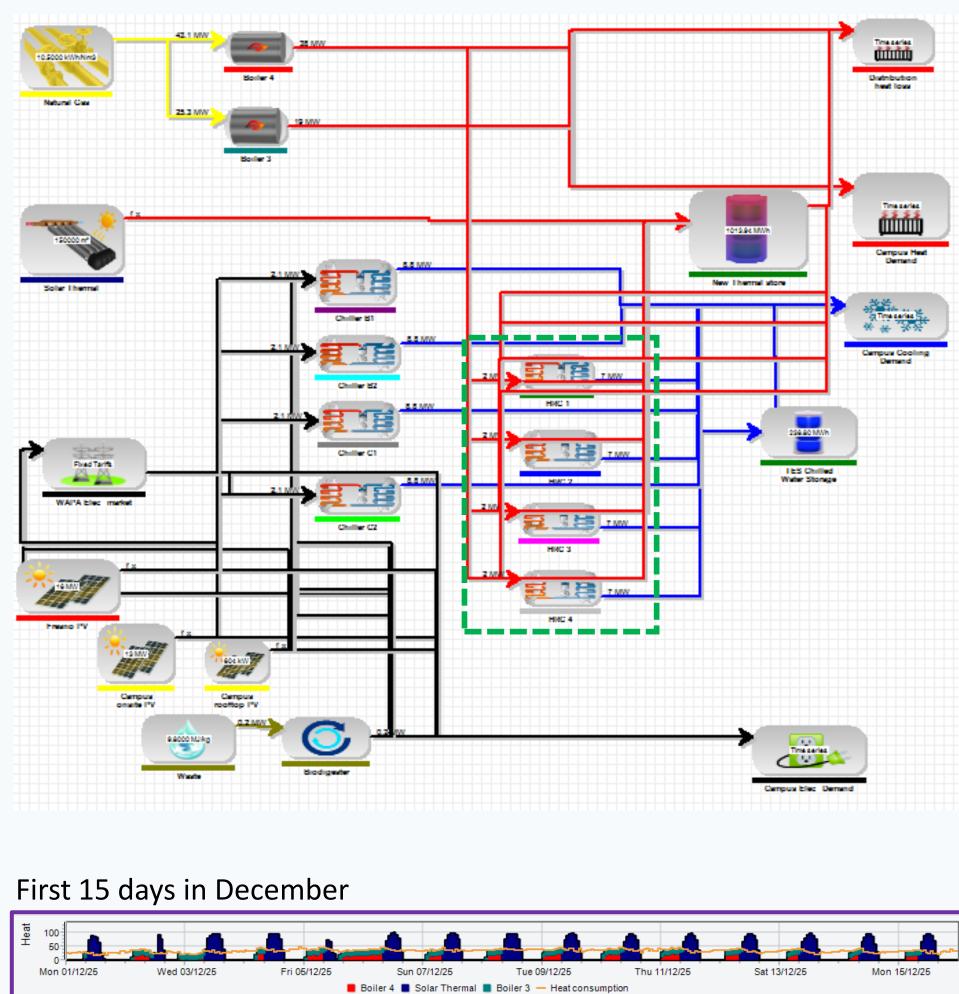
		-	-										
Heat	100 0 Wed 01/01/25	Sat 01/02/25	Sat 01/03/25	Tue 01/04/25	Thu 01/05/25		Tue 01/07/25	Fri 01/08/25	Mon 01/09/25		Sat 01/11/25	Mon 01/12/25	Thu 01/
ţ	40	1.00.000 and 1.00.000	to complete an edge of	and the second second second	Boiler 4	Solar Thermal	Boiler 3 -	Heat consumpt	ion	the state of the second		a Alexandre	
Electricity	20 0 Wed 01/01/25	Sat 01/02/25	Sat 01/03/25	Tue 01/04/25 Campus onsit	Thu 01/05/25 te PV Biodig		Tue 01/07/25 s rooftop PV	Fri 01/08/25 Fresno PV —	Mon 01/09/25 Electricity consur	Wed 01/10/25	Sat 01/11/25	Mon 01/12/25	Thu 01/
Cooling	50 0 Wed 01/01/25	Sat 01/02/25	Sat 01/03/25	Tue 01/04/25	Thu 01/05/25	Sun 01/06/25 2 Chiller 3	Tue 01/07/25 Chiller 4	Fri 01/08/25	Mon 01/09/25 oling demand	Wed 01/10/25	Sat 01/11/25	Mon 01/12/25	Thu 01/
Gas	50 -	1										والألبار والمرارية	ותייי
a	0 Wed 01/01/25	Sat 01/02/25	Sat 01/03/25	Tue 01/04/25	Thu 01/05/25	Sun 01/06/25 — Natural 0	Tue 01/07/25 Gas consumption	Fri 01/08/25	Mon 01/09/25	Wed 01/10/25	Sat 01/11/25	Mon 01/12/25	Thu 01/
_	1,000 500 0		a Anna Anna	Annoted Participation	energin produced	in the second	an An Warman	and the second second		nderen hurndricht	NAMA PARA	. Manual popular	
Iherma	Wed 01/01/25	Sat 01/02/25	Sat 01/03/25	Tue 01/04/25	Thu 01/05/25	Sun 01/06/25 Storage capac	Tue 01/07/25 Sity — Storage	Fri 01/08/25 content	Mon 01/09/25	Wed 01/10/25	Sat 01/11/25	Mon 01/12/25	Thu 01/
ld store	200		VV	A	W	M	"V"WA	MAN	MV		$\mathcal{N}^{\mathbf{m}}$	· \V	
8	Wed 01/01/25	Sat 01/02/25	Sat 01/03/25	Tue 01/04/25	Thu 01/05/25	Sun 01/06/25	Tue 01/07/25	Fri 01/08/25	Mon 01/09/25	Wed 01/10/25	Sat 01/11/25	Mon 01/12/25	Thu 01/

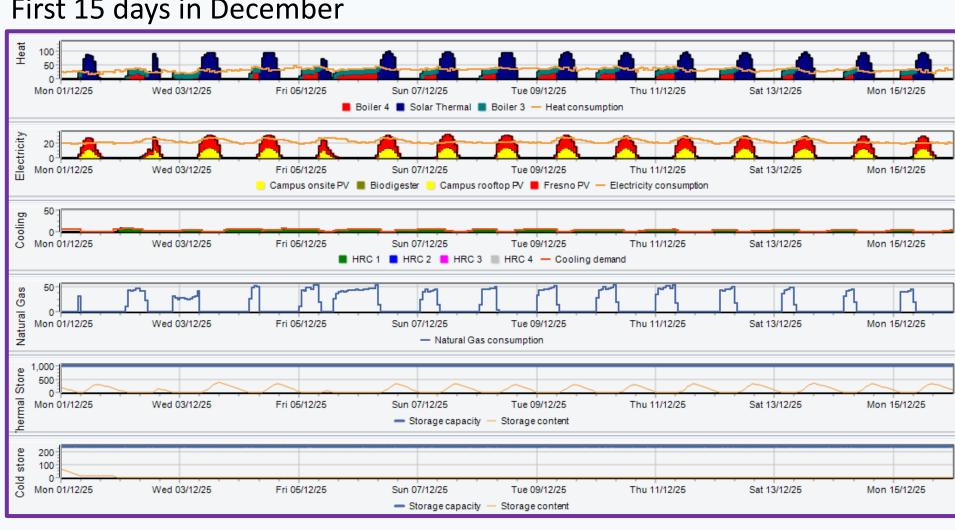
ions/Year	2025
[ton]	
, Natural Gas	3,051
, Waste	250
, Elec. imported	45,178
Total	48,478
Reduction	54%

Storage capacity — Storage content

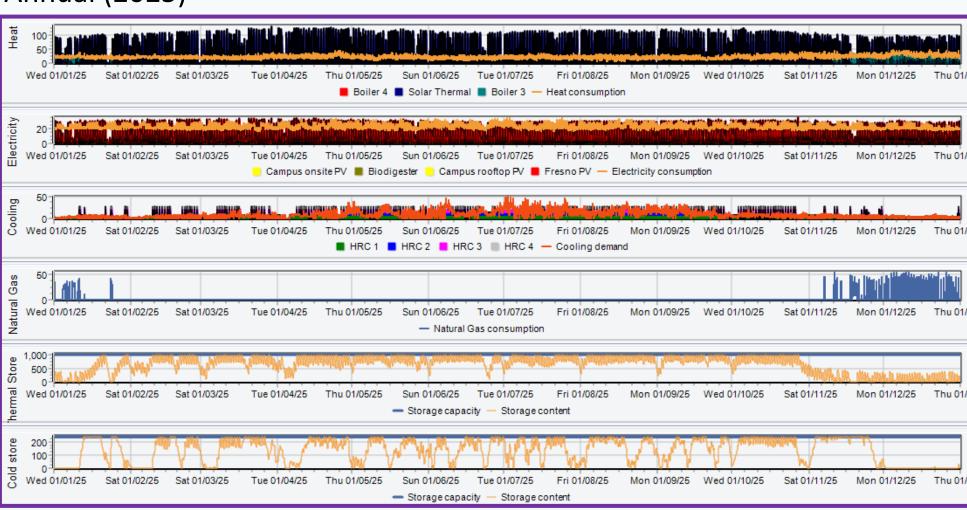
Description

energy. **Specifications:**





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 2

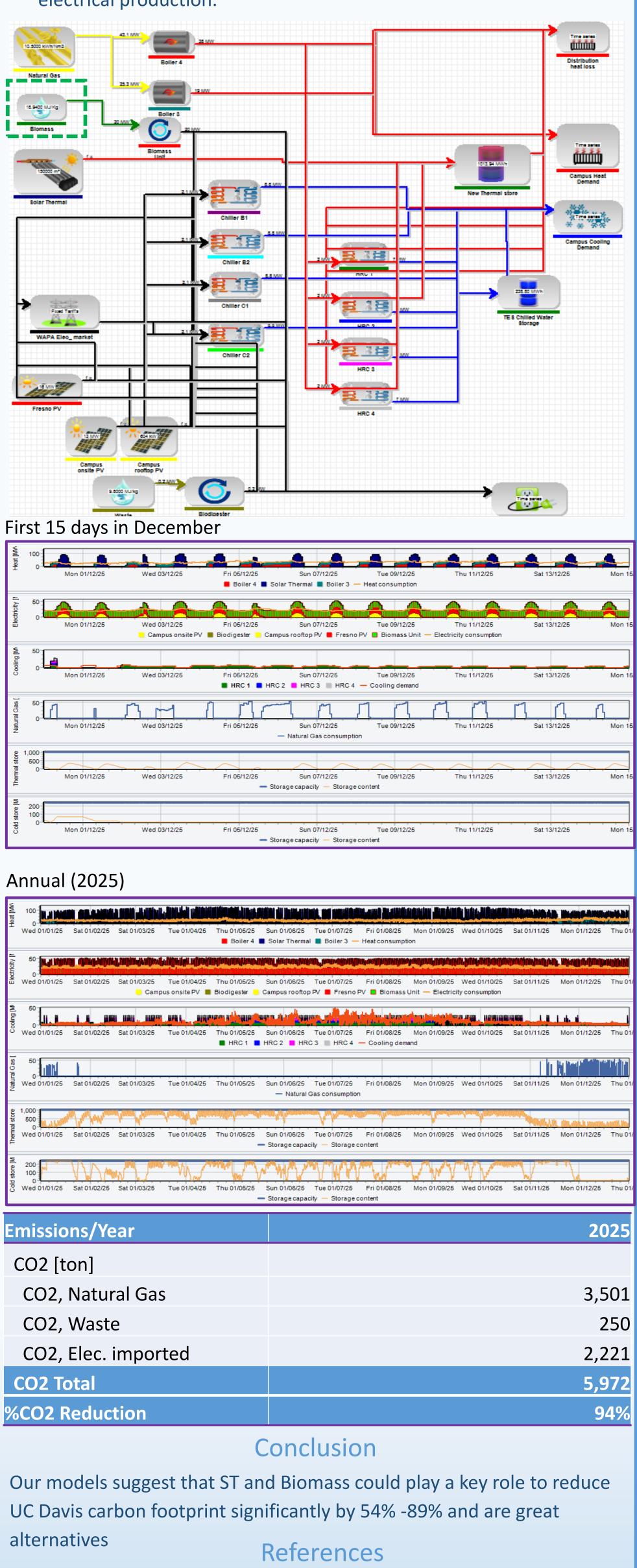
Alternative 1 with added Heat Recovery Chiller (HRC). We replaced conventional electric chillers with more efficient HRC to reduce wasted

• 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

Description

Alternative 2 with added 20 MW Biomass boiler off Campus. **Specifications:**

electrical production.



[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.



Model Alternative 3

• 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