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DER-VET Task Force

ESIC Working Group 1: Grid Services and Analysis

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Webcast Reminders

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Abide by Antitrust Guidelines

Chat to “Everyone” for maximum interaction

The slides and recordings will be posted to www.der-vet.com/esictf/

Agenda

- DER-VET for Emissions Co-Optimization
- DER-VET for CHP Analysis

DER-VET for Emissions Co-Optimization

DER-VET for Emissions Co-Optimization: Overview

- **Objective:** Develop approach towards standardizing project-level, price-taker methodologies for ESS, other DER, and microgrids to estimate the change in emissions due to their proposed operations (Scope 2 Emissions per WRI Corporate Standard)

- **Need:** State of the art tools (including DER-VET™), do not adequately address emissions co-optimization today

- **Analysis:** Selects a representative microgrid uses EPRI's DER-VET™ combined with a new prototype emissions optimization module developed for this exercise to explore three emissions optimization approaches

Forthcoming EPRI White Paper: *Modeling Greenhouse Gas Emissions in Energy Storage and Distributed Energy Resource Decision-Making Frameworks* [Product ID: 3002021604]

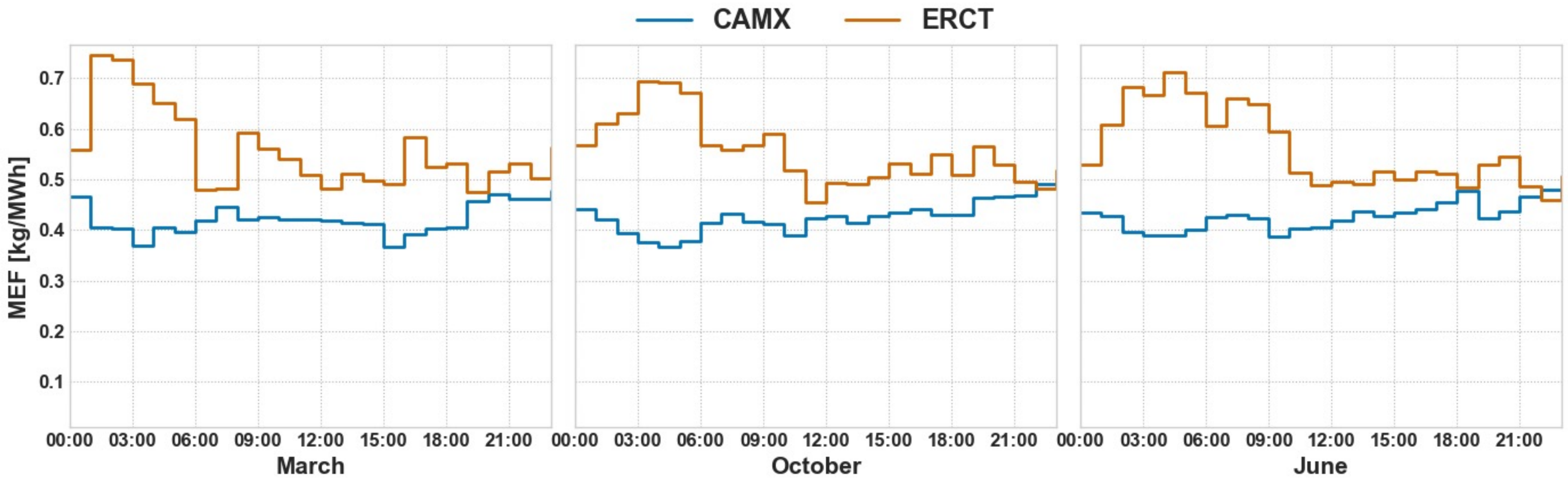
DER-VET for Emissions Co-Optimization: Approaches

1) **Ex Post Facto Calculation of Emissions:** Emissions calculation is performed after solving for the economic dispatch of the microgrid
2) **Optimize to Minimize Emissions:** Dispatches ESS and other DER to minimize the operational direct and indirect emissions
3) **Co-optimize Emissions and Economics:** Poses a solution where both emissions and economics are objectives in the dispatch optimization.
   - Explores the solution space by finding the Pareto Frontier, along which any solution can be considered the "optimum" with a combination of emissions and economics
   - Thus, decision-makers consider which solution(s) along the Pareto Frontier balances the project's priorities

Forthcoming EPRI White Paper: ***Modeling Greenhouse Gas Emissions in Energy Storage and Distributed Energy Resource Decision-Making Frameworks*** **[Product ID: 3002021604]**

New Input Data for DER-VET: Marginal Emission Factors

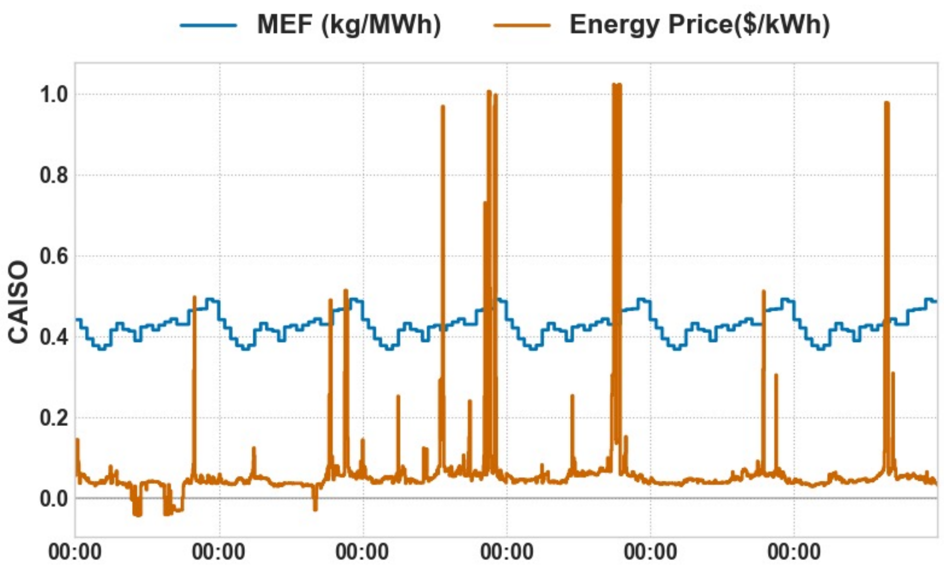
- Marginal emission factors (MEF) are the emissions intensities of the marginal generators in the system—the last generators needed to meet demand at a given time, and the first to respond given an intervention
- MEF vary substantially by region, such as the CAISO and ERCOT samples below:

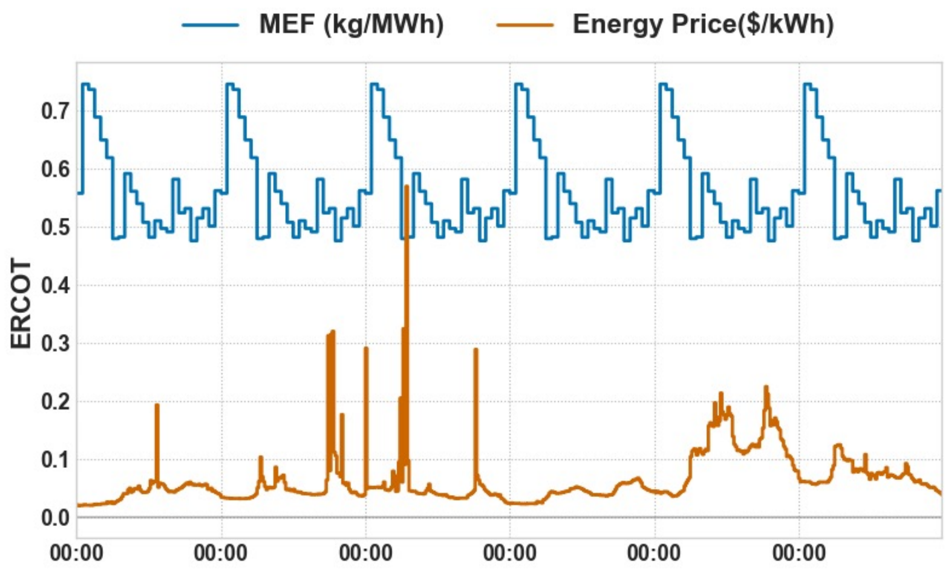


Regression-based 2014 CAMX and ERCT hourly MEFs during different seasons

Representative Microgrid Scenarios for Analysis

Microgrid	Characteristic	
ESS	Size	250 kW, 4-hour
	Round trip efficiency	75%
PV	Size	1000 kW
Grid Services and Costs	The microgrid participates in energy time shift and does not consider installation, fixed, nor variable costs.	





Results

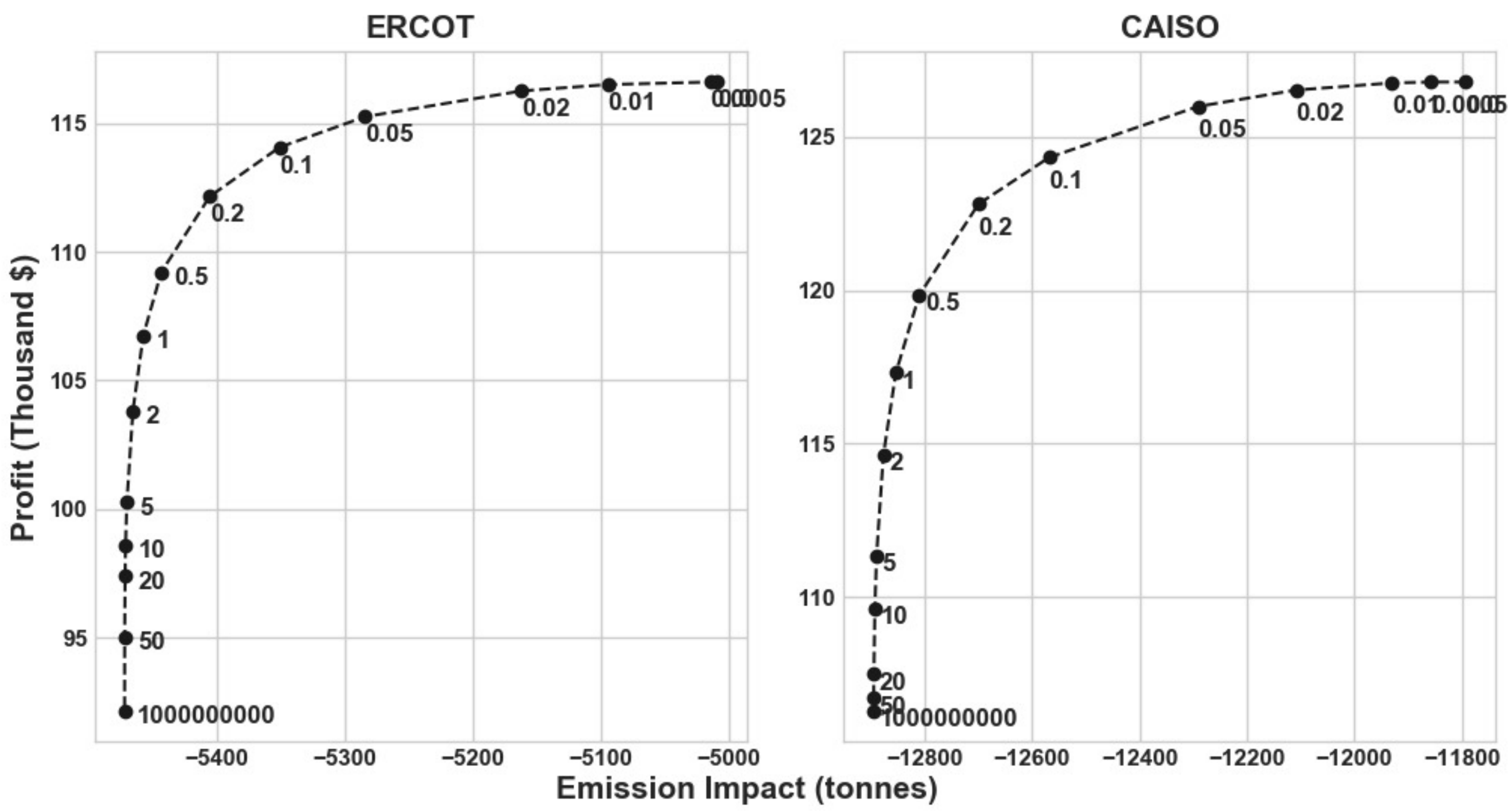
Ex Post Facto Calculation of Emissions

Grid Region	Value of Project in 2014	Emissions Reduction in 2014
CAISO	$127k	-11,792t
ERCOT	$117k	-5,009t

Optimize to Minimize Emissions

Grid Region	Value of Project in 2014	Emissions Reduction in 2014
CAISO	$106k	-12,895t
ERCOT	$92k	-5,471t

Results: Co-optimize Emissions and Economics



Pareto Frontier:

- Instead of mapping the mass of emissions to a cost through a social cost, this analysis applies a value of GHG and explores the solution space by finding the Pareto Frontier
- When optimizing two conflicting objectives, the tradeoffs between them can be understood by increasing the weight of one objective and keeping the other constant The weight (α) represents the value of GHG
- The weight is increased from 0 to some very large number (N). For each weight, the objective values are collected, meaning the emission impact and total net costs are collected
- Lastly, the frontier is plotted with each objective on its own axis. Along the Pareto Frontier, any solution can be considered the “optimum”
- Stakeholders should consider which solution balances their priorities

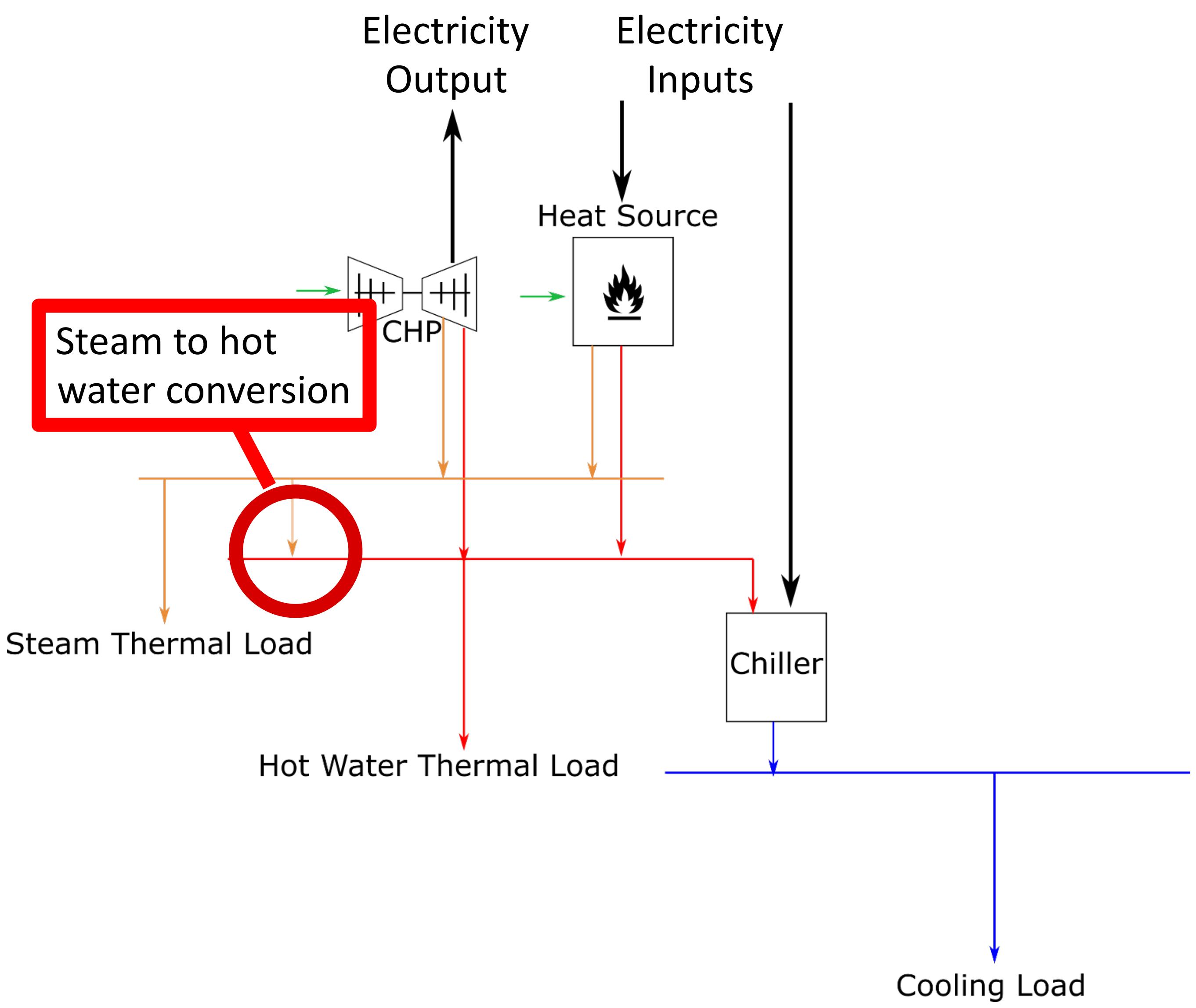
Potential Next Steps for DER-VET Development

- Link DER-VET to existing MEF calculators
- Include Scope 1 and 3 emissions for cradle-to-grave analysis (especially optimal sizing objectives)
- Combination of different DER such as controllable loads or electric vehicle charge management
- Different applications of ESS and/or other DER such as distribution or transmission-connected projects providing grid services and participating in wholesale markets
- Consider microgrid support during an outage of the bulk power system to understand the tradeoffs between emissions and resilience
- Look at the impact of different degradation modeling approaches

DER-VET for CHP Anlaysis

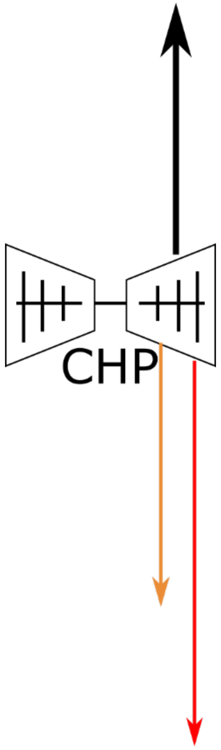
CHP Diagram

- Separate steam, hot water, and cooling thermal loads
- Thermal load must be served by on-site DERs (cannot be supplied by an external grid)
- Steam can be converted to hot water but not the other way around
- Heat can be converted to cooling through a chiller
- Excess heat generation can be 'dumped' to make a solution feasible
  - Electric power constraints could cause a conflict



CHP Formulation

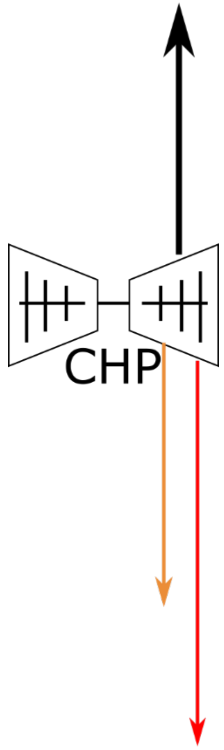
- Constant electric power to heat ratio
  - Applies even if generating at part load



$$\frac{\text{Electric Power (kW)}}{\text{Steam Thermal Power (kW)} + \text{Hot Water Thermal Power (kW)}} = \text{Constant}$$

CHP Formulation

- Maximum steam ratio
  - May over-generate hot water and dump the excess to meet steam load



$$\frac{\text{Steam Thermal Power (kW)}}{\text{Hot Water Thermal Power (kW)}} \leq \text{Constant}$$

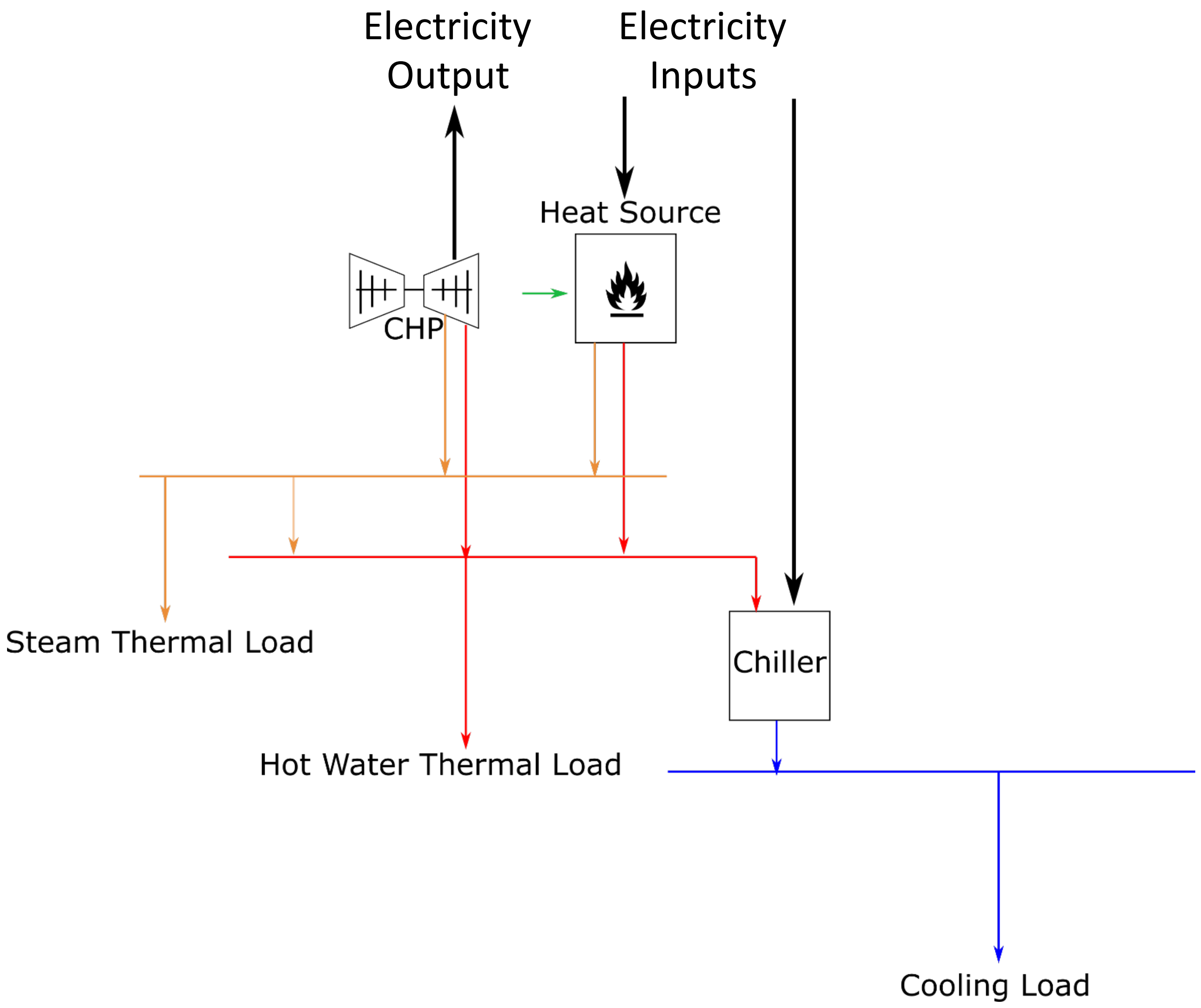
CHP continued

Standard engineering judgements are being left out of the current implementation, relying on user inputs instead

- User must use their own knowledge to ensure the thermal loads are addressable by the DERs selected.
  - DER-VET will not consider temperature or any other parameter – only distinguish steam vs hot water.

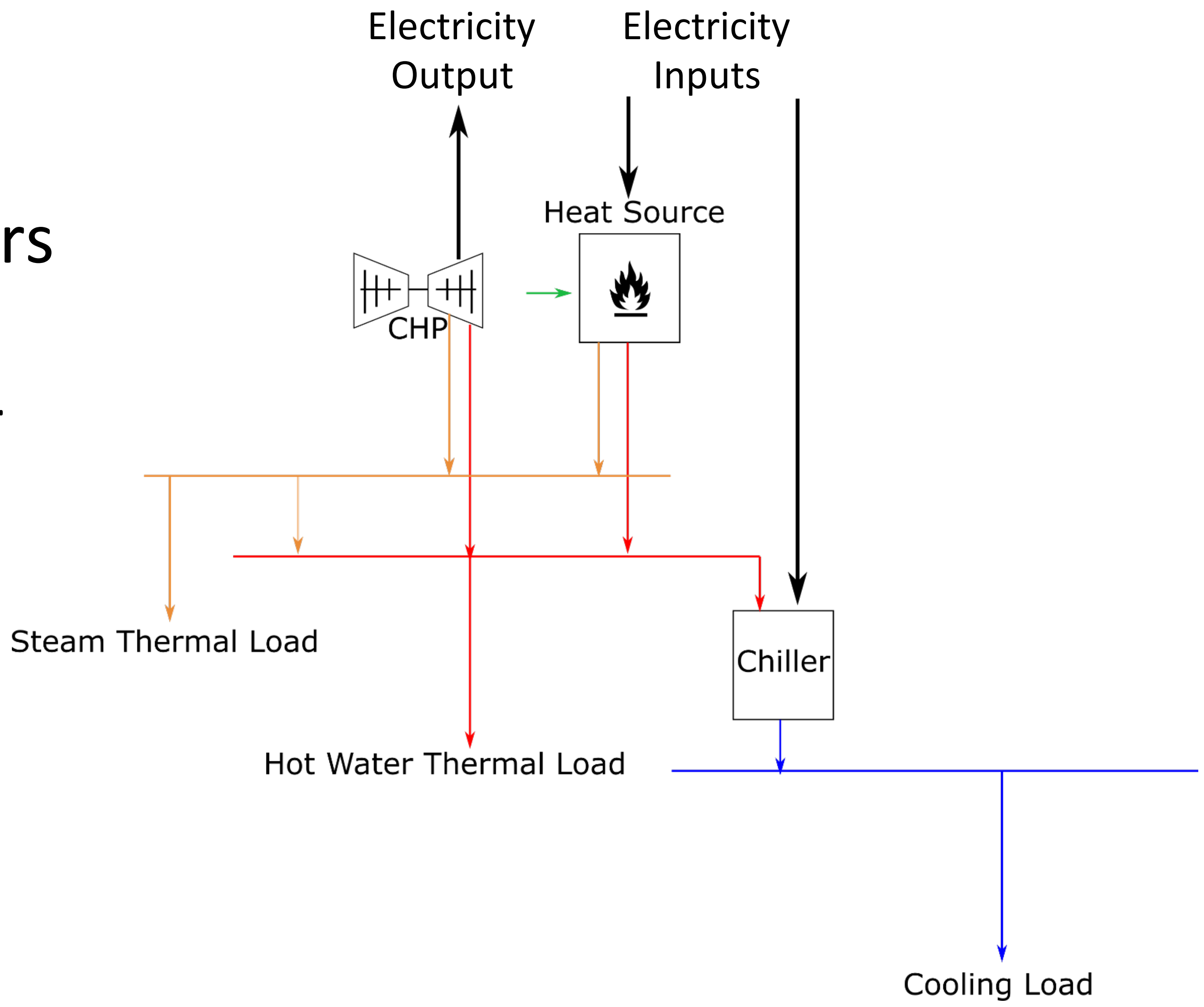
Boilers

- Convert electricity or natural gas into steam or hot water in any ratio
- Can be used in tandem with CHP or on its own to serve heating loads



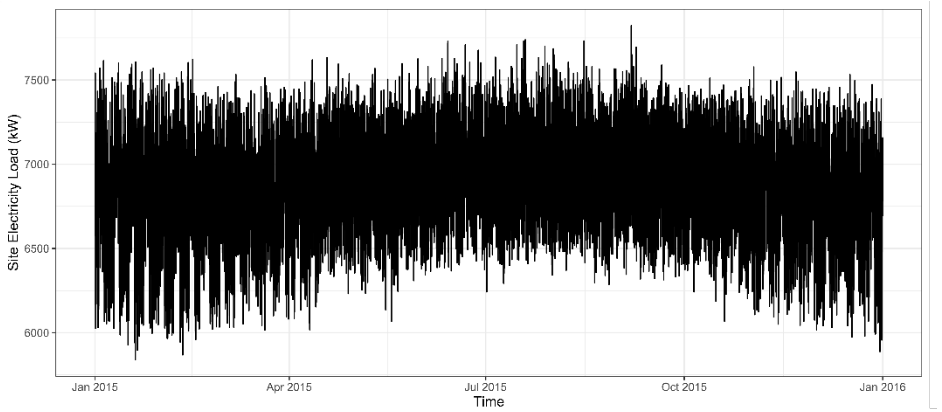
Chillers

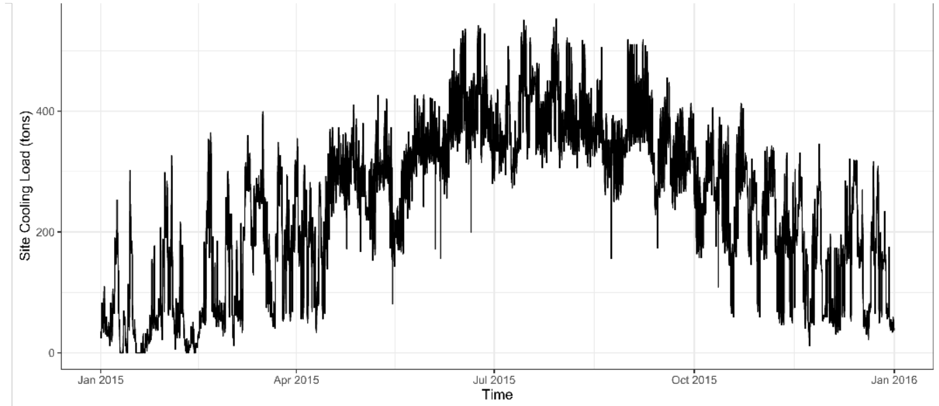
- Converts electricity, natural gas, or heat from CHP/boilers to cooling
- Only technology in DER-VET that can serve cooling loads

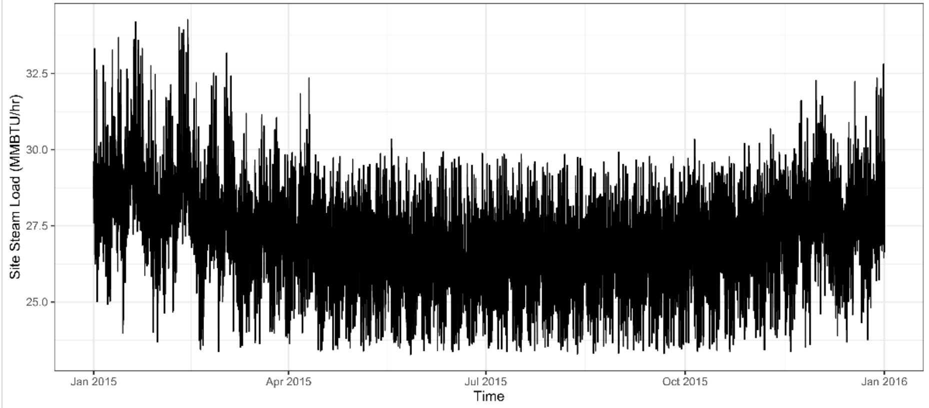


Example

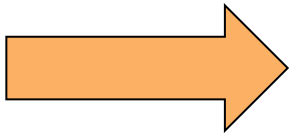
- Industrial site with
  - ~7.8 MW peak electric load
  - ~550 ton peak cooling load
  - ~34 MMBTU/hr peak steam load
  - No hot water load







For visual comparison, I converted all units to kW. DER-VET accepts tons of cooling and MMBTU/hr of heating as thermal input units.



CHP Specifications

- Size is specified in maximum kW of electricity generation
- Heat rate is specified in MMBTU of fuel per MWh of electricity generated
- Large max steam ratio for no HW generation
- Variable O&M + fuel costs determine if CHP runs

43	CHP	1	name	CHP	N/A	
44	CHP	1	rated_capacity	5800	kW/generator	[0, rated_capacity)
49	CHP	1	electric_heat_ratio	1	unitless	[0, inf)
50	CHP	1	heat_rate	4	MMBtu/MWh	[0, inf)
52	CHP	1	max_steam_ratio	1000000	ratio	(0, 1]
56	CHP	1	variable_om_cost	0	$/kWh	[0, variable_om_cost)
57	CHP	1	fixed_om_cost	0	$/yr	[0, fixed_om_cost)
58	CHP	1	ccost_kW	0	$/kW-generator	[0, ccost_kW)
59	CHP	1	ccost	0	$/generator	[0, ccost)
72	CHP	1	fuel_type	gas		{liquid,gas,other}

Chiller Specifications

- Capacity specified in tons
- Power source can be heat, electricity, or natural gas
- COP depends on the kind of chiller

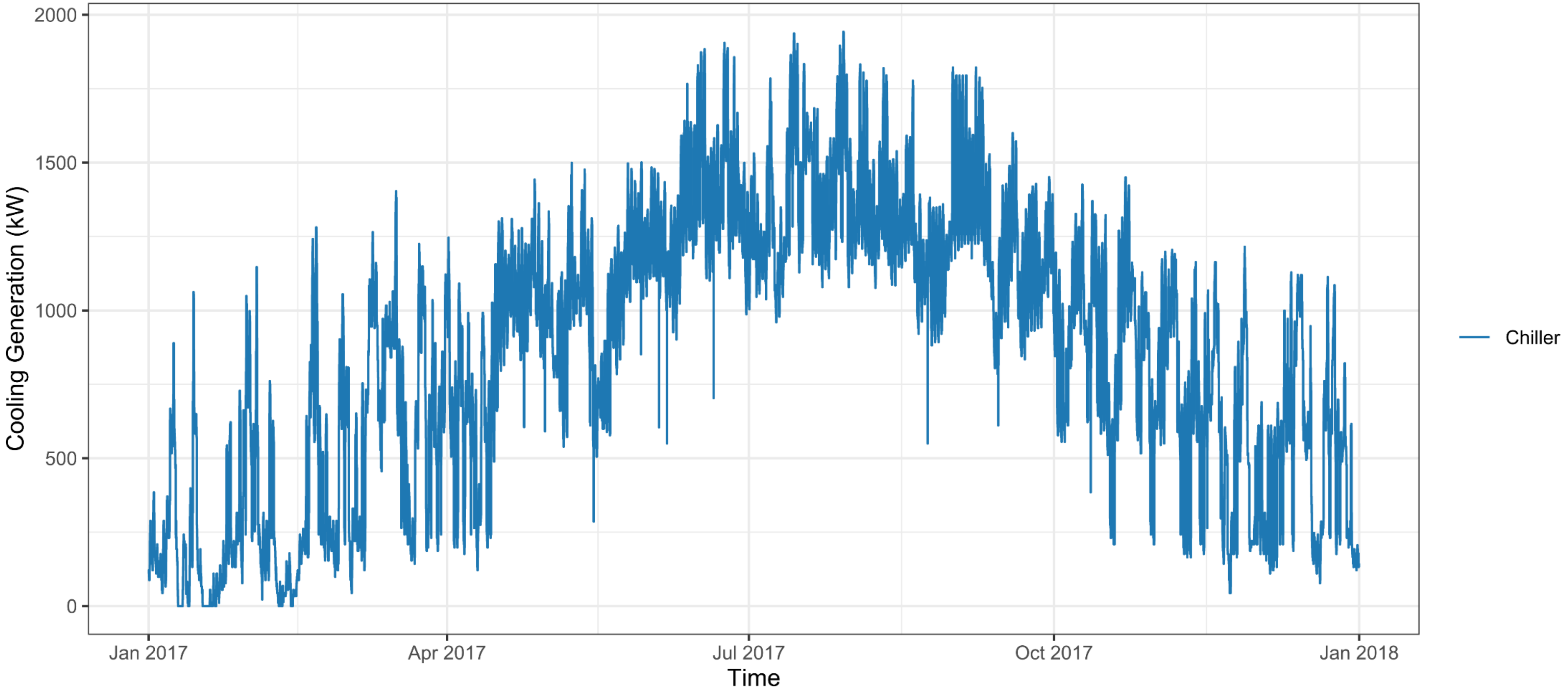
76	Chiller	1	name	Chiller	N/A	
77	Chiller	1	rated_capacity	600	tons/chiller	[0, rated_capacity)
81	Chiller	1	power_source	natural gas	N/A	{electricity,natural gas,heat}
82	Chiller	1	coefficient_of_performance	0.7	ratio	[0, cop)
83	Chiller	1	fixed_om_cost	0	$/yr	[0, fixed_om_cost)

Boiler Specifications

- Capacity specified in MMBTU/hr
- Power source can be either electricity or natural gas

98	Boiler	1	name	Boiler		N/A	
99	Boiler	1	rated_capacity		20	MMBtu/boiler	[0, rated_capacity)
103	Boiler	1	power_source	electricity		N/A	{electricity,natural gas}
104	Boiler	1	coefficient_of_performance		0.95	ratio	[0, cop)
105	Boiler	1	fixed_om_cost		0	$/yr	[0, fixed_om_cost)
106	Boiler	1	ccost_MMBtu		0	$/MMBtu-boiler	[0, ccost_MMBtu)
107	Boiler	1	ccost		0	$/boiler	[0, ccost)

Results



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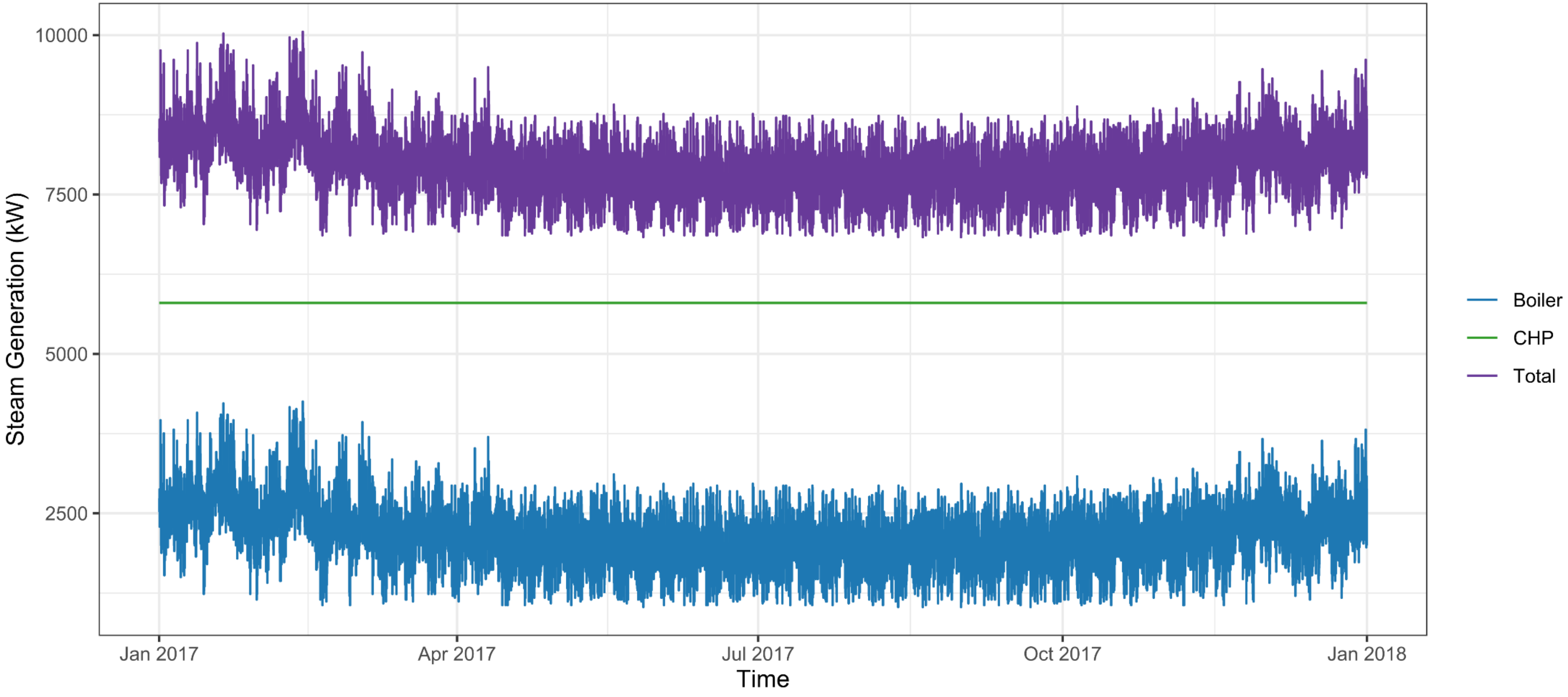
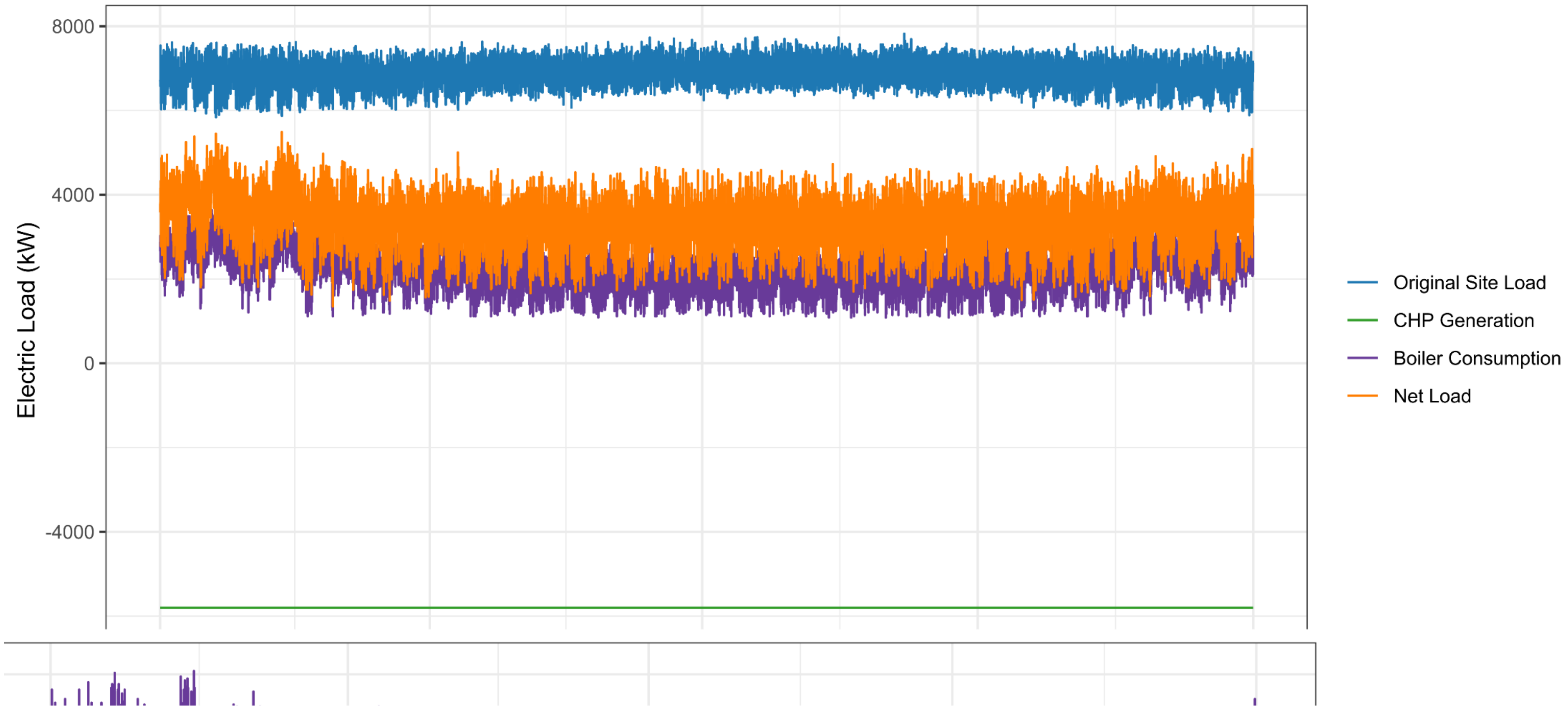
Results



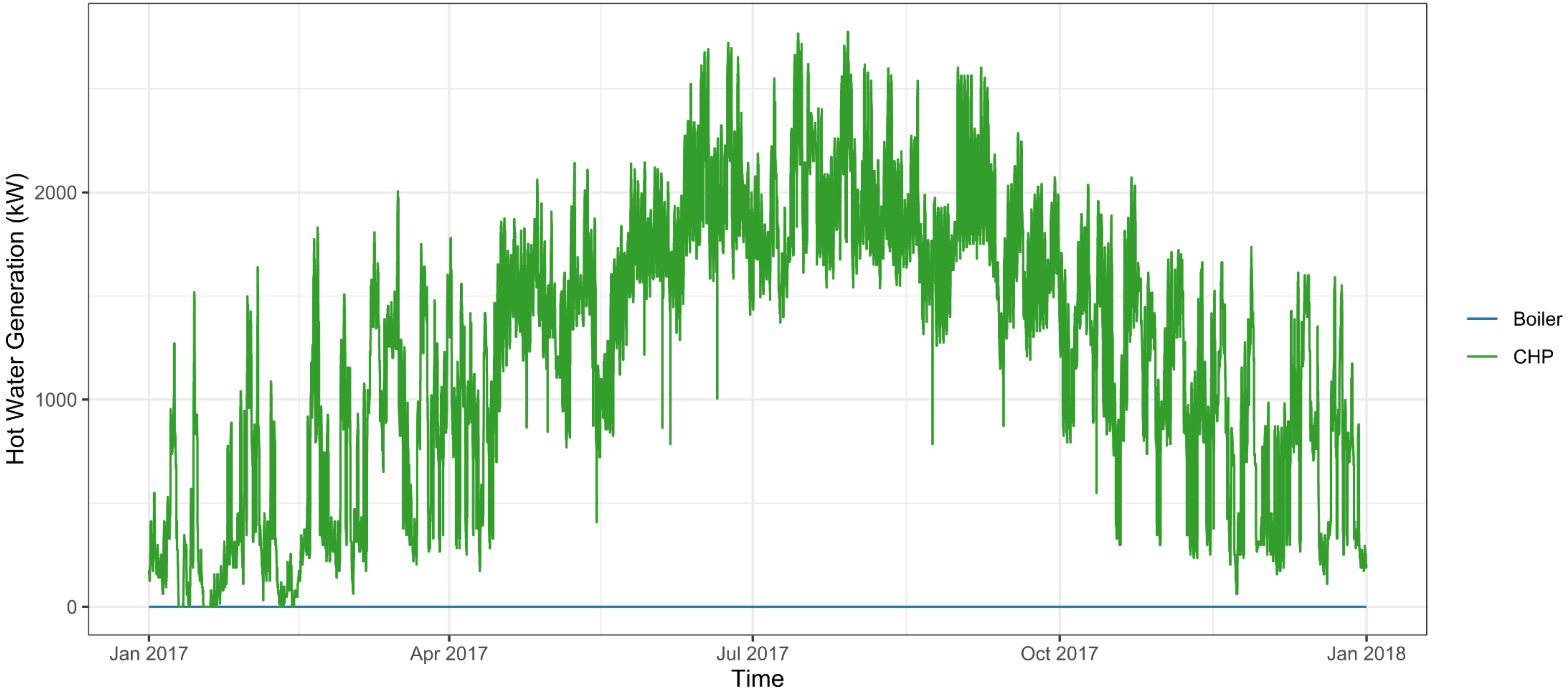
Steam Generation (kW)
10000
7500
5000
2500
Jan 2017
Apr 2017
Jul 2017
Oct 2017
Jan 2018
Time
Boiler
CHP
Total

Results



8000
4000
0
-4000
Electric Load (kW)
Original Site Load
CHP Generation
Boiler Consumption
Net Load

Now, power the chiller with heat



Next Meeting Jan 6, 2022
11 AM Pacific Time

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