UIUC Data Report

Summary of Data for the University of Illinois

Prepared for:
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Funding Acknowledgement

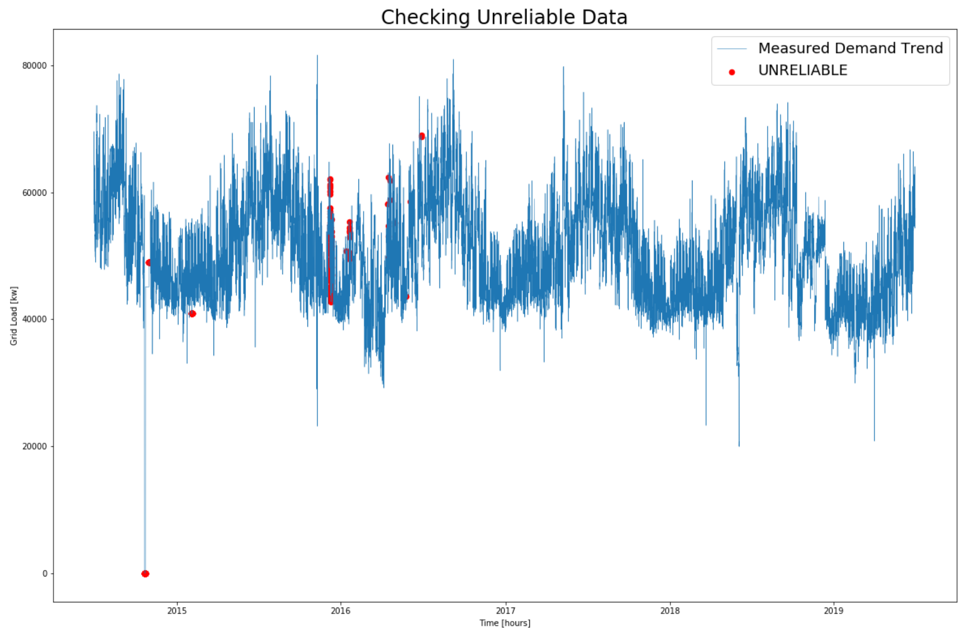

Figure 1: Some of the campus data has been flagged as unreliable. This usually caused by instrument failure.

1 Task 1.1: Data Mining and Interface

The University of Illinois at Urbana-Champaign (UIUC) has a vast amount of data that can be used to understand patterns and trends at a deep level. Table 1 summarizes all of the data the NEUP team can access. Before the data from UIUC Facilities and Services (F&S) can be used, it must be checked for data flagged as "unreliable" or otherwise incorrect values. The first step in this data processing is shown in Figure 1 This data has been mined and processed to obtain some interesting relationships. We've also found some interesting *absent* relationships. Figure 3 shows two significant peaks in the temperature frequency curve, and several significant peaks in the demand frequency curve. These peaks indicate *seasonalities* for each set of data. The peaks at 1 and 365 indicate yearly and daily trends, respectively. However, campus demand exhibits trends that temperature does not, such as weekly variation due to low demand on weekends. For this reason, the yearly trends for demand and temperature are highly correlated, with a Pearson correlation of $r = 0.97$, while the daily trends have a much lower correlation of $r = 0.69$. Figure 2 shows this correlation and a

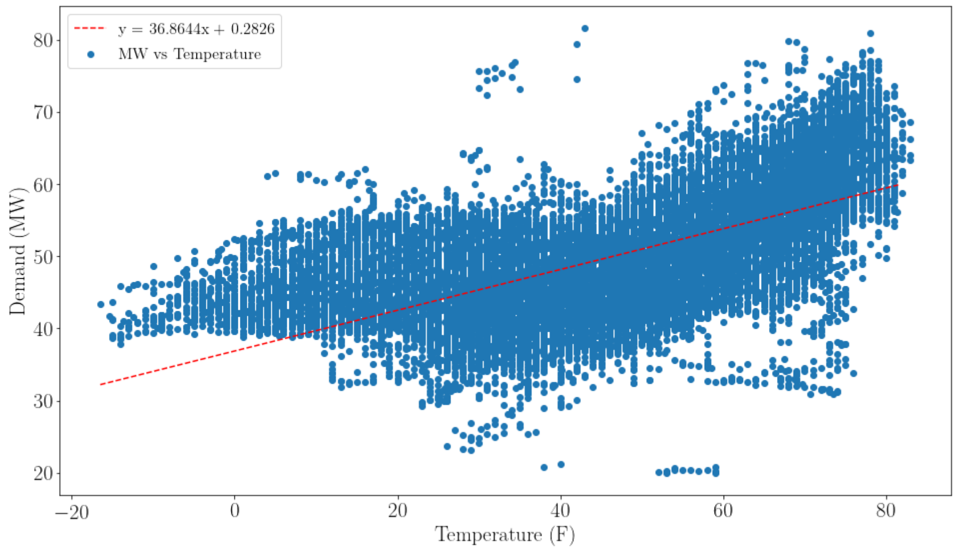

Figure 2: The correlation and best fit line for campus demand and wet bulb temperature.

polynomial characteristic function that fits the data. This line give a simple first order relationship that allows us to guess a demand based on the temperature. Figure 4 shows the yearly trends for electricity demand and air temperature on campus.

1.1 Characterization: Typical Years

The energy system has been further characterized by determining *typical years* on campus. These typical years were generated by identifying the typical month – "typical" is defined as the closest to a mean value – for each month of the year and combining them to form a typical year. This task was performed using the `RAVEN` tool from INL. Figure 5 shows the typical year of steam, Figure 6 shows the typical year of electricity demand, Figure 7 shows the typical year of wind power delivered to UIUC, and Figure 8 shows the typical year of solar power delivered to the campus. These typical years are useful for generating synthetic data, also with the `RAVEN` tool, that can be used for energy system optimization with `Modelica` [1, 2]. Figure 9 demonstrates this capability.

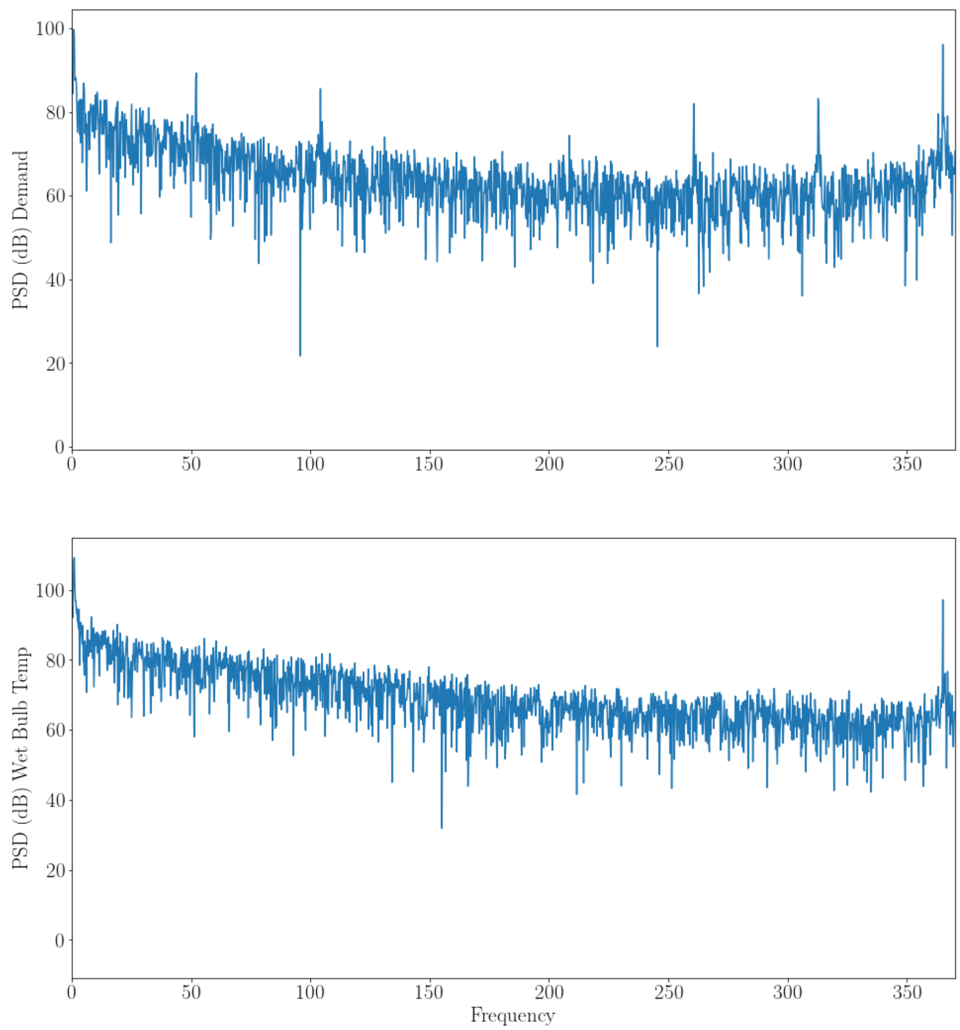

Figure 3: Show the frequency peaks after taking the Fourier transform of data.

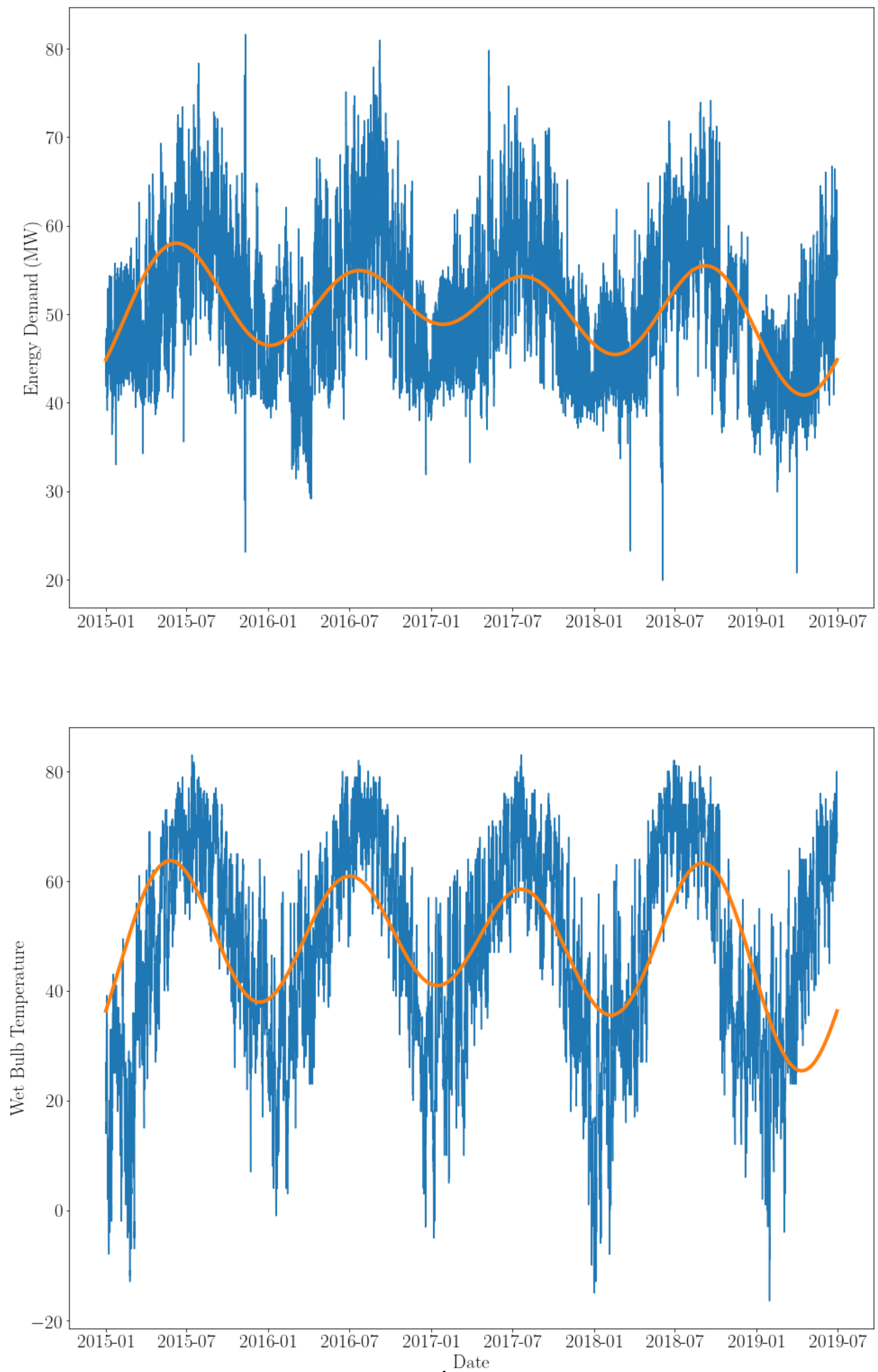

Figure 4: Show the yearly trends for demand and temperature on campus.

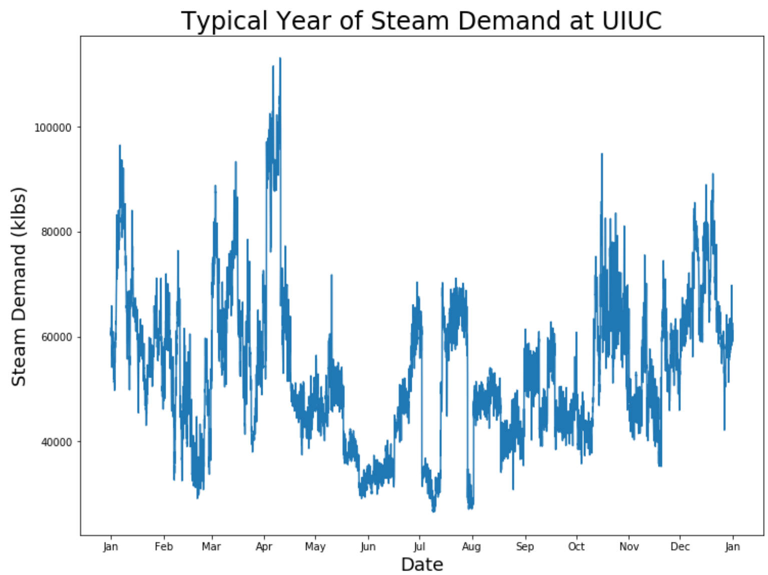

Figure 5: A typical year of hourly steam demand on the UIUC campus

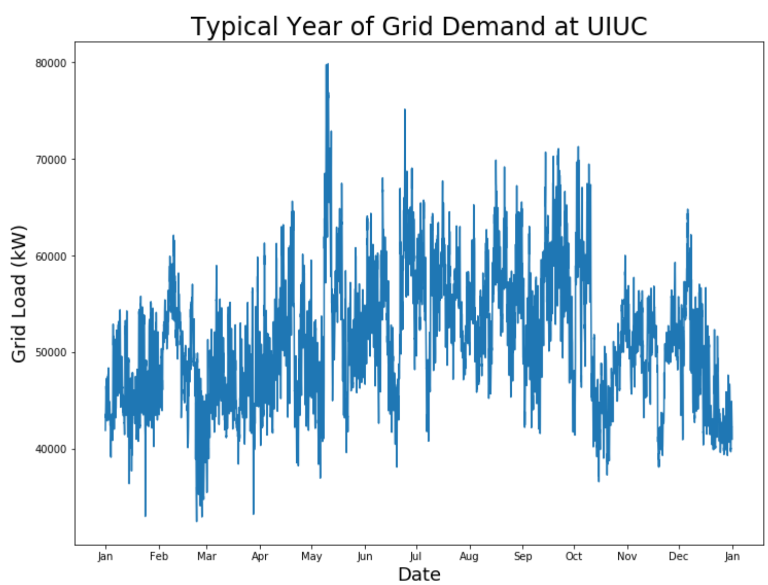

Figure 6: A typical year of hourly electricity demand on the UIUC campus

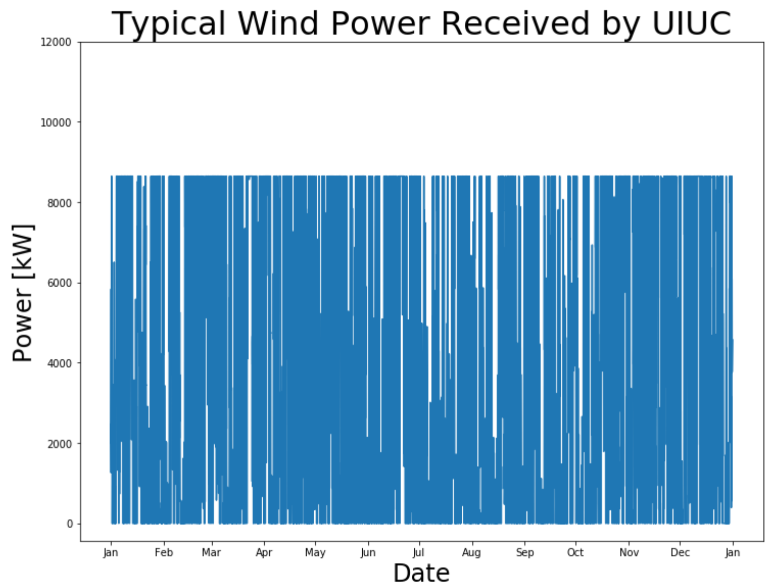

Figure 7: A typical year of hourly wind energy supplied to the UIUC campus

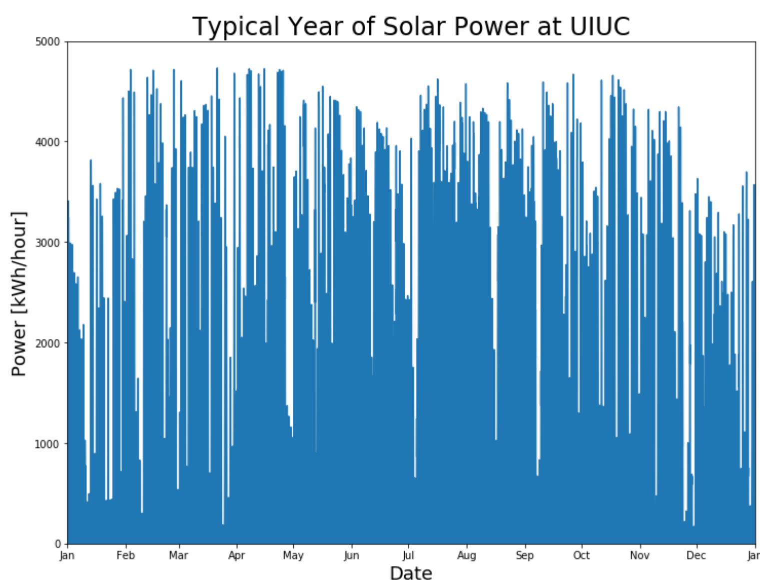

Figure 8: A typical year of hourly solar energy supplied to the UIUC campus

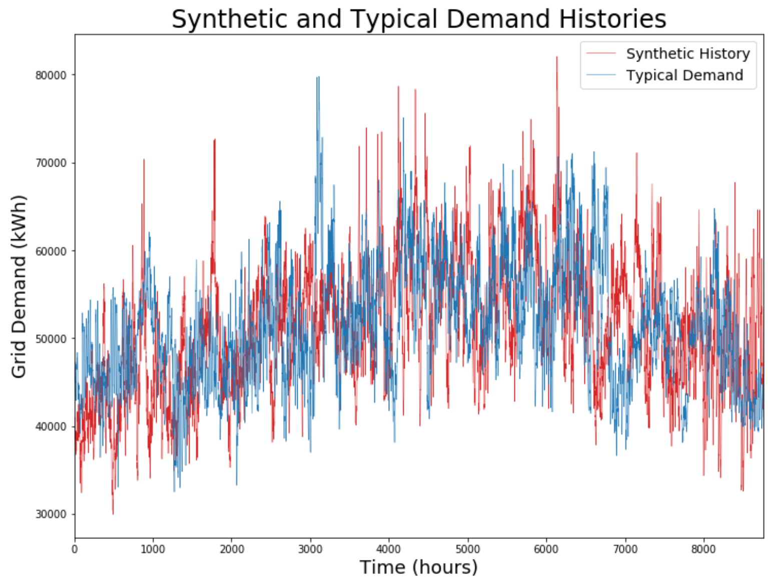

Figure 9: A typical year of hourly electricity demand on the UIUC campus

1.2 Other Data

There is more to the UIUC campus energy system than steam and electricity. UIUC also has a significant vehicle fleet. Analyzing this data allows us to determine the demand for gasoline equivalent energy on campus. This demand may be replaced by either electric or hydrogen powered vehicles in the future. Figure 10 shows the demand for three different fuel types on the UIUC campus.

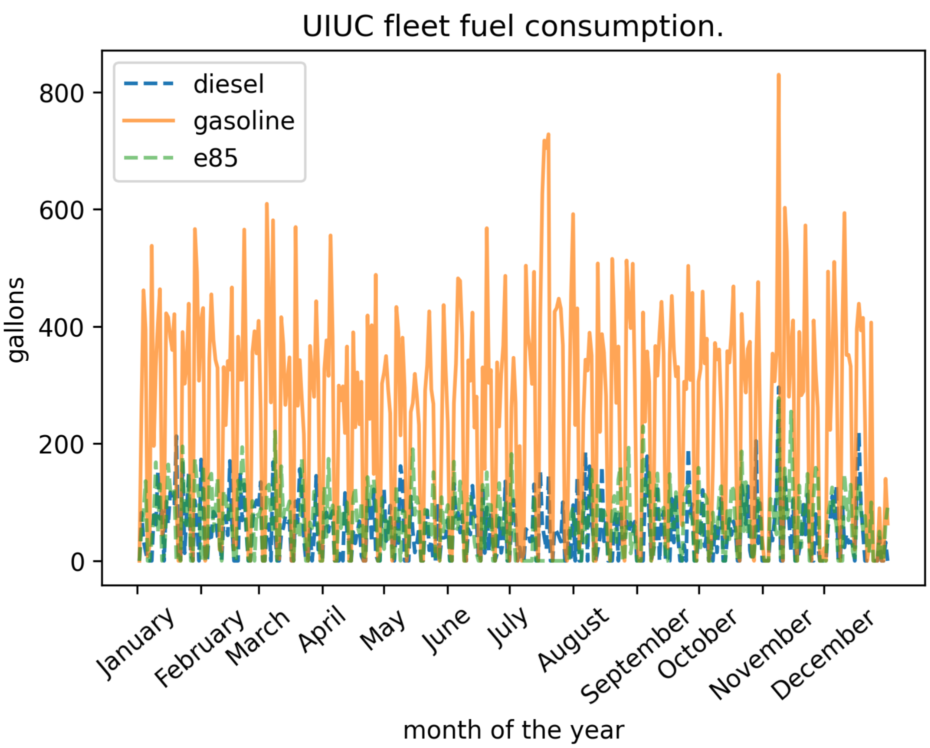

Figure 10: The demand for three types of fuel for one year on the UIUC campus.

Table 1: Summary of Currently Available Data

Data	Resolution	Span	Supply/Demand	Units	Source
Abbott Electricity Generation	Hourly	Fiscal[a] Years [2015, 2019]	Supply	kW	UIUC F&S[c]
Campus Electricity Demand	Hourly	Fiscal Years [2014, 2019]	Demand	kW	UIUC F&S
Wind Energy to Campus	Hourly	Fiscal Years [2016, 2019]	Supply	kW	UIUC F&S
UIUC Solar Farm 1.0	15-minute	Calendar Years (2015, 2019]	Supply	kW	AlsoEnergy [3]
Solar Irradiance	30-minute	Calendar Years [2013, 2018]	[-]	W/m^2	OpenEI [4]
Campus Steam Demand	Hourly	Fiscal Years [2015, 2019]	Supply	Klbs	UIUC F&S
Lincoln Weather Data[b]	Hourly	Calendar Years [2010,2019]	[-]	Varied	NOAA [5]
Champaign Weather Data [b]	Hourly	Calendar Years [2010,2019]	[-]	Varied	NOAA [5]
UIUC Fleet Fuel Demand	Daily	Calendar Year [2019]	Demand	Gallons, Dollars	UIUC F&S
CU-MTD Fuel Demand	Daily	Calendar Year [2019]	Demand	Gallons, Dollars	CU-MTD[c]
Abbott: Low Pressure Steam	Minute	Calendar Year [2019]	Supply	Klbs	UIUC F&S
Abbott: High Pressure Steam	Minute	Calendar Year [2019]	Supply	Klbs	UIUC F&S
Campus Electricity Demand	Minute	Calendar Year [2019]	Demand	kW	UIUC F&S
Chilled Water System	Minute	Calendar Year [2019]	Supply/Demand	Tons	UIUC F&S
Thermal Energy Storage	Minute	Calendar Year [2019]	Storage	Tons	UIUC F&S
UIUC Solar Farm	Minute	Calendar Year [2019]	Supply	kW	UIUC F&S
UIUC Total Natural Gas	Minute	Calendar Year [2019]	Demand	BTU	UIUC F&S
Bluewaters Supercomputer	Hourly	Fiscal Years [2014,2018]	Demand	kW	UIUC F&S

(a) The UIUC fiscal year runs from August 1 to July 31

(b) See Table 2 for further breakdown of weather data.

(c) This data is proprietary *unsure about citation*.

Table 2: Description of available weather data

Variable	Units
Dry Bulb Temp	$^\circ$F
Wet Bulb Temp	$^\circ$F
Precipitation	inches
Relative Humididty	%
Wind Direction	$^\circ$
Wind Speed	m/s
Station Pressure	in. Hg

References

[1] Aaron Epiney, Cristian Rabiti, Andrea Alfonsi, Paul Talbot, and Francesco Ganda. Report on the economic optimization of a demonstration case for a static n-r HES configuration using RAVEN.

[2] T. E. Baker, A. S. Epiney, C. Rabiti, and E. Shittu. Optimal sizing of flexible nuclear hybrid energy system components considering wind volatility. 212:498–508.

[3] AlsoEnergy. University of illinois solar farm dashboard. http://go.illinois.edu/solar.

[4] Manajit Sengupta, Yu Xie, Anthony Lopez, Aron Habte, Galen Maclaurin, and James Shelby. The national solar radiation data base (NSRDB). 89:51–60.

[5] Climate data online (CDO) - the national climatic data center's (NCDC) climate data online (CDO) provides free access to NCDC's archive of historical weather and climate data in addition to station history information. | national climatic data center (NCDC).