# TEAM PROJECT NO. 1
## Due October 27, 2020

NREL's Commercial Building Research Group, spearheaded by Senior Engineer Shanti Pless, has been involved in modeling and designing a multi-unit development of all-electric factory-built modular apartments, called iUnits. Elliot Flats is a 40-unit rental community in the heart of the popular lower highlands neighborhood in Denver, Colorado and the first of several planned modular developments using the iUnit concept. The building features 30 modular studios and 10 one-bedroom iUnits, offering walkability to restaurants, bars, running and biking trails, public transit and easily accessible via bike or bus to downtown Denver, light rail and other community amenities. More information and images of the development can be found at http://iunit.co and the poster uploaded to Canvas.

The single largest electric load in these all-electric apartments are the electric water heaters and certain assumptions were made during the modeling process pertaining to the variability of the occupant driven hot water use and resulting hot water heater operation. This project aims at characterizing the variability of the DHW related electricity use among these 40 iUnits in an effort to better understand and describe this dominant electric load to allow for higher fidelity modeling of future multi-family residential buildings and a better understanding of potential electric grid impacts.

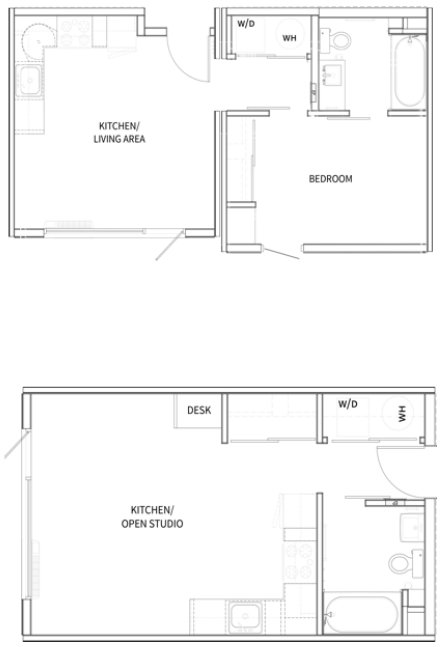


Figure 1: iUnit Floor Plans

Uploaded to Canvas is a set of large monthly CSV files of time series data representing a total of one year of minute-by-minute data for total electric use for each of the 40 all-electric apartments. Each apartment is equipped with very similar equipment, including hot water tank, AC/heat, and appliances. The data also includes common area loads (hallway AC and lighting, elevators, telecom room internet switches, etc.) and a 14 kW PV system. The last few columns include one of the 40 apartment's end uses separately metered, allowing you to characterize the water heater temporal signatures.

1. You are to first conduct an exploratory analysis using the R tool chain we have adopted (R, RStudio, R Markdown, ggplot2, …) of the hot water electricity use across the 40 apartments to characterize the variability of electricity use for hot water purposes using common representations such as carpet plots and time series box plots and to eventually develop a model of hot water related electricity use as a function of time of day and day type. Please be aware that this is data from real buildings with potential quality issues including missing data and outliers; thus, proper data quality check as described in the "Cleaning Data in R" is recommended.

2. Based on the DHW heater characteristics gleaned from the one submetered apartment, develop rules and methods to extract the roughly 3.5 kW DHW events from the other apartments, which are not submetered. You should yield a minute-by-minute time series of binary DHW activity. From that you know the electricity consumed for hot water for every minute, hour, and day, allowing you aggregate across multiple time scales. Please note that you can convert electricity use for DHW into gallons or liters of DHW by assuming a reasonable mains water temperature (10-12°C) and tank temperature (50-55°C).
3. A background report (https://www.nrel.gov/docs/fy10osti/47685.pdf) describes the modeling approach adopted in BEopt. Read the 11-page report in order to understand the BEopt DHW input schedule assumptions used below.
4. You are to compare the variability in DHW electricity use observed in a) the BEopt model adopted for the iUnit project (https://beopt.nrel.gov, iUnit model provided on D2L) with b) the measured iUnit Eliot development data. The BEopt model includes hourly output for the as-built model (1_Hourly.csv) and the 15-minute hot water schedules (DHW_1bed_unit0_15min*.csv) used by BEopt for estimating draw variability across the apartments.

A few notes about the data:

- For anonymity, the apartment units have been renamed with random numbers (e.g., "UnitAnon01") that are different from the original numbers, such that there is no correlation between the BEopt naming and the measured data file.
- The column labeled "Common.Use.kW" is for other building loads that are not associated with specific units.
- The column called "UnitAnon21. kW" has different values than the column called "UnitAnon21.Total.kW". These appear to be measurements from different sets of current transformers, but we would need more installation details to confirm.
- Monitored PV data are not available prior to midday Feb. 15, 2017.
- Aside from minor formatting (e.g., headers, timestamps), the data is close to raw.

Your analysis will directly aid in NREL and the Commercial Building Research Group making more realistic design decisions in the future. This team project will be conducted in teams of two or three members.