# Distributed Climate Control (DCC) - Project Summary

By Team **Slam Town**
Dan Coen
Conor Sheridan

**Overview**: Welcome to the Distributed Climate Control (DCC) project. This system will help businesses, homeowners, and other institutions save money on energy spending by dramatically reducing the amount of heating and cooling spent on air space that no one is occupying, as well as contributing to global efforts to create affordable, sustainable energy technologies. Our project specifically aims to provide information specifying how many people are in a room, and where they are situated. This information will be used by a HVAC system which can target specific regions of a room. This project is inspired by the ARPA-E's research and funding of advanced energy systems.

**Intellectual Merit**: This Small Business Innovation Research Phase I project will have to effectively use a variety of sensors to obtain features to train an accurate machine learning model. The device will combine thermal, color, and depth imaging to track where in a room people are, and specifically how many people occupy certain areas so that an HVAC device could heat or cool only regions of the room occupied by people. The sensors used will be a flir lepton thermal camera and a kinect v2 RGB-D camera. Significant challenges of this problem include accurately calibrating the system in the room despite not having a long-range depth sensor, and making the system portable so that it can be placed at a high vantage point and out of the way from any of the activity in the room. Additionally, the device should be able to communicate to a separate, more powerful machine which can help with additional processing including training the headcount and distribution model. Due to the small field-of-view of the thermal camera and the need to combine the images of multiple sensors, the kinect and flir lepton thermal camera will have to pan and tilt to capture a full image of the room, requiring strong and accurate motor control to capture a point in time accurately in a short time frame.

**Broader/Commercial Impact**: This project will demonstrate a new method of saving energy in a way that is attractive to businesses and homeowners. The non-intrusive nature of our device combined with the amount of money to be saved by consumers makes a strong argument for the DCC's success on the market, and furthers research of sustainable and forward-thinking energy technologies. Additionally, the DCC will explore the ability to create a device with currently obtainable and affordable technology, strengthening the meaningfulness of an effective prototype.

**Distributed Climate Control (DCC) - Elevator Pitch**

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Heating, ventilation, and air conditioning make up 48% of the energy used in a typical U.S. home. HVAC makes up the largest energy expenditure of households, as well as many typical businesses. However, a great portion of HVAC resources are spent in locations where people don't even occupy, repeatedly heating and cooling air surrounding nothing. This is waste of money, and energy which could easily be solved by our product: The Distributed Climate Control system.

DCC is an embedded solution to today's HVAC problems. By using an assortment of sensors and S.O.C.'s, we have designed an inexpensive, accurate way to determine the number of people occupying a room, where they are situated, and how comfortable the air temperature surrounding them is. Using this data, HVAC systems will be able to target locations of a room where people exist and are situated in uncomfortable climates. This data will be collected real time, so that people entering and leaving the room will instantly allow the systems to know when to start and stop.

Our implementation involves using a Kinect RGB-D sensor to capture rigidbodies in the room as well as high resolution images. This data will be combined with a heatmap captured by the flir lepton 3 thermal camera in order to train a machine learning model which can be calibrated to work with variable sized rooms and large groups of people. The thermal camera will also be able to determine the relative temperature in room locations, meaning that the HVAC system can further save energy and money by shutting off if a well-populated region is already sufficiently cooled. Both camera modules will be mounted on top of a single automated pan and tilt bracket driven by servo motors, allowing the two sensor modules to synchronize their data easily and accurately.

There are several main problems that need to be solved in order for our system to have full functionality. One of these is training a machine learning algorithm to interpret our data and produce accurate information on population and heat distribution in a room. It is likely most of the training done for our machine learning model will be done by hand via counting the amount of people in the room and telling our algorithm the correct answer, or by having to build our own some type of program to assist us in training the model; in either case this requires a significant amount of time. Other problems that arise with this are data storage and getting real-time results. In order to train our algorithm and process all of the different types of data we are getting, we will need to be able to store large amounts of data. We will need to figure out the best way of storing/streaming our data to simplify this process. Obtaining results in real-time is also a large problem that we may run into. Since we are doing our processing on the UP Board, it could prove difficult to get our information routinely and reduce latency.