Sustainability Decathlon - HVAC and Thermal Storage for a Sustainable Accessory Dwelling Unit

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Introduction|

The costs of living in California are gradually rising, putting the lower income demographics at risk of foreclosures. California alone is responsible for roughly 28% of the homeless population in the United States and over the course of a decade from 2010 to 2020 this population has risen roughly 30% to 161,000 impoverished people (1).

Figure 1 -Detached Accessory Dwelling Unit

Solution| Accessory Dwelling Units **(Figure 1)** (ADUs) are becoming increasingly popular in low-income neighborhoods to provide smaller scale housing at a cheaper price.

Objective|

The University of California Irvine is partnering with Orange Coast College as part of the Orange County Sustainability Decathlon to design a detached Accessory Dwelling Unit for a Placentia, CA neighborhood. Mechanical engineers are needed to research and deliver an *affordable* and *efficient* HVAC and Thermal Storage design using commercially available off-the-shelf components.

Key Features of the ADU|

- 4-6 young male occupants
  - Hobbies include cooking and exercising
- ~750 square foot
- Crawl space beneath house
- 2 bedrooms, 2 bathrooms (see **Figure 2**)

References

(1) *United States Interagency Council on Homelessness (USICH)*, https://www.usich.gov/.
(2) *OC Sustainability Decathlon*, 27 July 2022, https://ocsd23.com/.

Figure 2 - ADU Floor Plan

Heating and Air Conditioning|

1 Major Component (see **Figure 6**)

- **LG Ceiling Cassette 3-Zone System**
  - SEER: 22.5
  - EER: 13.5
  - HSPF: 11
  - 24000 BTU

ADU requires a 4300 Btu/hr load requirement, which is smaller than all commercially available units we researched. This LG unit was the closest we could get the minimum requirement, system is oversized currently and will need further research.
Indoor Unit Sizes: 7k, 7k, 9k Btu
Outdoor Unit Size: 24,000 Btu

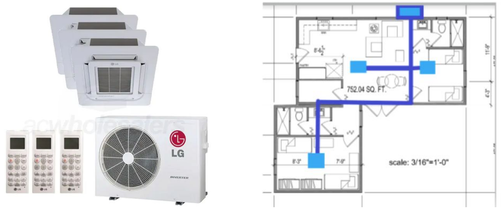

Figure 6 - Heating Cooling Schematic
(Left))-LG Ceiling Cassettes 3-Zone System
(Right)-3 Zone locations with ADU floor plan

Thermal Storage|

3 Major Components

- **Arctica 2000 Series**
  - 5,900 BTU/hr Output
  - 70 - 100 CFM Range
  - Wall mounted on southern facing wall(Angle is determined by Latitude)
- **110 Gallon Thermal Storage Tank**
  - Use Paraffin wax to hold the heat collected from solar air heater
  - Serpentine ducts inside will run air through paraffin wax and transfer heat
- **Flow Rate Damper Valve Ducts**
  - Direct flow from main ventilation supply line through paraffin wax when heating is required

Ventilation Design|

3 Major Components (see **Figure 4**)

- **Panasonic Intelli-Balance 100 ERV**
  - Balanced Energy Recovery Ventilation
  - 50 - 100 CFM Range w/ Boost Function
  - Ceiling Mounted inside Crawl Space
- **BOSCH 300 Series 30" Pyramid Canopy Kitchen Chimney Hood with Chimney Extension**
  - Maximum 300 CFM
  - 3 Speed Push Button Control
- **ATMOX 72 CFM Crawl Space Exhaust Fan**
  - Mechanical Exhaust Fan and *Polyethylene vapor retarder* sheeting needed to satisfy crawl space ventilation codes

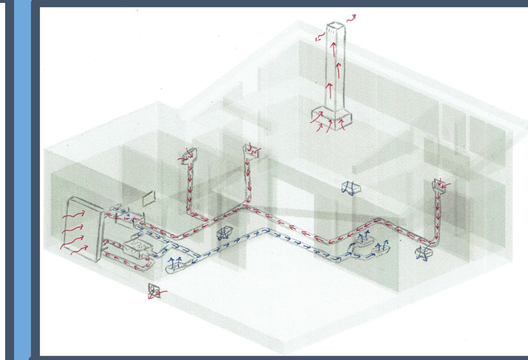

Figure 3 - Ventilation Schematic w/ Thermal Storage
Red Arrows = Exhaust Air
Blue Arrows = Supply Air

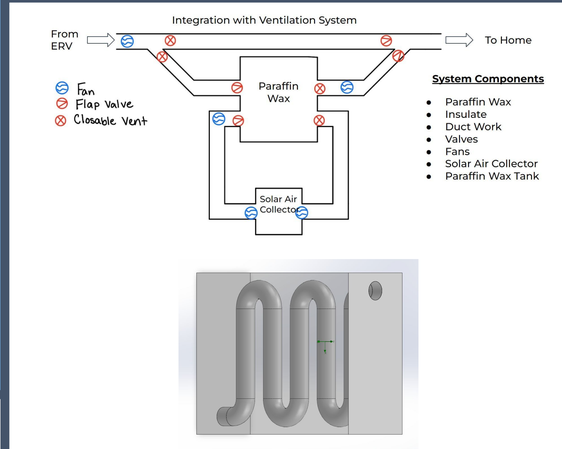

Figure 5 - Thermal Storage Schematics
(Top)-Thermal Storage Integration with Ventilation
(Bottom)-CAD Model of Ductwork in Paraffin Tank

Figure 4 - Major Ventilation Components:
(Left) Panasonic Intelli-Balance 100 ERV, (Middle) BOSCH 300 Series Kitchen Range Hood, (Right) ATMOX 72 CFM Fan

Team Contribution|

We are one of the first engineering groups to perform research into the internal mechanical systems for this ADU along with two other subteams working with domestic hot water and efficient water usage.

Future Improvements|

- Finding a central control system that uses sensors to display IAQ statuses of each room
- Thermal flow analysis with Paraffin Wax

Societal Impact|

This project is part of a larger effort to combat homelessness and climate change around the world by using practical engineering design processes and analysis.