Project 4 Description:

Red Feather Thermal Energy for Homes

Team Members:
Edwin Beraud
Will Legrand
Jake Shaw
Jeff Macauley

Client: Mark Hall

Project Description

- Create a sustainable heating solution for homes on the Navajo and Hopi reservations
- Current heating systems are inefficient and dangerous for residents
- Electricity and natural gas is not available to most people on the reservation
- Red Feather Development Group

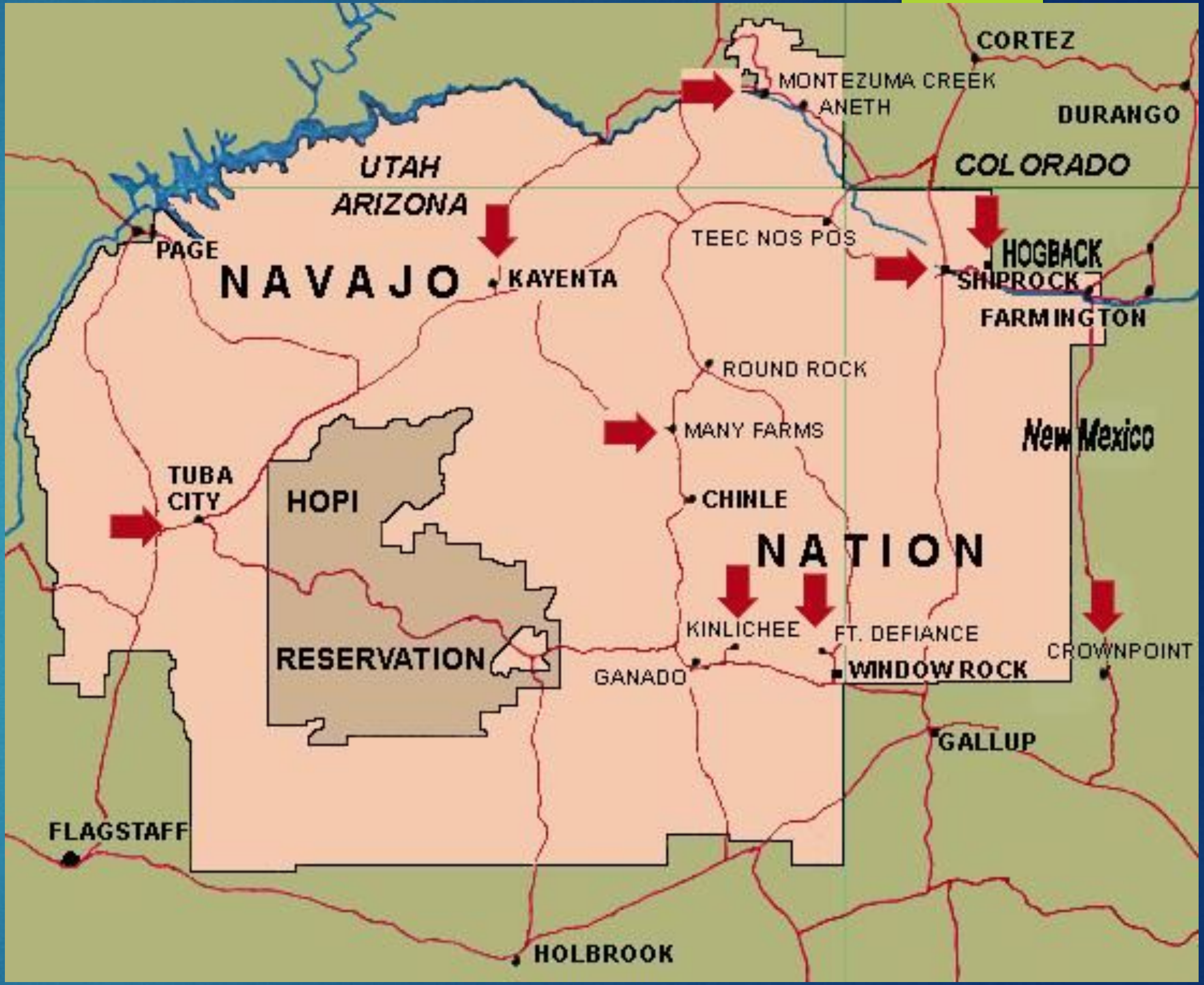


Figure 1: Navajo and Hopi Reservations [23]

Background and Benchmarking

Shingle Roofs vs PV-PCM Roofs

Installation of Shingle Roof vs PV-PCM Roof [8],[29]

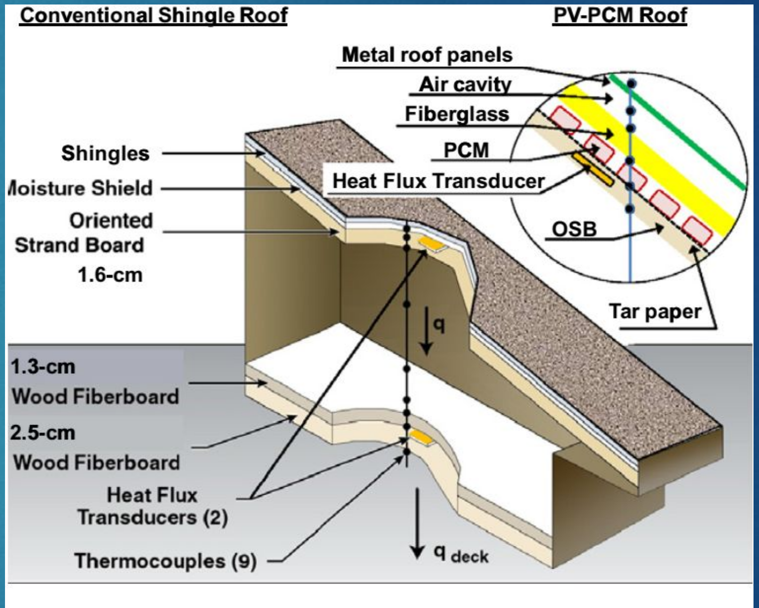


Fig. 2. Construction details of tested roofs.

Installation of Shingle Roof vs PV-PCM Roof [29]

Background and Benchmarking

Solar air heater

Figure 2: Ecolaris Solar Furnace [25]

Figure 3: Ecolaris Solar Furnace Operation [25]

Background and Benchmarking

Insulation Types: Fiberglass, Cellulose, Polystyrene, Rockwool, Cotton
Each has a different Thermal Resistance (R) Value to display how quickly heat transfers across it.

Figure 4: Fiberglass Batt Insulation in Roof [26]

Background and Benchmarking

Solar Thermix - Phoenix based company that emphasizes in reducing fossel fuel usage through application of phase change materials, solar furnaces

Figure 5: Solar Thermix Logo [30]

Background and Benchmarking

Figure 6: In-wall radiant heating in a home [27]

- Supplies heat directly to the panels using either electricity or tubing that carries hot water. Highly efficient but expensive to install.

Customer Requirements

- Cannot pose unacceptable health (primarily air quality) or safety (primarily fire) risks to the home occupants or neighbors.
- Must be an improvement from current heating solution (cost savings plus air quality improvement)
- Keeps home at a comfortable temperature in Winter
- Must account for heat loss from home regarding insulation/windows/doors. -Software modeling
- System must be reliable with temperature fluctuations (assuming no cooling requirements)

Engineering Requirements

- Amount of product pollutants produced (10 µg/m3 annually, 30 µg/m3, +/- 5µg/m3)
- Cost of Materials and Installation ($1200, +/- $300)
- Thermal Efficiency (70%, +/- 10%)
- Temperature maintained inside home (72 °F, +/- 3 °F)
- Thermal Resistance Value (R 2.2 m^2*K/W, + 0.3 m^2*K/W)
- Battery Backup System (10 hrs, +/- 2 hrs)
- Extended lifespan (10 years +)

House of Quality and Results

House of Quality (HoQ)									
Customer Requirement	100% Weight	Engineering Requirement	Pollutants Produced (µg NO2,SO2 per KWH)	Cost of Materials and Installation ($)	Thermal Efficiency (%)	Temperature Maintained inside Home (F)	Thermal Resistance Value (R)	Battery Backup System (hrs)	Lifespan
			↓	↓	↑	↑	↑	↑	↑
1.Cannot pose unacceptable health (primarily air quality) or safety (primarily fire) risks to the home occupants or neighbors.	25%		9	3	1	0	0	1	1
2.Must be an improvement from current heating solution (cost savings plus air quality improvement).	30%		1	9	3	0	1	3	0
3.Keeps home at a comfortable temperature in Winter	15%		0	3	9	9	9	1	3
4.Must account for heat loss from home related to insulation/windows/doors.	20%		0	1	9	3	9	0	0
5.System must be reliable with temperature fluctuations (assuming no cooling requirements)	10%		0	1	3	9	3	9	9
Absolute Technical Importance (ATI)			3.55	4.2	4.6	2.85	3.75	2.2	1.6
Relative Technical Importance (RTI)			4	2	1	5	3	6	7
Target ER values			10 µg/m3 - annually 30 µg/m3 - 24hr	$1,200	70%	72 F	R = 2.2 m^2K/W	10 hrs	10 years
Tolerances of Ers			+/- 5 µg/m3	+/- $300	+/- 10%	+/- 3 F	+ 0.3 m^2 K/W	+/- 2 hrs	+/- 1 year
Testing Procedure (TP#)			Air Quality meter	BOM	Themodynamics	Thermometer	Analytical	TBD	Thermal Cycles

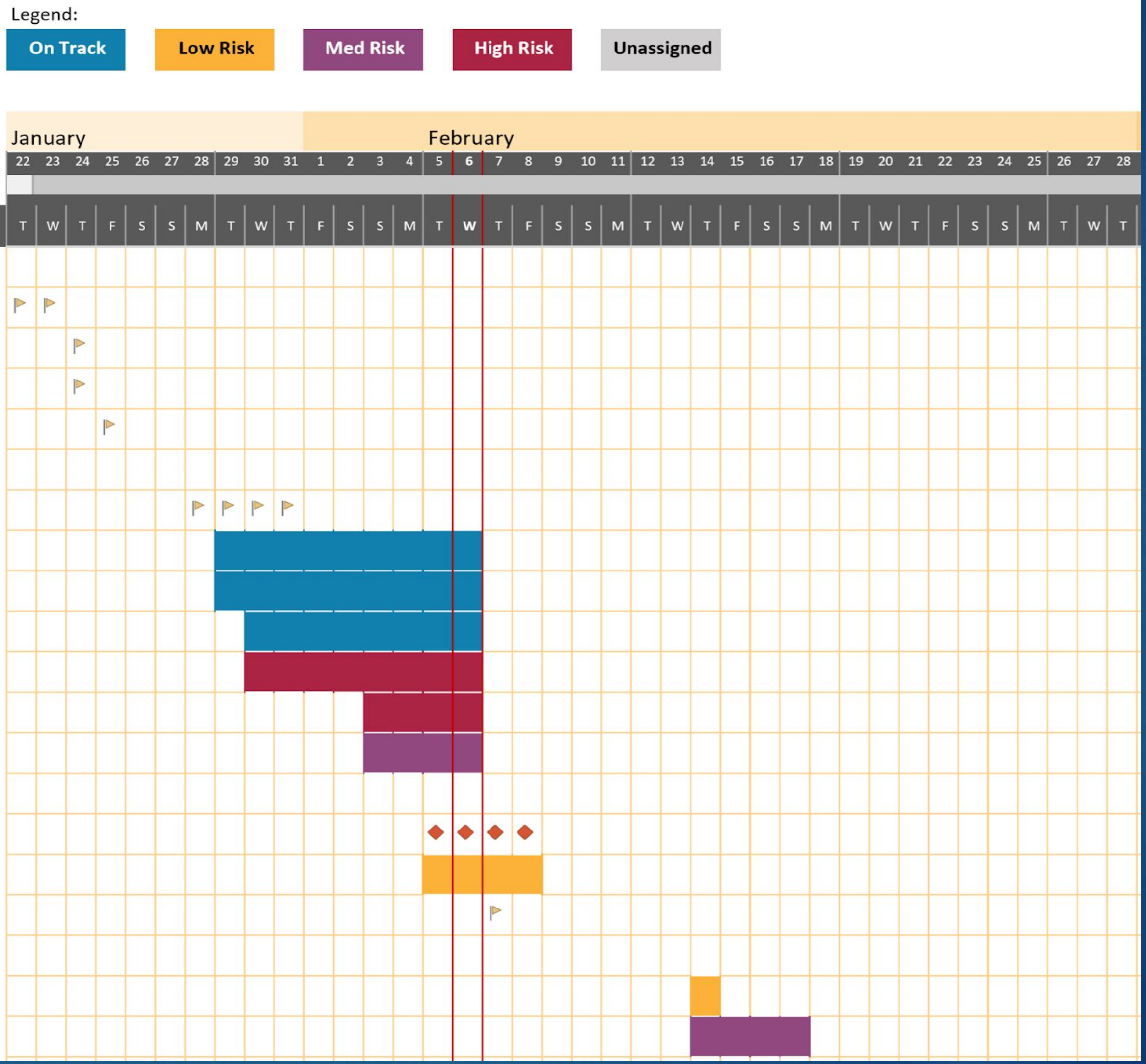
Schedule

PROJECT TITLE **Red Feather**

Project number 4
Project Lead Jeff M.

Project Start Date: 1/22/2019
Scrolling Increment: 0

Milestone Description	Category	Assigned To	Progress	Start	No. Days
Week 1					
5 Sources	Milestone	All	100%	1/22/2019	2
Staff Meeting 1	Milestone	All	100%	1/24/2019	1
Meet the GTA	Milestone	All	100%	1/24/2019	1
Team Charter	Milestone	All	100%	1/25/2019	1
Week 2					
Meet with Client	Milestone	All	100%	1/28/2019	4
Project description	On Track	Jake	100%	1/29/2019	9
5 Bench Marks	On Track	All	90%	1/29/2019	9
20 sources	On Track	All	90%	1/30/2019	8
Customer Reqs.	High Risk	All	100%	1/30/2019	8
QFD	High Risk	Edwin, Jeff, Will	80%	2/3/2019	4
Budget	Med Risk	Jake	40%	2/3/2019	4
Week 3					
Meet with Advisors	Goal	All	0%	2/5/2019	4
Insulation Comaprison	Low Risk	TBD	0%	2/5/2019	4
Presentation	Milestone	All	80%	2/7/2019	1
Week 4					
Team Meeting	Low Risk	TBD	0%	2/14/2019	1
Home Model Simulation	Med Risk	TBD	0%	2/14/2019	4



Budget

- No official budget given for this project
- Our client proposed an upfront cost of $900-$1500 (includes final design and installation costs)
- We hope to gain sponsorship from companies interested in renewable energy
- Total cost for a low-income family, with sponsorship, should be $300 or less

Figure 7: Businesses established in Arizona who are interested in solar energy [28]

Research Materials

Articles

[1] A. Chel and G. Kaushik, "Renewable energy technologies for sustainable development of energy efficient building", 2017. [Online].

[2] S. Enibe, "Thermal analysis of a natural circulation solar air heater with phase change material energy storage", Renewable Energy, vol. 28, no. 14, pp. 2269-2299, 2003.

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[4] L. Cabeza and N. Tay, High-temperature thermal storage systems using phase change materials. London: Elsevier/Academic press.

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[6] Lavinia Gabriela SOCACIU, "Thermal Energy Storage with Phase Change Material," Leonardo Electron. J. Pract. Technol., no. 20, pp. 75–98, 2012.

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[17] B. K. Hodge, *Alternative Energy Systems and Applications*. Second edition. Wiley. 2010.

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[18] J. Scott, A. B. Brush, J. Krumm, B. Meyers, M. Hazas, S. Hodges, and N. Villar, “PreHeat: controlling home heating using occupancy prediction,” Proceedings of the 13th international conference on Ubiquitous computing - UbiComp 11, pp. 281–290, Sep. 2011.

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[20] “Radiant Heating,” *Department of Energy*. [Online].Available: https://www.energy.gov/energysaver/home-heating-systems/radiant-heating.[Accessed: 03-Feb-2019].

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[21] M. J. Moran, H. N. Shapiro, D. D. Boettner, and M. B. Bailey, Fundamentals of engineering thermodynamics, 8th ed. Hoboken, NJ: John Wiley & Sons, Inc., 2018.

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Questions?

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