Executive Summary
The Social Behavioral Sciences (SBS) West building at the Northern Arizona University (NAU) mountain campus is not up to the ventilation code standard for modern buildings and it is inefficient with its annual energy usage, with heating and cooling being a major factor of consumption. The Bio-Inspired Energy Efficiency (BEE) team is to develop an electro-mechanical system to bring SBS West up to ventilation standards and reduce its energy consumption through analyzing the natural world. The team will use a pre-existing Solar Ventilation design developed by members of the team to implement into SBS West. The design will be paired with the current HVAC system to improve efficiency of the system as a whole, along with fulfilling the ventilation standards. The system involves using adjustable vents and solar panels to generate electricity using natural air and the sun. For ventilation, the system utilizes motors and/or temperature dependant components to expand and contract the panel based on the ambient temperature and the temperature inside of the building. The outcome of the system is to ease the use of the current HVAC system, generate addition electricity to aid the current system and bring the building up to current ventilation standards. Additionally, the ventilation and solar array will ease the cost of the system's implementation. The process of determining this final design includes preliminary research, project management, understanding the issue presented, concept generation, analytical calculation, cost analysis, resolving potential ethical issues, prototyping and future work.

To: Jonathan Heitzinger
From: Bio-Inspired Energy Efficiency (BEE)
Date: 10/07/2018
Subject: Scope of Work Memo

The memo includes a layout of the team and client based deliverables expected throughout the project along with an estimate of expenses. Each subject will have their own section within the memo, regarding which deliverables were determined by the team, those determined by the client and estimated budget.

Client Based Deliverables

After meeting with our client, Jonathan Heitzinger, the project of reducing energy consumption across the NAU campus is estimated to be too large for one team to complete in the time provided.

The project which the Bio-Inspired Energy Efficiency team will be working on is to, create a bio-inspired design which will adapt or replace the current Heating, Ventilation, and Air-Conditioning (HVAC) system in the Social and Behavioral Sciences West (SBS West) building at Northern Arizona University. This project is to bring SBS West up to the proper ventilation codes while increasing the overall efficiency of the current HVAC system. The clientele for this project is Jonathan Heitzinge, who works with NAU facilities in making sure buildings and systems are up to code and implements any innovations and/or renovations needed to improve a building's overall performance.

There are a number of analytical analyses that need to done to insure the proposed system can be implemented within SBS West. These analyses include ventilation, solar, economical, installation, and many aspects yet to be determined.

Team based Deliverables

This section includes an overall layout of the team based deliverables that are assigned throughout the semester in order by date.

The first deliverable is to provide a memo about the team's analytical analysis. This memo must contain an explanation of what each member of the team's technical analysis. This assignment is due on October 12, 2018. The second deliverable is presenting the team's progress on the project. This presentation is scheduled for October 22, 2018. Contents in the presentation must include an updated project description, multiple design concepts, concept selection of the generated designs, an updated schedule of the project, and an estimated budget of the project. The third deliverable is the final presentation of the semester. This presentation is scheduled to

be on November 19, 2018. The presentation must include an updated project description, an overview of the selected design along with a computer aided design (CAD) package and a bill of materials (BOM). Additionally, an explanation of the design requirements and how it applies to the customer needs. Finally, an updated schedule and budget for the following semester must be included in the presentation.

Estimated Budget

Budget for this project is dependent on sponsorship and funding provided. Based on previous projects involving solar, teams have gone over budget by about $1,500. To prevent the team from going over budget, a cost estimation is provided since the team has not selected a final design. The costs of the budget were split into three separate instances; Beta Prototype which is a scaled down version of the final design mainly consisting of 3-D printed components, scaled Alpha Prototype which is a scaled down version of the final design, and an actual Alpha prototype which is a complete vent and panel from the final design. These prototypes were split into four major costs, machined parts, 3-D printing, fasteners, and variable costs. Variable cost includes outsourcing, pre-existing components, software, and any other costs unable to be determined at this time. The three instances are estimated below.

1) **Beta Prototype (low budget): ~$500 - $1000**
    a) Machined parts ~ $150 - $200
    b) 3-D printing ~ $100 - $150
    c) Fasteners ~ $50 - $100
    d) Variable costs ~ $100 - $200
2) **Scaled Alpha Prototype (medium budget) :~$1000 - $1500**
    a) Machined parts ~ $250 - $500
    b) 3-D printing ~ $100 - $150
    c) Fasteners ~ $100 - $200
    d) Variable costs ~ $200 - $400
3) **Actual Alpha Prototype (ideal budget) :~$1500 or greater**
    a) Machined parts ~ $500 - $1500
    b) 3-D printing ~ $100 - $150
    c) Fasteners ~ $100 - $200
    d) Variable costs ~ $500 or greater

The team would like to achieve the largest budget possible for the most freedom in their design, along with testing the design's application.

Conclusion

This project will be to innovate a solar radiative system (as of now this uses adaptive temperature vents, along with a solar array) which has already been designed by members of the senior design team. However, the design has many changes and adaptations which need to be made. Additionally, this project requires extensive mechanical, electrical, and economical analysis to insure the proposed HVAC system design is up to code, brings SBS west up to code, and provides energy efficiency. The most important aspect of this design is to insure it is not only bio-inspired and energy efficient but affordable as well. The original payout of the system was to be approximately five years. This has recently been changed due to further analysis providing evidence that this payout would not be met. However, the payout period has been extended due to the building not meeting ventilation or energy codes. The payout period will now analysis (energy production and reduction, code suitability, economical, etc.), solar array (energy production and reduction , economical, etc.), building simulation with proposed system, and effects on pre-existing HVAC system, as well as other building systems.