**PROJECT TITLE: Minnesota Shrimp Production Using Clean Energy**

**I. PROJECT STATEMENT**

We propose to develop a modular shrimp production system using integrated solar thermal, solar electric, and energy storage systems to drive the production process. Minnesotans enjoy a diverse selection of seafood in our diets whether locally-caught fresh walleye, salmon, Maine lobster, or gulf coast shrimp. Many types of seafood travel from locations across the globe to reach Minnesota. This impacts food quality and safety but also the energy and carbon footprint of the food we eat. One option is to raise seafood locally. This can be done by creating a climate conducive to raising various species of fish and crustaceans. However, energy consumed in creating this artificial climate can be significant. For example, shrimp require a constant 95O F water temperature and water filtration throughout production. A commercially-available solar thermal system can be designed to heat water for year-long shrimp production. A typical barrier for solar thermal systems in Minnesota is the lack of a consistent use for the hot water (e.g. winter versus summer load). Shrimp production appears to be a good match considering the need for a consistent source of warm water yearlong. Solar PV paired with a battery can also provide the electrical energy needed to recirculate and filter the water. We envision a modular, shipping container shrimp production system that can be set on a prepared surface. The shipping containers are natural platforms for solar thermal and solar PV systems. The modular configuration will allow for production systems that are sized to meet local demand for fresh, locally raised shrimp. Benefits of a successful project include:

* Increased utilization of local renewable energy resources,
* Renewable generation matched with new energy loads lowering impact to electric utilities,
* Contained environment virtually eliminating ecological impact of commercial seafood production,
* Distributed, local food production across the state providing fresh seafood,
* New business opportunities and markets for Minnesota farmers,
* Development of a technology platform that can be manufactured in Minnesota, and
* Increased economic development opportunities in Greater Minnesota.

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1: Design and develop a modular shrimp production system using solar energy systems.**  **Description:**A modular shrimp production system will be designed using a modified shipping container. The project team will work with an engineering firm to develop the design. A 40-foot shipping container equipped with electric service, lights, and HVAC system for conditioning the room temperature will be purchased. The container will be delivered to the University of Minnesota West Central Research and Outreach Center (WCROC) near Morris, MN. The shipping container will be dropped on a level, prepared site with access to water, electricity, and fiber optics. Additional insulation will be added on-site. The modular container will contain four tanks for the shrimp – a nursery tank and three grower tanks. Water filtration systems and recirculation pumps will also be installed. Brackets will be installed on the south-facing exterior side as well as the roof to accommodate installation of solar thermal and solar photovoltaic panels. A heat exchanger, hot water storage tank, and pump will be installed to store solar thermal energy. A battery system will also be installed to store energy generated by the solar PV system. The intent is to have adequate solar energy capacity and storage to provide a majority of the energy load both day and night throughout the year. Finally, an internet enabled control and data acquisition system will be installed along with the accompanying control and data sensors and meters to measure water flow, temperature, pH, as well as air temperature and energy consumption. All necessary permits will be obtained. The modular production system will then be fully commissioned and tested prior to introducing shrimp. After completing three replicated trials of shrimp production, the system will be optimized and a second set of at least three replicated trials will be performed. |  |

**ENRTF BUDGET: $571,225**

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| **Outcome** | **Completion Date** |
| *1. Complete a design of a modular, shrimp production system incorporating solar energy and energy storage.* | *11/01/2020* |
| *2. Complete installation of a modular, shrimp production systems utilizing a modified shipping container with solar thermal and solar PV systems attached.* | *07/01/2021* |
| *3. Commission the modular, shrimp production system.* | *08/01/2021* |
| *4. Optimize the mechanical systems within the modular, shrimp production system.* | *03/01/2022* |

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| **Activity 2: Field test a modular shrimp production system**  **Description:**The modular shrimp production system, utilizing solar thermal and solar PV systems, will be field tested at the WCROC farm near Morris, MN. The tanks will be inoculated with beneficial bacteria and the water conditioned to appropriate levels. Shrimp feed will be sourced from domestic vendors. Juvenile shrimp or larvae will be purchased and raised within the nursery tank until they reach approximately one gram in weight and then will be transitioned to the grower tank(s). Then, the fast-growing shrimp will be introduced to one of three larger grower tanks within the modular building and raised to harvest weight at approximately six months. Upon harvest the shrimp will be weighed and processed. Variables measured will include total shrimp weight, feed efficiency, survival rate, water quantity and temperature, and energy production and consumption. Microbial populations, important for the growth of the shrimp, will be monitored throughout the nursery and grower phases. Three replicate grower trials will be completed and then the system will be re-evaluated and potentially re-configured to improve modular shrimp production. At least three additional replications will then be completed. Each replicate duration from the larvae stage to grower and grower to harvest is estimated to take 40 to 60 days depending on the target harvest weight. The target harvest weight may change during the study in order to optimize overall system production. A basic techno-economic assessment of the technology will be performed with results disseminated to Minnesota farmers through a various forms including the Midwest Farm Energy Conference and the WCROC web-site. A tech-to-market plan will be developed including options to pursue fabrication of the production system within Minnesota. A comprehensive final report will be submitted to the commission.  **ENRTF BUDGET: $557,775** |  |

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| **Outcome** | **Completion Date** |
| *1. Complete first shrimp production study and analyze results.* | *01/01/2022* |
| *2. Optimize the biological processes within the modular, shrimp production system.* | *03/01/2022* |
| *3. Complete second shrimp production study and analyze the results.* | *03/01/2023* |
| *4. Perform a basic techno-economic assessment of the modular production system.* | *05/01/2023* |
| *5. A technology-to-market plan will be developed.* | *05/01/2023* |
| *6. A comprehensive final report will be submitted to the commission.* | *06/30/2023* |

**III. PROJECT PARTNERS AND COLLABORATORS:** Professor Robert Gardner will lead this project. He has expertise in beneficial microbial production in water-based systems. Dr. Joel Tallaksen and Eric Buchanan have expertise in clean energy system development and analysis. Curtis Reese will oversee shrimp production having significant experience in aquaculture production systems. All participants are located at the WCROC.

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:** A tech-to-market plan will developed. The plan will provide a pathway to commercialization. If successful, the system will be self-sustaining and new businesses created.

**V. SEE ADDITIONAL PROPOSAL COMPONENTS:** Including **A. Proposal Budget Spreadsheet, B. Visual Component, and F. Project Manager Qualifications and Organization Description.**