INTRODUCTION:

The primary objective of this Project Readiness Package (PRP) is to describe the proposed project by documenting requirements (customer needs and expectations, specifications, deliverables, anticipated budget, skills and resources needed, and people/ organizations affiliated with the project. This PRP will be utilized by faculty to evaluate project suitability in terms of challenge, depth, scope, skills, budget, and student / faculty resources needed. It will also serve as an important source of information for students during the planning phase to develop a project plan and schedule.

In this document, italicized text provides explanatory information regarding the desired content. If a particular item or aspect of a section is not applicable for a given project, enter N/A (not applicable). For questions, contact Mark Smith at 475-7102, mark.smith@rit.edu.

ADMINISTRATIVE INFORMATION:

- Project Name (tentative): Prototype Thermoelectric Charcoal Cook Stove for Haiti
- Project Number, if known: P13441
- Preferred Start/End Quarter in Senior Design:

  ☐ Fall/Winter ☐ Fall/Spring ☒ Winter/Spring

- Faculty Champion: *(technical mentor: supports proposal development, anticipated technical mentor during project execution; may also be Sponsor)*

Name	Dept.	Email	Phone
Rob Stevens	ME	rjseme@rit.edu	475-2153

For assistance identifying a Champion: B. Debartolo (ME), G. Slack (EE), J. Kaemmerlen (ISE), R. Melton (CE)

- Other Support, if known: *(faculty or others willing to provide expertise in areas outside the domain of the Faculty Champion)*

Name	Dept.	Email	Phone
Jag Tandon		jctddm@rit.edu	223-3167
Neal Eckhaus		neckhaus@gmail.com	

- Project "Guide" if known: *(project mentor: guides team through Senior Design process and grades students; may also be Faculty Champion)*

  Ed Hanzlik

- Primary Customer, if known (name, phone, email): *(actual or representative user of project output; articulates needs/requirements)*

  H.O.P.E (Haiti Outreach - Pwoje Espwa), James Myers, 475-4772, jamisr@rit.edu
  Sara Brownell, Haiti expert, sabeie@rit.edu

- Sponsor(s): *(provider(s) of financial support)*

Name/Organization	Contact Info.	Type & Amount of Support Committed
MSD Internal	Mark Smith	$500

PROJECT OVERVIEW: *2-3 paragraphs that provide a general description of the project – background, motivation, customers, problem you're trying to solve, project objectives*.

According to the World Health Organization more than three billion people depend on biomass fuels (wood, dung, or agricultural residues) primarily for cooking. The practice of cooking with biomass has decimated many ecosystems and requires an enormous amount of human effort to gather. In addition, there is considerable evidence that exposure to biomass smoke increases the risk of common and serious diseases in both children and adults. According to the WHO studies, indoor smoke from solid fuels causes an estimated 1.6 million deaths annually.

To minimize these harmful effects associated with cooking more efficient cook stoves have been proposed. These new stoves use significantly less biomass fuel thus reducing deforestation rates. These enhanced stoves also reduce indoor air pollution, thereby reducing deaths and illnesses due to biomass cooking. RIT is working with an NGO partner in Haiti, H.O.P.E., and initially funded by an EPA Energy Research Grant to develop an enhanced stove. The goal of this project is to build on the work done by previous projects P10461, 11461, 11462, 12441, and 12442 to develop an improved cook stove for vendors and institutional users. The improved cook stove should substantially reduce (by more than 50%) the emissions and fuel needed for cooking compared to the traditional stoves currently used in Haiti. The first generation of stoves developed by team P10461 and 11461 was designed to use force draft to improve combustion and heat transfer to the pot. The forced air requires an electric fan, which is to be powered by a thermoelectric module. The development of this next generation stove will require close coupling between complex thermal and electrical systems. This project will build on the experience and prototype developed by team P12441 and P12442 to develop a highly efficient and clean stove that is affordable, easy to operate, and improves cooking control compared to existing Haitian stoves.

The project main deliverable is two fully functional cook stoves that will be sent to Haiti during the summer of 2013 for field testing. The stoves should have twice the efficiency of base Haitian stove, significantly reduced emissions, and a robust power system for operating the stove fan and charging external devices. The team will also provide assembly documentation and a user manual.

DETAILED PROJECT DESCRIPTION:

The goal of this section is provide enough detail for faculty to assess whether the proposed project scope and required skills are appropriate for 5th year engineering students working over two quarters. The sequence of the steps listed below may depend on your project, and the process is usually iterative, so feel free to customize. Emphasis is on the "whats" (qualitative and quantitative), not the "hows" (solutions), except for the section on "potential concepts," which is necessary to assess the appropriateness of required skills and project scope. Not all of the information in this section may be shared with students. (Attach extra documentation as needed).

- Customer Needs and Objectives: *Comprehensive list of what the customer/user wants or needs to be able to do in the "voice of the customer," not in terms of how it might be done; desired attributes of the solution.*
    - Affordable (initial cost <$30 at high production quantities of 1000+)
    - Cheaper to operate than current stove (less fuel for same cooking tasks)
    - Significantly cleaner than current stove (reduced CO and PM emissions)
    - Easy to operate (require little user interaction and simple and intuitive processes, require the same or less effort than current practices for starting and cooking with stove.)
    - Same or improved cooking controls (control cooking conditions for traditional Haitian cooking practices). Obtain rapid boil quickly and then bring to simmer.
    - Be able to be fabricated and assembled using Haitian artisan practices
    - Transportable so that a single adult can move the stove 500 meters unassisted.
    - Rugged, can handle being dropped by user multiple times, withstand harsh conditions such as rain and high temperatures.

- Durable, should operate for five or more years with a use rate of at least twice a day or have simple, cheap, and easily replaceable parts. Thermoelectric module will not fail due to high temperatures and gradients.
- Able to charge multiple (2 to 3) cell phones and other typical 5V USB loads over the course of a typical institutional or vendor single stove use.
- Power fan used for a force air stove during entire stove operation.
- Able to start fan multiple times in cases where there are multiple stove restarts.
- Safe to operate, operator should not be injured during normal use and transport of the cook stove.

- Internal needs:
  - Maintain appropriate temperature gradient across thermoelectric module
  - Achieve desired temperature gradient quickly
  - Fully charge battery

- Functional Decomposition: *Functions and sub-functions (verb-noun pairs) that are associated with a system/solution that will satisfy customer needs and objectives. Focus on "what" has to be achieved and not on "how" it is to be achieved – decompose the system only as far as the (sub) functions are solution independent. This can be a simple function list or a diagram (functional diagram, FAST (why-how) diagram, function tree).*

- Potential Concepts*: Generate a short list of potential concepts (solutions) to realize the system and associated functions. This may involve benchmarking or reverse engineering of existing solutions. For each concept and its associated function(s), generate a list of key tasks or skills needed to design and realize the function(s), and identify which disciplines (ME, EE, CE, ISE, ...) are likely to be involved in the design and realization of the function(s). See the "PRP_Checklist" document for a list of student skills by department.* ***Potential concepts, skills, and tasks should not be shared with students.***

- Specifications (or Engineering/Functional Requirements): *Translates "voice of the customer" into "voice of the engineer." Specifications describe what the system should (shall) do in language that has engineering formality. Specifications are quantitative and measureable because they must be testable/ verifiable, so they consist of a metric (dimension with units) and a value. We recommend utilizing the aforementioned functional decomposition to identify specifications at the function/ sub-function levels. Target values are adequate at this point – final values will likely be set after students develop concepts and make tradeoffs on the basis of chosen concepts. Consider the following types of specifications:geometry (dimensions, space), kinematics (type & direction of motion), forces, material, signals, safety, ergonomics (comfort, human interface issues), quality, production (waste, factory limitations), assembly, transport/packaging, operations (environmental/noise), maintenance, regulatory (UL, IEEE, FDA, FCC, RIT).*
  - Production cost: <$30 for materials at 1-10K quantities, less than 4 hours of a Haitian's craftsman labor per stove.
  - Fuel use: 50% of traditional Haitian rebar fuel use for both Full Water Boil Test (WBT) and established Controlled Cooking Test (CCT).
  - CO emissions: 25% of tradition Haitian rebar stove emissions for both WBT and CCT
  - PM emissions: 25% of tradition Haitian rebar stove emissions for both WBT and CCT
  - Time to boil during WBT using traditional starting practice is ¾ the time currently achieved with the Haitian rebar stove.
  - Surfaces of the stove that will be contacted by stove operator should not exceed 50°C.
  - Less than 15 minutes to start and bring 2.5 liters of water to boil using traditional starting techniques.
  - Range of heat output 1-6 kW (heat transferred to pot).
  - Capable of using with pot diameters from 20-60 cm.
  - Withstand pot mass up to 25 kg.
  - Five or less tasks to maintain fire throughout a CCT after initial stove start.
  - Any part that will need to be replaced within a three year stove life should:
    - Be less than $3.
    - Require less than 60 minutes to replace.

    - Be able to be replaced with no or simple hand tools.
  - Stove weight should be less than 8 kg.
  - Stove volume should not exceed 0.2 m^3.
  - Stove entire construction should be possible using basic Haitian fabrication capabilities
  - Survive 20x 2-meter drop tests.
  - Ergonomics metrics?
  - Operate fan continuously during stove operation.
  - Power all loads (fan, batteries completely charged for 10 starts, and 2-3 cell phone charges[8Wh]) using a Thermonanic TE Module (TEP1-1264-3.4) with 3 hour cooking cycle.
  - Package size for entire power pack except thermoelectric module is restricted to 3"x3"x1.5"
  - Power pack unit should be less than 3 lbs.
  - Package should prevent damage or significant reduction in product life to electrical components during a downpour.
  - Charging of auxiliary loads such as cell phones should be using a standard USB connection.
  - Power unit handle some sort of dynamic crush test
  - Power unit survive 20 2-meter drop test.

- Internal Specifications:
  - Keep a minimum temperature gradient of 200°C across a Thermonanic TE (TEP1-1264-3.4) thermoelectric module under peak power conditions (i.e. electrically loading module with the internal resistance of the module.)
  - Reach desired temperature gradient within 20 minutes of starting the fire.
  - Consume less than 0.6 W (i.e. ideal case, 1 W absolute max) to operate all stove internal electrical loads (i.e. fan and controls).
  - Thermoelectric module never exceeds max operating temperature (380°C continuously and 400°C intermittently on hot side and 200°C on cold side) and pressure conditions.
  - Thermoelectric module is mechanically loaded evenly and loading does not exceed module failure limit.

- Constraints: *External factors that, in some way, limit the selection of solution alternatives. They are usually imposed on the design and are not directly related to the functional objectives of the system but apply across the system (eg. cost and schedule constraints). Constraints are often included in the specifications list but they often violate the abstractness property by specifying "how".*
  Project should be completed over two quarters with a total project budget of $500.
  Project will use available Thermonanic TE (TEP1-1264-3.4) modules.

- Project Deliverables: *Expected output, what will be "delivered" – be as specific and thorough as possible.*
  Two working cook stoves that have been fully tested and characterized and ready to be sent to Haiti for further field testing. In addition, there should be documentation on how to fabricate and assemble the stove. Instructions should be included on how to operate the stove to maximize performance. An intuitive operation manual should be provided for the end-user.

- Budget Estimate: *Major cost items anticipated.*
  $500. TE modules will be provided as well as power supplies and some DAQ equipment for testing.

- Intellectual Property (IP) considerations: *Describe any IP concerns or limitations associated with the project. Is there patent potential? Will confidentiality of any data or information be required?*
  No

- Other Information: *Describe potential benefits and liabilities, known project risks, etc.*

- Continuation Project Information, if appropriate: *Include prior project(s) information, and how prior project(s) relate to the proposed project.*
  P12441 and P12442. See Edge site for details.

STUDENT STAFFING:

- Skills Checklist: *Complete the "PRP_Checklist" document and include with your submission.*

- Anticipated Staffing Levels by Discipline:

Discipline	How Many?	Anticipated Skills Needed (*concise descriptions*)
EE	3	Circuit design, power management circuits, circuit board test/debug, board layout, circuit simulation, microcontroller selection/application, control, analyze entire thermoelectric system
ME	3	Mechanical design (structural analysis, technical drawings, fabrication), material processing (machining and assembly), thermal design and analysis (heat sink and source design, wall thermal transport, heat transfer to pot), flow analysis (flow modeling through sinks and in and around combustion chamber), combustion analysis, material selection and durability assessment
CE		
ISE	1	Project management, packaging, ergonomic design/evaluation, material selection, and sustainability metric assessment. Design of experiments, stove testing/characterization, and system integration.
Other		

OTHER RESOURCES ANTICIPATED:

Describe resources needed to support successful development, implementation, and utilization of the project. This could include specific faculty expertise, laboratory space and equipment, outside services, customer facilities, etc. Indicate if resources are available, to your knowledge.

Category	**Description**	**Resource Available?**
Faculty		☐
		☐
		☐
Environment	**Sustainable Energy Lab in ME Department (**Lab for testing thermoelectric modules and subsystems. Power supplies, simple multimeters, DAQ system, and thermoelectric modules are available.)	☒
		☐

		☐
Equipment	**See notes above on environment. SEL also has a complete test stand for modified water boil tests, full water boil tests, and the kitchen cooking test. Multiple stoves area available for benchmarking and preliminary testing.**	☐
		☐
Materials	**See notes above on environment**	☐
		☐
Other		☐

Prepared by: Rob Stevens & Ed Hanzlik Date: 10/23/12