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): Bicycle Rotational Energy Harvesting System
- Project Number, if known: P12414
- 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

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

- Project "Guide" if known: *(project mentor: guides team through Senior Design process and grades students; may also be Faculty Champion)* Sarah Brownell, 585-330-6434, sabeie@rit.edu
- Primary Customer, if known (name, phone, email): *(actual or representative user of project output; articulates needs/requirements)* Sarah Brownell, 585-330-6434, sabeie@rit.edu
- Sponsor(s): *(provider(s) of financial support)*

Name/Organization	Contact Info.	Type & Amount of Support Committed
Mark Smith		

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

A quarter of the world, and up to 80% of people in poor countries do not have access to electricity. These families still struggle to better themselves through educational and commercial activities, and would benefit from access to small amounts of electricity for lighting, communication, and water treatment. Many currently use kerosene lamps or candles for light to study and work by at night. The lamps break easily and both light sources release sooty, lung-damaging smoke into the house, and cause fires if tipped over or placed too near curtains or bedding. The proliferation of phone companies targeting this low income demographic has increased overall access to cell phones for communication and business. However, people without electricity must then pay to have their phone charged by someone who has a generator or solar panel. They usually have to leave their phone for a few hours where they are easily stolen, along with all their contacts. Additionally, some of the faster and more effective water treatment methods such as UV disinfection could be made available to more users if electricity to power them were more widespread. In general, low income families in poor countries are at an extreme disadvantage without power.

The mission of this family of projects is to develop compelling solutions to the problem of providing efficient, reliable, and affordable sources of energy derived from the harvesting of wasted human energy in the developing world where there is a lack of access to reliable power sources. Healthy humans can produce about 0.1 hp for 8 hours or up to 0.4 hp for a few minutes before becoming exhausted. Over the course of a day humans expend 10^5 J to 10^7 Joules for activities or on average 40 watts if distributed over 24 hours. Since humans run on food—generally an expensive fuel—the ideal way to extract power from humans is by harnessing energy that is currently "wasted" during everyday activities. Otherwise, power generation must be easy and even fun so as not to add burden to their already difficult lives. If technologies for harnessing, storing, and transforming human power into useful electricity can be made and delivered inexpensively to low income families (in combination with low power consuming devices), their ability to succeed in school, generate income, and protect their health will be improved. Such technologies not only have humanitarian applications, but could satisfy unexploited market opportunities for high-volume, low-margin products.

No individual team is expected to solve the Harvesting Waste Energy from Humans project alone. Rather, it is desired that the cumulative impact of the research and development of this family of projects will be felt over time, and there should be no doubt within the international community that this family of student projects was the key contributor to solving the problem of sustainable sources of personal energy generation and storage.

This project will focus on harvesting energy—ideally energy that would otherwise be wasted—from the momentum of a moving bicycle to charge a cell phone or batteries for LED lighting. The final design should be an attachment for an existing bicycle rather than the design of a new bicycle. Students should consider and compare the feasibility (energy output and cost) of using regenerative breaking methods as well as that of continual energy harvesting techniques. They should also not limit their creative efforts to only these two types of solutions!!! For regenerative braking systems, energy would only be harvested while breaking and the amount would depend on the energy generated while slowing down or coming to a complete stop. During continual harvesting small amounts of energy, small enough not to noticeably increase the effort for the rider, would be harvested any time the bicycle is rolling. Other methods may also be possible and should be considered.

DETAILED PROJECT DESCRIPTION:

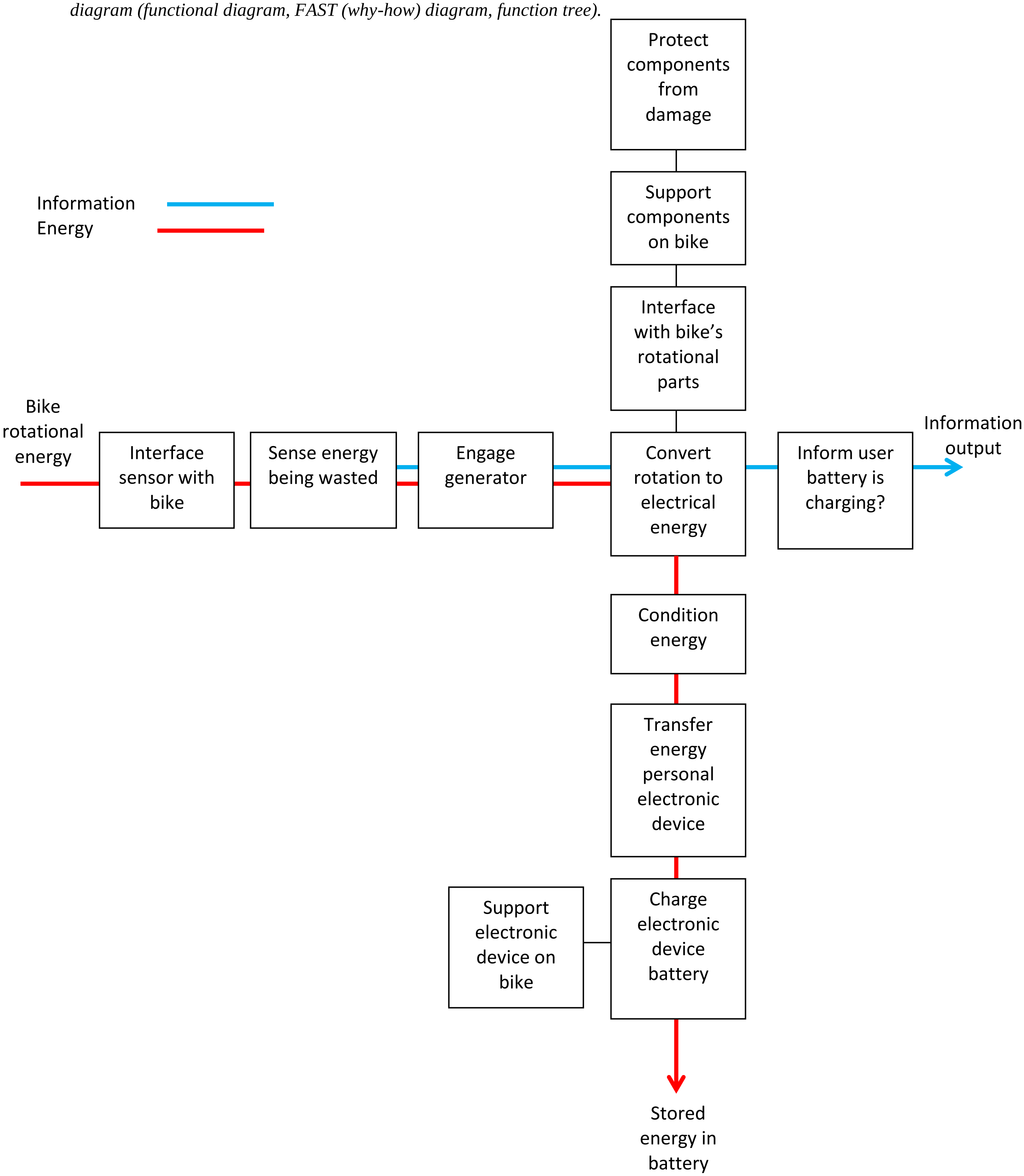
The goal of this section is provide enough detail for faculty to assess whether the proposed project scope and required skills are appropriate for 5th year engineering students working over two quarters. The sequence of the steps listed below may depend on your project, and the process is usually iterative, 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.*

Objective: Power simple personal devices using energy stored in the momentum of a bicycle

		Importance Weight
Need #	**Customer Needs**	low = 1, moderate = 3, high = 9
Need 1	The device provides power to charge a cell phone or a rechargeable battery to power LED lighting	
Need 2	The device attaches to a wide variety of bicycle types	
Need 3	The device adds only a minimal increase in effort for the operator pedaling the bicycle, ideally none at all	
Need 4	The device uses standard connectors to personal electronic devices	
Need 5	The device is light weight	
Need 6	The device is inexpensive to purchase, install and maintain	
Need 7	The device is easy to install	
Need 8	The device is easy to operate	
Need 9	The device is easy to maintain	
Need 10	The device resists environmental damage from dust, water, etc.	
Need 11	The device works well on rough roads	
Need 12	The device protects user safety	
Need 13	The device is a stylish accessory to the bicycle	

- 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).*



- 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).*

Preliminary Specifications. Team will need to complete benchmarking and a House of Quality to determine if all specifications are covered.

Needs	Specifications	Units	Ideal	Marginal
	Output voltage	VDC		
	Power output	W	>5	>2
	Energy Conversion Efficiency	%		
	Maximum charging rate range (depends on battery)	J/s		
	Estimated biking time to generate power 1 W-hr (if the device does not generate continuously)	hrs	<0.5	<1
	Maximum increased effort for bicyclist	%	0	<3
	Variation in bicycle dimensions (actual specs will depend on design of generating system, "wheel sizes range" for example)			
	Uses standard connectors to interface with cell phone or battery charger for LEDs	binary	Yes	Yes
	Weight	kg	<1	<3
	Number of people required to install device	people	1	2
	Number of tools required to install device		<2	<5
	Time required for set up (each use)	min	<10	<20
	Time to train operator to use device	min	<10	<30
	Minimum operating temperature	degrees C	<0	<5
	Maximum operating temperature	degrees C	>45	>40
	Increased temperature to bicycle parts (rim, gears, ??)			
	Manufactured Cost (lots of 100)	$	<20	<40
	Installation Cost	$	0	<5
	Wires resist pulling forces	N		
	Electronics protected from rain/splashing	binary	yes	yes
	Resists damage from impacts/crashes	N		
	People rating the device at 4 or above on a scale of 1-5 for "aesthetically appealing"	%	70	50

- 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".*

  - The device should harvest the energy from the momentum of the moving bicycle.
  - The unit price for this device should be affordable, because of the primary target is for developing countries, such as Haiti.
  - The design shall comply with ergonomics aspect, since this product will be in human daily activities.
  - The product should be weather /water resistant.
  - The design shall comply with all applicable RIT Policies and Procedures. The team's design project report should include references to, and compliance with all applicable RIT Policies and Procedures.
  - Each team will be required to keep track of all expenses incurred with their project.
  - Material Safety Data Sheets (MSDS) are required for all materials.
  - Each team in this roadmap is expected to demonstrate the value and outcome of their project at the annual Imagine RIT festival in the spring.
  - Each team in this roadmap is expected to produce outcomes and artifacts which are inspiring to middle school and high school students.
  - It is preferable to manufacture and assemble components in-house from raw materials where feasible.
  - Students should articulate the reasoning and logic behind tolerances and specifications on manufacturing dimensions and purchasing specifications.
  - Project success will be based on how fast the technology could be reproduced or re-manufactured by individuals with low levels of training or exposure.
  - All work to be completed by students in this track is expected to be released to the public domain. Students, Faculty, Staff, and other participants in the project will be expected to release rights to their designs, documents, drawings, etc., to the public domain, so that others may freely build upon the results and findings without constraint.
  - Students, Faculty, and Staff associated with the project are encouraged to publish findings, data, and results openly.
  - All information researched and created should be clearly documented. Also it should be easily to understand and organized in such a way that allows others to come up to speed with the project quickly.

- Project Deliverables: *Expected output, what will be "delivered" – be as specific and thorough as possible.*

  - Working prototype
  - Bill of Materials
  - Manufacturing and assembly plan
  - Test Plan
  - Test Results
  - Estimated production costs in lots of 100
  - Technical paper
  - Poster

- Budget Estimate: *Major cost items anticipated.*

Product Benchmarking	$150
Prototype construction	$350
Testing	$100
TOTAL	$600

- 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?*

- 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.*

STUDENT STAFFING:

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

- Anticipated Staffing Levels by Discipline:

Position Title	Position Description
Discipline: ME Positions: 2	These individuals will be responsible for the design enclosure/support. The challenge is to develop an enclosure that can be integrated into any environment. This device should work under several conditions (weight, speed and impact). Another responsibility is to design static and dynamic load and testing of regenerative brake Interest in manufacturing and metal fabrication will be crucial for success, mechanics experience is preferred. Applicable courses include: Design of Machine Elements, Materials Selections, and Engineering Design Graphics, CNC, Vibration.
Discipline: EE Positions: 1	This individual will be responsible for converting the rotational energy in term of kinetic energy of a bicycle into electrical power. Two major challenges exist for this condition: The first is to make the electrical conversion as efficient as possible. The second is to make the system robust enough to withstand a broad range of environmental conditions. May have to work closely with ME students to develop an enclosure to protect the electrical components. This individual should have experience with generators and power conversion. Willing to research and test to find the most efficient conversion method. Interest is sustainability and renewable energy would be beneficial.
Discipline: EE Positions: 1	This individual will be responsible for the control system and to design for the battery. Preferably experience with microcontrollers. Willing to research and test to find the most efficient microcontroller. Interest is sustainability and renewable energy would be beneficial.
Discipline: IE Positions: 1	This individual will have responsibilities to perform a cost benefit analysis to determine the ROI of the prototype as well as a mass manufactured system and to assess the ergonomic impact of adding the device to a bicycle. Due to the sustainability aspect of this project, this individual will complete life cycle assessment

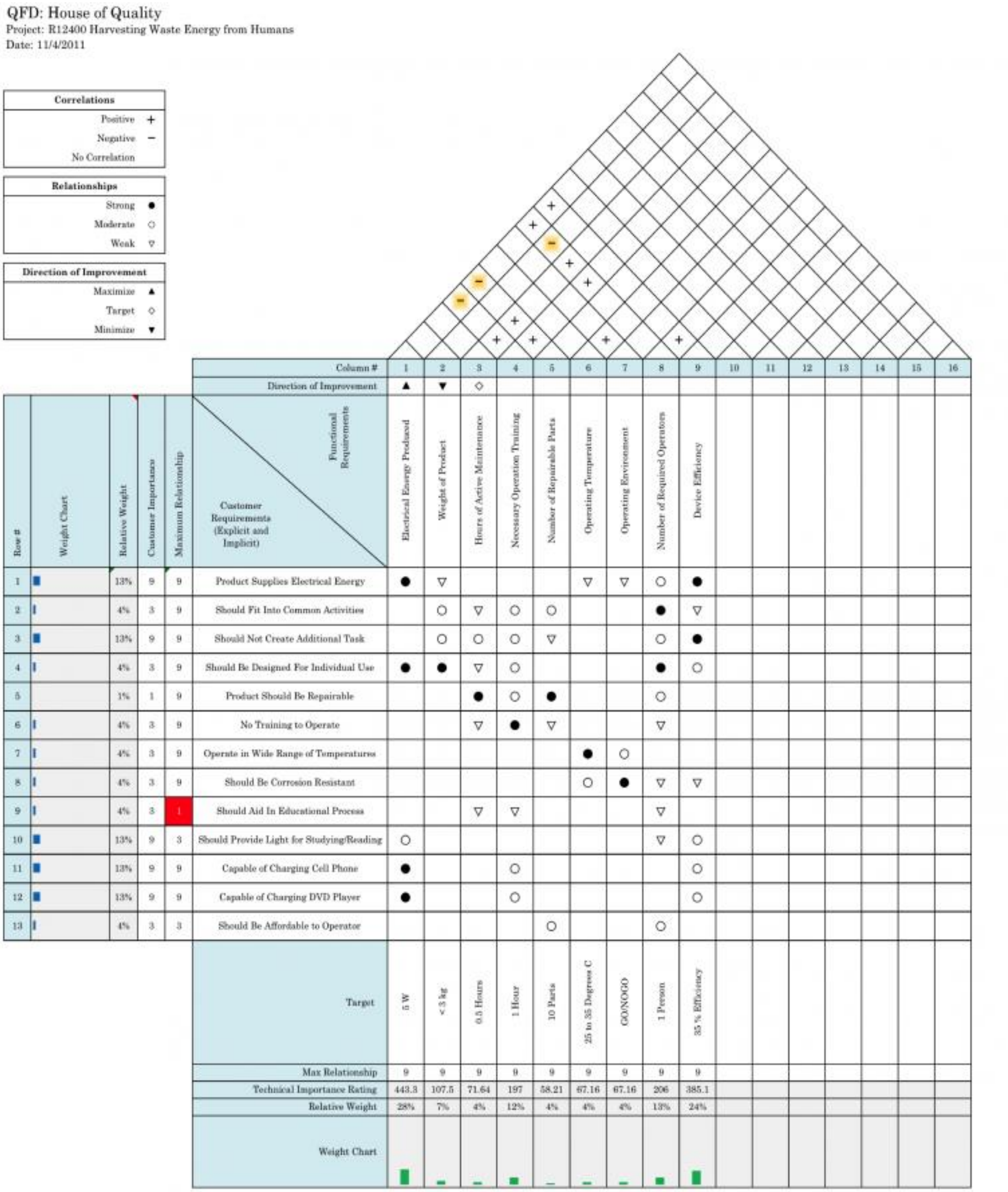
	and provide recommendations for material use and end of life options. Interest and experience with project management and sustainability is preferred. Interest is sustainability and renewable energy would be beneficial. Applicable courses include: Engineering Economy, Life Cycle Assessment, Design for Environment, Engineering Management, Design for Project Management

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.

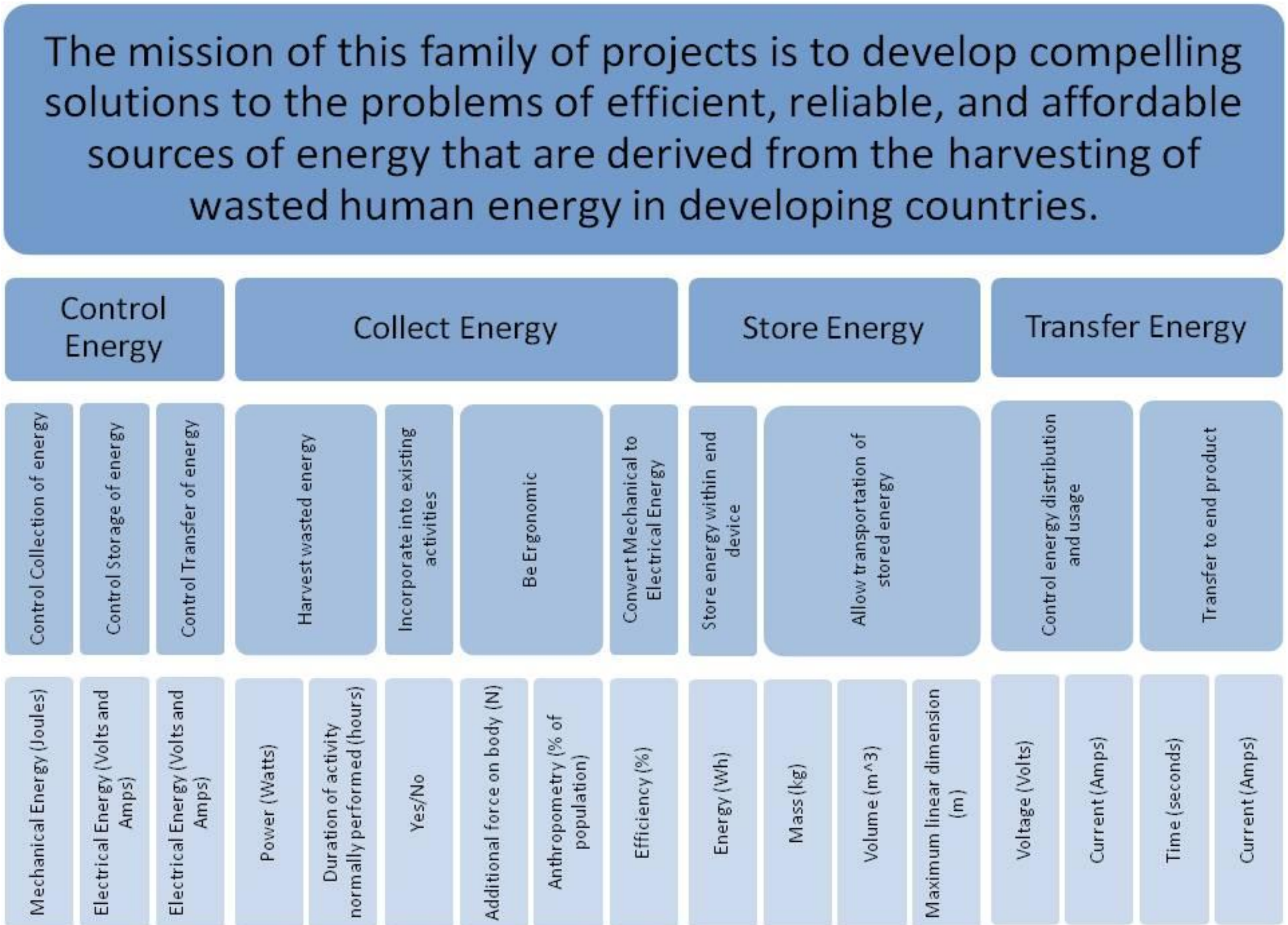
Category	**Source**	**Description**	**Resource Available (*mark with X*)**
Faculty	ME, EE, IE, Sustainability Faculty	Faculty advisors from each department for guidance/direction. Expertise in power conversion (EE),design and metal fabrication (ME), and sustainability principles (IE) is preferable.	X
Environment	RIT test location	The system could be tested with various bicycles, surfaces, speeds, and temperatures, to assess actual performance at a safe location on the RIT campus. Possible testing for ergonomics (oxygen use of the rider) Laboratory for testing various components, solid modeling software	X
Equipment	Lab	Machine shop access and tools available in the Design Center. Ergonomics testing equipment. Oscilloscope and other electrical prototyping and testing equipment. Stationary bike for early testing.	X
Materials	Local suppliers preferred	Generator, raw materials for stand/enclosure, power converters, electrical components, wires.	
Other			

The following diagrams are included for your reference. They apply to the "Harvesting Human Energy" project family roadmap as a whole.

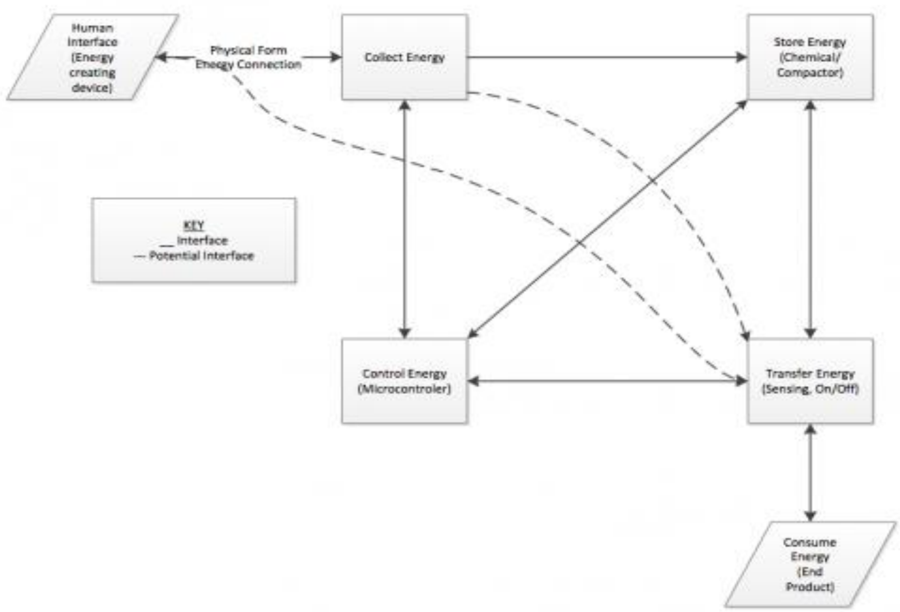


Row #	Relative Weight	Customer Importance	Maximum Relationship	Customer Requirements (Explicit and Implicit) / Functional Requirements	1 Electrical Energy Produced	2 Weight of Product	3 Hours of Active Maintenance	4 Necessary Operation Training	5 Number of Repairable Parts	6 Operating Temperature	7 Operating Environment	8 Number of Required Operators	9 Device Efficiency	10	11	12	13	14	15	16
				Direction of Improvement	▲	▼	◇													
1	13%	9	9	Product Supplies Electrical Energy	●	▽				▽	▽	○	●							
2	4%	3	9	Should Fit Into Common Activities		○	▽	○	○			●	▽							
3	13%	9	9	Should Not Create Additional Task		○	○	○	▽			○	●							
4	4%	3	9	Should Be Designed For Individual Use	●	●	▽	○				●	○							
5	1%	1	9	Product Should Be Repairable			●	○	●			○								
6	4%	3	9	No Training to Operate			▽	●	▽			▽								
7	4%	3	9	Operate in Wide Range of Temperatures						●	○									
8	4%	3	9	Should Be Corrosion Resistant						○	●	▽	▽							
9	4%	3	1	Should Aid In Educational Process			▽	▽				▽								
10	13%	9	3	Should Provide Light for Studying/Reading	○							▽	○							
11	13%	9	9	Capable of Charging Cell Phone	●			○					○							
12	13%	9	9	Capable of Charging DVD Player	●			○					○							
13	4%	3	3	Should Be Affordable to Operator					○			○								
				Target	5 W	< 3 kg	0.5 Hours	1 Hour	10 Parts	25 to 35 Degrees C	GO/NOGO	1 Person	35 % Efficiency							
				Max Relationship	9	9	9	9	9	9	9	9	9							
				Technical Importance Rating	443.3	107.5	71.64	197	58.21	67.16	67.16	206	385.1							
				Relative Weight	28%	7%	4%	12%	4%	4%	4%	13%	24%							

Functional Decomposition for the Harvesting Human Energy Roadmap



Functional Diagram for the Harvesting Human Energy Family Roadmap.



Prepared by: Sarah Brownell and Hendra Novi Date: 11/28/11