KGCOE MSD Technical Review Agenda

P11462: Thermoelectric and Fan System for Cook Stove

Meeting Purpose:

1. Overview of the project
2. Approve Engineering Specification and Customer Needs
3. Review concept generation and selection process
4. Propose a design and confirm feasibility
5. Cross-disciplinary review: identify issues and propose additional ideas

Materials to be reviewed:

1. Project Description
2. Customer Needs
3. Engineering Specifications
4. House of Quality
5. Morphological Chart
6. Concept Pugh Diagrams
7. Proposed Concept Design
8. Risk Assessment
9. Proposed Plan
10. Work Breakdown Structure

Meeting Date: January 14, 2011

Meeting Location: 09-4425

Meeting Time: 9:30 – 11:00 am

Timeline:

Meeting Timeline		
Start Time	**Topic of Review**	**Required Attendees**
9:30	Introduction	Dr. Liberson, Dr. Hoople
9:32	Customer Needs	Dr. Liberson, Dr. Hoople
9:35	Engineering Specifications	Dr. Liberson, Dr. Hoople
9:39	House of Quality	Dr. Liberson, Dr. Hoople
9:42	Questions, Concerns, Ideas	Dr. Liberson, Dr. Hoople
9:47	Morphological Chart	Dr. Liberson, Dr. Hoople
9:49	Highlight Key Pugh Drawings	Dr. Liberson, Dr. Hoople
9:55	Questions, Concerns, Ideas	Dr. Liberson, Dr. Hoople
10:00	Proposed Concept Design	Dr. Liberson, Dr. Hoople
10:08	Questions, Concerns, Ideas	Dr. Liberson, Dr. Hoople
10:13	Risk Assessment	Dr. Liberson, Dr. Hoople
10:17	Questions, Concerns, Ideas	Dr. Liberson, Dr. Hoople
10:22	Proposed Plan	Dr. Liberson, Dr. Hoople
10:26	Work Breakdown Structure	Dr. Liberson, Dr. Hoople
10:30	Questions, Concerns, Ideas	Dr. Liberson, Dr. Hoople

Project Description

Project Number	Project Name	Project Track	Project Family
11462	Thermoelectric power system for first generation of improved cook stove	Sustainable Design and Product Development	Sustainable Technologies for the Third World
Start Term	Faculty Guide	Project Sponsor	Customer Organization
Winter 2010-2011	Rob Stevens and Ed Hanzlik	Corning Sustainability Funds	H.O.P.E (Haiti Outreach-Pwoje Espwa)

Project Overview:

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 are significantly more biomass fuel efficient and thus reduce deforestation rates. These enhanced stoves also reduce indoor air pollution, thereby reducing deaths and illnesses due to biomass cooking.

Project Objective:

The goal of this project is to develop a thermoelectric power system for the first generation of RIT cook stove (project P10461). The thermoelectric power unit should convert heat directly into electricity to power a fan and provide power for auxiliary loads.

Name	Discipline	Role / Skills
Jared Rugg	ME	Team Leader
Brad Sawyer	ME	Lead Engineer
Jeff Bird	ME	Team Member
Tom Gorevski	EE	Team Member
Fahad Masood	EE	Team Member

Customer Needs

Needs	Importance	Description	Comments/Status
1	9	Provide forced air flow to fire in current RIT stove design	
2	3	System easily removed from stove	
3	9	Cheap cost of system	
4	3	5 year life span (3x use per day)	
5	9	No user interaction for system protection	
6	3	Variable flow rate control	
7	3	User-friendly operation	
8	1	Well packaged system	
9	3	Operational in harsh environments	
10	9	Works with charcoal fire	
11	3	Ability to charge auxiliary device	
12	3	Plan to apply to team 11461's stove	
13	1	Fan runs at start-up	
14	9	Safe to operate	
15	9	System must be transportable	
16	9	Thermoelectric use	

Importance Scale: 1 – Low Importance, 3 – Moderate Importance, 9 – High Importance

Engineering Specifications

Spec	Description	Importance	Relates to CN	Units	Marginal	Target	Comments/Status
1	Flow rate of air into stove	9	1,6,13	kg/min	0.8-1.0	0.5-1.2	
2	Flow control settings	3	6,13	#	2	3	evenly distributed across the flow range
3	Unit price	9	3	$	30	15	
4	Coupling time with no tools	1	2,7,12	min	10	5	
5	Removal time with no tools	1	2,7,12,15	min	10	5	
6	Product life span	3	4, 9	years	3	5	Assume 3 uses per day
7	Replaceable component life span	3	4, 9	years	1	2	Rod, Fan, Battery
8	Aux charging	3	11,16	Ah		1	Based on cell phone battery/ Being able to charge ~3 phones after stove is off
9	Battery size	3	11,13,16	Wh		~3.5	Energy required to keep fan running at startup - 5 startup cycles
10	Weight	1	7,8,12,15	kg	<2.5	<2	
11	Volume	1	7,8,12,15	L	8.4	3.5	
12	Time to reach peak performance	1	13,16	min	15	10	Within 90% of SS assuming charcoal ignites instantly
13	User actions during operational cycle	3	6,7,13	#	6	4	
14	User actions to protect system	3	5,7	#	1	0	
15	Maximum temperature inside enclosure	3	1,4,9,14	°C	60	50	
16	Maximum external temperature of housing	3	7,8,14	°C	54	45	
17	Maximum temperature of hot side of TEG	9	9,16	°C	200	225	

Importance Scale: 1 – Low Importance, 3 – Moderate Importance, 9 – High Importance

House of Quality

Develop thermoelectrically-powered fan system for use on first generation of fan stove.

				Engineering Metrics																
				Fan Specifications		Design Specifications					User Interaction				Charging		Thermoelectric		Heat Transfer	
			Customer Weights	Air flow rate	Flow control settings	Unit price	Product life span	Replaceable component life span	Weight	Volume	Coupling time	Decoupling time	Users actions during operation cycle	User actions to protect system	Auxiliary Charging	Battery size	Maximum temperature at hot side of TEG	Time to peak performance	Maximum temperature inside enclose	Maximum external temperature of housing
VOC - Affinity Groups	**CO #**	**VOC - Customer Objectives**	**Preferred Direction**	Target	Target	Down	Up	Up	Down	Down	Down	Down	Down	Down	Up	Up	Target	Down	Down	Down
Controlled airflow into bottom of stove	1	Provide forced air flow to fire in current RIT stove design	**19.0%**	9	9				1	1						1		3		
	6	Variable flow rate control		3	9	1							3		1	3	1			
	13	Fan runs at start-up		3	1								1			9		3		
Durability of product	4	5 year system life-span	**4.8%**		1		9	9												
	9	Operational in harsh environments					3	3	3	3				1					1	3
Thermoelectric Use	16	Thermoelectric use	**23.8%**			3	1	1							3	1	9	9	3	
	11	Ability to charge auxiliary device							1	1					9	3	3	1	1	
	10	Works with charcoal fire															9		3	3
Ease of operation	7	User-friendly operation	**9.5%**		3				3	3	3	3	3	3	3					1
Cost	3	Cheap cost of system	**28.6%**		3	9	1	1	3	3						3				
Safety	5	No user interaction for system protection	**14.3%**										3	9					1	
	14	Safe to operate			1				3	3			1	3						9
Means of attachment	8	Well packaged system	**0.0%**		1			3	3	3	1	1			1				1	9
	12	Plan to apply to 11461's stove							3	3	3	3								
	15	System must be transportable							3	3	3	3				3				
	2	System easily removed from system				1	3		3	3	9	9								
		Measure of Performance		kg/min	#	$	years	years	kg	L	min	min	#	#	Ah	Wh	°C	min	°C	°C
		Nominal Value		0.5-1.2	3	15	5	2	2	3.5	5	5	4	0			225	10	50	45
		Marginal Value		0.8-1.0	2	30	3	1	2.5	8.4	10	10	6	1	1	~3.5	200	15	60	54
			Raw score	1.71	2.9	3.29	0.95	0.95	1.33	1.33	0.29	0.29	0.71	1.57	1	1.29	2.14	2.71	0.86	0.1
			Relative Weight	7%	12%	14%	4%	4%	6%	6%	1%	1%	3%	7%	4%	5%	9%	12%	4%	0%

Morphological Chart

Functions	Means 1	Means 2	Means 3	Means 4	Means 5	Means 6
Provide air to stove fire	Fan	Compressed air source	Bellows			
Provide heat to hot side of power generating device	Metal rod	Contact block	Direct contact			
Control temp at the hot side of the power generating device	Temp sensor/reduced fan speed	Wax	Rod/Block sizing			
Convert heat into electricity	Thermoelectric					
Provide power to air flow device	Battery	Thermoelectric				
Provide cooling to cold side of power generating device	Heat sink	Tube/liquid cooling	Wax			
Control temp at the cold side of power generating device	Fan speed					
Connect/disconnect device from stove	Long bolts	Dowels	Stand	Hook system	Latches	Track system
Control air flow	Throttling	Fan speed	Adjustable scoop/bypass			
Store electrical energy	Battery					
Control electrical energy flow	Well designed circuit (flip-flops, op-amps)					
Enclose system/protect user	Metal case	Fully-enclosed components	Heat conduction barriers			
Provide auxiliary power hook-up	USB port					

Function Pugh Diagrams

	Provide air to stove fire		
Selection Criteria	**Fan (Reference)**	**Compressed Air**	**Bellows**
Cost	0	-	-
Complexity	0	-	-
Life-span	0	-	+
Durability	0	-	+
Safety	0	-	+
Packagability	0	-	-
Efficiency	0	-	-
Functionality	0	-	-
Sum + 's	0	0	3
Sum 0's	0	0	0
Sum -'s	0	8	5
Net Score	0	-8	-2
Rank	1	3	2
Continue?	Yes	No	No

	Control air flow		
Selection Criteria	**Fan Speed (Reference)**	**Bypass/Scoop**	**External Scoop**
Cost	0	-	+
Complexity	0	-	+
Life-span	0	0	0
Durability	0	+	+
Safety	0	0	-
Packagability	0	-	0
Efficiency	0	+	0
Functionality	0	0	+
Sum + 's	0	2	4
Sum 0's	0	3	1
Sum -'s	0	3	3
Net Score	0	-1	1
Rank	2	3	1
Continue?	Yes	No	Yes

	Control Temp on Hot Side of TE			
Selection Criteria	Temp Sensor	Wax	Rod/Block Sizing (Reference)	Bimetallic
Cost	-	-	0	0
Complexity	-	-	0	0
Life-span	-	0	0	0
Durability	-	-	0	0
Safety	+	+	0	+
Packagability	0	-	0	-
Efficiency	+	0	0	+
Functionality	+	+	0	+
Sum + 's	3	2	0	3
Sum 0's	1	2	0	4
Sum -'s	4	4	0	1
Net Score	-1	-2	0	2
Rank	3	4	2	1
Continue?	No	No	Yes	Yes

	Control Temp on Cold Side of TE		
Selection Criteria	Heat Sink (Reference)	Heat Pipe	Wax
Cost	0	-	0
Complexity	0	-	-
Life-span	0	0	0
Durability	0	0	0
Safety	0	-	0
Packagability	0	-	-
Efficiency	0	+	0
Functionality	0	0	-
Sum + 's	0	1	0
Sum 0's	0	3	5
Sum -'s	0	4	3
Net Score	0	-3	-3
Rank	1	2	2
Continue?	Yes	No	No

	Provide heat to TE	
Selection Criteria	**Rod (Reference)**	**Direct Mount TE**
Cost	0	+
Complexity	0	+
Life-span	0	+
Durability	0	0
Safety	0	-
Packagability	0	+
Controllability	0	-
Functionality	0	0
Sum + 's	0	4
Sum 0's	0	2
Sum -'s	0	2
Net Score	0	2
Rank	2	1
Continue?	Yes	Yes

	Power Generation and Storage		
Selection Criteria	**TE**	**Battery**	**TE & Battery (Reference)**
Cost	-	0	-
Complexity	+	0	-
Life-span	0	0	+
Durability	0	0	0
Safety	+	0	-
Packagability	+	0	-
Efficiency	-	0	+
Functionality	-	0	+
Sum + 's	2	0	3
Sum 0's	2	0	1
Sum -'s	4	0	4
Net Score	-2	0	-1
Rank	3	1	2
Continue?	No	No	Yes

	Enclose Components			
Selection Criteria	**Metal Case**	**Fully-enclosed components**	**Heat Conduction Barriers**	**No enclosure (Reference)**
Cost	-	-	-	0
Complexity	-	-	-	0
Life-span	+	+	+	0
Durability	+	+	+	0
Safety	+	+	+	0
Packagability	-	-	-	0
Functionality	+	0	0	0
Sum + 's	4	3	3	0
Sum 0's	0	1	1	6
Sum -'s	3	3	3	0
Net Score	1	0	0	0
Rank	1	2	2	2
Continue?	Yes	Yes	Yes	No

	Enclosure Location	
Selection Criteria	**Base Attachment**	**Side Attachment (Reference)**
Cost	-	0
Complexity	-	0
Life-span	0	0
Durability	-	0
Safety	+	0
Packagability	-	0
Efficiency/Power Consumption	-	0
Functionality	0	0
Sum + 's	1	0
Sum 0's	2	0
Sum -'s	5	0
Net Score	-4	0
Rank	2	1
Continue?	No	Yes

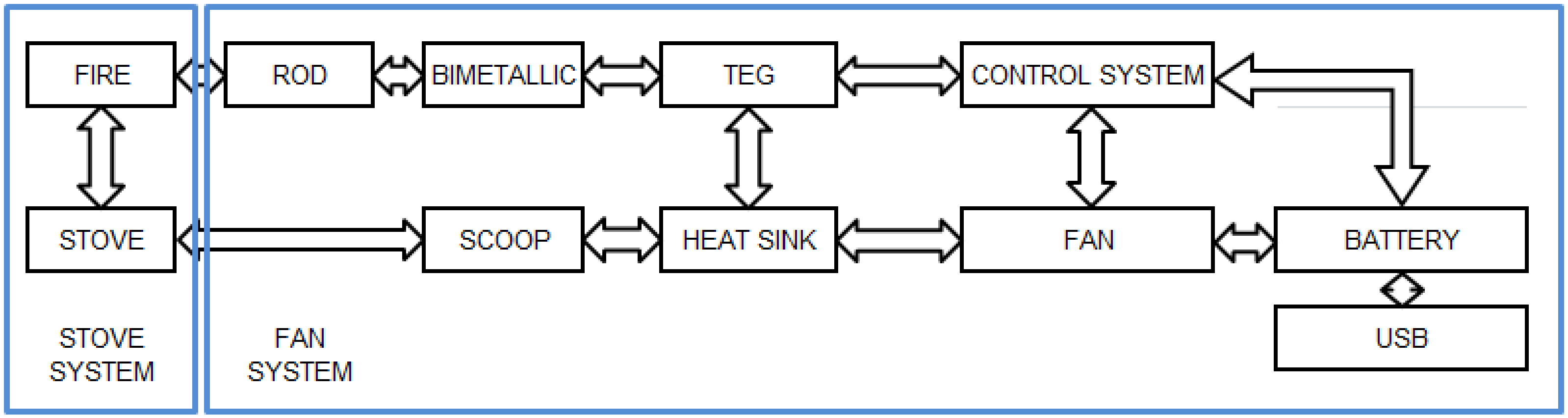
	Side Mount Mechanisms				
Selection Criteria	Long Bolts (Reference)	Dowels	Hook System	Latches	Track System
Cost	0	0	0	-	-
Complexity	0	0	-	-	-
Life-span	0	-	0	0	0
Durability	0	-	0	-	0
Safety	0	-	-	0	0
Packagability	0	+	0	0	-
Functionality	0	0	0	0	0
Sum + 's	0	1	0	0	0
Sum 0's	0	3	5	4	4
Sum -'s	0	3	2	3	3
Net Score	0	-2	-2	-3	-3
Rank	1	2	2	3	3
Continue?	Yes	Yes	Yes	Yes	No

Concepts					
Function	**A**	**B**	**C**	**D**	**E**
Airflow	Fan	Fan	Fan	Fan	Fan
TEG heating	Metal rod	Metal rod	Direct Contact	Metal rod	Direct Contact
"Hot side" temp control	Rod sizing	Bimetallic	Bimetallic	Rod sizing	Bimetallic
Heat to electrical	TE	TE	TE	TE	TE
Power fan	TE/Battery	TE/Battery	TE/Battery	TE/Battery	TE/Battery
TEG cooling	Heat sink	Heat sink	Heat sink	Heat sink	Heat sink
"Cold side" temp control	Fan speed	Fan speed	Fan speed	Fan speed	Fan speed
Attachment	Hook	Long bolts	Long bolts	Tape	Hook
Flow control	External Scoop	Fan speed	External Scoop	Fan Speed	Fan Speed
Energy storage	Battery	Battery	Battery	Battery	Battery
Control electricity	Circuit	Circuit	Circuit	Flip-flop/buck-boost	Circuit
Enclosure	Metal case	Metal case	Metal case	No enclosure	Metal case
AUX	USB port	USB port	USB port	USB	USB port

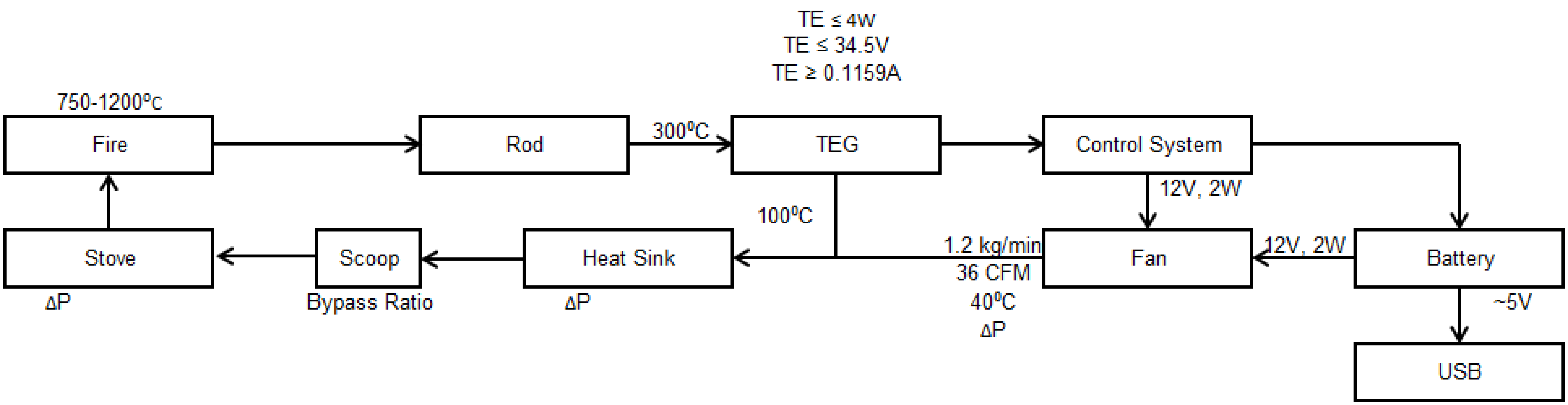
	Overall Concept Comparison				
Selection Criteria	**A**	**B**	**C**	**D (Reference)**	**E**
Cost	-	-	0	0	0
Complexity	-	-	-	0	+
Life-span	+	+	+	0	+
Durability	+	+	+	0	+
Safety	+	+	+	0	+
Packagability	-	0	+	0	+
Efficiency/Power Consumption	+	+	+	0	+
Functionality	+	+	+	0	+
Controllability	+	+	+	0	-
Sum + 's	6	6	7	0	7
Sum 0's	0	1	1	9	1
Sum -'s	3	2	1	0	1
Net Score	3	4	6	0	6
Rank	3	2	1	4	1
Continue?	No	Yes	Yes		Yes

Proposed Concept Design

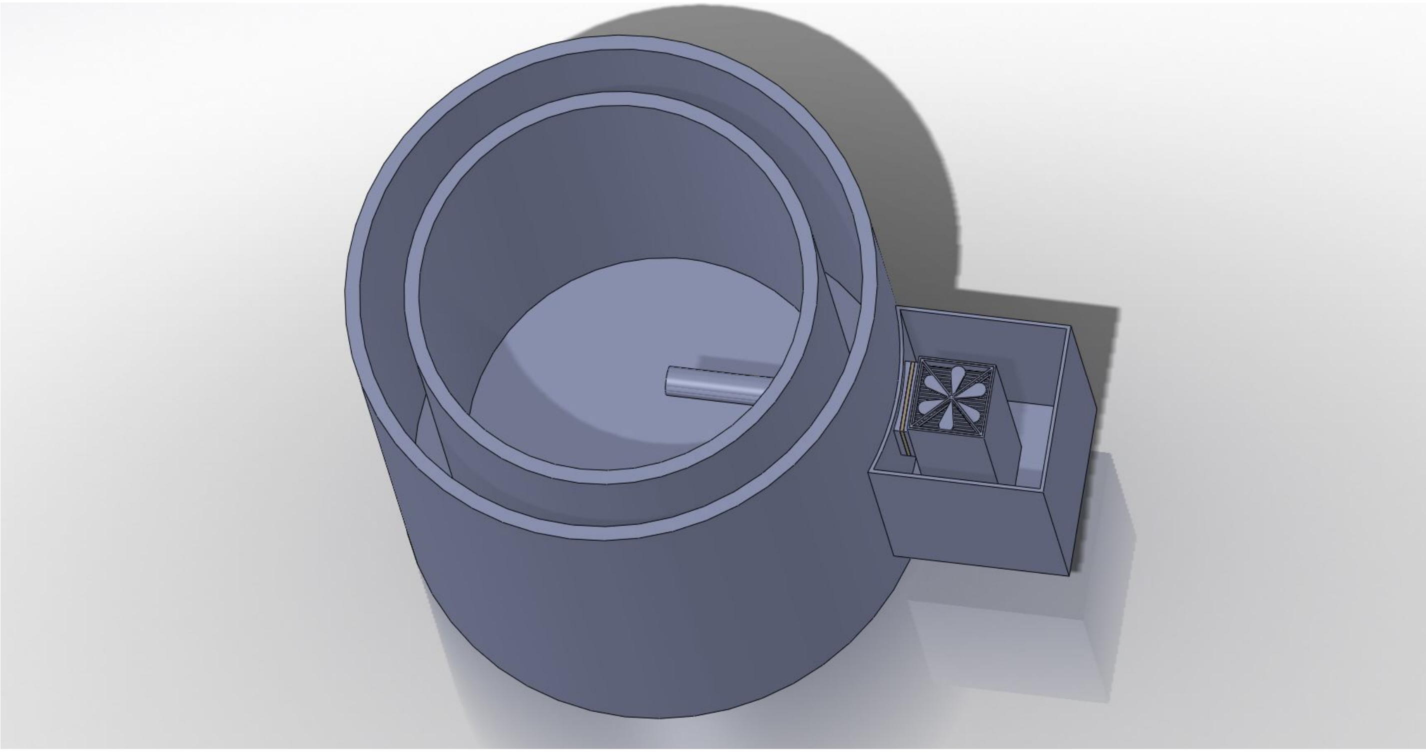
<u>Subsystem Interfaces</u>

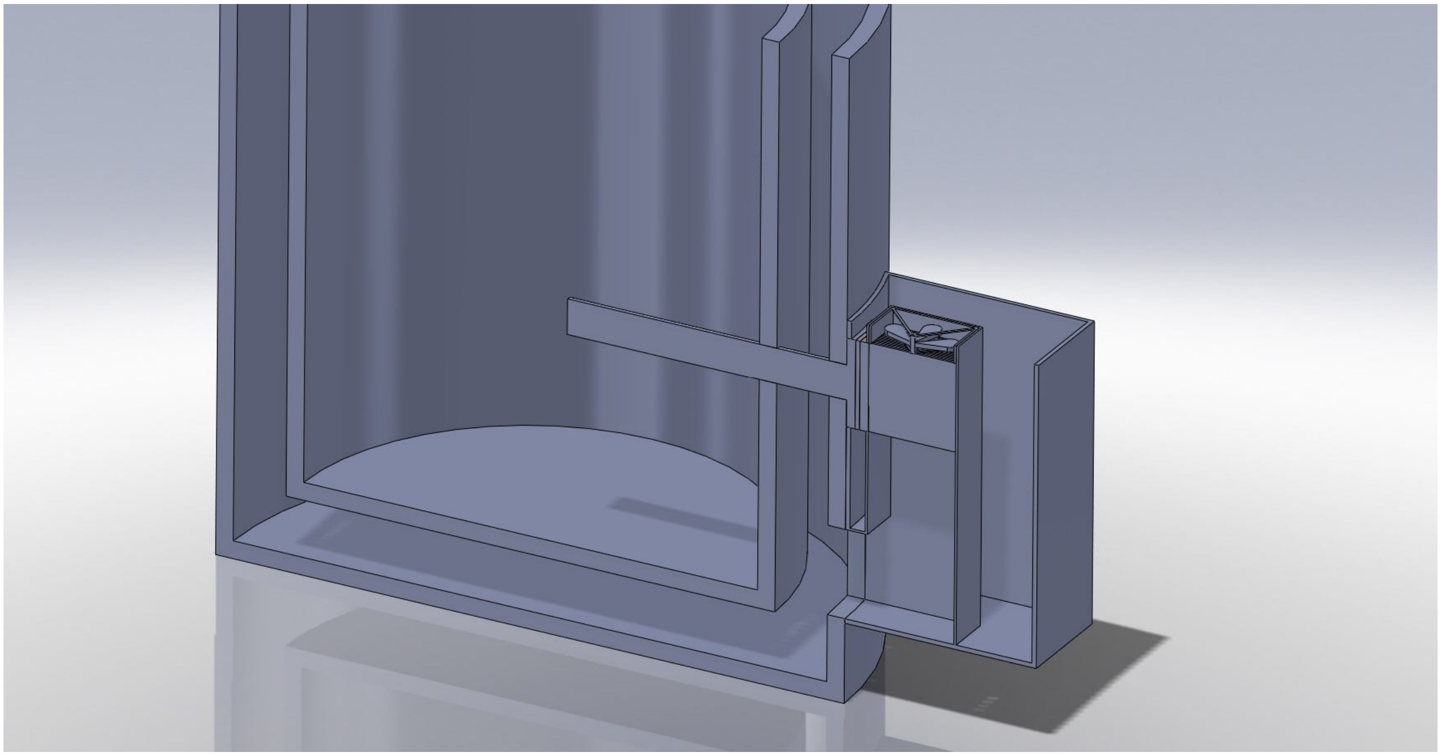


<u>Energy Flow</u>



Preliminary Mock-up



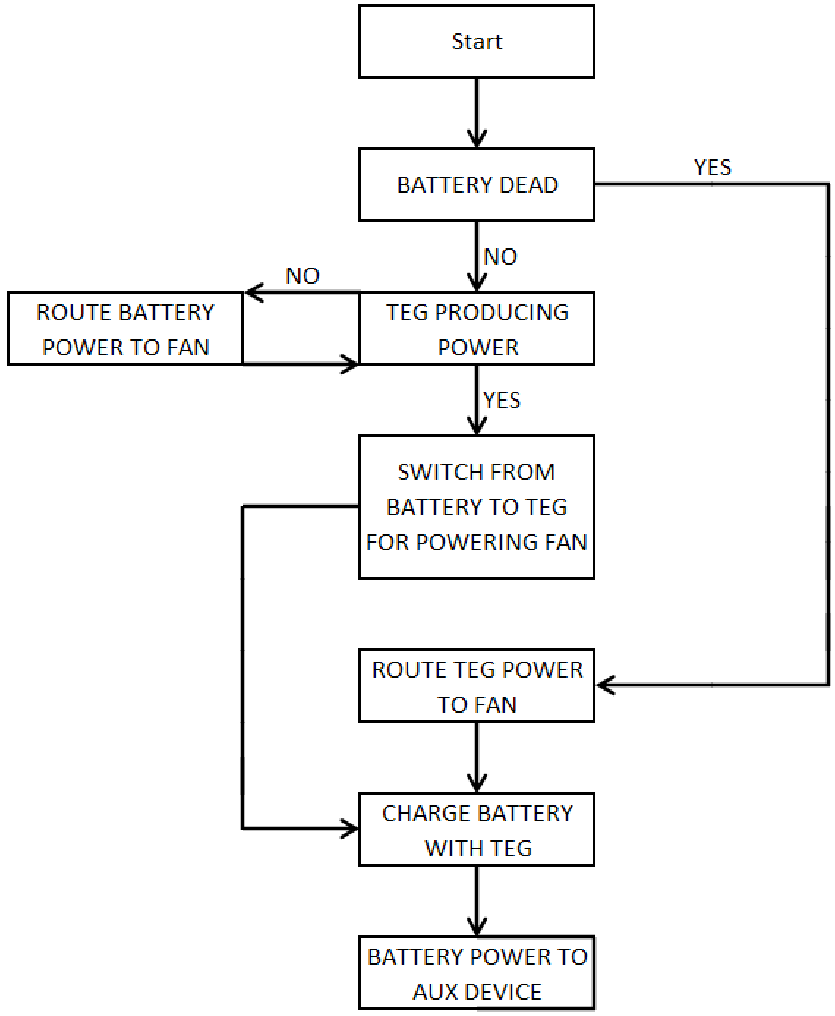


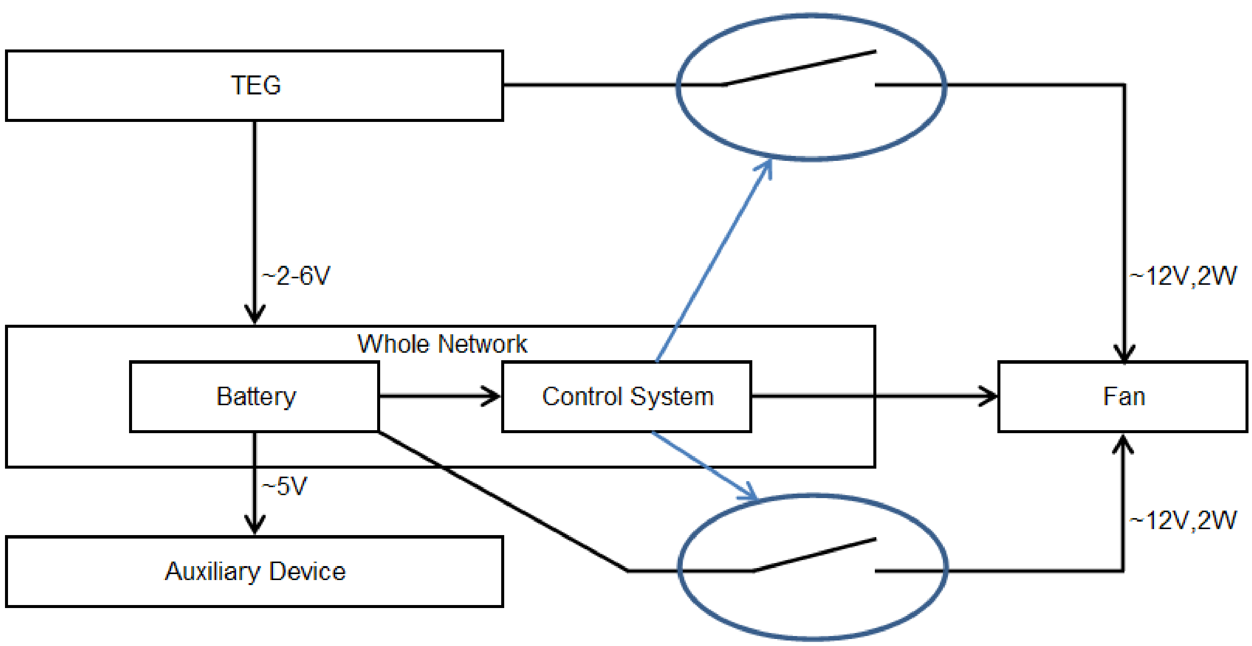
Links

http://www.customthermoelectric.com/powergen/pdf/1261G-7L31-10CX1_R2_spec_sht.pdf

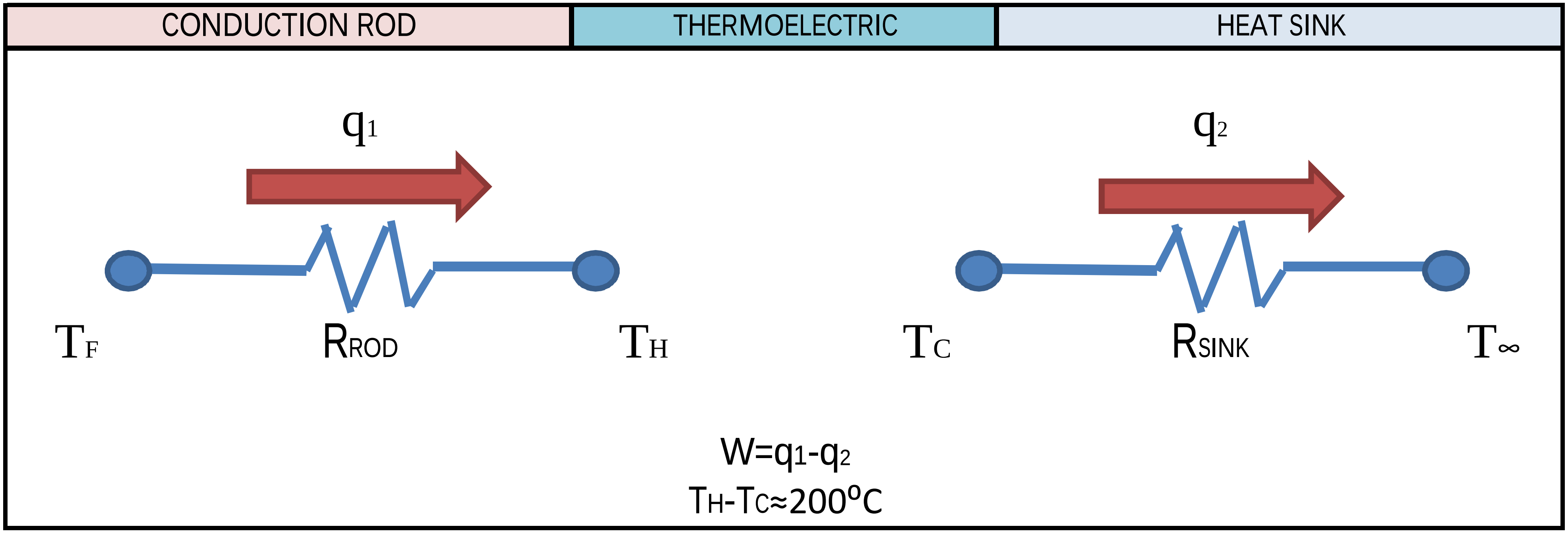
http://www.trianglecables.com/80sundcbalbe.html?utm_source=80sundcbalbe&utm_medium=shopping%2Bengine&utm_campaign=FROOG

Electrical System Design

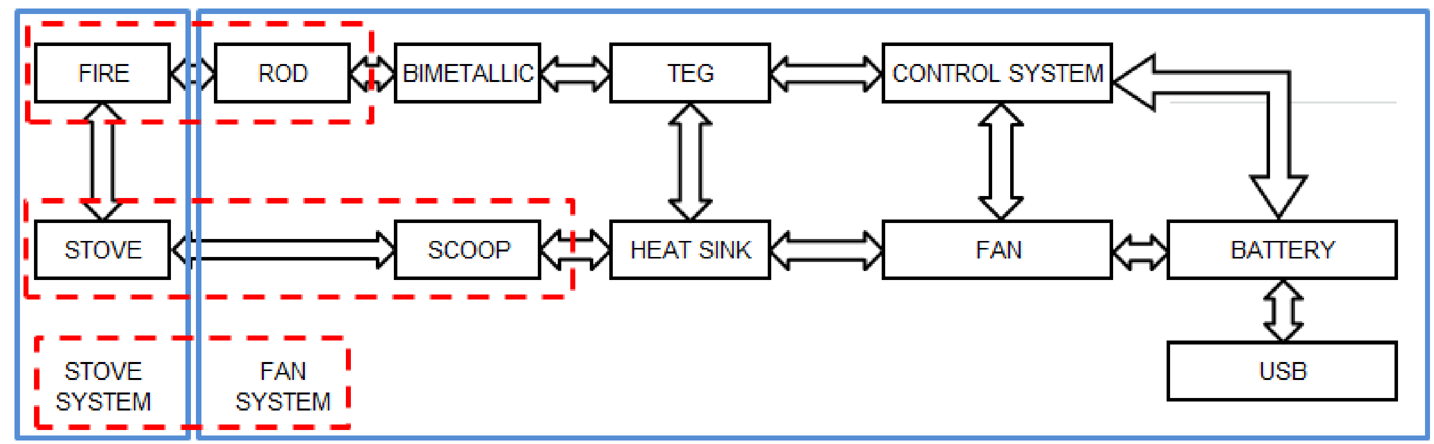




Initial Thermal Analysis Diagram



<u>Project Interfaces</u>



	11462 INTERFACE	STOVE INTERFACE	DEFINING FEATURES	CRITICAL SPECS			
INTERFACE 1	Heat Rod	Fire	Heat rod will take energy from fire. Heat rod will penetrate stove walls.	Diameter of rod	Fire Temperature		
INTERFACE 2	Duct Coupling	Stove Housing	Ducting will provide air flow at a given pressure. Duct will provide air into stove through square shaped hole in the outer wall of stove.	Dimensions of ducting	Location of entrance	Flow Rate	Pressure Drop
INTERFACE 3	Device Attachment	Stove Housing	The fan system will attach to the outside wall of the stove	Location of device on exterior of stove	Method of attachment	Architecture of exterior of stove	

Risk Assessment

ID	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
Risks Involved with Thermoelectric Generator								
1	TEG overheat	Total System Failure	Inadequate heat transfer control	2	3	6	In-depth heat transfer including FEM, testing	Jeff
2	Insufficient TEG cooling	Unsustainable operation	Heating up of TEG cold side	2	2	4	In-depth heat transfer including FEM, testing	Brad
3	Unable to maintain max TEG efficiency	TEG capabilities not optimized	Transient effect on components	2	2	4	In depth analysis(TEG I-V characteristics), Testing	**Tom**/Jeff
4	Inability to accurately model TEG	Optimal power not being used	TEG model changes as heat is consistently applied	2	2	4	In depth analysis(TEG I-V characteristics) / Testing	**Jeff**/Tom
5	TEG power producing capacity too small	Underpowered system	Unable to meet required ΔT or TEG incapable of producing required power	1	3	3	Design with minimal power consumption / Design to required specs using amplifiers.	**Jeff**/Tom

ID	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
Risks Involved with Battery/Charging System								
6	Battery failure/destruction	Total system failure	Poor battery sizing, excessive heat	2	3	6	Proper battery sizing, means to bypass battery	Fahad
7	Electrical components fail/overheat	System Failure	Excessive heating to components. Complicated design.	2	3	6	Keep components insulated and distant from heat. Simplify design to incorporate as little components as possible.	Fahad
8	Faulty design of control system	System failure	Components not sized properly or break due to overheating from fire	2	3	6	Design system in insulated location / In depth analysis of design requirements.	Tom/**Fahad**
9	Battery doesn't charge	Fan won't start immediately. Aux. device won't charge.	Poor battery sizing, too little current to battery, battery malfunction	2	2	4	Size the battery more accurately through better testing. Allow TEG to charge aux device.	Fahad
10	Battery is drained	Fan won't start immediately. Aux. device won't charge.	Battery too small and doesn't hold charge well. Excessive user interaction	3	1	3	Test battery many times to ensure charge is held. Incorporate an LED warning system to tell user that battery is drained.	Fahad

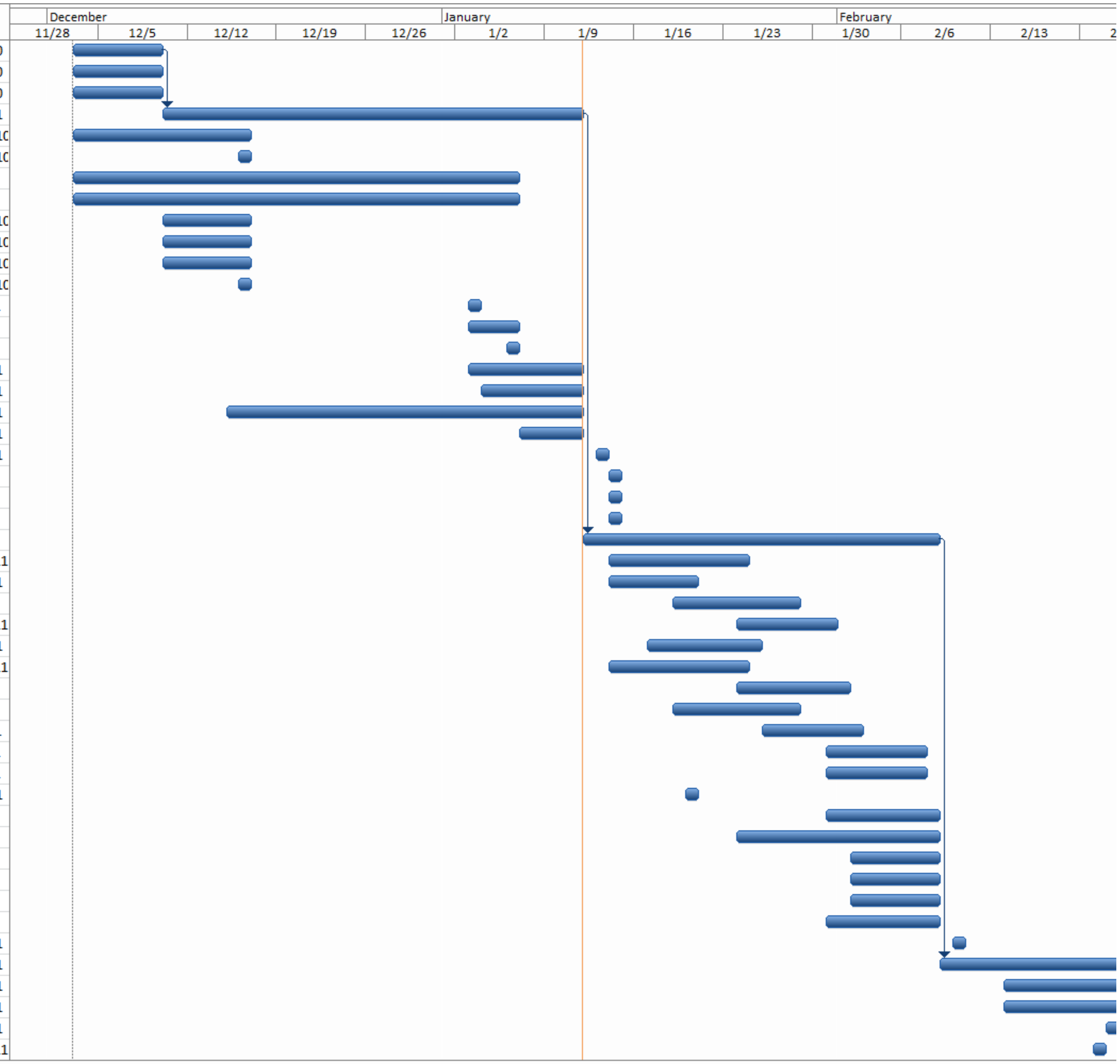
ID	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
Risks Involved with Fan								
11	Fan produces insufficient pressure drop	Forced air unable to reach fire	Poor modeling/testing of stove	2	2	4	Increase flow rate, Provide more power to fan.	Jared
12	Fan melts	Loss of airflow, main system failure	Fan placed too close to stove, stove heat estimated	1	3	3	Testing to correctly estimate temperatures at proposed location	Jared
13	Fan requires too much power	Fan will drain power from battery, overdraw TE	Poor fan selection or design, fan failure	1	2	2	Apply margin on battery size or fan sizing	Jared

ID	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
Risks Involved with Conduction Rod								
14	Heat conduction rod melting	Possible loss of heat transfer to thermoelectric	Inadequate analysis of stove operating temperatures and material properties	2	3	6	Analyze stove operating temperatures. Carefully select material to suit	Brad
15	Heat conduction rod conducts too much/not enough heat	Possible overheating of thermoelectric/ Insufficient power generation	Inadequate heat transfer analysis	2	3	6	Complete analysis of heat transfer characteristics of rod/block. Average stove operating temperatures taken into consideration	Brad
16	Rod takes too long to heat up	Improper system function. Fan may not operate at start-up	Inadequate transient heat transfer analysis. Inadequate understanding of transient temperatures in combustion chamber.	2	2	4	Test stove to get understanding of transient temperatures. Model transient temperature characteristics of rod.	Brad

ID	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
Risks Involved in General System/Project Management								
17	Transient modeling	Forced induction to fire may fail at start-up or battery will be drained	Insufficient transient heat transfer modeling. Insufficient energy storage capabilities	3	2	6	Rigorous transient heat transfer analysis. Careful selection of heat transfer method and materials. Testing of stove (transient temps)	Brad/Tom
18	Inadequate means to prototype (tooling)	Failure to provide prototype for testing. Failure to deliver product.	Complex components, exotic manufacturing methods (CNC), insufficient thought given to lead times.	2	3	6	Consider means of production when in design process. Plan ahead for lead times.	Brad
19	Casing conducts too much heat	Jeopardize user safety	insufficient insulation	2	3	6	Testing for the radiant heat near controls / Design for better flow control	Jeff
20	Product Cost	Over acceptable/affordable value for Haitians	Excessive component cost	2	2	4	Design based on cost, Accurately log expenditures.	Jared
21	Insufficiently connects to stove	Failure to meet CN 9,10. Possible damage to unit.	Poor design planning	2	2	4	Decide on robust design early in design process and test design. Tests should include durability testing.	Brad

Proposed Schedule

ID	Task Name	Duration	Start	Finish
1	Project Planning	5 days	Fri 12/3/10	Thu 12/9/10
2	Identify team roles	5 days	Fri 12/3/10	Thu 12/9/10
3	Agree to Team Values and Norms	5 days	Fri 12/3/10	Thu 12/9/10
4	System Level Design	23 days	Fri 12/10/10	Tue 1/11/11
5	Setup interviews with stakeholders	10 days	Fri 12/3/10	Thu 12/16/10
6	Mini-lecture on TE	1 day	Thu 12/16/10	Thu 12/16/10
7	Tabulate customer needs	25 days	Fri 12/3/10	Thu 1/6/11
8	Tabulate engineering specs	25 days	Fri 12/3/10	Thu 1/6/11
9	Establish subsystem functions	5 days	Fri 12/10/10	Thu 12/16/10
10	Research function solutions	5 days	Fri 12/10/10	Thu 12/16/10
11	Brainstorm function solutions	5 days	Fri 12/10/10	Thu 12/16/10
12	Fill out 1st Peer Evaluations	1 day	Thu 12/16/10	Thu 12/16/10
13	Down-select to feasible solutons	1 day	Mon 1/3/11	Mon 1/3/11
14	Perform Pugh analysis of solutions	4 days	Mon 1/3/11	Thu 1/6/11
15	Select solution	1 day	Thu 1/6/11	Thu 1/6/11
16	Establish subsystem interface specs	7 days	Mon 1/3/11	Tue 1/11/11
17	Create illustrations of system architecture	6 days	Tue 1/4/11	Tue 1/11/11
18	Identify risks	20 days	Wed 12/15/1	Tue 1/11/11
19	Perform initial proof-of-concept calculations and simula	3 days	Fri 1/7/11	Tue 1/11/11
20	Systems Level Design Review	1 day	Thu 1/13/11	Thu 1/13/11
21	Finalize Costumer Needs	1 day	Fri 1/14/11	Fri 1/14/11
22	Finalize Engineering Specs	1 day	Fri 1/14/11	Fri 1/14/11
23	Update risk assessment	1 day	Fri 1/14/11	Fri 1/14/11
24	Detailed Design	20 days	Wed 1/12/11	Tue 2/8/11
25	Perform analysis of necessary fan size	7 days	Fri 1/14/11	Mon 1/24/11
26	Reseach USB attachment specs	5 days	Fri 1/14/11	Thu 1/20/11
27	Perform heat sink sizing analysis	8 days	Wed 1/19/11	Fri 1/28/11
28	Test heat sink equivalent for performance curves	6 days	Mon 1/24/11	Mon 1/31/11
29	Perform analysis of TE for performance curve	7 days	Mon 1/17/11	Tue 1/25/11
30	Perform thermal conductor sizing analysis	7 days	Fri 1/14/11	Mon 1/24/11
31	Test thermal conductor equivalent for performance curv	7 days	Mon 1/24/11	Tue 2/1/11
32	Perform battery sizing analysis	8 days	Wed 1/19/11	Fri 1/28/11
33	Design control system	6 days	Wed 1/26/11	Wed 2/2/11
34	Design housing	6 days	Mon 1/31/11	Mon 2/7/11
35	Design attachment system	6 days	Mon 1/31/11	Mon 2/7/11
36	Fill out 2nd Peer Evaluations	1 day	Thu 1/20/11	Thu 1/20/11
37	Create illustrations of subsystem analyses	7 days	Mon 1/31/11	Tue 2/8/11
38	Establish test procedures for MSD II	12 days	Mon 1/24/11	Tue 2/8/11
39	Tabulate BOM w/ vendors, lead times, prices	5 days	Wed 2/2/11	Tue 2/8/11
40	Produce rough prototype	5 days	Wed 2/2/11	Tue 2/8/11
41	Review and update risk assessment	5 days	Wed 2/2/11	Tue 2/8/11
42	Create DDR Technical Handout	7 days	Mon 1/31/11	Tue 2/8/11
43	Detailed Design Review	1 day	Thu 2/10/11	Thu 2/10/11
44	Project Review	10 days	Wed 2/9/11	Tue 2/22/11
45	Apply DDR take-aways to analyses	7 days	Mon 2/14/11	Tue 2/22/11
46	Finalize documentation	7 days	Mon 2/14/11	Tue 2/22/11
47	Project Management Review	1 day	Tue 2/22/11	Tue 2/22/11
48	Fill out 3rd Peer Evaluations	1 day	Mon 2/21/11	Mon 2/21/11



Work Breakdown Structure

Component/Subsystem	***Owner***	***Tasks Involved***
Fan	Jared	Size fan for flow, determine power requirements, determine fan mounting position and method of mounting, determine fan cost, test fans for flow and power needs at given flow rates.
Heat Conduction Rod	Brad	Size rod for required heat transfer, analyze combustion chamber temperatures, test rod temperatures in stand-alone tests, and use FEM to study transient heat transfer characteristics.
T.E.G	Tom	Model electrical behavior of TEG under load, conduct tests to determine true output of TEG with given ΔT, test effects of given electrical loads on TEG.
Heat Sink	Jeff	Conduct feasibility study for different heat sink sizes at given heat flux, determine projected air flow across heat sink (coordinate with Jared), model heat transfer capabilities of heat sink, and test heat transfer capabilities of heat sink.
Control System (Power Distribution)	Tom	Determine desired function of control system, develop schematics of electrical system, run simulations of electrical system, determine effects of electrical system on TEG
Battery	Fahad	Determine energy needs of system, size battery according to energy needs of system, determine effect of battery charging on TEG output (Coordinate with Tom). Determine feasibility of battery location. Conduct tests determining battery charging characteristics and battery power output to fan.
Auxiliary Device Charging	Fahad	Determine location of auxiliary charging port, determine power needs of auxiliary devices, communicate power needs to Control System owner, test ability of system to charge auxiliary device.
System Enclosure	Jeff	Coordinate with all other owners regarding space needs, determine enclosure materials and enclosure architecture, analyze heat transfer characteristics of enclosure, and determine possible means to produce enclosure.
Attachment to Stove	Brad	Determine durability of attachment method, consider ergonomic factors, study cost of attachment method
T.E.G Thermal Protection (Bimetallic)	Jared	Determine feasibility of bimetallic system, determine cost of bimetallic, test bimetallic device in temperature test.