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February 06, 2012

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specification for a Rain and Solar Power Generator

Dear Dr. Rawicz:

The attached document, *Function Specification for a Rain and Solar Power Generator*, outlines the functional specification for our project for ENSC 440 (Engineering Science Project). Our achievement is to design and implement a power generator which can create electricity for sunny and rainy weather conditions. Our project uses green energy that will cause no effect on nature.

Our functional specification outlines high level requirements for its various production phases of development. All information in this document will justify the demand and development of our project.

Green Power Innovation consists of five skilled, hard-working, and talented fourth-year engineering students: Frank Feng, Zhiyu Hu, Max Liu, Jeff Bian, and Xiao Dong. If you have any questions or concerns about our proposal, please feel free to contact me by phone at (778) 996-5591 or by e-mail at ffa5@sfu.ca.

Sincerely,

Frank Feng
President and CEO
Green Power

Enclosure: *Functional Specification for a Rain and Solar Power Generator*

2012

Functional Specification for a Rain & Solar Power Generation System

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EXECTIVE SUMMARY

Clean energy is specifically refers to energy produced usually from renewable resources without creating environmental debt [1]. The basic forms of clean energy are often cited as those that come from water, wind, or sun solar [2]. Nowadays, renewable energy has played an urgent and substantial role in our energy supply. There are important initial costs that support them, but these costs are absolutely dwarfed by those the world economy will have to bear in trying to adapt to the worst impacts of climate change - not to mention the tragic human and environmental consequences that would come with it [3]. Supporting renewable energy is more important than ever before.

Our company develops a renewable energy generator system that consists of a rain power generator and a solar power generator. The device will collect thee raindrops and sunlight to produce electrical power. In addition, the system will be highly effective in all space and climate.

The functional specification covered in this document is designed and implemented for the prototype version of the rain and solar generation system. This prototype is only shows a model of the system, however, for example, all the roof area of the building could be collecting raindrops for create electric energy.

The design and implementation of our product will be accomplished with an expected date of completion of April 20, 2012.

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Glossary

GPI	Green Power Innovations
ISO	International Organization for Standardization
OSHA	Occupational Safety and Health Standards
RSPG	Rain and Solar Power Generator
SPG	Solar Power Generator
RPG	Rain Power Generator
UI	User Interface

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1 Introduction

The Rain and Solar Power Generator (RSPG) system, which collects green energy, is a new style design. The system collects solar power and raindrops to create electric power. This document details the functional specifications for the RSPG system proposed by GPI.

1.1 Scope

This document outlines the functional requirements for our product. All requirements are fully described for both proof-of-concept device and production device. The requirements provide by this document will be used to guide the design of RSPG system in the future development.

1.2 Intended Audience

The functional specifications shall be used by all five GPI members. The project manger shall use this document to track the process and accuracy of developed product. Test engineers shall use this document for reliability testing. Design engineers will follow this document as the guideline for development and production.

1.3 Classification

Throughout this document, the following convention will be used to denote functional requirements:

[Rn-P] **A functional requirement.**

Where 'n' is the functional requirement number and 'p' is the priority of the functional requirement. The priority is shown below:

I First Priority; the requirement must applied to prototype.

II Secondary Priority; the requirement will applies to prototype if time permits.

III Tertiary priority; the requirement will applies to the final production system only not planned for prototype.

2 System Requirements

General requirements regarding to the Rain & solar power generation system are presented in this section.

2.1 System Overview

An overview figure and physical parts of Solar and rain power generation system are given as **Figure 1** and **Figure 2**.
It's clear from the name that the Solar & Rain power generations system has two major function parties: Solar power generator and rain power generator. As shown in figure 1, these two function parties will be both selected and converted though a current & voltage regulation and then could be used to charge battery or provide power for local load.

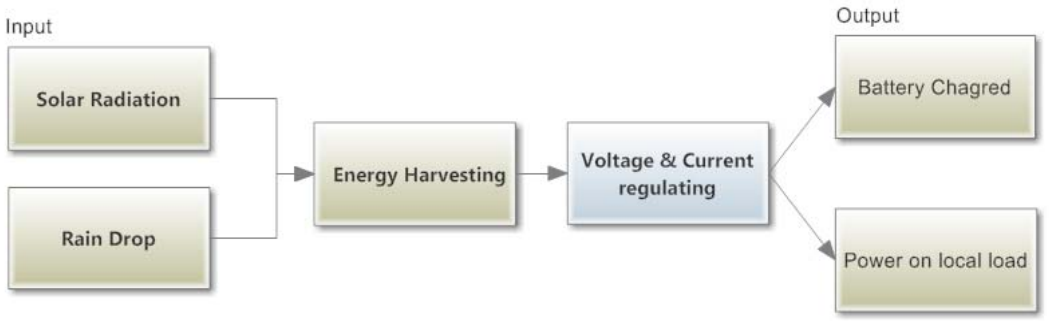

Figure 1: System Function Block Diagram

Due to the limited time and financial budget in the initial project development stage, Figure 2 only lists few representative components. The corresponding parts are Satellite Dish, Solar Panel, Pumping System, and Rain Power Generator Box.

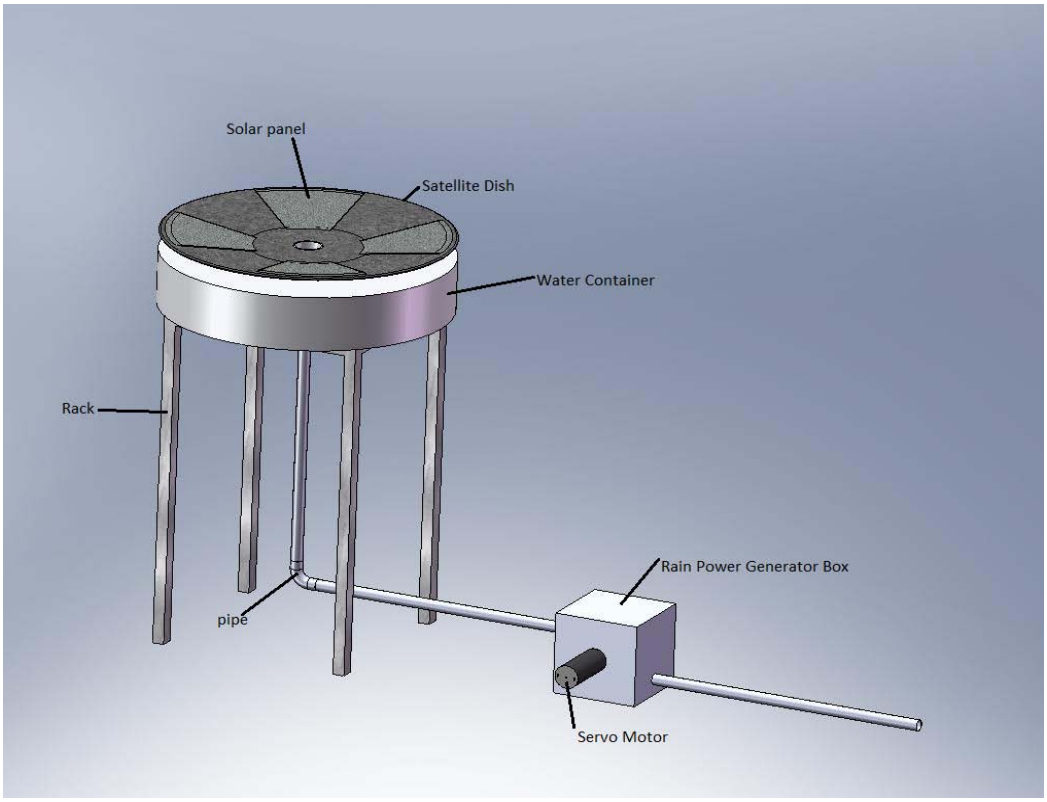

Figure 2: System Physical Block Scope

The satellite dish function mainly acts as a rain harvester whose shape and material is suitable for various climate and environmental conditions [4].

There are several solar panels attached along the satellite dish surface which will collect solar energy. In this case, these solar panels should be flexible and also immune to deformation due to the frequently temperature change and extreme weathers.

The pumping system consists of the water tank, water pipe, and supporting rack. Water tank stores appropriate amount of water to maintain water level at a relative height which is sufficient to pressurize the rain power generation box. Water pipe guides pressurized water to rain power generation box. Supporting rack directly attaches to only the low surface of the water tank and bears the above system.

Rain power generator box consists of two main components: turbo fan and servo motor. Turbo fan transforms the water gravity energy to rotational energy, also drives rotors and cuts magnetic field which convert the gravity energy to electric energy.

2.2 General Requirements

[R1- I] **The system must be easily assembled and disassembled.**

[R2- II] **The system can be placed at different landscapes.**

[R3- II] **The system must has a locking state which prevents disjoint unless user intents to do so.**

[R4- II] **The system shall have a maximum cost of $1000[1]. [5]**

2.3 Physical Requirements

[R5- I] **The system shall have a variable size according to different requirements.[2]**

[R6- II] **The system's outlook shall fit in a local landscape.**

[R7- II] **The system shall fit in a maximum size of 150cm*150cm*200cm.**

2.4 Electrical Requirements

[R8- I] **The system must have the minimum output power of 1W.**

[R9- I] **The system output must not interference with normal 110/120V at 60Hz AC power provider.**

[R10- II] **The system should output with a DC voltage range between 1V to 25V, AC voltage 110/120 60Hz.**

2.5 Mechanical Requirements

[R11- II] **The system can be assembled without using installation tools.**

[R12- II] **Each part should be assembled with safety locks.**

2.6 Environmental Requirements

[R13- I] **The system must be used outdoors only.**

[R14- I] **The system withstands in the any weather conditions [6].**

[R15- I] **The system must operate normally under normal temperatures (above 0°C).**

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[1] Project proposal Budget is set to $808.95 but we expect $100-200 more on Pipes and Water Filter system, thus $1000 is a reasonable price. (Please refer to "Table 2 Table 2 Estimated Cost " for price information)

[2] System must designed suitable for different landscape thus the assembled system may varying with pipe length and other conditions

[R16- II] **The system generated noise shall be below 50 dB.**

[R17- III] **The noise generated during electricity generation period shall be minimized.**

2.7 Standards

[R18- III] **The systems shall conform to OSHA-1910.269 standards [7].**

[R19- III] **The systems shall conform to ISO 9001 & ISO 14001 standards [8].**

2.8 Reliability and Durability

[R20- I] **The system shall be resistant to breakage under normal weather or temperature conditions.**

[R21- I] **The user interface shall be resistant to breakage under normal operating conditions.**

[R22- III] **Regular service intervals shall be at least seasonally.**

[R23- III] **Regular cleaning service for the filtering net shall be monthly.**

[R24- III] **The whole system shall be operational for at least 5 years before requiring replacements.**

2.9 Safety Requirements

[R25- I] **The system must against water leakage anytime.**

[R26- I] **The system shall not be short circuit at all time.**

[R27- II] **All electrical devices shall be confined from water.**

[R28- II] **The system shall have protection for any electronic leakage.**

[R29- II] **The system shall have all electronic and mechanical components and power connections enclosed.**

[R31- III] **The system shall be able to detect any kind of failure and then notify the user. In this case, the system shall shut down immediately and wait for technicians to fix it.**

[R30- III] **The system shall shut down immediately when leakage happens.**

2.10 Performance Requirements

[R31- II] The system shall begin to generator power within 60 seconds.

[R32- II] The system shall continuous generating power for at least 600 seconds after activation.

2.11 Usability Requirements.

[R33- II] The system shall start generate electricity when water goes through turbo.

[R34- II] The system shall store the electricity if no indication of usage is given by the user.

[R35- II] The system shall release water automatically when certain amount of water is stored in the water tank.

[R36- III] The firmware of the system shall be upgradeable by service persons.

2.12 Luxury Functions

[R37- II] The system shall be able to let user to set up a time to release the water from the water tank.

[R38- II] The system shall warn the user when battery is full charged.

[R39- II] The system shall warn the user when less than 10 percent of electricity is left in the battery and no electricity is being generated.

[R40- II] The system shall be able to let user to set up a default usage of electricity.

[R41- III] The system shall indicate how much electricity is left and what can be done with it.

3 Satellite Dish

The satellite dish acts as solar panel to utilize sunlight. The satellite dish is used to mount the solar panels in order to generate power in sunny days. In addition, another function of the satellite dish is to transfer the rain water into the water tank (refer to 4).

3.1 General Requirements

[R42- I] The radius of satellite dish must be at least 50-70 cm.

[R43- I] The height of the satellite dish must be between 5cm and 10cm

[R44- I] There is a hole at the centre of satellite dish and the radius is between 5cm and 7cm.

[R45- I] The slope of the wall of the satellite dish must be less than 10°.

3.2 Physical Requirements

[R46- I] The radius of satellite dish must be at least 30 cm.

[R47- I] The satellite dish must be removable.

[R48- I] The satellite dish must be hard enough to afford the weight of solar panels plus raindrops.

[R49- II] The satellite dish shall have enough space for four solar panels. Each has a size of 28.8cm *19.8cm*1.8cm.

[R50- II] The filter net shall have the size as the hole (refer to 3.1), and the material shall be anti-eroded.

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4 Plumbing System

The plumbing system consists of a water tank and a long pipe. The main function is to release the water at a certain height (120 cm is the estimated value, the actual value will be determined upon testing) so as to transform the gravitational energy of water to electrical power. The end of the pipe will be directly connected to the turbine and the turbine connects to a DC motor. The function of the water tank is to store water and release it when the water level reaches full.

The following requirements for the plumbing systems reflect the guidelines prescribed by GPI.

4.1 General Requirements

[R51- I] The water tank must contain at 10-15L of water.
[R52- I] The radius of water tank must be 50-70 cm.
[R53- I] The distance between the bottom of the water tank and ground must be at least 120 cm
[R54- I] The radius of pipe has the range from 1.5 cm to 2 cm
[R55- I] The gate of water tank must be controlled by user at any time
[R56- I] The water tank and the satellite dish must be supported by a rack

4.2 Physical Requirements

[R57- I] The water tank will absolutely secure against leakage.
[R58- I] The water tank must be removable.
[R59- II] The bearing limit of rack must be at least 20kg.
[R60- II] The material of the water tank must be light, but robust, preferably plastic.
[R61- II] The material of the rack must be also light, corrosion-resistant, preferably alloy.
[R62- II] The material of the pipe must be elastic, thus easy to handle

5 Solar Power Generator

The SPG has been already developed and used in current market, the reason we add this component is that we want to make our design suitable for any weather condition. The solar panel will be even distributed on the satellite dish in order to absorb sunlight as much as possible. The solar panel will be directly connected to applications and electrical devices.

5.1 General Requirements

[R63- II] Each solar panel may has a size of 28.8cm *19.8cm*1.8cm.[3]

5.2 Physical Requirements

[R64- I] The solar panels must be waterproof
[R65- I] The solar panels must fit on the satellite dish and stationary
[R66- I] The solar panels must be suitable for prolonged outdoor use
[R67- II] Each solar panel has a weight of roughly 0.6Kg

5.3 Electrical Requirements

[R68- II] Each solar panel can generate maximum power of 5W
[R69- II] Each solar panel can generate maximum power voltage of 17.3V
[R70- II] Each solar panel has open-circuit voltage of 22V
[R71- II] Each solar panel has short-circuit current of 0.32A

5.4 Safety Requirements

[R72- I] The solar power generator must secure against electrical leakage.
[R73- I] After the solar panels withstands the specified load for some time, it has to confirm there is no obvious structural and mechanical damage

[3] Please refer to "Table 2 Table 2 Estimated Cost " from project proposal for detailed solar panel information

6 Rain Power Generator

The RPG consists of a turbine and a DC motor. The main function is to flush the rain water onto the turbine so as to make it rotate. Subsequently, the turbine will rotate the DC motor, thus, the DC motor will generate power.

6.1 General Requirements

[R74- II] The servo motor has a size of 8.255cm diameter * 21.9075cm[4]
[R75- II] The turbo blade has a size of 10 to 15 cm diameter * 3 to 5cm thickness
[R76- II] The weight of the DC servo motor is about 5.44Kg
[R77- II] The weight of the turbo blade must be at most 500g [9]

6.2 Physical Requirements

[R78- I] The motor must be isolated from water
[R79- I] The turbo blade must be anti-corrosion
[R80- II] The motor has replaceable brushes
[R81- II] The motor has a range of RPM from 50 to 1265

6.3 Electrical Requirements

[R82- II] The motor must have a range of open circuit voltage from 1.65V to 42V with given range of RPM. (Please refer to appendix for detailed Voltage VS RPM Information)
[R83- II] The motor must have a range of short circuit current from 0.6A to 15.3A with given range of RPM. (Please refer to appendix for detailed Current VS RPM Information)

6.4 Safety Requirements

[R84- I] The rain power generator must secure against electrical leakage.
[R85- I] The rain power generator must secure against water leakage.

[4] Please refer to "Table 2 Table 2 Estimated Cost " from project proposal for detailed motor information

7 User Interface

The UI consists of a bunch of input buttons and a monitory panel. The user interface unit can allow user to select different power generation mode, as well as monitory system states.

7.1 General Requirements

[R86- II] The user can turn on or turn off the switch of water container immediately with a control panel consisting of some push buttons and switches.

[R87- II] The outputs on the user interface unit shall consist of status indicators to indicate the power generation mode.

[R88- II] The outputs on the user interface unit shall consist of battery status indicator.

[R89- II] The user can choose to store electricity into the battery or consume electricity immediately.

7.2 Usability Requirements

[R90- I] The user shall indicate through the user interface when the electricity is ready for using.

[R91- II] The user interface must be convenient and precisely indicating the status.

[R92- II] The control panel shall have the input lock feature.

7.3 Physical Requirements

[R93- I] The control panel shall be water proofed.

[R94- II] The control panel shall be far away from the plumbing system.

8 System Test plan

The general approach to system testing will consist of testing on important components, each module, combined modules and the final completed system. The important components such as solar panel, turbo and electricity generator will be tested immediately after being received. Each module will be then developed and specific testing procedures will be determined during the development stage. After all the modules are tested, they will be integrated together for the overall system and final tests will be taken in place.

The whole system shall meet all the requirements listed in the requirements sections and testing is required to make sure everything follows the proof-of-concept. Variety in requirements may be allowed as the design could be modified to better achieve the result. Important requirements must be included and tested:

- The solar panel must be able to generate the electricity properly.
- The lid must work properly and the water tank shall be large enough for water storage.
- The water passed through the pipe shall be without large pieces of garbage.
- The turbo must work properly when water passing through turbine blades.
- The electricity generator shall work properly when turbo is functioning.
- The types of electricity shall be right before using or storing.
- Any part related to electricity shall be water-proof.
- The whole system shall work properly under all normal weather conditions.
- All safety requirements must be followed to guarantee the safety of the system.

Typical Usage Scenario:

- User notices that the electricity is being generated and choose to use or store the electricity.
- User can know how much electricity is left in the battery, and can choose to turn on/off the battery.
- User can choose to turn on the water tank to generate electricity or keep water in the tank.
- After all, the system will be tested in the real world scenario with different environments, any adjustments or improvements will be made according to the test results.

9 Conclusions

The functional specification clearly states the requirements for our Rain and Solar Power Generator system. All developments shall follow the requirements outlined above applying to the proof-of-concept model. The model is undergoing well and will be completed by the delivery date of April 20, 2012.

10 References

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11 Appendix

High Power Low Speed Motor specifics:

The motors have the following features/specifications:

Weigh: ~12 lbs,

Dimensions: 3.25" Diameter x 8.625" Long.

Shaft: 12mm Diameter x ~1.375" Long

Continuous Torque: 1.8 Nm, Peak Torque 7.2 Nm

Back Emf 42 V

Table1: test values of both the open voltage and short circuit current of motor []

Motor RPM	Open Circuit Voltage (V)	Short Circuit Current (A)	Output Power (W)
50	1.65	0.6	0.99
100	3.31	1.3	4.303
200	6.62	2.6	17.212
300	9.96	3.9	38.844
350	11.63	4.7	54.661
360	11.96	4.9	58.604
375	12.46	5	62.3
400	13.28	5.3	70.384
500	16.6	6.6	109.56
600	19.92	8	159.36
700	23.23	9.2	213.716
800	26.53	10.5	278.565
900	29.84	11.7	349.128
1000	33.15	13	430.95
1200	39.77	15	596.55
1265	42	15.3	642.6