To: David Willy

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Subject: Implementation memo I



The proposal of this project is to expand the existing CWC PCC data collection system to obtain more functions and compatibility, and to write a number of detailed experimental manuals according to the functions of the new system. The request we received was to expand the capacity of the existing system. We found that the original equipment can already measure voltage, current, wind speed, temperature and pressure, so we plan to add two subsystems to collect solar and thermal data. The purpose of making this device is to support the outreach activities of the Energy Club, so we took into account the issue of portability. All subsystems are detachable and modular. So far, the installation and testing of the wind system has been achieved. Regarding the temperature measurement subsystem, the development of labview has been realized, and the modularization still needs to wait for new accessories.

Our design contributes to people's interest in enhancing wind power generation, and it can also be recycled or converted into a small weather observation machine. The project will expand the functionality of the CWC PCC data collection system currently used for micro wind turbines. Specifically, the project will add more flexible load options and higher-resolution acquisitions to characterize solar cells and thermoelectric generators that will be used in energy club outreach activities. Current systems collect voltage, current, wind speed, temperature, and pressure to characterize wind turbines.

After analyzing CR and ER and existing designs, we came up with several concepts. In the concept of the entire system, we mainly consider how to combine subsystems. We have produced two concepts: integration and modularity. The two different concepts will be described and analyzed in detail below.

One of the concepts is to connect and fix all power generation subsystems to the analysis and operation subsystem, that is, integration. The advantage of this concept is that it is more convenient to use, and the operator only needs to start the system without connecting to the subsystem and debugging. At the same time, because all the components have been fixed, the reliability of this concept is higher. The disadvantage of this concept is that it is not easy to carry. Since the system can support three different electrical experiments, if the operator only needs to do one of them, it is very inconvenient to take out the entire system. In addition, because all the subsystems are integrated, when the system fails, the workload of locating errors will be very large. This is also one of the shortcomings of this concept.

Unlike another concept, modularity does not interconnect subsystems. The operator needs to connect the corresponding subsystem and debug it. So the disadvantage of this concept is that it will make the operator have more workload. The advantage of this concept is that it is portable. When carrying out a specific experiment, the operator only needs to carry the corresponding subsystem. At the same time, we plan to install a test interface in each subsystem to reduce the workload of debugging and maintenance.

Because our project is mainly to expand the old system rather than design a new system, and the customer has very specific requirements for our concept choice, and the methods to meet CR and ER are very limited. For each different subsystem, we only have about two alternative concepts.

In the last semester, we believe that these concepts can meet CR and ER to the greatest extent, and have great feasibility: RaspberryPi, Eventek KPS305D adjustable switching power supply, wind turbine (box fan), solar panel (Sunlight) , Seebeck TEG (Ice).

This semester we changed the core of the information integration system. Raspberry Pi uses the Linux system. The team members do not know much about the system. There are barriers to understanding during installation and debugging. The cost of learning Linux is too high, and the original system can reduce the workload. Based on the above reasons, it is considered to change to the original system. At present, the Raspberry Pi system is still the main development.

We tested the temperature measurement system last week, and the results were good, but we failed to achieve modularity. Now we have purchased connectors and wires, and placed the thermocouple externally as a separate subsystem.

We tested the wind energy system two weeks before. The original system is operating normally, and we have discovered the shortcomings of the wind energy system. Because the original design of the wind turbine cannot be changed, the component occupies too much space and the new load is added. The engineering requirements are facing revisions.

# Customer Requirements (CRs)

The customer requested two new sub-systems, and we derived from these two new sub-systems that solar and thermoelectric are needed. The customer is not satisfied with the current equipment, mainly because of the size problem. He did not say clearly, but proposed to replace the system with a lighter and smaller raspberry. So we sum up the following six points: easily carry, easily use, easily debug, reliability, solar, thermoelectric：

| Easily carry | 4.5 |
| --- | --- |
| Solar | 4.1 |
| Easily use | 3.6 |
| Thermoelectric | 4.8 |
| Easily debug | 4.9 |
| Reliability | 4.5 |

Table 1. CR

The team believes that the realization of the function is the most important requirement. Among other requirements, "easy to debug" is equally important. In this regard, the team will work hard on instructions and installation and disassembly.

First, we must implement solar and thermal power. This is a content requirement. Secondly, whether it is easy to debug depends on the nature of the data acquisition system, which is an auxiliary tool. If the tool is damaged and cannot be repaired in time, it will definitely affect the main test. Third, based on the lowest weight of easy use, and the use of this device still requires certain basic knowledge, we will explain in detail how to use it in the manual.

# Engineering Requirements (ERs)

Then we investigated the elements required for a data collection system. Based on these elements, we concluded the following engineering requirements: Weight, size, simple operating system, test interface, modularization, durable, incorporate, rotational Energy, displays a phenomena of engineering.

Because this project is a graduate design of mechanical engineering, the team wants to reflect the students' professionalism and professionalism in this project, rather than looking for simpler solutions. The team optimizes the user experience and convenience as much as possible.

| Weight |
| --- |
| Size |
| Simple operating system |
| Test interface |
| Modularization |
| Durability |
| Price |
| Reliability |

Table 2.ER

1. It is hoped that the total weight should be kept below 15 kg (except the load).

2. The total size of the four modules is maintained at 100x80x80cm

3. Collect the operations to the operating system. Only the security button of the module is reserved. The three functions can be turned off by the operating system. The test content of each function is clear and easy to understand and can be exported.

4. Carry out information exchange through the Ni arduino system to ensure that the interfaces of each module are clear, and it is best to mark the work.

5. To ensure absolute modularity, the connection lines are completely reserved on the subsystems except for the operating system.

6. Short-term operation for 1 hour without errors, 6 months without maintenance.

7. To be carried out within the client's budget, no more than 1,500 US dollars.

8. Ensure that the equipment will not be damaged by the outside due to handling.

## ER #1(changed from fall): Weight

### ER #1: Weight Target = 15 kg (except the load)

It is hoped that the total weight should be kept below 10 kg. The load requested by the customer exceeded the team's expectation. The standardization and large-scale Single Channel Programmable Electronic Load can be described as the most important part of this project. Coupled with the weight of the wind turbine, it is a delusion to maintain the original engineering requirements. In the future, reasonable installation methods will be adopted to reduce the weight of the main body.

### ER #1: Weight Tolerance = 3 kg

Considering the weight of consumables produced during the installation process and possible design changes, the weight tolerance is designed to be 3kg.

## ER #2(changed from fall): Size

### ER #2: Size - Target = 100x80x80cm

The total size of the four modules is maintained at 100x80x80cm. Load makes it difficult for the design to reach the original design goal. We increased the length to ensure that the volume is reasonable and still within an acceptable range.

### ER #2: Size - Tolerance = 20x20x20cm

The team hopes that the final product can be packed in a large suitcase.

## ER #3: Simple operating system

### ER #3: Simple operating system - Target = separated

Collect the operations to the operating system. Only the security button of the module is reserved. The three functions can be turned off by the operating system. The test content of each function is clear and easy to understand and can be exported.

### ER #3: Cost under $1,500 - Tolerance = safe button on the box

It is acceptable to install the safety button on the surface of the box, which is in line with the integrated design..

## ER #4 : Test interface

### ER #4: Test interface - Target = Raspberry Pi

Carry out information exchange through the Raspberry Pi system or Ni arduino system and Labview to ensure that the interfaces of each module are clear, and it is best to mark the work. The team found that the implementation of the Raspberry Pi system was too repetitive, so if there is a situation where the function cannot be realized, it is considered to keep the original system unchanged.

### ER #4: Test interface - Tolerance = Ni arduino

Consider continuing to use the original system. The engineering required to use the original system is much smaller than that of the Raspberry Pi system. Changing the system does not affect the construction period.

## ER #5 : Modularization

### ER #5: Modularization - Target = 4 subsystems

To ensure absolute modularity, the connection lines are completely reserved on the subsystems except for the operating system.

### ER #5: Modularization - Tolerance = 3 subsystems

Considering that the volume of the temperature measurement system is too small, the team may merge the two systems that measure light energy and heat energy.

## ER #6 : Durability

### ER #6: Durability - Target = 6 months

Short-term operation for 1 hour without errors, 6 months without maintenance. The team believes that the 6-month warranty period is not difficult. In view of the preservation of the original system, we will also write the storage method in the manual.

### ER #6: Durability - Tolerance = 1 months

In view of the weather conditions of flagstaff, a series of unexpected situations such as rust and broken parts may occur, and the warranty period will also be shortened.

## ER #7 : Cost under $1,500

### ER #7: Cost under $1,500 - Target = $1,500

To be carried out within the client's budget, no more than 1,500 US dollars. The team has purchased the more expensive main parts, as well as the wires, connectors, tools, etc. to connect the system. The current use of the funds is 869.79 US dollars. There is still a considerable distance from the customer's upper limit.

### ER #7: Cost under $1,500 - Tolerance = +/- $100

The team believes that exceeding the budget is extremely difficult to achieve, but it does not rule out the possibility of various emergencies, so it proposes a tolerance of $100.

## ER #8 : Reliability

### ER #8: Reliability - Target = no damage outside

Ensure that the equipment will not be damaged by the outside due to handling. This aspect will be written in the manual in detail.

### ER #8: Reliability - Tolerance = damage can be fixed

This aspect will be written in the manual in detail. The maintenance method of each subsystem will be written in the manual in detail.

# Design Changes

There are no major changes in this project, and some changes are as follows. The programming language of the project was originally intended to use python or Java. The team previously studied the original system. It can be determined that the programming language of NI Labview used in the original system is C++. Considering compatibility and reducing workload, the team is discussing whether to continue to use Ni arduino and labview. The team originally planned to put all the subsystems into the container, but the volume of the wind turbine was too large, and because it needed to retain the original base design, it was looking for a more suitable solution.

## Design Iteration 1: Change in data collection system discussion

This change stems from the testing and distrust of the Raspberry Pi. If the work we have done cannot be run on the Raspberry Pi, we will use labview to connect to NI to reassemble and write the program very quickly, because the underlying logic is the same, so there is no big problem.

The design of Raspberry Pi is not a failure, but an advance control of possible risks. I hope that the original design can succeed, and that there is still a way out in the event of unsuccessfulness. At present, the Raspberry Pi design is in trouble, and the team still uses the original system to test the hardware. This has a great possibility. The team will continue to use the original system and run the information collection system on the laptop.

## Design Iteration 1: Change in subsystem

The team originally planned to put all the subsystems into the container, but the volume of the wind turbine was too large, and because it needed to retain the original base design, it was looking for a more suitable solution. The independence of the wind energy measurement system is inevitable because of its huge volume and independent usage. As a subsystem, it cannot be stored and folded normally, and takes up a large space. This problem cannot be solved, and transportation is a problem, so we consider placing it regardless , Fusion of the other two subsystems. The thermal energy system and the light energy system are likely to be placed together, so the volume and functional arrangement are reasonable.

# Future Work

Next, the team's work is mainly divided into two parts, building each subsystem and corresponding programming. Among them, the construction work includes building suitable frames or bases for the parts of each subsystem and preparing an appropriate working environment for each subsystem. The programming system includes writing related programs for each subsystem so that the analysis system can collect and analyze various data.

## Further Design

To achieve the goal of modularization, we will preset the working environment of each subsystem; that is, the generator and sensor will be fixed on the preset frame or base, and the wires and interfaces will be fixed. The pyranometer will be set in the center of the base for the solar subsystem, and the solar panels will be evenly distributed around the pyranometer. Such a design can minimize the error of the obtained data. For the thermoelectric subsystem, the team plans to use wood to build an insulated container to get a stable temperature difference. At the same time, because wood is a ubiquitous material and easy to process, it can also reduce the team's workload.

In terms of programming, the team will be consistent with the original design and use NI LabVIEW to write the corresponding simulation operation interface for the two new subsystems. NI LabVIEW can make the analysis subsystem have better human-computer interaction and ensure compatibility with the wind turbine system.

## Schedule Breakdown

The detailed schedual and division of work of the team are shown in the table below：

| Week | Object | Yuxuan Gu | Yuanhua Zhao |
| --- | --- | --- | --- |
| 4 | Wind Turbine Subsystem | Building | Programming |
| 5 | Testing | |
| 6 | Solar Power Subsystem | Building | Programming |
| 7 | Testing | |
| 8 | Thermoelectric Subsystem | Building | Programming |
| 9 | Testing | |
| 10 | Whole system | Testing | |
| 11 |
| 12 | Writing operation manual | |
| 13 |