ENWARE SMART SHOWER SYSTEM

ECTE350 - Engineering Design and Management

Autumn Session Report - Deliverable 2

Team 5

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1 Executive Summary

Daedal has been tasked with the development of the User Interface for the Smart Shower system designed by Enware. Additionally, research will be conducted to identify possible methods for energy generation from the shower system.

The following report details our preliminary results from our investigation into the design process and methods required to complete these tasks. In this report we cover existing similar products which aim to address the same problems our project confronts.

Furthermore, we cover our preliminary results and plans towards manufacturing a solution for both the hardware and software aspects of our project. This report analyses the work completed in the above research and design during the Autumn Session.

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3 Introduction

As technology has advanced and society is becoming more interconnected online via media platforms and data sharing, markets have been identified which can extend this to physical hardware.

The collection of data that relates to physical resources in homes is made more accessible now due to the Internet of Things (IoT) movement and in part, the subsequent lower cost to implement such systems.The integration of not only data gathering, but additionally the actuation of physical hardware (two-way communication) will lead to improvements across many facets of life.

Enware currently supplies a turn-key solution for controlling water to showers and sinks. It comprises of rotary sensors in replacement of taps, which govern the actuation of valves to control water flow. Due to the smooth and easy operation of the sensors, people living with arthritis can gain a small but significant improvement in their quality of life. By using Enware's existing hardware, Daedal can focus resources on the development of an innovative web/app based User Interface (UI). The benefits that remote actuation and data gathering provide, include but are not limited to:

- Convenience of preheating shower prior to entering.
- Monitoring time in shower. Identifying if leaks are present or possible accident in shower.
- Limiting temperature. Minimising the possibility of hot water burns in young children as well as the elderly.

Additional to the implementation of a UI and sensors, Enware has identified a gap in the market for a battery powered smart shower. The current product requires a connection to mains power which limits it to new builds and large renovations. Daedal will undertake research and testing of energy generation methods, with the target of determining if a battery powered smart shower is feasible. If it is determined that substantial energy can be harvested, following efforts will go into removing loads from the mains (sensors and wifi modules).

4 Market Research

4.1 Market and Customer Analysis

Enware's product was initially aimed to provide the elderly with independence. This was achieved through automating and monitoring the shower and bathroom sink system. However, the target market of the final product will be expanded to homeowners, young parents and environmental conscious users. The final product provides users with convenience, safety and peace of mind. In addition, there has been an upward trend in home automation in Australia in recent years which contributes to the need for a capable and affordable smart shower system to be introduced to the market.

4.2 Competitors

Current products vary in 'smart' functions, applications and price range. Two of the leading direct competitors with similar functions are listed below:

4.2.1 Moen U Digital Shower Controller[8]

Product can be controlled via an iPhone or Android app to adjust temperature and shower duration (no custom water pressure). Presets in the app lets user create profiles with custom temperatures for different family members. Shower can be prepared in advance by the user via the app or voice control (Google Home or Amazon Alexa), pausing waterflow when desired temperature is reached, with notification sent to users' phone. The digital controller software can be updated over the air.

Product package includes a digital controller and a digital thermostatic valve which is used to mix the hot and cold water inlet to get desired temperature, the temperature is calibrated up to 50 times per minute. The shower system is powered by the main grid, with the digital controller hardwired to the valve. However there is an optional battery backup option (in case of power outage) where it can, according to their website, allow up to 2 showers per day for 3 days without WiFi connectivity.

The U by Moen Smart Shower cost up to $2200 USD for the 4-outlet unit and $1160 USD for the 2-outlet unit, excluding shower heads and installation cost as it can only be installed by a professional plumber, making it extremely costly and unable to be retrofitted to existing system.

Figure 1: U by Moen digital valve

4.2.2 Livin[3]

Much like the previously mentioned U by Moen showers in terms of 'smart' functions. Showers preparation, temperature, duration and different shower profile settings can be controlled and monitored via an app or voice control (Amazon Alexa or Google Home). Some added features include music control (requires external speaker) using the shower digital controller. The company claims that the system is easy to install with simple hand tools and it can be retrofitted with most single-handle valve types on the market. The entire system is powered by a detachable and rechargeable battery unit that is able to last up to 2 months with normal use, according to the company. In case the battery run out, the shower can still be controlled with the manual handle.

Product package includes valve, shower head, mounting plate, adapter, battery and charging dock for the battery. The shower system costs $599 USD. However as of May 2019, the product is not yet brought to the market despite its initial plan being in Fall 2018 due to financial problems.

Figure 2: Livin smart shower

4.3 Product Advantages and Disadvantages

The main advantage of our system is that it is adding value to an existing product to further enhance its capabilities. This is achieved through the inclusion of an advanced user interface. Our product may also provide retrofitting capability dependant upon our energy generation tests.

One disadvantage of our smart shower system is compatibility only with double-handle type valves ie. separate hot and cold inlets to the system. This can be resolved with modifications post-production.

4.4 Marketing Strategy

Since our product is integrated with Enware's existing system, our marketing strategy is based around adding value to an existing solution. As there are not many smart shower systems on the market, the product will be able to cement a foothold in an emerging sector. This will be achieved in collaboration with Enware.

5 Product Design

5.1 Hardware

5.1.1 Overview

Daedal is focused on researching and developing the possibilities of thermoelectric and hydroelectric generation as the current system is directly supplied from the electrical grid. Daedal's approach is to create a system using the energy produced through showering, and to explore if it is feasible to internally supply the system. This is to be achieved through thermoelectric generation, using the temperature difference between the inlet and outlet as well as using the moving water to create hydroelectric generation.

5.1.2 Background

5.1.2.1 Thermoelectric Generator

Thermoelectric generators are a solid state device that operates on the principle known as the Seebeck effect. The Seebeck effect defines that a voltage is produced between two different conductive materials when there is a temperature difference between them [6]. The greater the temperature difference between the conductors, the greater the voltage. If a load is connected between the terminals, a direct current will flow. Thermoelectric generators have the unique property, that when a voltage is applied (rather than produced) to the terminals, a temperature difference is setup across the device. Additionally, swapping the polarity on the device will also swap the temperature difference on the materials (heat side will become the cool side).

The generated voltage follows the equation:

$$\Delta V = S_{ab}(T_h - T_c)$$

S_{ab} is the Seebeck coefficient measured in V/K between two materials. The Seebeck coefficient is also dependant on temperature which results in an optimal temperature for the junctions to be at. When operating at this temperature, maximum power is achieved. T_h is the hot side temperature and T_c is the cold side temperature.

A key design challenge when using thermoelectric generators is to minimise heat conduction from one side of the device to the other. If this occurs, the temperature difference between sides is reduced which results in lower output voltage.

5.1.2.2 Hydroelectric Generator

Hydroelectric generators have a turbine which are connected to an electrical generator. If the turbine is rotated, so is the generator which in-turn generates electricity. The amount of power produced can be related by the following equation[4].

$$P = \frac{\rho g H_l}{\eta}$$

where:

P = Power (watts)

η = Efficiency

ρ = Density (water = 1000 kg/m^3)

g = gravity (m/s^2)

H_l = head loss (m), amount of fluid pressure over a distance

Through the understanding of fluid mechanics the properties can be explored and calculations done to understand the losses and generation occuring during operation.

Turbines can have multiple designs each of which have benefits and drawbacks. Turbines similar to a water wheel are simple but large. Alternatively, axial turbines similar to jet engines are small but more complicated to manufacture.

A key design challenge when using turbines for such uses are, to minimise pressure loss across turbine while extracting the ideal amount of power.

5.1.3 Design of Test Layout

The initial design for the research and development of a self generating system is simple with easy access to each generation source. Due to the nature of electricity and water, it is important to isolate these properly. This can be achieved by following industry standards. The design is set up to be able to individually test each generation. The test layout will also measure the temperature and pressure of the system, with different configurations, to validate what would both produce the best electrical generation and comfort of the user.

If results are found, that it is feasible to make the system independent of the electrical grid. A redesign of the layout and addition of a battery system will be added.

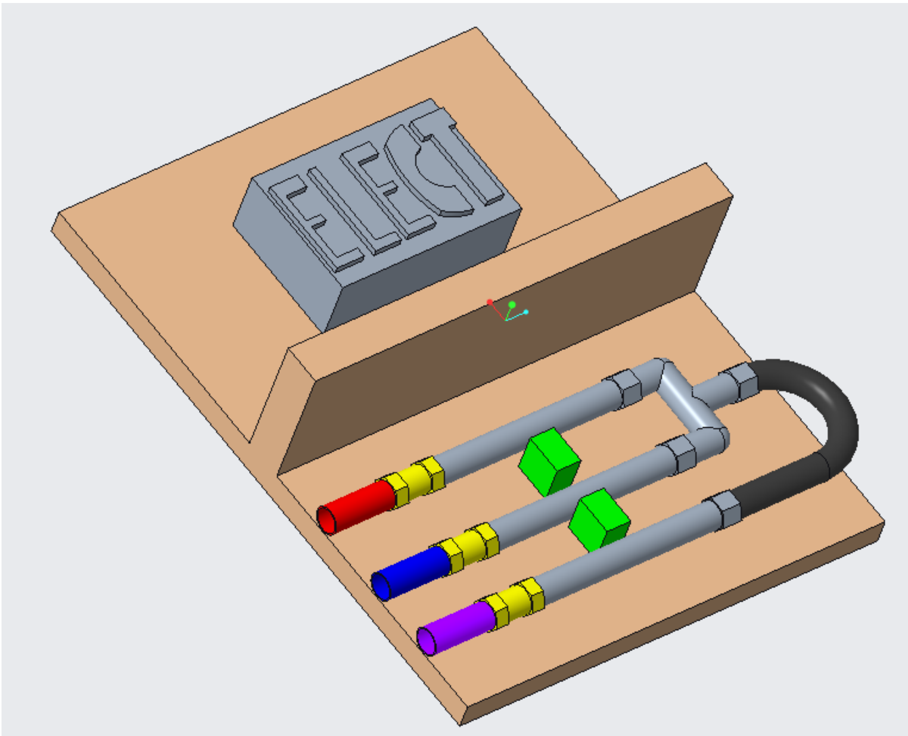

Figure 3: CAD model of Testing System

5.1.4 Electrical Schematics

The electrical layout for the test layout is designed with modularity as the key requirement. Each generator will have its set of electrical connections running to banana plugs. A wattmeter and load resistor will also be mounted onto the test layout with connections running to banana plugs also. Figure 4 displays the connection layout.

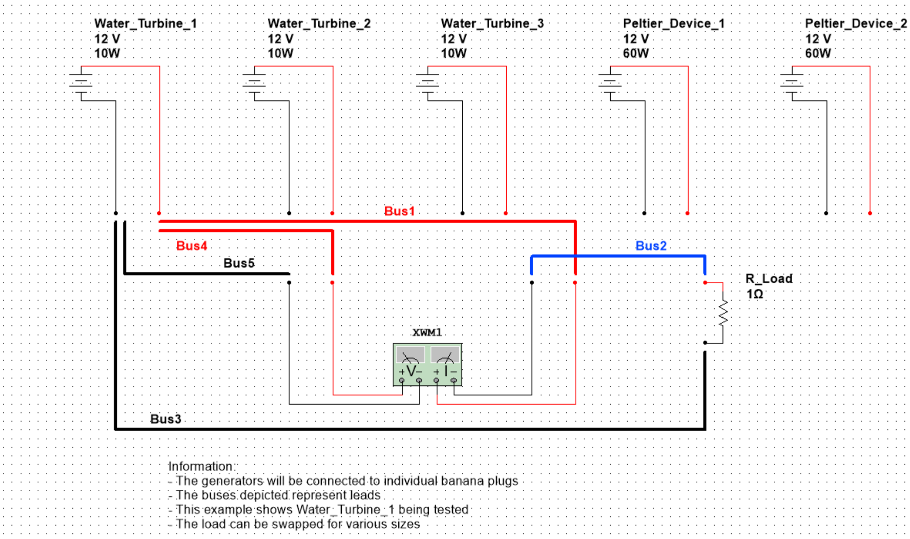

Figure 4: Test layout electrical schematic

5.1.5 Testing Procedures

As described in the design, multiple elements need to be tested, recorded and reviewed to determine if it is feasible to remove the system from the electrical grid. The results needed are current, voltage and power of both the hydroelectric and thermoelectric generators, as well as volumetric flow rate of the inlet and outlet pipes. The recording of the electrical equipment will determine if the generated electricity is enough to power the system, where as the measuring of the flow rate can determine how much pressure is lost to the system and if that impacts the users experience.

To create the best overview of success in the research and development is to repeat the tests over each scenario to determine what is going to create the most electricity while not impacting the experience of the user. These scenarios are:

- No generators - comparing result
- 1 inlet pipe turbine generator
- 2 inlet pipe turbine generators
- 2 inlet pipe and 1 outlet pipe turbine generators
- 1 outlet turbine generator
- Thermoelectric generation between hot and cold inlet pipes
- Thermoelectric generation between cold inlet and mixed outlet pipe

- Both scenarios of thermoelectric generation above
- 2 inlet and 1 outlet turbine generators and both thermoelectric generators

From this collected data, Daedal will be able to completely determine the feasibility of removing the system from the electrical grid by either adding or removing more generators.

Below is an example of how the electrical side of the test layout will be connected during testing. Figure 5 depicts water turbine 1 being tested.

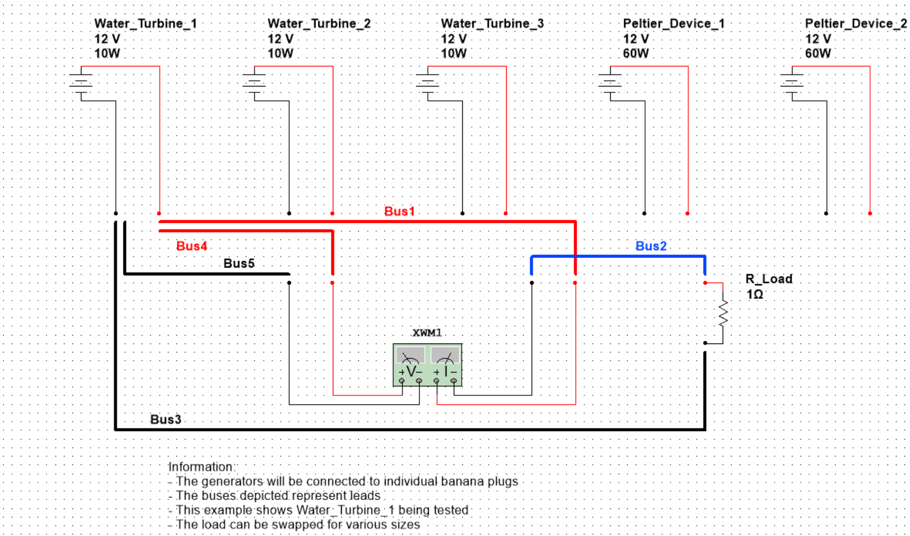

Figure 5: Wiring of test layout for testing water turbine 1

5.1.6 Expected Outcomes

During our testing we expect electricity to be generated. However, the exact amount generated, as well as pressure lost in the shower system is unknown. Daedal is predicting the designs above may produce enough to make the system completely independent of the electrical grid. Dependent of results, Daedal will aim to create a solution for making the system completely or partially independent of the electrical grid creating a more sustainable product.

5.2 Software

5.2.1 Overview

The software for the web interface of our smart shower is designed to be easily used by anyone wishing to control the shower whilst ensuring the safety and privacy of our users. Our software solutions include native compatibility with all aspects of our hardware solutions, long term storage and analysis of showering data for many users using the smart shower system. Additionally our software solution will provide secure administrative control over both users and devices to ensure safe and easy operation for users of all age levels.

5.2.2 Server Setup

The Raspberry Pi will collect the data, store it and provide a means to observe the data by running a locally hosted server. To do this the Raspberry Pi will run the Raspbian Stretch Lite Operation System from the Raspberry Pi Foundation[5]. Installed on this system will be Node Package Manager, Node.js and MySQL to form the core of our data storage and server setup. These will be installed via the command line using the following commands:

```
> sudo apt-get update
> sudo apt-get upgrade
> wget
  https://nodejs.org/dist/v10.15.3/node-v10.15.3-linux-armv6l.tar.xz
> tar -xzf node-v10.15.3-linux-armv6l.tar.gz
> cd node-v6.11.1-linux-armv6l/
> sudo cp -R * /usr/local/
> npm install mysql
```

Figure 6: Environment Install Bash Commands

Once that is completed the server can be run using a javascript file that handles both the http connection and the database side of the server.

The database will consist of two parts, a MySQL server storing the information (Contact Details, Settings, Preferences, Restrictions, etc.) of the users and the devices, in this format:

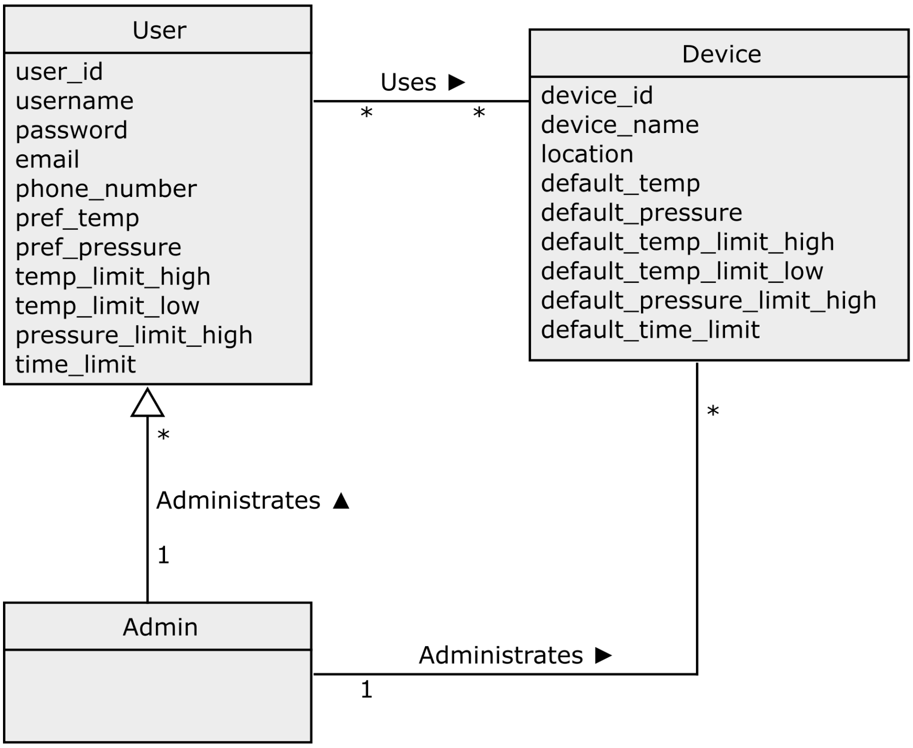

Figure 7: Settings Database UML Diagram

The second part will be a JSON-based database holding the data logged from the device, so that we can analyse this data and present it in a human readable format. We will also attempt to set up an api for accessing the raw data, via the http server. The JSON-database will have the following structure:

```
{
    "$device_id": "????????????????",
    "connections": [
        {
            "start_time": ##########,
            "end_time": ##########,
            "$user_id": "????????????????",
            "data": [
                {
                    "timestamp": ##########,
                    "temp": ##.#,
                    "pressure": ##.##
                }, ...
            ]
        }, ...
    ]
}
```

Figure 8: Data Database JSON Structure

A javascript file will both manage the database connections as well as the setup and connections to the http server. So that the device may be controlled from anywhere on the local network. If an internet connection is unknown or not available the Raspberry Pi will automatically create a WiFi hotspot prompting anyone that connects to it to input WiFi credentials for one of the detected available networks. This javascript document will have the following structure:

```
import required packages
setup global variables
function checkInternetConnection() {
    Check for available internet connections
    Check if available internet connections are known
    if known connect
    else
        create wifi hotspot
        prompt for internet login details
        update known internet connections
        Connect
}
function SetupMySQLDatabase() {}
function ConnectToMySQLDatabase() {}
function CreateHTTPServer() {
    Listen for connections
    Get requested data
    Write requested data
    Loop
}
```

Figure 9: Server Setup and Management File

5.2.3 Interface Design

The goal for the design of the interface is to create an environment which is easy to use, taking into consideration elderly people who are losing their physical dexterity. To achieve this we have decided to create a web interface which focuses on making the buttons large, clear and easy to use. Additionally, the layout has been designed in order to maximise the visibility of the most critical information. This is showcased in the following mockup:

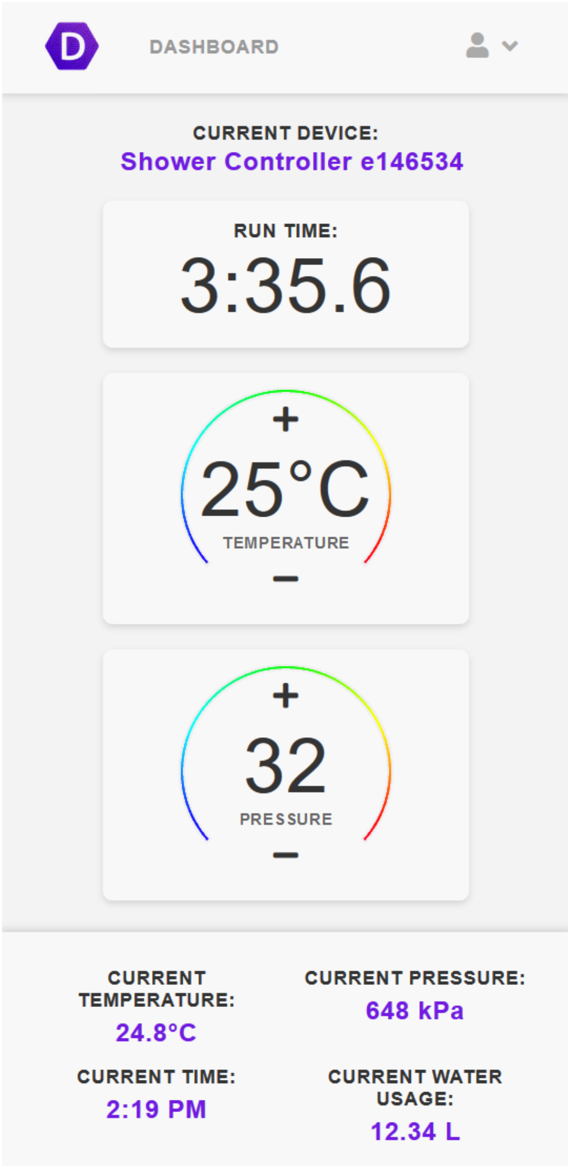

Figure 10: Mobile Interface Mockup

Our interface design also aims to be flexible so that it works and achieves its goals on many devices and screen sizes. To do this we have designed the web interface to adapt to the size of the screen. You can see an example of a larger screen size below in Figure 11.

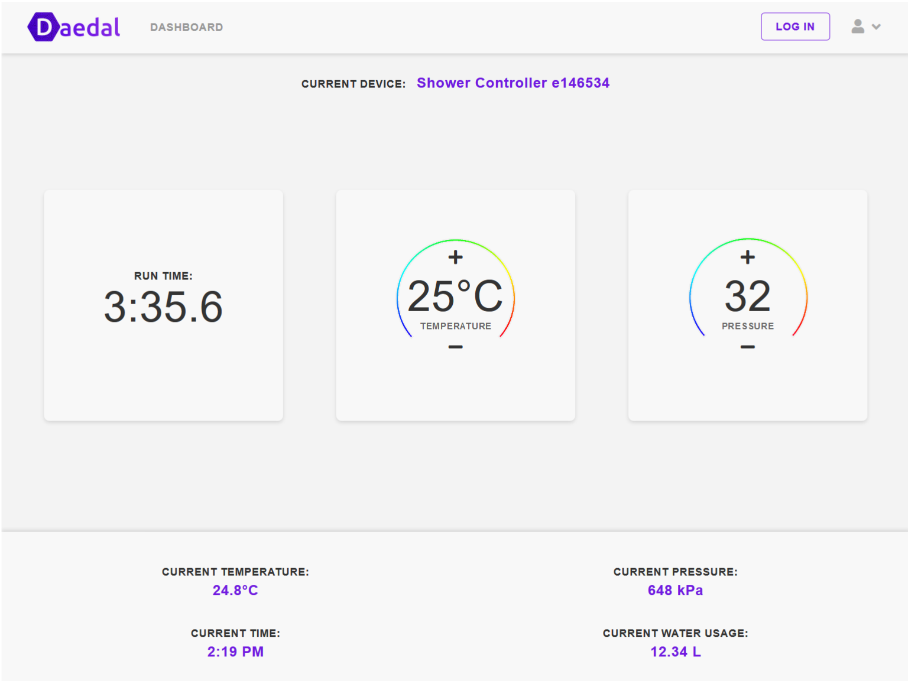

Figure 11: Tablet/Desktop Interface Mockup

The final purpose of our web interface is to display the data taken from the shower system in various formats, providing a means for administrators to control the devices and users they manage. The interface for these controls can be seen below in Figure 12.

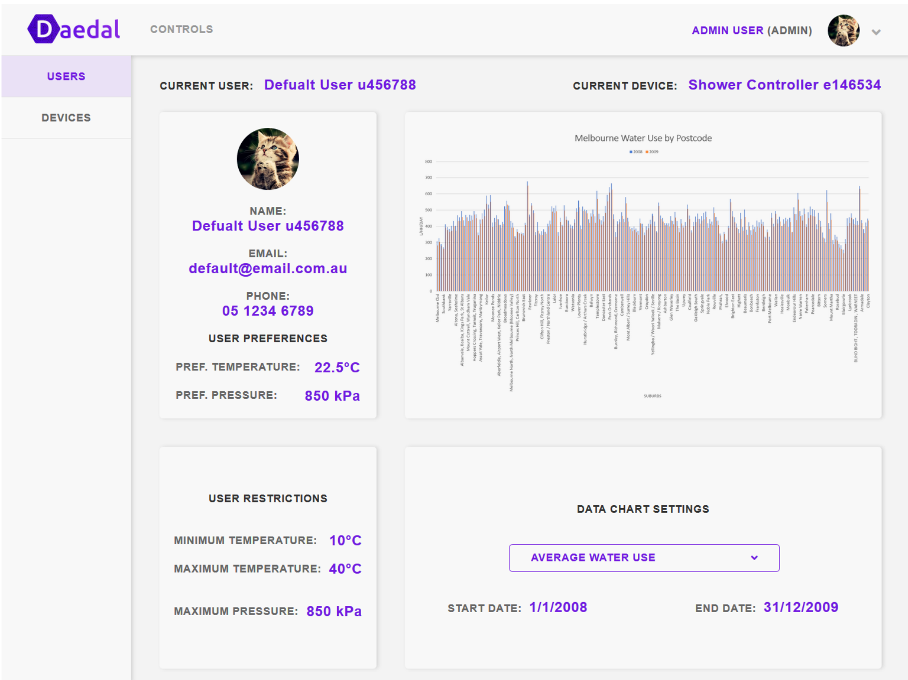

Figure 12: Tablet/Desktop Data and Admin Interface Mockup

When a user seeks to view the above page they must first be logged on. They can do this by entering their details into a form accessed through the "Login" button or the settings dropdown on the main screen.

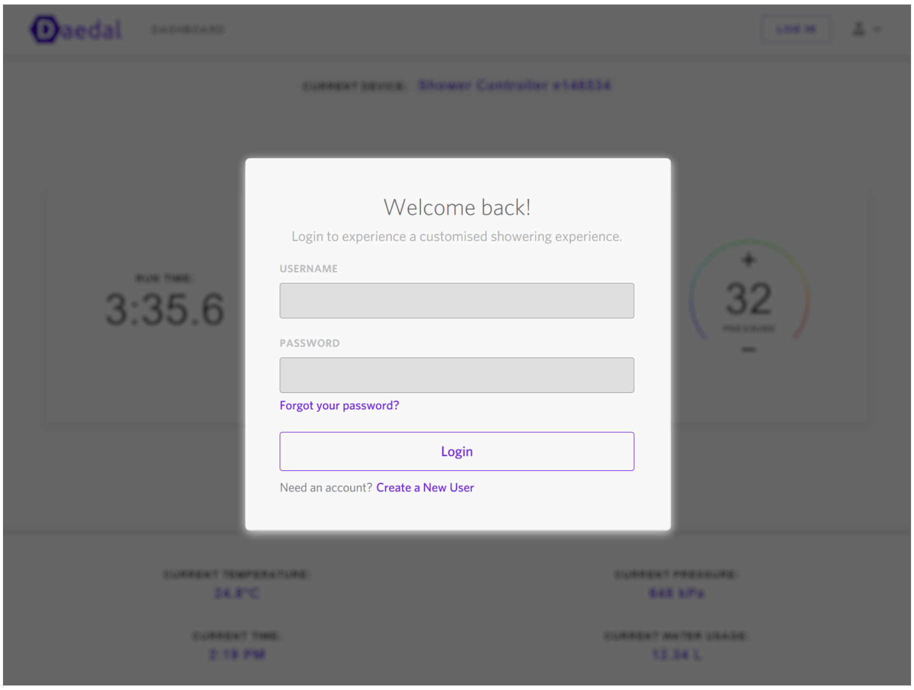

Figure 13: Login Interface Mockup

5.2.4 Interface Functions

Fields	**Functions**
Username	Drops down to show list of users
Password	Allows to enter password
Login	Interfaces to respective admin/user
Create a new user	Interfaces to new user setup page

Table 1: LogIn interface fields

```
function LogInButtonClicked() {
    Get the username
    Get the password
    Hash the password
    Send the username and password hash to the server
    if (the username and password matches a user) {
        Login
    } else {
        Display Error
        Clear the login form
        Prompt the user to reattempt the login form
    }
}
```

Figure 14: Function for when the LogIn Button is clicked

Fields	**Functions**
Users	Displays a list of all users controlled by admin
Devices	Displays a list of all devices controlled by admin
Minimum Temperature User Restriction	Sets the lower limit the temperature can be set to
Maximum Temperature User Restriction	Sets the upper limit the temperature can be set to
Maximum Pressure User Restriction	Sets the upper limit the pressure can be set to
Data Chart Settings Dropdown	Select what data to display in the chart
Data Chart Settings Start Date	Set the start date for the data displayed in the chart
Data Chart Settings End Date	Set the end date for the data displayed in the chart

Table 2: User Restrictions interface fields

```
function UpdateDataChart() {
    Get start date
    Get end date
    Get result of data chart dropdown
    function RetrieveDataFromDatabase() {}
    function PerformOperationsOnData() {}
    function DisplayDataInChart() {}
}
```

Figure 15: Function for updating the data chart

```
function SetUserRestrictions() {
    Get Minimum Temperature User Restriction
    Get Maximum Temperature User Restriction
    Get Maximum Pressure User Restriction
    function WriteRestrictionsToDatabase() {}
}
```

Figure 16: Function for setting the user restrictions

Fields	**Functions**
Display Set Temperature	Displays the set temperature preference for user
Display Set Pressure	Displays the set pressure preference for user
Increment Set Temperature	Increments the set temperature preference for user
Decrement Set Temperature	Decrements the set temperature preference for user
Increment Set Pressure	Increments the set pressure preference for user
Decrement Set Pressure	Decrements the set pressure preference for user
Display Current Run Time	Displays how long the shower has been running for
Display Current Temperature	Displays the current temperature of the shower
Display Current Clock Time	Displays the current 12/24 hour clock time
Display Current Pressure	Displays the current pressure of the shower
Display Current Total Water Usage	Displays the total amount of water used this sessionn

Table 3: Main page user interface fields

```
function ChangeTemperature/Pressure() {
    Detect Changes to Temperature or Pressure
    if (input less than or greater than control limits set by admin) {
        Display error
    } else {
        Write Temperature or Pressure to hardware
        Write Temperature or Pressure changes to database
    }
}
```

Figure 17: Function for the Temperature or Pressure

```
Loop once a second {
    Get current temperature
    Display current temperature
    Get the current time
    Display the current time
    Get current pressure
    Display current pressure
    Get current net water usage
    Display current net water usage
} End Loop
```

Figure 18: Update current displayed values loop

5.2.5 Data Logging

The data logging must ensure that key information is constantly updated and stored into the database for user consumption. For our device, the key values being looked at are:

- Time (s)
- Temperature (°C)
- Pressure (kPa)
- Flow rate (L/s)
- Time duration of/without use

```
Loop while flow rate > 0 (i.e. shower is on) {
    Store the initial time when the shower is turned on
    Inner loop while the shower is on {
        Store time into time vector
        Store temperature into temperature vector
        Store flow rate into flow vector
        Calculate pressure from flow rate
        Store pressure into pressure vector
        Store the final time before the shower is turned on again
    } End inner loop

    Calculate the time the shower is in use
    Update the time used vector

    Loop (Calculate the average of the time that the shower is used) {
        Update the average time used each iteration of the loop
    } End the loop
    Store the average time used
} End loop
```

Figure 19: Shower turned on data logging pseuducode

```
Loop while flow rate = 0 (i.e. shower is off) {
    Store the initial time when the shower is turned off
    Inner loop while the shower is off {
        Store time into time vector
        Store the final time before the shower is turned on again
    } End inner loop

    Calculate the time the shower is not in use
    Update the time without use vector

    Loop (Calculate the average of the time that the shower is not used) {
        Update the average time not used each iteration of the loop
    } End the loop
    Store the average time without use
} End loop
```

Figure 20: Shower turned off data logging pseuducode

5.2.6 Notifications

One of the key benefits of storing all the data is being able to effectively use it to benefit the client. The aim of the notifications is to help the client monitor and track specific water usage goals, or perhaps unusual behavioural patterns for elderly or disabled users who live alone. The code will constantly update the average time when the shower is not being used, making it effective and accurate for long term use. Similarly the water consumption code will constantly update the user on how they are progressing against their predetermined water usage targets.

5.2.7 Shower not used for a long period of time

```
If (time - notification time) > average time without use {
    If (time without use > (average time without use) x 4) {
        Send warning notification to admin ‘Warning, unusual behaviour’
        Store notification time
    } End inner loop
} End outer loop
```

Figure 21: Shower not used for a long period of time pseuducode

5.2.8 Water consumption vs target consumption

```
When month starts set Month start time
monthly water usage =
    water usage from month start time to next month start time
Loop {
    If monthly water usage is greater than monthly water usage target {
        Send notification ‘You have exceeded your target usage’
    }
} End loop
```

Figure 22: Water consumption vs target consumption pseuducode

6 Project Analysis

6.1 Performance Against Plan

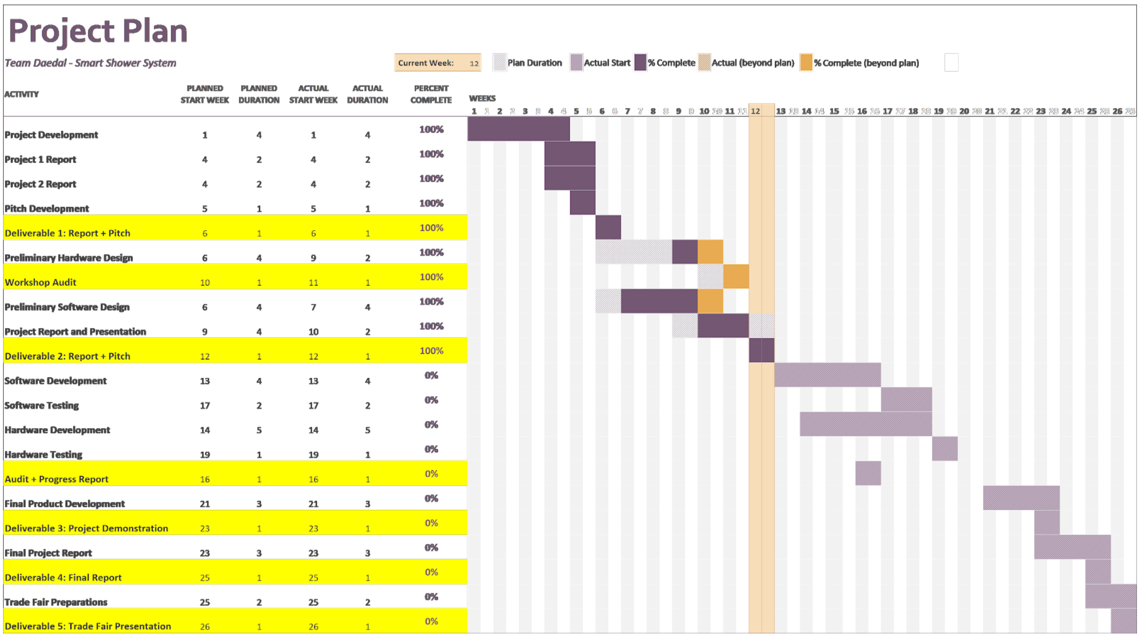

Figure 23: Project Plan Gantt Chart

From the figure above (larger version available at Figure 24 in the appendix), it can be seen that the project plan so far has not gone as initially planned. This is mainly due to the meeting with Enware that was held in week 8, which drastically changed our project direction. Initially the plan was to contact the Industry sponsor immediately after project approval to gain insight. Due to complications in initial communication with Enware, a meeting could not be organised until 3 weeks after approval.

This setback was unexpected, but when the initial design was brought up with Enware in the first meeting, it was revealed that the system is already under development. Subsequently, a team meeting was held to address the new information from Enware.The team decided that major changes were to be made to the initial plan. This caused the delay in starting the preliminary hardware design.

The effect of this was that the team had to work twice as hard to complete the preliminary hardware design before week 11. Since the initial plan expected everything to be completed early, the deadline was still met despite finishing later than expected.

From the software side of the project, since receiving the information from Enware not much has changed in the design. Initially the team agreed to spend a few weeks gaining familiarity with the Raspberry Pi and learning about Python. Pseudo code was required for the report in week 12. The plan was to have it completed by week 10, but, due to the lack of knowledge of the systems involved, extra time was required. Since the expected deadline was quite ambitious, despite the extra week required, the software team is still on track with expected progress.

6.2 Budget Analysis

The major costs related to the smart shower project have been accrued due to the research and development time supplied by team members. The other major cost being hardware components required for testing. Initially 6 hours per team member per week was allocated but due to time challenges each team member only supplied 3 hours/week. This has resulted in 72 hours saved under the expected time. A single hour of work is billed at \$45/hour. There has currently been 216 hours accrued on the project, bringing the total billed hours to \$9720 and giving a cost savings of \$9720. Furthermore, the team saved an additional \$350 from consultation and workshop time due to collaboration with other teams.

The estimation for hardware pricing was \$215.99 from the initial project pitch. After meeting with Enware and finalising the project scope, this cost has been reduced to \$179.52, resulting in approximately a \$36 saving. Deadal was given a budget of \$350 of which \$170.48 is remaining, to be used for unforseen circumstances if required.

The table below indicates detailed costs on the works carried out. The team used equal amounts in time with both hardware and software related work. The most amount of time was involved in the team meetings on making decisions. This is largely due to indirection resulting from difficulty getting ahold of the client. The team handled the decision making well and made up for lost time while also saving close to 50% of the cost.

Expense	**Expected Hours**	**Actual Hours**	**Cost/Hour**	**Expected Subtotal**	**Actual Subtotal**
Research and development	432	216	$45	$19 440	$9 720
Consultation	3	0.5	$60	$180	$30
Workshop time	3	0	$75	$225	$0
			Total	**$20 065.00**	**$9 750.00**

Table 4: Projected vs Actual Expenses

Work area	**March**	**April**	**May**	**Subtotal**	**Cost**
Hardware	15	16	30	61	$2 745
Software	15	13	32	60	$2 700
Deliverables		10	15	25	$1 125
Administration	1	1.5	2	4.5	$202.50
Meetings	10	20	35.5	65.5	$2 947.50
			Total	**216**	**$9 750.00**

Table 5: Time spent across work areas each month

Item	Part Number	Supplier	Quantity	Unit Price	Total Price
Water turbine	SEN0029	Core Electronics	3	$15.81	$47.43
Peltier Thermo-Electric Module	ADA1330	Core Electronics	2	$22.70	$45.40
Banana Socket RED	CEO5221	Core Electronics	8	$0.46	$3.68
Banana Socket BLACK	CEO5165	Core Electronics	8	$0.46	$3.68
Wattmeter	ADA3624	Core Electronics	1	$47.40	$47.40
Load Resistor	RR0565	Jaycar	1	$0.55	$0.55
Raspberry Pi Zero W	CEO5324	Core Electronics	1	$21.40	$21.40
SD Card	SDSQ16GB	Officeworks	1	$9.98	$9.98
				Total	**$179.52**

Table 6: Budget for parts to be purchased

6.2.1 Cost and Profit Analysis

As we are working in conjunction with Enware, we have additional resources at hand besides the $350. These resources that are provided are not a direct cost to the team, but are required to be acknowledged for deciding on a price to market the device.

The production of a single prototype will cost $179.52 in hardware. This cost does not include individual hourly costs. By adding a margin to this we can sell the final product for $229.99. From our budgeting, it is predicted that $19680 will be spent on labour cost (both autumn and spring session combined). From our market research, it has been determined that 850 to 1000 products can be sold in the first financial year of the final product. Taking into consideration marketing, an additional $5000 is required per year. Having a margin of $50.47 per product, the breakeven point is realised at 489 products. If projected sales are met, we are looking at a profit of $18219.5 to $25790 in the first year.

To stay competitive in today's market the price of our product should stay well within the market range[7]. The market analysis showed us the cheapest product is provided by Moen and costs $1160 excluding plumbing costs, as it can only be installed professionally. The next product competing with Daedals smart shower is envisioned by Livin Shower for $600, which is still under Research and Development(R&D). We have set a margin of over 50% difference in product cost making it viable and highly desirable for everyday families and homes.

6.3 Workshop Audit

Aim:

The aim of the workshop is to prove that our design is feasible and within our scope.

Discussion:

After discussing our design with the workshop officer, there were three key issues that were brought up in terms of the hardware aspect of our project:

1. The design of the thermoelectric generator testing layout.
2. The power requirements of our prototype design.
3. The presentation of the prototype at the innovation fair.

Results:

The outcome of the key points was:

1. To successfully generate power using the thermoelectric generator, we will have to organise for one of the mechanical workshop machinists to make a part for us out of aluminium. This can be done once we physically have our thermoelectric generator, as we will then be able to design the part to fit around it.
2. Since the power requirements are quite low for our design, the workshop will not need to approve of any power sources we might need, as they will not be 240V.

3. The presentation of the project will be a major issue due to the large amounts of water required to properly demonstrate our prototype. The safety aspect of this, i.e. water leaks and electrical cables, means that the best way to demonstrate at the trade fair will be through a pre-recorded video. This isn't the ideal method of demonstration, but, given the circumstances it will have to suffice, as we will not have access to water outlets at the trade fair.

6.3.1 Saftey Considerations

The major requirement of shower products is to give users a safe and comfortable feeling. To meet these goals, the software has to work with the hardware in an expected manner.

First of all, in order to prevent users from being scalded, the software must be robust and enforce strict safety measures in temperature controls. Comprehensive testing is required to ensure that under no circumstances, the users' safety is compromised. In terms of hardware, we will ensure sensitivity and stability of the electrical connections before assembly of the controller.

In addition, we also consider the user's control experience, so we have designed default water temperature function and the last water temperature function. After which the user can adjust the temperature as needed (we have set the temperature range in the database to prevent the water temperature from being too high).

All components of the shower system must be waterproof to prevent possible electrocution and malfunctions. This is the major safety concern for the design.

7 Sustainabliity and Ethics

7.1 Sustainabliity

In this day and age, sustainability is an important part that is considered in all areas of creation of product.

As modern technology is evolving into a sustainability focused mindset, our design follows suit. The materials required to produce the design must be taken into consideration. Similarly, water usage is monitored through the application of the device. This is due to the importance of conserving Earth's natural resources.

Daedal aims to focus on making the system, designed by Enware, independent of the electrical mains system. This is achieved by generating electricity from the water passing through the shower plumbing, as well as the temperature difference between the pipes. By shifting the system off the electrical grid, this will reduce the impact on natural resources.

A part of the system is to make the user more conscience of their water usage. Since clean drinkable water is a finite resource, it is imperative that society minimises the use of water as much as possible.

The results of the hardware system will determine if it is feasible to remove the system off the electrical grid. If it is not, Daedal aims to reduce the burden the system creates by placing a subsystem onto a battery.

The aim of this product in terms of Deadal's development is to create a product that is affordable. Due to the wide use of showers throughout the world, to create both social and economical sustainability it is vital that the product is accessible for everyone.

7.2 Ethics

Ethics is a highly considered aspect of design. It is a focus of Enware's as a company, and therefore ours. We aim to develop our product to benefit those that are mentally or physically disadvantaged. This is to be done by assisting Enware and their direction of interest with a wireless application control of their system.

This is to work alongside Enware's current control methods and offer a more modern method of controlling the shower.

Enware has developed tap sensors to visually assist with determining the temperature of the water output. Daedal aims to further this by controlling the temperature and pressure from a wireless application. This aims to give further assistance and clarity to those disadvantaged. Also it can assist those caring for the disadvantaged by giving them a method to easily control and adjust the water of the shower from outside the shower itself.

The inclusion of settings forced onto the system by an external application allows many parameters to be set. This is highly beneficial to those that need to set temperature and pressure to stop harm occurring. The main application for this is controlling the temperature for children and the elderly, who are more prone to accidentally changing shower temperature.

Another key ethical issue is independence. A study has shown that 17.5% of 60-69 year olds, 24.3% of 70-79 year olds and 33.8% of 80+ year old Australians live alone[1].Of those living alone, there are many who may have mild-severe cognitive disabilities which may impact them on a daily basis. Our product utilises a behavioural notification system, which can alert a loved one or a carer if the user is not showering for an irregular amount of time. Purely for hygienic reasons, it is good to make sure the user is showering, but this may also be indicative of a larger issue. The notification system is crucial for allowing users to have independence, while also having peace of mind in case something goes wrong.

In addition to the safety benefits provided by our product, it is also key to note the environmental benefits that the product is looking to achieve. The constantly updated water usage data on the user interface, as well as notifications to the user will maintain the users' knowledge of their water usage habits. By allowing users to set water usage goals, and keeping them updated on their progress, it will further enforce in their mind the importance of minimising time in the shower.

8 Conclusions and Recommendations

8.1 Conclusion

The main focus for Daedal is to further the existing product's capabilities in both hardware and software. For hardware, the task is to research and explore the possibility of an independently powered system by utilising waste energy produced during showers, through the use of thermoelectric and hydroelectric generators. This system will be examined with a test layout designed and developed in-house. The team is confident that enough energy can be generated ahead of testing, as the required power is much less than anticipated. Regarding software, Daedal will be further extending the smart functions of the product by developing digital water monitoring through sensors, data logging, UX/UI and wireless control of the system using a Raspberry Pi Zero module or a smart phone application.

During the initial stage, there were some unexpected setbacks which slowed down the team's progress. However the team is confident of finishing the required testing and software development come the spring session. Once the product is finalised, Daedal can then focus on troubleshooting and perfecting the system both hardware and software-wise.

8.2 Recommendations

1. Considering that the team is working a little slower than expected, and we have obtained the relevant model from Enware. We can continue our software design and hardware assembly for some time during the coming holiday.

2. Because teamwork is lagging behind expectations, we can try to take some time to improve the project management process in order to match project schedule and ensure cohesion and efficiency of the whole team.

3. Team projects may stall at some point because all members lack expertise, such as programming. In this case, we can consider outsourcing work to experts who can accomplish tasks faster, rather than letting someone in the team learn all the information they need.

9 References

References

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A Project Plan Gantt Chart (Full Size)

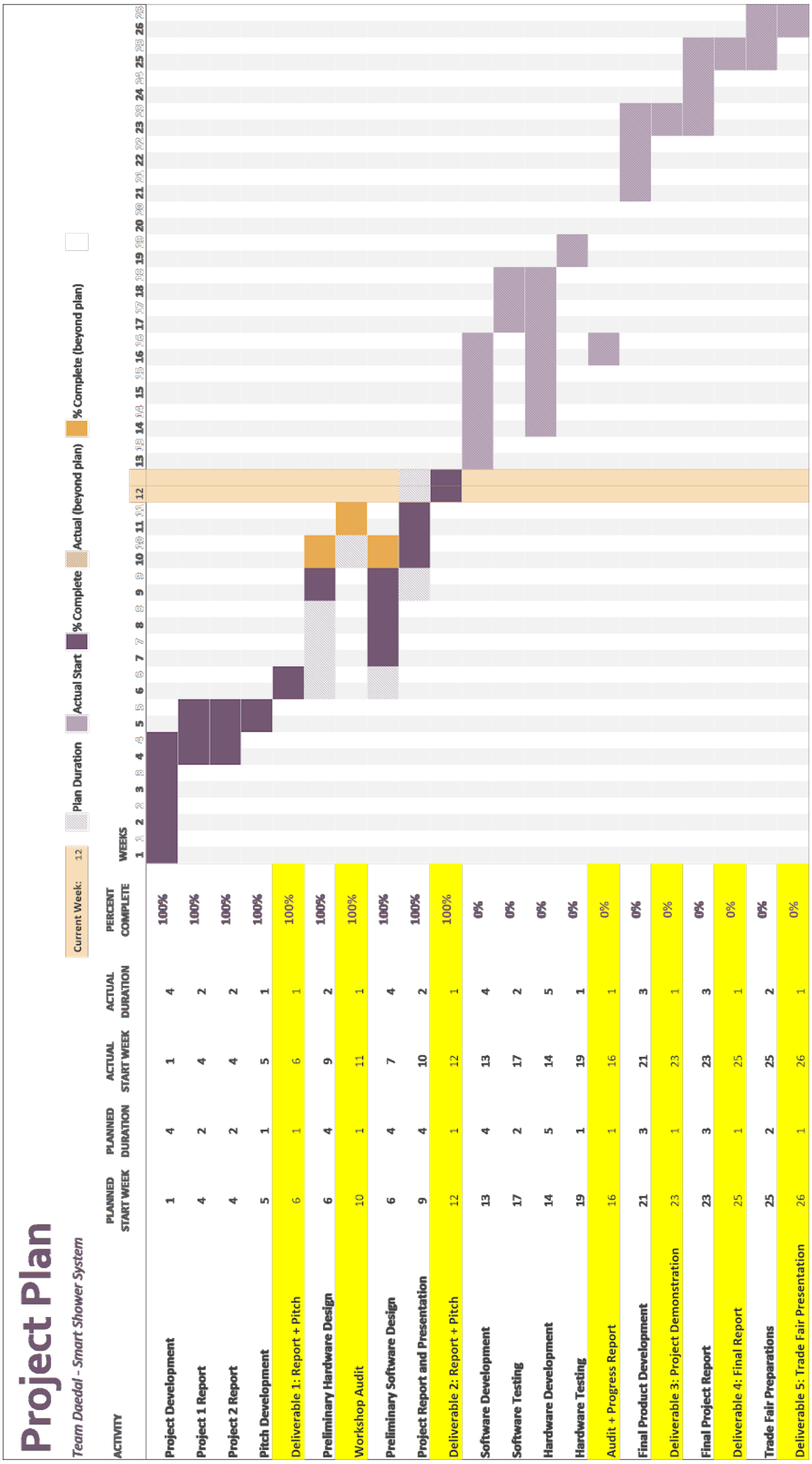

Figure 24: Project Plan Gantt Chart (Full Size)

B Completed Code Examples

```
var http = require('http');
var fs = require('fs');
var mysql = require('mysql');

// var con = mysql.createConnection({
//     host: "localhost",
//     user: "root",
//     password: "mysql"
// });

var server = http.createServer(function (request, response) {
    console.log(request.url);
    if (request.url == "/") {
        fs.readFile('./index.html', function(err, data) {
            response.setHeader('Content-type', 'text/html');
            response.write(data);
            response.end();
        });
    } else {
        fs.readFile('./' + request.url, function(err, data) {
            if (!err) {
                var dotoffset = request.url.lastIndexOf('.');
                var mimetype = dotoffset == -1
                                ? 'text/plain' : {
                                    '.html' : 'text/html',
                                    '.ico' : 'image/x-icon',
                                    '.jpg' : 'image/jpeg',
                                    '.png' : 'image/png',
                                    '.css' : 'text/css',
                                    '.js' : 'text/javascript',
                                    '.ttf' : 'font/ttf',
                                    '.woff' : 'font/woff',
                                    '.svg' : 'image/svg+xml',
                                    '.map' : 'text-plain'
                                    }[ request.url.substr(dotoffset) ];
                response.setHeader('Content-type' , mimetype);
                response.end(data);
            } else {
                response.writeHead(404, "Not Found");
                response.end();
            }
        });
    }
}).listen(8080);
```

Figure 25: Server setup javascript code example

```
var attempt = 3; // Variable to count number of attempts.

// Below function Executes on click of login button.
function validate(){
    var username = document.getElementById("username").value;
    var password = document.getElementById("password").value;

    if ( username == "Formget" && password == "formget#123") {
        alert ("Login successfully");
        window.location = "success.html"; // Redirecting to other page.
        return false;
    } else {
        attempt --;// Decrementing by one.
        alert("You have left " + attempt + " attempt;");

        // Disabling fields after 3 attempts.
        if( attempt == 0){
            document.getElementById("username").disabled = true;
            document.getElementById("password").disabled = true;
            document.getElementById("submit").disabled = true;
            return false;
        }
    }
}
```

Figure 26: JavaScript Login Form Example[2]

C Individual Performance Reviews

C.1 Thomas Battye-Smith (5570001)

From the start of the semester my contributions include:

- The design of the control system for the ISD Smart Battery. This included researching various methods for battery voltage monitoring, coulomb counting and cell balancing methods.
- I completed the electrical schematics and hardware list for the project pitch report ISD Smart Battery. Additionally, I completed the first half of the presentation for ISD Battery.
- Upon being assigned to Enware Smart Shower project, I went to the initial meeting to gather information and direction.
- For the autumn session report, I have completed the introduction, electrical schematic, hardware (generator) overview.
- Additionally I met with Wayne Ireland for the WHS assessment.

C.2 Quang Hung Pham (5560512)

From the beginning of the project, my contributions so far include: research on measuring the battery's State of Charge and LED output for the smart drone battery project for Industry Spec Drones, and battery parts sourcing, which included the cells we were going to use for our project should it be chosen, and a battery monitoring IC. I also prepared and presented the second half of the smart drone battery pitch in Week 6.

For our chosen project (Enware smart shower system), my role as part of the hardware team is to research and gain an understanding in thermoelectric and hydroelectric system. For the report, I did Market Analysis which included marketing summary, strategy, competitor analysis, product advantages and disadvantages, and in addition, the report conclusion.

C.3 Ilija Babic (5777446)

At the start of the project I was tasked with the market analysis of the smart drone battery pitch, and the user interface for our smart shower pitch. Since our smart shower system was approved as our project, my role changed to software engineer. My main task for the first few weeks was to gain an understanding of the raspberry pi and python. I then went to the initial meeting with Enware to discuss our project, and from that meeting it was decided that our whole project needed to change. As we approached the report deadline, I organised another meeting with Enware to discuss the software aspect of our product, and obtain their prototype, along with the necessary documentation. I also in the meantime completed the pseudocode for the data logging and user notifications, as well as elaborating on the ethics of our design from the software perspective. I then went with the group to the workshop audit, and afterwards completed the workshop audit report. After completing all of that, I then did the Gantt chart and progress report, and started to work on our group presentation.

C.4 Yuhao Cui (6101422)

My contributions so far this semester have included:

1. After consulting the relevant information, the key requirements and problems of UAV smart battery are summarized and simply answered.

2. The budget estimate of ISD smart battery project is completed, and the input function of Enway smart shower system is designed.

3. Responsible for completing the second half of the speech on smart shower system(6th week).

4. After the smart shower system was selected as the project of our team, I was responsible for writing the JAVA code of controlling the running time.

5. Participated in the second meeting with Enware, discussed the software aspect of our product, and got their model and related documents.

6. Participate in workshop audit with team members.

7. Completed “Safety Consideration” and “Recommendation” for the autumn session report(12th week).

C.5 Lachlan Fowke (5065549)

- Initially team leader, sustainability and ethics for first choice project and editor for second project proposal report
- Set up and attended first meeting with Enware
- Design CAD drawing of testing design
- Hardware overview, explained the design, test procedures, expected results, sustainability, developed initial ethics and assisted in editing for the autumn report
- Lead in mechanical components
- Presenting hardware section of end of autumn presentation.

C.6 Timothy Martin (5726803)

In the Autumn Session, I have contributed to my team in various ways. At the beginning of the semester, for the first deliverable I invented the idea for a Smart Shower project which we ended up using. I also helped my team in creating the first deliverable by providing the target specification, project plan (including the data flow diagram and a block diagram of the proposed design), a section on the capabilities of the team and an estimated full costing for the project.

For the second deliverable I assisted in parts of the creation of the presentation and presented the first half of the Smart Shower project to the board and my peers.

Since these deliverables I have acted as project manager for our team by writing meeting minutes, ensuring all team members are aware of their roles and are progressing in their sections of the project, having good general knowledge on the overall design and plans for our project and making decisions relating to the software aspects of the project in regards to chosen language, platform and as well as ensuring we are compatible with the current prototype from Enware.

For the second deliverable report I have produced the server setup and interface design aspects of the report, filling in summaries and other more general areas of the report, managing the references and formatting the report using LaTeX to ensure a nice, professional document is produced at the end.

For the continuation of this project I shall be concentrated on the software by using my existing experience with, both the language we are using and the platforms we are building upon to assist the less experienced members of our software team to learn how to program the software solutions we will be employing. I also intend to do some of the grunt-work for both the hardware and software portions of the project, so that I may gain kills and experience working in areas where other members of my team are more experienced.

C.7 Amalesh Nagenthiran (4184312)

At the start of the project my roles was to research and write the report on the inputs of the battery. Researched ways to measure the inputs needed, best way to connect the battery (series or parallel), calculations on suitable battery charger size. For our wild card project, the team agreed on Tim's smart shower system. My role for the wildcard was sustainability and ethics. For the pitch in deliverable two I designed the proposal for both the smart shower and drone battery for the presentation

Since our smart shower system was approved as our project, my role changed to software engineer. My main task for the first few weeks was to gain an understanding of the raspberry pi and python and after the team went to the initial meeting with Enware we realised the whole project needed to change and I started understanding node.js and javascript and researched on understanding how to read from the raspberry pi pins with the aforementioned software, as we approached the project report deadline I went to the software team meeting with Enware to get a better understanding of the product and the workshop audit with the team, in the meantime developed the functions for the smart shower system along with their pseudocode and also a sample code for the login verification. I also designed a prototype user interface to be able to visualise the buttons and their functions which could also be used on mobile by clients to understand the system and we will be using the interface video in the project presentation. I completed the User interface function design, Marketing strategy, commercialisation strategy and the resources and budget part of the report and will be going over the requirements and document checking to make sure we aren't missing anything. For the final presentation we will be using the same file that I made for the smart shower pitch which will retain most of the information and will start editing it. I will also be delivering part of the presentation for deliverable 4.