Solar Panel Modelling Project

According to **International Data Corporation** (**IDC**), in the last two years, we have produced more data than all of human existence in the history of the world. Seems hard to believe, but consider that each day we publish 230 million Tweets, send 294 billion emails and perform a billion Google searches - all that data starts to add up. But with less than a quarter (23%) of organisations having an enterprise-wide Big Data strategy, it becomes crucial to investigate how businesses can be better prepared to manage Big Data. To cope with the explosion of Big Data, and the growth of the 'Internet of Things', IT systems need to perform better than ever before. So it's time to start to rethink how to acquire and design versatile storage, highly flexible I/O and more power. The rise of the digital economy and the associated increase in demand for customised products has caused modern premium IT Infrastructures to become a complex system – requiring more power. To respond to business challenges with agility, modern businesses have to evolve quickly to stay competitive. This often means acquiring and deploying current state of the art IT systems. Central to this, organisations are constantly looking for ways to reduce their Total Cost of Ownership (TCO) of these IT systems often caused by IT sprawl. IT sprawl can lead to inefficiencies, including:

- Resource under or over utilization
- High management overhead
- Increased power consumption
- Increased cooling requirement

In this project you will design and implement a 24 hour solar power generation and distribution system that will help a home owner to reduce their TCO.

Below an example of a 24 hour solar power generation and distribution system is described.

This project requires you to either develop a **web or mobile application** for the 24 hour solar power generation and distribution system. All the fundamental requirements, physics and maths for the system have been provided. However, to make it your own project, you have to do some background research into solar panel technologies and hence your project proposal document should motivate the need and benefits for such a system. Your proposal should be well researched and written in a way to convince the client to put his or her money on it.

1 Introduction

This example is suggested to help a company called SSTL that builds and operates small satellites understand the potential of Enterprise System approach, and the capabilities and interface of enterprise technology solutions.

Below is a simple, non-space relate problem that you can implement using a body of enterprise technology solutions/processes. It is deliberately basic so that an end-to-end example can be easily developed and explored.

1.1 SSTL Evaluation Goals

SSTL would like to evaluate the following:

- Generation of a requirements / specifications tree.
- Demonstration of how calculations are performed and can be reviewed.
- Evidence of how requirements can be linked to calculations and verified once the calculations have been performed.
- Link of requirements to parameters in an equation.
- Demonstration of how changes are tracked in the model. How can the user / reviewer be alerted when some part of the model is changed.
- Demonstration of how trade-offs can be performed. If there are multiple options / inputs, can all these be presented in one system model to allow the reviewer to select the best option?
- The output of results in a user friendly style (e.g., graphs, tables).
- Demonstration of how the model can be reviewed without detailed knowledge of the final application produced.
- Can the system model be reviewed by someone not running the host application? E.g., a compiled version of the model.

- SSTL would also like advice and feedback regarding the capabilities of your engineered solution. SSTL are interested to understand the following:

- How “use cases” can be applied.
- How a graphical representation of the problem can be created.
- How SSTL can use your engineered enterprise solution for system modelling, of real engineering systems. SSTL’s focus is not just on requirements management, but on end-to-end engineering modelling.

2 End-to-End Example

2.1 Customer

A homeowner wants to put one solar panel on the roof of their house to generate electricity. There are two options for solar panel location, and two options for solar panel technology. The homeowner is interested in what the best value for money solution is, and if it is compatible with their existing electricity circuits in the house.

For information, the homeowner is based in Guildford, with coordinates 51.24° latitude, -0.59° longitude.

2.2 Customer Requirements

Table 2-1: Customer requirements for the solar panel installation.

Requirement ID	Requirement	Comment
Cust-010	Maximum power generated by the solar panel under any conditions must be less than 2000 W	The customer electricity system can not handle more than 2000 W.
Cust-020	The power generated should be less than 60 pence per Watt, evaluated at noon on each day of the year.	See comment below regarding evaluation.

Note that for the purposes of this investigation, two specific instances will be used to evaluate the customer requirements. These instances are noon (when it is assumed the sun is at its highest point in the sky), in mid of summer and mid of winter:

Assumed maximum noon-time power generation: 21/06/14. Sun elevation angle above the horizon = 60 degrees.
Assumed minimum noon-time power generation: 21/12/14. Sun elevation angle above the horizon = 15 degrees.

2.3 System Specifications

Table 2-2: Solar panel specification options to choose from for the solar panel installation.

Specification ID	Specification	Comment
Roof-010	Two roof locations are available.	Note that this might become three locations at a later date.
Roof-011	Roof location #1: area = 7 m^2	Assume the solar panel covers the entire surface of the roof.
Roof-012	Roof location #1: elevation = 25 °	Assume the solar panel lies flat on the roof surface.
Roof-013	Roof location #2: area = 10 m^2	Assume the solar panel covers the entire surface of the roof.
Roof-014	Roof location #2: elevation = 40 °	Assume the solar panel lies flat on the roof surface.
Panel-010	Two solar panel technologies are being assessed.	Note that a third technology may be considered.
Panel-010	Panel #1: efficiency = 0.2	
Panel-012	Panel #1: cost per m^2 = £100 / m^2	
Panel-013	Panel #2: efficiency = 0.15	
Panel-014	Panel #2: cost per m^2 = £85 / m^2	

2.4 Calculations Required

Constants and symbols are explained below. Note that the symbols can be changed if it makes the model easier to create.

Table 2-3: Description of symbols used in the model equations.

Description	Symbol	Value	Units
Power of sunlight incident on 1m^2 the Earth's surface.	P_{Sun}	1000	W/m^2
Elevation of the sun above the horizon when facing due south	E_{Sun}	60 or 15	Degrees
Elevation angle of roof as described in the specifications section. Assume the solar panel lays flat on the roof.	E_{Roof}	25 or 40	Degrees
Solar panel efficiency as described in the specifications section.	C	0.2 / 0.15	No units
Roof area available for solar panel as described in the specifications section.	A	7 / 10	m^2
Cost per square meter for the solar panel as described in the specifications section.	M	100 / 85	£ / m^2

The following equations are recommended to verify the customer requirements can be met with the specified roof and panel technology.

Table 2-4: Recommended equations to implement the solar panel model.

Relevant Requirement	Description	Equation	Units
	Elevation angle of sun on solar panel, "$E_{SunRoof}$".	$E_{SunRoof} = E_{Sun} + E_{Roof}$	Degrees
Cust-010	Total power generated by a solar panel, "P_{Panel}".	$P_{Panel} = C \times P_{Sun} \times A \times \sin(E_{SunRoof})$	W
	Total installation cost for a solar panel, "M_{Total}".	$M_{Total} = A \times M$	£
Cust-020	Cost of power generated for chosen roof location and panel technology, "F".	$F = M_{Total} / P_{Panel}$	£ / W

2.5 Background Information

A solar panel will generate the maximum power when the sun's rays are perpendicular to the surface of the panel, as shown below. In this case the angle between the sun's rays and the panel is 90 degrees.

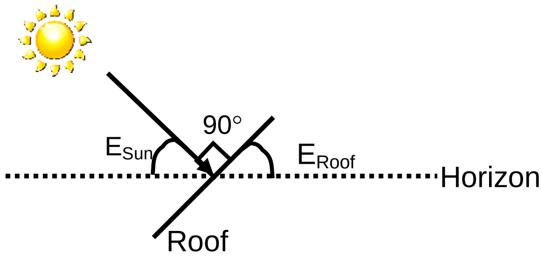

Figure 2-1: Definition of angles between the sun, solar panel and horizon when the sun's rays and solar panel are perpendicular.

The sun's rays and the solar panel may not be perpendicular, as shown below. In this case the angle between the incident solar rays and panel must be calculated using the elevation angle between the sun and the horizon (E_{Sun}), and the elevation angle of the roof (E_{Roof}).

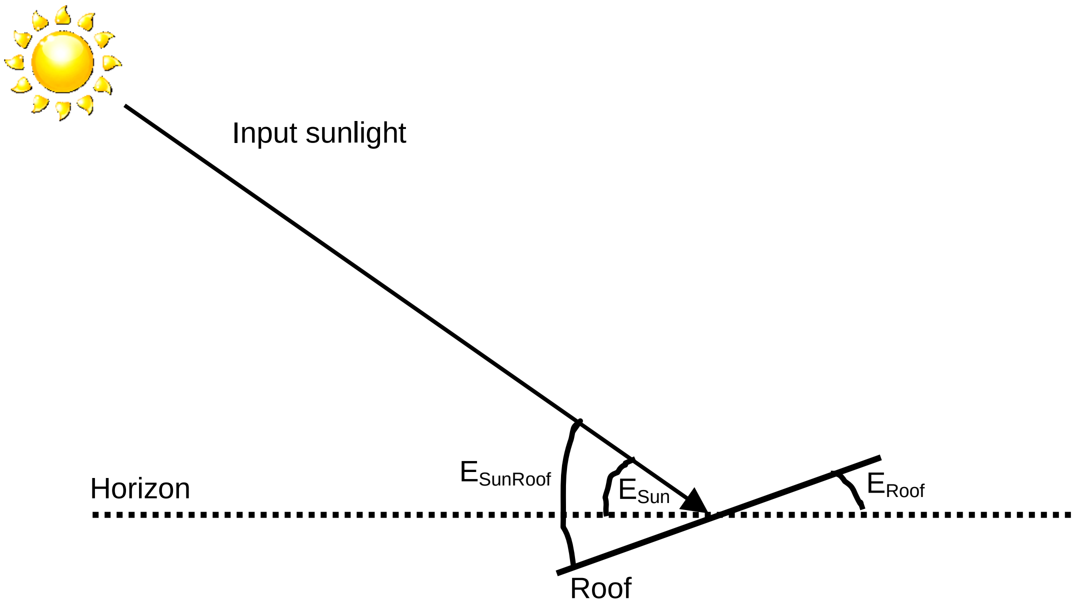

Figure 2-2: Definition of angles between the sun, solar panel and horizon.

3 Modelling a "Day-In-The-Life" Scenario

This section describes a Day-In-The-Life scenario of an operational solar panel system. The aim of this exercise is to model 24 hours of power generation and power consumption. The example presented is simplistic, however the concept is similar to satellite power modelling.

3.1 System to be Modelled

The customer wants to install a power generating, storage and distribution system, shown in Figure 3-1.

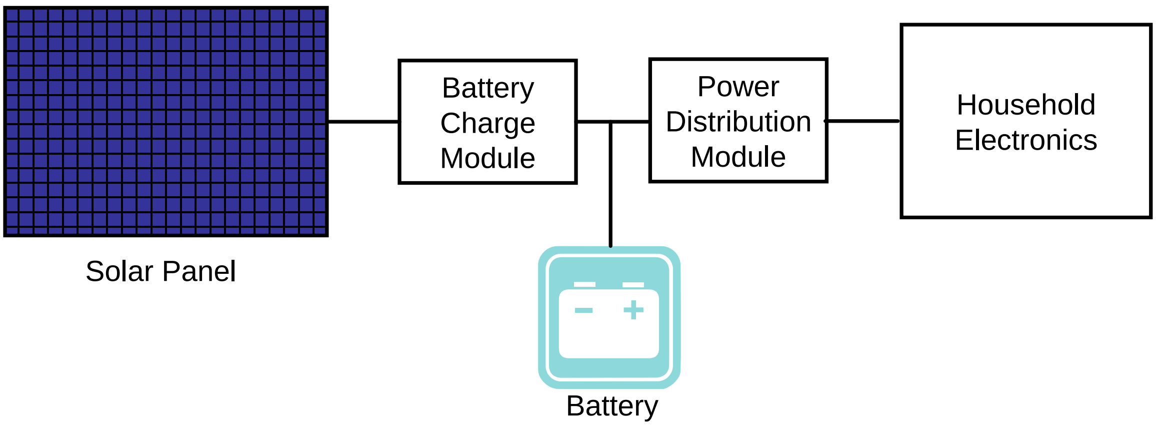

Figure 3-1: Block diagram of power system installed by the customer.

The system is comprised of:

- A solar panel fixed to the roof of the customer's house.
- A Battery Charge Module (BCM) that manages the power generated by the solar panel. The BCM performs the following tasks:
    - If the panel is sunlit and generating power, the BCM will charge the battery if the battery requires charging.
    - If the panel is sunlit and generating power, the BCM supplies power to the Power Distribution Module.
- A battery that can provide power to the PDM when the solar array can not meet the required power demand (for example at night). The battery can also be recharged by the BCM if it has discharged some or all of its electrical energy.
- A Power Distribution Module (PDM) that has power input from either the battery or solar array, and then distributes it to the household electronics.
- A power draw, also referred to as the base load. This is electronics the customer wants to power.

The customer has requested that the power generation, storage and distribution design be modelled over a 24 hour period. As will be discussed in Section 3.2, the power demand by the house is constant throughout the 24 hour period. However the 24 hour period will have a duration of night when no power can be generated, the sun will rise, increase in elevation above the horizon, and then eventually set. This changing sun elevation results in the solar panel generating different amounts of power during the day.

It is expected that the model will show that during the night the battery discharges at a steady rate. When the sun rises and the solar panel starts to generate power the battery will recharge.

The customer wishes to know if the system can keep the household powered constantly throughout the 24 hour period in summer, when the days are longest and the sun has the highest elevation, and in winter when the days are shortest. If the battery becomes fully discharged at any point in the 24 hours it is likely that this design cannot meet the customer requirements.

3.2 Customer Requirements

Table 3-1: Customer requirements for the overall power system installation.

Requirement ID	Requirement	Comment
Cust-030	The system as specified should be able to constantly power 300 W of household electronics.	
Cust-040	Maximum battery depth of discharge should not exceed 75% of the battery total capacity.	This is required to keep the battery working in an optimal way.
Cust-050	The system should sustain constant power discharge, defined in Cust-030, in winter and summer.	Two modelling periods will be suggested, winter solstice and summer solstice.

3.3 System Specifications

Assume that the customer has selected roof location option #1, and solar panel option #2 as defined in Section 2.3. These specification are repeated again below with some new battery, BCM and PDM specifications.

Table 3-2: System specification for the overall power system installation.

Specification ID	Specification	Comment
Roof-011	Roof location #1: area = 7 m^2	Assume the solar panel covers the entire surface of the roof.
Roof-012	Roof location #1: elevation = 25 °	Assume the solar panel lies flat on the roof surface.
Panel-013	Panel #2: efficiency = 0.15	
BCM-010	BCM efficiency is 85 %	
PDM-010	PDM efficiency is 90 %	
Batt-010	Battery capacity is 250 Amp Hours	
Batt-020	Battery voltage is 12 V	
House-010	The house will consume 300 W	

3.4 Sun Elevation above the Horizon

Table 3-3 provides the sun elevation above the horizon for the longest day of the year (21/06/14) and the shortest day of the year (21/12/14). This data was generated from a website – see Figure 3-2 at the end of this document for the source.

The sun angle data is presented in one hour time steps. As discussed in later sections, it is recommended that one hour time steps be used in the implementation of this model.

Table 3-3: Sun elevation above the horizon for the winter and summer solstice, at coordinates 51.24° latitude, -0.59° longitude.

Time (hh:mm)	Elevation of sun above the horizon on 21/06/11 (deg)	Elevation of sun above the horizon on 21/12/11 (deg)
00:00	Below horizon	Below horizon
01:00	Below horizon	Below horizon
02:00	Below horizon	Below horizon
03:00	Below horizon	Below horizon
04:00	2	Below horizon
05:00	9	Below horizon
06:00	18	Below horizon
07:00	27	Below horizon
08:00	37	Below horizon
09:00	46	6
10:00	54	11
11:00	60	14
12:00	62	15
13:00	60	14
14:00	54	11
15:00	46	6
16:00	37	Below horizon
17:00	27	Below horizon
18:00	18	Below horizon
19:00	9	Below horizon
20:00	2	Below horizon
21:00	Below horizon	Below horizon
22:00	Below horizon	Below horizon
23:00	Below horizon	Below horizon

3.5 Calculations Required

Section 3 is an enhancement of the model created in Section 2. The symbols and equations defined in Section 2 may be referred to in this section.

Constants and symbols presented in Section 3 are explained below. Note that the symbols can be changed if it makes the model easier to create.

Table 3-4: Description of symbols used in the model equations.

Description	Symbol	Value	Units
BCM efficiency. This parameter represents the efficiency of the BCM when it is managing the power generated by the solar array. The BCM is managing the array power to charge the battery or supply the PDM.	BCM_{eff}	0.85	No units
PDM efficiency. This parameter represents the efficiency of the PDM as it regulates and distributes the power from the BCM or battery.	PDM_{eff}	0.9	No units
Battery capacity. This is the maximum capacity of the battery.	$Batt_{Cap}$	250	Amp Hours
Battery voltage. This is operating voltage of the battery. This example assumes a "camper van" style 12 V battery.	$Batt_{volt}$	12	Volts
Household electronics power consumption.	P_{House}	300	W

The following equations are recommended to model the proposed system. It is suggested that the implementation is in a sequence of steps based on one hour time steps defined in Table 3-3. Some of the calculations below will require results from the calculations performed in a previous time step.

Table 3-5: Recommended equations to implement the day-in-the-life model.

Relevant Requirement	Description	Equation	Units
	Total power output by the BCM, "P_{BCM}".	$P_{BCM} = C \times P_{Sun} \times A \times BCM_{eff} \times \sin(E_{SunRoof})$	W
Cust-030	Constant base load of power, "P_{Base}".	$P_{Base} = P_{House} + ((1 - PDM_{eff}) \times P_{House})$	W
	Power Balance, "P_{Bal}".	$P_{Bal} = P_{BCM} - P_{Base}$	W
	Instantaneous charge or discharge current, "I_{Charge}".	$I_{Charge} = P_{Bal} / Batt_{Volt}$	A
	Battery state of charge at each timestep, "$Batt_{Charge}$".	$Batt_{Charge} = Batt_{Charge}$ (at previous time step) + I_{Charge} (of the current time step) (see comments below)	A Hr (Amp Hour)
Cust-040 Cust-050	Battery depth of discharge, "B_{DoD}".	$B_{Dod} = (1 - (Batt_{Charge} / Batt_{Cap})) \times 100$	%

3.5.1 Comments on Model Implementation

The calculations in Section 3.5 are recommended based on a particular implementation of the system in Section 3.1.

Please note that while calculations are given, the notes below also highlight where the Enterprise model solution may need to perform other non-mathematical functions such as "IF" statements. More **IF** statements may be needed to ensure the system modelled represents the real physical limits of the hardware or real world.

- The power output from the BCM, P_{BCM}, is very similar to the calculation for the power generated by the solar array, P_{Panel}. The additional parameter represents the efficiency of the BCM in managing the panel power. The real-world impact of the BCM efficiency is that the BCM consumes a small amount of power it is managing from the array and will have the effect of reducing the power available from the solar panel.
- The total power demanded by the household electronics, P_{House}, is calculated to include the efficiency of the PDM. The real world impact of the PDM efficiency is that to manage and distribute the power the PDM consumes a small amount of power. The implementation suggested is that this additional power consumption is added to the base load of power consumed, and the effect of this is to increase the base load power demand of the house from 300 W to 330 W.
- The power balance is the difference between the power available at the output of the BCM, and the power required by the PDM to meet the demand of the house.
- The instantaneous charge or discharge current represents the charge or discharge current of the battery.
- The battery state of charge is the charge of the battery taking into account any charge or discharge.
    - As this calculation depends on the previous time step battery charge, this calculation will need to be initiated with an initial entry. It is suggested the maximum battery capacity ($Batt_{cap}$) is used.
    - The calculation at each time step will use the previous time step battery state of charge, and add to that the current time step charge current. This charge current may be negative, indicating a battery discharge.
    - The battery state of charge calculation represents real physical hardware and should therefore not exceed the maximum battery charge, $Batt_{cap}$, and it should not be less than 0 Amp hours. An **IF** statement is suggested to make this check. If the battery capacity reaches that maximum capacity it can be assumed fully charged and no more charging is possible (assume the BCM hardware at this point stops charging the battery). If the battery capacity reaches 0 Amp hours, the battery can not be discharged any further.
- The battery depth of discharge is calculated by dividing the calculated battery state of charge at each time step with the total battery capacity. The expected range of this value is between 0% (fully charged) and 100 % (fully discharged).

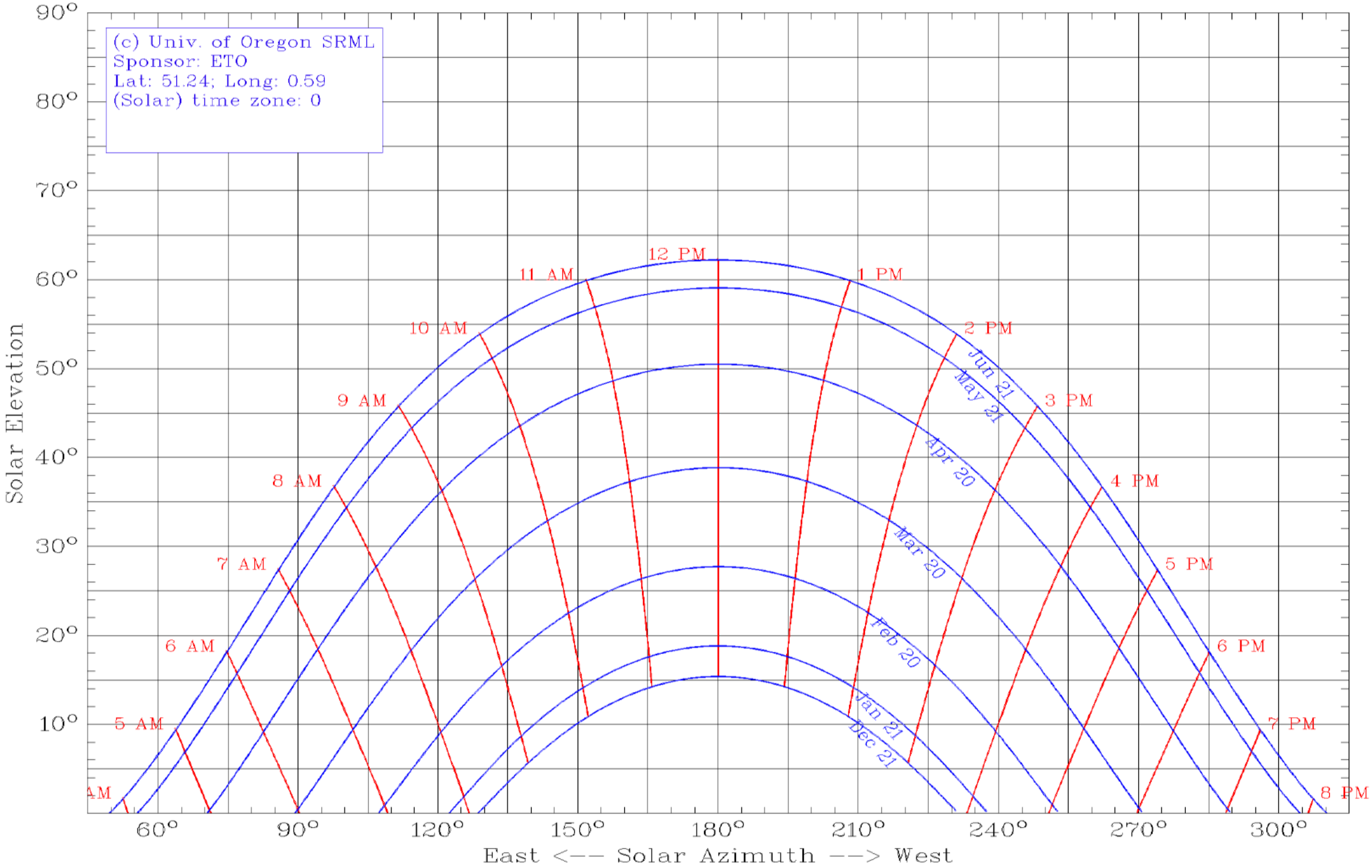

Figure 3-2: Elevation of the sun above the horizon. Chart generated from http://solardat.uoregon.edu/SunChartProgram.html

4 Addition of Data Network and Transmitters

The Enterprise System model created in Sections 1, 2 and 3 will now be enhanced with the addition of a data network to link the power system to an onboard computer (OBC) and two data links so that power system telemetry can be accessed by the home user and the business that supplied the equipment, "Solar Panels Ltd."

The purpose of this task is to investigate the addition of system model components to the entire system, and addition of modes of operation that include power demand and data generation.

4.1 Context of System Upgrade

The company that installed the original solar panel, BCM, and PCM, are testing a new upgrade to the system. This upgrade features better control of the power generation equipment via a local computer, a means for the customer and installation engineer to "log in" to the system over WiFi to monitor it, and for system information to be autonomously sent via text message back to the company that installed the system.

4.2 Data Network and Transmitters System Diagram

Figure 4-1 shows a diagram of the solar power system with the addition of a data network, an onboard computer and transmitters (Tx) and receivers (Rx).

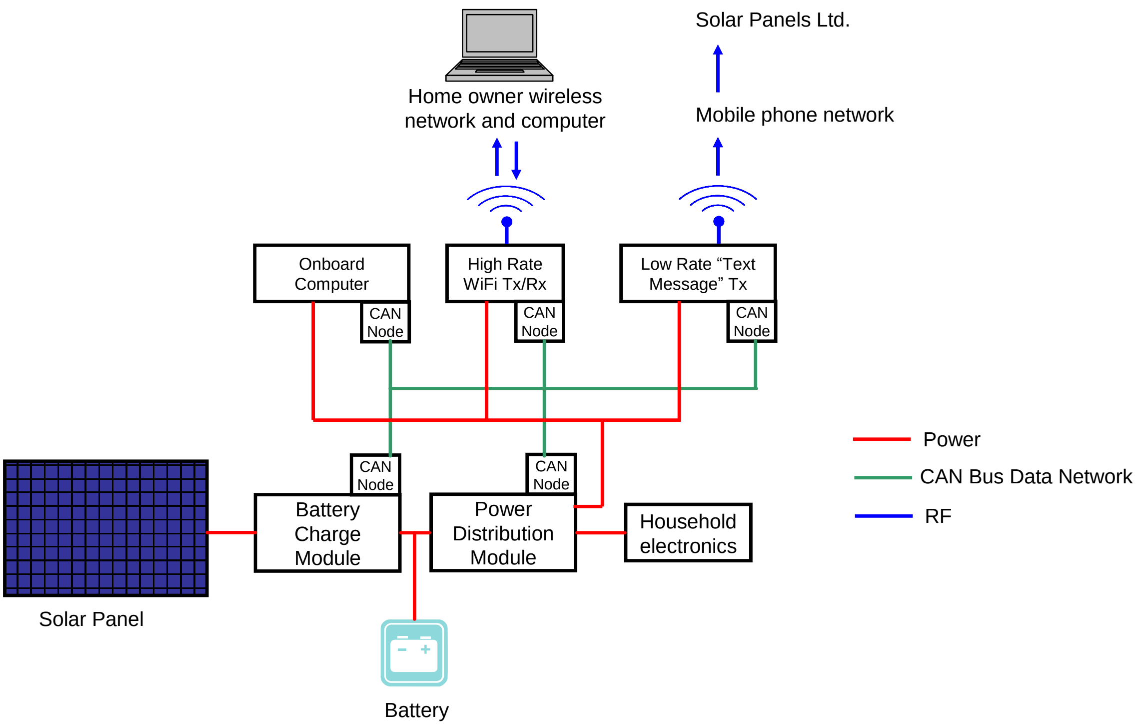

Figure 4-1: Solar panel power system with data network and communications modules.

The OBC and data network have been added so that the OBC can monitor the power system (Solar Panel, BCM, Battery, PCM) autonomously, detect any failures and record the usage and performance of the system.

The hardware modules in the system have been fitted with Controller Area Network (CAN) nodes. These nodes are an interface between the hardware they are attached to, and a CAN bus. The CAN bus is a length of cabling, also referred to as a harness, which links all nodes together.

[“CAN” technology originates in automotive industry. This article provides more information on CAN technology: http://en.wikipedia.org/wiki/CAN_bus Note that no information in the article is needed to complete this task.]

The OBC transmits messages onto the CAN bus that are addressed to specific nodes. These messages can either be telemetry requests or telecommands. If the OBC sends a telemetry request to another node on the CAN bus, that node will receive the request and respond by sending back to the OBC node, over the CAN bus, the telemetry point requested. Example telemetry points are:

- Amount of electrical current the solar panel is generating, sampled from the BCM module.
- If the battery is being charged or discharged, sampled from the BCM module.
- The electrical current being supplied to the household electronics, sampled from the PCM module.

When the OBC issues a telecommand it is sending a command to a target module, with the intention of changing some aspect of that modules behaviour or state. Example telecommands are:

- Commanding the BCM module to start or stop supplying current to the battery.
- Commanding the PCM module to start or stop supply current to the household electronics.

So that telemetry requests or telecommands can be issued to one target CAN node, each node has a unique number.

Table 4-1: CAN node numbers of the modules in the system networked using the CAN bus.

Module	Node Number (decimal)
OBC	10
BCM	20
PDM	30
Low Rate Transmitter	40
High Rate WiFi Transmitter and Receiver	50

In addition to the OBC and CAN bus, communications modules have been added. A High Rate transmitter/receiver (HR Tx/Rx) based on Wi-Fi technology has been added so that the homeowner or the company that installed the system, Solar Panels Ltd., can “log in” to the power system and access the OBC and other modules on the

CAN bus. The WiFi module has a limited range, but can transfer data at a high data rate.

A second Low Rate transmit only transmitter module (LR Tx) has been added so that system telemetry can be transmitted back the company that installed the system. This transmit only device uses the mobile phone network and "text message" system.

All the new devices are powered locally from the power generated by the solar panel or power stored by the battery.

4.3 Evaluation of the System

The designers of this system need to calculate the amount of data generated by the modules attached, the amount of data to store in the OBC in form of log files, and the amount of data to transmit as text messages. They are also interested in determining the total period of time that the solar power system can supply a customers power needs – this is know as the availability of the system.

4.3.1 OBC and Communications Modules Specifications

The OBC and communications modules specifications are given below in Table 4-2.

Table 4-2: Specification of the OBC, CAN bus, High Rate Transmitter-Receiver (Tx/Rx), and Low Rate Transmitter.

Specification ID	Specification	Comment
OBC-010	OBC can operate in a low activity "System Monitor" state, or a high activity "Full Control" state	
OBC-020	In "System Monitor" state, the OBC consumes 5 W of power.	The 5 W of power is required for: • Writing telemetry log file data to the OBC flash memory. • Powering the OBC CAN node. • Running the OBC processor to request a pre-defined set of telemetry points from other modules on the CAN bus.
OBC-021	In "System Monitor" state the OBC can request 100 telemetry points per second and write them to its memory.	
OBC-030	In "Full Control" state the OBC consumes 10 W of power.	The 10 W of power is required for: • All activities defined in Ops-020 and Ops-021. • Allowing all telemetry stored in log files to be sent to the high rate WiFi Tx/Rx.
OBC-031	In "Full Control" state the OBC can gather and send to the user logged on via the WiFi module all telemetry	

Specification ID	Specification	Comment
	points available in the system.	
OBC-032	In "Full Control" and "System Monitor" states, the OBC will every 5 seconds sample a telemetry point in the WiFi module to detect if a user has logged on to the WiFi module. If the OBC is in System Monitor state, and the WiFi module telemetry point is set indicating a user is logged on, the OBC must change state to Full Control.	
OBC-040	The OBC memory for storing telemetry log files is 1 Gbyte.	
OBC-050	The OBC has 100 telemetry points that report the status and operation of the OBC.	
OBC-060	The OBC can determine the state of charge of the battery by sampling telemetry from the BCM module. If the OBC detects that the battery is less than 75 % charged as defined by requirement Cust-040, then the OBC will command the PCM to stop supply power to the household electronics, thus conserving the remaining battery power. The only items that continue to draw power are the OBC, High Rate Tx/Rx and Low Rate Tx.	
HRTxRx-010	The high rate WiFi module operates "Hibernation" mode and "Operational" mode.	
HRTxRx-011	If the WiFi Tx/Rx is in Hibernation mode and it detects a WiFi user trying to log on, it must set a telemetry point to indicated a user logged on. The WiFi module must also change modes from Hibernation to Operational modes.	
HRTxRx-012	If the WiFi Tx/Rx fails to detect any user logged on for 5 minutes it must automatically revert to Hibernation mode.	
HRTxRx-020	In "Hibernation" mode the WiFi Tx/Rx consumes 5 W of power.	In this state the WiFi Tx/Rx is in a receive only mode and is detecting if any user external to the system is trying to log on to the WiFi module. It is also powering its CAN node.
HRTxRx-030	In "Operational" mode the WiFi Tx/Rx consumes 15 W of power.	In this state the WiFi Tx/Rx is in transmit and receive modes and can provide full connectivity to the CAN

Specification ID	Specification	Comment
		bus. It is also powering its CAN node.
HRTxRx-040	The high rate Tx/Rx has a total of 10 telemetry points available to sample over the CAN bus. These telemetry points give the status and operational mode of the module.	
LRTx-010	The Low Rate "Text" Tx operates in one "Always On" mode.	
LRTx-020	The Low Rate Tx consumes a constant 5 W of power.	This 5 W is required for maintaining a signal with the mobile phone operator, keeping its CAN node powered, and for sending the text messages when commanded to do so by the OBC.
LRTx-030	The low rate Tx has a total of 5 telemetry points available to sample over the CAN bus. These telemetry points give the status of the module.	
LRTx-040	The text message sent by the LrTx can be up to 160 characters, each character representing 7 bits. This is 1120 bits per SMS message on a GSM network.	See http://en.wikipedia.org/wiki/SMS for details of the SMS standard.
CAN-010	All telemetry points, and all telecommands are encoded to 8 bits.	
BCM-020	A total of 100 telemetry points are available from this module. These telemetry points define the status and mode of operation of the module.	
PCM-020	A total of 100 telemetry points are available from this module. These telemetry points define the status and mode of operation of the module.	

4.3.2 Questions to Be Answered

The following open questions need to be answered:

1. The company wishes to gather as much telemetry as possible using the text message system. Calculate the number of individual text messages that would be required to send all telemetry points.
2. The company wants to keep its bills as low as possible. For each installed system it doesn't want to spend more than £100 in text messages per year, with each text message costing 10p. Assuming that all telemetry points still need to be transmitted, what is the maximum number of times the full set of telemetry can be sent via text message before the £100 is used up. Suggest a reduced amount of telemetry to be transmitted if it increases the rate at which telemetry can be transmitted.

3. The company also wishes to retrieve the data stored on the OBC memory. When the OBC memory is full it will start to overwrite the earliest data stored. To avoid this the company will need to send an engineer to each installation to download the data from the OBC using the High Rate WiFi module. How quickly will the OBC memory fill up, and therefore how many times in a year must an engineer visit each installation.
4. The new equipment added to system draws power directly from the PCM. This will affect the power balance in the system, particularly the length of time the battery can supply the household electronics and additional system modules when no power is generated by the panel. Assume that the home owner logs into the system WiFi and checks the system status once at 12:00 for 60 minutes, and once at 22:00 for 60 minutes. Factor these new operational modes and power consumptions into the power balance modelled in Section 3. Ensure that the specification OBC-060 is modelled.
5. The company wants to determine what percentage of the year the system can satisfy the power demanded by the home electronics. Calculate the availability on the mid-summer and mid-winter dates outlined in Section 3. Is there any time when the battery is discharged 100 %?