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Decision-Making Framework For Small Business With Limited Available Capital

Milad Around
Ryerson University

Decision-making Framework for Small Business with Limited Available Capital

By:

Milad Arouni B.Eng., P.Eng.

University of Toronto

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Author's Declaration Page

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Milad Arouni

Abstract

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Milad Arouni

Program of Mechanical and Industrial Engineering

Ryerson University

In the world of business special attention is paid to entrepreneurs for their potential and large corporations for their impact on the market. Due to this, small businesses often fall short of resources and tools to help them grow.

The aim of this dissertation is to introduce a framework for decision making to small businesses as a tool to help embed more structure into their organization.

The framework was then applied to two distinct case studies to display its functionality and usefulness. The framework consists of several steps:

1) corporate plan and financial assessment 2) a current state analysis 3) a quantitative and mathematical feasibility study of the decision

The framework in each case study resulted in an objective and qualified decision. It also suggests that, due to the unique structure and characteristics of each small business, the framework proposed would only be relevant and applicable on a general level and more work is required to refine the details in order to be able apply it universally to business entities with limited working capital.

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Dedication

To my loving fiancé, Leila. You have been an inspiration and symbol strength in my life. Without your support, this would not have been possible. You have stood by me through good times and the bad; picked me up from my lowest and helped me soar to the highest levels

I dedicate this to you.

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List of Acronyms and Units

BILD	Building Industry and Land Development
CMHC	Canadian Mortgage and Housing Corporation
ESI	Embedded Sense Incorporated
FIT	Feed in Tariff
FV	Present Value
GTA	Greater Toronto Area
HR	Human Resources
I/O	Input / Output
kWh	Kilo Watt Hour
kW	Kilo Watt
MCU	Microcontroller Unit
microFIT	micro Feed in Tariff
OEM	Original Equipment Manufacturer
OPA	Ontario Power Authority
PCB	Printed Circuit Board
PV	Present Value
SWOT	Strength, Weakness, Opportunity, Threat
TAT	Turn Around Time
UK	United Kingdom
USA	United States of America
USD	United States Dollar

Chapter 1: Introduction and Literature Review

Decision-making is a critical part of any business and is defined as "a fundamental part of the management process" (Hui-Chao, 2004). Critical thinking and efficient decision-making may reduce the need for resources such as manpower, time, and costs (Dicken, 1971). As such, psychologists and economists have been trying to model decision-making for an individual (Edwards, 1954). Typically, decision-making has been approached in two ways in existing literature, qualitative and quantitative (Hui-Chao, 2004). Qualitative decision-making research suggests that one's personality and attitude can directly affect the decision-making process, whereas quantitative decision-making research suggests that numbers and statistics are the determining factors in the decision-making process (Hui-Chao, 2004). Simon categorizes decisions into two steps, programmed and non-programmed decisions (Simon, 1977). Programmed are the everyday decisions for a decision-maker and non-programmed are strategic and other type of decisions. Hui-Chao in 2004 expanded upon Simon's theory and categorizes decisions into three classes: Short-term operating control decisions, periodic control decisions and strategic decision-making (Hui-Chao, 2004).

Some of the existing literature has tried to specify several steps to model rational decision-making. For example, Buzerman specified six specific steps (Bazerman, 2001, pp.3-4) and Cyert et al. have specified nine (Cyert et al., 1959).

Cooper et al. have suggested a structured approach to decision-making (Cooper, 1981). A way to embed structure into decision-making is to come up with a framework for it, but first one must identify and define the decision maker.

1.1 Who is a 'Decision-Maker'?

The business 'decision-maker' was really defined by Jon Stuart Mill in 1874, who came up with the term of "economic man." In an article Persky (1995) references Mill and his work where he argues that "[Political economy] does not treat the whole of man's nature as modified by the social state, nor of the whole conduct of man in society. It is concerned with him solely as a being who desires to possess wealth, and who is capable of judging the comparative efficacy of means for obtaining that end" (Persky, 1995, p.4).

Later, Mill argued that "an arbitrary definition of man, as a being who inevitably does that by which he may obtain the greatest amounts of necessaries, conveniences, and luxuries, with the smallest quantity of labour and physical self-denial with which they can be obtained" (Mill, 1874).

This work later gave way to the term "economic man" which is defined as a model of a person with the following traits:

1) He is completely informed and knows all the course of action that is open to him and realizes the outcomes of those decisions (Finetti, 1937; Georgescu-Roegen, 1950; Edwards, 1954).

2) His decisions are infinitely sensitive, meaning that the alternatives are a continuous function and are infinitely divisible (Stone, 1951; Edwards, 1954).
3) He is rational and can order the states in which he can get and make his decisions to maximize something (Edwards, 1954).

1.2 The "Economic Man"

The theory of an "economic man" has been argued, discussed and modeled for years in the academic world, in the business world and others for decision-making strategies. In the business world, this theory has been examined to better understand the behaviour of business executives, managers, and entrepreneurs. It has been these studies that have led to some psychological and behavioural research comparing entrepreneurs to large business managers. The results of some of these studies concluded that there are no differences between the two classes of businessmen (Busenitz & Barney, 1997; McClelland, 1961; Low & MacMillan, 1988; Brockhaus & Horwitz, 1982). A study by Busewitz and Barney (1997), examined the differences between entrepreneurs and large business managers in term of their surrounding environments. They argue that these differences exist not due to the psychological and behavioural differences but due to environmental conditions, resource availability, and existing structure of their decision-making process. One of the major distinguishing factors in decision-making process between entrepreneurs and managers, noted in several papers, is the increased level of uncertainty faced by entrepreneurs (Hambrick & Crozier, 1985; Covin & Slevin, 1989), when compared to managers of larger firms (Mintzberg, 1973). It is argued that because managers have more resources available to them, they are able to make more rational decisions (Busenitz & Barney, 1997). Furthermore, managers tend to have more time for making their decisions and therefore can examine more options. Finally, there are elaborate decision-making policies and schemes available to large business managers (Busenitz & Barney, 1997; Nelson & Winter, 1982). It is due to the entrepreneurs' lack of these things that their decisions are mainly based on biases and heuristics (Pitz & Sachs, 1984).

However, a problem arises when we start to talk about small businesses - the middle ground between large and entrepreneur businesses. While there are many studies that examine the difference between these two, suggesting theories and frameworks for better and more effective decision making, many of these studies fail to focus on the business that falls between the two models - the small business.

1.3 Definition of Small Business

The ability to define a small business is important so as to avoid the misunderstanding of the term. There have been several attempts at defining a small business (Scott & Bruce, 1987; Cooper, 1981; Carland et al., 1984; Bates, 1990; Culkin & Smith, 2000; Begley & Boyd, 1987). Often, they are looked at as a small firm that is managed by its owner or part owners and has a small market share (Culkin & Smith, 2000).

In Canada and for the purpose of this paper, a small business is defined as an organization with less than 50 employees and one with revenue stream below five million dollars (Industry Canada, 2011). The Industry Canada definition for small business is a very general one. This generalization exists throughout the business and academic world. Small businesses are often referred to as a sector (Carland et al., 1984). This is not due to the similarities in the business operations or structure but because of the obvious and apparent differences that exist between small businesses and the rest of the corporate world.

What makes a small business so different than what previous research has indicated is the minimally applicable or not applicable myth that a small business is simply a scaled down version of a large one. While this can be argued in terms of size and structure of the business, it is not completely true due to the key differences that exist in terms of the decision-making process and logistics. Larger businesses are inherently more complex in their structure, organization, departmentalization, and specialization, as such; small businesses just do not function or act like large ones do (Culkin & Smith, 2000).

Another key difference between small and large firms is the availability of capital or in simpler terms 'deep pockets' (Dean et al., 1998). Larger firms inherently have larger budgets to work with and therefore have more tools available to them. One can argue that any business has its limitations in terms of capital. This statement is true; a bad decision can have devastating effects on the survival of any business, however it's the availability of the resources that becomes the main distinguishing factor. A larger organization will naturally have easier access to financial support in terms of investors and banks; therefore, it can afford to invest in decision-making tools and resources. A small business by definition of Industry Canada can have an income of as little as $30,000 annually and therefore may not be able to readily purchase the same tools as a larger organization. Bates (1990) in his study points out that business owners with higher education and larger cash flow are more likely to secure a loan from a financial institution (Bates, 1990; Romano et al., 2000).

As previously mentioned, a lot of the existing literature group small businesses with entrepreneurial firms in their comparisons of small and large firms. (Dean et al., 1998; Carland et al., 1984; Scott & Bruce, 1987; Bates, 1990; Edmister, 1972; Gilligan et al., 1983; Begley & Boyd, 1987). While the two entities are very similar in the early stages of their operation, grouping a small business with entrepreneurs is not accurate. For instance, a small business past its' inception stage has started to employ individuals and is either in its growth stage or in a state of maturity. There are few papers that attempt to distinguish between the two classes of business.

Carland et al. (1984) differentiated small business and entrepreneurship on the basis of innovation and whether or not the business is employing a new tactic or introducing a new product into the market. This paper also expands this idea to argue that mid-size and large firms can also be regarded as entrepreneurial on this basis (Carland et al., 1984).

Begley and Boyd differentiate between small business and entrepreneurship in psychological characteristics, company growth and profitability (Begley & Boyd, 1987). They define entrepreneurship holders as more of 'A-type' personalities, hurried, and hard-driving with aggressive profiles. In terms of company growth and profitability, entrepreneurships are fast growing whereas a small business concentrates more heavily on profitability (Begley & Boyd, 1987).

While in both Carland and Begley's papers emphasis on the distinguishing factor is placed on the business owner's personality and appetite for growth, there are key organizational differences that do and/or should exist between the two entities (Carland et al., 1984; Begley & Boyd, 1987). Therefore, the true definition of a small business should ideally include all the aspects and theories that have been discussed above - the result of which is a complex entity that is vital to survival of any economy.

1.4 What makes small businesses so important?

Ironically, it is small businesses that play a more prominent role in existing economic models such as Canada's. There are more than one million registered small businesses in Canada in 2011 (Industry Canada, 2011). This number accounts for over 98% of the total number of businesses and is responsible for over 48% of the total labour force across this country (Industry Canada, 2011).

However, the survival rate of such companies is very low, for such reasons as limited capital and cash flow availability. According to Statistics Canada, over 58% of these businesses fail before their 5th year anniversary (Industry Canada, 2011). Therefore, it is crucial to put in a place a vehicle to help these businesses survive, grow, and be prosperous beyond their first five years of operation. Hence, it is especially important to define a framework that will work for a company that falls between the large business/corporation and being an entrepreneur. There is very little help that currently exists. This is mainly due to a general lack of understanding, little research and few available tools. It is the opinion of this writer that small businesses often are overlooked due to their existence between an entrepreneurial business and a large business.

1.5 Small Business Decision Making

One of the most useful tools that exist for a large firm decision-maker is the available data and past precedent cases. Additionally, there exist firms who specialize in gathering data and compiling them in meaningful stats to be used. Culkin and Smith (2000) in their paper wrote, "With any problem, the search for a solution almost always begins with past precedent; has it been seen before and if so, how was it handled. If one can find a satisfactory solution in this manner, job done. Large businesses will likely have this structure in place. However, in small businesses, there is usually no place for a specialist and hence likely no past precedent" (Culkin & Smith, 2000). With the introduction of the world wide web and the slew of information that is currently available, small businesses now have access to past performances and decisions of other firms to help guide them in the decision making process. However, the challenge lies with knowing where to look and how to find reliable sources of information. So, the search for a solution may be random, trial and error or perhaps based upon the experience of another firm that had a similar type of problem. Moreover, the information acquired may not be accurate in the sense of completeness. Dicken (1971) argued that an organization would filter out what they don't know about and hence will never become aware of all the facts and will make decisions based on limited data. The issue with this type of problem solving is that for small businesses, resources and data available are limited. Hence the will increase uncertainty within a decision, without the decision-maker being aware of it (Dicken, 1971).

Essentially, the decision-making unit is the owner/manager (Culkin & Smith, 2000) and as such, there tends to be an over-emphasis on things such as control, lifestyle, and job security over rates of return on their investments (Romano et al., 2000). The business owner often lacks the necessary training to be a good decision maker. These business owners are often highly technical people with minimal business experience (Cooper, 1981). More often than not, the skill of running a business and decision-making comes with experience and making mistakes.

In a small business, it has been argued that financing decisions are determined to a large extent by the values, business objectives, and aspirations of the owner (Romano et al., 2000). When problems are approached in this manner, uncertainties are increased, as decisions are not being made based on knowledge of particular situations but rather on biases and sometimes heuristics. Contributing to the bias may be the import of only certain types of information, as many businesses do (Dicken, 1971). As such, it is important to understand what an individual needs in order to make decisions that are educated and efficient. This kind of heuristics and biases are, in the opinion of this writer, the reason why small businesses in Canada have survival expectancy of only five years (Industry Canada, 2011).

In order to prolong this survival period and rate, small business owner must receive proper and adequate training and education in managing a business and decision-making or they must be given tools to help guide their decision-making and management processes. Management education and training is not always readily accessible and is a very time consuming process. A small business owner is often pressed for time to a point that his or her personal and professional life become one. Therefore, in order for a small business owner to make better-educated decisions, it is critical for he or she to have adequate tools and resources available.

1.6 A review of some existing frameworks

The current literature is consistent of many decision-making frameworks. These papers focus predominantly on probability theory and programming techniques such as Linear Programming Technique for Multidimensional Analysis of Preference (LINMAP) (Wang & Li, 2012; Srinivasan & Shocker, 1973). This technique is based on weighted outputs for decision-making and comparisons of alternatives. Much like the LINMAP the classical model of multiple criteria decision-making model is also based on prioritization and evaluation of existing alternatives (Wang & Li, 2012). These models and techniques are highly mathematical and require an understanding of programming theory and statistical analysis - a skill not common to a small business owner. Campanella et al. (2011) in their framework explain the typical model for decision-making based on an $m \times n$ matrix. Where m represents the number of alternatives and n, the number of criteria. Each value in this matrix is between 0 and, 1 which represent "not satisfactory" or "complete satisfaction" respectively (Campanella & Ribeiro, 2011). This field of study is extended to incorporate uncertainty (Atanassov, 1986; Zadeh, 1965), the relative importance of each criterion, fuzzy logic (Campanella & Ribeiro, 2011) and etc.

While, these decision-theories and frameworks are excellent tools to help in understanding the mathematical theory of decision-making; they are not practical tools. Most existing literature and frameworks in the field of decision-making are based on complex mathematical theories and applications, which are not suitable for everyday operations of a small business owner.

1.7 Existing Gap for Small Business Framework

The existing literature in decision-making and small business cover a range of topics that are worthy of review and further study. Decision-making literature has the tendency to approach the subject from either a purely mathematical (Bates, 1990) or psychological point of view (Gilligan et al., 1983). Small business literature on the other hand is most focused on the behavioural and characteristic of the owner(s) (Culkin & Smith, 2000), which is consistent in explaining why the literature often groups small businesses and large organizations together. Existing papers make the argument that a small business is not "a small large business" due to the influence of the owner on its operation. However, what gets lost in that translation is that small business is also not "a large entrepreneurial firm." In a small business , there must exist elements of organization, structure and rational decision-making. As such, falling in between the two business classes requires a hybrid model of decision-making and a new set of tools that differ from ones available to entrepreneurs and large businesses.

The objective in this thesis study is to create a decision-making framework for small businesses with special consideration to their limited capital. This is done while considering the above statement that a small business is a simply "a small business" and should be treated and considered as a separate entity in the economic world. Hence, it will require a set of unique tools and guidelines that would help the business owner in his or her daily operations, logistics and decision-making.

In the following chapters, a framework will be developed and proposed based on careful examination of previous studies and utilization of logistical and tactical methods of operating a business. Then, the proposed framework will be tested through implementation in case studies with two distinctly different business models with unique decisions.

The framework developed in this thesis will be a preliminary step in creating a set of tools to help small businesses. It is the anticipation of this writer that this framework will serve as a tool similar to what is being used in large corporations with special consideration of its end users - small business managers; thus ultimately introduce more structure and certainty into logistics and decision-making practices, while being cognizant of the limited capital availability, to help their survival chances.

1.8 Who could use this framework?

The framework proposed in this thesis study is intended for small business decision-makers who are operating a small business as defined above. The framework is designed to cater to the owner/decision-makers with little to no business management education and to identify a series of steps and tools, which can be used in order to make a more rational decision based on available data and facts. This structure will inject more objectivity to a business environment and will step away from a more traditional decision-making in small business, which is based on little to no available data and often is based on 'gut feeling'.

Though this framework can be applied to all levels of business for any type decision-making, it will be far less detailed than what is being used in large organizations by the executives and managers, however, it will demand due diligence and will impose a data driven mentality that is on par with ideals of those organizations. The small business decision-maker would be able to apply each step and go through a logical decision-making process with little use of heuristics.

Chapter 2: Proposed Theory

"Decision-making is regarded as a fundamental part of the management process" (Hui-Choa, 2004; Gilligan et al., 1983) and it is vital to the survival of all businesses regardless of their size. Large organizations usually have decision-making processes in place to ensure a more quantitative approach (Nelson & Winter, 1982), while entrepreneurial and small organizations rely mostly on qualitative knowledge and experience (Barney & Wright, 1998). Several theories currently exist regarding the procedure and logistics of making a decision. Cyert et al. in 1959 broke down the decision making process into 9 distinct steps. These steps are 1) Forecasting competitors, 2) Forecasting Demand, 3) Estimating average unit cost, 4) Specify objectives 5) Evaluate, 6) Re-examine cost estimate, 7) Re-examine demand estimate 8) Re-examine profit goal, and 9) Deciding (Cyert et al., 1959). Bazerman, in 2001, came up with the theory of dividing the decision making process into 6 steps. These steps comprised of 1) Characterizing the problem, 2) specify all criteria, 3) evaluate all criteria, 4) produce relevant alternatives 5) evaluate each alternative 6) determine the highest perceived value. (Bazerman, 2001)Earlier Hammond et al. in 1999 characterized elements of smart choices in eight steps. Moreover, in an article by Lee and Wirasinghe in 2010 this process is in seven steps (Lee & Wiashinghe, 2010). The steps mentioned in all the aforementioned decision making processes are general logical steps, which provide little guidance to the decision-maker and would be of little use to a small business owner whom often has limited management skills and is pressed for time. Therefore, in order to create a decision-making procedure or framework for a small business owner, one must include a few of features. Firstly, a decision-making framework must be simple to understand. Often, as the case above the steps in decision-making framework is general, which leaves the decision-maker to interpret the process as he or she sees fit. Secondly, a decision-making framework must specify tools and resources for each step. By specifying appropriate tools, the decision-maker is able to understand and follow the process more accurately.

The decision-making framework proposed, in this paper, is designed to introduce a more structured and quantitative approach to the decision-making process of these businesses while taking into account capabilities and capital availability. This framework can be broken down into 3 major steps/milestones. These steps are designed to take a holistic and broad approach to each problem in order to solve them. They comprise of (1) corporate plan and financial assessment, (2) a current state analysis and finally (3) a quantitative and mathematical feasibility study of the decision (see Figure 1).

The three steps chosen are based on a simplified version of the decision-making procedure from Cyert et al (1984) The nine steps mentioned in this study are categorized into three major steps. These steps are designed to help the small business owner to go through his or her decision-making process by first, looking at the market and the where company fits. Second, to look at capabilities and identify criteria available to him or her within the company. Third and last is to evaluate the options and alternatives by means of mathematical model and with access to data.

Each step is broken down further into more detailed sub-steps where the business owner will have an option of tools that he or she can use in order to complete the step. For example, the first step is the corporate plan and financial assessment. This step can involve the use of a range of tools, which will be discussed later on. The entire framework is designed this way so that the small business owner can easily pick the tools that are most convenient and accessible to them. It should also be noted that this framework is designed with a simplistic approach in order to enable a business owner with little to no business education and know-how. He or she would be able to:

1) Assess the market and the position of the company
2) Assess the capabilities of the company based on data available
3) Make a decision based on mathematical evaluation of available alternatives

While the framework seems to be general and applicable to all business sizes, it is designed to better fit with the small business setting. This is done through several key features. Firstly, the simplicity of the framework will allow any business owner regardless of their educational background and business experience to understand the logic and reasoning. More often than not, complicated processes are rejected by owners because they do not understand them and their benefits.

Secondly, the framework is based on the assumption that small businesses do not operate with appropriate structure put in place to adequately succeed. This point is directly tied to the definition of a small business - discussed above.

It is worth mentioning that this framework compared to traditional decision-making processes is not adequate for large businesses and firms due to the complexity of the organization and existing relationships between decision makers. This framework must become more detailed to account for several other factors such as management - employee relationships in order to be adequately applied to larger firms.

2.1 Corporate Plan and Financial Assessment

This step comprises of performing a full assessment of the organization with respect to its competitors in the market. Here, the decision-maker assesses the competitors, does an extensive SWOT (Strengths, Weaknesses, Opportunities, Threats) (Pahl & Richter, 2009) analysis and finally, an overview of market channels and applications. SWOT analysis is a planning tool technique that was developed in 1960’s by Albert Humphrey and used to evaluate a companies strengths, weaknesses, opertunities and threats. The above mentioned tools and techniques, will enable the decision-maker to obtain a detailed view of all external factors that would affect the organization and enables him/her to assess details, such as timing of the decision and its possible outcomes for the company with respect to the market.

There are other tools that can be used to fulfill the requirements of this step. One of these tools is a gap analysis, where the business owner will determine the gap that exists between the market and his or her company. There are many other tools that can be used in this step. The main aim of utilization of these tools is to bring the business owners attention to the market that he or she is operating in. It will also allow the owner/decision maker to get a good understanding of the relative position of the company with respect to its competitors.

2.2 Current State Analysis

After looking at all the external factors and implications of the decision, the next step is look within the organization and analyze its current state. In this step, the decision-maker looks at all the factors that would be involved and/or require modification. This step is mostly a data collection step for the company where information such as finances, production, manufacturing, overhead, etc. would be collected and analyzed. In cases where modeling current states are complex, simulation softwares are available to help the decision-maker produce an accurate model. The aim of this step is to verify whether the current state of the organization would be sufficient for decision implementation. With smaller firms, this step usually reveals the low capital availability. Here the decision maker would look for alternatives to make the activity/decision a reality. This information is then used in the next step, which is the decision feasibility.

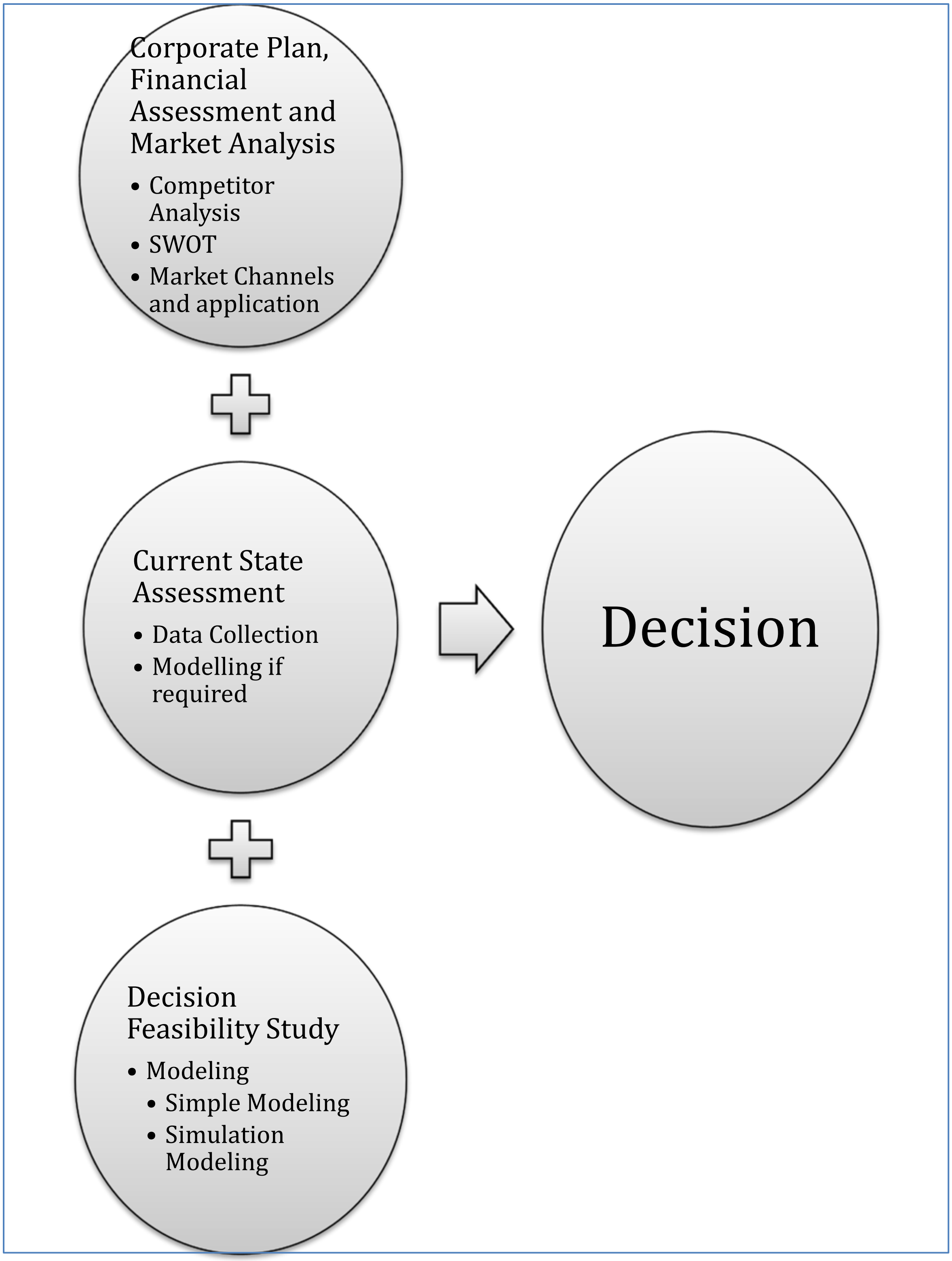


Figure 1 - Decision-making framework for small businesses

2.3 Decision Feasibility Assessment

The final step in this decision-making framework is an extensive feasibility study. In this step, the decision-maker, after taking into account the considerations from the previous steps, assess the possible alternatives and options with a purely quantitative approach. This is done through use of either mathematical or simulation modeling. Mathematical modeling can be used when the number of variables in the decision is small and the decision making can be done through simpler mathematical operations. In these, simpler cases, based on the uniqueness of the decision and the influencing factors a simple mathematical model is created. This model will include all the factors and variables which enables the decision-maker to assess the outcome of each alternative.

In more complex cases, where it is difficult to accurately model a decision via simple variables and equations, simulation softwares can be used. These softwares, will take into account all the parameters required to create a model that will mimic the problem/decision and allow the decision-maker to see the alternatives available and their associated outcomes. The use of these softwares would require an additional sub-step in the framework, which is the verification and the validity of the input and output data to ensure statistical significance of the results. It is called input and output analysis. The abovementioned steps will help a decision-maker in a small business, structure his/her decision process. It will allow for more informative and objective decisions.

In the following sections, the framework above is used in two separate case studies with small businesses, to display its use and validity of the proposed framework for small business decisions with low capital availability.

The first case study, will address an outsourcing decision for a small engineering firm, that is attempting to enter the manufacturing sector. In this case, the feasibility study required the use of a simulation software, Arena, to accurately model the existing production and also assess the possible alternatives.

The second case study, focuses on a purchasing and marketing decision for a small construction company. This decision is heavily reliant on a revenue vs cost comparison, which is done through development of mathematical models based on the existing variables.

The purpose of these case studies is to firstly demonstrate and validate the proposed framework and secondly to show its versatility in its applicability to a variety of decisions for any small business with limited capital.

Chapter 3: Methods

This paper used two industry based small business case studies. The first was of Embedded Sense Inc. and the second was of Manet Company. Each case study followed the steps proposed by the framework. The decision-making procedure began with a detailed market analysis using available information on market trends, existing competitors and other public data. The next step included an overall look at the state of the company - its finances, direction and market analysis. This was conducted through an informal interview process. Finally, a feasibility analysis determined a final conclusion. The feasibility step utilized a mathematical model based on the company's specific circumstances. Using this mathematical model, a sensitivity analysis was done to help determine the best decision for the company.

3.1 – Case Study 1: Embedded Sense Incorporated (Company Overview)

Embedded Sense Inc. (ESI) is a small business engineering firm that has been operating since 2004 and has a small but growing global client base of repeat customers. The company's core competency has been its flexibility to design and deliver entire products with detailed specifications to its customers. The company has a dedicated production facility, where most of the assembly and testing are done. When required, ESI uses specialty companies to source parts and components for its projects.

Since 2008, the company has been making progress towards developing its own line of microcontroller boards, Original Equipment Manufacturer (OEM). With this addition, the company is anticipating a large spike in production and will need to prepare itself for potential demand increase of its products. While, the addition of the new division to the company will ideally require its own manufacturing facility, tools, and equipment; such resources are not viable for this small business. It is not possible to allocate the funding required for a new facility. ESI is looking to make a decision to either build its boards in-house and possibly expand the current production line or outsource the manufacturing of its boards.

3.1.1 – Corporate Plan, Financial Outlook and Market Analysis

The ESI case was conducted over a short period of only four months. First step of the framework required an in-depth investigation of ESI's corporate plans and financial outlook. In this step, it was necessary and critical to know and assess the relative position of the company with respect to the market and also to be able to accurately draw a current financial picture. This will then allow for a more informative and comprehensive decision base in regards to the future of the company.

A thorough and detailed assessment of the potential market for the microcontroller boards was conducted. Several factors that had to be taken into account; including the i) search for potential competitors, ii) Strength, Weakness, Opportunity and Threats (SWOT) analysis iii) analysis and selection of market channels within the line's production capabilities.

The investigation of ESI's corporate plan and financial outlook started with several meetings with the president and CEO of Embedded Sense Inc. where informal interviews were conducted. In these interviews, questions pertaining to the general direction of the company, overhead expenses, marketing and advertising budget as well as cash flow was discussed and recorded.

The production manager and technicians at ESI were also interviewed throughout the four-month observation period. In these interviews, the participants were asked to verify the gathered data, the random variable distribution mock-ups that was created from the gathered data, and models as well as give insight into why and how the production process has been setup in its current state. The data, random variable distributions for input and models were recorded and created by this investigator based on observations.

3.1.2 – Assessment of Current State of Production

The second step of the framework involved monitoring and acquiring data from the production process. In this step, all the process times were recorded from the time an order was received to shipping. Due to a lack of sufficient time period of observation, in the case of Embedded Sense Inc., the number of physical time measurements for each process was limited. During the four-month period of this study, ESI's engineering division handled only five projects, one of which, included work by the OEM division. However, a fair representation of each process was done with the use of measured data and information from production manager at ESI regarding past projects. This data was verified by the production manager at every stage of the process and then mapped to the closest mathematical distribution using a best-fit curve based on available data. The acquired distribution models and parameters were entered into a simulation model. This model consisted of an accurate representation for day-to-day operations at ESI. Next, the existing model (Current State of Production Model) was analyzed for validity of results with respect to statistical significance and error percentage.

3.1.3 – Assessment of Feasibility

The final step of the proposed framework involved the suggestion and modeling of alternate manufacturing processes and to investigate their performance and feasibility. To do this, separate interviews where held with the human resources (hr) manager and production manager.

During the course of interviews with hr manager, the feasibility of hiring more personnel and the true cost of hiring an employee was discussed. Moreover, the subject of hidden costs pertaining to time taken from managers and interviewers during the process of hiring was discussed and labeled as a major concern for a growing small business such as ESI.

The interviews with the production manager involved discussions about costs of new equipment acquisition, cost of training, the nature of a learning curve and costs associated with maintenance, repairs and production downtime. Furthermore, the alternative solutions such as outsourcing were deliberated on.

The results from these alternate models were statistically validated and then compared with ones from the "Current State of Production Model".

3.2 – Case Study 2: Manet Company (Company Overview) and FIT/microFIT Program (Overview)

Manet Company is a small construction firm in Thornhill, Ontario, which specializes in construction projects of single and multi-family residential dwellings. It has been operating since 2005. The company's core competency is its ability to deliver a customized project from conception to completion. As a construction company, it is vital for Manet to be involved in latest green projects and Manet Company has shown interest in participating in the FIT/microFIT program, explained below.

What is FIT/microFIT program?

Today's energy consumption and industry survival is very dependent on raw materials of which coal and crude oil are at the forefront. The use of these resources has increased dramatically as the earth's population and demand for energy has increased. Unfortunately, the increase in demand may be more than the supply available; it is estimated that the coal and crude oil will be used up in the future. Additionally, the use of these materials to create energy has created an insurmountable amount of pollution that has negatively affected the quality of life on earth for all organisms.

The aforementioned reasons are at the forefront of why renewable energy sources are a necessity for earth's survival. These sources include, wind, solar, biothermal/geothermal, and water. Fortunately today, many countries have recognized the need for employing renewable energy sources. Some of the leading countries in renewable energy initiatives include the United States of America (USA), Canada, Germany, and United Kingdom (UK). These countries are running several programs, including Feed-in Tariff Program (FIT Program), to promote the use of renewable energy sources for consumers, commercial and industrial businesses.

Amongst these FIT programs, Germany has been the most successful (Jacobsson & Lauber, 2006) and as a result has been used as a model for the UK and Canada's FIT program (Toronto Star, 2011). The Ontario Power Authority (OPA) introduced Ontario's FIT program in 2009 (Legislative Assembly of Ontario, 2009). The FIT program was divided into two categories of systems with capacities of over and under 10kWh; FIT and microFIT respectively. The program allows for individuals to install and operate renewable energy facilities and sell the produced energy to their local hydro company at a swollen rate. The FIT/microFIT segregation allows for consumers and businesses to participate in this program with even a small investment.

The rates vary depending on the renewable energy source, type of installation and size of project. For example, a 10kWh ground-mount solar system pays a rate of approximately 64.2 cents per kilowatt. Table 1 and Table 2 show the different rates depending on renewable source, type of installation and size for the microFIT and FIT programs respectively.

Table 1 - microFIT program prices and rates (Ontario Power Authority, 2009)

micro Feed-in-Tariff Program Prices for Renewable Energy Projects in the microFIT Program Base Date: September 30, 2009	
Renewable Fuel	**Contract Price Cents/kWh**
Biomass	13.8
Biogas	16.0
Waterpower	13.1
Landfill gas	11.1
Solar PV Rooftop	80.2
Solar PV Non-Rooftop	64.2
Wind	13.5

An individual or business can participate in either of these programs by going through an approval process for a renewable energy project. Once approved, a 20-year contract is signed between the project owner and the Ontario government. As per this contract, regular payments are made to the owner depending on his or her project's energy production on a monthly basis.

3.2.1 - Corporate Plan, Financial Outlook and Market Analysis

The first step of the framework applied to Manet Company's decision-making for microFIT/FIT participation decision was done in a similar fashion as with ESI's case. The Manet Company case was conducted over a short period of five months. First, an in-depth investigation of corporate plans and financial outlook was conducted through informal interviews with the company president and owner regarding specific details of the company finances pertaining to overhead costs, revenues, and profit margins as well as product turn-around time (TAT). The financial information gathered drew an accurate representation of the current state of the company.

Table 2 - FIT program prices (Ontario Power Authority, 2009)

Feed-in-Tariff Program Prices for Renewable Energy Projects in the FIT and CFIT Programs Base Date: September 30, 2009			
Renewable Fuel	**Size tranches**	**Rate Cents/kWh**	**Escalation %**
Biomass			
	≤ 10 MW	13.8	20%
	> 10MW	13.0	20%
Biogas			
On-Farm	≤ 100 kW	19.5	20%
On-Farm	> 100 kW ≤ 250kW	18.5	20%
Biogas	≤ 500 kW	16.0	20%
Biogas	> 500 kW ≤ 10 MW	14.7	20%
Biogas	> 10 MW	10.4	20%
Waterpower			
	≤ 10MW	13.1	20%
	> 10 MW ≤ 50 MW	12.2	20%
Landfill gas			
	≤ 10MW	11.1	20%
	> 10 MW	10.3	20%
Solar PV			
Rooftop	≤ 250 kW	71.3	0%
Rooftop	> 250 kW ≤ 500 kW	63.5	0%
Rooftop	> 500 kW	53.9	0%
Ground Mount	≤ 10 MW	44.3	0%
Wind			
Onshore	Any Size	13.5	20%

The interviews were directed around the company's strong desire to establish itself as a "green" organization and to reduce its carbon footprint. The second main discussion point was in regards to existing state of the market and the direct competition. Last point, was in regards to customers' tendency to choose a "green" construction company over other and the potential marketing edge that this project would give the company.

Like ESI, a thorough and detailed assessment of the market and potential market for Manet was conducted. Similar to ESI's case, this task proved to be a complex one, which included the i) search for potential competitors ii) SWOT analysis and iii) analysis and selection of applications and market channels who either use or can use existing FIT/microFIT participants.

3.2.2 – Assessment of the Current State of Production

Second step of the framework was the internal assessment of the Manet Company. In this step, informal interviews were conducted with the company president and owner regarding the specific details of the company finances pertaining to overhead costs, revenues, TAT, and profit margins. The financial information gathered helped in drawing an accurate representation of the current state of the company. The decision of participation or purchase in this case was only dependant on only the cash flow and consequently the turnaround time of Manet.

This was due to the simple business model that Manet Company has adopted with limited overhead and liquid assets.

3.2.3 – Assessment of Feasibility

In the final step of the framework, results acquired from the previous steps were used for a brief/small elimination process to determine the type of system that should be used in the event that participation in the FIT/microFIT program is feasible. Then, using the system chosen, analysis is partitioned into two sections; a cost and revenue model. Each of these models has a set of variables to be considered and calculated for each selected system. In a following step, these models are plotted on the same graph to show the optimal size of system that should be used at Manet Company.

Chapter 4: Results

4.1 Embedded Sense Incorporated

4.1.1 Corporate Plan, Financial Outlook and Market Analysis

Results for this section are a culmination of responses from the president of the company on a series of informal interviews and i) in-depth research done on potential competitors, ii) a detailed SWOT analysis and iii) analysis and selection of market channels within the product line's capabilities.

Competitors

There are many similar boards in the market from different manufacturers such as Atmel, Arduino, Olimex, Zorin, Rabbit, Parallax and Zilog; however, the most notable competitors are Zorin Co., Arduino, Parallax, and Rabbit. Most of the above mentioned and existing companies produce development tools; however, the four competitors, mentioned above, are active within ESI's target markets.

Zorin Co. is a small company based in Seattle with a partnering branch in Ghana. The company has been running since 1985 with activities in Internet hosting and software solutions. Zorin Co. produces several boards, one of which is a microcontroller with a Buffalo HC-11 MCU. Although Zorin does not seem capable of competing with ESI's line, it is good to be aware of their existence and note their capabilities as a future competitor.

Arduino, based in Italy, is focused on robotics boards and is currently one of the sole sources for robotics controllers. Arduino's simple programming and easy to use interface is their sole market strategy and advertised feature. Arduino boards are very popular with the Robotics retailers due to their low price and visibly appealing boards. Arduino's boards do not have the capabilities and the I/O interface of ESI but their market popularity and settlement makes them the primary competitor for ESI in the robotics market segment. (See Figure 2)

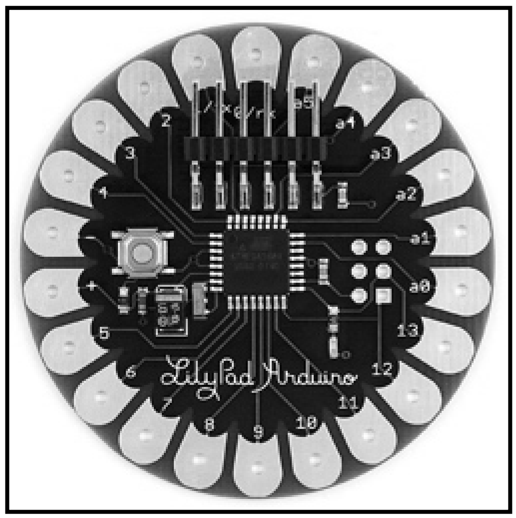


Figure 2 - This is the Lilypad design by Arduino. The capabilities of this board are comparable to ESI's E8160 board (Arduino, 2010)

Parallax is a California based company that focuses on variety of boards and gadgets; their primary market is a hobbyist. Developed in the 1990's, they have developed four microcontroller models that retail around $90.00 (USD) and are equivalent to E8160 model at ESI.

Rabbit is the biggest competitor for ESI. Rabbit is a branch of a Digi International Company with a net profit of $44.5M (USD) per quarter (Digi

International, 2011). Currently, Rabbit is host to many types of single board solutions and their ability to produce their own MCU makes them flexible on cost. Rabbit's boards are not readily integrated and there is no robotics sector in their sales. However, given their size and resources, Rabbit can at any time develop and launch a competing line.

SWOT Analysis

Strengths: ESIs OEM line is very versatile and easy to adapt to any application. Its low power consumption and I/O (Input/Output) interface make it ideal for any product or market. The stack design and small size allows the user to design the entire product with ESI's embedded, interface and accessory products. ESI has knowledgeable staff members that are ready to support its customers. Past experience in various projects and applications make it easy for ESI to produce and meet customer's needs.

Weakness: The line is a brand new product in the market**.** ESIs small in-house production leads to longer production time and higher cost. ESI has no partnering distributors and limited advertising budget.

Opportunities: New markets are emerging from a yearlong recession (at the time of this study). Trade restrictions are being lifted between the USA and Canada.

Threats: Well-established and better-known competitors present in the market segment are likely to be threats.

Applications and Market Channels

The products to be introduced are high level, application based, microcontroller / development boards using Microchip PIC controllers as the microcontroller unit (MCU). These boards have been labeled as E8100, E8120, E8140, and E8160 starting with highest performance based board and decreasing in size and speed respectively. The E81xx series are low cost, space efficient and highly flexible boards that can be interfaced with any existing products to accelerate time of delivery to the market while providing high intelligence and control for a variety of tasks. Moreover, the support software makes the boards very easy to program and debug. With the boards' high interfacing capabilities, the entire line can be used as a complete control system for number of application where master-slave or stack concept is necessary. Furthermore, the line is supported with a series of add-on accessories that enable the user to integrate and deliver a more complete, unique and specific design that can all be done in small and time efficient steps.

As a highly flexible and versatile line, the E81xx series can be placed in many market segments. However, it may be difficult or a nearly impossible task to establish and gain exposure in all the market segments that are available to ESI for this product release. Therefore, ESI's focus will be towards a distinct number of market segments in order to maximize exposure and display the necessary customer support for the products.

These market segments have been researched, studied and are believed to be the best suited for the existing line based on available application, relative resemblance of use, markets available and trends. These market segments are classified as i) robotics, ii) data acquisition in research and medical applications, iii) energy consumption monitors, and iv) application management.

i. The robotics market has been growing consistently for the past 2-3 years in two sectors, automation (industrial robot in assembly lines) and smaller robotics used in professional and personal environment. While both sectors are target for ESI, the later sector is a much “younger” segment and has more room for development and expansion. The next two figures (#3,4) are taken from the 2007 robotics market analysis, which shows the trend and projection of the market in professional and personal robotics sectors.

   As seen in Figure 3, considerable growth is expected in the defense, security and field robotics sector while the logistics sector shows a smaller projected increase. Figure 4 shows the spike that the industry will experience with entertainment and leisure robots in the upcoming years. It should be noted that at this point in time, there is only one notable manufacturer of robotic vacuum cleaner company by the name of iRobot. This will undoubtedly increase in the upcoming years, as the patent protection period for the iRobot will expire.

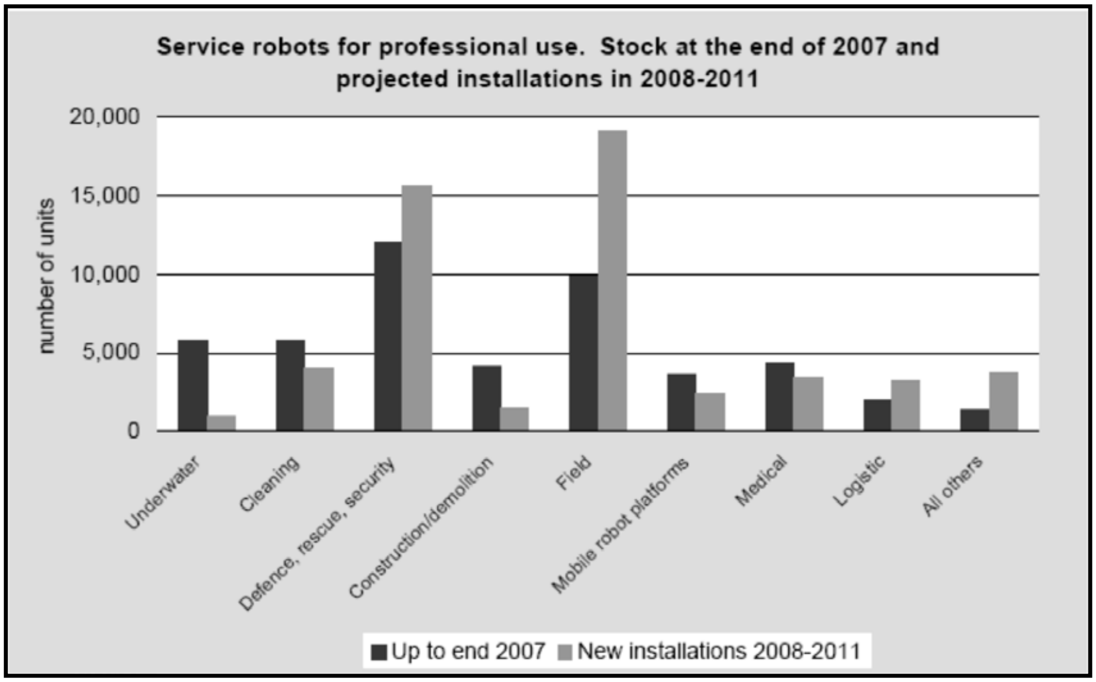


Figure 3 - Service robot sector for professional use (International Federation of Robotics, 2008)

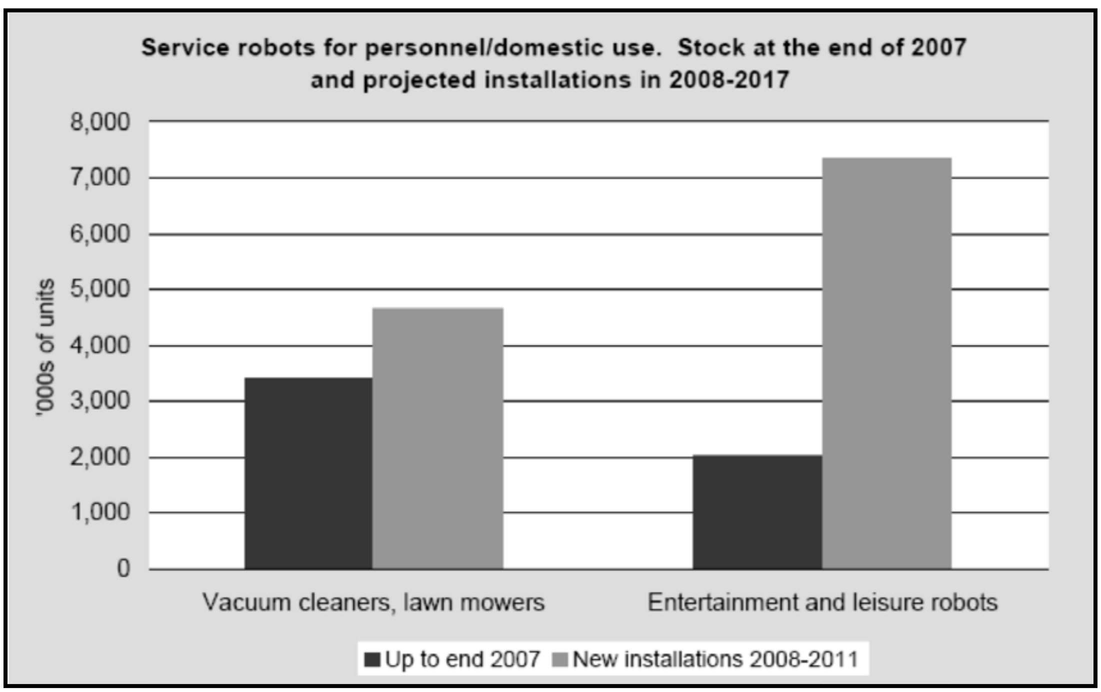


Figure 4 – Projected growth of personal and domestic robotics sector (International Federation of Robotics, 2008)

The estimated growth of the service robots was for 12.1 million new robots to be made in 2008-2011. From this estimate, 4.6 million would be vacuum cleaners and lawnmowers, while 7.4 million units will be entertainment and leisure based.

ESI's boards are a great fit for the abovementioned robotics sectors. With high number of input and output ports (I/O ports), interfacing drivers and their low consumption of energy, the ESI line is the perfect candidates for small size robotics applications. Furthermore, the targeted customers in this sector are different from other competitors; ESI will be marketing primarily to robotics hobbyists, children and teens, and university students and professors with related field of study.

ii. Much like the robotics sector, data acquisition in research and medical application products are on the rise with the introduction of new technology and methods of acquiring information from both patients and research subjects.

Today, the medical equipment manufacturers are using more and more development tools to reduce time-to-market on their products and with the introduction of wireless application, more and more devices are adding the module to their product lines. Kumar (2008) presents this in an article.

ESI's boards are easily integrated with Wi-Fi modules in a one-step process by clipping the Wi-Fi module onto the board. This feature together with low power consumption of the boards makes the E81xx line very attractive to medical and data acquisition markets. Currently, the integration of Wi-Fi is a relatively new procedure in the market; therefore featuring the Wi-Fi option would be a prime marketing strategy for ESI.

The Medical Market Fact Book-2008 (Espicorn, 2008) shows that the medical device industry was at a $223.2B USD worth of sales in 2009 and has continuously experiencing a constant annual growth until 2013 (see Figure 5 and Table 3).

Table 3 - Global market for medical devices and forecast (Billion US Dollars) (International Trade Administration, 2010)

Region/Year	2009	2010	2011	2012	2013
Americas	$102.4B	$107.1B	$112.1B	$117.4B	$122.8B
Asia/Pacific	$42.5B	$46.1B	$49.9B	$54.3B	$58.9B
Central/E Europe	$10.3B	$11.3B	$12.4B	$13.6B	$14.8B
Mid East/Africa	$5.7B	$6B	$6.3B	$6.7B	$7B
Western Europe	$62.3B	$66.7B	$71.6B	$76.9B	$82.5B
Total	**$223.2B**	**$237.2B**	**$252.3B**	**$268.9B**	**$286B**

iii. In today's market, there is a growing concern regarding energy efficiency and in light of a recent outgrowth in energy prices, the awareness for consumption has increased. In this market, several companies have already developed products that allow a household, business, and factory to review and monitor their consumption. This application is fairly new to the market and based on the available data, market and technology this trend seems to be a good target market for the E81xx line.

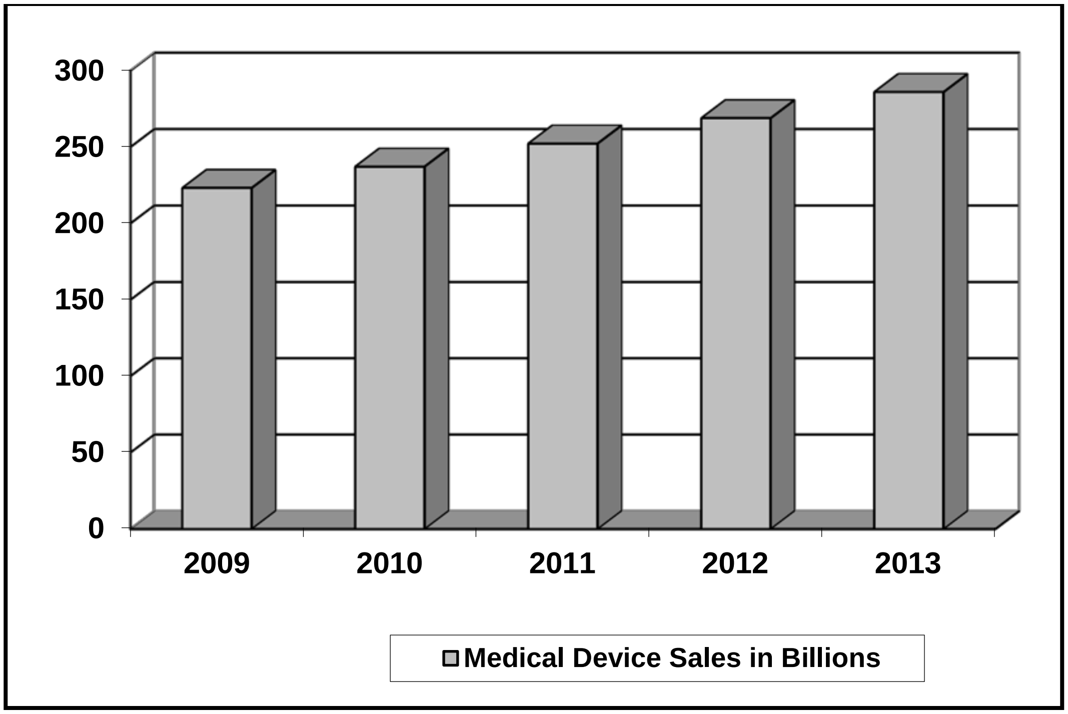


Figure 5 – Medical devices industry and projection

Recent studies have shown that more people are becoming aware of the term “carbon footprint” (Natural Marketing Institute, 2010). This term simply calculates the consumption of an entity and measures its impact on the environment. According to the research by Natural Marketing Institute’s LOHAS Consumer Trends Database in 2010, 73% of Americans are aware of the term Carbon Footprint; that is an increase of nearly 20% from 2008 (Natural Marketing Institute, 2010). This increasing awareness, together with upward trend in energy prices, shown in Figure 6, has made a number of people aware of their energy consumption, electricity and gas in particular.

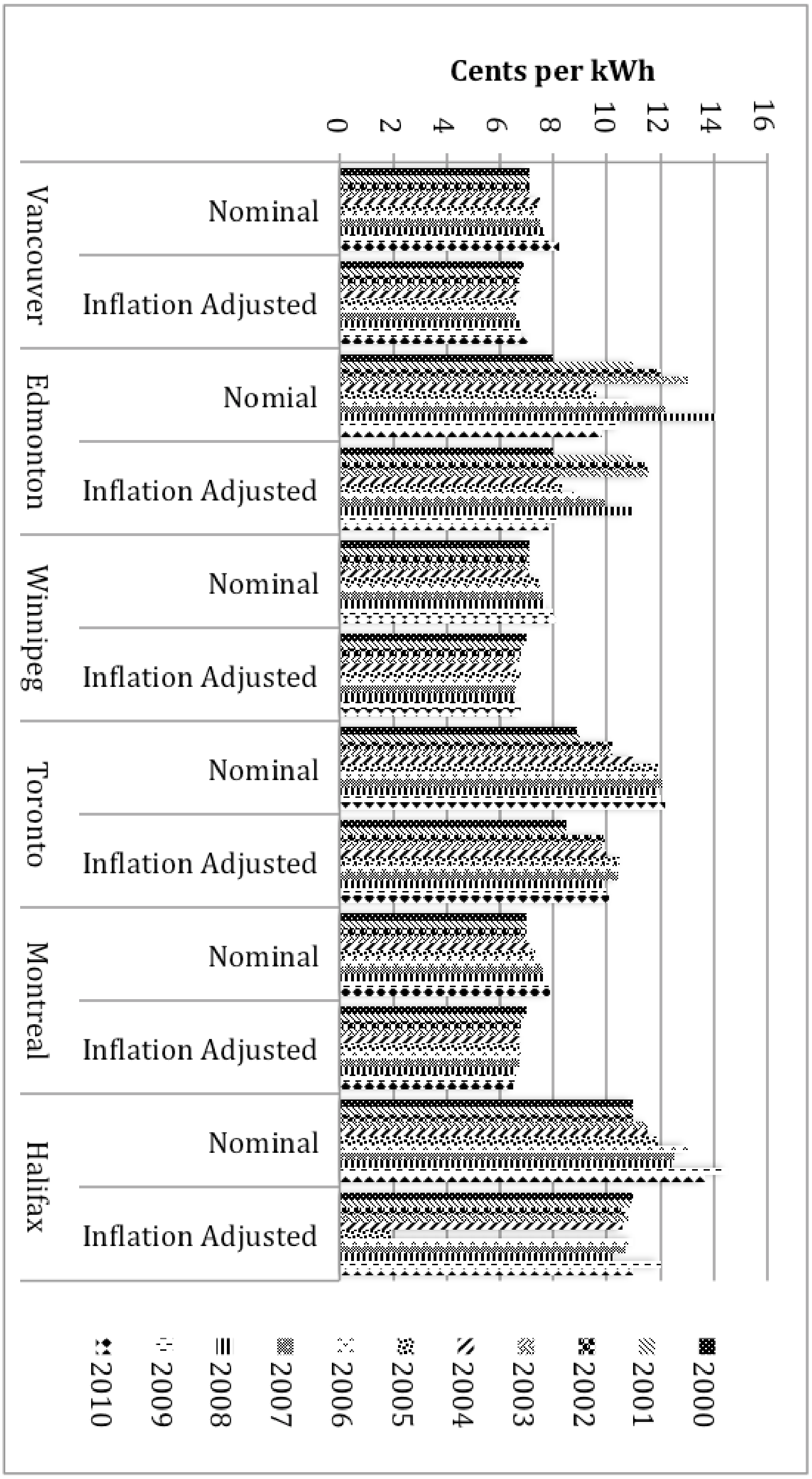


Figure 6 - Average electricity prices in the past years & projection from 00-10 (National Energy Board, 2011)

iv. The application management sector is directly linked to the energy consumption and energy efficiency topics mentioned in the previous section. ESI has past experience in power management applications (Iron Mountain) and the OEM line's capability supports this application well. Given the numerous government programs for energy efficiency in commercial and industrial sectors for energy efficiency and power management, ESI has the opportunity to establish itself and the OEM line as the primary source for power management and building automation systems. Currently, there is a vital need for control of different sectors of an assembly plants and to be able turn certain machines off remotely. This program has already been initiated in Europe with great success and is currently being used by automakers.

The typical trend in the allocation of the above mentioned investments are 60% in the building sector, 25% in industrial sector, and 10% in the transportation sector of the market. Moreover a recent study has shown that about three quarters (72%) of organizations are now paying more attention to energy efficiency and energy savings due overall cost reduction and government incentive programs. The government programs and increasing awareness of businesses to reducing operational cost is a good opportunity for ESI.

4.1.2 – Assessment of Current State of Production

To assess the current production capability of ESI, a simulation model was created on Arena simulation package. Given the overall turn-around time of 20-30 days at ESI; and also, the random or inconsistent nature in which inquiries arrive, the acquisition of adequate quantity of entries was very difficult in the short period of time (4 months).

An existing production model of ESI was done on the Arena Simulation package with the use of about 20 process blocks. A number of variables must be defined in each of these blocks, namely the randomness by which the process is governed and also the number of workers or tools required. In order to accurately model each block, a series of physical time measurements are taken and then compared with the most accurate random distribution model; using the various methods of goodness-of-fit test, like chi-squared.

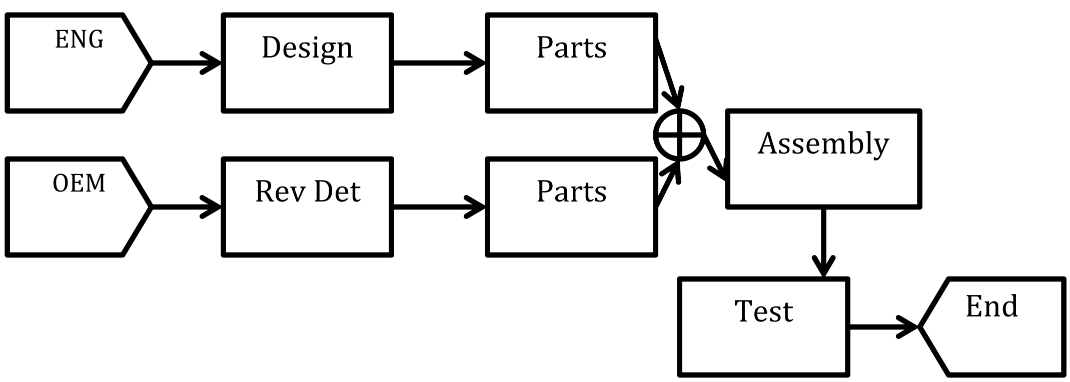


Figure 7 – Current ESI production layout

The existing layout for production at Embedded Sense consists of one production manager, two engineers and two technicians / assemblers. As mentioned previously, ESI has an engineering division and is now adding an OEM division. Hence, two separate lines for production of engineering and OEM products were drawn in the simulation model. These two lines are separate only in the early stages of production for any given project, during the stages of design; revision differentiation (Rev Det), part acquisition, and part verification. In the stages of assembly and testing, the two separate lines will converge into one, where the production rules of operation-due-date apply. A simplified graphical representation of this layout is shown in Figure 7.

Input Modeling

Using a combination of recorded and previous data from the production manager, a fair representation of each process was acquired. These numbers were entered in the software package called Easyfit to determine the "best-fit" distribution for each process. In Easyfit, the chi-square test is used as the goodness-of-fit test due to sample sizes of or larger than 5.

Chi-squared test requires to classify the data in several equal probability intervals higher than 5. Then using the following formula χ_o^2 is calculated (Greenwood, 2006)

$$\chi_o^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

In this equation, O_i and E_i represent the observed and expected frequency result for the i^{th} number. For example in 100 data in 10 intervals the expected number in each interval using a uniform distribution $E_i = 10$. The next step in the

Chi-squared test compares χ^2_o to $\chi^2_{\alpha,k-s-1}$. This is acquired from the Chi-squared percentage table, included in Appendix A, with degrees of freedom k-s-1 where k is number of intervals and s is number of estimated parameters in the distribution. For example, for triangular distribution, s=3.

Next, the determined distributions, using chi-squared goodness-of-fit, were entered in the simulation model and the system was simulated. The best-fit-curve results can be found in Appendix A.

Output Analysis

Accurate input modeling allows for the Arena software package to simulate the system accurately, however, output analysis and verification of the results in the Arena model is required to verify the truth and the statistical significance.

The simulation model was used to gain better insight on the adequacy of the existing production layout. In order to do this, output analysis was done on the results and parameters of the model. Through performing output analysis, the results of the simulation model are verified for statistical significance and reduce the significance level and conversely increase the confidence coefficient on the result distribution. It is desirable to have results that are purely random and not dependant on any factor, hence not statistically significant.

The results of the 'output analysis' of the ESI model shows that the model must be executed 50 times in order to achieve desired results with the significance level of 5%. The calculations and tables for calculating the feasibility of the data and the statistical significance can be found in Appendix A. The results shown after 50 consecutive executions of the model shows that utilization of the assemblers will be report average 96% in an 8-hour shift. This leaves no time for maintenance of the facility and miscellaneous activities. Moreover, with the current layout, there exists an 84 item-long queue that will prevent deadlines being met. This is a huge disadvantage, as ESI's small operation depends heavily on repeat customer inquiries and therefore must be able to provide the expected customer service.

4.1.3 - Assessment of Manufacturing Capabilities

As discussed previously, investigating to see the effects of an additional workstation to the overall utilization of workers and queue lines for assembly and testing could be pursued. Table 4 below represents various scenarios and alternatives of the production department at ESI; the effects of an additional workstation to the overall utilization of workers and queue lines for assembly and testing. These results are in anticipation of the OEM line producing 100 boards per quarter. Currently the company only manufactures about 10 boards per quarter in addition to 5 engineering contracts. This yields to a queue length of 10 with worker utilization of 49%.

Table 4 - ESI's existing model compared with proposed alternatives for production procedure

	Worker Utilization	Queue Length for Assembly	Difference with respect to Existing Layout
Existing	96%	84	N/A
1 Workstation Added	92%	75	4% Reduction in Utilization Queue length reduction of 9
2 Workstations Added	89%	63	7% Reduction in Utilization Queue length reduction of 21
Outsource OEM	20%	0	76% Reduction in Utilization Queue length reduction of 84

As can be seen, by adding a third workstation and worker, both utilization and queue length decrease. While there is 4% change in utilization of the workers, it translates to 9 items reduced in the assembly queue. These results show that further expansion may be required in order to reduce the queue size further and meet the expected demand.

The next alternative looks at adding two workstations in the manufacturing process. The results of this simulation show about 7% reduction in worker utilization and further reduction of the manufacturing queue lines by 21. It's noteworthy to see the effects of adding more workstations yield to lesser amount of improvement in the overall process. While adding more workstations reduce the queue lines and increase the output of the system, it does not have enough of an effect to be considered as a viable solution for manufacturing engineering solution and OEM products in-house for ESI.

The next step in improving the in-house process would be an in-depth look into the details and flow of the manufacturing process, which are beyond the scope of this paper.

A third alternative, to the production model at ESI is to outsource the OEM orders entirely to a third-party through partnership. While there risks exists with outsourcing, the entire production manufacturing, this maybe one of the only solutions, given the direction of the company and also available capital. Figure 8 shows the simulation model for this alternative, which eliminates the added workstation(s) for OEM production. While the early and latter stages of the manufacturing process is done at ESI, the assembly and testing stages of the OEM boards occur outside of ESI and therefore reduce the queue lines in-house. Table 5 shows the queue lines in outsourcing scheme are reduced to no items on average, which is a significant improvement for adequate manufacturing at ESI. It is significant to note that the worker utilization in the outsourcing model is very low, which is adequate for a system because, the worker responsibilities at ESI are not limited to the manufacturing process. The workers are also responsible for

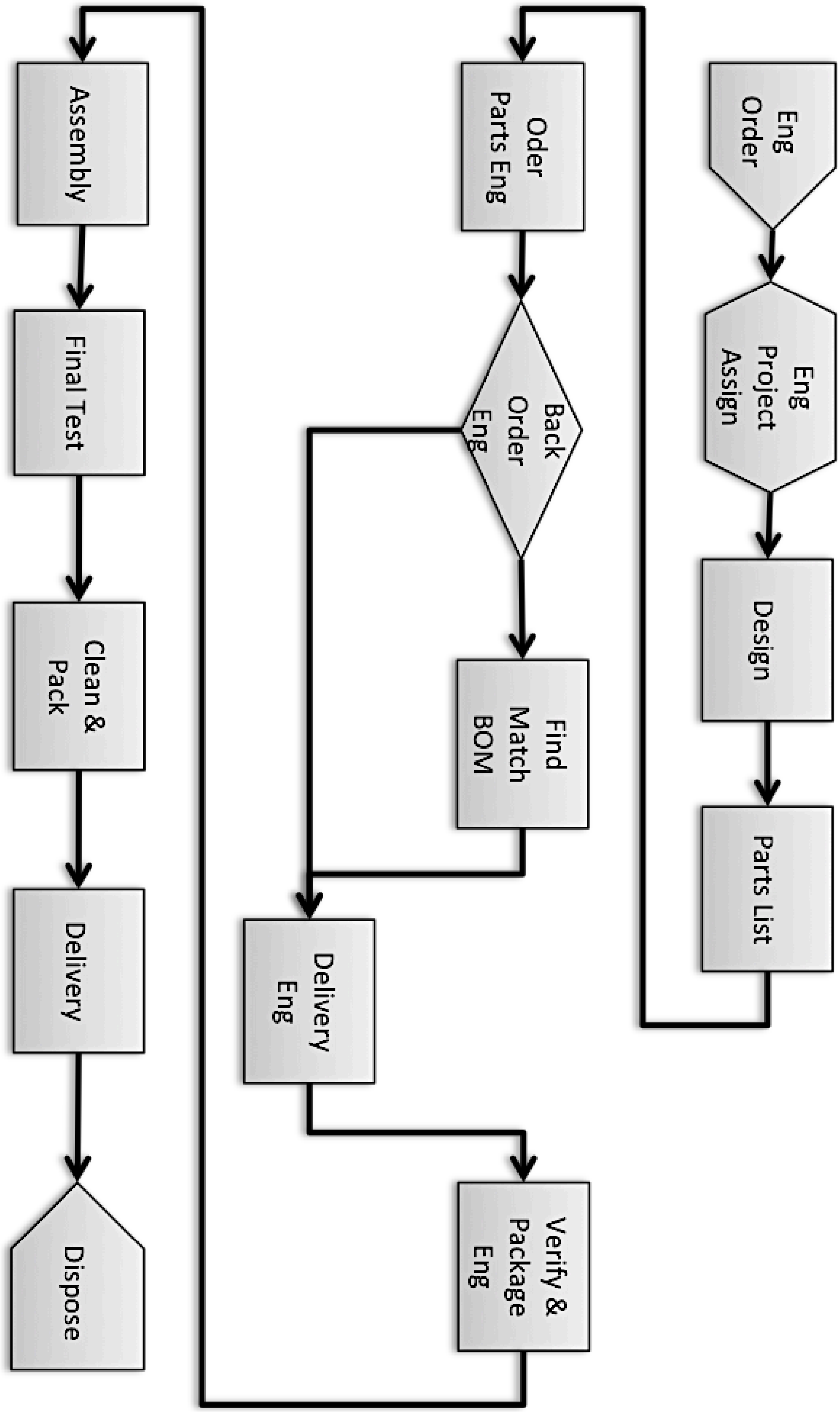


Figure 8 – Embedded Sense Inc. outsourcing model for E81xx

maintenance and upkeep of their stations, and also specialty tasks that occur during the course of the day. These tasks on average occupy a worker's time and utilization to about 40-50% of his or her daily time. Therefore, when calculating the utilization in this case, an added 40-50% must be considered.

To investigate the possibility of expansion of this production line, several meetings were held with the HR and production managers in order to financially quantify the true costs associated with hiring new staff and also acquiring the necessary equipment.

Expansion from a Human Resources Standpoint

From the human resources perspective, the true cost of hiring any employee is about 130-140% of the wage allotted in the first year. This together, with factors such as cost of posting a job, the time taken away from production manager during candidate selection and interviews, training and an employee's learning curve, makes the hiring process very costly and inefficient. Figure 9 represents the true cost of hiring an employee from the perspective of an employer and so it is easy to see that adjustments with respect to various benefits and savings increase the cost for an employer by about 30%. It was calculated that in order to hire a new employee, it would cost ESI nearly twice the amount, when all the aforementioned factors are taken into account. Moreover, as ESI will require more than 1-2 new employees in order to adequately expand the existing production department, it is not feasible to consider expansion at this point. Outsourcing the assembly and testing labour is a better option.

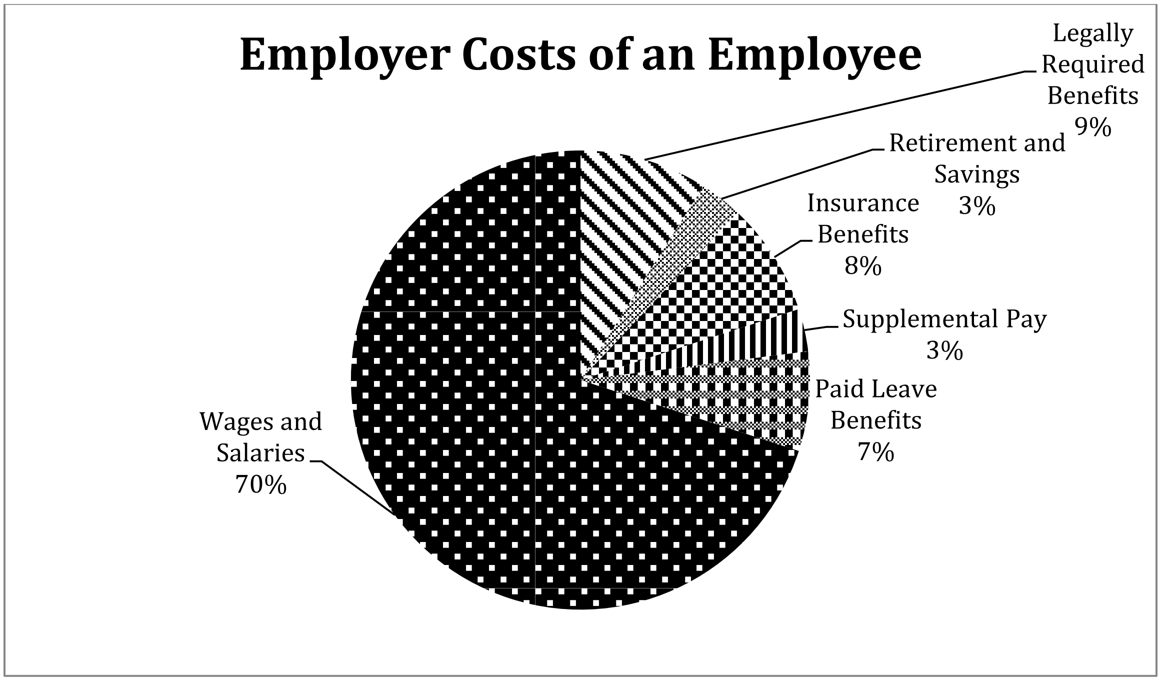


Figure 9 - True cost of hiring an employee (Kaiser, 2009)

Expansion from a Production Standpoint

From a production manager's point of view, in order to expand the line, several new machines are required, specifically a surface-mount soldering machine. (See Figure 10)

This machine will be able to solder small components on to the surface of a Printed Circuit Board (PCB). Currently, this task is done by hand and with several high level techniques from the assemblers but with a very slow pace. Aside, from the cost of acquiring the machine, there are additional costs associated with it such as training, maintenance/service and possible repairs. Furthermore, there also exists the possibility of downtime on these machines and therefore, a certain cost that is associated with loss of production.

Figure 10 - Surface mount machine (ManCorp, 2011).

4.2 – Manet Company

4.2.1 – Corporate Plan, Financial Outlook and Market Analysis

Results for this section are a culmination of responses from the president of the company on a series of informal interviews and i) research done on potential competitors, ii) a detailed SWOT analysis and iii) analysis and selection of applications and market channels within the lines capabilities.

Competitors

A thorough and careful assessment of the construction and housing market in the Greater Toronto Area (GTA) was done via statistics from the Canadian Mortgage and Housing Corporation (CMHC) and other sources on the World Wide Web. According to the Housing Market Table released by CMHC in Sept. 2011, there are currently 6418 residential low-rise homes under construction in the GTA (Canadian Mortgage and Housing Corporation, 2011). This figure is down compared to 2010 by nearly 1000 homes. Building Industry and Land Development Association (BILD) also reports a decline of about 25% on a year-to-year comparison for finished low-rise homes (Building Industry and Land Development Association, 2011).

Furthermore, according to the March 2011 report of RealNet Canada, that there is only a 5-month supply of new homes available in the GTA (Newhomes.org, 2011). This decline in supply is a direct result of the recent economic downturn (Wolf, 2010) and recession. According to the CMHC's outlook for the housing market, this trend will pick up in the upcoming years as depicted in Figure 11.

Interviews were conducted with the president of Manet Company after the market outlook. He expressed his strong desire to contribute to the environment through use of eco-friendly material and certified products such as Energy Star and R2000 in his projects. Both R2000 and Energy Star are industry standards for high efficient materials in the construction and real estate industry. He feels that it is critical to his business's well-being to communicate the company's "green" efforts to potential customers and clients.

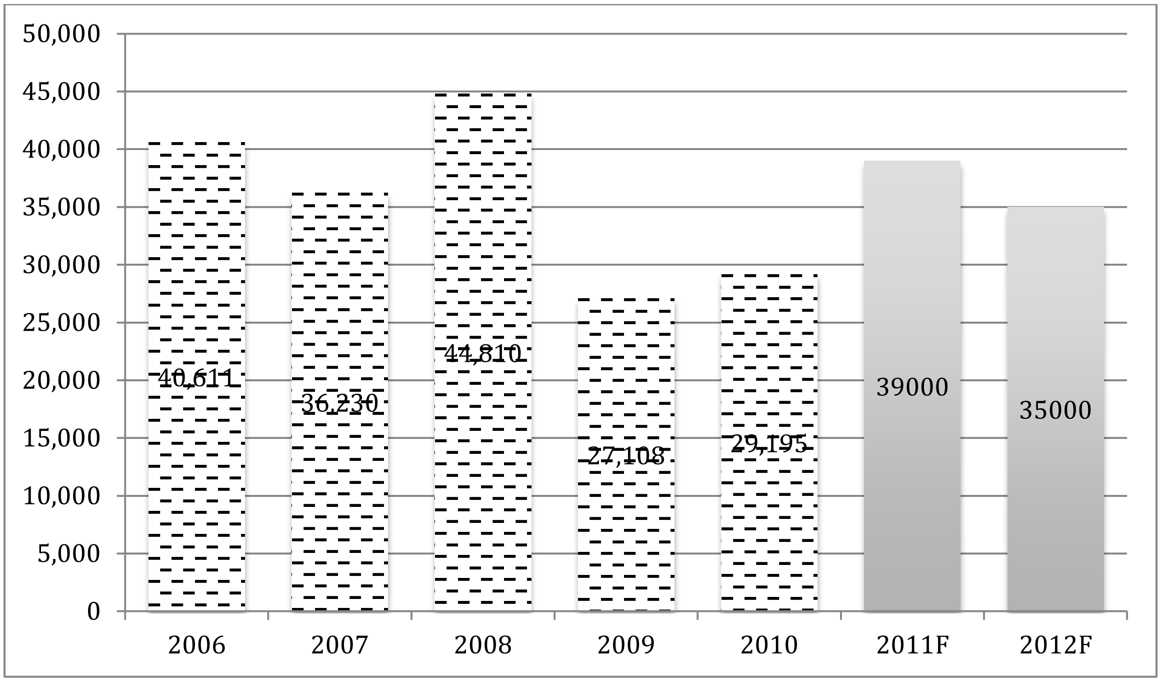


Figure 11 – Greater Toronto Area housing market total sales forecast (Canadian Mortgage and Housing Corporation, 2011)

A market scan showed that there are only 18 other certified green builders in the Greater Toronto Area and joining this group has potential for a major boost for the company.

SWOT Analysis

Strengths: Manet would require low investments to sustain its business. By utilizing subcontractors, Manet's overhead costs are kept very low. Moreover, designing custom homes, a green initiatives strategy and direct supervision over customers' products are features that will make Manet unique amongst other construction companies.

Weaknesses: As they are a small business, they are more susceptible to market fluctuations and are dependent on cash flow.

Opportunities: As one of the few unique green builders in the GTA who also do custom work, they are unique. The FIT projects they conduct can serve as a revenue stream. Additionally, as a company who is concerned with green initiatives, the FIT projects can serve to lower their carbon footprint.

Threats: The current global recession and further economic downturns can largely affect a company like Manet. Big construction companies may flood the market and a population, which is opting to purchase condos and not homes can all have negative impacts.

Applications and Market Channels

As a construction company, Manet Company has access to several sectors in which it can operate and provide it services, namely i) residential, ii) commercial, and industrial. By introducing itself as a "green" construction company, Manet Company would be able to tap into different market areas. According to a study done by Industry Canada, the number one driving factor for fortune 100 businesses adopting "green" is brand improvement (Sustainability Purchasing Network, 2008).

Residential

As a residential construction company, Manet would be able to attract customers who are care about the environment. Data shows that 91% of Canadians are concerned about global warming and 89% are in favour of immediate action (Persram et al., 2007). Together with the existing expertise of Manet Company in the residential market, make this sector optimal to operate within.

Commercial and industrial

The commercial and industrial construction sector will have limited opportunities for Manet Company as they usually require larger capital allocation and contribution. However; "green" branding will expose the business to more high-end clients and will assist with increasing market awareness. This will be beneficial to Manet Company in the future and can potentially create opportunities within these sectors.

4.2.2 – Assessment of Current State of Production

Manet Company, a small residential home developing company has been in business in the Greater Toronto Area (GTA) since 2005. During this time, the company has averaged about two self-funded projects per year. These projects are usually built on general specification and are sold after completion. Moreover, the company also, manages one project per year where it's funded by an external source or customer. These projects bring in revenue of roughly $350,000 annually.

The company's overhead consists of several permanent employees that overlook and assist in daily operations, insurance, Tarion license (Tarion, 2011), and miscellaneous costs associated with running each project. According to the president of Manet Company, these figures bring in a total of $250,000 in overhead cost.

The company's profit margin at the end of each year is injected back into the company to allow for expansion. The president of the company has indicated that he would be willing to invest half of the annual profit margin into the FIT/microFIT project, given the results of the study display obvious benefits to the company.

To recap, the preliminary interviews with Manet Company's president have shown that the company has about $50,000 of capital available for investing into the FIT/microFIT project. The option of $50,000 will be explored further in the following milestones and then compared with a fully financed project with no down payment.

4.2.3 – Assessment of Feasibility

In order to build these models, several factors must first be determined. These factors are the type and size of the project. In order to qualify for the FIT/microFIT program, one must install and operate a renewable energy facility through wind, waterpower, bioenergy or solar. In the case for Manet Company, Bioenergy and waterpower facilities are not viable options, as the office is located in the city of Toronto. In order to have bioenergy facility, which includes biogas, biomass, and landfill projects, the participants must locate their facilities outside of city limits for obvious sanitary reasons and as per the Ontario Regulation 359/09, Renewable Energy Approvals (Government of Ontario, 2011). One of the goals for Manet Company's interest in a FIT/microFIT facility is to gain public exposure, and therefore the idea of a remote facility does not fit within the company's aim. The same arguments are also true in the case of waterpower facilities.

Wind energy facilities are often quite large, 50kW+ systems, and produce a considerable amount of energy when wind is available; hence, in terms of producing revenue through the FIT program (facilities over 10kW) it would be a viable choice. However, in the recent update to Ontario Regulation 359/09, Renewable Energy Approvals in the Environmental Protection Act, clearance restrictions have increased. In this regulation the clearance distance for any wind turbines are set to minimum of 550 meters depending on sound power levels. Table 5 shows the setbacks required for wind turbine installations. This restriction, among others, will pose major problems in installation of a wind energy facility for Manet Company.

The only remaining renewable energy source option is solar. Solar energy facilities pose no sanitary issues and also do not have noise pollution.

There are two types of solar energy facilities, fixed and tracker system. The fixed system facilities consist of rows of solar panels connected in series. They are often installed on rooftops or on racks in large flat areas at a 30-degree angle. Due to the nature of a solar panel, larger systems will take an enormous surface area for installation.

Table 5 - Wind turbine sound level restrictions, O. Reg. 521/10, s. 33 (7) (Government of Ontario, 2011)

Item	Wind turbine sound level restrictions		
	Number of wind turbines calculated in accordance with subsection (2)	Sound power level of wind turbine (expressed in dBA)	Total distance from the centre of the base of the wind turbine to a noise receptor described in subsection 55 (2.1) (expressed in metres)
1.	1-5	102	550
		103 – 104	600
		105	850
		106 – 107	950
2.	6-10	102	650
		103 – 104	700
		105	1000
		106 – 107	1200
3.	11-25	102	750
		103 – 104	850
		105	1250
		106 – 107	1500

Figure 12 - Fixed panel solar farm (Tap-in Marketing, 2012)

The other type is a tracker system facility. Tracker systems are typically installed on ground and are designed to follow the sun with use of sun sensor throughout the day. This action creates maximum exposure of the panels to the sunlight. Typically, a tracker will harness and produce about 40% more energy than a fixed system (Cooke, 2011). This would pose as an advantage in a revenue model; however it is worth mentioning that OPA's FIT/microFIT rates differ for ground-mount and rooftop mount energy facilities. This section will include revenue and cost models for six different systems; 3kW, 6kW and 10 kW fixed system and also 3kW, 6kW, and 10kW tracker systems. Due to restrictions in available space at Manet Companies facility, larger systems are not considered. The results of each will be compared to conclude an optimal suggestion to Manet Company.

Revenue Model

The revenue model consists of several key variables such as energy production capacity of each panel, the efficiency of the overall system, tracker or fixed system, rate set by the OPA based on ground or rooftop installation, and the average number of possible sunny days. The revenue model for all the solar systems is very similar and can be summarized using the following variable designations.

p = panel production capacity (kW)

n = number of panels in system

f = efficiency of the overall system (%)

$$t = \begin{cases} 1 & \text{if tracker system type} \\ 0 & \text{if fixed system type} \end{cases}$$

r = OPA rate (cents/kWh)

N = hours of sunny days in Toronto monthly (hrs)

Using these variables, one can model the revenue production of any size solar system using the following formulas:

$$Monthly\ Revenue\ (R_m) = pnf\left(1 + t(0.4)\right)\frac{rN}{100} \tag{1}$$

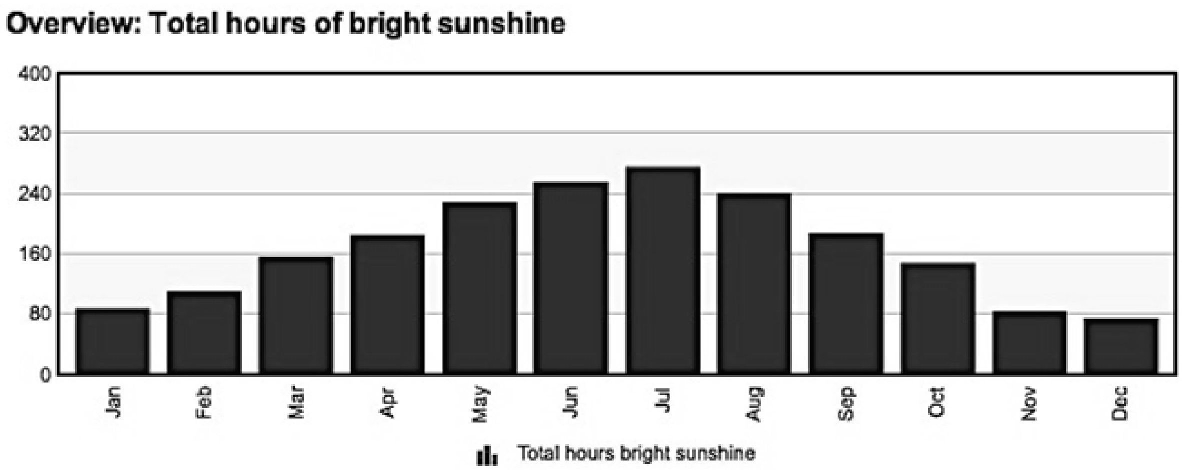
$$Total\ Revenue\ at\ Future\ Value\ \left(R_{fv}\right) = R_m\left[\frac{(1+i)^N - 1}{i}\right] \tag{2}$$

The above formulas take into account the number of panels used and their efficiencies. It is worth noting that the efficiency of a solar panel will diminish throughout its lifetime, however for simplicity, the efficiency of the panel is set for 90% for the duration of the FIT/microFIT contract. Also, further assumptions are made in terms of the type of solar panel used. For the purposes of this study, the panels used are SunPower Corporation 230W Monocrystalline module is used. An extensive list of all the solar panels with their relative efficiencies is included in Appendix B for further review.

The term t in equation (1) defines the system type in terms of a fixed panel or tracker system. As mentioned above, a tracker system will produce 40% more energy than a fixed panel system. Therefore, to represent a tracker system t=1, otherwise t=0.

The term *r* represents OPA's rate of purchase per kWh in cents. This rate is set for 64.2 cents for ground-mount and 80.2 cents for rooftop facilities.

The variable *N* is the average hours of sunlight in a given month. Figure 13 depicts the number of hours of sunshine in the GTA monthly.



Sun

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Total hours bright sunshine	88	110	156	185	229	256	276	241	188	148	84	75
Days with measurable bright sunshine	21	21	24	26	28	28	30	30	27	27	20	19
Extreme daily bright sunshine hours	9	10	12	13	15	15	14	14	12	10	10	9
Date	Jan 22 1989	Feb 20 1972	Mar 27 1973	Apr 22 1975	May 30 1996	Jun 26 1999	Jul 19 1997	Aug 04 1972	Sep 01 1986	Oct 20 1986	Nov 04 1975	Dec 01 1971

Figure 13 - Total hours of sunlight on a per month basis in the GTA (The Weather Network, 2012)

Revenue Model results

Using equation (1) and the assumptions made above the following results for all the proposed systems are found below in Table 6.

Table 6 - Annual revenue of various sized microFIT solar facilities

	Tracker			Fixed		
System Size	**3kW**	**6kW**	**10kW**	**3kW**	**6kW**	**10kW**
Panel Production (kW)	0.23	0.23	0.23	0.23	0.23	0.23
Number of Panels	13	26	44	13	26	44
Efficiency	0.90	0.90	0.90	0.90	0.90	0.90
Tracker (t)	1	1	1	0	0	0
r (¢/kWh)	64.2	64.2	64.2	80.2	80.2	80.2
N (hrs/month)	163	163	163	163	163	163
Monthly Revenue	$395	$791	$1,338	$353	$705	$1,194
Total Revenue (FV)	$162,462	$324,923	$549,870	$144,965	$289,929	$490,649

Table 6, above shows the annual revenue of the proposed systems based on the revenue equation, derived previously. These revenue figures will be reproduced annually for the duration of the OPA's microFIT contract term of 20 years. Therefore, total revenue earned on 10kW tracker system is $286,487 in the present value (PV) of the FIT/microFIT program.

Cost Model

Similar to the revenue model, there are several factors that contribute to the cost model. These factors consist of the cost of the system and installation, interest rates, insurance, and system maintenance. These factors were designated with the following variables.

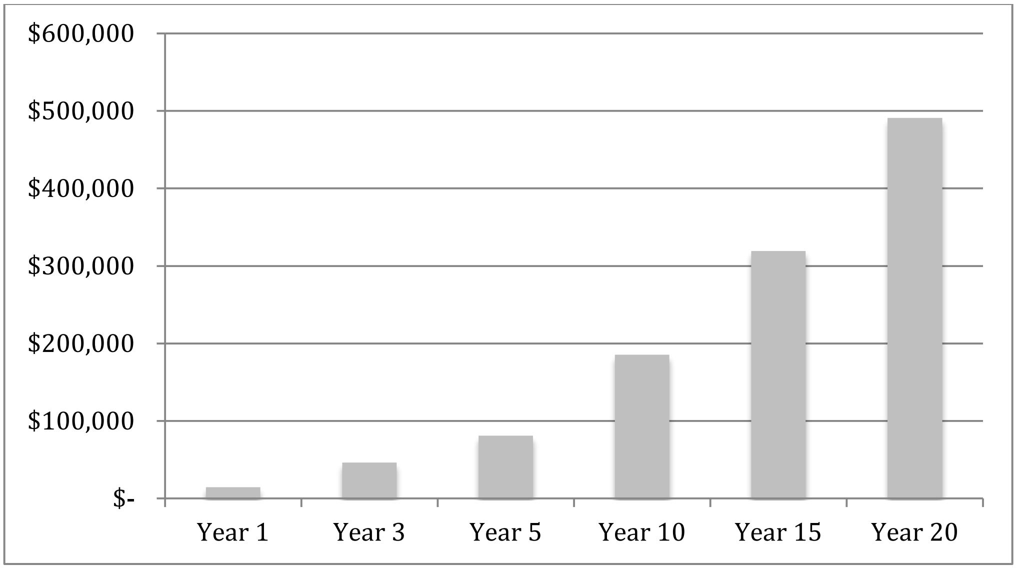


Figure 14 - 10kW tracker system revenue generation

P = Purchase price and installation ($)

i = Rate of interest for borrowing monthly (%)

m = Maintenance costs ($/month)

z = Insurance costs ($/month)

$$t = \begin{cases} 1 & \text{if tracker system type} \\ 0 & \text{if fixed system type} \end{cases}$$

N = Period of loan in months (month)

The above variables can be used in the following equation for total cost of system at present value.

$$Monthly\ Cost\ (mc) = P\left[\frac{i(1+i)^N}{(1+i)^N-1}\right] + m(1+t) + z \qquad (3)$$

$$Total\ Cost\ at\ Future\ Value\ (T_{fv}) = mc\left[\frac{(1+i)^N-1}{i}\right] \qquad (4)$$

Equation (3) and (4) take into account the lending rate *i* that apply to the purchase price and installation *P.* The lending rate is calculated as 5% annually. It is worth noting that for simplicity, the rate will be assumed fixed at 5% over the 20-year period. Additionally, the repayment period is also set to 20 years; however it is possible to repay the entire loan amount in about 10 years. There are also organizations that would provide zero-interest loans (Rumble Energy, 2011) however, the approval process for these institutions are unique and the subsequent calculations are beyond the scope of this project. The cost of the system varies with company. Table 7 shows the cost of 3kW, 6kW and 10kW system acquired from several solar companies.

Table 7 - Survey of solar system costs in Ontario (Prices in Canadian dollars.)

Company	Tracker/Fixed	3kW	6kW	10kW
Solar Direct Canada	Fixed	$20,500	$38,000	$58,000
Solar Direct Canada	Tracker	$35,000	$50,000	$80,000
SolarTraxx Inc.	Tracker	$30,000	$45,000	$75,000
eSolar®	Tracker			$80,000
eSolar®	Fixed			$58,000
Sky Solar	Fixed		$35,000	$50,000
SolarSelect	Fixed	$23,000	$36,000	

The variables *m* and *z* is the monthly cost for maintenance and insurance for solar facilities. A typical solar system requires maintenance twice a year. This maintenance schedule will include cleaning panels and checking all components of the system. Also, these maintenance checks will often include minor system adjustments as well. Maintenance costs are assumed to be $1000 annually on the basis of $100/hour labour costs including an industry 'norm' of 4-hour incidental and travel time charge in addition to one of hour of minor adjustment and system repairs. This figure is almost doubled in the case of tracker systems due to the increase in number of components and also lubrication required for moving parts. Therefore, in equation (3), the variable t = 1 for a tracker systems and t = 0 otherwise.

The cost of insurance is dependent on insurance company, the type coverage and deductible. For the purposes of these calculations, an average of several insurance company quotations were taken as $497, $523 and $558 for full coverage of 3kW, 6kW and 10kW systems respectively.

Cost Model Results

Using equations (3, 4) and taking all assumptions into account, the calculated total cost of all abovementioned solar systems is shown in Table 8 below.

Table 8 - Total 20-year cost of various size microFIT solar facilities

	Tracker			Fixed		
System Size	*3kW*	*6kW*	*10kW*	*3kW*	*6kW*	*10kW*
C ($)	$33,000	$48,000	$78,000	$22,000	$36,000	$56,000
Annual Interest (%)	5%	5%	5%	5%	5%	5%
Duration (months)	240	240	240	240	240	240
Tracker (t)	1	1	1	0	0	0
Maintenance (Monthly)	$167	$167	$167	$83	$83	$83
Insurance (Monthly)	$41	$44	$47	$41	$44	$47
Monthly Cost	$426	$527	$728	$270	$365	$499
Total Cost (FV)	$175,046	$216,627	$299,205	$110,956	$149,821	$205,274

Here, the total cost of the system with a payoff period of 20 years. This cost can be reduced with shorter payoff periods. Table below shows about a 20% difference in the overall price of the system on a 10-year payoff period. This result is not part of the feasibility study, as it will not have a significant weight on the outcome of the decision. However it will be shared with the president of Manet Company as supplementary data. (See Table 9)

Table 9 - Payoff period comparison on total price of system

10 Yrs	Total Cost (FV)	$86,663	$111,705	$161,568	$55,606	$79000	$112,393
20 Yrs	Total Cost (FV)	$175,046	$216,627	$299,205	$110,956	$149,821	$205,274

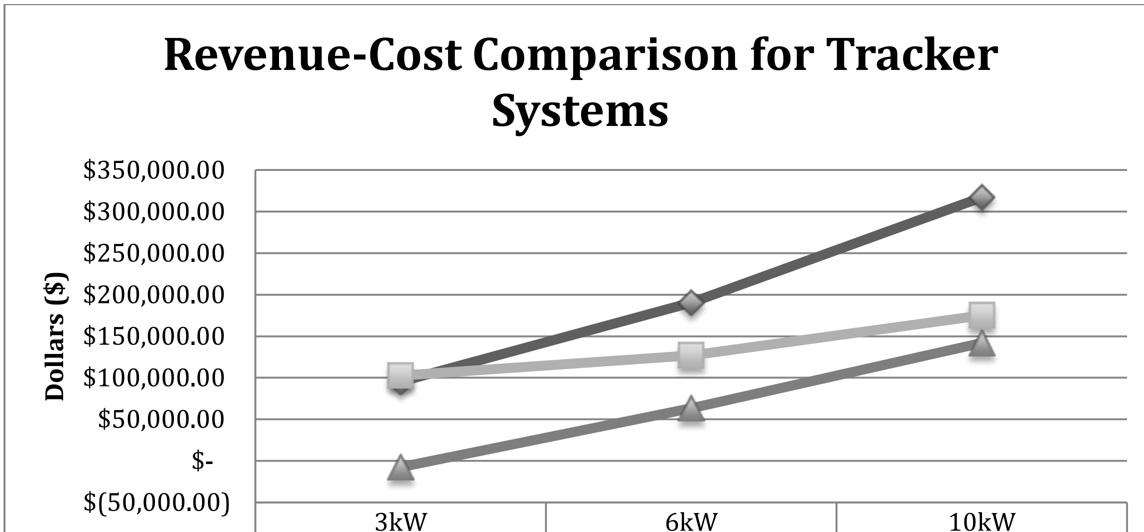
Revenue-Cost Comparison

To determine the feasibility of participation for Manet, a revenue-cost comparison was done. In this comparison, two aspects will be examined. 1) Is the long-term revenue greater than costs? 2) How much is the difference?

Table 10 - Comparison results from revenue model and cost model

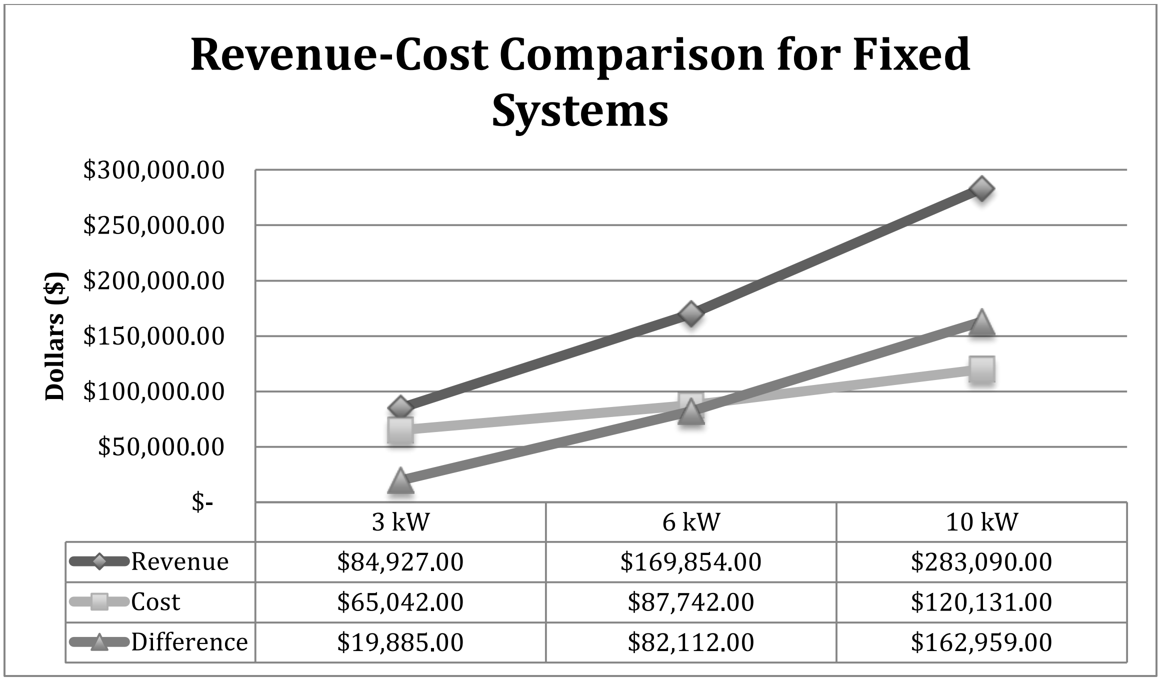
	Tracker			Fixed		
Size of System	3kW	6kW	10kW	3kW	6kW	10kW
Revenue - Cost (Monthly)	$(30)	$263	$610	$83	$341	$694
Revenue - Cost (FV)	$(12,584)	$108,296	$250,665	$34,009	$140,108	$285,376

From the above table10 and figures14 and 15, it is evident that all systems will produce long-term profit with the exception of the 3kW tracker, which will result in a loss of approximately $7,500 in present value and about $12,000 in future value. Therefore, it is financially feasible for Manet Company to partake in the FIT/microFIT initiative by choosing a system with capacity of greater than 3kW. Moreover, the comparison analysis shows that over the 20-year period, a 10kW fixed system will yield more profit than other systems. This is contrary to popular belief that a tracker system will yield the largest profit margin. It shows that the additional cost of purchase and maintenance will result in more costs and therefore less profit in all-size systems. However, it is worth noting that, a fixed system will require a larger operation area, which may not be available to all potential participants. It is recommended for all potential participants as well as Manet Company to further investigate the available facility area versus size of system when making a decision.



	3kW	6kW	10kW
Revenue	$95,178.00	$190,355.00	$317,258.00
Cost	$102,630.80	$126,915.00	$175,149.00
Difference	$(7,452.80)	$63,440.00	$142,109.00

Figure 15 - Revenue-cost comparison for tracker systems



	3 kW	6 kW	10 kW
Revenue	$84,927.00	$169,854.00	$283,090.00
Cost	$65,042.00	$87,742.00	$120,131.00
Difference	$19,885.00	$82,112.00	$162,959.00

Figure 16 - Revenue-cost comparison for fixed systems

Chapter 5: Discussion

5.1 – Embedded Sense Incorporated

Utilizing the proposed framework in the case of ESI revealed several points. The business plan and SWOT analysis in step 1 revealed key points about the market that ESI is about to enter. It was useful in showing the major competitors that currently exist. It further revealed the strengths and weaknesses of ESI detailed in chapter 3. This will assist the owner in identifying what he needs to focus on, in terms of advertising and marketing. Also, this shows what improvements he can make in the future to better position his company in the market.

While this step proved to be beneficial to the company in realizing its position with respect to the market, it proved to be a very time consuming and rigorous process. One can argue that a small business owner may not have the time to do analysis of this detail for its business for every decision. This is one of the shortcomings of the framework. The time required for the analysis of the market is something that may not be available.

Step two of the framework involved an assessment of ESI's current manufacturing facility. The simulation model accurately modeled the production capabilities of ESI and allowed the owner to see the existing production limits. From this step, the overall utilization of the workers within the production process became evident. The framework step assisted the owner in realizing the deficiencies in the current state of the company.

In order to complete this step, simulation software, Arena, was used. Use of the software simplifies the complexities of doing analysis of the current state of a facility such as ESI. Unfortunately, this software requires an operator who has the necessary knowledge to use it and cannot be easily understood and utilized by any business owner. Furthermore, the cost of such software is fairly significant and may not be seen as a justifiable cost for all small businesses.

The third and final step in the decision-making framework is designed to quantify a given decision by mathematically modeling the possible solutions and comparing them. The results after 50 consecutive executions of the existing model show that utilization of the assemblers will be roughly around 96% in an 8 hour shift, which leaves no time for maintenance of the facility and miscellaneous activities. Moreover, with the current layout, there exists an 84 item-long queue that will prevent deadlines from being met. This is a huge disadvantage, as ESI's small operation depends heavily on repeat customer inquiries and therefore must be able to provide the expected customer service. Alternatively, the addition of one or two lines of assembly will only yield a small improvement of the overall production. Table 5, above, shows a reduction of 25% in the 84–item queue due to the addition of two workstations Though this is a very pleasing outcome, it is not a feasible solution for ESI as the cost of this addition will take away from allocated marketing budget. Moreover, the 25% reduction still leaves a queue of about 63 items, which will still affect the reputation of the company and customer satisfaction.

This leaves the option of outsourcing as the only viable solution. Table 5 showed that with the option of outsourcing, the queue length is reduced to zero items, which will allow for more in-house work of the assembler on the engineering division of ESI and will ensure better customer service and satisfaction. Furthermore, outsourcing will allow ESI to allocate more capital to marketing and allow the company to compete with the well-established companies that exist in the market already.

Outsourcing will bring about risks for the company that may affect its survival. Outsourcing one of the core capabilities of the company lowers the level of security at ESI and introduces the risk of having their unique design stolen and copied by larger organization. This would surely be detrimental to ESI's survival as larger organizations have lower overhead per item produced and have the ability to under sell their products to capture the market.

To minimize this risk, a few alternatives may be beneficial to ESI. First option is to utilize a hybrid-outsourcing model. The hybrid model would allow ESI to perform most of the manufacturing of their boards via an outsourcing partner and leaving critical components to be assembled and tested in-house. This would add some protection on ESI's board design. This model is beyond the scope of this study and was not done due to lack of time and resources. It is foreseen that this model will more likely not require the addition of one or two workstations and will most likely work with the existing production layout and resources. The model that requires additional workstations would require ESI to make a significant investment of adding workstations, which is not feasible at this time due to lack of capital availability.

The second alternative model involving more risk may be mitigated and restricted by time. In this model, ESI will adopt a short and long-term business plan. The short business plan will include outsourcing products via a partner and will focus ESI's capital on marketing and market establishment. The long-term plan will include either a full in-house production or the hybrid model mentioned above. This would allow ESI to focus its available cash and capital on market capture. Placing a time restriction on outsourcing the company's core capability may also reduce the risk. Furthermore, this would give ESI more time to establish itself in the market and expand its production at a later date.

In the case of ESI's outsourcing decision, the proposed framework helped the owner to realize key points about the existing market, limitations of current facility and possible shortcomings that would be associated with in-house manufacturing. Simulation analysis revealed that in order to ensure the long-term survival and success of the company, it is advisable for ESI to pursue outsourcing for its OEM manufacturing.

The proposed framework tested in this case study revealed some shortcomings of its own. Step 1 of the framework is very time consuming for a small business owner. In order to produce an accurate representation of the company within the market, one must consider either spending a fair amount of time researching the market or hire external help to perform this analysis. For many small businesses, either solution may not be a feasible one. Moreover, in step 2, the utilization of simulation software requires expertise of that software. While the results are fairly valuable, the expertise of using such software may not be available in every small business setting. The alternative option is to attempt to model the facility mathematically, without using simulation software, which would be very difficult because of the complexity of the model.

5.2 – Manet Company

Based on the decision-making framework proposed in this paper, it is feasible for Manet Company to participate in the FIT/microFIT program. This program will produce a revenue stream for the company, as well assist in gaining a marketing edge in a highly competitive housing market. Furthermore, it will support the company's "green" initiative and reduce the company's carbon footprint.

Step 1 of the framework for Manet Company was very similar to step 1 of ESI's case study. This step helped reveal the current position of Manet Company with respect to its competitors. It also helped Manet Company in realizing the company strengths and weaknesses, as outlined in chapter 3. As was the case with

ESI, this realization will help the owner recognize areas of improvement as well as areas in which the company can prosper.

Another similarity between step 1 of both case studies was the time required to complete a thorough analysis. This amount of time is not readily available for Manet's owner as his business is dynamic and day-to-day activities require his full attention.

In step 2, Manet Company assessed its financial capability. The process involved in this step was much more simple than what was required in case of ESI and therefore did not require a specialist. Moreover, the company finances are something that almost all business owners pay close attention to and therefore the data and analysis required is mostly available.

After completing step 2 and upon further analysis it was determined that although the company is able to allocate some capital to partake in the FIT/microFIT program, due to the economic outlook of the housing market, it is probably advisable to venture alternative options such as financing. Moreover, the available financing options with low interest rates will give Manet Company the option to invest the available capital in a more liquid venture.

Moreover, the economic downturn has had a major impact on Manet Company. The company is currently experiencing one of the longest sales cycles in its five years of operation. According to its president "The homes that we used to sell within three months of completion, now take close to a year." This difference of nine months has a tremendous effect on each project's bottom line and has drastically cut into Manet's profit margins. "Sometimes we have even sold projects at a loss." says the president of Manet. This statement was true for several other construction companies in the GTA. This along with the aforementioned, are reasons why Manet should not invest its current available capital. However, with the available financing options, it was determined that the feasibility of the decision to participate in the microFIT/Fit program should be investigated.

The third step of the framework involved a mathematical analysis of cost vs. revenue. The calculations showed that it was advisable and to Manet Company's benefit to participate in the program by signing up for a 10kW fixed solar system.

The proposed framework in the Manet Company case study proved to be a useful tool. It provided the owner with valuable information about the GTA housing market and also made him aware of existing financing options available. The final step revealed a substantial revenue stream for Manet Company while creating the marketing image that the owner was looking for. A very important advantage of using the framework was that it showed Manet's owner that investment in the current housing market is not advisable.

Unlike ESI's case study, the framework proved to have fewer disadvantages. This was perhaps due to the simplicity of the decision model. The model and decision in the case of ESI was a very complex model, which involved many more components such as utilization functions for engineers and worker, turnaround time of a project, procurement process, delivery, and quality of work. However, in the case of Manet Company this model and decision was limited to simpler cost and revenue functions.

The application of the proposed framework on the two case studies revealed several key points about the framework. The initial two steps of the framework helps the business owners approach a problem in a holistic and structured manner. This process will help them in identifying or verifying the company characteristics, strengths, and weaknesses. A potential argument against this framework can be made in performing the market study. This steps requires time and due diligence. As a small business owner, one can argue that there is not enough time in the day to operate the business and therefore performing an extensive market research is not feasible. However, one must recognize that the survival of any business is highly dependent on the knowledge of the competitors and market in which the business operates. Therefore, an extensive and complete market research is very important and should be done. In that regards, utilizing this framework is beneficial to a small business owner.

Another challenge of implementing the proposed framework is related to the third step of the framework that is more specialized and requires more expertise. Moreover, the framework is much better suited for cases with relatively less complex decisions. Complexity in this case, refers to number of criteria that must be taken into account. In case of ESI, the complexity of the decision being made required use of simulation software, since it would have been very difficult to model it mathematically. The correct use of this software requires expertise and know-how that is most likely not available to a small business owner. Therefore, in order for a small business owner to use this framework, he or she must either spend the time to learn the simulation software or hire a third party consultant that has familiarity with the software package. These solutions may not be feasible for a small business with limited capital.

Chapter 6: Conclusion, Contributions and Future Work

6.1 - Conclusion

In the case studies above, the proposed decision-making framework was examined in real life situations with two small businesses. By progressing through the proposed steps, a financial picture of each company and their relative position within the market was produced. Through implementing a mathematical or simulation model of the proposed question, an analysis and assessment of potential solutions were recommended.

The ESI and Manet case studies show that small businesses are unique in the way they operate and set goals. Similarly, while most companies' goal is to grow and be prosperous, the way in which they attempt to reach that goal differs from one company to the next. Just as any two people are different from one another, so are any two small businesses. To create an absolute framework applicable to any small business is difficult as each is unique. One can generalize the steps in the framework, but it is necessary to tailor each step to the individual needs and situation of the organization.

The framework proved to identify important points to the owners of each company, however the process revealed some difficulties in its implementations with small business owners. The framework proved very useful where the decision involved simpler variables and models as the case with Manet Company. In a decision model where complex variables were required, the framework could not be completed without utilization of expertise with adequate tools such as simulation software. Furthermore, the time required for a business owner to perform step one adequately is a concern for the business owners. However, it can be argued that a business owner must spend the time to familiarize him or herself with the market and therefore should have a very good understanding of what is involved in step one. In order to ensure that business owners are observing the market objectively and are not only monitoring a select few aspects, it would be advisable that this step would be done by a third party. This can be done with a range of costs based on variety of factors such as detail level.

Furthermore, the above case studies show that while the framework is a good general tool and guideline for a small business to follow, it cannot be applied to all business models without making variations to fit with the businesses' unique issue and state. This was encountered several times during the course of this paper, in areas such as financial modeling, market research, SWOT analysis and even the feasibility assessment. This framework should be developed further in future work to find a balance between generality and specificity of each case.

6.2 – Contributions

The existing literature approaches the subject of decision making from two distinct aspects – quantitative and qualitative. The quantitative approach focuses on mathematical formulas and matrices to create a logical and best-suited solution.

This approach has continuously grown to be more complicated as more aspects and variables are added. On the other hand, the qualitative approach focuses on the emotional aspect of the decision-maker. It considers variables such as the character, behaviour and environment that could affect the decision maker. Clearly, there exists a gap between these two approaches that has been addressed in this paper. Moreover, much like decision-making, business literature has little focus on the small business in its true sense. The literature either covers aspects pertaining to large corporations or entrepreneurial entities – labeled as 'small firms'. This paper makes a distinction between these entrepreneurial firms and their large counter parts by focusing on the business size the bridges these two extremes.

The framework proposed in this paper is a tool for a small business owner to utilize in making decisions. It takes into account the steps required for a structured decision used in large organizations and further simplifies the process to suit a small business environment. This is a bridging approach of the current literature which either focus on the qualitative aspect of small business decision-making or a highly complex mathematical and quantitative facet. This framework combines these two approaches to propose a real-world tool that can be used in day-to-day operations of a small business. The tool provided in this paper, can be utilized to provide more structure in a small business setting and assist in survival and prosperity of the business.

6.3 – Future Work

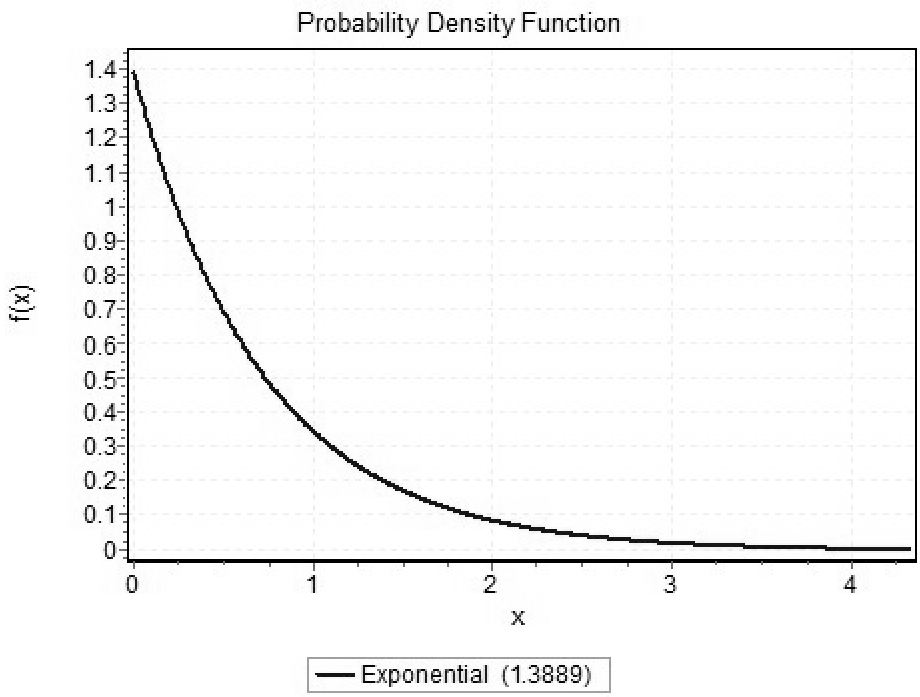
The focus of this research was to develop a general decision-making framework within which to assist small businesses. As the structure and model of each business differs from one another, so does their decision-making processes' taking into account the variables to each problem.

While not applicable to every business model, it would be in the future scope of work to develop the structure of this tool into one that would apply to different decision types within an organization. The new collection of frameworks would give a structured approach and process to specific types of decisions that a decision-maker is faced, to aid in the long-term success and survival of their organization.

Ultimately a business's success is dependent on its leadership. Decisions made at the senior level make or break any company. In today's economy, company's decisions, regardless of their size, can affect that company's livelihood and continued existence.

Appendices

Appendix A: Supplemental Material for Embedded Sense Inc. Case Study



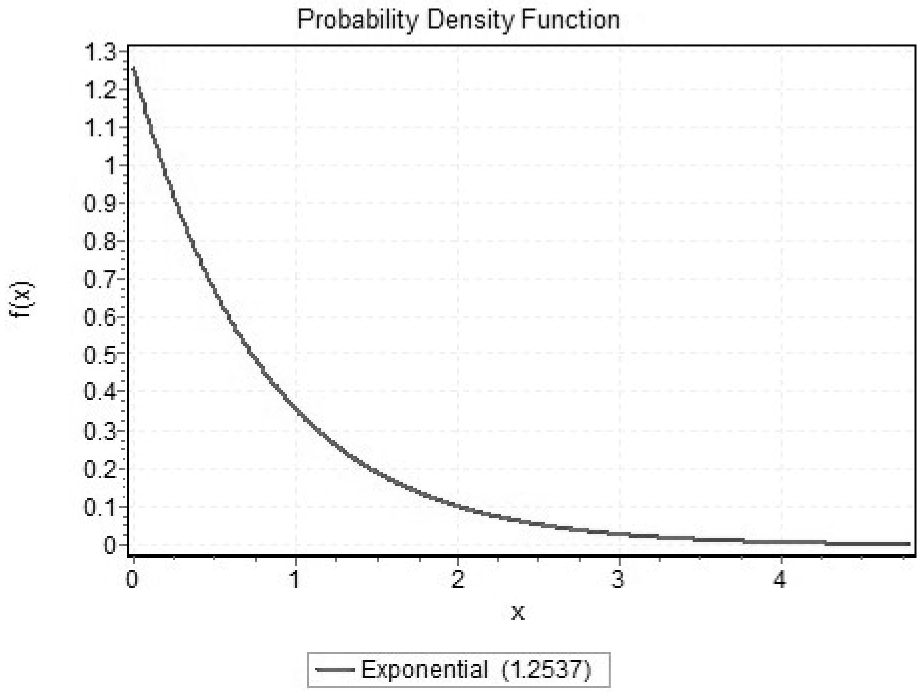


Table 5-2
Critical Values of the χ^2 Distribution

df \ p	0.995	0.975	0.9	0.5	0.1	0.05	0.025	0.01	0.005	df
1	.000	.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	1
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	2
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	3
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	4
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	5
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	6
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	7
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	8
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	9
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	10
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	11
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	12
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	13
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	14
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	15

Chi-Squared Table (University of Miami, 2012)

ESI Current Model with Low Demand Simulation Report

7:58:19AM **Category Overview** July 13, 2012

Values Across All Replications

Unnamed Project

Replications: 50 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	11

Model Filename: C:\Users\MikeA.ADVANCED\Google Drive\Thesis\Thesis Models\ESIexistingn Page 1 of 6

Unnamed Project

Replications: 50 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	904.82	2.85	879.00	930.46	879.00	930.46
OEM	234.63	0.93	229.65	243.02	228.44	269.18

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	1691.42	4.13	1666.38	1730.42	1666.38	1730.42
OEM	2209.11	14.86	1995.74	2312.74	1799.74	2385.67

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	2596.23	4.94	2547.18	2627.21	2547.18	2627.21
OEM	2443.74	14.87	2231.88	2548.26	2029.17	2636.35

Other

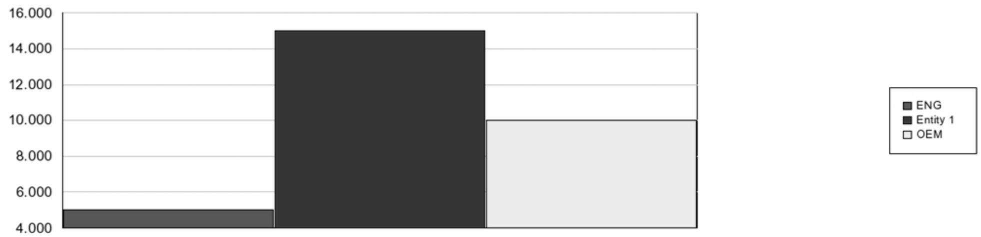
Unnamed Project

Replications: 50 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
ENG	5.0000	0.00	5.0000	5.0000
Entity 1	15.0000	0.00	15.0000	15.0000
OEM	10.0000	0.00	10.0000	10.0000



Number Out	Average	Half Width	Minimum Average	Maximum Average
ENG	1.0000	0.00	1.0000	1.0000
Entity 1	15.0000	0.00	15.0000	15.0000
OEM	10.0000	0.00	10.0000	10.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	4.8848	0.01	4.7759	4.9772	0.00	5.0000
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
OEM	9.2982	0.05	8.5046	9.7165	0.00	10.0000

Unnamed Project

Replications: 50 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	627.00	3.07	598.91	645.36	0.00	1287.72
BOM order.Queue	22.4811	1.89	14.3095	36.1597	0.00163062	79.7030
BOM verification.Queue	0.2234	0.06	0.00	0.8611	0.00	2.0625
Clean and Pack.Queue	208.68	1.56	205.97	231.45	71.2369	633.41
Component Order.Queue	23.4167	3.15	14.1366	57.8555	14.1366	57.8555
Design.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Final Test.Queue	829.91	2.72	790.05	834.15	307.72	1334.73
Find Match ENG.Queue	1.8851	2.71	0.00	55.7816	0.00	55.7816
Find matching part BOM.Queue	40.9796	5.80	0.00	82.0159	0.00	115.35
Order Packaging.Queue	1.8071	0.43	0.00	3.5231	0.00	3.5231
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	509.76	14.85	292.82	612.02	61.1503	666.69
Verify and package Eng.Queue	0.00	0.00	0.00	0.00	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	2.6243	0.01	2.5040	2.7021	0.00	10.0000
BOM order.Queue	0.08551652	0.01	0.05454900	0.1377	0.00	9.0000
BOM verification.Queue	0.00084934	0.00	0.00	0.00325142	0.00	1.0000
Clean and Pack.Queue	0.8734	0.01	0.8581	0.9723	0.00	10.0000
Component Order.Queue	0.00890837	0.00	0.00538330	0.02203367	0.00	1.0000
Design.Queue	3.8970	0.01	3.7851	3.9780	0.00	4.0000
Final Test.Queue	3.4736	0.01	3.3189	3.5119	0.00	10.0000
Find Match ENG.Queue	0.00071945	0.00	0.00	0.02130501	0.00	1.0000
Find matching part BOM.Queue	0.04159826	0.01	0.00	0.1796	0.00	5.0000
Order Packaging.Queue	0.00068793	0.00	0.00	0.00134253	0.00	1.0000
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	1.9394	0.06	1.1158	2.3337	0.00	10.0000
Verify and package Eng.Queue	0.00	0.00	0.00	0.00	0.00	0.00

Unnamed Project

Replications: 50 Time Units: Hours

Resource

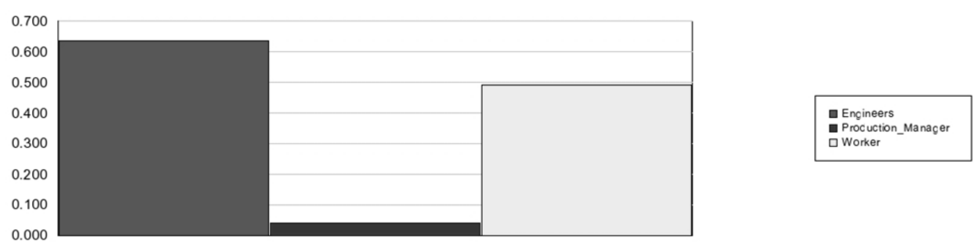
Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	0.6348	0.00	0.6251	0.6487	0.00	1.0000
Production_Manager	0.04180722	0.00	0.01904587	0.06966988	0.00	1.0000
Worker	0.4917	0.00	0.4880	0.4949	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	1.2696	0.00	1.2502	1.2974	0.00	2.0000
Production_Manager	0.04180722	0.00	0.01904587	0.06966988	0.00	1.0000
Worker	1.4751	0.00	1.4641	1.4847	0.00	3.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	2.0000	0.00	2.0000	2.0000	2.0000	2.0000
Production_Manager	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Worker	3.0000	0.00	3.0000	3.0000	3.0000	3.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Engineers	0.6348	0.00	0.6251	0.6487
Production_Manager	0.04180722	0.00	0.01904587	0.06966988
Worker	0.4917	0.00	0.4880	0.4949



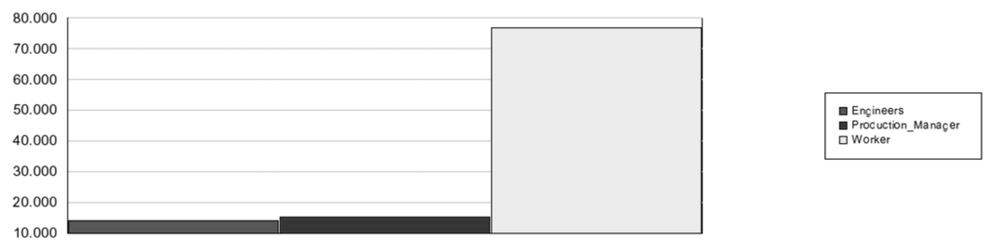
Unnamed Project

Replications: 50 Time Units: Hours

Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Engineers	14.1800	0.41	12.0000	18.0000
Production_Manager	15.1800	0.41	13.0000	19.0000
Worker	77.0000	0.00	77.0000	77.0000



ESI Current Model with High Demand Simulation Report

7:45:26AM | **Category Overview** | July 13, 2012

Values Across All Replications

Unnamed Project

Replications: 50 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	101

Model Filename: C:\Users\MikeA.ADVANCED\Google Drive\Thesis\Thesis Models\ESIexistingn Page 1 of 6

Unnamed Project

Replications: 50 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	907.92	3.68	879.91	940.02	879.91	940.02
OEM	235.72	0.32	233.43	237.77	228.04	272.78

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	14077.92	233.83	11245.38	15111.80	11245.38	15111.80
OEM	15574.43	72.30	14937.11	15984.40	2350.58	17533.52

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	14985.84	232.97	12149.43	16019.64	12149.43	16019.64
OEM	15810.15	72.34	15170.53	16221.11	2580.04	17792.77

Other

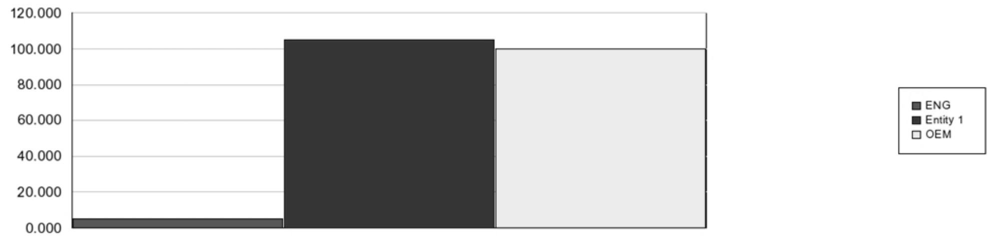
Unnamed Project

Replications: 50 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
ENG	5.0000	0.00	5.0000	5.0000
Entity 1	105.00	0.00	105.00	105.00
OEM	100.00	0.00	100.00	100.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
ENG	1.0000	0.00	1.0000	1.0000
Entity 1	105.00	0.00	105.00	105.00
OEM	100.00	0.00	100.00	100.00

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	4.7953	0.01	4.6389	4.8433	0.00	5.0000
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
OEM	85.4544	0.39	81.9785	87.7613	0.00	100.00

Unnamed Project

Replications: 50 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	4716.17	98.34	4003.09	5269.71	0.00	11605.01
BOM order.Queue	18.7062	2.85	7.6798	53.3953	0.00	265.69
BOM verification.Queue	1808.82	135.15	1044.07	2930.27	0.00	10945.33
Clean and Pack.Queue	3714.28	70.43	3273.65	4308.89	64.3808	11697.49
Component Order.Queue	23.8653	3.55	12.3739	55.4584	12.3739	55.4584
Design.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Final Test.Queue	5233.74	147.74	4138.19	6076.67	18.3249	11192.32
Find Match ENG.Queue	6.7562	5.59	0.00	81.1852	0.00	81.1852
Find matching part BOM.Queue	25.4812	5.27	3.8022	92.8234	0.00	267.59
Order Packaging.Queue	1.5394	0.43	0.00	3.3691	0.00	3.3691
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	78.7539	5.30	34.2321	141.68	0.00	662.58
Verify and package Eng.Queue	135.69	26.74	5.8284	375.49	5.8284	375.49

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	25.7460	0.54	21.8535	28.7753	0.00	84.0000
BOM order.Queue	0.1011	0.02	0.04154569	0.2885	0.00	33.0000
BOM verification.Queue	9.7766	0.73	5.6423	15.8384	0.00	84.0000
Clean and Pack.Queue	20.2765	0.38	17.8758	23.5229	0.00	83.0000
Component Order.Queue	0.00128987	0.00	0.00066875	0.00299685	0.00	1.0000
Design.Queue	3.9853	0.00	3.9694	3.9969	0.00	4.0000
Final Test.Queue	28.5715	0.81	22.5910	33.1817	0.00	84.0000
Find Match ENG.Queue	0.00036521	0.00	0.00	0.00438826	0.00	1.0000
Find matching part BOM.Queue	0.03470576	0.01	0.00496044	0.1204	0.00	11.0000
Order Packaging.Queue	0.00008321	0.00	0.00	0.00018205	0.00	1.0000
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	0.4257	0.03	0.1850	0.7658	0.00	37.0000
Verify and package Eng.Queue	0.00733399	0.00	0.00031525	0.02029843	0.00	1.0000

Unnamed Project

Replications: 50 Time Units: Hours

Resource

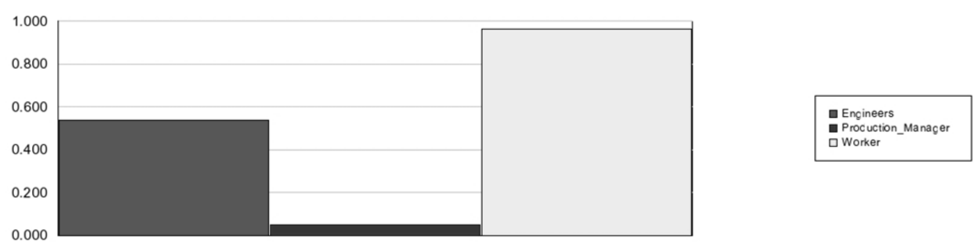
Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	0.5367	0.00	0.5304	0.5424	0.00	1.0000
Production_Manager	0.05076207	0.00	0.03813162	0.06184861	0.00	1.0000
Worker	0.9617	0.00	0.9611	0.9628	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	1.0733	0.00	1.0608	1.0847	0.00	2.0000
Production_Manager	0.05076207	0.00	0.03813162	0.06184861	0.00	1.0000
Worker	1.9235	0.00	1.9222	1.9255	0.00	2.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	2.0000	0.00	2.0000	2.0000	2.0000	2.0000
Production_Manager	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Worker	2.0000	0.00	2.0000	2.0000	2.0000	2.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Engineers	0.5367	0.00	0.5304	0.5424
Production_Manager	0.05076207	0.00	0.03813162	0.06184861
Worker	0.9617	0.00	0.9611	0.9628



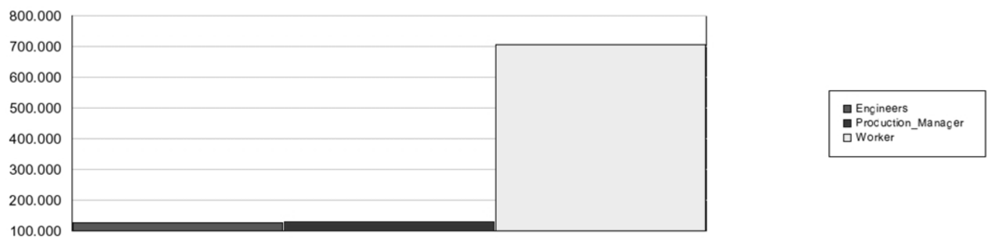
Unnamed Project

Replications: 50 Time Units: Hours

Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Engineers	127.22	1.38	118.00	136.00
Production_Manager	128.22	1.38	119.00	137.00
Worker	707.00	0.00	707.00	707.00



ESI One Additional Station Model with High Demand Simulation Report

7:43:47AM **Category Overview** July 13, 2012

Values Across All Replications

Unnamed Project

Replications: 50 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	101

Model Filename: C:\Users\MikeA.ADVANCED\Google Drive\Thesis\Thesis Models\ESIexistingn Page 1 of 6

Unnamed Project

Replications: 50 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	908.34	3.74	880.74	945.21	880.74	945.21
OEM	235.50	0.35	233.26	238.19	228.13	272.12

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	5305.17	379.78	1694.93	7711.07	1694.93	7711.07
OEM	6832.90	98.38	6052.97	7692.67	1284.86	9009.01

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	6213.51	380.35	2603.42	8635.23	2603.42	8635.23
OEM	7068.41	98.28	6289.75	7925.92	1514.54	9264.35

Other

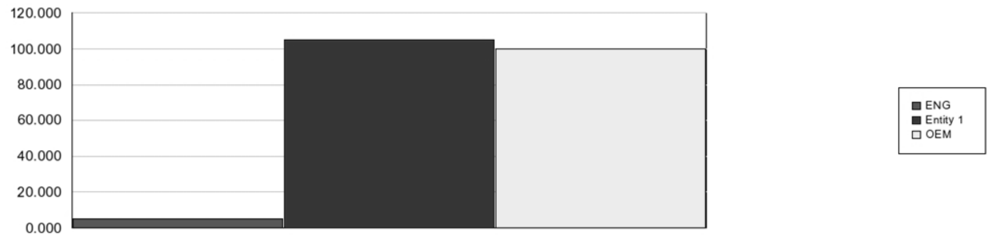
Unnamed Project

Replications: 50 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
ENG	5.0000	0.00	5.0000	5.0000
Entity 1	105.00	0.00	105.00	105.00
OEM	100.00	0.00	100.00	100.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
ENG	1.0000	0.00	1.0000	1.0000
Entity 1	105.00	0.00	105.00	105.00
OEM	100.00	0.00	100.00	100.00

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	4.6183	0.04	4.2589	4.8718	0.00	5.0000
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
OEM	73.5546	1.02	65.5715	82.4915	0.00	100.00

Unnamed Project

Replications: 50 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	1775.94	52.83	1568.55	2285.91	0.00	5282.40
BOM order.Queue	19.7728	3.06	8.7430	59.4316	0.00	251.65
BOM verification.Queue	1169.48	48.66	702.58	1387.25	0.00	5268.94
Clean and Pack.Queue	1944.47	18.50	1741.61	2032.81	0.00	5302.63
Component Order.Queue	23.8908	3.56	12.3739	54.9232	12.3739	54.9232
Design.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Final Test.Queue	1833.07	73.00	1556.64	2556.17	9.5005	5036.80
Find Match ENG.Queue	11.3212	8.81	0.00	140.86	0.00	140.86
Find matching part BOM.Queue	27.7930	5.09	1.7329	91.8646	0.00	283.46
Order Packaging.Queue	1.5394	0.43	0.00	3.3691	0.00	3.3691
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	79.1052	5.34	33.9642	141.44	0.00	662.58
Verify and package Eng.Queue	132.22	49.68	0.00	942.88	0.00	942.88

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	18.6651	0.55	16.4919	23.9774	0.00	75.0000
BOM order.Queue	0.2057	0.03	0.0911	0.6179	0.00	33.0000
BOM verification.Queue	12.1701	0.51	7.2965	14.4422	0.00	74.0000
Clean and Pack.Queue	20.4370	0.20	18.3381	21.3880	0.00	74.0000
Component Order.Queue	0.00248602	0.00	0.00128685	0.00571252	0.00	1.0000
Design.Queue	3.9717	0.00	3.9411	3.9940	0.00	4.0000
Final Test.Queue	19.2654	0.77	16.3696	26.8121	0.00	75.0000
Find Match ENG.Queue	0.00117805	0.00	0.00	0.01467008	0.00	1.0000
Find matching part BOM.Queue	0.07181286	0.01	0.00450585	0.2582	0.00	11.0000
Order Packaging.Queue	0.00016021	0.00	0.00	0.00035072	0.00	1.0000
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	0.8232	0.06	0.3535	1.4720	0.00	37.0000
Verify and package Eng.Queue	0.01375914	0.01	0.00	0.0980	0.00	1.0000

Unnamed Project

Replications: 50 Time Units: Hours

Resource

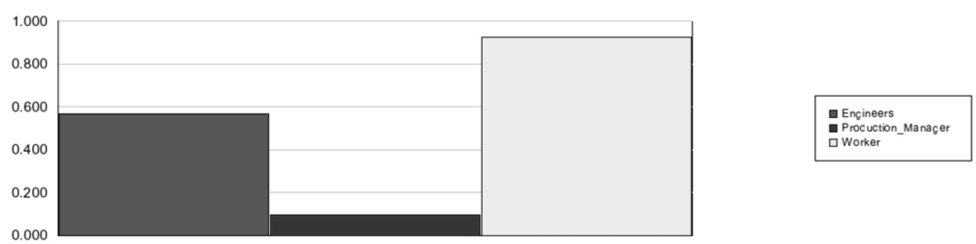
Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	0.5695	0.00	0.5589	0.5832	0.00	1.0000
Production_Manager	0.0955	0.00	0.07467068	0.1231	0.00	1.0000
Worker	0.9258	0.00	0.9237	0.9279	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	1.1389	0.00	1.1177	1.1663	0.00	2.0000
Production_Manager	0.0955	0.00	0.07467068	0.1231	0.00	1.0000
Worker	3.7032	0.00	3.6946	3.7115	0.00	4.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	2.0000	0.00	2.0000	2.0000	2.0000	2.0000
Production_Manager	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Worker	4.0000	0.00	4.0000	4.0000	4.0000	4.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Engineers	0.5695	0.00	0.5589	0.5832
Production_Manager	0.0955	0.00	0.07467068	0.1231
Worker	0.9258	0.00	0.9237	0.9279



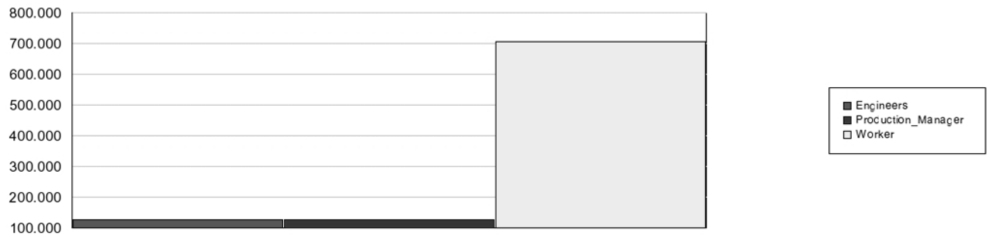
Unnamed Project

Replications: 50 Time Units: Hours

Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Engineers	126.56	1.44	118.00	137.00
Production_Manager	127.56	1.44	119.00	138.00
Worker	707.00	0.00	707.00	707.00



ESI Two Additional Station Model with High Demand Simulation Report

Values Across All Replications

Unnamed Project

Replications: 50 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	101

Unnamed Project

Replications: 50 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	906.75	3.41	880.52	951.92	880.52	951.92
OEM	235.68	0.32	233.20	237.60	228.18	268.13

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	2732.27	234.81	1175.97	5472.75	1175.97	5472.75
OEM	3977.58	84.47	3237.39	4768.21	932.84	6059.47

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	3639.02	236.05	2086.68	6396.92	2086.68	6396.92
OEM	4213.26	84.53	3472.75	5002.52	1162.40	6316.51

Other

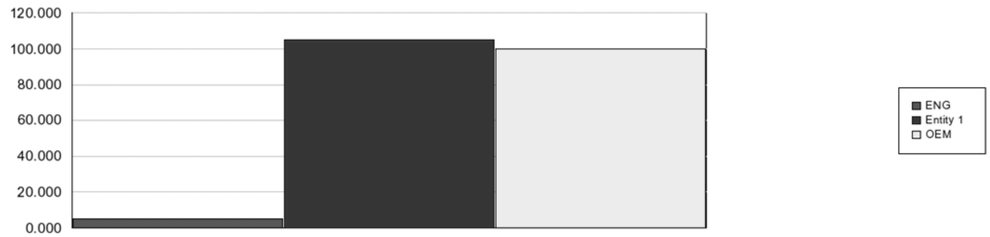
Unnamed Project

Replications: 50 Time Units: Hours

Entity

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
ENG	5.0000	0.00	5.0000	5.0000
Entity 1	105.00	0.00	105.00	105.00
OEM	100.00	0.00	100.00	100.00



Number Out	Average	Half Width	Minimum Average	Maximum Average
ENG	1.0000	0.00	1.0000	1.0000
Entity 1	105.00	0.00	105.00	105.00
OEM	100.00	0.00	100.00	100.00

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	4.5065	0.04	4.2757	4.8998	0.00	5.0000
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000
OEM	63.3862	1.27	52.1974	75.2819	0.00	99.00

Unnamed Project

Replications: 50 Time Units: Hours

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	997.77	25.34	777.15	1296.17	0.00	3012.97
BOM order.Queue	19.6902	3.19	8.2487	62.7369	0.00	214.30
BOM verification.Queue	662.84	23.83	502.12	826.11	0.00	3083.10
Clean and Pack.Queue	1184.06	19.51	1020.45	1297.00	0.00	3096.58
Component Order.Queue	23.8851	3.56	12.3739	55.8572	12.3739	55.8572
Design.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Final Test.Queue	1020.51	32.39	765.36	1397.50	6.0188	3098.60
Find Match ENG.Queue	9.3226	8.45	0.00	139.35	0.00	139.35
Find matching part BOM.Queue	28.3789	5.66	2.6849	95.0589	0.00	230.35
Order Packaging.Queue	1.5394	0.43	0.00	3.3691	0.00	3.3691
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	79.1123	5.46	33.5750	141.06	0.00	662.58
Verify and package Eng.Queue	132.22	54.26	0.00	1227.96	0.00	1227.96

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	15.1609	0.39	11.7978	19.7008	0.00	63.0000
BOM order.Queue	0.2962	0.05	0.1240	0.9404	0.00	33.0000
BOM verification.Queue	9.9723	0.36	7.5553	12.4274	0.00	58.0000
Clean and Pack.Queue	17.9916	0.30	15.5168	19.6373	0.00	63.0000
Component Order.Queue	0.00359291	0.00	0.00185695	0.00840323	0.00	1.0000
Design.Queue	3.9590	0.01	3.9150	3.9913	0.00	4.0000
Final Test.Queue	15.5063	0.49	11.6188	21.2410	0.00	63.0000
Find Match ENG.Queue	0.00140242	0.00	0.00	0.02099455	0.00	1.0000
Find matching part BOM.Queue	0.1089	0.02	0.00645661	0.3562	0.00	9.0000
Order Packaging.Queue	0.00023162	0.00	0.00	0.00050682	0.00	1.0000
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Rev Determination.Queue	1.1902	0.08	0.5055	2.1227	0.00	37.0000
Verify and package Eng.Queue	0.01989510	0.01	0.00	0.1848	0.00	1.0000

Unnamed Project

Replications: 50 Time Units: Hours

Resource

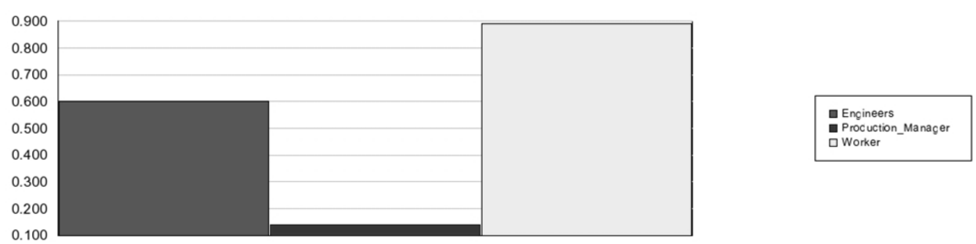
Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	0.6017	0.00	0.5831	0.6162	0.00	1.0000
Production_Manager	0.1405	0.00	0.1022	0.1695	0.00	1.0000
Worker	0.8923	0.00	0.8890	0.8950	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	1.2033	0.00	1.1662	1.2323	0.00	2.0000
Production_Manager	0.1405	0.00	0.1022	0.1695	0.00	1.0000
Worker	5.3537	0.00	5.3341	5.3698	0.00	6.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	2.0000	0.00	2.0000	2.0000	2.0000	2.0000
Production_Manager	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Worker	6.0000	0.00	6.0000	6.0000	6.0000	6.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Engineers	0.6017	0.00	0.5831	0.6162
Production_Manager	0.1405	0.00	0.1022	0.1695
Worker	0.8923	0.00	0.8890	0.8950



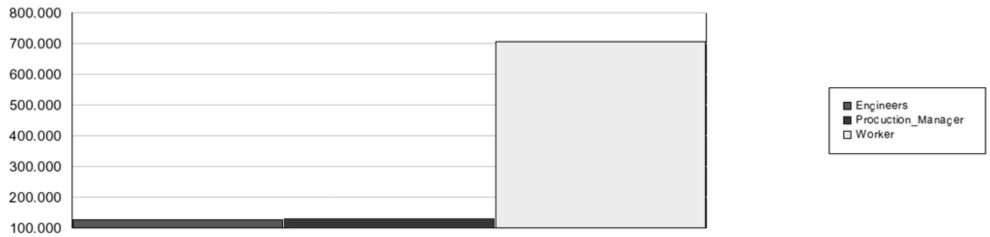
Unnamed Project

Replications: 50 Time Units: Hours

Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Engineers	127.24	1.30	118.00	135.00
Production_Manager	128.24	1.30	119.00	136.00
Worker	707.00	0.00	707.00	707.00



ESI Proposed Outsourcing Model Simulation Report

7:50:30AM **Category Overview** July 13, 2012

Values Across All Replications

Unnamed Project

Replications: 50 Time Units: Hours

Key Performance Indicators

System	Average
Number Out	1

Model Filename: C:\Users\MikeA.ADVANCED\Google Drive\Thesis\Thesis Models\ESIFULLOu Page 1 of 5

Unnamed Project

Replications: 50 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	906.97	3.20	888.22	944.56	888.22	944.56

NVA Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00

Wait Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00

Transfer Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00

Other Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	0.00	0.00	0.00	0.00	0.00	0.00

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	906.97	3.20	888.22	944.56	888.22	944.56

Other

Number In	Average	Half Width	Minimum Average	Maximum Average
ENG	2.0000	0.00	2.0000	2.0000
Entity 1	2.0000	0.00	2.0000	2.0000

Unnamed Project

Replications: 50 Time Units: Hours

Entity

Other

Number Out	Average	Half Width	Minimum Average	Maximum Average
ENG	1.0000	0.00	1.0000	1.0000
Entity 1	2.0000	0.00	2.0000	2.0000

WIP	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
ENG	1.9809	0.00	1.9449	1.9995	0.00	2.0000
Entity 1	0.00	0.00	0.00	0.00	0.00	1.0000

Queue

Time

Waiting Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Clean and Pack.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Component Order.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Design.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Final Test.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Find Match ENG.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Order Packaging.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Verify and package Eng.Queue	0.00	0.00	0.00	0.00	0.00	0.00

Other

Number Waiting	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Assemble.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Clean and Pack.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Component Order.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Design.Queue	0.9809	0.00	0.9449	0.9995	0.00	1.0000
Final Test.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Find Match ENG.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Order Packaging.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Order PCB.Queue	0.00	0.00	0.00	0.00	0.00	0.00
Verify and package Eng.Queue	0.00	0.00	0.00	0.00	0.00	0.00

Unnamed Project

Replications: 50 Time Units: Hours

Resource

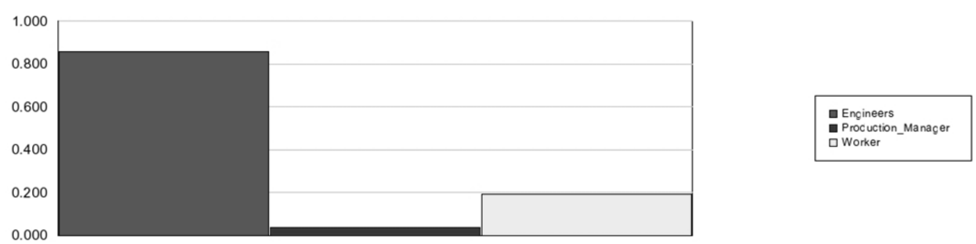
Usage

Instantaneous Utilization	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	0.8589	0.00	0.8546	0.8660	0.00	1.0000
Production_Manager	0.03569232	0.00	0.02384991	0.06468291	0.00	1.0000
Worker	0.1948	0.00	0.1870	0.1993	0.00	1.0000

Number Busy	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	1.7177	0.00	1.7091	1.7320	0.00	2.0000
Production_Manager	0.03569232	0.00	0.02384991	0.06468291	0.00	1.0000
Worker	0.3895	0.00	0.3741	0.3985	0.00	2.0000

Number Scheduled	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Engineers	2.0000	0.00	2.0000	2.0000	2.0000	2.0000
Production_Manager	1.0000	0.00	1.0000	1.0000	1.0000	1.0000
Worker	2.0000	0.00	2.0000	2.0000	2.0000	2.0000

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Engineers	0.8589	0.00	0.8546	0.8660
Production_Manager	0.03569232	0.00	0.02384991	0.06468291
Worker	0.1948	0.00	0.1870	0.1993



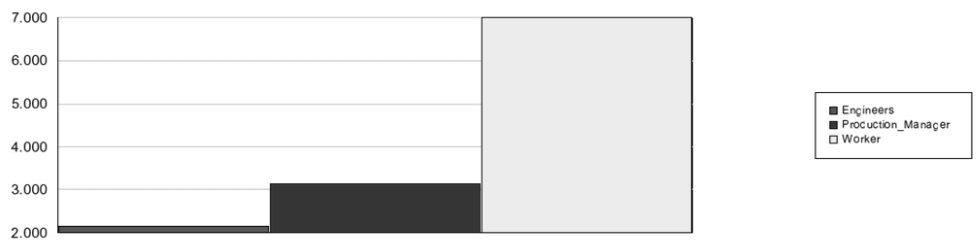
Unnamed Project

Replications: 50 Time Units: Hours

Resource

Usage

Total Number Seized	Average	Half Width	Minimum Average	Maximum Average
Engineers	2.1400	0.10	2.0000	3.0000
Production_Manager	3.1400	0.10	3.0000	4.0000
Worker	7.0000	0.00	7.0000	7.0000



Appendix B: Supplemental Material for Manet Company Ltd. Case Study

List of Solar Modules and their relative efficiencies (Sroeco Solar, 2009)

Manufacturer	Panel	STC Rating	PTC Rating	Area (Sq Ft)	Efficiency (PTC/Area)
SunPower	PL-SUNP-SPR-315E	315	290	17.556	**16.519**
SunPower	SPR-315E-WHT-D	315	290	17.556	**16.519**
SunPower	SPR-315E-WHT-U	315	290	17.556	**16.519**
SunPower	T5-SPR-315	315	290	17.556	**16.519**
SunPower	PL-SUNP-SPR-310	310	285.3	17.556	**16.251**
SunPower	SPR-310-WHT-U	310	285.3	17.556	**16.251**
SunPower	T5-SPR-310	310	285.3	17.556	**16.251**
SunPower	PL-SUNP-SPR-305	305	280.6	17.556	**15.983**
SunPower	SPR-305-WHT-U	305	280.6	17.556	**15.983**
SunPower	T5-SPR-305	305	280.6	17.556	**15.983**
SunPower	SPR-230-WHT-U	230	209.5	13.39	**15.646**
Sanyo Electric	HIP-205BA19	205	190.7	12.486	**15.273**
SunPower	PL-SUNP-SPR-290	290	266.4	17.556	**15.174**
SunPower	SPR-290-WHT-U	290	266.4	17.556	**15.174**
SunPower	T5-SPR-290	290	266.4	17.556	**15.174**
SunPower	SPR-225-BLK-U	225	202.9	13.39	**15.153**
SunPower	SPR-220-WHT-U	220	200.2	13.39	**14.951**
Sanyo Electric	HIP-200BA19	200	185.9	12.486	**14.889**
Sanyo Electric	HIP-215NKHA1	215	199.6	13.423	**14.870**
Sanyo Electric	HIP-215NKHA5	215	199.6	13.423	**14.870**
SunPower	SPR-220-BLK-U	220	198.2	13.39	**14.802**
SunPower	SPR-217-WHT-U	217	197.4	13.39	**14.742**
SunPower	SPR-215-WHT-U	215	195.5	13.39	**14.600**
Sanyo Electric	HIP-205BA3	205	185.1	12.691	**14.586**
SunPower	PL-PLT-63L-BLK-U	63	55.1	3.7781	**14.584**
Sanyo Electric	HIP-200BA3	200	184.5	12.691	**14.538**
Sanyo Electric	HIP-210NKHA1	210	194.9	13.423	**14.520**
Sanyo Electric	HIP-210NKHA5	210	194.9	13.423	**14.520**
Sanyo Electric	HIP-195BA19	195	181.1	12.486	**14.504**
Sanyo Electric	HIP-200DA3	200	186.2	13.057	**14.261**
SunPower	SPR-210-WHT-U	210	190.8	13.39	**14.249**
Sanyo Electric	HIP-205NKHA1	205	190.2	13.423	**14.170**
Sanyo Electric	HIP-205NKHA5	205	190.2	13.423	**14.170**
Sanyo Electric	HIP-195BA3	195	179.8	12.691	**14.168**
Sanyo Electric	HIP-190BA19	190	176.4	12.486	**14.128**
SunPower	SPR-210-BLK-U	210	188.9	13.39	**14.107**
Sanyo Electric	HIP-195DA3	195	181.5	13.057	**13.901**
Sanyo Electric	HIP-186BA19	186	172.6	12.486	**13.823**
Sanyo Electric	HIP-200NKHA1	200	185.4	13.423	**13.813**
Sanyo Electric	HIP-200NKHA5	200	185.4	13.423	**13.813**

References

Arduino, 2010. *Arduino Board: LilyPad*. [Online] Available at: arduino.cc/en/main/arduinoboardlilypad [Accessed 12 September 2011].

Atanassov, K., 1986. Intuitionistic Fuzzy Sets. *Fuzzy Sets and Systems*, 20, pp.87-96.

Barney, J.B. & Wright, P.M., 1998. On Becoming a Strategic Partner: The Role of Human Resources in Gaining Competitive Advantage. *Human Resource Management*, 37(1), pp.31-46.

Bates, T., 1990. Entrepreneur Human Capital Inputs and Small Business Longivity. *MIT Press*, 72(4), pp.551-59.

Bazerman, M., 2001. *Judgement in Manegerial Decision Making*. 5th ed. New York, NY, USA: John Wiley & Sons Inc.

Begley, T. & Boyd, D., 1987. A Comparison of Entrepreneurs and Managers of Small Business Firms. *Journal of Management*, 13(1), pp.99-108.

Brockhaus, R.H. & Horwitz, P.S., 1982. The Psycology of The Entrepreneur. In C.A. Kent, D. Sexton & K.H. Vesper, eds. *Encyclopedia of Entreprenuership*. Englewood Cliffs: Prentice Hall. pp.39-57.

Building Industry and Land Development Association, 2011. *News Releases*. [Online] Available at: http://www.bildgta.ca/media_releases_2011.asp [Accessed 12 December 2011].

Busenitz, L.W. & Barney, J.B., 1997. Difference Between Entreprenuers and Managers in Large Organizations: Biases and Heuristics in Strategic Decision-Making. *Journal of Business Venturing*, 12(1), pp.9-30.

Campanella, G. & Ribeiro, R., 2011. A Framework for Dynamic Multiple-criteria Decision Making. *Decision Support Systems*, 52, pp.52-60.

Canadian Mortgage and Housing Corporation, 2011. *Canadian Mortgage and Housing Corporation*. [Online] Available at: http://www.cmhc-schl.gc.ca/odpub/esub/64319/64319_2011_B02.pdf?fr=1335813695906 [Accessed 13 April 2012].

Canadian Mortgage and Housing Corporation, 2011. *Publications and Reports*. [Online] Available at: https://www03.cmhc-schl.gc.ca/catalog/productList.cfm?cat=99⟨=en&fr=1336927993264 [Accessed 27 October 2011].

Carland, J., Hoy, F., Boulton, W. & Carland, J., 1984. Differentiating Entrepreneurs from

Small Business Owners: A Conceptualization. *The Academy of Management Review*, 9(2), pp.354-59.

Cooke, D., 2011. Single vs. Dual Axis Solar Tracking. *Altenergymag.com*, 01 May. p.1.

Cooper, A., 1981. Strategic Management: New Ventures and Small Business. *Long Range Planning* , 14(5), pp.39-45.

Covin, J.G. & Slevin, D.P., 1989. Strategic Management of Small Firms in Hostile and Benign Environments. *Strategic Management Journal*, 10(1), pp.75-87.

Culkin, N. & Smith, D., 2000. An Emotional Business: A Guide to Understanding the Motivations of Small Business Decision Takers. *Qualitative Market Research: An International Journal*, 3(3), pp.145-57.

Cyert, R., Feigenbaum, E. & March, J., 1959. Models in a Behavioral Theory of the Firm. *Behavioral Science*, 4(2), pp.81-95.

Dean , T., Brown, R. & Bamford, C., 1998. Differences in Large and Small Firm Responoses to Environmental Contex: Strategic Implications from a Comparative Analysis of Business Formations. *Strategic Management Journal*, 19, pp.709-28.

Dicken, P., 1971. Some Aspects of the Decisio Making Behavior of Business Organizations. *Economic Geography*, 47(3), pp.426-37.

Digi International, 2011. *Digi International Fiscal Reports*. Minneapolis: Digi International.

Edmister, R., 1972. An Empirical Test of Finacial Ratio Analysis for Small Business Failure Prediction. *The Journal of Finacial and Quantitative Analysis*, 7(2), pp.1477-93.

Edwards, W., 1954. Theory of Decision Making. *Psychological Bulletin*, 51(4), pp.380-417.

Espicorn, 2008. *The World Medical Markets Fact Book 2008*. [Online] Available at: www.medicalnewstoday.com/releases/ [Accessed 4 October 2010].

Finetti, B.d., 1937. La Prevision: Ses Lois Logiques, Ses Sources Subjectives. *Annales de l'Institut Henri Poincare*, 7, pp.1-68. Translated by Henry E. Kyburg Jr..

Georgescu-Roegen, N., 1950. The Theory of Choice and The Constancy of Economic Laws. *Quarterly Journal of Economics*, 64(1), pp.125-38.

Gilligan, C., Neale, B. & Murray, D., 1983. Business Decision Making. In *Business Decision Making*. Deddington: Phillip Allan. p.1.

Government of Ontario, 2011. *Ontarion Regulation 359/09*. [Online] Government of Ontario Available at: http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_090359_e.htm [Accessed 5 December 2011].

Greenwood, P.N.M., 2006. *A Guide to Chi-Squared Testing*. New York: Wiley.

Hambrick, D.C. & Crozier, L., 1985. Stumblers and Stars in Management of Rapid Growth. *Journal of Business Venturing*, 1(1), pp.31-45.

Hammond, J., Keeney, R. & Raiffa, H., 1999. *Smart Choices, A Practical Guide to Making Better Decisions*. Boston, MA, USA: Harvard Business School Press.

Hui-Choa, L., 2004. Decision Theory and Analysis. *Futurics*, 28(1), pp.27-46.

Industry Canada, 2011. *Key Small Business Statistics*. Ottawa: Multimedia Services Section.

International Federation of Robotics, 2008. *Machine Market*. [Online] Available at: www.maschinemarkt.vogel.de [Accessed 5 October 2011].

International Trade Administration, 2010. *Medical Devices Industry Assessment*. [Online] Available at: ita.doc.gov/td/health/ [Accessed 2 October 2010].

Jacobsson, S. & Lauber, V., 2006. The Politics and Policy of Energy System Transformation - explaining the German Diffusion of Renewable Energy Technology. *Energy Policy*, 34, pp.256-76.

Kaiser, N., 2009. *Fully-Baked: The Real Cost of Adding a New Employee*. [Online] Available at: http://www.npost.com/blog/2009/03/30/fully-baked-the-real-cost-of-adding-a-new-employee/ [Accessed 29 Augustus 2011].

Kumar, D.V., 2008. *Spring Computing Technologies*. [Online] Available at: www.springcomputing.in/documents/emebedded_technologies_in_medical_devices.pdf [Accessed 11 October 2010].

Lee, W. & Wiashinghe, E., 2010. Putting Structure in Decision Making. *Supply Chain Management Review*, 05/06. pp.28-35.

Legislative Assembly of Ontario, 2009. *Bill 150, Green Energy and Green Economy Act, 2009*. [Online] Available at: www.ontla.on.ca/web/bills [Accessed 21 November 2011].

Low, M.B. & MacMillan, I.C., 1988. Entrepreneurship: Past Research and Future Challenges. *Journal of Management*, 12(2), pp.139-61.

ManCorp, 2011. *ManCorp Homepage*. [Online] Available at: https://www.manncorp.com/index.php?auto=done [Accessed 20 January 2012].

McClelland, D., 1961. *The Achieving Society*. 1967th ed. New York: Macmillan Publishing Company.

Mill, J.S., 1874. On Definition of Political Economy, and on The Method of Investigation Proper to it. In *Essays On Some Unsettled Questions of Political Economy*. London: Longmans, Green, Reader and Dyer. pp.120-64.

Mintzberg, H., 1973. *The Nature of Managerial Work*. Englewood Cliffs: Prentice Hall.

National Energy Board, 2011. *Energy Facts October 2011*. [Online] National Energy Board

Available at:
http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/prcng/cndnnrgprcngtrndfct2011/cndnnrgprcngtrndfct-eng.pdf [Accessed 6 November 2011].

Natural Marketing Institute, 2010. *Lifestyle of Health and Sustainability: Consumer Trends*. [Online] Available at: www.nmisolutions.com [Accessed 12 February 2011].

Nelson, R.R. & Winter, S.G., 1982. *An Evolutionary Theory of Economic Change*. Washington D.C.: Library of Congress Cataloging in Publication Data.

Newhomes.org, 2011. *News Details*. [Online] Available at: http://newhomes.org/news_detail.asp?id=1024 [Accessed 12 December 2011].

Ontario Power Authority, 2009. *Feed-in-Tariff Price Schedule*. [Online] Available at: fit.powerauthority.on.ca [Accessed 23 September 2011].

Pahl, N. & Richter, A., 2009. *SWOT Analysis - Idea, Methodology and A Practical Approach*. Santa Cruz: Grin Verlag.

Persky, J., 1995. Retrospectives The Ethology of Homo Economicus. *Journal of Economic Perspectives*, pp.221-31.

Persram, S., Lucuik, M. & Larsson, N., 2007. *Marketing Green Buildings to Tenants of Leased Properties*. Report. LEED.

Pitz, G.F. & Sachs, N.J., 1984. Judgement and Decision: Theory of Application. *Annual Review of Psychology*, 35(1), pp.139-64.

Romano, C., Tanewski, G. & Syrnios, K., 2000. Capital Structure Decision Making: A Model for Family Business. *Journal of Business Venturing* , 16, pp.285-310.

Rumble Energy, 2011. *microFIT Financing*. [Online] Available at: http://www.rumble-energy.com/index.php?p=41 [Accessed 23 September 2011].

Scott, M. & Bruce, R., 1987. Five Stages of Growth in Small Business. *Long Range Planning*, 20(3), pp.45-52.

Simon, H., 1977. *The New Science of Management Decision*. Saddle River, NJ, USA: Prentice Hall.

Srinivasan, V. & Shocker, A., 1973. Linear Programming Techniques for Multidimensional Analysis of Preference. *Psychometrica*, 38, pp.337-42.

Sroeco Solar, 2009. *Top 40 Most Efficient Solar Panels*. [Online] Available athttp://sroeco.com/solar/top-40-most-efficient-solar-panels [Accessed 20 February 2011].

Stone, R., 1951. *The Role of Measurement in Economics*. Cambridge: Cambridge University

Press.

Sustainability Purchasing Network, 2008. *Sustainability purchasing Trends and Drivers*. Statistics. Vancouver: Sustainability Purchasing Network Industry Canada.

Tap-in Marketing, 2012. *OptiSolar*. [Online] Available at: http://www.tapinmarketing.ca/portfolio/optisolar/ [Accessed 01 April 2012].

Tarion, 2011. *Tarion Homepage*. [Online] Available at: www.tarion.com [Accessed 05 December 2011].

The Weather Network, 2012. *Toronto, Ontario*. [Online] Available at: http://www.theweathernetwork.com/statistics/suncloud/cl6158350 [Accessed 20 April 2010].

Toronto Star, 2011. *Ontario's path to green prosperity*. [Online] Available at: www.thestar.com/ [Accessed 01 November 2011].

University of Miami, 2012. [Online] Available at: http://www.bio.miami.edu/dana/pix/chisquare.gif [Accessed 01 May 2012].

Wang, Z. & Li, K., 2012. An Interval-Valued Intuitionistic Fuzzy Multiattribute Group Decision Making Framwork with Incomplete Preferences Over Alternatives. *Expert Systems with Applications* , 39, pp.13509-16.

Wolf, D., 2010. *Canada's Housing Sector in Recession and Recovery: Beyond Bricks and Mortar*. [Online] Available at: http://www.bankofcanada.ca/wp-content/uploads/2010/05/sp110110.pdf [Accessed 05 December 2011].

Zadeh, L., 1965. Fuzzy Sets. *Information and Control*, 8, pp.338-56.