Managing an Engineering Project – The Case of a Biomass Power Plant

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ETM 545: Project Management Fall 2013
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ABSTRACT

This report has been constructed to describe the comprehensive process in creating a "Project Plan" for the above titled "Biomass Power Plant." We address in this breakdown the project management tasks, tools, and methods used, in addition to discuss and compare other commonly used project planning practices and techniques. The report also includes individual contributor experiences drawn from their careers and industries that are applicable to projects of this nature.

Keywords: Biomass, Power Plant, Project Management, Managing Risk, Project Success.

Contents

1. Introduction

A project is defined as “"A temporary endeavor undertaken to create a unique product, service, or result” [1], and project management is defined as “application of knowledge, skills, tools, and techniques to project activities to meet project requirements.” [3] We learn that Project Management, although under-recognized as a key element in the rise of civilization as we know it, has been practiced for thousands of years, since and possibly before the Egyptian Era [2]. Some of the earliest projects ever managed in human history were developed by the Egyptians [1]. Project management started getting recognition in the 1940’s during the Manhattan project. It was observed that different government entities, as well as engineering firms, started applying project management practices systematically to attempt to control costs and ensure delivery due dates.

As observed in the history of project management, it is possible to see the important role project management plays in developing new technologies as well. Biomass Power Plants are difficult engineering challenges, large in size, complexity, and technically challenging. This is because they are part of a new trend towards developing environmentally sustainable and energy efficient power production facilities.

Our case addresses the Biomass Power Plant actually constructed in Schwendi, Germany, as conceptualized its owner, Shilling, a local businessman with a background in timber. The purpose of the plant is to provide a heat source for his company’s wood drying kilns, as well as potentially shared with the community hospital and homes. The source of the biomass are the cast off byproducts of his milling processes. The team applies project management skills, tools, approaches and scheduling techniques to address the project needs in a hypothetical manner.

This paper is divided into sections, each covering selection criteria for an engineering project such as this one. We start with a literature review to determine if there have been any previous projects that might have been implemented within the same field, and to learn more about the field of project management in general. The second section will discusses the project scope and the goal of this project. We will then review the different methods of data collection that we utilized and found suitable for this project, followed by an analysis section that presents leadership and decision making aspects of the project, in particular, and the fields, in general. We discuss the roles and responsibilities of the program manager, project manager and functional manager with respect to the project, as well as identify the project challenges with which we were faced and the subsequent solutions. Lastly, we will develop conclusions and recommendations based on our findings.

2. Theoretical Framework and Literature Review

Over the last three decades project management endeavor has become mature. The Project Management Institute (PMI) was established in 1969 to advance project management from the field. On the other hand, academicians, researchers, and professionals have done a significant amount of research work in project management. These research works cover a wide-variety of areas that enriched this discipline and also have been helpful in undertaking large, complex, and challenging projects. For example, recent prominent projects include the Sydney Opera House in Australia, the Euro-Tunnel in Europe, the Tacoma Narrows Suspension Bridge in USA, and Calcutta Metro in India to name a few [4]. These project implementations provide us stories of both success and failure, and lessons learned

There are many challenges involved in a project's entire life cycle. Project Managers must work closely with relevant stakeholders to overcome challenges and get development work done on-time, to, a level of quality expected, and at an anticipated price.

Project leaders have overall responsibility for the success of a project. In a business operations setting, the **leadership** needs to have the quality of global thinking [5]. It is important to note, leaders are not made by mere title. Stevenson and Starkweather's research results show that "executives valued six critical core competencies: leadership, the ability to communicate at multiple levels, verbal and written skills, attitude and the ability to deal with ambiguity and change, as opposed to other competencies such as experience, work history, education, and technical expertise" [6]. Lloyd-Walker and Walker propose an authentic leadership for 21st century project delivery [7]. They suggest adopting a **capability maturity model** (CMM) template to measure maturity of authentic leadership. Besides project manager leadership skills, there needs to be clarity in authority among the project sponsor, program manager, and project manager as to who owns which roles and responsibilities. The lack of clarity surrounding program management especially in construction industry quite often remains an issue [8]. Findings suggest a positive effect in modern projects between an **ISO 9000 certified quality management system** and performance improvement in construction projects.

Creating a supportive work environment is an important part of the project manager/leader's job [9]. The project manager/leader needs to ensure the professional needs of the team members to have a strong effect on the project **team performance** [10]. For a project to be successful, the project team as a *whole* needs to be competent --as opposed to having individual-level competency. "Management must be aware of team level controls and the competencies within a team and not focus on the individual members of a system development team" [11]. Aladwani asserts that there is a strong relationship between the project team's general problem solving capability and project performance [12]. On the other hand, interpersonal conflicts can negatively affect a project's delivery [13]. Cheung et al. suggest that trust is central to every transaction and is the key driver in fostering cooperation, especially in construction projects [14]. The Biomass project is heavily dependent on third parties, suppliers and contractors. Hence, the project manager needs to work within the team, as well as outside the team developing a **trust framework**.

In implementing technically challenging projects, achieving technological product breakthroughs and adopting emerging tools and technologies, it is important for a PM to deliver a project successfully and *on time*. Bower and Christensen, in their seminal article in Harvard Business Review, observed that "many companies have learned the hard way the perils of ignoring new technologies that do not initially meet the needs of mainstream customers" [15]. They suggest radical advances in terms of adopting disruptive technologies as opposed to making incremental advances with preexisting technologies. Organizations must work hard to meet the challenge of disruptive change [16].

Managing performance is key. Parast and Hsieh et al. present the effect of Six Sigma projects on innovation and firm performance [17, 18]. The Biomass Power Plant project involves selection and installation of technology such as the biomass boiler, Rankine cycle, and steam turbine. To improve and monitor performance of these machines and tools adoption of **Six Sigma methodologies** can enhance technological innovation. Six Sigma programs help particularly in variance reduction, improve efficiency, and enhancing incremental innovation in biomass project.

Research suggests that project **delay** happens due to long duration of contract, civil work, land acquisition and consultant hiring and due to lack of commitment, inefficient site management, poor site coordination, lack of communication, and lack of clarify in project scope [19, 20]. This finding suggests that precaution is needed upfront for construction projects like a biomass project involving contracts with many third parties for supply of materials, contract works, and the input of consultants. Kutsch and Hall talk about deliberate ignorance in **project risk** management [21]. They suggest "through the identification, analysis and response to risk, project managers can achieve planned project outcomes." Bakker et al. emphasize "both technical risk factors and organizational risk factors, such as senior management support and user participation, are highly influential" [22]. Given that our case study is a construction project with huge financial undertaking, large, highly technical and complex, and involves contracts with many suppliers, it is important to measure the risk factors. Construction projects that are heavily dependent on contractors have certain additional risks. Zhao et al. assert that disagreement on conditions in contract is one of the most critical risk factor [23]. There can develop adversarial working relationships between contracting parties. Chan et al. suggest using cost contracts to align the interest of owners and contractors to achieve win-win situation [24].

Flyvbjerg proposes taking the **outside view** about the project for the sake of quality control and due diligence to get decisions right [25]. Yang et al. propose knowledge leadership to improve project and organizational performance [26]. Their research shows a strong positive relationship between customer knowledge management and project performance.

Schedule and cost overrun are typical concerns in construction projects [27]. In many cases, it happens because task dependencies and their completion time are not initially assessed with care. To overcome this problem, a careful analysis of dependencies of tasks and governance mechanism is needed at the early stage of the project [28]. This tremendously helps avoid delay of tasks due to non-completion of a predecessor task. The Biomass Project as a construction project, also demands the measurement of project progress and monitoring time and cost deviations from the plan as shown in Appendix B.

Aliverdi et al. emphasize using statistical quality control charts in the monitoring of project duration and costs [29]. Chou et al. propose using cost simulation procedures along with hypothesis testing to **measure and control cost overruns** in construction projects [30].

The results of our literature review brings a depth of understanding to project management in theory and in the development of this case study in particular. Seeing the correspondence of the research with our project work, makes our project that much more meaningful.

3. Project Scope

The goal of our project is to develop a management guide towards completing the Biomass Power Plant. This is done through the attempt of simulating the actual project and attempting to go and address all the requirements needed to complete the project. To achieve that goal we first developer a set of deliverables that we put in a Work Breakdown Structure (WBS), as can be seen in Appendix A, Section IV. The goal of the WBS is to manage our project scope by clarifying the required results to deliver the final product. The different deliverables were developed by individual team members, each focused on two contributions: first, their technical background and expertise and second, their own experience in the field. The project plan done by Sallam, summarized the initial programming of the project. Then, the deliverables were defined with their associated tasks for the 'Work Breakdown Structure ' (WBS), which was developed by Justin and Daragh from information provided by the whole group. Alexis and Theresa then developed a responsibility matrix outlined in Appendix A, Section VI, based on the deliverables and technical expertise, assigning each member a set of deliverables and tasks. Then partial schedules were developed by each, with performance precedents defined, and work-days estimated for budget purposes. See appendix B for the example of a complete construction schedule developed by Justin. Lastly, the project was compiled by Daragh for inclusion in the report. The report literature review was contributed by Nayem. Each group member contributed towards the project taking up parts of the paper to draft as well as edit. Credit must be given to the Cadence Project Manager Software, along with Microsoft Project, which were both used in our study.

4. Data Collection

Two different types of data that contributed to this project: qualitative & quantitative. Our approach towards gathering data in the qualitative matter occurred through a literature review of the topic, in general and for each of our sections of the report. We utilized research tools such as Google scholar and the different database resources available through PSU library. Due to the nature of the project being hypothetical, the goal was to gather enough information on the requirements behind the construction of similar facilities to enable us complete this project.

For the quantitative matter we divided the project into different sections assigning each person tasks on a responsibility matrix. The goal was for each person to research and determine the expected overall man-hours required as well as the cost analysis towards completing the part to which was assigned to them, which can be seen in Appendices B and C. In each situation, we brought our own experience into play to create a best-estimate for quantities of time, personal, and cost.

5. Interpretations and Analysis

5.1. Methodologies

Different types of projects require different management approaches. One of the first steps to planning a project is deciding which project management methodology to use in order to make the project run as efficiently as possible. Most PM methodologies are flexible and adaptable to size, risk, and complexity of projects, as well as companies, institutions and sectors [31]. Additionally, project management methodologies can be used universally, mapping out the 'when' and 'how' to use which tools, thus making their use consistent from project to project [31].

The Biomass Power Plant project was planned using the waterfall methodology through the aid of the Cadence ProjectMaster tool that can be found online. The waterfall method is one of the more traditional project management methodologies used for projects. It can be defined as a sequential design process in which progress is seen as steadily flowing downwards through phases of conception, initiation, analysis, design, construction, testing, implementation and maintenance [32]. The waterfall model maintains that one should move to a new phase when its preceding phase is completed and perfected. The success of every step for the Biomass project was dependent on the completion of the previous step, although some tasks naturally run parallel to one another. Our team worked each step weekly, and at the end we were able to combine the completed steps into a project plan that outlines how the project was managed.

The waterfall PM methodology used for the planning the Biomass project worked really well for us, but does not work for every type of project. In order to gain some insight as to what other project management methodologies exist as compared to the waterfall method used for the Biomass project, we looked into project management methodologies that are used in new product development and IT projects as well as process improvement type projects.

New product development projects require a lot of project planning and R&D. Because many of the decisions cannot be made up front with these kind of projects, the waterfall method of PM would not have been a good approach for these type of projects. Unlike the waterfall method of following a sequential design process, a good PM approach for a new product development project would be the agile methodology, which follows an incremental approach similar to the waterfall method, but allows for changes to be made after initial planning as shown in Figure 1 [32].

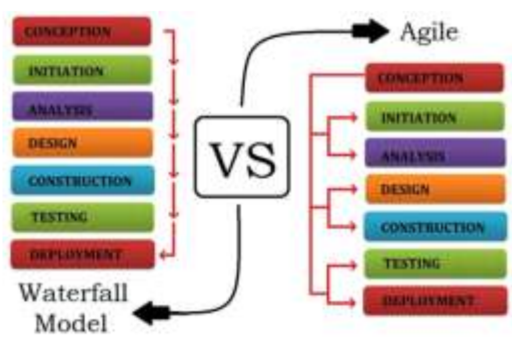


Figure 1. Waterfall vs. Agile Methodology [33]

Projects that are typically approached with the agile PM methodology are referred to as 'Black Swan' projects. These kind of projects do not follow a 'linear' path and require a long pre-planning phase as well as constant communication between functional areas and teams [34]. In new product development projects, the agile methodology can be very advantageous in that changes can be made throughout each step of the project, thus making it easier to add features that will keep the project up to date with the latest developments in industry and technology [32]. Additionally, because testing occurs often, bugs can be found and fixed throughout the development cycle instead of at the end, thus eliminating the rework of multiple steps in a project as opposed to just one.

Process improvement projects are very common in manufacturing companies and typically require the use of the LEAN Manufacturing PM method of Six Sigma. Six Sigma is a statistically based method to reduce variation in manufacturing processes, and is similar to the agile PM method in that there is room for changes to be made to the project throughout its duration. There are two different methodologies that can be followed when conducting a Six Sigma project: DAMIC and DMADV. DMAIC stands for Define, Measure, Analyze, Implement, and Control, and DMADV stands for Define, Measure, Analyze, Design, and Verify. DMAIC is commonly used for projects aimed at improving an existing product or process, whereas DMADV is used for projects aimed at improving new products or process designs.

I work for a company that manufactures aerospace parts and assemblies, and I am currently working on a project where my goal is to improve the process in which we induction harden aerospace grade gears. I am using the DMADV method of define, measure, analyze, design, verify to organize my project. Induction hardening is the process in which you change the physical properties on the surface of a steel part, through a sequence of heating and quenching, in order to increase the mechanical properties and cycle life of the part. This process takes place in an induction hardening machine, where only one part can be induction hardened at a time. The machine operator inputs a set of parameters into the machine console, and those parameters define at what power intensity and amount of time each part is to be heated. Because every part is different, each part requires a different recipe. Our current process for writing the recipes is a method of guessing, checking, and tweaking recipes used for like parts. Unfortunately, there is no way of non-destructively testing an induction hardened part, so if one destructively-tested part out of a lot does not pass inspection, the entire lot gets rejected.

The goal of my Six Sigma project is to develop a standard process for developing the recipe for any given product to be used on the induction hardening machine, based on the geometry and size of the part, thus eliminating the uncertainty in the process, resulting in fewer rejections. My project has two deliverables; hardness and depth of the induction hardened layer of a machined part. Per engineering requirements, there is a specified range in measurement that the deliverables must fall between; if they fail to meet the requirements, the parts are rejected and cannot be reused. From measuring these deliverables, I am able to collect and analyze the data needed to design a refined test.

Use of the waterfall and agile method of PM for this project would not work because the implementation of this process has already gone through the PM stages of these methodologies. Six Sigma is dependent on the data gathered from the current process, which is why the waterfall and agile methods of project management aren't used for process or product improvement. My project is currently in the 2nd stage of three design and analyze phases. After my third stage, I hope to have gathered enough information to verify my design and conclude my project. If this project succeeds, it could result in saving thousands of machined parts from being scrapped every year. This is just one example of how choosing the correct PM methodology could result in a saving a company time and money, and why it is important to look into all of the PM methodologies before starting a project.

5.2. Project Selection

As with every project, there is always a "go/no-go" decision to make. However with all the different places to investment capital, what sets one project on the path to fulfillment, while others languish or fall off the development path entirely? How are projects defined and accepted for further development? How are motivations judged and priorities set?

Power Station Schilling is no different. The owner's vision for an environmentally sensitive, esthetically powerful form for a biomass power plant set priorities, which took shape through the project work. His evaluation of the potential cost savings to his energy costs for his mills' lumber drying process prompted him, as did the financial incentives the German government offered; a matter of timing. This section of our report examines these issues of project conception, definition, refinement and evaluation in general, and in particular to the

Shilling Biomass Power Plant.

Always there is a vision, a priority, a need, a problem defined. The spark of an idea, whether it's a major building project or a tiny computer chip starts the process. Pressures of competition can spur projects into being, as can new opportunities. Sometimes it's the timing that is just right for a project to come into being; special resources including talented personnel are in place and available, sometime not. Sometimes there are incentives, external to the entity, which prompts project development. Often there are interrelated projects that together create a forward focus for future development.

Schilling made a decision (assigned a priority) to building a biomass power plant in the small village of Schwendi in southern Germany. It would serve to create energy (heat) for the operations of a family sawmill operation with a 200-year old history in this part of Germany. The timing of the opportunity was linked to federal incentives which made the plant a viable project financially. His commitment to using an Italian design-build firm for the architecture and engineering of the plant follows from his commitment to quality (company image) and caretaking (standing in the community). This plant has the potential to provide heat to an additional 1,450 homes as well as a local hospital. Potential risks involved rejection by the local governing body protective of the 'idyllic landscape' and 'skeptical of new ideas' [35]

Companies and organizations that use project management as a tool for development make decisions about their priorities through project portfolio management techniques. Archer and Ghasemzadeh's definition of project portfolios is ''a group of projects that are carried out under the sponsorship and/or management of a particular organization'' [36].

The portfolio of projects is like a stock portfolio, except it holds assets, programs, or systems, all of which are in development on their way to fruition. Just as a stock portfolio is held over time, evaluated, and decisions made to find the right balance, projects must continue to be evaluated for their performance and success at various stages. Project portfolio management involves in each case:

- Initial screening, evaluation, selection and prioritization of proposals

- Reprioritization of projects as new are added, and as time passes
- Assigning resources and reallocating them as priorities are assigned [37]

There are many different techniques, qualitative and quantitative, to evaluate projects, sometimes totally divergent in their approach. Some methods are so complex that while the metrics may reveal important information, management shies away from using them for many different reasons. Management may not focus on project often enough to develop the evaluation tools, or because they require too much work to gather input data; the form of output may not be usable or there may be insufficient analysis of risk to be reliable; they may fail to acknowledge interrelationships and interrelated issues not directly in line with project analysis [38].

As companies turn more and more to project management as the means to building their product line, systems or facilities, and as professional project managers take a stronger role at the corporate level, these tools and techniques for project evaluation will be easier to access and employ successfully. The important point to take-away from project portfolio management is that it is an ongoing process; one which must consider every project for it's alignment with corporate mission and vision statements, and control mission creep as it enters the organization through the focus of project work.

5.3 Project Portfolio Selection (PPS)

Selecting individual projects for a company portfolio is a process, rather than a one-time scoring or optimizing problems. The general framework that supports this process involves clearly identifiable stages, some of them entail pre-process work providing guidance to those involved in the process. For example strategy development will focus on issues and resources; constraints of the organization. The organizations higher management teams will have to refine and clarify these goals first, in order for subsequent project to be in alignment with them, and generate outcomes that advance the organization as a whole.

Selecting the evaluation method(s) is pre-process work as well. The type, scale, import of the project are considered as well as the organizations work methods, culture, and problem solving techniques. The climate economically and culturally within house can effect the type of analysis chosen to screen projects. A new product design team may have one way of working that a system refinement for a manufacturing process would choose differently.

The general framework for PPS will involves three activities completed prior to formal reviews occur. Analysts and managers charged with setting up the decision would research these issues. Pre-screening guidelines evaluate that the project fits the strategic focus of the portfolio of a whole, and the particular fit of this project to it. This preliminary analysis is the first gate to pass, and should properly have earned a champion to advance the idea and ensure it's implementation if followed through with having earned approval.

The individual project undergoes analysis based on metric parameters common to finance such as net present value, internal rate of return, weighted score calculations, etc. Each project having these metrics in place can begin to be measured against each other for potential performance success. Pre-screening cuts potentially low performing projects from the array. Finally, the focus is on 'optimal portfolio selection' and 'portfolio adjustment', activities, which management decision makers can make individually, or by management committees at regular intervals. Even here, priorities rule - for example, in new product development the goal may be to maximize the score for market suitability. In a building portfolio, maximizing net present value may rule the decision process. These are not 'value-free' processes. Again, alignment with mission and vision is important to weigh against. Value functionality can be weighted, and eventually reduced to one objective for comparison.

The optimization model weighs timing, project interdependencies, resources, and other criteria attempting to make the most of the total portfolio benefit. It is this balancing act that gives breath and depth to an organizations goals and lets them take form in projects.

Adjusting the portfolio is the final stage in this circular process. Decision makers in high enough management levels to speak from experience and technical knowledge make other adjustments to the project portfolio by adding and deleting projects. With the regular, perhaps quarterly review, results can be cycled back into the process, controls monitored for outcome, project schedules, budgets and resources shifted. Here, the group dynamics of review participants is important to the process, as negotiations are made to satisfy what may be a wider array of priorities than the metrics alone suggest. If not purely 'optimized' by metric based decision, the results should at least be 'satisfying' to key stakeholders and champions [39].

Outside the project development review process:

Outside the edges of the project portfolio, there may be other budget concerns that compete with the clearly defined projects in line for development. While the desire to create projects of these 'trailing issues' is often strong, the fact they have not been fully 'vested' through a stage-gate analysis hinders their official adoption into project status. They continue to draw resources, personnel, and time away from projects. If not carefully controlled, they easily become distractions to project teams, or individuals, charged with "just taking a quick look at this little issue" [40].

Project selection in a multiple project industrial context:

While working in South Carolina for Jacobs, a large multinational engineering firm, I was involved in project work and management on a $1.5 Billion manufacturing plant for a German chemical company. The scale of this project was such that, at the time, it was the largest project being engineered in the SE quadrant of the US. It involved the design, development and construction of more than 30 structures on a large campus in rural Tennessee. While I was not privy to the project selection process, I can surmise some of the factors involved in its selection for development. The company, while headquartered near Munich, has production facilities all over the world. Chemists in this company [a confidential client] developed a new process of silicon crystal manufacturing. My curiosity led me to do a patent search, and I believe they created a way to 'seed' crystals into a 'slurry' form, rather than the traditional hard composite crystal form typically sliced into segments used for solar collectors. This process was quite new, although it had been in production in an older plant in Germany, and was being brought on-line in a new Chinese Plant, as well. The process of manufacturing and process engineering continued to evolve over the course of our design work as well; employing lessons-learned from the new Chinese plant's commissioning.

Creating a plant in Tennessee allowed this company to further refine and improve the manufacturing process and also gave it direct access to the US market which was heating up at the time [2010-11]. A new manufacturing plant with a new process would give them a competitive advantage, access to markets, and would eliminate cross-global shipping expenses. Interestingly enough, all of the market analysis and net value pay-off calculations couldn't have predicted the failure of several American solar cell manufacturers, nor the steep decline in the commodity value of raw silicone. The way this played out in the actual project is that the "spare no expense, just build it fast" mentality shifted to one of "re-design to reduce construction costs". I am sure there were many high-level meetings about the issues related to this plant's development, continual shifting of priorities, and assessment of its place in a large portfolio of projects.

5.3. Leadership and Decision Making

Effective leadership is a vital component to the success of any project or program. Leadership is a measure of the capacity to be a leader. There are eight proposed Leadership theories identifiable as; Great man theory, Trait Theory, Behavioral theory, Participative leadership, Situational leadership, Contingency theory, Transactional Leadership and Transformational leadership [41]. No one style is the correct approach for PM, a combination of styles should be used to match the situation at hand, whether team building, gaining "buy in", handling a crisis or taking control.

The leadership style can be further broken into three functions; Decision making style, active management style and personal authority style. The factors that determine which of the eight styles is appropriate to apply to the functions are; the personality and maturity of the PM, urgency of the situation, maturity of the team member, maturity of the team, organizational structure and company culture [42].

For the bio-mass project being a construction/engineering project, the appropriate theories to deploy would be situational or contingency [43], breaking that down further applying a democratic style for an experienced construction team, and an autocratic style for a less experienced team would also be appropriate. If the project consisted mainly or contractors the PM would be more task oriented and if the project consisted of more internal employees the PM would be more relationship oriented.

In my experience working for in the technology industry I have seen a range of leadership styles applied in the PM roles. The two latest styles being democratic and laissez faire, I felt the first PM using the first style was actually leading, whereas the second PM did not appear as a leader. In the case of the democratic style PM the decision making process was highly participative but conclusion was driven by the PM which was a good approach considering the project team was experienced and as engineers would discuss the finer details at noisome without making a decision. In the case of the laissez faire PM the project decision-making process suffered as timely decisions were not made and resulted in schedule slippage.

5.4. Program Manager and Functional Manager Roles and Responsibilities

A typical Program Manager's role is to manage projects that are related so that they can provide enhanced benefits, guidance, support and coordinated control to the project managers. They do their best to meet program and project goals. According to Rita [46], the role of the program manger may include:

- Managing related projects to achieve results not obtainable by managing each project separately.
- Ensuring projects selected support the strategic goals of the organization.
- Providing oversight to adjust projects for the program's benefit.
- Guiding and supporting individual project manager's efforts.

This definition is shared widely throughout the professional project management community, PMI [47], and other standards and practices entities and is apparent in the project management of the Biomass Power Plant project. We describe a scenario for a company doing this sort of project work, woven into the descriptions which follow. The Program Managers on this project are lending their expert judgment and their capabilities in several of the areas concerning these types of power plants. Amongst them, are decades of experiences and lessons learned that would allow a project like this to succeed when facing certain pitfalls associated with projects of this magnitude. This expertise is crucial and critical to the project's success but we also have taken advantage of our organizational process assets, which our Program Managers use to drive the project manager. Due to the tenure in this industry we have cataloged procedures, policies, knowledge bases, processes, documentation, templates, plans, and the like that help guide our program managers, functional managers, and project managers. Enterprise environmental factors also play into the extent of this Biomass Plant Project. We have strived to build a strong culture and structure throughout 'our business' for this project, which has generated a cohesive team that communicates well internally and externally. "In its organizational context, a cultural ambience for project management deals with the social expression manifested by the participants engaged in managing projects. Within such organizations a culture emerges that reflects certain behavioral patterns characteristic of the members of that organization. Such behavioral characteristics influence the attitudes and the modus operandi of the people" [44]. Communication was also critical to the success of the projects and allowed the pieces of the project puzzle to come together. Creating an atmosphere with these behavioral patterns as the foundation which drove our business and project management strategies delivered a prosperous project. Our organizational approach to the structure of the company is to operate as a matrix organization in this case.

The company operates more along the lines of a strong matrix organization, where the project manager has the majority of the control over the project. "In an attempt to couple some of the advantages of the pure project organization with some of the desirable features of the functional organization, and to avoid some of the disadvantages of each, the matrix organization was developed. In effect, the functional and the pure project organizations represent extremes. The matrix organization is a combination of the two. It is a pure project organization overlaid on the functional divisions of the parent firm. [1] With our operations as a matrix company, we emphasize that our projects be run in a projectized fashion with origins that are functional. According to Crosswinds, "The functional manager position doesn't play much of a role in the process other than dealing with people and controlling resources. Typically, you see this role conflicting with the project manager and direction of the project. The potential conflict stems from the fact that the functional manager has a primary interest in running some business division or a department and only a secondary – if any – interest in a project that often pulls people away from their regular jobs in that division or a department. An example is a manger in an accounting department"[45]. The project manager involved with the Biomass Project has a high level of project authority, access to resources to work on the project, oversees the cost management of the project, and a decent sized support team.

Having the strong matrix organization that the company does, to manage a project of this magnitude, our functional managers and their teams are integral to the success of our project. Each of the respective divisions fulfills their roles to the best of their abilities. Our prototypical organization has a sales, marketing, administration, engineering design, engineering planning, construction management, HR, and financial functional managers that of which have a role in every aspect of the Biomass Project. Aforementioned, the company's approach is to allow the project manager direct the work of the supplemental team members, while their respective functional managers more or less support their team with the technology and tools necessary to complete their assignments. Throughout various functions of the project, we require less than full time employees (FTE) for various segments of the project. Taking a closer look at the organization, the responsibility matrix for this project can been seen in Appendix A, Section VI and the Work Breakdown Structure (Appendix A, Section IV) attached, reflects how the work is disseminated throughout the firm.

The program manager and functional manager both work closely with the project manager of the Biomass Power Plant Project. Our project manager facilitates the scope of the project work, oversees the schedule, costs, quality, human resources, communications, risk, procurement, and manage the expectations of the stakeholders. To be successful, we expect the project manager to be proactive and communicate constantly throughout the project. They are responsible for establishing the overall organizational structure of the project but do not have control over dictating which resources will utilized. The assignment designations are made by the functional managers. Planning and integrating several processes is an important and necessary role that the project manager is liable for throughout the project. Additionally, managing the integration, scope, time, cost, quality, human resources, communication, risk, procurement, and stakeholder involvement is key to the success of the project.

The Program Manager, Functional Manger, and Project Manager have distinct portions of the project for which they are responsible. Applying the matrix organization that we have with our experience and SME's, we had a strong, successful, and fruitful project. The team players involved with the Biomass Power Plant Project, theoretically, have worked together on previous projects of similar scope and have benefited from lessons learned from those experiences. "An evaluation of the management of projects that fail-that do not accomplish what was expected-is essential. Also, an evaluation of the management of successful projects can be useful. Such evaluation should be centered around the harmony of the results with the intended purpose reflected in a higher-level organizational plan" [44]. It is because of this evaluation of management that our team was able to make several assumptions for the challenges we faced. They were able to be proactive and provided predictive solutions.

6. Project Challenges and Solutions

With the program managers and functional managers involved with the project, our team feels that we can avoid some but not all of the typical project challenges that are faced on projects of this level of complexity. The expert judgment that we have within the confines of our group shall help solve and bring resolutions to issues faced. Some of the challenges that we have already identified are:

- Permitting – power generation, EAS/EIS Environmental concerns, species, water, clean air act.
- Funding/Tax Incentives
- Procurement and LEED considerations
- Design (efficiency/geotech) – liquefaction concerns for this area/poor soils, months of surcharge and stabilization needed.
- Scheduling – due to lead times, we have to make a sizeable down payment on the electrical equipment, primarily the power transformer and the turbine generators for the project.

Our functional managers have compiled the best of their respective groups and our project manager heading the project has managed similar scoped projects over the past decade. The initial challenges described above will be disseminated below.

The permitting encountered has put us through some trials and tribulation on this project. When considering the size of magnitude of this project, we consulted Golder Associates who has performed a thorough analysis of permitting and is familiar with working within the confines of the European Union [49]. According to this resource and our experience, it took approximately a year to receive the bio-energy permits necessary to advance the project. While filing for the permits, concurrently we reached out to the local community and respective permitting agencies for their support. Due to the location of this project being near the Alps and because of the regional skeptical support, it was imperative to gain district council approval which it took nearly a year to complete this preliminary phase of the project. We held several public involvement meetings and outreach events for feedback and input purposes. The community did have input on the overall design and visitor center which gained positive support which aided the project in receiving a favorable decision by the district council. After making it over this hurdle, our next issue was tied directly to the Environmental Impact Assessment (EIA). It is typical for these types of projects to take up to five years to gain the EIA. Because of our internally permitting team, having already performed similar tasks on past projects, we were able to have approval on our EIA in just less than three years. We were able to skirt several of the typical logjams of a project because we have already identified the following list from historical and lessons learned on previous projects.

- Our land use was already determined and proactively engaged because of our internal permitting group's expertise in this type of filing.
- The legislative issues typically encountered were expedited because of our familiarity with the typical litigation and filings.
- Our relationships with the various permitting entities in the region kept the process moving which is a typical time-sink on projects.
- Due to these relationships, we were able to speak directly to influential political decision makers of the region.
- Certain Bio-energy legislation is lacking in certain countries of the union, hence the reason we chose Germany.

These factors all played into the success of how quickly we were able to complete the permitting phase of our project. There were some minor edits and modifications that were performed during this phase but none of them were time-consuming enough to impact the schedule. Once the environmental and government dealings were completed, working with the local government agencies was easier in comparison. Gaining the access permits for the roads to the project as well as building permits and typical construction permits were more or less a formality in the process due to the proactivity that has been conducted to date.

With the legislation that was passed in 2000 by the Germany Renewable Energy Sources Act [49], it has afforded projects like this Biomass Power Plant Project to be profitable enough to proceed. After preparing the pro forma statement for funding of the project, the sale of the power that is being generated to this region, we can compete, gain a return on our investment, and better the environment. Our project lifecycle has been estimated at 20 years. The challenge faced with the tax credit and feed-in tariffs is that they have a pre-determined digression rate which decreases for the specific parts and installations to inspire the advancements of the specific technology. With the design and projections for the project with the assumed materials and down payments for a portion of the large procurement items, any major delay in the project could be detrimental with a decrease based on how the tax incentive has been stated. We are utilizing a similar design, that of which our functional groups have refined and nearly perfected to be our solutions for minimizing risk associated with this project. As a preemptive measure, our principal engineer and 20 year veteran is the lead on the engineering portion of the project. The specifications and design have been reviewed and checked several times in preparation for moving forward with the construction of the project. Most recently we have issued purchase orders for the components for the generators and the long lead-time electrical items such as the power transformer, relay panels, and breakers.

The reason for the early procurement and purchase of these items is because of the long schedules that are required for obtaining specialized materials specific for the creation of the generators, power transformer, relay panels, and breakers. Purchasing raw materials is only a portion of the product lifecycle in which it takes to create the necessary components. Testing and refinement are also critical to the success of the products. On previous projects, we have had issues with various vendors delivering these critical materials on time because of testing failures. With a large power transformer required on a previous project, for three voltage taps for operations and for future upgrades by the transmission authority of the region, we made adjustments as they were dictated to us which delayed the project and in the last testing phase, an insulator was detected and damaged. The vendor installed another one but had to retest and this procedure delayed the delivery by an additional 45 days. To be proactive and based on SME expert judgment, we have installed several days of additional float and contingency in the schedule for each of this critical path procurement items. Because of the crucial need for the success of this project and for possible future expansion and redundancy, we considered two power transformers which would circumvent issues in the short-term for the construction schedule as well as backup for the operation of the project. Unfortunately, the additional costs were rather substantial and we did not proceed with the purchase of an additional power transformer.

Design of certain aspects of the project have been a concern and present challenges that can impact the triple-constraint. Based on the geotechnical data received, it appears this area is older glacial drift. This presents some concern with regard to seismic activity. We are going to implement geo-piers into our design as a preventative measure but until we proceed with a more detailed geotechnical report, once the project begins to move forward. The geotechnical report will also help identify why type of grounding we need in the substation as well as to whether or not we will need an additional grounding transformer. This report will help us with the road design as well. We believe we can pull this report together in a timely fashion and have only performed an exploratory sampling for the bidding process. To resolve any issues or concerns, we have a soils lab within the confines of our engineering group that has the expertise because of involvement on previous projects of similar magnitude but also has performed work for other projects in this region and similar areas. Architectural issues have been resolved during the initial planning and permitting phase for which we have a design that has been approved by the local community and regional agencies. The other aspects of the design are fairly canned and will merely need modifications which our SME's can handle and provide insight into for the successful progression of the project and to meet our schedule constraints.

Looking closely at the schedule outlined in Appendix A, you see that our schedule has taken into consideration several additions for contingency purposes to offset the various critical paths that have been identified using a Monte Carlo approach. "When relationships between inputs and outputs in the projects are complex, Monte Carlo simulations (Evan et al., 1998) can handle such uncertainty by exposing the many possible consequences of embarking on a project." [1] This approach has helped us refine the schedule as well as predict possible risks in the schedule. It is a technique that is easy to use and eliminates several input parameters and variables that are required for tiresome calculations and analysis. Because of the scale of this project and the liability and overall financial risk, we perform these types of analysis frequently.

7. Conclusions and Recommendations

We took certain methodical approaches to handle such large and complex engineering and construction project that takes several years to complete. In order to make adequate preparations in terms of project management capabilities, utilization of project management tools, techniques, and best known methods (BKMs) we did an extensive literature research. This helped us to get an understanding of the current state of project management techniques especially for construction projects. Existing literature review gave us enough insights in managing such a technically challenging project. Besides, each of us has quite a bit of experience as project manager or project team members that we gained at work.

In this project, we attempted to determine the scope and project goal at the very beginning. We carefully examined the issues of project conception, definition, refinement and evaluation, in general, and in particular to the Power Shilling. To achieve the goal of the project we first developed a set of deliverables that we put in a Work Breakdown Structure (WBS). The goal of the WBS is to manage our project scope by clarifying the required results to deliver the final product. We outlined the deliverables, measures and exclusions of the project. After the scope was determined, each deliverable was assigned a list of tasks that outlined how the deliverable will be properly executed. We created a responsibility matrix. Each responsible member was in charge of figuring out cost estimates, time it takes to complete each task, as well as task dependencies.

We successfully identified the leadership and decision making aspects of the project. According to the existing literature, there are eight leadership theories. We figured that no one style is the correct approach for PM; we decided combination of styles would be ideal to handle the management of this project. For the bio-mass project being a construction/engineering project we thought the appropriate theories to deploy would be situational or contingency. We carefully outlined the roles and responsibilities of the program manager, project manager, and functional manager. The Program Manager, Functional Manger, and Project Manager have distinct portions of the project for which they are responsible. With defining the distinct roles and responsibilities our team feels that we can avoid some but not all of the typical project challenges that are faced on projects of this magnitude and size. We determined that Program Manager on this project will be lending the expert judgment and their capabilities in several of the areas concerning these types of power plants.

We emphasized that enterprise environmental factors also play into projects of the magnitude of this Biomass Plant Project. From the beginning of the project we strived to build a strong culture and structure throughout our business which has helped us build a cohesive team that communicates well internally and externally. We provided the project manager of this Biomass project with a high level of project authority, access to resources to work on the project, oversees the cost management of the project, and a decent sized support team. This has helped successful execution of project management activities throughout the project life cycle. With the structure that we currently utilize, the project manager is the focal point of our team. We emphasized that planning and integrating several processes are important and necessary role that the project manager is liable for throughout the project.

At the outset, we identified some of the challenges of this project. We also came up with strategies to overcome those challenges. For example, it took approximately a year to receive the bio-energy permits necessary to advance the project. While filing for the permits, concurrently we reached out to the local community and respective permitting agencies for their support. We held several public involvement meetings and outreach events for feedback and input purposes. We were able to overcome the hurdle of getting Environmental Impact Assessment (EIA) approval faster. Given the size of magnitude of this project, we hired a consulting company (Golder Associates) to help us perform a thorough analysis of the project situations. To minimize the risks associated with this engineering project, as a preemptive measure, one principal engineer and 20 year veteran is assigned to lead on the engineering of the project. We made sure that the specifications and design are reviewed and checked several times in preparation for moving forward with the construction of the project.

By empowering the program manager, project manager, functional manager with authorities, and well defined roles and responsibilities. We have been successful in delivering this complex engineering project on time.

For Biomass Power Plant project implementations we feel that further research can be conducted on how to replicate the success of our project implementations on more industry-wide scale. We believe that would help in fostering a fostering a project management framework for power plant construction projects. We also recommend that further research be conducted as to how to minimize the duration of such projects. For example, can the components be modularized and scaled to be 'out of the box' and so reduce duplicate engineering time and cost for future projects of a similar mature? This will help future projects to overcome the dilemma of running such project using the waterfall methodology versus developing the 'product' of a power plant, without tools and technologies being used become outdated quite a bit by the end of such project completion.

Appendix A: Project Plan

PSU

Biomass Power Plant
ETM545

Project Plan
Version: 1.6
December 07, 2013

Project Manager: Theresa Hailey

Project team:
Daragh Finn
Justin Kurger
Alexis Wittman
Sallam Thabet
Nayem Rahman

Contents

Biomass Power Plant ETM545

I. Introduction

Hans-Erich Schilling wanted to build a biomass power plant with a standout design that would blend in with the idyllic landscape and encourage local interest in sustainability….

II. Objective

To design and build a Biomass Power Plant costing $10.75 million, which celebrates green energy production while respectfully integrating itself into the rural landscape, by 2014

III. Scope

DELIVERABLES:

- Project Plan
- Pre-Design
- Site
- Structure
- Infrastructure
- Procurement of Necessary Equipment
- Commission
- Transfer
- Bio Mass Plant
- Contract

MEASURES:

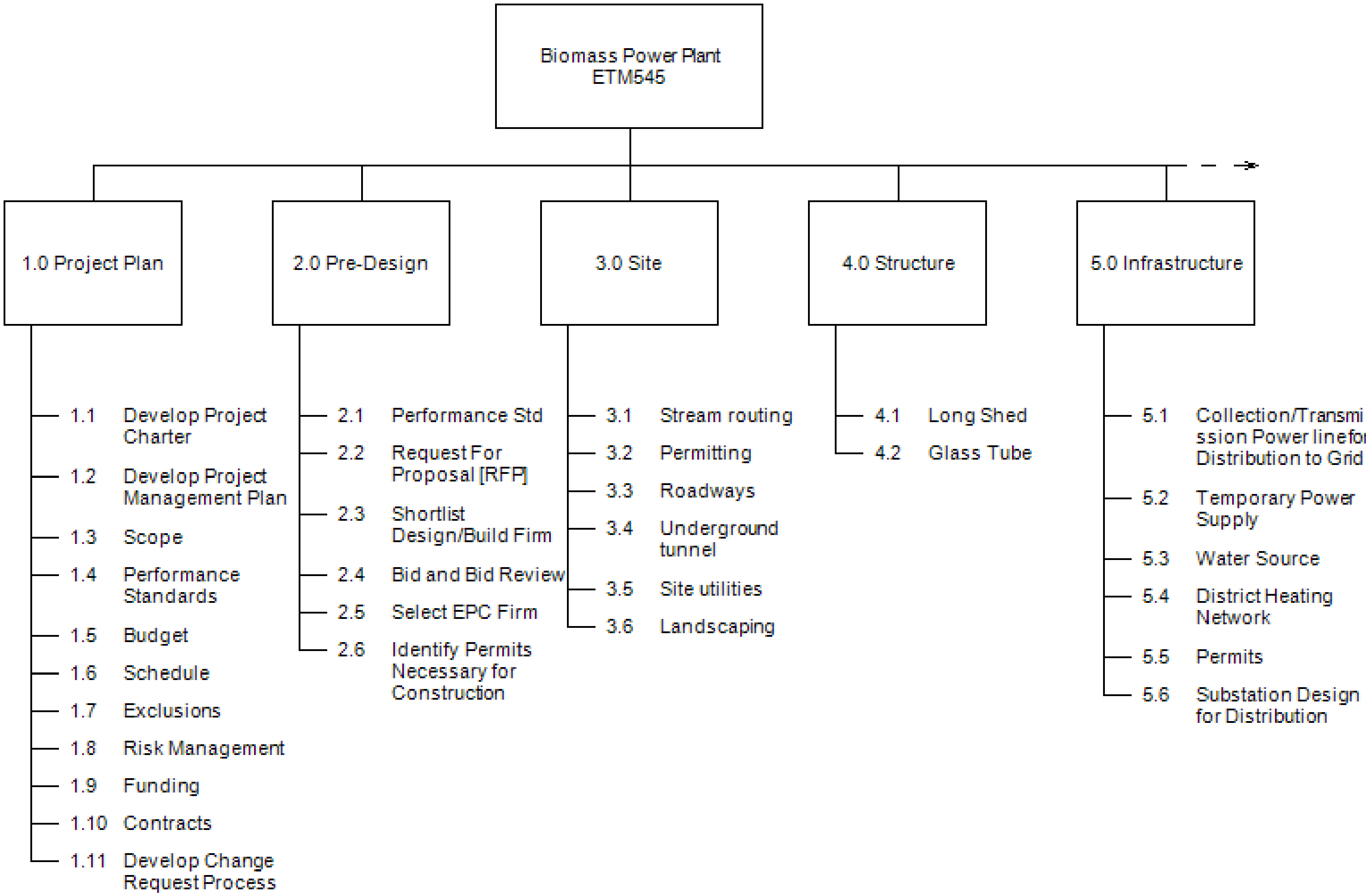
- Gross area: 10,794 sq. ft.

- Cost: $10.75 million
- Completion Date: 2014 (Duration 12 Months)
- Needs to power 1450 single-family houses
- Silicon heats oil to 365 degrees F
- Continuously available power generation of approximately 3.0 MW (1.0 MW can feed approximately 700 homes)

EXCLUSIONS:

- Internal aesthetics and decorations (ex. Plants and paintings)
- We will not provide the Fish
- Furniture for offices (owner provided)
- Land procurement, property rights and negotiations should be prepared and agreements in place before we receive NTP

IV. Work Breakdown Structure



Biomass Power Plant
ETM545

- 6.0 Procurement of Necessary Equipment
  - 6.1 Combustion Chamber
  - 6.2 ORC Machine
  - 6.3 Silicon Oil
  - 6.4 Turbine
  - 6.5 Generator
  - 6.6 Heat Exchanger
  - 6.7 Water Pump
  - 6.8 Substation Equipment
  - 6.9 Collection/Transmission Power Line
- 7.0 Commission
  - 7.1 Commissioning Plan
  - 7.2 Arch Flash Hazard Analysis
  - 7.3 Outage Scheduled
  - 7.4 Test Operation
- 8.0 Transfer
  - 8.1 Training
  - 8.2 Documentation
  - 8.3 Operations
- 9.0 Bio Mass Plant
  - 9.1 3.0MW of Continuous Power Generation
  - 9.2 Integrate in local grid
  - 9.3 Power 1450 homes
  - 9.4 Heat sawmill
  - 9.5 Heat hospital
- 10.0 Contract
  - 10.1 Recieve Completion Certificates for Required Scope of Work
  - 10.2 Close Contract/Estoppel
  - 10.3 Punch List
  - 10.4 Release Retainage

V. Roles and Responsibilities

Project Manager

ROLE

Communicator: The Project Manager is the primary source for project information and must be proactive in this role. The Project Manager must identify all affected parties, seek all information required, and ensure all involved are kept informed.

Organizer: The Project Manager establishes the organizational structure for the project. However, in many cases, the Project Manager will not have the authority to dedicate resources to the project. Resources are often acquired through negotiation with Functional Managers and the Sponsor.

Planner: Planning takes place throughout the entire project and at all levels. It is the role of the Project Manager to ensure an integrated plan is created, is sufficient for the purpose and receives proper authorization. As the project planner, the Project Manager is also expected to identify linkages to the big picture, showing the fit of the project to the overall company goals, business direction and vision defined by senior executives.

Catalyst: The Project Manager ensures the project plan is executed according to the authorized cost, schedule, and performance, and according to company policies (such as project management policies). The Project Manager must seek Sponsor authorization to any changes in the plan. The Project Manager needs to show a proactive, opportunistic, quick-response-to-problems profile.

RESPONSIBILITIES

1. **Identify task responsibilities with Team Members**
2. **Communicate with Functional Managers**
3. **Communicate with committees**
4. **Communicate to Sponsors, Clients, and Stakeholders**
5. **Establish the organizational structure**
6. **Take the lead in establishing the Steering Committee structure**
7. **Take the lead in assembling the Project Team**
8. **Secure representation from affected departments**
9. **Lead the team in developing the project plan**
10. **Forecast project cost, schedule, and performance**
11. **Ensure a smooth turnover to ongoing operations**
12. **Prepare project documentation (project notebook)**
13. **Issue status reports**
14. **Hold team status meetings**
15. **Resolve conflicts related to cost, schedule, and performance**
16. **Meet departmental standards for project management (as opposed to technical standards inside participating departments)**
17. **Ensure performance on all tasks**

Functional Manager: Manager of Project Manager

ROLE

The Project Manager's manager supports and guides the Project Manager. The Project Manager's direct supervisor fills this position.

Coach/Mentor: Advises the Project Manager on leadership techniques and serves as a sounding board for political issues. Is an information resource to the Project Manager.

Door Opener: Helps the Project Manager gain access to higher-level company management. Supports the Projects Manager as focal point for communications.

Resource Provider: Provides human and financial resources to the project within the limits of their control.

Trainer: Provides tutorials to the Project Manager on project management tools and techniques in a one-on-one environment.

Process Promoter: Is a strong advocate inside and outside the department in the consistent use of the company-defined project management process.

RESPONSIBILITIES

1. **Select or participate in the selection of the Project Manager**
2. **Support the Project Manager**
3. **Monitor status of projects**
4. **Train and develop Project Manager**
5. **Conduct performance reviews**
6. **Provide additional resources as appropriate**
7. **Resolve resource bottlenecks**
8. **Ensure quality of performance**
9. **Provide managerial assistance when needed**
10. **Participate on Steering Committee when appropriate**
11. **Ensure that the Project Manager is utilizing the company project management process**

Functional Managers: Managers of Team Members

ROLE

The Functional Manager serves as a support person to staff assigned to the project by assigning resources, providing technical expertise and advice, and by making key technical decisions. The Functional Manager develops, educates, reviews, and supports the Team Member or Project Manager.

The Team Member's manager manages the function work unit and provides resources when requested. All managers are responsible for the performance of their people assigned to the project. The Team Member's direct supervisor fills this position.

RESPONSIBILITIES

1. **Ensure the technical skills of Team Members**
2. **Communicate with the Project Manager**
3. **Negotiate assignments of Team Members**
4. **Educate and develop Team Members**
5. **Conduct evaluation performance reviews**
6. **Provide additional resources as appropriate**
7. **Resolve resource bottlenecks**
8. **Ensure quality of performance**
9. **Fill vacancies when turnover occurs so that commitments are still delivered**
10. **Set sequence and priority of work**
11. **Write performance review**
12. **Provide technical direction for tasks as necessary**

Technical Leader

ROLE

The Technical Leader serves as key support to the Project Manager in large projects that have significant technology content. They provide key architecture or platform design for the multiple technologies and their integration in the product or service. Other titles often used are: Senior Project Engineer, Systems Engineer and Chief Scientist.

Architect: The Technical Leader is the primary source for backbone definition of the technical architecture of the project result or product. They must be technically current or on the leading edge and obtain input from technical experts for the present and future application of technology as it relates to this project.

Creator: The Technical Leader often has the principal role in the invention of new technology required for the project.

Integrator: Integration of multiple technologies is required by most large projects. The Technical Leader ensures that interface requirements have been defined and are working smoothly.

Communicator: The Technical Leader must explain the technology and architecture, as circumstances require, in lay terms for non-technical people and in precise technical

terms for specialists. As chief technical spokesperson to this variety of audiences, rapid and complete understanding is the target.

RESPONSIBILITIES

1. **Create and document technical definition and direction in a form that can be understood by all Team Members**
2. **Assist the Project Manager with the identification of technical tasks and the creation of a cross-functional project plan. The Technical Leader will be the author of those sections of the plan that deal with product description and functions, reliability requirements, technical issues, verification, and validation**
3. **Provide key information for project plan sections which deal with production cost, regulatory requirements and manufacturing processes**
4. **Works independently, and with others, to perform assigned tasks**
5. **Communicate and resolve technical changes to the product within CSP constraints**
6. **Design, develop and document product designs that meet functional, quality, cost, reliability, manufacturability and safety requirements. Assure continuity of design**
7. **Provide pertinent patent information for filing**
8. **Be positive and gain the respect of the team, customers, and suppliers**
9. **Understand, use and advocate the use of appropriate engineering tools**
10. **Participate in supplier selection**
11. **Gain knowledge of similar company products by interacting with Assembly, Operations and Quality, and use such knowledge to achieve common parts usage**
12. **Visit customer and significant suppliers**
13. **Identify, discuss and resolve areas of potential overlapping responsibilities with the Project Manager before conflicts are visible to the team**

Team Members

ROLE

Subject Matter Expert (SME): The Team Member is assigned as a specialist from their organization to do task work that requires their special knowledge and skill.

Task Manager: Team Members review the tasks assigned to them. They accept or re-negotiate the cost, schedule, and performance of the specific tasks assigned. Team Members complete specific tasks to which they have committed.

Communicator: The Team Member communicates with both the Functional Manager and Project Manager. While the Project Manager will make project decisions, the Functional Manager will make day-to-day management decisions. As a problem increases in significance (i.e. the Team Member will be unable to resolve it alone), the Team Member notifies the Managers of the problem and suggests alternative solutions.

Client/Supplier Representative: Some Team Members are selected to represent Client or Supplier perspective. As Team Members they may be responsible for, or contribute to, tasks.

RESPONSIBILITIES

1. **Assist with project and task planning**
2. **Commit to and complete the tasks assigned within cost, schedule and and performance**
3. **Suggest alternatives for problems, issues and roadblocks**
4. **Communicate with their functional manager and project manager**
5. **Prepare special or technical documentation**
6. **Meet departmental standards on assigned tasks**

Steering Committee

ROLE

Internal Customer: The Sponsor is the internal company recipient of project results. The Sponsor(s) also fund(s) the project.

Authority Figure: The Sponsor will have the final say in decisions that affect cost, schedule and performance constraints.

Project Manager's Advisor: Typically senior managers, Sponsors or Steering Committee members can provide political advice or assistance to the Project Manager.

RESPONSIBILITIES

1. **Provide or secure funding for the project**
2. **Define or approve project scope**
3. **Approve changes to the project objective as a result of scope changes**
4. **Make phase end decisions, i.e. project authorization, approval, acceptance**
5. **Interpret or formulate existing or new policy as requested**
6. **Receive status monthly from the Project Manager**
7. **Promote the project and its linkage to company goals and directions**

Project Administrator

ROLE

The Project Administrator (PA, also called the Project Coordinator) is responsible for project support. The PA is responsible for distributing summary status reports on project

progress. The PA maintains a library of all end-of phase documents and assists the Project Manager in all phases of the project life cycle.

RESPONSIBILITIES

1. Drafts monthly status reports with the Project Manager

2. Maintains an archive of project progress, changes and issues for audit purposes

3. Supports preparation of the project budget by validating and entering data in software

4. Compiles and tracks project control documents

5. Functions in accordance with appropriate accounting procedures and other safeguards & guidelines

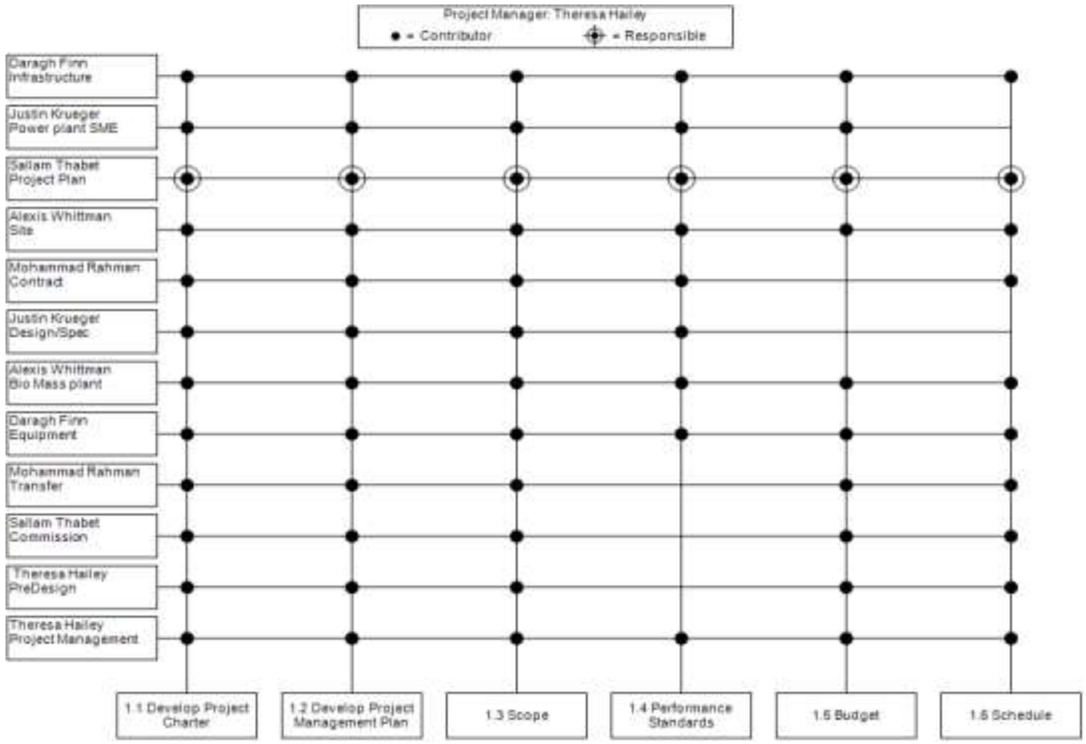
6. Provides assistance to Project Manager in documenting and compiling project assumptions

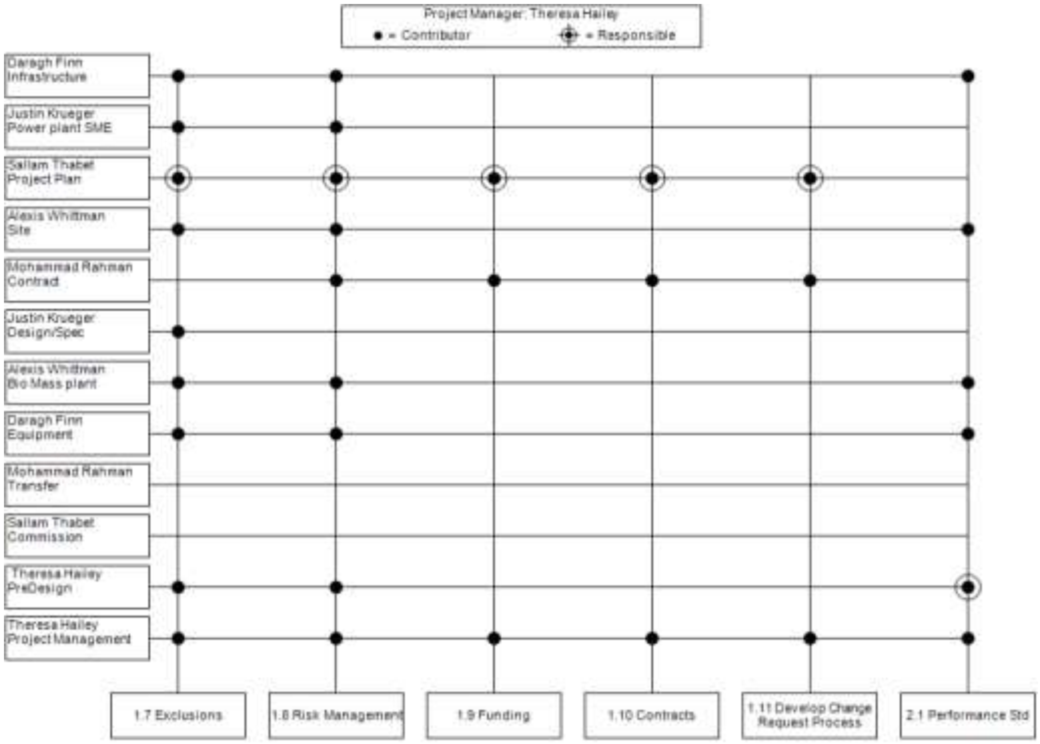
7. Documents decisions and action items from weekly Project Team meeting

8. Gathers data for project plan in accordance with direction from Project Manager

9. Maintains currency of project plan

VI. Responsibility Matrix

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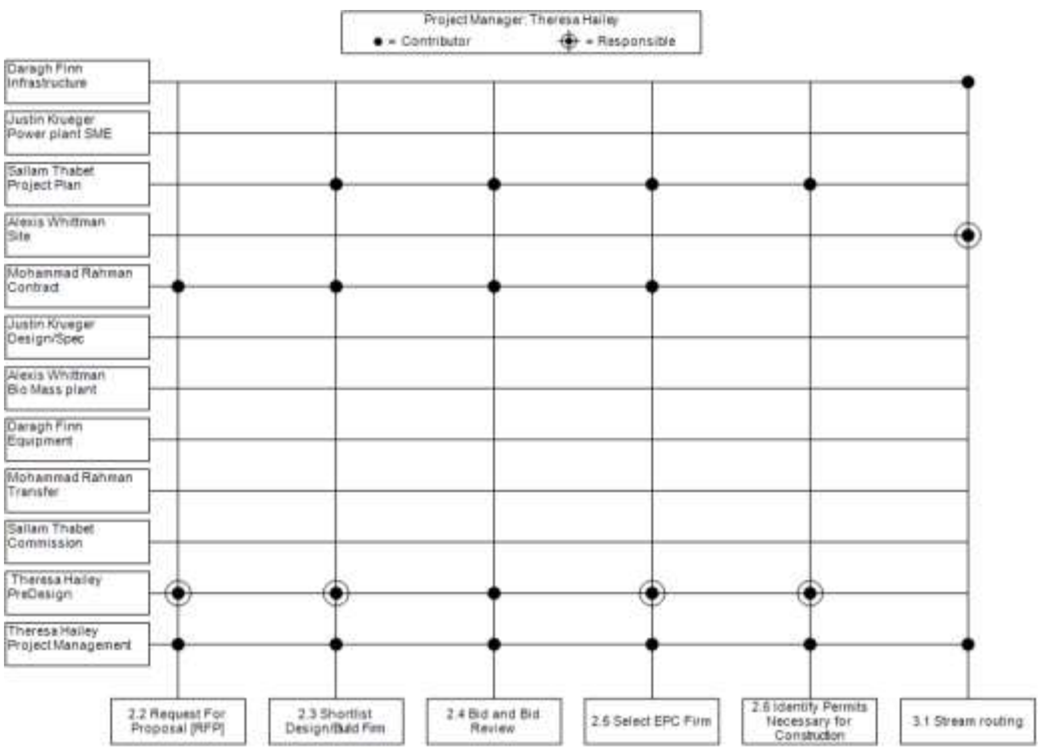
Sallam Thabet Project Plan
Alexis Whittman Site
Mohammad Rahman Contract
Justin Krueger Design/Spec
Alexis Whittman Bio Mass plant
Daragh Finn Equipment
Mohammad Rahman Transfer
Sallam Thabet Commission
Theresa Hailey PreDesign
Theresa Hailey Project Management
1.7 Exclusions
1.8 Risk Management
1.9 Funding
1.10 Contracts
1.11 Develop Change Request Process
2.1 Performance Std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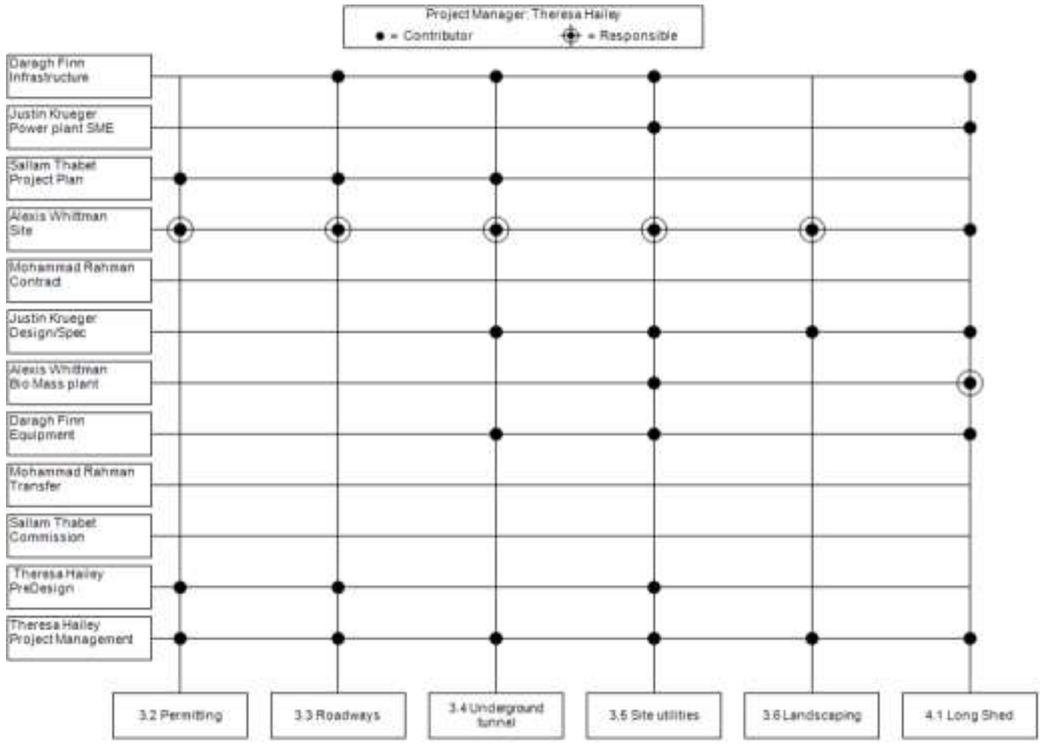
Theresa Hailey PreDesign
Theresa Hailey Project Management
2.2 Request For Proposal (RFP)
2.3 Shortlist Design/Build Firm
2.4 Bid and Bid Review
2.5 Select EPC Firm
2.6 Identify Permits Necessary for Construction
3.1 Stream routing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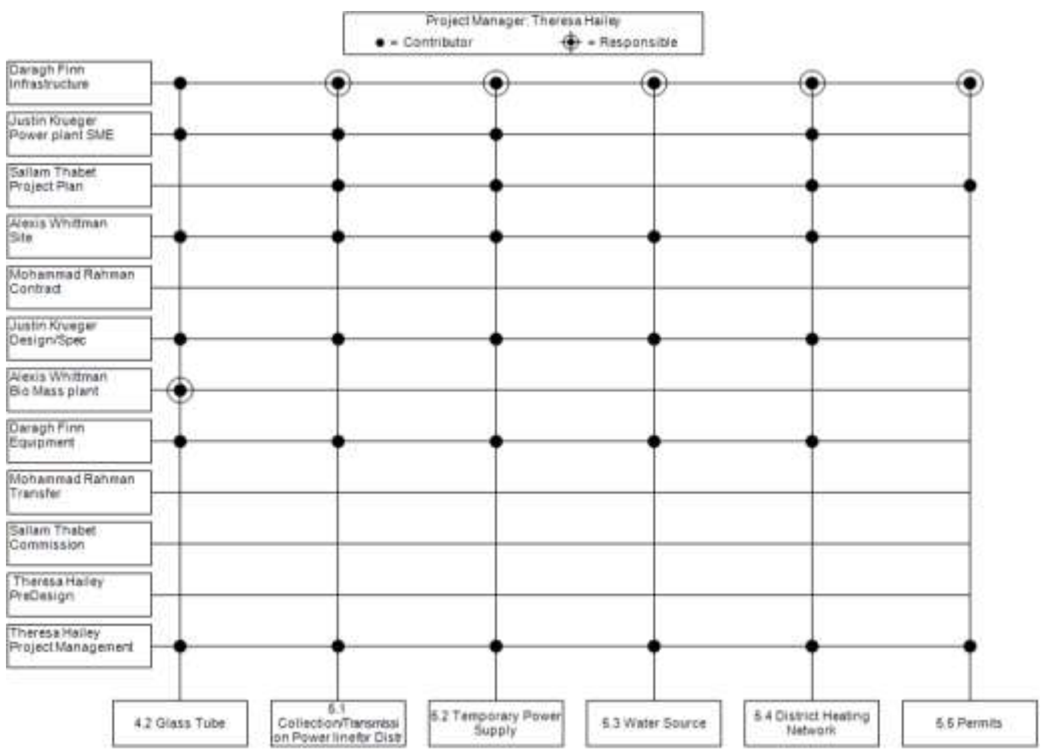
3.3 Roadways
3.4 Underground tunnel
3.5 Site utilities
3.6 Landscaping
4.1 Long Shed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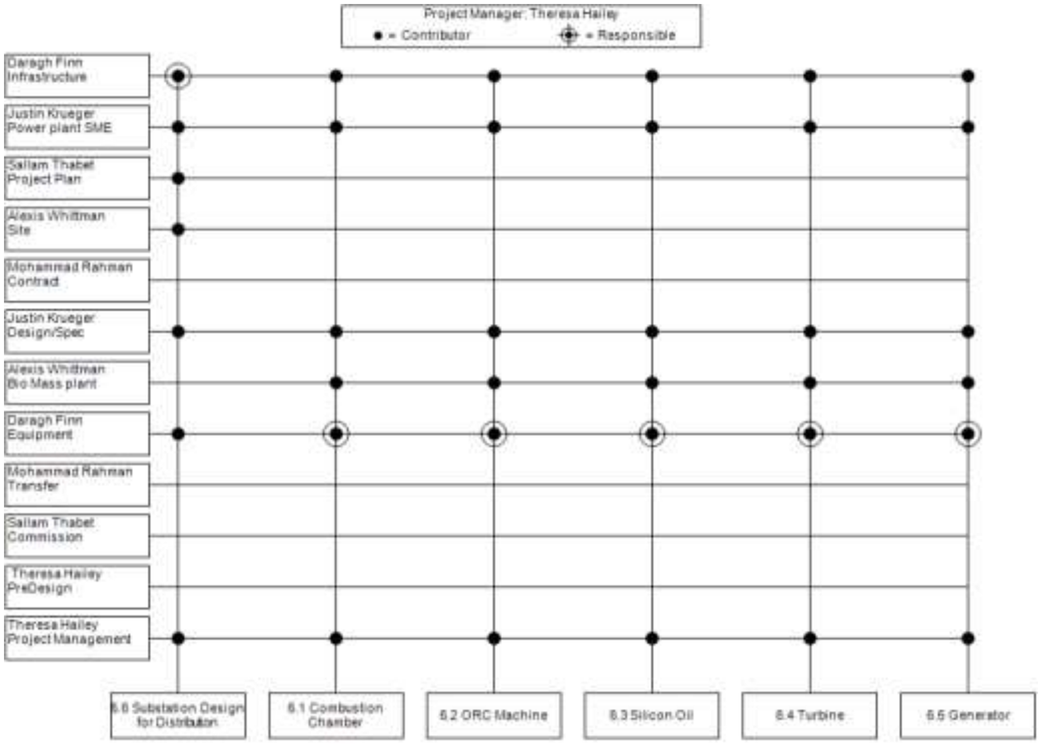
4.2 Glass Tube
5.1 Collection/Transmission Power line for Distr
5.2 Temporary Power Supply
5.3 Water Source
5.4 District Heating Network
5.5 Permits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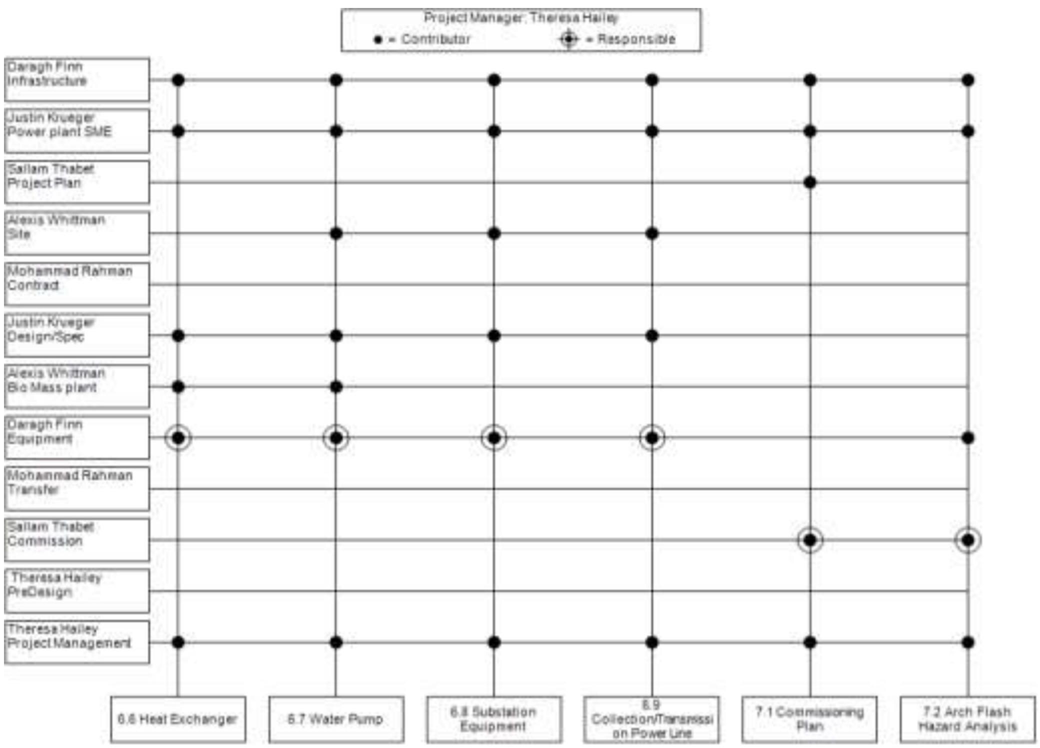
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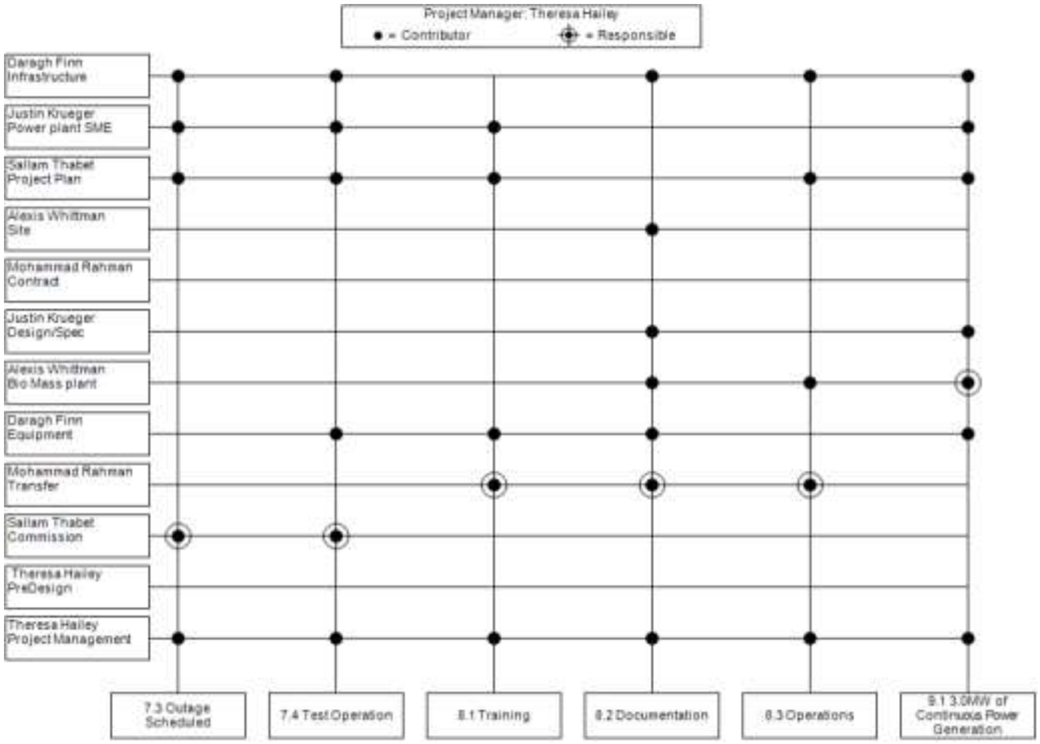
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Mohammad Rahman Contract
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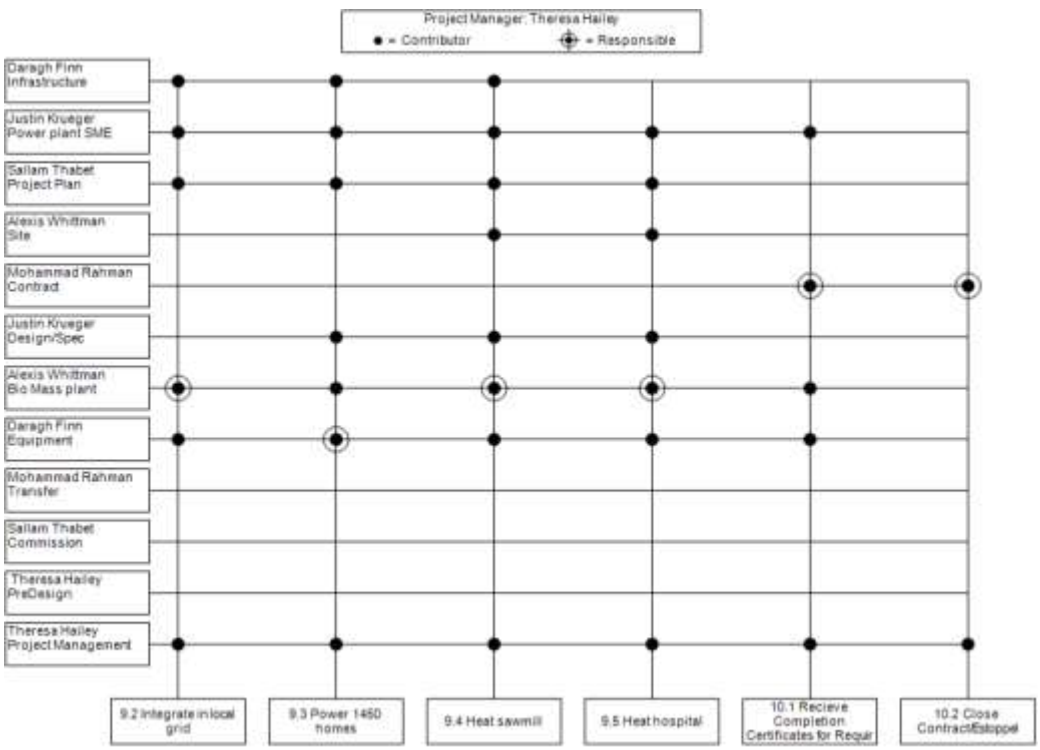
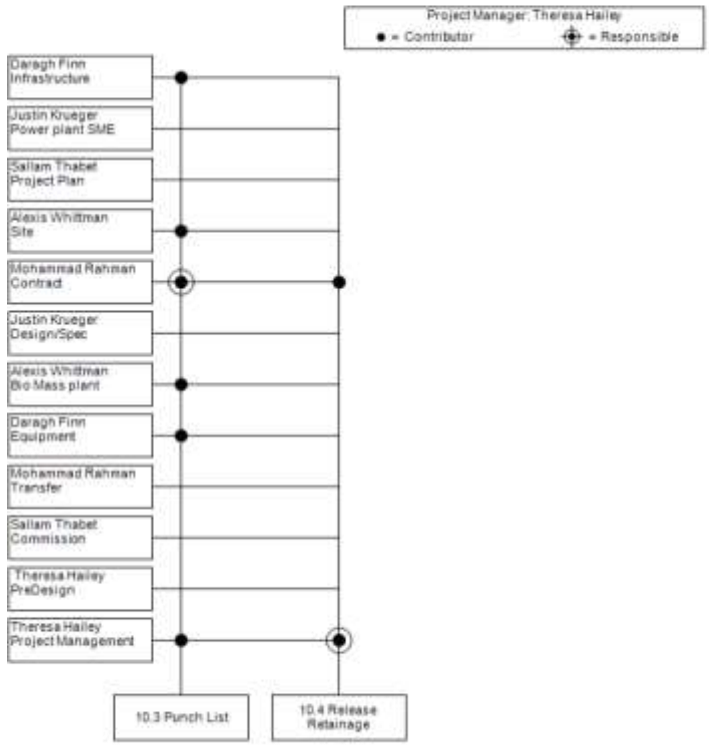
Alexis Whittman Bio Mass plant
Daragh Finn Equipment
Mohammad Rahman Transfer
Sallam Thabet Commission
Theresa Hailey PreDesign
Theresa Hailey Project Management
7.3 Outage Scheduled
7.4 Test Operation
8.1 Training
8.2 Documentation
8.3 Operations
9.1 3.0MW of Continuous Power Generation


Project Manager: Theresa Hailey
● = Contributor
= Responsible
Daragh Finn Infrastructure
Justin Krueger Power plant SME
Sallam Thabet Project Plan
Alexis Whittman Site
Mohammad Rahman Contract
Justin Krueger Design/Spec
Alexis Whittman Bio Mass plant
Daragh Finn Equipment
Mohammad Rahman Transfer
Sallam Thabet Commission
Theresa Hailey PreDesign
Theresa Hailey Project Management
9.2 Integrate in local grid
9.3 Power 1460 homes
9.4 Heat sawmill
9.5 Heat hospital
10.1 Recieve Completion Certificates for Requir
10.2 Close Contract/Estoppel



Project Manager: Theresa Hailey
= Contributor
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Daragh Finn
Infrastructure
Justin Krueger
Power plant SME
Sallam Thabet
Project Plan
Alexis Whittman
Site
Mohammad Rahman
Contract
Justin Krueger
Design/Spec
Alexis Whittman
Bio Mass plant
Daragh Finn
Equipment
Mohammad Rahman
Transfer
Sallam Thabet
Commission
Theresa Hailey
PreDesign
Theresa Hailey
Project Management
10.3 Punch List
10.4 Release Retainage

VII. ISSUES, RISKS, AND ASSUMPTIONS

Number	*Description*	*Assigned to Task #*	*Assigned to Person*
1	District council approval is required to build a biomass power plant –assumed approved prior to project	-	-
2	Site Permits – power generation, EAS/EIS Environmental concerns, species, water, clean air act.	3.0	Alexis Wittman
3	Infrastructure Permits	5.5	Daragh Finn
4	Procurement - Long lead items, making the assumption, that the materials and equipment are readily available, this will not be a concern but in most cases, for the substation and collection system components, breakers, switches, relay panels, and transformers are long lead items	6.0	Daragh Finn
5	Backup generation for outages, possible agreement with existing utility for critical facility (hospital)	5.2	Daragh Finn
6	Scheduling – due to lead times, we have to make a sizeable down payment on the electrical equipment, primarily the power transformer and the turbine generators for the project.	1.6	Sallam Thabet
7	Design (efficiency/geotech) – liquefaction concerns for this area/poor soils, months of surcharge and stabilization needed.	3.0	Alex Wittman
8	Funding/Tax Incentives	1.9	Sallam Thabet

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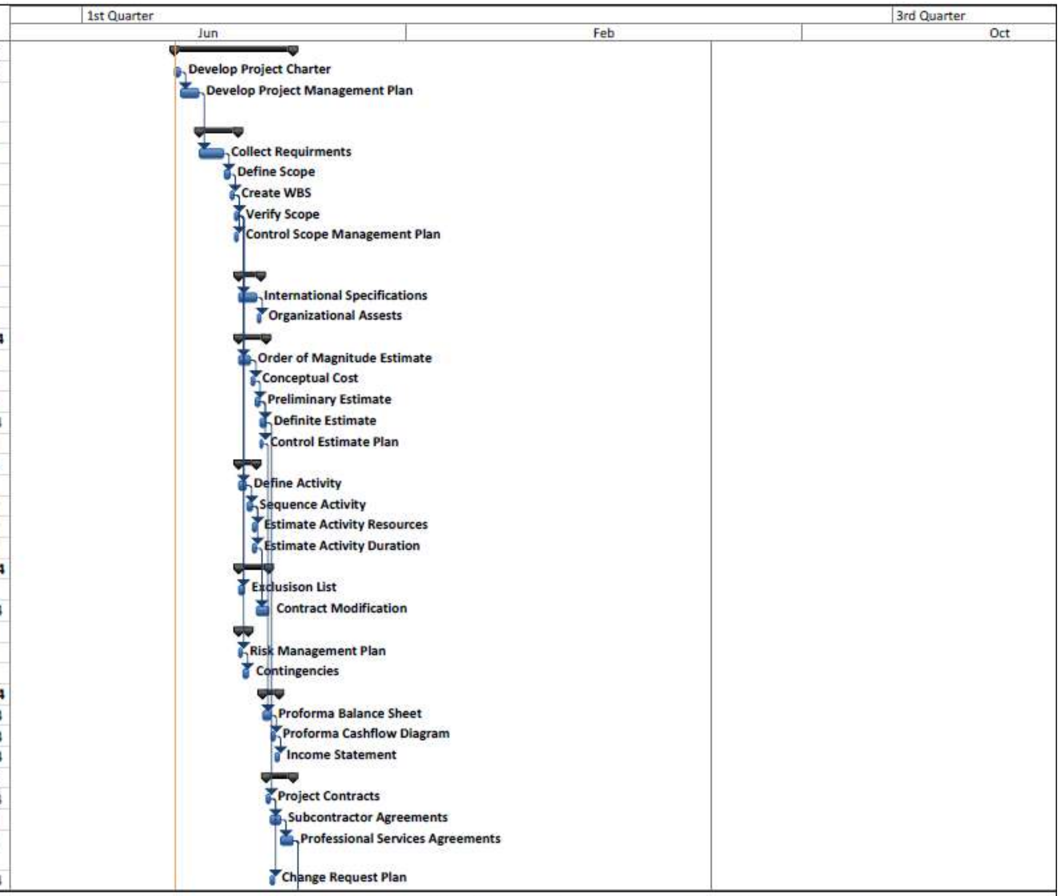
Appendix B: Project Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Project Plan**	**287 days**	**Mon 12/9/13**	**Tue 1/13/15**
2		Develop Project Charter	15 days	Mon 12/9/13	Fri 12/27/13
3		Develop Project Management Plan	45 days	Mon 12/30/13	Fri 2/28/14
4		**Scope**	**95 days**	**Mon 3/3/14**	**Fri 7/11/14**
5		Collect Requirments	60 days	Mon 3/3/14	Fri 5/23/14
6		Define Scope	15 days	Mon 5/26/14	Fri 6/13/14
7		Create WBS	10 days	Mon 6/16/14	Fri 6/27/14
8		Verify Scope	10 days	Mon 6/30/14	Fri 7/11/14
9		Control Scope Management Plan	10 days	Mon 6/30/14	Fri 7/11/14
10		**Performance Standards**	**55 days**	**Mon 7/14/14**	**Fri 9/26/14**
11		International Specifications	45 days	Mon 7/14/14	Fri 9/12/14
12		Organizational Assests	10 days	Mon 9/15/14	Fri 9/26/14
13		**Budget**	**67 days**	**Mon 7/14/14**	**Tue 10/14/14**
14		Order of Magnitude Estimate	30 days	Mon 7/14/14	Fri 8/22/14
15		Conceptual Cost	10 days	Mon 8/25/14	Fri 9/5/14
16		Preliminary Estimate	12 days	Mon 9/8/14	Tue 9/23/14
17		Definite Estimate	15 days	Wed 9/24/14	Tue 10/14/14
18		Control Estimate Plan	7 days	Wed 9/24/14	Thu 10/2/14
19		**Schedule**	**44 days**	**Mon 7/14/14**	**Thu 9/11/14**
20		Define Activity	20 days	Mon 7/14/14	Fri 8/8/14
21		Sequence Activity	14 days	Mon 8/11/14	Thu 8/28/14
22		Estimate Activity Resources	10 days	Fri 8/29/14	Thu 9/11/14
23		Estimate Activity Duration	10 days	Fri 8/29/14	Thu 9/11/14
24		**Exclusions**	**74 days**	**Mon 7/14/14**	**Thu 10/23/14**
25		Exclusion List	15 days	Mon 7/14/14	Fri 8/1/14
26		Contract Modification	30 days	Fri 9/12/14	Thu 10/23/14
27		**Risk Management**	**25 days**	**Mon 7/14/14**	**Fri 8/15/14**
28		Risk Management Plan	10 days	Mon 7/14/14	Fri 7/25/14
29		Contingencies	15 days	Mon 7/28/14	Fri 8/15/14
30		**Funding**	**40 days**	**Fri 10/3/14**	**Thu 11/27/14**
31		Proforma Balance Sheet	20 days	Fri 10/3/14	Thu 10/30/14
32		Proforma Cashflow Diagram	10 days	Fri 10/31/14	Thu 11/13/14
33		Income Statement	10 days	Fri 11/14/14	Thu 11/27/14
34		**Contracts**	**65 days**	**Wed 10/15/14**	**Tue 1/13/15**
35		Project Contracts	10 days	Wed 10/15/14	Tue 10/28/14
36		Subcontractor Agreements	25 days	Wed 10/29/14	Tue 12/2/14
37		Professional Services Agreements	30 days	Wed 12/3/14	Tue 1/13/15
38		Change Request Plan	10 days	Wed 10/29/14	Tue 11/11/14



Project: Biomass Power Plant ETM
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Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress

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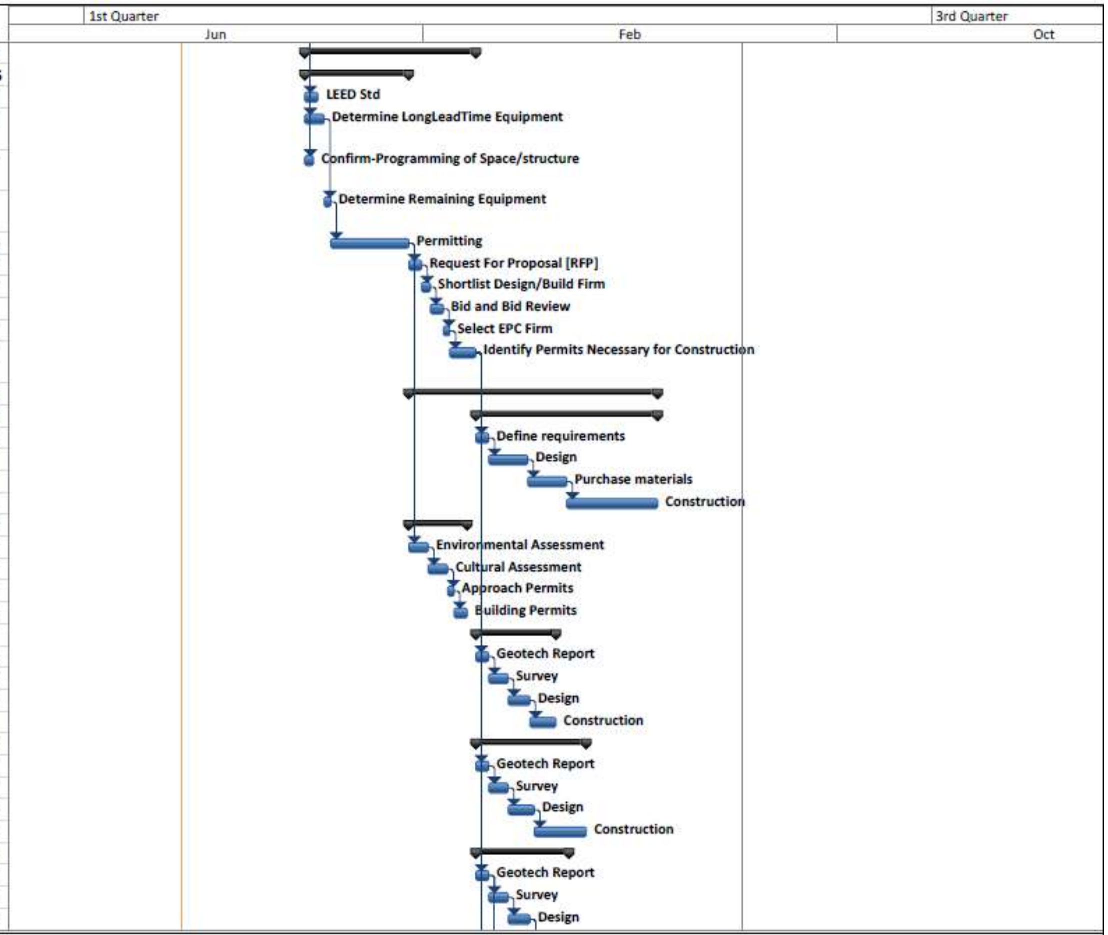
ID	Task Mode	Task Name	Duration	Start	Finish
39		**Pre-Design**	**395 days**	**Wed 1/14/15**	**Tue 7/19/16**
40		**Performance Std**	**240 days**	**Wed 1/14/15**	**Tue 12/15/15**
41		LEED Std	30 days	Wed 1/14/15	Tue 2/24/15
42		Determine LongLeadTime Equipment	45 days	Wed 1/14/15	Tue 3/17/15
43		Confirm-Programming of Space/structure	20 days	Wed 1/14/15	Tue 2/10/15
44		Determine Remaining Equipment	15 days	Wed 3/18/15	Tue 4/7/15
45		Permitting	180 days	Wed 4/8/15	Tue 12/15/15
46		Request For Proposal [RFP]	30 days	Wed 12/16/15	Tue 1/26/16
47		Shortlist Design/Build Firm	20 days	Wed 1/27/16	Tue 2/23/16
48		Bid and Bid Review	30 days	Wed 2/24/16	Tue 4/5/16
49		Select EPC Firm	15 days	Wed 4/6/16	Tue 4/26/16
50		Identify Permits Necessary for Construction	60 days	Wed 4/27/16	Tue 7/19/16
51		**Site**	**575 days**	**Wed 12/16/15**	**Tue 2/27/18**
52		**Stream routing**	**420 days**	**Wed 7/20/16**	**Tue 2/27/18**
53		Define requirements	30 days	Wed 7/20/16	Tue 8/30/16
54		Design	90 days	Wed 8/31/16	Tue 1/3/17
55		Purchase materials	90 days	Wed 1/4/17	Tue 5/9/17
56		Construction	210 days	Wed 5/10/17	Tue 2/27/18
57		**Permitting**	**135 days**	**Wed 12/16/15**	**Tue 6/21/16**
58		Environmental Assessment	45 days	Wed 12/16/15	Tue 2/16/16
59		Cultural Assessment	45 days	Wed 2/17/16	Tue 4/19/16
60		Approach Permits	15 days	Wed 4/20/16	Tue 5/10/16
61		Building Permits	30 days	Wed 5/11/16	Tue 6/21/16
62		**Roadways**	**185 days**	**Wed 7/20/16**	**Tue 4/4/17**
63		Geotech Report	30 days	Wed 7/20/16	Tue 8/30/16
64		Survey	45 days	Wed 8/31/16	Tue 11/1/16
65		Design	50 days	Wed 11/2/16	Tue 1/10/17
66		Construction	60 days	Wed 1/11/17	Tue 4/4/17
67		**Underground tunnel**	**255 days**	**Wed 7/20/16**	**Tue 7/11/17**
68		Geotech Report	30 days	Wed 7/20/16	Tue 8/30/16
69		Survey	45 days	Wed 8/31/16	Tue 11/1/16
70		Design	60 days	Wed 11/2/16	Tue 1/24/17
71		Construction	120 days	Wed 1/25/17	Tue 7/11/17
72		**Site utilities**	**215 days**	**Wed 7/20/16**	**Tue 5/16/17**
73		Geotech Report	30 days	Wed 7/20/16	Tue 8/30/16
74		Survey	45 days	Wed 8/31/16	Tue 11/1/16
75		Design	50 days	Wed 11/2/16	Tue 1/10/17

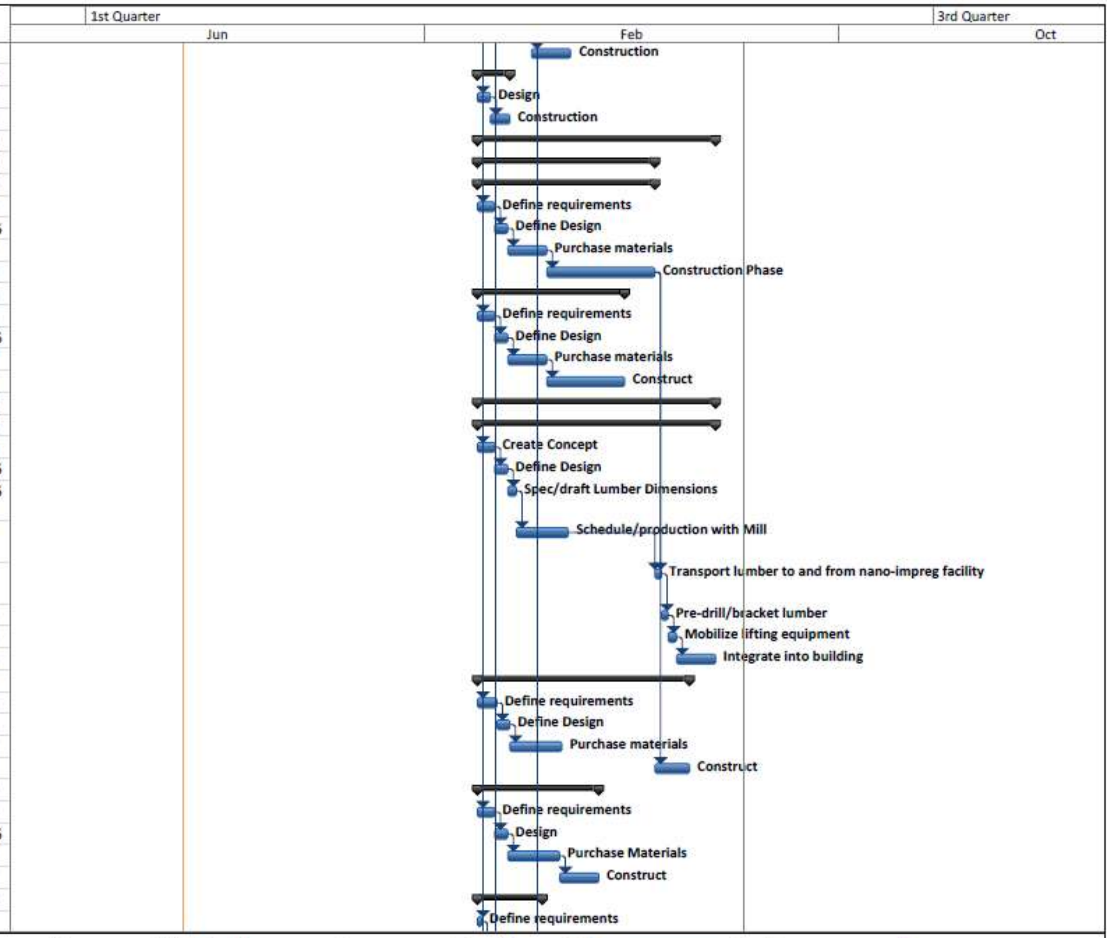


Project: Biomass Power Plant ETM
Date: Tue 12/10/13

Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone		External Milestone		Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			

Page 2

ID	Task Mode	Task Name	Duration	Start	Finish
76		Construction	90 days	Wed 1/11/17	Tue 5/16/17
77		**Landscaping**	**75 days**	**Wed 7/20/16**	**Tue 11/1/16**
78		Design	30 days	Wed 7/20/16	Tue 8/30/16
79		Construction	45 days	Wed 8/31/16	Tue 11/1/16
80		**Structure**	**550 days**	**Wed 7/20/16**	**Tue 8/28/18**
81		**Long Shed**	**410 days**	**Wed 7/20/16**	**Tue 2/13/18**
82		**Loading Dock**	**410 days**	**Wed 7/20/16**	**Tue 2/13/18**
83		Define requirements	40 days	Wed 7/20/16	Tue 9/13/16
84		Define Design	30 days	Wed 9/14/16	Tue 10/25/16
85		Purchase materials	90 days	Wed 10/26/16	Tue 2/28/17
86		Construction Phase	250 days	Wed 3/1/17	Tue 2/13/18
87		**Organic Material Mix area**	**340 days**	**Wed 7/20/16**	**Tue 11/7/17**
88		Define requirements	40 days	Wed 7/20/16	Tue 9/13/16
89		Define Design	30 days	Wed 9/14/16	Tue 10/25/16
90		Purchase materials	90 days	Wed 10/26/16	Tue 2/28/17
91		Construct	180 days	Wed 3/1/17	Tue 11/7/17
92		**Glass Tube**	**550 days**	**Wed 7/20/16**	**Tue 8/28/18**
93		**Country Fence circular scree**	**550 days**	**Wed 7/20/16**	**Tue 8/28/18**
94		Create Concept	40 days	Wed 7/20/16	Tue 9/13/16
95		Define Design	30 days	Wed 9/14/16	Tue 10/25/16
96		Spec/draft Lumber Dimensions	20 days	Wed 10/26/16	Tue 11/22/16
97		Schedule/production with Mill	120 days	Wed 11/23/16	Tue 5/9/17
98		Transport lumber to and from nano-impreg facility	15 days	Wed 2/14/18	Tue 3/6/18
99		Pre-drill/bracket lumber	15 days	Wed 3/7/18	Tue 3/27/18
100		Mobilize lifting equipment	20 days	Wed 3/28/18	Tue 4/24/18
101		Integrate into building	90 days	Wed 4/25/18	Tue 8/28/18
102		**Offices**	**490 days**	**Wed 7/20/16**	**Tue 6/5/18**
103		Define requirements	45 days	Wed 7/20/16	Tue 9/20/16
104		Define Design	30 days	Wed 9/21/16	Tue 11/1/16
105		Purchase materials	120 days	Wed 11/2/16	Tue 4/18/17
106		Construct	80 days	Wed 2/14/18	Tue 6/5/18
107		**Roof**	**280 days**	**Wed 7/20/16**	**Tue 8/15/17**
108		Define requirements	40 days	Wed 7/20/16	Tue 9/13/16
109		Design	30 days	Wed 9/14/16	Tue 10/25/16
110		Purchase Materials	120 days	Wed 10/26/16	Tue 4/11/17
111		Construct	90 days	Wed 4/12/17	Tue 8/15/17
112		**Exterior stair**	**150 days**	**Wed 7/20/16**	**Tue 2/14/17**
113		Define requirements	10 days	Wed 7/20/16	Tue 8/2/16



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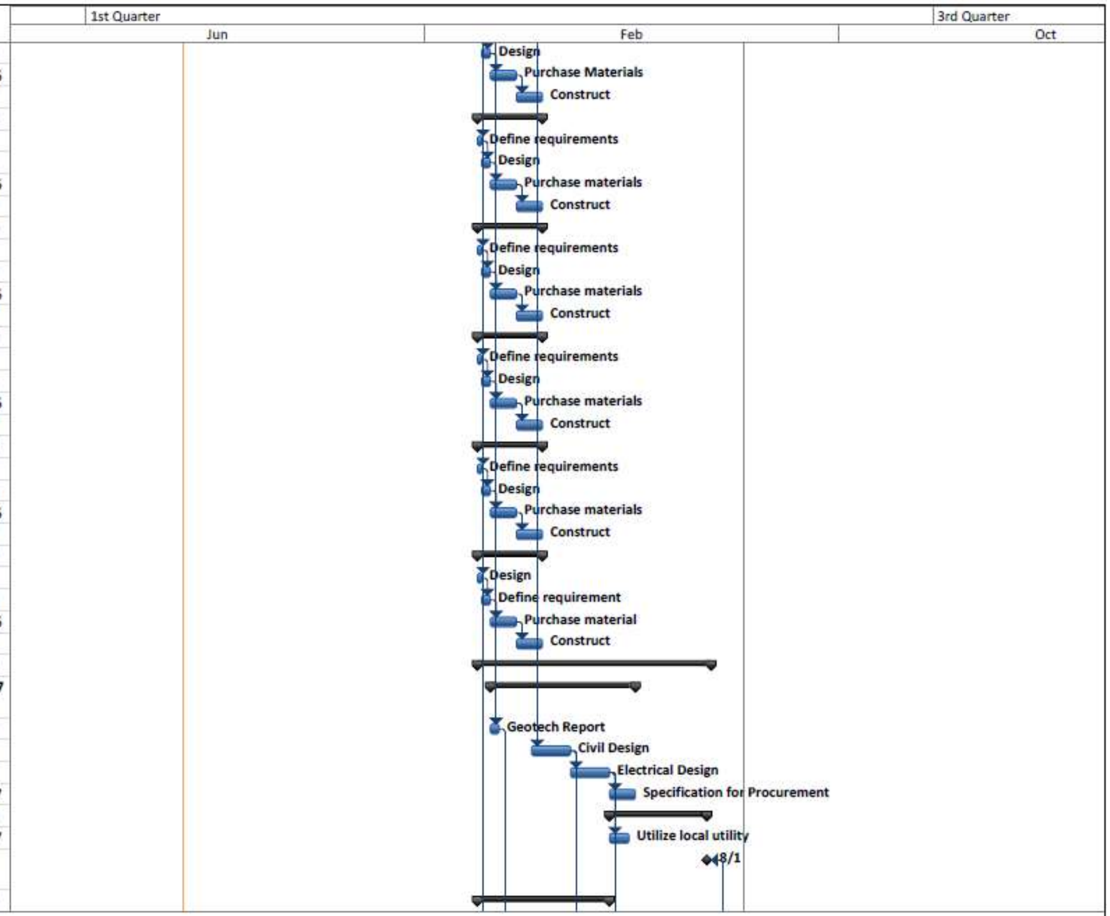
Task		Project Summary		Inactive Milestone		Manual Summary Rollup	
Split		External Tasks		Inactive Summary		Manual Summary	
Milestone		External Milestone		Manual Task		Start-only	
Summary		Inactive Task		Duration-only		Finish-only	
						Deadline	
						Progress	

ID	Task Mode	Task Name	Duration	Start	Finish
114		Design	20 days	Wed 8/3/16	Tue 8/30/16
115		Purchase Materials	60 days	Wed 8/31/16	Tue 11/22/16
116		Construct	60 days	Wed 11/23/16	Tue 2/14/17
117		**East terrace**	**150 days**	**Wed 7/20/16**	**Tue 2/14/17**
118		Define requirements	10 days	Wed 7/20/16	Tue 8/2/16
119		Design	20 days	Wed 8/3/16	Tue 8/30/16
120		Purchase materials	60 days	Wed 8/31/16	Tue 11/22/16
121		Construct	60 days	Wed 11/23/16	Tue 2/14/17
122		**Fish pools**	**150 days**	**Wed 7/20/16**	**Tue 2/14/17**
123		Define requirements	10 days	Wed 7/20/16	Tue 8/2/16
124		Design	20 days	Wed 8/3/16	Tue 8/30/16
125		Purchase materials	60 days	Wed 8/31/16	Tue 11/22/16
126		Construct	60 days	Wed 11/23/16	Tue 2/14/17
127		**Restrooms**	**150 days**	**Wed 7/20/16**	**Tue 2/14/17**
128		Define requirements	10 days	Wed 7/20/16	Tue 8/2/16
129		Design	20 days	Wed 8/3/16	Tue 8/30/16
130		Purchase materials	60 days	Wed 8/31/16	Tue 11/22/16
131		Construct	60 days	Wed 11/23/16	Tue 2/14/17
132		**Fire safety system**	**150 days**	**Wed 7/20/16**	**Tue 2/14/17**
133		Define requirements	10 days	Wed 7/20/16	Tue 8/2/16
134		Design	20 days	Wed 8/3/16	Tue 8/30/16
135		Purchase materials	60 days	Wed 8/31/16	Tue 11/22/16
136		Construct	60 days	Wed 11/23/16	Tue 2/14/17
137		**Generator room**	**150 days**	**Wed 7/20/16**	**Tue 2/14/17**
138		Design	10 days	Wed 7/20/16	Tue 8/2/16
139		Define requirement	20 days	Wed 8/3/16	Tue 8/30/16
140		Purchase material	60 days	Wed 8/31/16	Tue 11/22/16
141		Construct	60 days	Wed 11/23/16	Tue 2/14/17
142		**Infrastructure**	**540 days?**	**Wed 7/20/16**	**Tue 8/14/18**
143		**Collection/Transmission Power line for Distribution to**	**335 days**	**Wed 8/31/16**	**Tue 12/12/17**
144		Geotech Report	20 days	Wed 8/31/16	Tue 9/27/16
145		Civil Design	90 days	Wed 1/11/17	Tue 5/16/17
146		Electrical Design	90 days	Wed 5/17/17	Tue 9/19/17
147		Specification for Procuremen	60 days	Wed 9/20/17	Tue 12/12/17
148		**Temporary Power Supply**	**225 days?**	**Wed 9/20/17**	**Wed 8/1/18**
149		Utilize local utility	45 days	Wed 9/20/17	Tue 11/21/17
150		Use Generators for Station Service	0 days?	Wed 8/1/18	Wed 8/1/18
151		**Water Source**	**305 days**	**Wed 7/20/16**	**Tue 9/19/17**



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Split		External Tasks		Inactive Summary		Manual Summary	
Milestone		External Milestone		Manual Task		Start-only	
Summary		Inactive Task		Duration-only		Finish-only	
Deadline		Progress					

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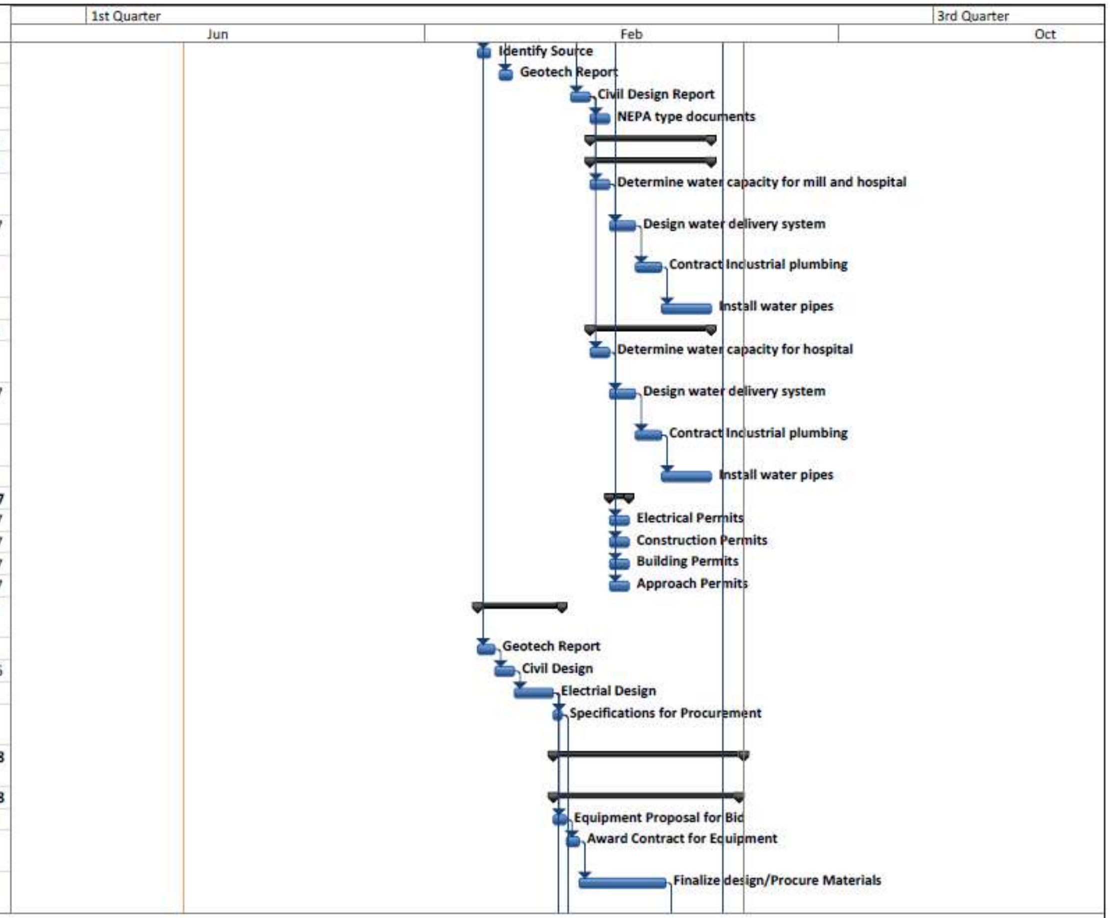
ID	Task Mode	Task Name	Duration	Start	Finish
152		Identify Source	30 days	Wed 7/20/16	Tue 8/30/16
153		Geotech Report	30 days	Wed 9/28/16	Tue 11/8/16
154		Civil Design Report	45 days	Wed 5/17/17	Tue 7/18/17
155		NEPA type documents	45 days	Wed 7/19/17	Tue 9/19/17
156		**District Heating Network**	**280 days**	**Wed 7/19/17**	**Tue 8/14/18**
157		**Heating to Mill**	**280 days**	**Wed 7/19/17**	**Tue 8/14/18**
158		Determine water capacity for mill and hospital	45 days	Wed 7/19/17	Tue 9/19/17
159		Design water delivery system	60 days	Wed 9/20/17	Tue 12/12/17
160		Contract Industrial plumbing	60 days	Wed 12/13/17	Tue 3/6/18
161		Install water pipes	115 days	Wed 3/7/18	Tue 8/14/18
162		**Heating to Hospital**	**280 days**	**Wed 7/19/17**	**Tue 8/14/18**
163		Determine water capacity for hospital	45 days	Wed 7/19/17	Tue 9/19/17
164		Design water delivery system	60 days	Wed 9/20/17	Tue 12/12/17
165		Contract Industrial plumbing	60 days	Wed 12/13/17	Tue 3/6/18
166		Install water pipes	115 days	Wed 3/7/18	Tue 8/14/18
167		**Permits Construction**	**45 days**	**Wed 9/20/17**	**Tue 11/21/17**
168		Electrical Permits	45 days	Wed 9/20/17	Tue 11/21/17
169		Construction Permits	45 days	Wed 9/20/17	Tue 11/21/17
170		Building Permits	45 days	Wed 9/20/17	Tue 11/21/17
171		Approach Permits	45 days	Wed 9/20/17	Tue 11/21/17
172		**Substation Design for Distribution**	**195 days**	**Wed 7/20/16**	**Tue 4/18/17**
173		Geotech Report	40 days	Wed 7/20/16	Tue 9/13/16
174		Civil Design	45 days	Wed 9/14/16	Tue 11/15/16
175		Electrial Design	90 days	Wed 11/16/16	Tue 3/21/17
176		Specifications for Procurement	20 days	Wed 3/22/17	Tue 4/18/17
177		**Procurement of Necessary Equipment**	**440 days**	**Wed 3/22/17**	**Tue 11/27/18**
178		**Combustion Chamber**	**430 days**	**Wed 3/22/17**	**Tue 11/13/18**
179		Equipment Proposal for Bid	30 days	Wed 3/22/17	Tue 5/2/17
180		Award Contract for Equipment	30 days	Wed 5/3/17	Tue 6/13/17
181		Finalize design/Procure Materials	200 days	Wed 6/14/17	Tue 3/20/18



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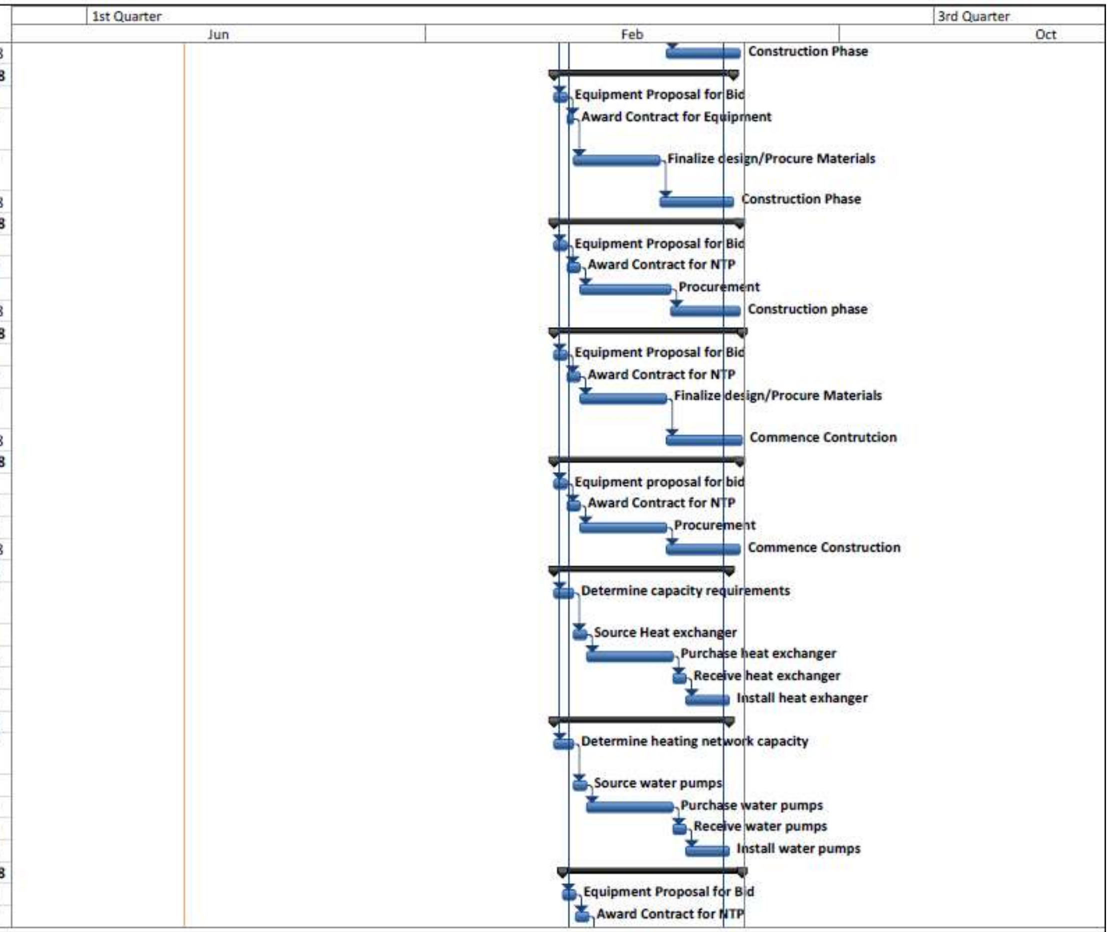
Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone	◆	External Milestone	◆	Manual Task		Start-only			
Summary		Inactive Task		Duration-only		Finish-only			

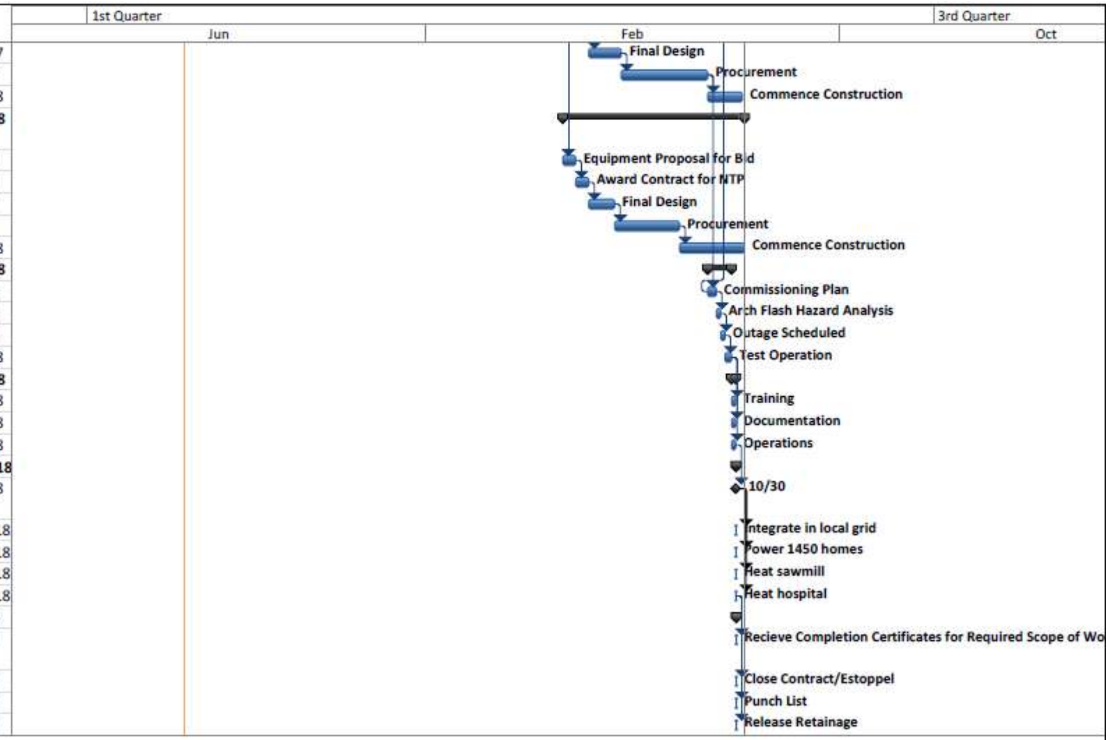
ID	Task Mode	Task Name	Duration	Start	Finish
182		Construction Phase	170 days	Wed 3/21/18	Tue 11/13/18
183		**ORC Machine**	**415 days**	**Wed 3/22/17**	**Tue 10/23/18**
184		Equipment Proposal for Bid	30 days	Wed 3/22/17	Tue 5/2/17
185		Award Contract for Equipment	15 days	Wed 5/3/17	Tue 5/23/17
186		Finalize design/Procure Materials	200 days	Wed 5/24/17	Tue 2/27/18
187		Construction Phase	170 days	Wed 2/28/18	Tue 10/23/18
188		**Silicon Oil**	**430 days**	**Wed 3/22/17**	**Tue 11/13/18**
189		Equipment Proposal for Bid	30 days	Wed 3/22/17	Tue 5/2/17
190		Award Contract for NTP	30 days	Wed 5/3/17	Tue 6/13/17
191		Procurement	210 days	Wed 6/14/17	Tue 4/3/18
192		Construction phase	160 days	Wed 4/4/18	Tue 11/13/18
193		**Turbine**	**435 days**	**Wed 3/22/17**	**Tue 11/20/18**
194		Equipment Proposal for Bid	30 days	Wed 3/22/17	Tue 5/2/17
195		Award Contract for NTP	30 days	Wed 5/3/17	Tue 6/13/17
196		Finalize design/Procure Materials	200 days	Wed 6/14/17	Tue 3/20/18
197		Commence Contrutcion	175 days	Wed 3/21/18	Tue 11/20/18
198		**Generator**	**430 days**	**Wed 3/22/17**	**Tue 11/13/18**
199		Equipment proposal for bid	30 days	Wed 3/22/17	Tue 5/2/17
200		Award Contract for NTP	30 days	Wed 5/3/17	Tue 6/13/17
201		Procurement	200 days	Wed 6/14/17	Tue 3/20/18
202		Commence Construction	170 days	Wed 3/21/18	Tue 11/13/18
203		**Heat Exchanger**	**405 days**	**Wed 3/22/17**	**Tue 10/9/18**
204		Determine capacity requirements	45 days	Wed 3/22/17	Tue 5/23/17
205		Source Heat exchanger	30 days	Wed 5/24/17	Tue 7/4/17
206		Purchase heat exchanger	200 days	Wed 7/5/17	Tue 4/10/18
207		Receive heat exchanger	30 days	Wed 4/11/18	Tue 5/22/18
208		Install heat exhanger	100 days	Wed 5/23/18	Tue 10/9/18
209		**Water Pump**	**405 days**	**Wed 3/22/17**	**Tue 10/9/18**
210		Determine heating network capacity	45 days	Wed 3/22/17	Tue 5/23/17
211		Source water pumps	30 days	Wed 5/24/17	Tue 7/4/17
212		Purchase water pumps	200 days	Wed 7/5/17	Tue 4/10/18
213		Receive water pumps	30 days	Wed 4/11/18	Tue 5/22/18
214		Install water pumps	100 days	Wed 5/23/18	Tue 10/9/18
215		**Substation Equipment**	**415 days**	**Wed 4/19/17**	**Tue 11/20/18**
216		Equipment Proposal for Bid	30 days	Wed 4/19/17	Tue 5/30/17
217		Award Contract for NTP	30 days	Wed 5/31/17	Tue 7/11/17



Project: Biomass Power Plant ETM
Date: Tue 12/10/13

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

ID	Task Mode	Task Name	Duration	Start	Finish
218		Final Design	75 days	Wed 7/12/17	Tue 10/24/17
219		Procurement	200 days	Wed 10/25/17	Tue 7/31/18
220		Commence Construction	80 days	Wed 8/1/18	Tue 11/20/18
221		**Collection/Transmission Power Line**	**420 days**	**Wed 4/19/17**	**Tue 11/27/18**
222		Equipment Proposal for Bid	30 days	Wed 4/19/17	Tue 5/30/17
223		Award Contract for NTP	30 days	Wed 5/31/17	Tue 7/11/17
224		Final Design	60 days	Wed 7/12/17	Tue 10/3/17
225		Procurement	150 days	Wed 10/4/17	Tue 5/1/18
226		Commence Construction	150 days	Wed 5/2/18	Tue 11/27/18
227		**Commission**	**55 days**	**Wed 8/1/18**	**Tue 10/16/18**
228		Commissioning Plan	20 days	Wed 8/1/18	Tue 8/28/18
229		Arch Flash Hazard Analysis	10 days	Wed 8/29/18	Tue 9/11/18
230		Outage Scheduled	10 days	Wed 9/12/18	Tue 9/25/18
231		Test Operation	15 days	Wed 9/26/18	Tue 10/16/18
232		**Transfer**	**10 days**	**Wed 10/17/18**	**Tue 10/30/18**
233		Training	10 days	Wed 10/17/18	Tue 10/30/18
234		Documentation	10 days	Wed 10/17/18	Tue 10/30/18
235		Operations	10 days	Wed 10/17/18	Tue 10/30/18
236		**Bio Mass Plant**	**1 day**	**Tue 10/30/18**	**Wed 10/31/18**
237		3.0MW of Continuous Power Generation	0 days	Tue 10/30/18	Tue 10/30/18
238		Integrate in local grid	1 day	Wed 10/31/18	Wed 10/31/18
239		Power 1450 homes	1 day	Wed 10/31/18	Wed 10/31/18
240		Heat sawmill	1 day	Wed 10/31/18	Wed 10/31/18
241		Heat hospital	1 day	Wed 10/31/18	Wed 10/31/18
242		**Contract**	**1 day**	**Thu 11/1/18**	**Thu 11/1/18**
243		Recieve Completion Certificates for Required Scope	1 day	Thu 11/1/18	Thu 11/1/18
244		Close Contract/Estoppel	1 day	Thu 11/1/18	Thu 11/1/18
245		Punch List	1 day	Thu 11/1/18	Thu 11/1/18
246		Release Retainage	1 day	Thu 11/1/18	Thu 11/1/18



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Appendix C: Project Costs

Source of Project Cost

Shilling Bio-mass Project

	PROJECT TASKS	LABOR HOURS	LABOR COST ($)	TRAVEL COST ($)	Overhead (20%)	TOTAL PER TASK
PROJECT DESIGN	1.0 Project Planning	984.0	$78,720.00	$20,000.00	$15,744.00	$114,464.00
	2.0 Predesign (RFP, Sht List, Bid, Selectic	2,520.0	$201,600.00	$17,000.00	$40,328.00	$258,928.00
	3.0 Site Design	2,400.0	$192,000.00	$10,000.00	$38,400.00	$240,401.00
	4.0 Structures	2,720.0	$217,600.00	$20,000.00	$43,520.00	$281,121.00
	5.0 Infrastructure	2,569.0	$205,500.00	$10,000.00	$41,104.00	$256,605.00
	Subtotal	**11,193.0**	**$895,420.00**	**$77,000.00**	**$179,096.00**	**$1,162,714.00**
PROJECT DEVELOPMENT	6.0 Combustion, Turbines, Generators	2,850.0	$228,000.00	$15,000.00	$45,600.00	$288,600.00
	7.0 Commissioning, Arch Hazard, Training	1,000.0	$80,000.00	$20,000.00	$16,000.00	$116,000.00
	8.0 Training, Documentation, Operations	750.0	$60,000.00	$20,000.00	$12,000.00	$92,000.00
	9.0 Power Generation, Integration	4,032.0	$322,560.00	$20,000.00	$64,512.00	$407,072.00
	10.0 Completion, Punch Lists, Release	820.0	$65,600.00	$20,000.00	$13,120.00	$98,720.00
	Subtotal	**9,452.0**	**$756,160.00**	**$95,000.00**	**$151,232.00**	**$2,023,688.00**
OTHER COST	Permits	0.0	$0.00	$0.00	$0.00	$42,000.00
	Subtotal	**0.0**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
	Subtotals	**20645.0**	**$1,651,580.00**	**$172,000.00**	**$330,328.00**	**$2,153,908.00**
	Risk (Contingency)	2065.0	$165,200.00	$17,200.00	$33,040.00	**$215,391.00**
	Total (Scheduled)	**22710.0**	**$1,816,800.00**	**$189,200.00**	**$363,360.00**	**$2,369,299.00**

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Project Cost Estimating

Developing estimates of project cost is one of the most important functions of project planning and management. Developing financial data gives the project owner a basis for going forward. Just as the project gains definition, so the estimate becomes more defined as the project develops. *It is a process, not a product.* It has to satisfy the owner's desired goals for project development. Construction project costs are unique in every case, unlike a product being developed for market for example, because each construction project is typically unique in its quality, design, siting, materials and construction methodologies. Furthermore, these costs are always changing with market conditions.

Predicting the quality of the project work during early planning stages can also be difficult as determinations are made on personal experience and expert knowledge -- which can vary from project team to project team. Quality can be defined simply as 'fitness-for-use' or satisfying the customer's needs [1]. In the case of our project, Robert Shilling has determined a very high level of quality by requesting both a high-end architectural/engineering group and conformance with LEED standards. LEED is a accreditation of buildings based on their energy use, sustainability and conformance with predetermined goals set by the U.S. Green Building Council. This high level of performance will add both to design/engineering costs as well as construction cost.

The lack of detailed information related to the architectural and engineering works prevents the detailed measurement of quantities of materials, labor, and plant. and the large number reasonable assumptions that have to be made in order to arrive at an appropriate solution.[2]

In our project, The Shilling Biomass Power Plant, we estimate the design and engineering costs (project cost) for ten aspects of design development based on our Work Breakdown Structure (WBS):

- Pre-Design (Requests for Proposals, Short Lists of Bidders, Bid Selection, etc)
- Permitting
- Site Design
- Structures
- Infrastructure
- Equipment
- Commissioning, testing
- Training Documentation
- Power Generation / Integration
- Completion, Punch-lists, Release

We start by estimating the 'man-days' of work. These are our 'best-guess' of the time involved in defining the facility and engineering program requirements, designing the project site, building and engineering units, the permitting and approval process, through to final commissioning and turning over operations to Shilling staff.

Our assumption is that the average pay rate for these design professionals is set at $80.00 [USD]. Some tasks can be handed by junior level engineers with oversight by higher paid professionals. We developed the total hours for each section of the budget, applied the $80/hr multiplier to arrive at the design cost. We also applied an overhead figure of 20% to account for office expenses. Travel is added as a cost item based on our assumption that we would require site visits in order to accomplish a number of the tasks such as information gathering, permitting/approval, design presentations, construction oversight, and transfer of knowledge or training after commissioning.

While risk assessment involves far more than just applying a multiplier for cost and time overruns, we did apply a 10% figure to cover additional time/money for the project. This assumes that the project can be described accurately through the contract documents and specifications, and will not require extensive redesign based on site conditions or construction issues later on.

The next stage of cost estimating would be to develop the construction cost estimates. Beyond a ball-park figure simply based on raw square footage calculations, these would require at the very least, schematic design drawings from architecture and engineering groups. Then as contract documents are developed (the working drawings) additional estimates can be compiled from take-off measurement where square footage quantities of each building material can accurately be assessed based on costing data for the particular geographic region of the project site. Finally, preliminary bids are taken from contractors, and true cost figures can be measured against those earlier estimates. If these bids come in too high, the design team may find it necessary to do value engineering - or the evaluation of what 'cuts' to the design can be made to make it fall within early budget figures.

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