PROJECT MANAGEMENT STRATEGY FOR UTILITY SCALE SOLAR

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Executive Summary

The solar industry is a young and booming industry. Therefore, there are many new and lucrative career fields and other sub-disciplines within the project management array. The idea behind this guide is for the new or aspiring solar project managers to read this guide and have an immediate understanding of the field they will be working in. The guide is not meant to be 500 pages of data, it is meant to explain everything needed to know in a quick and easy to digest way to get started in the position. There are multiple books about project management on the market, including the Project Management Book of Knowledge and PMP study guides, what sets this apart is not only the specificity of utility scale solar, but the strategies which will be introduced to the reader to help them achieve success on their own projects.[1] Employers demand we must meet both budget and schedule in project management. This guide will help the reader understand how to do exactly that in an easy-to-understand strategic approach to project management. Also added is the concept of the big four, which included Quality and safety along with budget and schedule for a well-rounded approach.

The chapters are straight forward, advising the reader on each sub discipline required for the successful completion of a project. I start with an introduction to the solar industry and how it works, and finish with testing the specific strategy path outlined and results. This guide is meant to be an easy read with a mix of technical tools and examples making it easily digestible for somebody who has no idea what they are getting into. The tools introduced in this paper are the stakeholder's communications plan, Team Charter, Strategy Cascade, SMART goals, SWOT, TOWS, risk register, and Porter's Five Forces model. The reader is also introduced to other strategies, like budgeting, scheduling, and contracting. Practical examples of safety and QA/QC plans are also added for the reader. A fake project was used with common real-world issues for all examples and tools, keeping the same project consistent during my examples so the reader could easily follow along with the logic.

[1] Project Management Institute. (2017). *A guide to the Project Management Body of Knowledge (PMBOK guide)* (6th ed.). Project Management Institute.

Every tool introduced throughout this guide is meant to help the reader understand and evaluate a certain aspect of a project and help guide the decision-making process. As the project manager, they will be expected to make the decisions and be held accountable for them. These tools will help them understand the "why and how" a decision is made and help communicate it to others. The analysis tools should be completed not only by the reader, but with their execution team involved, with every Subject Matter Expert (SME) adding their input and value to the process. As the Project Manager (PM), they will need to ensure all SMEs are communicating and on the same page and using these tools will help to guide some of their discussion.

Simply following the "within budget, and on schedule" methodology is an antiquated mindset when approaching a project. Think of not only the project but all the stakeholder's needs. For instance, is this "clean energy" project as sustainable as it can be? Or are there better approaches? Is it a project built with poor quality in the name of value engineering? Was this project built on time and under budget, but with such a poor safety record the client won't work with you again? Or is it a quality product you can stand behind to secure future projects with prospective clients down the line? Solar is a small industry, reputation matters here. This guide aims to set the reader up not only for completion, but for the future project pipeline that will inevitably come their way.

Chapter 1

How Utility Scale Solar Works

Utility scale solar provides clean and reliable electricity to the grid with a fixed price. It is one of the premier options to reduce carbon emissions. Utility scale solar power plants primarily utilize photovoltaic (PV) solar modules. There are key components which need to be understood by the project manager of the facility. Piles or posts are large beams supporting the weight of the racking system. The racking system is what the module itself is attached to. These racking systems are either fixed in position or move throughout the day to track with the sun. The modules themselves are fed to either a combiner box or directly to an inverter through DC cabling. The inverter converts the electricity to AC and sends it to a distribution transformer which steps it up and sends it to the utility distribution lines via medium voltage cable. The distribution lines then send it to a nearby substation which again steps the power up for placement onto a transmission line. There are some nuances here and there, which will be later covered in more detail but it's really that simple. By understanding the basic movement of the power, it will provide clarity on the "why" certain sequencing is done throughout the construction of the project.

Regulating Solar Generation Facilities

The facility itself is large and is sold to wholesale utility buyers and regulated by the Federal Energy Regulatory Commission (FERC).[2] FERC oversees the North American Electric Reliability Corporation (NERC), who is responsible for minimizing risks to the grid. They develop and enforce reliability standards as well as inspect the technical specifications of each project on the grid.[3]

[2] *Utility-Scale Solar*. Solar Energy Industries Association. https://www.seia.org/initiatives/utility-scale-solar-power

[3] *About NERC*. North American Electric Reliability Corporation (NERC). https://www.nerc.com/AboutNERC/Pages/default.aspx

Regional transmission organizations (RTO) coordinated the wholesale electricity market. One example is PJM, who operates in parts of North Carolina and stretches to Michigan and Illinois.[4] Other RTOs are NYISO, ISO-NE, MISO, SPP, CAISO, and ERCOT.[5] To develop a project, plans must be submitted to the corresponding RTO for approval. The RTO's will conduct a feasibility and system impact study along with others to ensure the grid can handle the solar generating facility and the deliverability under peak load conditions. They also identify what transmission upgrades would be needed and the cost to do so which would roll over to the developer.[6]

Power purchase agreements are financial agreements between the developer who sells the power and a customer with a fixed rate. This rate is usually lower than a local utility's rate. The customer receives a lower price for power while the developer receives income from the sale of electricity as well as any incentives which may come from solar at the time. PPA's usually last from 10 to 25 years.[7]

We have spoken about FERC, NERC, and the RTOs, but there is one more very important element to discuss, and that's the Authority Having Jurisdiction (AHJ). This is usually at the town or county level, depending on which state you are building the project in. They will be responsible for issuing your construction permits. From environmental, to electrical, and anything necessary in between. There are certain permits which stand out from this, such as a department of transportation permit or Army Corp of Engineer's permit if needed, but for the

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[4] *Who We Are*. (n.d.). Retrieved April 10, 2022, from https://www.pjm.com/about-pjm/who-we-are.aspx

[5] *RTOs and ISOs*. (2022). FERC. https://www.ferc.gov/power-sales-and-markets/rtos-and-isos

[6] Connecting to the grid FAQ's. (n.d.). *PJM Learning Center*. Retrieved April 10, 2022, from https://learn.pjm.com/three priorities/planning-for-the-future/connecting-grid

[7] *Solar Power Purchase Agreements*. (n.d.). Solar Energy Industries Association. https://www.seia.org/research-resources/solar-power-purchase-agreements

most part, the AHJ will be your main permitting authority. They will also conduct environmental and electrical inspections throughout the life cycle of your project and closing out your permit with the AHJ can be one of the longest and toughest processes, especially if you are building in an area of considerable environmental impact, such as Virginia. States like Virginia and New York put a heavy emphasis on environmental protections, mitigations, and site stabilization which provide an additional layer of complications during construction and close-out opposed to projects in the desert or states with less stringent environmental standards.

Chapter 2

The Project Manager's Role and Strategies to Start a Project

There are two main terms you need to understand the difference between before discussing the project manager's role, project, and portfolio. A project is self-explanatory, a portfolio is a grouping of projects usually tied to the same financial structure. If there are 4 projects being built and sold together as a package, that is a portfolio. If you, as a project manager (PM) are working on three projects, but they are not tied to a specific account, you are not working on a portfolio, you just have three separate projects. If you are working on three projects in a three-project portfolio, congratulations, you're a portfolio manager. Usually this is not the case, and a portfolio will have multiple PM's.

Rarely will a PM be the direct supervisor of an individual, this will usually fall to other groups of said company. Procurement Specialists will work for Procurement, Construction staff will work for Construction, sometimes a PM will have an Assistant PM or a related title, but that will be the extent of it. Instead, think of the project itself as your employee. It needs to function properly, on time and under budget, if something threatens to derail the project, those issues need to be identified by the PM. Contractor and subcontractor management is also a critical area in which the PM will operate.

If there are too many people assigned to the project it is your task as the PM, and the person accounting for the budget, to message the overage and ensure the budget and schedule stay on track. Sometimes this is a fine line to walk, and a balance needs to occur, but generally, if the quality of the construction has been good, the contracts are strong, the schedule was built accurately, and there are no major safety violations causing a shutdown, the budget will fall in line. That's assuming of course, the budget was built as detailed and thorough as possible. Schedule and budget may seem easy to manage on the surface, but there's a lot of coordination which needs to occur. Communication is key in this role. The PM is not the

engineer, procurement specialist, construction expert, or even the developer. You are an expert in nothing but the project itself. It is your job to get the technical experts in the same room and talking to each other about resolutions or paths forward. Additionally, it is your job to message when equipment is needed on the project. If the equipment is not delivered due to your lack of communication or misunderstanding the schedule, you are responsible for that schedule slip. This slip could cause a delay of work change order from your subcontract and having to rearrange sequencing which requires a redesign of the schedule. Just one oversight could cause a snowball effect negatively impacting the project. Sometimes being a PM feels like fighting fires and tackling emergencies on a constant basis. It is not an easy career, but it is rewarding.

The Big Four (Budget, Schedule, Quality, and Safety)

Every company has one goal, to make money. The budget is king on the project. Not understanding the budget is a critical error for any PM. It should also be understood what affects the budget. Keeping the schedule, quality, and safety tight will keep the budget in line. If there's a slip in any one of these, they risk affecting others. The easiest example would be for the quality of the work to be so bad, that significant rework needs to occur, affecting not only the schedule, but the budget. Similarly, having to shut down the project due to a safety incident, will affect your schedule. These four items are the foundations for your project and are closely related.

Another example, the Module Installer was already a few days behind due to weather delays. A safety incident occurred which resulted in injury and time off of one of their personnel. As a result, another couple of hours were lost due to a safety stand down, this is when the project is shut down to discuss the incident with the project staff. As the PM you don't have the proper time to react because you are communicating the incident as well as all other requested information from all stakeholders who need to know. A safety incident can result in what is known as a "recordable." A recordable, is one of the major items when evaluating a company for a project. If their safety record is bad, from too many recordables, then they have pretty much eliminated themselves from future contracts and opportunities. We will visit this more in

the chapter about safety. Now you need to worry about getting back on schedule, which probably means overtime, or pushing the crews to work faster to catch up. Working overtime leads to exhaustion and fatigue, which leads to complacency, which once again leads to more safety incidents. Working either overtime or pushing the crews to work harder to catch up, leads to sloppy quality in the build. Which leads to re-work, which leads to even further loss in schedule which ultimately effects the budget.

PM Strategies

A great PM will understand the project's needs, risks, and constraints. Sometimes these are not obvious or even known until it's too late. There are, however, certain initial analysis which can help expose these items and ensure success including strategy leveling, team charter completion, stakeholder understanding, and performance of a strategy cascade. I will lead this discussion with the levels of strategy. This is a simple analysis which should help to define your general needs and help further build additional and more detailed strategies. Basically, you need to know where to start, this helps you write it down and communicate it if you need to. We will start with 3 levels, but this could be broken down further if needed to.

Corporate strategy: Build project that meets corporate goals in a certain location by a certain time under a certain amount.

Project strategy: Develop schedule and budget for project. Identify possible risks and feasibility of said project.

PM strategy: Identify possible equipment, engineering, contractors, and associated staff and resources required to deliver budget, schedule, quality, and safety information. Gather all possible permit related information. Start bidding process for contractors. Acquire permits for projects and execute all contracts required to start the project.

The above 3 levels are a guide of what to do when receiving notice of the project. The PM strategy should be your start of how to achieve the project strategy and ultimately the corporate strategy of building the project. This analysis changes throughout the lifecycle of the

project. The PM's strategy will change during the construction of the project and again during the closeout of it as well.

Stakeholders and Communications Plan

The next analysis is conducted to identify all stakeholders, resources, and a communications plan. There are some occasions you may not know a certain resource available to you, or a certain necessary element or process until it's too late. The below communications and stakeholder plan is to ensure all areas are covered. I have attached an example below with some of the broader groups:

Stakeholder	Message	Purpose	Means/Frequency	Evaluation
Engineering	Initiate the design. RFP process. Periodic updates, and drawing reviews 30%, 60%, 90%, IFC.	Project engineering design.	Weekly if schedule shows a need for it. Periodic based on %.	Delivered drawing sets.
Procurement/Logistics	Clearly be able to illustrate the cost/benefit and technical specifications of equipment needed. Lead times and delivery dates.	Ensure successful delivery of equipment and schedule.	Weekly if needed at start of project though delivery of final equipment.	Successful delivery of all equipment.
Construction manager	Input during design phase. Input of feasibility for the schedule and labor of project.	Minimize execution, schedule, budget risk.	Weekly standing meeting on top of probable daily conversations.	Completion of project.

Company leadership	Periodic project updates.	Communicate any budget or schedule slip.	Weekly, maybe monthly.	Action items from meeting.
AHJ	Permitting and inspection needs.	Required	As needed	Issue and closure of permit.
Commissioning	Communicate schedule and dates needing commissioning.	Schedule requirement	Towards the end of project, as needed.	Project commissioned
Project Owner	Project update	Required update	As mandated. Probably monthly	Action items from meeting.
Subcontractor civil	Schedule and price. Status of work update.	Required update to understand project progress.	Every morning	Progress updated
Subcontractor mechanical	Schedule and price. Status of work update.	Required update to understand project progress.	Every morning	Progress updated
Subcontractor electrical	Schedule and price. Status of work update.	Required update to understand project progress.	Every morning	Progress updated
Safety	Discuss any safety incidents or needs.	Reporting purposes and prevention	Weekly	Action items needed
QA/QC	Discuss any QA/QC concerns.	Reporting purposes and evaluation.	Weekly	Action items needed
Third party inspector	Required for certain scopes. Witness test or county inspections are examples.	Required inspections for closing out project.	As needed	Action items needed

Figure 1: Stakeholders and Communications Plan

Team Charter

While the Communication and Stakeholders Plan are good at identifying everybody involved with the project, I recommend a Team Charter to identify your construction specific members and what their tasks are. The charter is also good for recording meetings where you and your team will conduct other analysis such as the SWOT. It identifies who led the discussion, who took part, and their contact info if anybody may need it. This is similar to a meeting minutes log, but meant to be more formal and can even be considered as a sign off of acceptance. That sign off could prove to be very important for the risk register. In the long run, the team charter would be very useful as a handoff sheet for any new personnel added to the project later. This charter should be modified and updated continuously to fit your specific project needs.

TEAM LEADERSHIP		
Workshop Role	**Name**	**Contact Information**
Sponsor		
Workshop Leader		
Team Leader		
Process Owner		
Lean Project Manager		

	TEAM MEMBERSHIP		
	Job Role / Title	**Name**	**Contact/General Information**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Figure 2: Team Charter

Strategy Cascade at the Project Execution Level

Next, we should discuss the strategy cascade, a simple analysis which illuminates not only the risks and weakness, but some of the advantages of your general strategy.

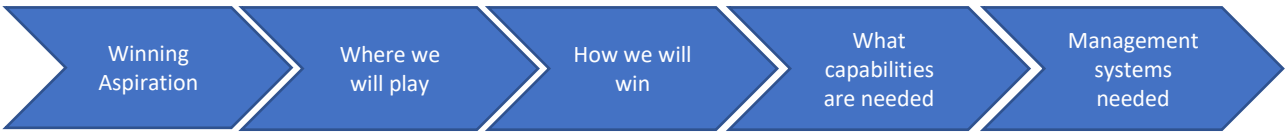


Figure 3: Strategy Cascade

Winning aspiration: To complete the project on time and under budget.

Where we will play: Project size and location. Used to determine if other projects were built in the same area and if so, what data can be collected about it. Was it wet and muddy? Or was there a lot of rock? These are examples of what to think about here.

How we will win: Think of some high-level advantages here. Did the contractor have a great relationship with the AHJ in this area. Is there no rock affecting post drive or barely any trees which need to be cleared resulting in a cheaper and faster civil scope?

What capabilities are needed: Is there anything lacking which will need to be addressed? Do we have the capability to recruit labor in the area? Will you need help from a technological front for a certain reason, for instance, to conduct daily reporting for the construction team?

What management systems will be needed: Will you need to hire a safety manager? Or a QA/QC manager? Is there any scope of the project unmanaged?

Chapter 3

Project Specific Strategy and Analysis Tools

We covered some analysis tools in Chapter 2. In Chapter 3 we are going to further expand our analysis to help us build a proper execution strategy for the project. We are going to start with SMART (Specific, Measurable, Achievable, Relevant, Time based) goals. SMART goals are a great way to establish generalized goals and creating a rough timeline before putting them down on a schedule. We will then be covering a SWOT analysis, a TOWS analysis, and finally an alteration to the Porter's 5 Forces Model customized to fit a solar project. Each analysis designed to help you evaluate the project from a different vantage point and create execution strategies tailored for your specific project's needs.

Here is an example chart with SMART goals:

Specific	**Measurable**	**Achievable**	**Relevant**	**Time-based**
Build the project under a certain budget	Monthly review of current budget actuals compared to tracked spending.	Monitoring of labor (internal and external) and schedule of activities.	Budget and schedule are two most relevant.	Refresh with budget actuals every month and monitor spending.
Build the project on time	Create schedule with milestones per block, array, circuit, section, task, etc... Whichever unit of measurement you decide.	Monitoring progress weekly and adjusting execution construction strategy based on schedule needs.	Budget and schedule are two most relevant.	Update progress weekly and monitor for schedule slip.
Build with exceptional quality	Reporting from QA/QC representatives illustrate how well the build is.	Monitoring of reports. Not releasing subsequent areas for build until the previous area has been repaired. Setting the standard with a first build inspection.	Poor quality results in re-work which slows down the schedule and costs more in man hours.	Monitor QA/QC reports weekly. Daily if they are not showing desired result.
No safety incidents	Safety inspections and reports. Incidents recorded.	Constant implementation and marketing of a strong safety culture.	Safety of employees should always be the main priority of any	*Daily safety talks. Monthly safety presentations. Safety talks customized for*

			workplace. Certain safety incidents are OSHA recordables.	*each task before beginning.*

Figure 4: SMART goals

Now that we have looked at SMART goals from a generalized view, let's break it down into a more specific section. Let's build out SMART goals based on racking installation in certain areas.

Specific	**Measurable**	**Achievable**	**Relevant**	**Time-based**
Install racking Zone A.	Monitoring progress daily and adjusting execution construction strategy based on schedule needs.	Monitoring of labor (internal and external) and schedule of activities.	First section needs to finish on time to stay on schedule and start module installation.	Expected finish by end of week 1.
Install racking Zone B.	Monitoring progress daily and adjusting execution construction strategy based on schedule needs.	Monitoring of labor (internal and external) and schedule of activities.	Module crew expected to finish Zone A, will need to move to Zone B next.	Expected finish by end of week 2.
Install racking Zone C.	Monitoring progress daily and adjusting execution construction strategy based on schedule needs.	Monitoring of labor (internal and external) and schedule of activities.	Module crew to start working when complete.	Expected finish by end of week 3.
Install racking Zone D.	Monitoring progress daily and adjusting execution construction strategy based on schedule needs.	Monitoring of labor (internal and external) and schedule of activities.	Module crew to start working when complete.	Expected finish by end of week 4.

This chart is generalized and is only considering four small areas. However, there are certain strategies we can take away from the analysis; module installation needs to start at the beginning of Week 2. From this we can gather QA/QC will need to inspect before module can move in. So, they should start no later than one day after racking installation. The idea being the repairs and reinspection can happen in most of Zone A which gives the module installation enough runway to progress. Having a separate labor crew just working on these repairs and calling for inspections is a safe strategy to make sure the schedule doesn't slip. Another strategy to keep in mind is the speed of the build and whether you need more or even less labor. For example, if Zone A has 500 racks which need to be built, then that is 100 racks which need to be built a day in a five-day work week. If a crew only builds 80 the first two days, it may mean you need to add labor. How you strategize this is up to you, adding labor affects the budget. Another option is working Saturday to make up for it. But again, overtime takes away from the budget. You must weigh your options with your circumstances and measure whether it is worth effecting the budget to save the schedule. Sometimes the best option would be to bring out some members of the module crew early to help with the installation of racking. Once they are caught up, they can start the module installation, maybe even a couple of days ahead of schedule. Managing labor is not easy, and usually falls to the project Superintendent and Construction manager. When building out the schedule ahead of time, these strategies and options are best discussed up front. For instance, ask what happens if we run behind in this area at this time? A "Plan B" and a "Plan C" is best discussed before they are needed so they may be considered in the schedule and budget development. Bad weather is certain to happen, plan for it by adding extra days to the schedule. The SMART goals are here to help develop these strategies in a way which is easy to understand and discuss with others if needed. Some people find construction schedules to be confusing. This chart is not.

SWOT Analysis

The SWOT analysis helps to pencil your project's Strengths, Weaknesses, Opportunities, and Threats. It's simple but it does require some serious thought and consideration into each of these areas. Using three to five bullets in each area is ideal. For example, I only want to use the top four strengths as they most benefit us. Everything else is just a convenience and there's no point in convoluting the analysis with too much information. The analysis should be simple and not so much of a burden that you never do it. An example SWOT analysis is below:

Project X	**Opportunities: What trends can help us?** **O1:** The civil scope will be fast and inexpensive. **O2:** Money saved by the layout of the project. Less customization in the racking has provided the opportunity to save on the budget. **O3:** Electrical subcontractor is known and trusted.	**Threats: What trends may have a negative impact?** **T1:** Tight schedule **T2:** Hurricane season upcoming. **T3:** Possible delivery delays of modules.
Strengths: What do we do well? **S1:** No tree clearing **S2:** No rock found in Geotech report. **S3:** Project is rather flat with a box like design. **S4:** The local AHJ is pro-solar and easy to work with.		
Weaknesses: What can we improve? **W1:** Very long medium voltage run to the interconnection. **W2:** Mechanical subcontractor is new to us, and we have no experience to		

foresee performance guarantees. **W3:** High expectations and standards set by the project owner. **W4:** New project construction team.		

Figure 5: SWOT Analysis

TOWS Analysis

The TOWS analysis is a great way to identify areas of urgency and advantage while building a bridge into the execution strategies that you as the PM will have to recommend and ultimately execute. They build upon the items already identified in the SWOT analysis to identify possible strategies. Being able to illustrate and speak to the way you are approaching the project a certain way speaks to your ability as a project manager. The four internal squares in the already built SWOT analysis constitutes your TOWS strategy.

Project X	**Opportunities: What trends can help us?** **O1:** The civil scope will be fast and inexpensive. **O2:** Money saved by the layout of the project. Less customization in the racking has provided the opportunity to save on the budget. **O3:** Electrical subcontractor is known and trusted.	**Threats: What trends may have a negative impact?** **T1:** Tight schedule **T2:** Hurricane season upcoming. **T3:** Possible delivery delays of modules.
Strengths: What do we do well? **S1:** No tree clearing **S2:** No rock found in Geotech report. **S3:** Project is rather flat with a box like design.	**Strategies that use strengths to maximize opportunities.** **S1:** Civil scope will be fast. Use this to provide schedule relief elsewhere. **S2:** Electrical installation should be simple with a trusted subcontractor and a county willing to work and	**Strategies that use strengths to minimize threats.** **S1:** Tight schedule alleviated by the expedience of the civil scope. If need be, release the project to electrical and mechanical subcontractors by completed civil sections.

S4: The local AHJ is pro-solar and easy to work with.	provide timely inspections. This allows more focus on the mechanical installation of the project. **S3:** Money saved by the layout of the project helps if needed with mechanical labor.	**S2:** Project design allows us to build and open trenches in a particular order. The AHJ will understand the need for timely inspections during a hurricane season. Open a certain length of trench, install wire, inspect immediately and close. Do not leave an open trench open unnecessarily during the bad weather. **S3:** There are possible deliver delays of modules. We should build a sequence with electrical and mechanical which takes us up to the point of no deliveries. Evaluated how much more schedule is needed and update a schedule reflecting the delay. We will probably have to collapse racking crews on module crews to double the production of modules installed once we receive modules.
Weaknesses: What can we improve? **W1:** Very long medium voltage run to the interconnection. **W2:** Mechanical subcontractor is new to us, and we have no experience to foresee performance guarantees. **W3:** High expectations and standards set by the project owner. **W4:** New project construction team.	**Strategies that take advantage of opportunities to minimize weaknesses.** **S1:** The long interconnection run will take time, but it's a stand-alone task with no real bearing until the end of the project. The problem is the expense for the long run. This expense is alleviated by the amount saved not only on the civil scope but the opportunities from the layout of the project. **S2:** Trust in electrical subcontractor gives more opportunity to supervise mechanical subcontractor. **S3:** New construction team is afforded the opportunity of a rather straight forward and simple project. Great opportunity to start with a	**Strategies that minimize weaknesses and avoids threats.** **S1:** Our threats are schedule based. We should execute as much on the front end as possible to eat up and possible delays and work through the growing pains of working with the expectations of the owner. **S2:** New teams should be supervised by experienced company personnel while the project is being built. Throwing them out onto the project with no guidance or set expectations is asking for the project to fail, even if it is an easier project. **S3:** Owner expectations can be quite burdensome and costly,

	simple project to learn the ins and outs of the company.	especially on the safety aspect of the project. Keep this in mind when building out the schedule and budget. Read and understand the contract, know it inside and out and don't be surprised.

Figure 6: TOWS analysis

Porter's 5 Forces Model

Porter's 5 Forces Model is an analysis which helps illustrate the internal and external variables in a businesses operating environment. Normally it would be set-up to illustrate the 5 Forces as "Industry rivalry, Threat of new entrants, Bargaining power of suppliers, Threat of substitute products, and the Bargaining power of buyers". Over each force we write the severity of risk in bold red letters to help identify the problem areas. The below diagram is showing the five forces model for a generic business.

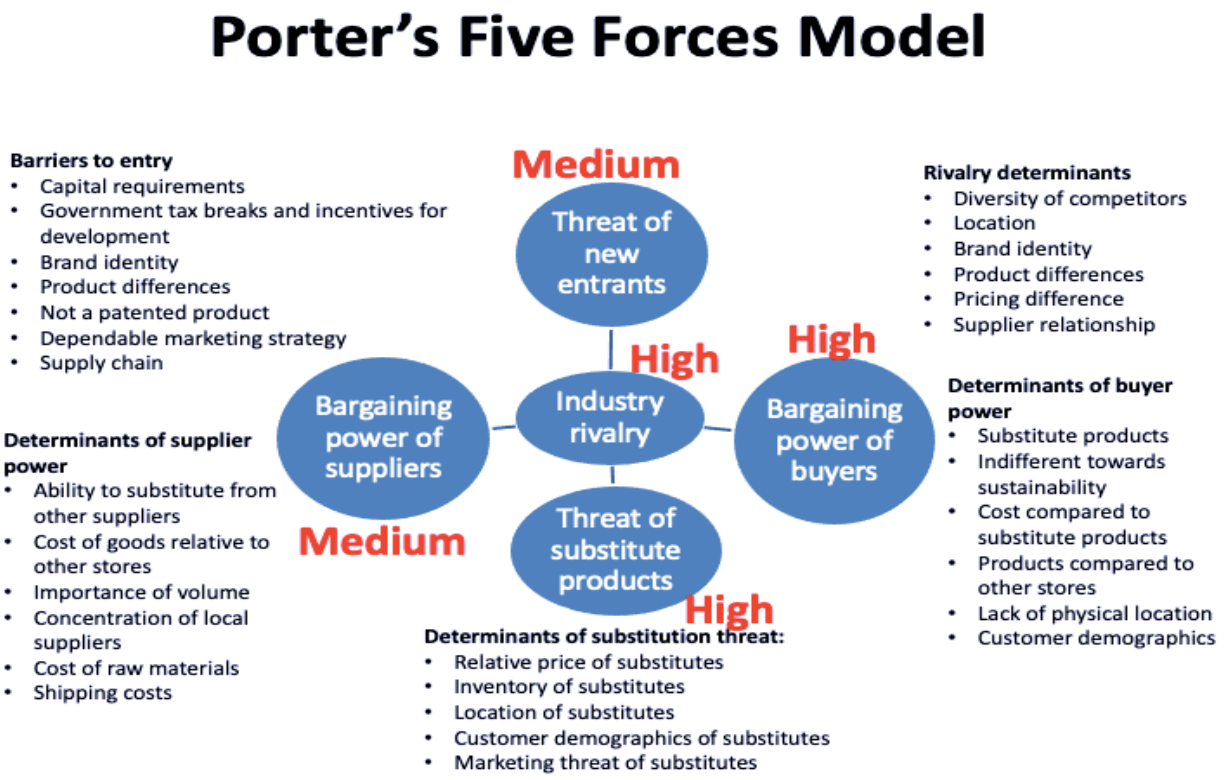
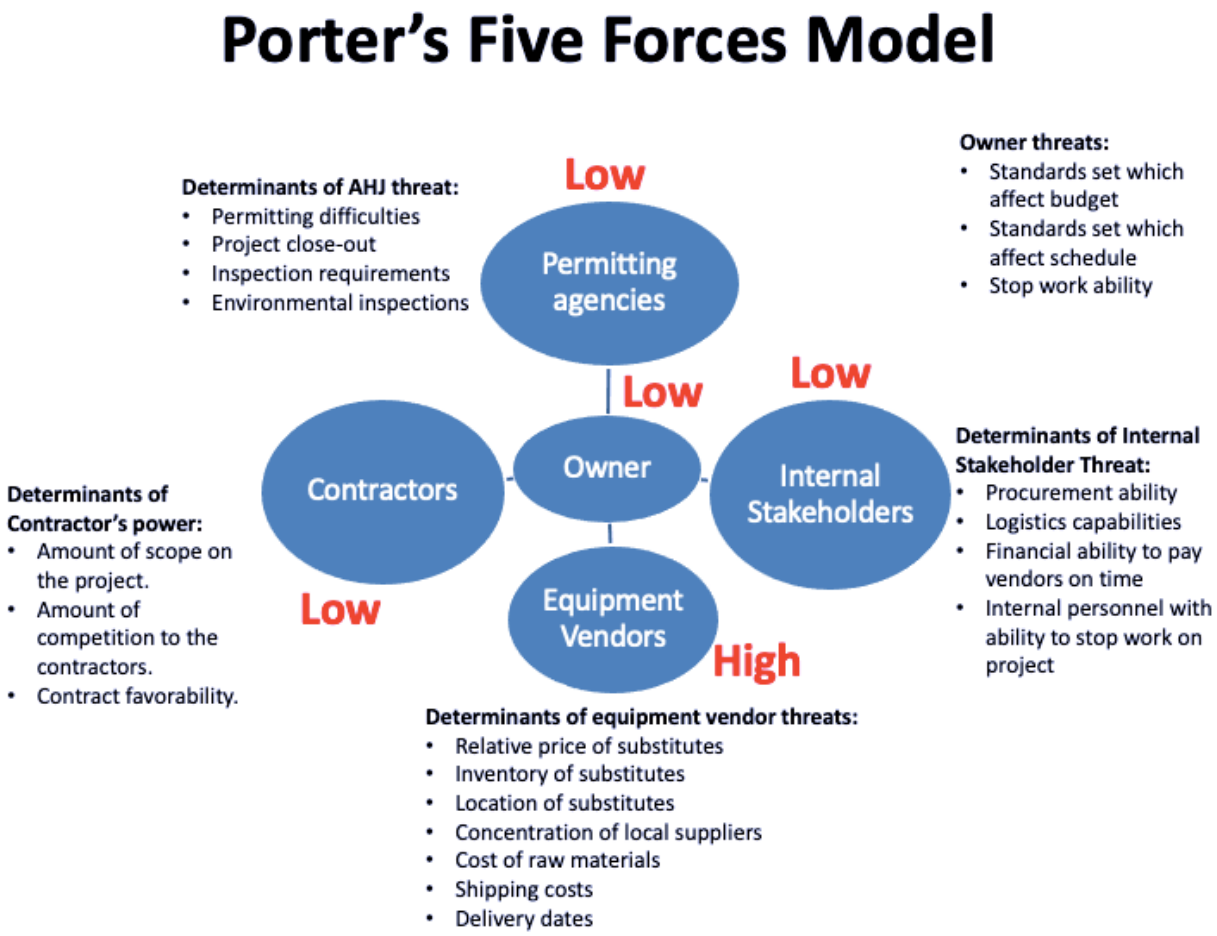


Figure 7: Porter's Five Forces Model

For the purpose of managing a project, we are going to change these 5 Forces to better reflect our solar project specifics. Our forces are going to look completely different as we are only worried about what directly affects us, and we might need to strategize for. Our 5 Forces are now:

- **The project owner-** The entity hiring your company to build the project. You may be in the company which hires the EPC to build the project. In that case you are the project owner's representative.
- **County and state permitting agencies-** The AHJ as discussed earlier. They dictate which conditions need to be met in your permits, as well as the entity to open and close your permits.
- **Internal company stakeholder's-** The different personnel within your company but not necessarily assigned to your project exclusively. Procurement, logistics, accounting, the director of project management are all examples of these positions. While you are managing your project, you are concurrently managing them and their assigned deliverables and expectations. This might sound harsh, but anybody within the company who has the power to stop work on your project is a threat. You might be on the same team, but they should be considered somebody to be managed, even if they are your manager.
- **Equipment vendors-** The racking and module manufacturers. Transformers and Inverters as well, your projects are largely held to the mercy of these manufacturers' costs and lead times.
- **Contractors/Subcontractors-** The actual company performing a specific scope of work. While it may seem on the surface, they would be easy to replace if not performing well, it's not quite that simple. If you are ever to a point you need to replace a subcontractor to catch up on schedule or budget, chances are one, if not both have been blown beyond recovery. Solid management of the subcontractor starts at day 1, if they fail, your project fails, which is where the risk comes in.

With these forces identified, let's plug them into the diagram and see if we can identify more detailed risk items within each section. We will use the same Project X from the SWOT/TOWS analysis to continue our conclusions.



The only real risk to the project is the module delivery window. A secondary risk could be the new subcontractor working on the project, but we are also assuming we haven't heard anything negative about them either. It's more of a neutral opinion than a negative at this point in time. Through conducting this analysis and the others above, we can tell we have a simple project which should be successful. At this point, it would have to be a lack of management why this project failed or something with no real way of predicting, like a pandemic.

Chapter 4

Building the Project Budget

Project budgets are usually measured in dollars per watt. Cents per watt for the granular items. This is broken down quite simply. A megawatt is a million watts. If the overall project budget is $50,682,000 on a 50mw dc project, then the cost per watt is $1.013. At the time of this writing, most projects aim to be under $1.00, usually somewhere in the low to mid $0.90 would lead to acceptable returns (as of 2023 publication date). As the project manager you are expected to identify the budget and most likely present and justify the numbers behind it. This is called "building the bridge". If your budget is too high, explain why and explain it in cents. It is worth noting that I am measuring the watts per cent in dc and not ac for the math. For example, the project could be 36mwac and 50mwdc. I am taking the dc into account for my math, not the ac.

As the project manager, you only have control over a small scope covered in the budget. When it comes to equipment procurement and technology selection, you probably won't have much of a choice in what is going to be installed. However, there are occasions where a red flag can be thrown, either due to high pricing or other extenuating circumstances. In reality, contractor/subcontractor pricing is where you will be most focused on. Or, if you're self-performing, labor will take your attention. Sub-contractor pricing is not flexible in the sense that a sub-contractor will ask you to lower prices if you ask them. It is flexible in the sense that, a subcontractor is a great source of value engineering on your project. When it comes to figuring out ways to do things cheaper, they are there to help. When your budget is tight, and the project is at risk of seizing due to budget, strategically they are a great source to help you move forward.

Change orders are another reason you will be focused on contractor pricing. While reviewing proposals, make sure every item in the contracts scope of work is identified. Change orders are a contractual change in the scope of work which would require additional payment to the contractor. Change orders are by nature, unexpected and not captured within the original

project budget. In other words, if you are building a project for $0.96, that budget will go up with every change order. Meaning you should capture as much uncertainty up front, continuously ask for clarity and additions to the proposal to make sure everything is captured. Change orders should be few if you have a strong contract and have done your due diligence with the estimate up front. We will discuss change orders and contracts further in later chapters.

Let's look at an example budget:

Project X	**50Mwdc**		
Owner Furnished Equipment			
Inverters	$2,500,000	$0.050	Wdc
GSU	$850,000	$0.017	Wdc
Racking	$7,200,000	$0.144	Wdc
Piles	$3,000,000	$0.060	Wdc
Modules	$16,500,000	$0.330	
OFE Subtotal -	**$30,050,000**	**$0.601**	**Wdc**
Engineering and Testing			
IFP Engineering	$800,000	$0.016	Wdc
Geotech Report	$77,000	$0.002	Wdc
EPC Overhead	$450,000	$0.009	Wdc
Array IFC Engineering	$750,000	$0.015	Wdc
Pile Load Testing	$150,000	$0.003	Wdc
Subtotal -	**$2,227,000**	**$0.045**	**Wdc**
EPC Proposal	**$16,543,000**	**$0.331**	**Wdc**
Includes electrical, mechanical, and civil			
Total EPC Estimate -	**$48,820,000**	**$0.976**	**Wdc**
Contingency -	**$3,000,000**	**$0.060**	**Wdc**

This example is very generalized, there's no detail in the subcontractor pricing. When collecting their proposals, you will want this detail broken out, especially when it comes to quantities. By quantities I'm referring to the "how many" of different pieces of equipment or material. Such as how many inverters, or linear feet of silt fence along with how much it cost per linear foot or each inverter. As we can see in the example above, modules are by far the most expensive piece of equipment. Most modules can be found anywhere from $0.32-$0.35. In tumultuous times such as when dealing with tariff restrictions, they can shoot up into the $0.40's range. Those prices essentially can cause a project to fail.

Circling back to the contractor pricing, which I have labeled EPC pricing, only 30% of the budget is something you have a say-so in. To keep this project in an affordable range, the project manager will need to send out request for proposals to many companies in hopes they will hit this $0.33 goal. Anything above will push the project into unaffordable and may not be worth the investment, depending on your company. The contingency is there to soak up any possible change orders.

It is important to note that you are expected to have a grasp and understanding of the budget, as well as have forecasted an accurate budget. This means, not only does exceeding your budget look bad, but so can coming in way under your forecasted budget analysis. You really do want the final number to be just right under the forecasted budget. If your budget came in significantly under, it illustrates a lack of understanding in the true costs of the budget. If this is ever the case, be prepared to build the bridge to explain ways you were able to value engineer or explain if there was a reduction in equipment price.

Now let's take a deeper look at the contractor bids in comparison to each other. It's easy to take the lowest bidder and sign a contract with them. But there could be considerable risk by doing so. The example below will give us a strategic approach to gathering accurate cost. Contractor A has covered all costs in their proposal. Contractor B (the lowest bidder) has missed a few items. This is not to say they have exactly missed these items; they could be enveloped in

other line items. More clarity would be needed here before you could award the contract to Contractor B. If the contractor has not accounted for these items, or if you haven't confirmed that they are broken out in other line items, then you are opening yourself up to possible change orders in the future. Some of these would be debatable, as they are basing these numbers off the scope of work, but regardless, it's a conversation you're better off not having after the project has begun. It's also worth noting, the lowest bidder may not always be the best option, if the costs are close, there are other methods of measurement as well, such as the company's reputation, safety record, and their financials. A proper vetting process should be followed for all companies submitting a proposal.

System Size DC	50,000,000	DC		
Customer Bid Form	Project X			
	Contractor A		**Contractor B**	
|| Laydown Yard	$150,060	$0.003	$ 74,963.08	$ 0.001
|| Survey / Construction Staking	$15,466	$0.000		$ -
|| Furnish & Install Permanent Fencing & Gates	$1,372,330	$0.027	$ 1,000,983.89	$ 0.020
|| Site Clearing / Tree Removal	$1,266,314	$0.025	$ 1,113,679.00	$ 0.022
|| Water Source Development / Dust Control / Soil Stabilization	$749,405	$0.015		$ -
|| SWPPP Maintenance & BMP Installations	$467,079	$0.009	$ 368,799.01	$ 0.007
|| Sediment Basins & Traps	$737,621	$0.015	$ 167,469.11	$ 0.003
|| Site Grading / All earthwork operations	$2,710,154	$0.054	$2,113,018.23	$ 0.04
|| Permanent SWPPP/ Soil Stabilization / Seeding / NOT	$1,111,237	$0.022	$ 938,578.08	$ 0.019
|| Perimeter Landscaping	$504,236	$0.010		$ -
|| Preparation and build of On-site Access Roads	$850,000	$0.017	$ 850,000.00	$ 0.017
|| Preparation and build of Off-site Access Roads	$51,554	$0.001		$ -
|| Furnish Foundation Piles	$1,638,438	$0.033		$ -
|| Pile Installation	$850,000	$0.017	$836,000.00	$ 0.017
|| Racking Installation	$759,864	$0.015	$863,719.00	$ 0.017
|| Module Installation	$969,776	$0.019	$958,163.00	$ 0.019
|| Install String Wire / Wire Management	$1,010,775	$0.020	$226,182.00	$ 0.005
|| Furnish and Install DC Homerun Cabling, Grounding & Accessories	$3,948,216	$0.079	$1,582,573.76	$ 0.032
|| Furnish and Install PV Harness & DC Disconnects	$1,937,728	$0.039	$1,900,000.00	$ 0.038
|| Furnish and Install CAB System	$367,000	$0.007	$400,000.00	$ 0.008
|| Furnish and Install AC Cable, Grounding, & Install/Term Inverters	$2,769,091	$0.055	$1,667,083.00	$ 0.033
|| Furnish and Install PV Plant Control & Communications DAS/SCADA	$751,862	$0.015	$314,872.76	$ 0.006
|| Commissioning / Witness Procedure	$276,968	$0.006	$339,177.14	$ 0.007
|| Mobilization	$546,339	$0.011	$191,133.65	$ 0.004
|| Contractor General Requirements	$300,000	$0.006	$207,981.40	$ 0.004
|| Contractor General Conditions	$431,634	$0.009	$420,655.36	$ 0.008
|| Accessory Structures	$0	$0.000	$0.00	$ -
|| Contractor Profit	$2,308,927	$0.046	$0.00	$ -
TOTAL	**$28,852,075**	**$0.577**	**$ 16,535,031.47**	**$ 0.331**

Chapter 5

Building the Project Schedule

When building the project schedule, it is important to understand that the equipment lead times may dictate the sequence of events. For example, if inverters take 36 weeks to deliver, you want those areas prepped and ready for installation by that time. You don't want to run late and must store them because it can be quite costly. You also don't want the contractor to finish that area too early with nothing else to do in the meantime while waiting. This could result in a delay of work change order. It is your responsibility to share these delivery dates, and the schedule, with the contractor so they can plan accordingly.

There are other milestones which need to be considered here as well. Mechanical completion, which refers to all the mechanical components installed on the project before hitting back feed. Back feed occurs when the project is ready to product power, and the inverters are turned on. Substantial completion is when all the commissioning has been conducted as well as some other items which may include some civil scope. Completion occurs when everything on the project is complete. All testing has occurred and passed. All environmental and construction permits closed as well. The Commercial Operation Date (COD) refers to the time the project can start selling power under the terms of the power purchase agreement.

The below schedule is generalized, and some companies may go into more granular detail or believe it or not, less detail. Most companies use either Microsoft Project or Primavera for their scheduling needs. The concept is the same with these schedules, every item is linked to another. When there is a delay or advancement in one item, the logic immediately adjusts the corresponding items to reflect the accuracy of the schedule. The schedule should be monitored and updated weekly by the PM. This will allow you to see not only the immediate area which may be affected, but the secondary, tertiary, and so on effects from the slip in the schedule. This schedule generally reflects the lifecycle of a 50mw project, from the initial engineering all the way to COD. It should provide you with an accurate timeline when comparing to other

schedules. Along with this generic schedule, it should be broken down similarly by circuits, or blocks, or arrays. Whichever the company prefers. For example, the below schedule minus the engineering and COD dates, could be made for each zone on a project. It is then broken down even further to reflect exactly how many inverters, racks, modules, and even commissioning tests need to occur. This would be useful in the case the project is so large, it becomes easier to break it down into separate, smaller projects. This may also be the case if there is more than one contractor as well.

Permit Review Comments Recieved		9/10/2021
Engineering Pre-con IFC Package	11/22/2021	2/20/2022
Submit Compliance Filings		10/27/2021
Receive AHJ Comments		12/27/2021
Submit SWPPP	12/28/2021	1/2/2022
SWPPP Permit Approved	1/3/2022	1/15/2022
Mobilize Tree Clearing Scope	6/14/2022	6/17/2022
SWPPP Clearing & Installation	6/17/2022	7/1/2022
Tree Clearing	6/27/2022	2/28/2022
Submit Pre-con IFC Package for Review	4/1/2022	5/31/2022
IFP Package Approval		6/1/2022
Permit Issued for Construction	6/1/2022	6/4/2022
Full Construction Mobilization	6/11/2022	6/18/2022
Clearing and SWPPP Installation	6/18/2022	8/6/2022
Drainage/Erosion Control Installation	7/2/2022	8/20/2022
Grubbing and Rough Grading	7/30/2022	10/13/2022
Topo Survey for Final Grade Design	8/29/2022	10/28/2022
Grade Design for Topo/Piles Approval	9/12/2022	11/11/2022
Final Grading	9/19/2022	11/18/2022
Deliver Piles	9/26/2022	11/14/2022
Pile Survey and Layout	10/3/2022	11/14/2022
Pile Installation	10/10/2022	11/21/2022
Deliver Racking	10/10/2022	11/21/2022
Inverter Skid Pile Installation	10/13/2022	11/24/2022
Inverter Skid Electrical Rough-in	10/20/2022	12/1/2022
MV Underground Installation	10/27/2022	12/8/2022
DC Feeder Installation	10/27/2022	12/8/2022
Combiner Box Installation	10/30/2022	12/11/2022
Torque Tube Installation	10/24/2022	12/5/2022
Receive/Stage Modules	10/17/2022	3/15/2021
Module Installation	10/31/2022	4/1/2023
Receive & Set Inverter Skids (11)	11/3/2022	12/8/2022
Harness and Module Terminations	11/7/2022	4/8/2023
Driveline Installation	11/14/2022	4/1/2023
Combiner Box Terminations	11/20/2022	1/1/2023
Inverter Skid NEMA Testing	11/27/2022	12/18/2022
Inverter Skid Terminations	12/4/2022	1/15/2023
SCADA System Installation	12/11/2022	1/15/2023
Pre-energization Testing and Cx	12/18/2022	4/22/2023
Plant Mechanical Completion	4/23/2023	4/30/2023
Backfeed Inverters	12/25/2022	2/5/2023
Inverter Start-up	1/1/2023	2/8/2023
Post Energization Testing and Cx	1/15/2023	4/22/2023
Plant Substantial Completion	4/23/2023	4/30/2023
Performance / Capacity Testing	5/3/2023	5/23/2023
COD	5/24/2023	5/31/2023
SWPPP NOT		5/1/2023
Final Completion		5/8/2023

The schedule will always identify the risks for you and be your best tool to find the solution. For example, if you are losing a week on racking installation, it will hinder the start of your module installation in that area. By identifying this on the schedule, you will realize there are electrical processes which must follow as well. But with enough time, you can come up with a plan to add some of the module installers to the racking crew which may help catch up some of those days. It also helps when coordinating when and where each activity should be working. There may need to be open trenches in some areas of the project, the schedule can identify that, and you will build racking or modules in another area to avoid all the activities collapsing in on themselves. It takes some thought and coordination, but there is no better tool for the PM to use then the schedule. It is also essential when building the bridge and explaining why some items are running late and what your plan is to catch up.

Remember to build some float, or extra time, into the project's schedule to account for bad weather days or other catch-up time if needed. Schedule slippage occurs often, for example sometimes you are held to the mercy of testing, or other third parties, out of your schedule's control. Sometimes remediation may need to occur. Just because you installed every module you planned to according to schedule, doesn't mean they will pass the QA/QC inspections.

Chapter 6

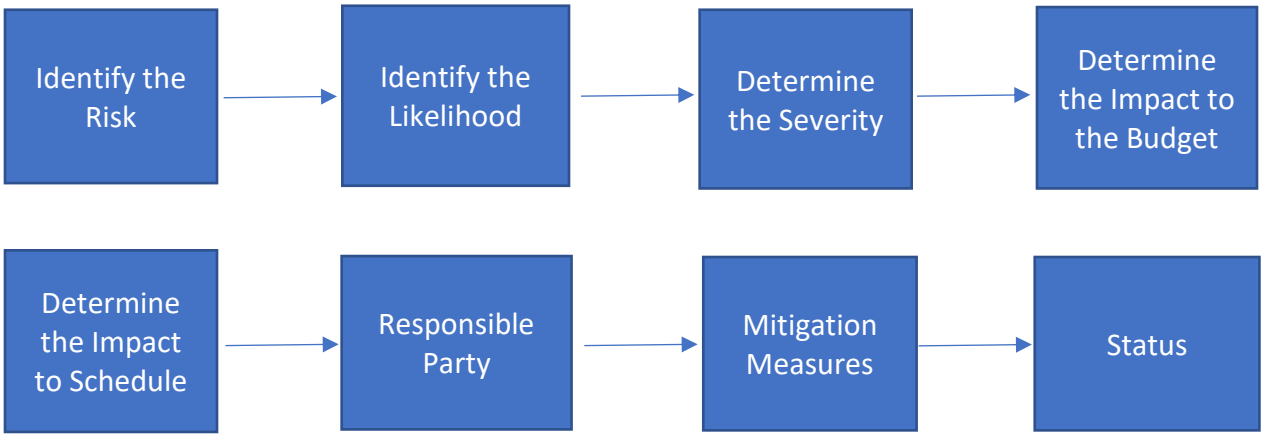
Project Risk Management

Identifying the risk to budget and schedule upfront is one of the core responsibilities of the PM. There are some items which can be reflected upfront in the budget build-out, and some which would halt the project entirely. Some companies will allow you to carry monetary value for risk in your budget. Others will expect it to come out of your contingency. Either way, your goal should be to identify the risks as early as possible and develop plans to mitigate the consequences of them

Building the Risk Register

Below is an example risk register. It should be filled out as a team and used as a tool to help guide you in identifying the risks. You're not going to eliminate the risk by using this tool, only identifying such risks.

The steps for filling out the Risk Register are explained here:



Identify the risk- Recognizing and transcribing the risk. Collaboration and communication with other departments will usually shed light on risks you may have been unaware of. It is important to sit down as a team and identify as much as you can together.

Identify the likelihood of the risk occurring- Is this a probability? Or just something that has the potential of occurring if not monitored closely? If this is the case, an environmental notice of

deficiency could be considered a risk if you don't monitor your environmental measures. But that wouldn't make sense to address here, that's a given on any project. But if you worked on a project in a county with a history of needing a lot of attention and demands, such as asking for more erosion control measures than designed, or wanting a third-party inspector, you may want to flag this as a risk to the budget.

Determine the severity of the risk- Is this risk a project killer (High)? Or is it just a minor cost to the budget or schedule (Low)? The severity of the risk should be an accurate representation of how it affects your project.

Determine the impact to the budget- This item is tricky, you may know that the risk has a cost impact, but you may not know what that cost is or have any way of calculating it. The best approach would be to try and estimate the costs. Once you have done so, it will be in your best interest to try and capture the risk in the budget building process.

Determine the impact to the schedule- This is another item that is tricky to capture. Usually, a day for day schedule slip works, but it may not always be the best solution. If a contractor needs to delay mobilization due to modules not arriving on time, you could probably count a day for day slip. But if you can't afford the schedule slip, they may need to work overtime to get caught up which would then affect the budget impact. Or that slip in the delay in modules affected that module install crew a week, which in turn affected the mod-to-mod wire management crew, which in turn affected terminations and so forth. A week up front could possibly cascade to longer down the line. This is where you will need to plug the current risk into the schedule and see the cascading effects.

Responsible party- This is identifying who oversees running down this risk, or who the main point of contact is.

Mitigation Measures- This is the plan of action to alleviate the risk or provide a solution. The responsible party should be the person leading this effort. You can build upon the risk register to also include contingency plans if this main mitigation plan does not work. In many cases, the mitigation measures will be a contingency plan, especially in the case of schedule delays. You will not fit the whole plan here if it requires extensive detail, again this is just created to help you recognize the risks.

Status- This item is identifying whether the risk is still open or closed. It is a self-describing item, but it should be said this tool should be used throughout the lifecycle of the project which would give reason to keep this column. Sometimes after completing a project, a write -up or maybe even a defense of the project may need to be written, keeping track of this register would be a handy tool in this case.

Example Risk Register

Item	Date	Description	Likelihood	Severity	Budget Impact	Schedule Impact	Responsibility	Mitigation measures	Status
1	6/20	No Purchase Order for modules have been placed. In today's market the module cost could increase sharply and suddenly.	Medium	High	High	Need delivery dates to build schedule. Only a risk because they should have been ordered.	Procurement/PM	PO's need to be placed immediately. What is $.33 today, could shoot up into the high thirties', maybe even forties based on the political situations in today's market. If it did, that would kill the project.	Open
2	6/20	Module delivery dates miss window	Medium	Medium	Medium	One day lost per one day delayed	Procurement/PM	Solidify the delivery window asap. Adjust construction schedule and plan accordingly.	Open
3	6/20	New Subcontractor	Low	High	Medium	N/A	PM/CM	Use Notice of deficiencies and administrative measures if necessary to keep contractor on track. Will be needed to replace if necessary. Weekly updates on progress and schedule.	Open
4	6/20	Permit amount uncertainty	Medium	Low	Low	None	PM	We still don't know how much the permits will cost and have no historical data to pull from. It's unlikely it will be a project killer, but still can't plan the impact to the budget.	Open
5	6/20	Short on some project staff	Low	Low	Low	None. Should be able to start the project on time.	HR	Hire and fill these positions. We have time.	Open

Figure 8: Risk Register

Communicating Risks and Constraints to Stakeholders

Remember it is your job to not only identify the risks, but to identify impacts and solutions, and present them to the proper stakeholders. Using this tool will help justify a need for budget or schedule increase. Use this to build the bridge when presenting the facts to the stakeholders. Do not hide anything from them, ever, if there is a problem, identify and communicate. As often as possible, your presented problems should be accompanied by a well-thought-out solution with its own schedule and budget impacts. Many risks could be alleviated within the first couple of months of the project, such as the module and permitting risks outlined in the register above. Requesting a risk specific budget line which could be released back to the company after they are resolved is a possible solution. If you are tracking and communicating a risk, you are covered as a PM. When an occurrence happens, you did not plan for, usually one of the first questions asked is “Could this have been foreseen and prevented?” If the answer is “Yes,” you might be in trouble thus the need for a TOWS assessment (as seen in figure 6 above).

Chapter 7

Quality Assurance and Quality Control (QA/QC)

As the PM, excellent quality should be a firm expectation from day one. If a safety incident can be considered an unexpected and surprise risk to the project, poor QA/QC is the opposite of that. It is like quicksand, pulling you in deeper and deeper until you can't feasibly see the project finishing on time. It just takes a moment of inattention for that negative momentum to accumulate, and as soon as you know it, you are way behind on the schedule and the morale of the project is low. As a PM, you must demand a plan of remediation and execution at the very first sign of poor QA/QC.

How to Implement and Enforce a QA/QC Plan

The quality control plan should reflect the project's contract and must illustrate how a company will facilitate and ensure the quality of the project throughout execution. A proper quality control plan should have the following at a minimum:

Quality control system overview- Explains and links how the plan will conform the contractual requirements. It should identify and detail the scope of the plan as well as draws the distinction between the QA/QC team and the constructors of the project.

The organization- Identifies the people and positions responsible for the successful implementation of the plan, both on and off-site personnel. Examples of such positions would be the QC manager, inspectors, superintendents, and foreman. The plan should draw the linkage between each position. The foreman of the crew is the first to inspect and pass to the quality control inspector.

Quality control records- Used to establish the administrative system for inspections and results. It should communicate how each section of a project will be passed as complete or what the process is for failure. Where to access these records and how to easily read them. These records should be accessed daily and used as a tool by the PM to drive discussions around quality on the project. Documentation is the minimum of a quality control plan.

Document control- Not to be confused with quality control records. This is the system for QA/QC on documentation such as engineered drawings and construction plans. An administrative QA/QC program which coincides with the mechanical execution of the project.
Inspection process- This section should constitute a plan and the inspection procedures. It should identify how many inspectors will be used, tools needed, and in what areas. The quality control manager should prepare the plan and incorporate any contractually obligated items. There may be different types of inspections needed as well, these should be called out in this section such as the first build inspection, re-inspection processes, and the projects final inspection.
Measuring and testing control- This area details the methods used to ensure the reliability of test equipment and procedures such as torque wrench calibrations. It may also describe the logic behind installation tolerance levels and what they are. This is usually a recapture of equipment drawings and details from the installation manuals. Testing may capture the detailed and expected steps of the test itself. Some example tests are Megger, VLF, and soil compaction.

List of Inspected Tasks

Your QA/QC plan should also include one major item, a list of inspected tasks. This item may have numerous names, depending on the company or contractor. Basically, it should outline the steps throughout the project which leads to QA/QC sign off before continuing to the next step. In other words, a road map of the project and it's mandatory deliverables. It should include the major items listed below:

- Design
    - Electrical, civil, structural drawings
- Post drive
    - Pile heights
    - Locations
- Conductors
    - Trenching depth and placement for medium voltage and fiber

    - Ground wire
    - Lug terminations
- Conduit
    - PVC connections
    - Stub ups
    - Trenching depths
- Equipment
    - Transformer/Inverter pads
    - Equipment set and anchored
    - Ground grid
    - Terminations
- Racking system
    - Torque tubes/Purlins
    - Nuts and bolts torqued
    - Proper overhang
- Modules
    - Nuts and bolts torqued
    - Proper spacing
    - No stepping
- Wire management
    - No mess or clutter
    - Proper material for securing, no zip-ties
    - Homeruns
- General
    - No cardboard or trash on project
    - All equipment removed
    - All documentation matches the projects reality

These items are a very basic list of items to be checked. On a project, this list should be expanded upon and certain elements, for example torque tube overhang or post height, should have specific values assigned to them.

Execution Strategy

How a PM tackles the QA/QC may differ from individuals and within companies, but I recommend a remediation team be available to repair the minor mistakes found in the inspections. The remediation team can also walk around with the QA/QC team while deficiencies are identified and repair on the spot. They would also be great when calling for re-inspections. However, for systemic issues a team like this would not be ideal because if it becomes obvious that the same deficiencies are popping up often, and in high volume, then the installation crews will need to stop and be retrained before continuing. It should also be noted the construction teams, should not be able to continue into a new section until quality control has approved them to do so. This is to prevent mass rework if the installation crews get too far ahead of the quality control inspectors. One last note about the quality department is that they should not work for either the PM, or the Construction Manager. This is to prevent either party from pressuring the inspector to accept poor quality work.

Chapter 8

Project Safety

The importance of safety cannot be undervalued, not just for the welfare of employees, but the impact to the project budget and schedule as well. A poor safety record will absolutely bury a company and your career. No matter how well a project is doing, an OSHA recordable will stain its success. An OSHA (Occupational Safety and Health Administration) recordable is a term used to describe an incident which results in "death, days away from work, restricted work or transfer to another job, medical treatment beyond first aid, or loss of consciousness.".[8]

Example Safety Plan

Safety Plan
Project X

The safety plan should open with a statement here, explaining what activity the plan is covering and where.

Location of Project

The project is located in a specified area with an attached graphic here.

Scope of Work:

Identify the scope by each major task and identify the main concerns for safety.

Civil:

- Silt fence installation

[8] Department of Labor. (2021). *1904.7—General recording criteria.* Occupational Safety and Health Administration. https://www.osha.gov/laws-regs/regulations/standardnumber/1904/1904.7

- Basin installation
- Cut trees
- Grub trees
- Mulch trees
- Chip removal and disposal offsite
- Traffic maintenance

Electrical:

- Trenching
- MV wire/Fiber installation
- DC installation
- Source wire
- Mod to mod connections
- Harness installation
- Combiner box installation
- Transformer/Inverter pad installation
- Transformer/Inverter set
- Terminations
- Testing
- Commissioning

Mechanical:

- Post driving
- Racking installation
- Module installation

Qualified safety personnel will ensure each task above will be identified as its own scope of work and outlined in the job safety assessment each morning before the start of the task. Each employee will know the hazards of each task and will have stop work authorization.

Project Person Roles and Responsibilities:

Company x will be responsible for the safety of its employees. All employees will have the necessary training and qualifications to complete the task.

Position	**Name**	**Number**
Project Manager	xxxxxxxx	xxxxxxxxx
Construction manager	xxxxxxxx	xxxxxxxxx
Safety Director	xxxxxxxx	xxxxxxxxx
Safety Manager	xxxxxxxx	xxxxxxxxx

Daily morning safety meeting:

Every morning we will conduct a safety meeting focused on the task at hand and the dangers and risks associated with it. We will ensure all employees are present and will sign the safety documentation stating it. Nobody will be authorized to work until they have signed the documentation. All crew leaders will be responsible for having the assigned documentation on hand. If an employee is assigned to a different crew later in the day, they will need to be briefed on the hazards and sign off on the documentation.

The accompanying documentation with the daily safety brief will cover at a minimum:

- The daily task and it's hazards
- Personal Protective Equipment (PPE) to be used
- Procedures to be followed
- Reminder of stop work authority for all employees
- Emergency and medical procedures

Example Job Hazard Analysis form

Activity	Risk Level
Landscaping	• Low • Medium • High

TASK	HAZARD	MITIGATION/CONTROLS
Pre-Construction • Review of Job Hazard Analysis • Daily safety brief • Tool inspection	• Communication issues • Lack of knowledge of the tools being used	• All crew members will review job hazard analysis prior to the start of work. • Any change ins cope will require a new analysis to be completed. • Hazards associated with each task will be reviewed.
Travel to and from work location	• Slip, trip, and falls	

TASK	HAZARD	MITIGATION/CONTROLS
	• Vehicular and equipment traffic • Moving tools to location • Heat	• Wear mandatory PPE • Warning signs, cones, flags should be placed over any hazardous area. • Ensure crews are properly dressed for the weather conditions onsite. • Ensure crews have easy access to water and shade • Keep walk/work area clear from obstructions. • Utilize a spotter when moving equipment at all times • Install “Landscaping crew ahead” signs in all entrances to work area.
Grass cutting	• Body Strain, Pinch Points, slips, trips, falls. • Weed wacker wire. • Lawn mower blades • Heat • Wildlife	• Don’t position yourself in tight areas such as in between vehicles and equipment. • Watch where you are walking and be careful of potholes and wildlife in the tall grass. • Do not operate lawnmower without steel toes or attempt to flip sideways while it is on. • Drink water and take frequent brakes as needed in the shade. • Wear PPE

Incident reporting and communication

In the case of an incident, communication between contractor and the PM will be maintained. All incidents must be reported immediately to the project supervisor. A formal incident report will be submitted within 24 hours of the incident to the project manager including a root cause analysis.

Emergency Contact Information

Detail the closest hospital or location of medical services with a graphic of the route to the facility.

Enforcing and Rewarding the Safety Plan

Often the safety culture is built around negative reinforcement and reactive “safety stand downs” due to incidents occurring. But it can also be used in a positive manner as a tool to improve the morale of the workforce on a project. Some companies have implemented rewards systems such as a raffle for people who submit a safety observation which could be used to help improve the overall program. Some offer lunches or time off for not having any incidents for a certain amount of time. Gift cards and high-end electronics have been given to top performing crews for their attention to safety. As the leader of the project, the safety of the workforce should be your top concern. That same responsibility should trickle to every other position of leadership on the project as well. The rewards system is not only meant to help the culture but reinforce the need for safety with a positive and encouraging message.

Chapter 9

Contracting and the RFP Process

Before the start of construction, it will be time to sign a contract with a contractor for the execution of either the whole project or pieces of it. Obviously signing a single (turnkey) contract with one contractor is the ideal situation, but sometimes it just doesn't work that way. Rarely is a contractor awarded the project without some sort of competitive bidding process. This is where the request for proposal (RFP) comes from. Some basic information of the project as well as a design basis, or even a 30% drawing set will be sent to a list of contractors requesting a proposal to do a specific scope of work. During this process you may or may not take them to the location of the future project and do a bid walk to highlight some key areas and answer some questions. This should be done with all the contractors at the same time. It is always fair for everybody to hear the same questions and answers. After the bid walk is complete, if a contractor sends you a question, that question and answer should be disseminated to the other contractors.

We already discussed comparing the bids to help build a budget, but we can also use them to ensure a complete contractual scope of work. By comparing quantities and items specifically called out in the bids, the PM can specifically call out and implement items within the scope to ensure no change orders are on the way. Once again, you are using the bids as a tool to help strengthen your contract.

Contracting strategy

When contracting either with a contractor to construct your project, or if you are the constructor hired by another company, most contracts will be in the form of an Engineering, Procurement, and Construction agreement (EPC). These agreements set forth the general terms and conditions between both parties. The agreement's corresponding exhibits will usually be the specifics of the project itself. In these exhibits you will find a detailed scope of work, along with other items such as environmental studies, payments schedules, and engineering

documents needed. Included will also be administrative forms such as form of change orders, milestone certificates, and form of lien waivers. When developing these contracts, pay close attention to the terms and requirements for change orders, force majeure, the project schedule, and how they tie into your guaranteed completion dates. All, if not most of these exhibits, should be well defined before the bidding process. Included in that meaning of well defined, is attention to detail in the environmental studies or tests identifying sub surface risk. Most companies will try and escape being held liable for subsurface risk, but if they are given the proper test reports identifying that risk, the liability should be held on them as long as the reality of construction reflects the conditions outlined in the reports. When a company identifies and can accept the risk, it usually signals their understanding of the conditions, meaning they reviewed the reports. While their overall price may be higher, this attention to detail will pay itself off in the long run. Companies that pay attention to the environmental studies of any type, tend to design, and build a project with all the environmental factors in mind, such as staying away from wetlands or historical areas. They also are more keen on other details you wouldn't normally consider, such as the placement of access gates and where to place spoil piles for any dirt removed from the project which need to be stabilized with grass seed on top to prevent erosion. If you see a larger price on any civil work because of these studies, don't dismiss them, they might have done their extra due diligence which will go a long way in the AHJ's opinions when it comes to permitting, ease of construction, prevention of change orders, and closing out the permit at the end.

The Bidding Process

The EPC agreement along with the corresponding exhibits will be sent to potential bidders as part of the RFP package. Included with these are documents which should be detailed in the exhibits, such as any design drawings available, environmental studies, equipment details and so on. This package is sent with a summary sheet detailing your company's RFP process, the objective, timeline and more. This sheet may be developed by the PM, depending on your company's organizational structure. A good summary sheet is another strategic tool to leverage the most quality bids possible in a timely manner. Remember, as a PM, time is never on your

side. Having to resend the RFP due to a lack of information is always a waste of time and a headache not only for you, but the bidders as well. Another thing to consider when having to resend the bids, material and labor pricing may fluctuate, so existing bids you do have, will need to be refreshed to update the market changes. Also, companies do not have to submit a bid, you are just requesting them to do so. In fact, it is common for companies to decline submitting a bid, usually due to their schedules or the project size does not fit their company's capabilities or growth projection. Due to this, and the variability of pricing, it is best to submit this RFP to as many companies as possible in hope you will receive competitive pricing in line with your project budget. High cost is another factor in having to start the RFP process over again.

The summary sheet should be outlined as follows:

- Always lead with the project overview: location, size, and name.
- A table of contents.
- The next item in the document should immediately be followed by the RFP objective. This objective should clearly state the purpose of this document is to set the basis for companies to provide competitive and accurate pricing. It should also state that in no way does a proposal submission constitute an offer by your company. Other important, large details should be added here, such as what kind of proposal are you looking for, PV field and substation for example. Or just the construction but not the engineering.
- Next item your company may mandate (and they should) will be a legal section detailing how the process with follow proper laws and ethics in the process of this RFP.
- Following that section, protect yourself from possible charges and clearly explain that any charges incurred by the bidder during preparation of the bid, such as plan reviews, legal expenses, and site walks, are at the expense of the bidder and not your company. Most companies will know this, but just in case they don't, this is a best practice to cover yourself.
- In the next section you should detail considerations and instruction for the RFP. Such as how they submit the RFP (email or data room). How you would like the bid broken out ($/Wdc). What equipment your company will provide and the corresponding exhibits

reflecting their details. You may request the bidder to attach a schedule reflecting their scope and the dates in which they can achieve certain milestones.

- Next section should include the RFP schedule. This is a small, but everything they need to know, schedule about the process. It starts with the RFP launch to bidders, then a site visit date for all bidders (if you plan on doing this). The site visit is followed by the RFP submission from bidders to your company. Depending on the project size and constraints of your schedule, the time between launch and submission varies, but a good rule of thumb is 4-6 weeks. There are a lot of documents for them to review and you want to give them the time to do so, as well as gather accurate material pricing and labor pricing from their potential sub-contractors.
- Next, you will need time to review the bids, flag any items missing or that stand out, and reach out to the bidders for clarification. This may take some time not only for you to review, but for them to provide any answers to your questions. Two-Three weeks should be enough time for you. You don't want to be the hold up in this process. Lastly is the award date, this is the date you intend to award the winner of the bid, not sign the contract. There is still work to be done before you can sign the contract.

Redline Reviews

After the award date comes preparation to sign the EPC agreement. The bidder will review the contract and exhibits, redline any concerns they have and submit to you. Yourself, legal, and any other stakeholders will review the comments, either accept, deny, or offer a compromise and then return the contract. This process can take months and is quite exhausting for a PM. However, it is the best time to study and learn the contract as you will be expected to know it during the execution of the project. It is your sole objective to ensure that your company and project are protected as much as possible.

Many companies with tight schedules end up accepting changes or compromises which they never should have to start the project as soon as possible to complete the project

on time. The consequences are usually never seen on the front end of the project, but the back end, when change orders and other obligations arrive that you should not be held liable for. The PM is stuck managing the situation and explaining why the contractor is entitled to a certain amount of change orders because of a hole in the contract. It can be a poor situation which seemed like a good idea up front, but while trying to close the project developed into a big problem. Don't let anybody in your company accept or compromise anything you may disagree with without documenting it for later. Keep the proof, to cover yourself later. This could be accomplished with an email detailing your recommendation to not accept and why. Keep the response if needed for later. You should also add the potential risk to the risk register which will also be seen by your company's decision makers before the start of construction. When the reviews are finished comes the signing of the EPC contract. Congratulations, it's time to build a project.

Chapter 10

Subcontractor Management

The relationship between contractor/subcontractor and project manager is a symbiotic one dictated by both parties protecting their respective companies and completing the project together. Gone are the days of the PM managing the contractor with an iron fist and tight contract. Due to the limited number of contractors who can build the ever-expanding number of gigawatts developed in the United States, these contractors have options and no need to endure any unnecessary treatment or conditions. Basically, you need them, they don't need you. This has created the necessity to view the contractor as more of a partner, and less as a subordinate. However, this doesn't give them permission to take advantage and to try and run up costs, you will still need to be firm with the contract management. It is also worth noting, you should only be responsible for communication with the contractor you are contracted with. You should not be advising, requesting, or ordering their sub-contractors to do any task. The EPC agreement will almost certainly include this, but it is best for all parties involved. If you ask a sub-contractor to complete a task, even with the best intentions, it will probably result in a change order or worse, such as a mistake happening and now your company is liable for damages.

Change orders

Change orders occur when there is a written alteration to a previously signed contract for work.[9] Be very careful what you request from a subcontractor, it could very well result in a change order or change request[10] when you don't expect it. If you ask for any type of alteration to the project, then make sure you capture the expected costs upfront and request approval with the cost and justification. Surprise change orders make you look bad as the PM. Obviously,

[9] Merriam-Webster. (n.d.). Change order. In *Merriam-Webster.com dictionary*. Retrieved August 11, 2022, from https://www.merriam-webster.com/dictionary/change%20orde

[10] Malik, P. (2022, July 29*). PMBOK Guide Change Management Process for PMP Exam: PM-by.*PMbyPM. Retrieved March 18, 2023, from https://www.pmbypm.com/pmp-change-management/

the cost impact of change orders was not captured in the budget of the project. This is what contingency and risk is for, swallowing the costs of potential changes. Change orders also can completely break a project if the contract is weak. Sometimes there are change orders which are reasonable, such as the county requiring further stabilization efforts, to keep the project compliant. Other times you may have asked the contractor to do something minor, such as move a pile of dirt from one location to another to make space for something else or keep the area presentable for a site visit from the higher ups. That simple request could lead to a change order for a few thousand dollars taking the labor and equipment into account. The contractor always has a mark-up on the COs for profit. While it may seem ridiculous, you're paying them to move a pile of dirt (twice), contractually it is justified on their part and it could be an unexpected expense if you didn't clarify upfront if the work would be a change order. Some contractors would rather stay in the good graces of whomever hired them so they may have future opportunities for work. Others may have purposefully bid low on the project based on contract documents and drawings with the intent of making profit on change orders. It is best to ask around your colleagues and investigate a contractor's reputation. If they are a change order hungry company, somebody will let you know. It is necessary to note that the need for change orders could come from outside the contractor, and from an entity such as the AHJ. They may request additional environmental measures be placed as a result of what is actually occurring on the project. An example would be water run off not working exactly to plan, resulting in further mitigation measures needing installation. While this may impact your project budget, it is not something you as the PM could have prevented, and should be easily explained to your company. Especially if it is something that adds to the sustainability of your project as well as puts you in the good graces with the AHJ.

Using the Schedule to Manage the Contractor

Depending on your role, whether you are an owner's representative, or the EPC PM, the project will be managed by a schedule. The schedule should be built with the contractor's input and sign off. As this will most likely be included in the contract it should not be a big deal. However, when you start to delay or change the schedule, you will open yourself up to a possible change

order. There were times when a contractor would take the impact to stay in the good graces of the owner however, that doesn't happen anymore. Every single day which is a slip in the schedule, could result in a change order. On the flip side of that, if the contractor falls behind on their own accord, it is their fault, at their own cost. Make sure to record and communicate the impacts it has to you as an owner. For example, the contractor ran late on the civil process which means you had nowhere to store your delivery of posts and racking. The trickle-down effect means you waited an extra week for post drive to start. If they are different contractor's this could be a problem. Who pays the post drivers for the delay? Especially if the rental equipment is sitting on the site? In a couple of months does the racking contractor have the ability to collect damages due to the one week delay? Not if you recorded and communicated the schedule slip as the fault of the contractor and not your own. Your contract should reflect these possible scenarios and protect you. Yes, if you cause a delay to the contractor, you will probably need to pay for the rental equipment sitting on the site. Therefore, if there is a delay in any way, record, communicate, and make sure you are protected from a possible change order in the future.

Retainage

I want to take a little time and discuss retainage and the importance of it. Retainage is defined as a percentage of a contract price retained from a contractor as assurance that subcontractors will be paid and that the job will be completed.[11] Some companies may refer to this as "retention". Let us consider the practicality of retainage as a tool. It is okay with holding a portion of retainage until the project is closed out with the local AHJ. The last thing you want is for the contractor to step away from the project after they have been completely paid for work completed but you still have open environmental permits to account for. At the same time, you cannot ethically hold retainage for work that has genuinely been completed for very long. The retainage you hold should aim to equal or be a little more than the value of work left to do. If you are holding $500,000 in retainage, but there is only approximately $25,000 of work left,

[11] Merriam-Webster. (n.d.). Retainage. In *Merriam-Webster.com legal dictionary*. Retrieved August 11, 2022, from https://www.merriam-webster.com/legal/retainage

then you should release the retainage. If you have an environmental permit still open and waiting for a little more grass to grow to achieve stabilization, then your retainage should be equal to the amount estimated to achieve stabilization if rework is necessary. This keeps the contractor paid, happy, and pushing to help close out the permit as fast as possible.

Chapter 11

Project Reporting

The project manager will be reporting on the project on a weekly basis. This could be to their direct supervisor or to the entire project management group they are attached to. The latter is what usually occurs and is also what I recommend. It is the best time to understand the health of other projects, especially those within your same region or others who may be using the same contractors. During this time, it is extremely important to report the truth of your project, including the bad news. The format of your reporting should follow a specific flow and give the facts.

Safety reporting: Your reports should always start with safety. Did you have any recordables or incidents? If so, lead with that, the reasons, and the outcomes. You should always provide a remediation effort to prevent it from happening again.

Schedule reporting: Now you report on any schedule slippage which may have occurred. If schedule slippage did occur, explain the plan to catch-up. If you are ahead of schedule, say it. Good news is always welcome. Sometimes PMs withhold this information in case there is a slip later they will have bankable time to catch-up with. While I understand this logic, I still recommend reporting the good news of being ahead of schedule. This is an industry where usually bad news is reported, layering in good news shines a positive spotlight on your project and usually results in the project less scrutinized.

Equipment reporting: Along with your report, delivery schedules should be known and communicated here. This proves you are tracking the delivery of equipment with the necessary manpower needed and the flow of the schedule. If there is a delay in equipment deliveries, communicate the schedule impacts and possible repercussions of it. Rarely is a delivery delay the fault of the PM, but not reporting on it is.

Budget reporting: This should encompass any high level movement of the budget or change orders. This shouldn't be granular, just high-level items. You will most likely have separate budget review meetings to discuss the granular details. Another example of an item to bring up

here, is the excess traffic of company visitors to your project. If they are billing time to your project that you did not account for, this is a good time to bring it up.

Other items: Lastly, finish your report with any other items which may fall outside of these areas. Such as a visit from a landowner with any complaints you want to bring up, or an update of the contractors themselves for the group. Potential sustainability impacts would be good to point out here as well, and the corrective actions taken to prevent any environmental impacts which may have occurred. Solar projects have a lot of opposition and it's not uncommon for local residents and neighbors to question your projects sustainability in an effort to make your company look bad. Burning felled trees and not recycling broken modules are hot button items the opposition will use to delegitimize your efforts. Finding sustainable ways to approach every task during the project may go a long way.

Reporting is a key element for the project management position, and nothing looks worse for you than staying silent. Constant communication is a must for being successful in this position. Take ownership of your results, explain the bad and your recommended solutions, and take pride in the good and don't be afraid to speak about it.

Chapter 12

Punch lists

At the end of the project's construction before final completion, your project team will be expected to deliver a punch list to the contractor. This punch list will identify all deficiencies in the construction of the project. Anything from missing torque marks on bolts, to low hanging modules that don't have the proper ground clearance as detailed in the drawings. This punch list should be extensive and encompass everything you can possibly find wrong with the project. Once you sign off on final completion, there may be no going back for many of these items. After final completion, the operations team who takes over the project may be able to file a warranty claim for some items, but for many deficiencies, the contractor will be able to claim we passed it during our quality control inspections. Usually, it is expected to start assembling the punch list around the time of mechanical completion, but once the final punch list is delivered, it is too late to add to it.

Management and Close-out

Many contractors may drag their feet when closing out the punch list. Certain subcontractors may have left the project by then, or the contractors may deem some items more important than others. It is not to your benefit to ease up on schedule during this time, especially if you have already hit your milestone dates and it is time to close the project. Weekly meetings should be exercised during this time with progress updates and plans on how to close out the remaining items. Retainage and a contractually identified punch list holdback amount should be utilized to incentivize the contractor to completion. If you are only holding back the value of that punch list item, the contractor may be able to exercise the right not to complete the item and waive the amount that would be owed to them if they completed the task.

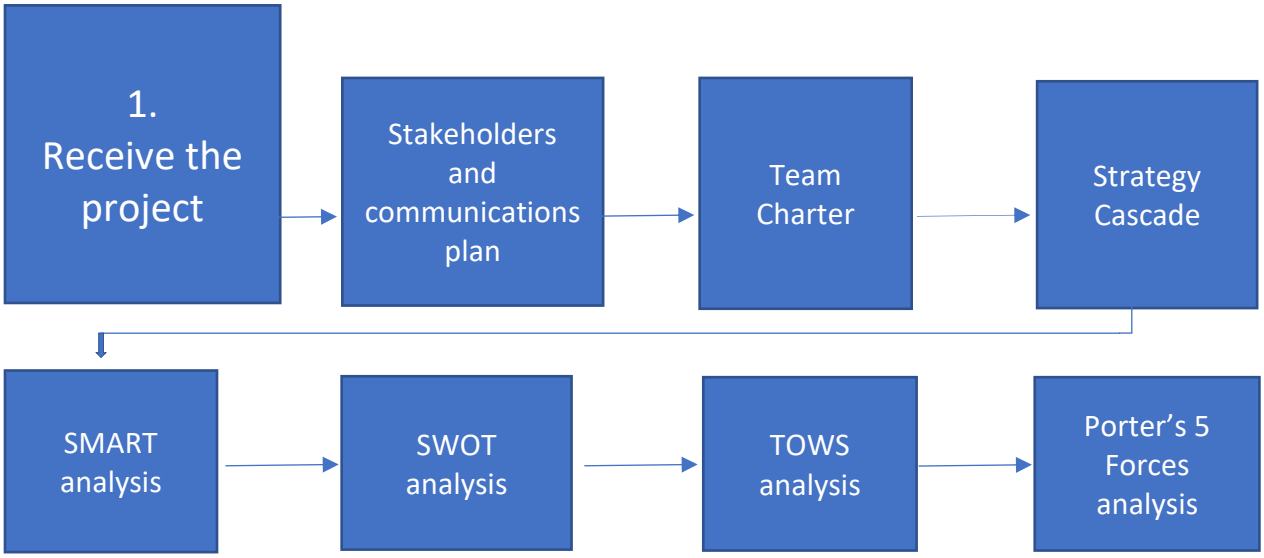
While this chapter is small, it is important because completion of the punch list is the time when the project team starts to feel fatigued and wants to move on. It is your responsibility to

motivate the team to finish the project so you can move on with no strings attached. Retainage, hold-backs, and the contractually required weekly and monthly updates are your tools to ensure this task is completed.

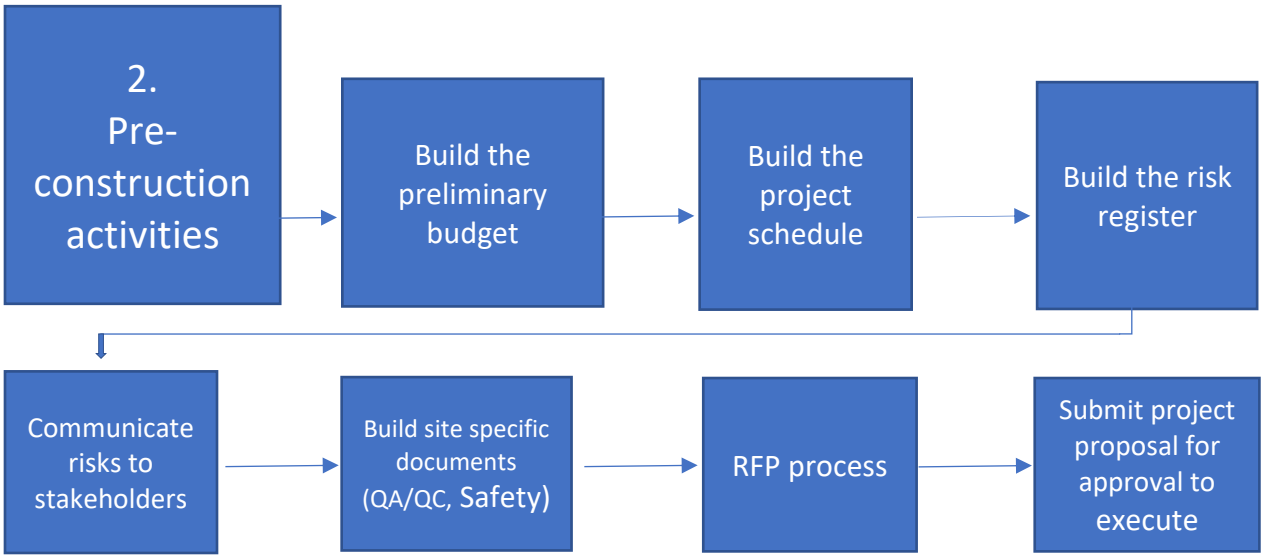
Chapter 13

Project Management Strategy Map

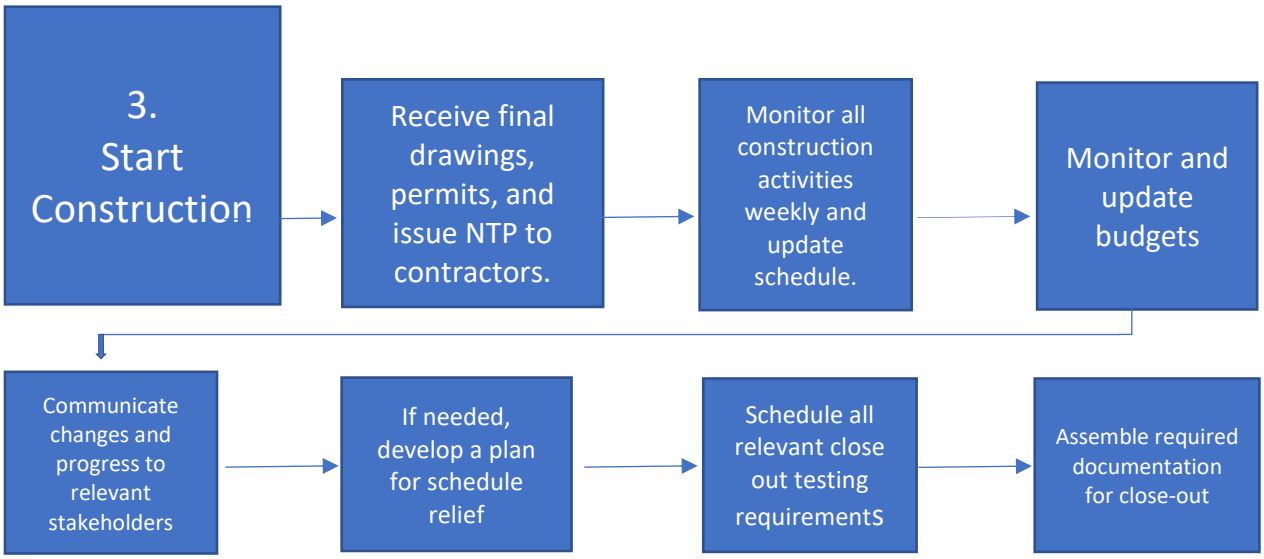
Below is a flow chart of what the strategy timeline would look like and when the specific tools should be implemented. The first milestone we will outline is receiving the project:



After conducting these analysis, we will have a better idea of the project, all stakeholders involved, the constraints, strengths, and optimal strategies to execute the project. We will then move on to pre-construction activities as outlined here:



After submitting the project for approval, it may be denied for any number of reasons. The most likely reasons for rejection are budget followed by schedule. If the proposal is rejected, you will most likely need to start one of these items over again such as searching for better technology options or starting the RFP over again. During this time, it may be necessary, due to time constraints, to complete a small portion of the project. An example would be starting tree clearing during certain times because the window for such an activity is short, due to an endangered species nesting time which doesn't allow you to fell trees during nesting season. If you have the permit available, it may be beneficial to request approval to commence a specific activity in the near term, to save the project schedule in the long term. Ordering equipment well before the start of construction due to their long lead times is another example.
After the project is approved it is time to commence construction. The below flow chart should be used for monitoring purposes:



If you have closely followed the strategy map by monitoring the schedule and budget, this really should be all the PM does during the construction of the project. This may seem like an over-simplification, as there will inevitably be some bumps in the road, but the idea behind all the upfront analysis is to mitigate as much risk as possible and find the easiest strategy to construction. If done correctly, a project really is smooth sailing and the construction should be

the easiest part for the project manager. Most of our work is done in the preconstruction phases. It is the reason a good PM can manage multiple projects in construction at the same time.

Chapter 14

Project conclusion and Testing

My original intention with this conclusion was to test the application of my strategy map towards the lifecycle of a real project, but due to time constraints I was not able to do so. However, I was able to test the strategy on a real problem we encountered during the close-out of a project. The description and results are as follows.

Scenario:

I was hired into a new company, and they immediately placed me on a project that was in trouble financially. The project was hemorrhaging millions of dollars every quarter due to the grass not growing. The county mandated that we reseed the project every growing season. The total acreage left to re-seed when I inherited the project was 1,564 acres. Until this point the company re-seeded 6 times and the grass would not grow. I was tasked with closing out this project so the company could stop taking a loss.

Strategies:

Step one was identifying my team and implementing workshops to discuss the best possible path towards a solution. In these workshops we started with Porter's 5 forces. As the only new change in the management of this project, this was the best way for me to understand the different entities involved. The major two forces identified was the county, and the contractor we hired to build the project.

Next, we conducted a SWOT analysis. I needed to understand our position better and what left us exposed. This was the best way and it was eye opening for some of the veterans on the team as well. I discovered that we are losing money because we were weak contractually with our contractor. Every time we were required to re-seed, it constituted a change order at a loss to my company, but there were tools we were not using at our disposal. Some of our strengths identified were we are the owner and we don't have to approve every change order without an attempt at an alternative. This meant we could look into other strategies. Also, the change in

project management was considered a good thing to the county, as their relationship with my predecessor had soured.

Some of our weaknesses identified were our weak contract with the contractor and our weak negotiations with the county. Never was an attempt made beforehand to discover the root cause of the lack of growth. Examining this we recognized an opportunity to change the seed mix and sequence of seeding. Our biggest threat was the county and the constant application of seed requirements. We were living with what should have been identified as the biggest threat and risk to the project beforehand. Proper redline reviews and negotiations would have identified the risk posed to us incurring all costs, in an area which is historically known as difficult to close, the environmental related permits.

Next, we conducted a TOWS analysis and formulated the strategy to take samples of the soils and send to a lab for their recommendation on the best methods to grow grass for stabilization, while implementing the native seed mix required. This resulted in a new proposed mix and a schedule along with recommended applications of fertilizer and lime. But this did not mean we would be able to implement it, we needed county approval. We developed a strategy cascade for the best course of action, it started with requesting to modify the current seed mix with the county, along with a detailed schedule of the seeding and maintenance. The county approved and we denied the current change order that was sent to us by the contractor, and required a new change order encompassing our requirements.

I built a new budget for the seeding activities moving forward along with the revised change order and schedule. My company approved and we were now implementing and monitoring the new plan.

Results:

As discussed earlier, my company previously attempted grass growth 6 times with no results. What I was recommending were two more growing seasons. The contractor initially quoted $20

million to achieve the work. However, since seeding has occurred 6 times already, we felt as a result of the study, some of the older seed would start to take hold with applications of fertilizer, lime, and time. We denied the change order and decided to take it month at a time and start in the worst areas. This proved a success, not only did we achieve the grass growth, but the total spend was $14.5 million. We also mandated a warranty for everything that was seeded within the last two growing seasons. That warranty came at a cost of $1 million, leaving the actual seeding cost to be $13.5 million. We saved more than $5 million and were able to achieve close out with the county.

Conclusion

This scenario outlines the current project management strategies within the solar industry as reactionary and minimal. On the surface it is easy to look back and think, why didn't anybody gather soil samples before? Or why didn't anybody ask for a warranty? This is normal in our industry and the root cause is the lack of communication between each department or stakeholder. The strategies I have outlined serve the purpose of facilitating this communication and finding the most efficient way to build a project. None of which were conducted at any point during this project. I believe taking the time to conduct proper analysis, with the flow and details required of each, by every member, will result in the successful completion of any project. What sets this apart from any current book or guide on project management, is the "how to apply" methodology. You will find many resources which document SWOT analysis, but none which will help you apply the analysis in a productive way toward the completion of your project in our industry. Combining all the strategies will better prepare you for the worst-case scenarios, or better yet, how to avoid them.

Aside from a risk register, I would argue that a lot of the tools in this paper remain untouched in the application of project management in the solar industry. The reason is most project managers are untrained, or don't prioritize proper planning of the projects. They may not see the value in such tools and judge them from on the surface as unnecessary. The application of the tools, and how to conduct an overall analysis to their usage is what I am attempting to

illustrate. Porter's 5 forces, communication plans, and the TOWs analysis all serve to force the PM and other stakeholders to strategize the proper approach to each project because they are all different. Porter's 5 forces introduces the PM to not only immediate threats to the project, but more potential risks in the long run, such as solar panel pricing and availability. The SWOT may identify your strength, opportunities, weaknesses, and threats, but the TOWS forces your team to generate a proper execution strategy reflective of your SOT analysis. I also want the reader to understand the importance of redline reviews and contracting. The PM is held to the stipulations in the contract, thus they should study, and campaign for a contract that protects them and their company during the execution of the contract. Intricacies like redline review strategies are not easily found in other project management literature such as the PMBOK, which excels as introducing the tools in detail, but leave out the detailed strategies specific to the expanding solar industry.[12] These tools and strategies are meant to guide the reader to conduct a case study of each project before execution so they can identify the best possible approach towards a successful construction process. Lastly, I hope this paper successfully stresses the importance to building a project sustainably, after all, clean energy is the industry we are in. While this guide is meant as a strategy for PMs, I would encourage the continuation of research into sustainability and reading articles such as "Earned Green Value Management for Project Management: A systemic Review.[13] Adding value to the project not only increases your project's stock, but your professionals tock as well. Every clean energy company has the mission to create long term value through clean energy, the more you can contribute to this effort, the more value you hold.

[12] Project Management Institute. (2017). *A guide to the Project Management Body of Knowledge (PMBOK guide)* (6th ed.). Project Management Institute.

[13] Koke, B., & Moehler, R. C. (2019). Earned Green Value management for project management: A systematic review. *Journal of Cleaner Production*, *230*, 180-197. https://doi.org/1 September

Appendix

Figure 1: Stakeholders and Communications Plan

Stakeholder	Message	Purpose	Means/Frequency	Evaluation
Engineering	Initiate the design. RFP process. Periodic updates, and drawing reviews 30%, 60%, 90%, IFC.	Project engineering design.	Weekly if schedule shows a need for it. Periodic based on %.	Delivered drawing sets.
Procurement/Logistics	Clearly be able to illustrate the cost/benefit and technical specifications of equipment needed. Lead times and delivery dates.	Ensure successful delivery of equipment and schedule.	Weekly if needed at start of project though delivery of final equipment.	Successful delivery of all equipment.
Construction manager	Input during design phase. Input of feasibility for the schedule and labor of project.	Minimize execution, schedule, budget risk.	Weekly standing meeting on top of probable daily conversations.	Completion of project.
Company leadership	Periodic project updates.	Communicate any budget or schedule slip.	Weekly, maybe monthly.	Action items from meeting.
AHJ	Permitting and inspection needs.	Required	As needed	Issue and closure of permit.
Commissioning	Communicate schedule and dates needing commissioning.	Schedule requirement	Towards the end of project, as needed.	Project commissioned

Project Owner	Project update	Required update	As mandated. Probably monthly	Action items from meeting.
Subcontractor civil	Schedule and price. Status of work update.	Required update to understand project progress.	Every morning	Progress updated
Subcontractor mechanical	Schedule and price. Status of work update.	Required update to understand project progress.	Every morning	Progress updated
Subcontractor electrical	Schedule and price. Status of work update.	Required update to understand project progress.	Every morning	Progress updated
Safety	Discuss any safety incidents or needs.	Reporting purposes and prevention	Weekly	Action items needed
QA/QC	Discuss any QA/QC concerns.	Reporting purposes and evaluation.	Weekly	Action items needed
Third party inspector	Required for certain scopes. Witness test or county inspections are examples.	Required inspections for closing out project.	As needed	Action items needed

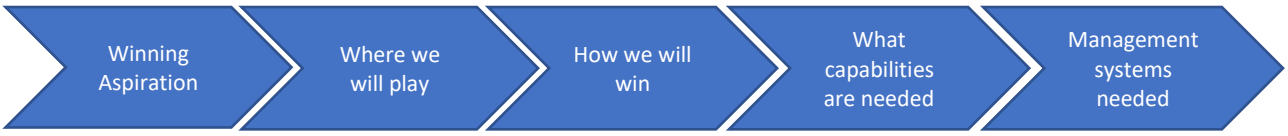
Figure 1: Stakeholders and Communications Plan

Figure 2: Team Charter

TEAM LEADERSHIP		
Workshop Role	**Name**	**Contact Information**
Sponsor		
Workshop Leader		
Team Leader		
Process Owner		
Lean Project Manager		

	TEAM MEMBERSHIP		
	Job Role / Title	**Name**	**Contact/General Information**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Figure 3: Strategy Cascade



Winning aspiration: To complete the project on time and under budget.

Where we will play: Project size and location

How we will win: Think of some high-level advantages here. Did the contractor have a great relationship with the AHJ in this area. Is there no rock affecting post drive or barely any trees which need to be cleared resulting in a cheaper and faster civil scope?

What capabilities are needed: Is there anything lacking which will need to be addressed? m?

What management systems will be needed: Will you need to hire a safety manager? Or a QA/QC manager? Is there any scope of the project unmanaged?

Figure 4: Smart Goals

Specific	**Measurable**	**Achievable**	**Relevant**	**Time-based**
Build the project under a certain budget	Monthly review of current budget actuals compared to tracked spending.	Monitoring of labor (internal and external) and schedule of activities.	Budget and schedule are two most relevant.	Refresh with budget actuals every month and monitor spending.
Build the project on time	Create schedule with milestones per block, array, circuit, section, task, etc... Whichever unit of measurement you decide.	Monitoring progress weekly and adjusting execution construction strategy based on schedule needs.	Budget and schedule are two most relevant.	Update progress weekly and monitor for schedule slip.
Build with exceptional quality	Reporting from QA/QC representatives illustrate how well the build is.	Monitoring of reports. Not releasing subsequent areas for build until the previous area has been repaired. Setting the standard with a first build inspection.	Poor quality results in re-work which slows down the schedule and costs more in man hours.	Monitor QA/QC reports weekly. Daily if they are not showing desired result.
No safety incidents	Safety inspections and reports. Incidents recorded.	Constant implementation and marketing of a strong safety culture.	Safety of employees should always be the main priority of any workplace. Certain safety incidents are OSHA recordables.	*Daily safety talks. Monthly safety presentations. Safety talks customized for each task before beginning.*

Figure 5: SWOT analysis

Project X	**Opportunities: What trends can help us?** **O1:** The civil scope will be fast and inexpensive. **O2:** Money saved by the layout of the project. Less customization in the racking has provided the opportunity to save on the budget. **O3:** Electrical subcontractor is known and trusted.	**Threats: What trends may have a negative impact?** **T1:** Tight schedule **T2:** Hurricane season upcoming. **T3:** Possible delivery delays of modules.
Strengths: What do we do well? **S1:** No tree clearing **S2:** No rock found in Geotech report. **S3:** Project is rather flat with a box like design. **S4:** The local AHJ is pro-solar and easy to work with.		
Weaknesses: What can we improve? **W1:** Very long medium voltage run to the interconnection. **W2:** Mechanical subcontractor is new to us, and we have no experience to foresee performance guarantees. **W3:** High expectations and standards set by the project owner. **W4:** New project construction team.		

Figure 6: TOWS analysis

Project X	**Opportunities: What trends can help us?** **O1:** The civil scope will be fast and inexpensive. **O2:** Money saved by the layout of the project. Less customization in the racking has provided the opportunity to save on the budget. **O3:** Electrical subcontractor is known and trusted.	**Threats: What trends may have a negative impact?** **T1:** Tight schedule **T2:** Hurricane season upcoming. **T3:** Possible delivery delays of modules.
Strengths: What do we do well? **S1:** No tree clearing **S2:** No rock found in Geotech report. **S3:** Project is rather flat with a box like design. **S4:** The local AHJ is pro-solar and easy to work with.	**Strategies that use strengths to maximize opportunities.** **S1:** Civil scope will be fast. Use this to provide schedule relief elsewhere. **S2:** Electrical installation should be simple with a trusted subcontractor and a county willing to work and provide timely inspections. This allows more focus on the mechanical installation of the project. **S3:** Money saved by the layout of the project helps if needed with mechanical labor.	**Strategies that use strengths to minimize threats.** **S1:** Tight schedule alleviated by the expedience of the civil scope. If need be, release the project to electrical and mechanical subcontractors by completed civil sections. **S2:** Project design allows us to build and open trenches in a particular order. The AHJ will understand the need for timely inspections during a hurricane season. Open a certain length of trench, install wire, inspect immediately and close. Do not leave an open trench open unnecessarily during the bad weather. **S3:** There are possible deliver delays of modules. We should build a sequence with electrical and mechanical which takes us up to the point of no deliveries. Evaluated how much more schedule is needed and update a schedule reflecting the delay. We will probably have to collapse racking crews on module crews to double the production of modules

		installed once we receive modules.
Weaknesses: What can we improve? **W1:** Very long medium voltage run to the interconnection. **W2:** Mechanical subcontractor is new to us, and we have no experience to foresee performance guarantees. **W3:** High expectations and standards set by the project owner. **W4:** New project construction team.	**Strategies that take advantage of opportunities to minimize weaknesses.** **S1:** The long interconnection run will take time, but it's a stand-alone task with no real bearing until the end of the project. The problem is the expense for the long run. This expense is alleviated by the amount saved not only on the civil scope but the opportunities from the layout of the project. **S2:** Trust in electrical subcontractor gives more opportunity to supervise mechanical subcontractor. **S3:** New construction team is afforded the opportunity of a rather straight forward and simple project. Great opportunity to start with a simple project to learn the ins and outs of the company.	**Strategies that minimize weaknesses and avoids threats.** **S1:** Our threats are schedule based. We should execute as much on the front end as possible to eat up and possible delays and work through the growing pains of working with the expectations of the owner. **S2:** New teams should be supervised by experienced company personnel while the project is being built. Throwing them out onto the project with no guidance or set expectations is asking for the project to fail, even if it is an easier project. **S3:** Owner expectations can be quite burdensome and costly, especially on the safety aspect of the project. Keep this in mind when building out the schedule and budget. Read and understand the contract, know it inside and out and don't be surprised.

Figure 7: Porter's Five Forces Model

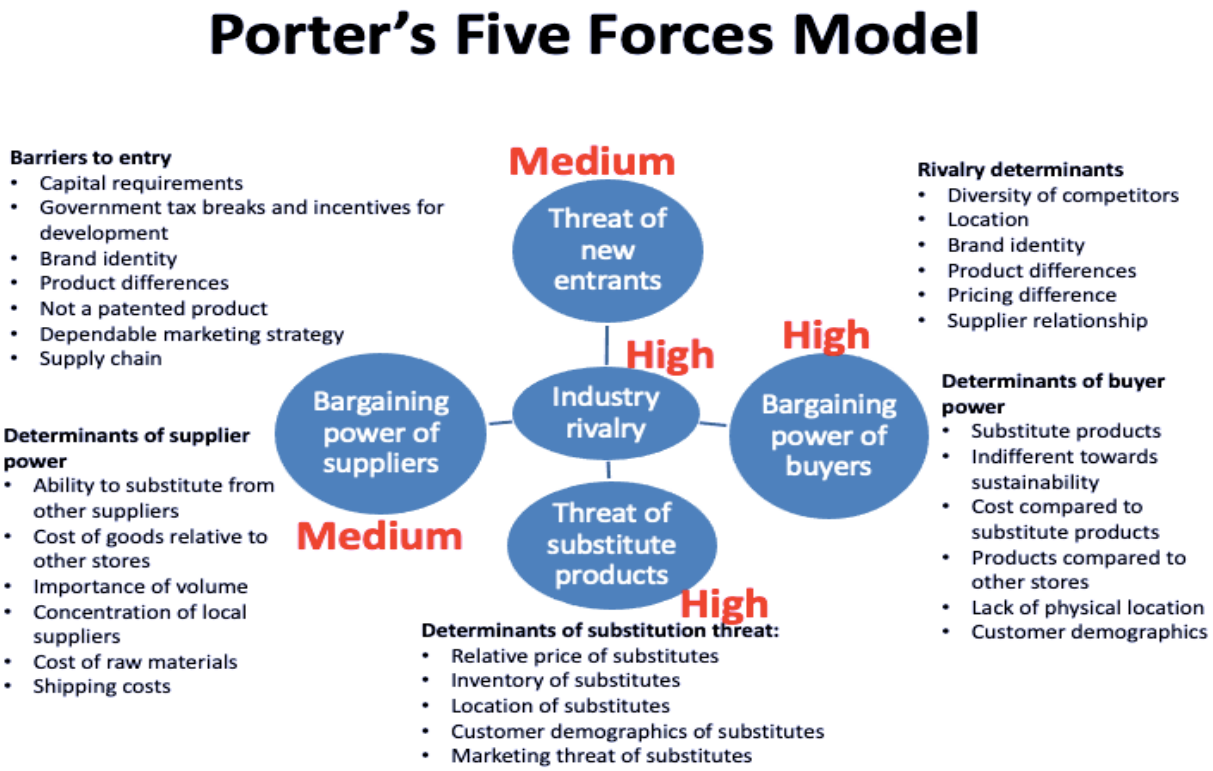


Figure 8: Risk Register

Item	Date	Description	Likelihood	Severity	Budget Impact	Schedule Impact	Responsibility	Mitigation measures	Status
1	6/20	No Purchase Order for modules have been placed. In today's market the module cost could increase sharply and suddenly.	Medium	High	High	Need delivery dates to build schedule. Only a risk because they should have been ordered.	Procurement/PM	PO's need to be placed immediately. What is $.33 today, could shoot up into the high thirties', maybe even forties based on the political situations in today's market. If it did, that would kill the project.	Open
2	6/20	Module delivery dates miss window	Medium	Medium	Medium	One day lost per one day delayed	Procurement/PM	Solidify the delivery window asap. Adjust construction schedule and plan accordingly.	Open
3	6/20	New Subcontractor	Low	High	Medium	N/A	PM/CM	Use Notice of deficiencies and administrative measures if necessary to keep contractor on track. Will be needed to replace if necessary. Weekly updates on progress and schedule.	Open
4	6/20	Permit amount uncertainty	Medium	Low	Low	None	PM	We still don't know how much the permits will cost and have no historical data to pull from. It's unlikely it will be a project killer, but still can't plan the impact to the budget.	Open
5	6/20	Short on some project staff	Low	Low	Low	None. Should be able to start the project on time.	HR	Hire and fill these positions. We have time.	Open