Engineers for a Sustainable World
DESIGN • EDUCATE • BUILD

Project Tracking Document

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Overview

The following guide is designed as a step by step guide to help ESW chapters identify, select, develop, and complete projects. Because of the wide variety of projects that different chapters may pursue, it is difficult to write a detailed procedure for completing a project. This guide will focus on the process of developing such a project from beginning to end.

This guide is broken into sections and chapters. Each chapter has a few brief questions at the end. The end-goal is the creation of a web form where your responses will be logged on the website for you to access and review at any time, and transmitted to ESW-National so project support staff can respond to any questions you have or discuss the project with you and/or your chapter leader. The questions are meant to help the ESW National Team understand the needs of your project and provide as much support as possible. Of equal importance is providing the opportunity for your group to reflect on the information covered and consider whether or not the work outlined in each chapter has been completed.

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Table of Contents

Section 1: Needs Finding 2
1.1 Intent / Customer goals 3
1.2 Customer Requirements 4
1.3 Technical Requirements 5
Section 2: Identifying a Solution 7
2.1 Evaluation Metrics 7
2.2 Brainstorming 8
2.3 Evaluate Options 9
Section 3: Propose Solution 11
Section 4: Developing a Project 12
4.1 In-depth Research 12
4.2 Make a Plan (Scheduling) 13
4.3 Budget 15
4.4 Identify Key Resources 15
Resources 18

Section 1: Needs Finding

A need in this sense is (likely) not a literal need (food, water, shelter, and clothing) but it is the requirement that we are trying to fulfill. This requirement may be for truly novel or, more likely, it will be to fill a gap in existing knowledge, technology, or practice on your campus or in the community. Said another way, the need is what the project needs to do/ be to be valuable to the end user.

A project starts not with finding a project, but with finding a need. By finding a need, then developing a project to meet that need, the project will be much more focused, and tailored to the specific requirements of the stakeholders. As a result of taking into account situation specific conditions the project is much more likely to be successful.

As an example, let's say I have the idea of turning the exercise bikes at the gym into generators to power some of the lights. This could very well be a good project. We should probably look at the sustainability of this project before pursuing it, but on the surface it seems like a good project which is well aligned with the goals of ESW and is something that we might easily get members interested in. Additionally, it is a highly visible project which is good for our organization, and is an easy idea to explain.

However, if we look at the bigger picture, what is the need? The goal of these bikes could be more specific, but it is likely to be to "reduce energy consumption at the gym." If we start with the need to reduce energy consumption at the gym, and dispose of the notion of these bikes, we will likely find more cost and time efficient ways to meet this goal. For example installing more efficient lighting, putting timers or motion sensors on the lights, installing programmable thermostats, improving insulation, etc.

So, how do we find a need? More importantly, how do we find an important need that is worth our time and energy? Additionally, let's not forget that it is important to choose projects which the membership is interested in pursuing. Needs are easy to find by looking around our campuses and our communities. Maybe we want to take on the high energy consumption of campus buildings, or the excess waste created in the cafeteria. Maybe we want to take on the lack of recycling containers on the town's main street, or the poor state or limited availability of public green space.

When looking for a need, we need to find something specific. We need specific customers or stakeholders, as well as partners, with whom we can communicate. Saying we want to build solar systems to bring electricity to a remote village is not specific enough. Let's take a look at why:

> What is the need... electricity? Electricity in itself is not a need; what is the need for? If the need is to charge a cell phone, that is a drastically different project than if the need is to light a school for night classes. The need for "electricity" does not cover the drastic difference between these two projects. If we overlooked this distinction we would likely have overbuilt the project, wasting time, resources, and money. Or we would have underbuilt the project and it would have gone unused because it failed to meet the users' needs.

One of the most important early steps in developing a project is finding the right project partners. ESW is comprised of students that are often, in the best case, only with the group for four years. Hopefully our projects will last more than four years. Not that they will take

that long to complete, but their effect will last for years to come. How can we ensure that our projects will serve their purpose for as long as possible? Finding the right partners, who may not be able to do the work without the help ESW will provide, but have a vested interest and the skills and resources to maintain the project is critical to the long term success of the project. This partner may or may not be one of the primary stakeholders in the project. For example, the partner may be a non-profit organization who has similar goals as ESW; to help people live better, more sustainable lives. In this case you and your partner are separate from the primary stakeholders, who are the people directly benefiting from the project. Conversely, if you are trying to improve the efficiency of a campus building, the Facilities department of your school may be your partner and one of the major stakeholders of the project.

Finding (a) good partner(s) who will have a long term relationship with the stakeholder(s) is very important to the long term success of a project. Additionally, after the successful completion of the first project, the partner is likely to suggest further needs/projects. If both parties are happy, a long term relationship may develop. At the same time, if it is not in the chapter's best interest to pursue further projects with that partner, you should not feel obligated to continue the relationship. The same applies if you look into a project, then decide that it's not right for your group. It's better to walk away from an idea on paper than to have a half-implemented solution that lacks the resources and commitment to finish.

Be wary of partners that suggest specific, fleshed out projects. While these partners may have started with the need and worked their way to developing a project before discussing with ESW, it is important to discuss the need and the process that leads to the projects. Your ESW group may have ideas for a project that finds a better way of meeting the same need.

Some ideas for project partners include:

- Campus facilities or dining departments
- Local parks and recreation departments
- Neighborhood development organizations
- K-12 schools (private is easier than public) or science museums
- Campus academic departments such as environmental engineering or sustainability studies
- Local businesses, especially those that cater to college students

Questions

- What is the need you will address?
- Why is this need worth of your group's time/energy?
- Who is/are the stakeholder(s) who will benefit from the project?
- Who is/are your partner(s) for the project?

1.1 Intent / Customer goals

Okay, so we have found a need. Ideally we have a project partner and a specific customer that we can work with. What's next? Figuring out what the customer really needs!

Ideally the need as defined above was specific, and gives a good clue as to what the customer actually wants. However, we need to make sure we fully understand the customer's goals. Let's take the example used previously of reducing energy consumption

at the campus gym. That seems like a straightforward goal. However, we should try to look for more details about the motivation of the project. What is the goal? Is it simply to be more sustainable? Is it to save money? Is it to appear more “green” or environmentally friendly (independent from actually being more sustainable)? Or is it something else?

Start by having a high level conversation with the customer to make sure that the goals of the project are understood. This is not a big step, but should serve as a check to make sure we understand what the customer is really trying to accomplish. This can be rolled in with the conversation from the next step: developing customer requirements.

Here are some questions which would be discussed/worked out with the customer:

- What does the customer actually want to accomplish?
- How is this project going to fit into and improve their life, their community, the planet, etc.?
- What is the ideal result? Create a vision or “perfect case” sort of long term plan
- Who are other customers and stakeholders who should be involved? What can they contribute to the vision and project process to help make it successful?

Questions:

- Did any differences in the understanding of the project goals arise?
- In broad terms, what is the goal of the project, and why is it worth pursuing?

1.2 Customer Requirements

So far we have identified a need and in speaking with the customer and project partner we have a good understanding of the goals of the project. The next step is to understand the customer requirements. The customer goals above were general concepts that are important for understanding the overall aim of the project. Customer requirements are much more specific than the goals. They are specific items that the customer requires from the solution. Obviously, this is very important information for us to understand if we are going to develop an effective solution for the customer, so don’t skimp on this step. Ask as many clarifying questions as possible. It might take more than one meeting with the customer to fully understand the goals and requirements of the project.

Failing to meet customer requirements means that it is unlikely that the solution will be adopted. Unfortunately this applies to customer requirements that were not uncovered or understood, so it is critical that this process be exhaustive and extensive.

Often asking the customer “what are your requirements for the project” is not going to cover it. The answers that result from such a broad question are not wrong, but they are likely not complete, and often are not specific enough to be actionable. A more in depth conversation of how the solution will take shape will be required. Also, accept that this may be an iterative process. Your group will work through this process and propose a solution to which the customer will say, thanks, but it’s not really what we want because “XYZ”, or could we improve this by adding “ABC”.

Let’s take the example of the gym again. Obviously “needs to reduce energy consumption” is a requirement. However, with careful discussion some other requirement that come out might include:

- Cannot require significant staff intervention to operate
- Cannot interfere negatively with gym goers experience

- Must not cause any new safety concerns
- Must not void warranty on any existing equipment

Here are a couple examples of how to narrow in on customer requirements:

Customer: “It must be easy to move”

You: “By one person? Or would a two person move be okay? Does it need to be carried up stairs? Could we put it on wheels?”

Customer: “It needs to be quiet”

You: “Quiet as in virtually silent? Or quiet as in not to interfere with a conversation 10 feet away? Or quite as into be heard from inside the house when located in the back yard?

Three things to avoid:

1. Going to the customer with a preconceived idea of what the solution will look like.
2. Preconceived ideas also often result in asking leading questions: “It seems like putting in some LED lights would be a good option, what do you think of that?
3. Asking closed questions which invite a one word response: “If I create the wonder-widget will that work for you?”

Remember to make sure to ask clarifying questions as needed. “Must be easy to use.” is not a very helpful customer requirement. How easy? Easy for whom?

If the customer has a specific idea of how address the need, now is a good time to address that. The important piece is not to challenge the customer, but to challenge the assumptions that are leading to that solution. Challenging the customer is likely to lead to hurt feelings. Challenging the assumption is likely to more potential solutions, which is good for all parties involved. The customer may have a good idea for how to approach a project, but make sure to look at things with fresh eyes and don’t get stuck with the first solution that presents itself.

Remember that after all these conversations with the customer and project partner, if things do not feel right, you can still back out of the project. If the ESW membership is not interested in the project, or is not excited about working with the customer and project partner, now is the time to accept that and back out. It is better to be honest about not being interested in a project than taking it on and doing a poor job or getting into it and not being able to finish it. Your customer and project partner will appreciate the honesty if things just are not right.

Questions

- What customer(s) and stakeholders have you spoken with so far in the process?
- What did we learn about the project from this process?
- What requirements will likely be the most challenging?
- Are there requirements that seem unreasonable?

1.3 Technical Requirements

Now that we have a good idea of the need for the project, the customers end goals, and their requirements to meet these goals, we need to work on converting these needs into technical requirements. Technical requirements are important because they give an

accurate set of metrics through which we can evaluate designs. Here are our previous examples of customer requirements turned into technical requirements:

Customer Requirement: “it should be easily movable”

Technical Requirement: The product must weigh no more than 40 lbs and have ergonomically located handles for a single person lift.

Customer Requirement: “it should be quiet so as not to interfere with nearby conversation”

Technical Requirement: The product must produce no more than 60 dB (A weighted) at a distance of 1 meter.

In the process of developing technical requirements it is important to make sure you understand the customer requirements, as discussed above. Before finalizing the technical requirements ask yourself these questions, and see if the requirements you have developed support these:

- Do we accurately understand the customer’s goal and requirements?
- Especially for international projects: what cultural barriers might exist which would influence the requirements, or our understanding of them?
- Do we fully understand how the product will be used?
- Do we have equal expectations for the performance of the product as the customer?

Before finalizing technical requirements take a minute to consider if your group has the ability to meet the requirements. If it is clear that a requirement cannot be met, go back to the customer and discuss alternatives. At this point it’s okay if there are things that you don’t know how to do off the top of your head. That’s the purpose of the design process, which we have yet to get to. However, if a customer has a requirement that is totally out of whack with reality, now is the time to start discussing it.

Hopefully the process of developing customer goals and requirements has led to an understanding of the ultimate need the product is to fill, without prescribing how the product will do so. This will allow the solution to be developed in consideration of your group’s skills and abilities.

Questions

- What is your list of technical requirements?
- What technical challenges seem most daunting?
- What non-technical challenges do you foresee?
- Are there customer requirements that could not be converted into technical requirements?
- Are there technical challenges that are simply beyond your knowledge capacity

Close of Section 1 Questions

- Overall, how do you feel the project development process is going?
- What overall concerns do you have about the project?
- What can ESW National do to support you in this project?
- Is this guide helpful? How could it be improved?

Section 2: Identifying a Solution

2.1 Evaluation Metrics

So far we've found a need, identified a specific customer for that need, and developed a relationship with one or more project partners. With the customer we have worked hard to understand the goal of the project and the customer requirements. We then turned those customer requirements into technical requirements.

Now it's time to start developing a solution. But, before we can dive headlong into developing potential solutions, we need to decide how we are going to evaluate those solutions.

Determining the metrics we will use to evaluate potential solutions early on will help us remain objective in the selection process. There may be a solution of particular interest to the group for any number of reasons. It is important however, to keep the end goals in mind and remain objective in the selection process. Having clear metrics to evaluate the solutions will help us maintain this objectivity and keep the customer's goals foremost in our minds.

The easiest place to start, the most straight-forward metrics, are the technical requirements. You'll probably want to reword these if they're lengthy, for example the metric might be "Meets portability requirement." Or "Meets sound level requirements." These shorter names will make the next step, where we want to arrange these in a concept selection matrix or other evaluation tool much easier.

Next it's time to think about metrics that may not be part of the requirements but are important to consider. Maybe these are things that couldn't be translated into technical requirements, but were still discussed with the customer. These could be secondary goals of the project, maybe something like "product should be visually appealing." This is not necessarily a requirement for success, but goals that would be great to achieve. Other things to consider are the timeline, the cost, the space and/or equipment requirements, etc. These are not necessarily specific project requirements, and indeed the customer may have no interest in these requirements. However, these internal components are important to your group's ability to complete the project, and thus are important metrics.

Finally, you may want to include "nice-to-have" or "add-on" type of items. These are things that should have little to no bearing on the successful implementation of the project, but would be good add-ons. Examples might be "provide good signage so others are made aware of the project" or add some other minor functionality. These are likely things that came up in discussions with the customer but were never deemed important enough to list as requirements.

I have laid out three different tiers above – three different levels of importance. These will fit well when we move to the recommended concept selection matrix, but it is not necessarily important to rank the metrics in these categories at this time.

Let's carry on with one of our running examples and explore some of the possible evaluation metrics for our energy efficiency project at the campus gym. To simplify things, let's assume that we have focused on finding efficiencies in the HVAC (heating, ventilating &

air conditioning) and lighting systems. Based on the previous chapters, here are some evaluation metrics that may result:

- Reduces energy consumption in the gym
- Lowers operating costs for the building
- Does not impose significant technologies campus facilities has no experience with
- Lifecycle assessment shows project to be beneficial
- Easy & intuitive to operate/set if required
- Improve comfort of building
- Not place an additional burden on facility staff
- Visible to gym goers and guests (appearance of sustainability)
- Good benefit/cost ratio
- Easy to install and maintain
- Total project cost no more than current budget of (xxx)
- Total project can be completed within one year

Questions

- What evaluation metrics will you use?
- Do these metrics accurately represent all requirements of the project? If not, what requirement could not be turned into a metric?

2.2 Brainstorming

You've probably been at this for at least a month now, maybe a couple months, finding an appropriate project, working with the stakeholders, developing the requirements, etc. After all this work, it's finally time to get to work on finding a solution. No doubt this is a critically important step in the project. But relax, it's just another step in the road, if a relatively exciting one.

One potential problem with having such a structured approach up to this point is that while you were working on all these other requirements up to this point, in the back of everyone's minds they were doing what engineers do; they were looking for (and finding) potential solutions. This is good. We want to get these ideas down. The challenge can be to look beyond them. Now that we have the full picture of project requirements it is time to step back and look for fresh solutions.

In other words it is time to brainstorm. It's time to come up with a multitude of ideas for solving this problem. Effective brainstorming is not always easy or something that most people are comfortable with. However, think about how much time and effort you have put into developing this project up to this point. This is not a part of the project that you want to rush. I find that brainstorming works best as a group setting. If you ask people to individually submit ideas the likely result is a lot of Google searches that result in the same couple of answers. I recommend starting by discussing as a group. Often ideas will flow from others ideas. After this meeting it is valuable for everyone to do a little research and come back together to discuss again, maybe a week later.

Another thing that helps me with this is stream of consciousness writing. Basically force yourself to write down whatever ideas come into your head. Start writing and don't let the pen stop moving until time is up. At the start, five minute is probably plenty of time. Having your group go through this process can be beneficial – have everyone write for five minutes then ask everyone to share two ideas that they came up with in their writing. One

of the biggest challenges in group brainstorming can be creating a welcoming environment where everyone feels comfortable throwing out new ideas. I don't have any specifics on how be more "welcoming" but be mindful of the environment and mood in the group.

After the brainstorming session you will hopefully have some outlandish ideas. That's okay. During the brainstorming process we don't want to dismiss any ideas, we want to get everything on paper first. In the next step we will start by weeding out some of these ideas and getting the list of potential solutions down to a reasonable size.

Another possibility that I want to get out there is that the process of brainstorming might show a tree structure where there are a couple basic approaches, then a lot of ways to achieve each of those. It may be valuable to make the selection in a two-step approach to limit the number of options to be considered. For example, I worked on a project involving high-productivity rooftop gardens. There are three basic growing mediums that can be used (although this depends some on the crop): soil, water (hydroponics), and air (aeroponics). In this case it was valuable to compare and contrast the general advantages of each medium first, proceeding to the next step (the concept selection matrix) to select one approach, then going back to the brainstorming step to develop fuller ideas once we knew what growing medium we were going to use. This iterative approach is up to you and will depend greatly on the project.

Questions

- How did the brainstorming process go?
- Do you feel valuable new ideas developed?
- How many ideas were developed?
- Was there anything specific that helped to create a lot of ideas?

2.3 Evaluate Options

Alright, we now have a long list of project ideas. The goal of this step is narrow this list down, and evaluate potential solutions using a concept selection matrix. This selection matrix will help us to gather all the ideas in one place and evaluate them fairly on the criteria developed previously.

This guide will not require you to use the proposed concept selection matrix. If your school teaches an alternative evaluation tool that your group is more comfortable with, feel free to use it. However, some form of objective selection tool for ranking options based on the metrics developed above is required. There are numerous approaches that work. However, an example concept selection matrix is provided in Excel format for your use, if you so choose. That template will be the focus of our discussion, so even if you don't use it you may want to take a look at it.

Completing the concept selection matrix is not an arduous task. However, we may want to slim down the list created during brainstorming a little before moving to evaluating each of these solutions. It's hard to say how many ideas should move forward to be on the concept selection matrix, but certainly at least five or six. One per active team member might be a reasonable goal. If there are ideas from brainstorming that are clearly infeasible or can't meet one or more of the project requirements, go ahead and remove them now.

Before moving on to building and populating the concept selection matrix it will be valuable to do a relatively small amount of research on each of the proposed solutions that are moving on from the brainstorming process. One option is to assign one or more ideas to each team member, who will act as that solutions advocate, researching it and presenting its benefits and disadvantages to the group. Depending on your group, it may also be beneficial to pair group members up or otherwise make small teams that will look into a number of solutions each.

Looking at the example matrix, first the evaluation metrics determined in section 3.1 are entered into Column (A). Each of the potential solutions are then entered into Row (1). Obviously, you want to keep the solution names short, but make them descriptive enough that people can understand them. This template then uses a metric weighting structure to weight things that are requirements as having a greater impact on the selection process than something that is a nice to have. I recommend using rankings 1-3 as below:

3: Most important. This is a critical aspect of the project and we really can't compromise on it
2: Important. This is important to outcome of the project. Any tradeoffs here need to be carefully considered.
1: Less Important. These are likely "wish list" type items. The project can be successful even if we compromise on a few of these.

In column (B) these ranking should be applied to each evaluation metric. Hopefully your conversations with the project stakeholders have led to a good understanding of these. Others metrics might be more personal to your group, such as time required to implement the project or cost; you will have to develop these rankings for yourself.

Once these weighting factors have been entered, it is time to start ranking each of the solutions. This is not a job for one or two people, but for the entire project team. Assuming that different people have researched different proposed solutions, they will have different biases about different solutions. It is important that the group take the time to discuss the pros and cons of each solution in relation to each metric. This process of filling out the concept selection matrix could take several hours, especially if this is the first time the some solutions are being presented to the group. Plan accordingly and don't rush things.

We will close this chapter with the completed selection matrix. The next chapter will require discussing this matrix with your project partners and agreeing on the winning solution to move forward with.

Questions

- Did you use the provided concept selection matrix? If so, was it helpful? If not, what method did you use and why?
- Do you feel confident about the values you assigned in the matrix?
- Is there a stand out winner, or do multiple projects seem like close competitors?

Section 3: Propose Solution

By the end of this section you will finally have a solution that you will move forward with. In the previous section we developed and completed the concept selection matrix. Now it's time to take a look at that matrix, work with the customer and project partners to make sure we all agree on the priorities of the project, and then start moving forward with the winning solution.

At the bottom of the matrix is a score for each proposed solution based on the ranking you gave for each criteria and the importance factor that you gave to that metric. It may be tempting to complete the concept selection matrix and simply say "this is it" and run with the "winning" solution. Before doing that though, we want to make sure that everyone involved with the project agrees to the criteria, priorities and rankings that the team developed. That's not to say we want to keep massaging the selection matrix until a solution that we "like" wins, but it is important to involve the customer and partner(s). This ensures that they understand that the selection process was extensive and can help to answer many questions that would otherwise pop up later about why an alternative approach was not chosen.

The winner chosen by the matrix will be the solution that the team will move forward with. That doesn't mean that it can't change if it has to. Up to this point, all the time and energy that was invested in the development of requirements and selecting a solution has been valuable and productive in reaching the final goal of the project. Even if it seemed painfully slow, this process was critically important to the successful outcome of the project. But after this point, a change will likely mean backtracking, and wasted time and energy.

Once your group, the customer, and the project partner(s) agree with the matrix you now have the solution that you will move forward with. Congratulations!

Questions

- Were any significant changes made to the concept selection matrix based on feedback from others? Why?
- Did the solution matrix result in the winning project that you expected?
- What is the solution that you will be moving forward with?

Section 4: Developing a Project

Okay, so we finally have a solution for our project. Well, let's try that again: We have finally selected a solution for our project. Now it's time to fully develop and plan that solution.

Before we can jump to implementing our solution we need to do some research, legwork and planning. In the following sections we will talk about how to break up a project into manageable pieces, how to identify milestones and create schedules, how to create a budget, and finally to identify challenge points and plan ahead to mitigate them.

4.1 In-depth Research

Let's take an example that we've been working with all along: energy efficiency at the campus gym. Let's say that the solution that was selected, using the concept selection matrix, was to create energy savings in the lighting system by implementing a control system which will automatically dim or turn off the lights in various zones of the building after a certain period of inactivity.

How are we going to implement this? One approach might be to solicit proposals from local contractors, evaluate them, and hire the lowest bidder that meets your requirements. To be fair, developing the request for proposals (RFP) for such a job is not an insignificant amount of work. However, it is not a very fulfilling or educational process for your group. In other words, it relegates your group to a much more administrative role. After all, we are Engineers for a Sustainable World, so let's do a little engineering work ourselves.

So what do we really need to do in this step? We need to do some research. We need to understand what options are out there. We need to understand what is involved in each of them. Most importantly we need to start identifying what will work for this project. Once you've done some research, take a look at the questions at the end of this section and begin to craft some thoughtful, honest answers. We have already (partially) answered some of these questions in selecting this solution, but we should further develop this information.

At the end of the day we want to identify what will be most challenging about this solution, but also reassure ourselves that the solution is viable.

The next step is to develop a better understanding of what constraints our project will have to operate under. For example, in selecting this project (hopefully) we understood that any high voltage equipment (usually above 48V) will have to be approved by Underwriters Laboratories (UL Listed) if we want to install it in a campus building. This rules out building a dimmer panel ourselves, though it likely says nothing about the photocells. And certainly you are going to have to work with the electricians on your campus to get all this installed. What level of involvement are they willing to take? Will you have to hire external help? And certainly they may have an opinion about you building and installing your own photocells.

Also, we need to talk with all project stakeholders again specifically about this solution. People like the campus facilities department (in our example,) will need to answer questions such as how they are willing to help. If any of these stakeholders will be responsible for ongoing maintenance (and every project needs to have a plan for maintenance!) it is important to discuss the requirements with them and their capacity to maintain the project.

Questions

- What challenges will your team face?
- What resources will be required?
- What outside expertise would you like to bring in? Do you have an avenue to obtain it?
- What will the project budget look like?
- What timeline are you looking at?
- What solutions are commercially available to help toward our selected solution?
- What partners are available to help with this? What new partners will you require?
- Have any issues arisen in working with project partners or other stakeholders on this solution?
- What other project specific information are you considering at this point?
- Does the project still feel doable?

4.2 Make a Plan (Scheduling)

Now that we have a better idea what will be involved in the project it is time to start laying out a plan for completion. Most important is to start developing a timeline. At this point it's probably not possible to have a highly detailed schedule. That's okay. The goal is to have something down on paper to help us understand the steps and phases of the project that remain.

Don't forget to take into account finals, midterms, breaks, and holidays. I know it can be tempting at the start of a project to say "oh, yeah, we'll get together via Skype over winter break and keep making progress." In my experience it rarely happens this way. Also, make sure to leave yourself some time for the unexpected. Things will happen, there will be hiccups along the road, and your timeline should have some flexibility to allow for that. If the schedule seems cramped now, it's going to seem even more cramped in another few months. Remember that this is all secondary to school work. Even if we would like to, we can't all put in 15 hours a week on ESW work while keeping up with our other responsibilities.

Below is an example schedule for our gym energy efficiency project, though it could apply to many other projects as well. Note that it's not super detailed, and only has deliverables or milestones roughly every two weeks. As the project continues and develops this timeline should be updated and more detail should be added; moving to, at minimum, weekly deliverables.

As you can see from this schedule, there is a lot going on. And it will only get busier looking as detail is added later on. Clearly there are more pieces in motion here than one or two people can handle. Although having a project leader is important, equally important is being able to delegate work.

At this point I recommend looking into what major sections the project can be broken down into. Creating these smaller chunks of work will help make the project appear more manageable, focus the team on the immediate task, and help to divide resources between different tasks. Not everyone can be involved in every part of the project. Some of these sections must be completed before another can start, some can be completed concurrently, and some can be staggered. That means that the same people can be on multiple section teams, but not necessarily any combination.

Month	Tasks (chronological order)
September	Welcome new members Begin search for new project Identify new customer/client and potential sponsors
October	Develop customer & technical requirements Brainstorming session
November	Select solution and discuss with stakeholder Solution development
December	Preliminary timeline, bill of materials, budget
January	Continued design work Complete detailed solution, final design review meeting
February	Finalized bill of materials/budget Begin procurement and final preparations for installation
March	Continued work on installation, procurement completed Installation completed
April	Testing and verification Final documentation
May	Lessons learned Project report submitted to ESW-National Documentation submitted to customer

Looking at the timeline above, the project could be broken down into these major sections:

- Detailed design – high voltage
- Detailed design – low voltage
- Procurement
- Documentation, signage, and community relations
- Testing & verification (pre and post installation)
- Installation

Next, we can assign team members to contribute to each of these sections. Each of these subteams should have a designated leader. Leaders should meet regularly with each other and the project leader to make sure that all of their work meshes together. More information on suggested leadership structures are available in the Resources.

As each subteam starts work they should build a detailed schedule for completing that section's work on time. Scheduling is not as simple a task as it may seem at first. A simple timeline as presented above is acceptable to get started, but as we work to develop a detailed schedule we will want to consider other formats.

One modification to the timeline structure that can be helpful is "backwards" scheduling: working backwards from the deliverable. This may be challenging if the steps to our end goal are not clear – we are naturally more comfortable thinking in a forward direction. Once we have an understanding of the steps to our project it may be helpful, however, to develop a timeline in the backwards process to see where you end up. Compare your deliverable dates to the timeline you made working "forward". If there are significant

differences between the two it likely means that the project timeline is very tight and you should re-consider the deadlines or the scope of work.

A Gantt chart is a commonly used structure for project scheduling which provides significantly more detail than a simple timeline. A Gantt chart shows not only when a task is scheduled to be finished, but when it will start and who is responsible for that task. A Gantt chart can also be helpful for showing dependencies: task A can overlap with tasks B & C, but must be complete before task D can begin.

There are many good tools available to help with scheduling of your project whether you're using a Gantt chart or some other format. Microsoft Project is a tool that is commonly used in industry; if your school has it available you may want to check it out. There are also many scheduling templates in Excel format readily available for free online.

Below is an example of a more detailed timeline the high voltage design team. They might create a timeline like this in their first week of work so they are ready to dive in and go when they get back from winter break.

4.3 Budget

While we would all like to have the money to do whatever we need to, this is obviously not the reality of our (or any) organization. As such, we must be conscious of how much our projects will cost, and how we will obtain funding to complete them. Hopefully cost was considered at some level in the solution selection process and you have a rough idea how much the project is going to cost.

Much like we developed a rough timeline, it is important to start developing a budget for the project. However, before we can start building a budget we need a list of materials, otherwise known as a bill of materials. The final bill of materials will depend on the final design, which we don't have yet. However, we want to start developing a list of the major components that we will need. Like everything else at this point, it is subject to change.

Once we have all the major components down we can start to put ballpark prices on these items and the total project. There may be many other small ancillary items that we know we need but have not specifically called out or priced yet. Adding a line item for miscellaneous may be a good choice at this point.

Below is an example preliminary budget for our smart lighting project at the gym. As you can see it is not a highly detailed document at this point. Note how the budget has been broken down by the sections of the project as discussed in the scheduling section. Each section team is then responsible for updating and controlling their own budgets.

Much like the schedule discussed previously, the budget is a living document. It should be updated regularly to incorporate changes and added detail as the project progresses.

4.4 Identify Key Resources

The last thing we have to do before diving headlong into nitty-gritty of completing the project is to identify key resources that will be needed to complete the project. In many ways we have already done this. We have hopefully considered things like cost and our group's abilities and limitations in the solution selection process. Now however we want to identify what the sticking points will be moving forward. In other words, what are the

challenges going to be? Is the biggest challenge going to be coming up with funding? Or will it be finding space to work on/store the project on campus? Or will it be finding a way to machine that part you're going to need?

Look back over the timeline – where does it look tight? What can be done to ease this?

Look over the bill of materials & budget – what challenges will arise?

Go back to the concept selection matrix – in what areas did the selected solution not shine? What can be done about those, if anything?

Going over all of this is likely to make the project look that much more daunting. Don't get discouraged. The goal here was to identify the pinch points that will hold up the project. The next part is the most important: figure out how each one of these challenges can be met. What steps will you take to ensure that these challenges are met? Certainly getting the group together to discuss these challenges and how they will be handled is important. However, your faculty advisor and other campus staff may be helpful with many aspects.

Here are some resources to consider contacting in answering these questions:

- Campus facilities department
- Engineering societies on campus (IEEE, ASME, etc.)
- Professors
- External organizations with relevant experience
- Community groups with relevant experience or similar focus/goals
- Professional mentors
- Companies in their area
- Fellow students
- Other ESW chapters
- Your ESW National Team contact(s)

Here is an example of identified challenges and the measures that will be taken to mitigate these challenges:

- Funding – we planned a total budget of $1,000. Coming up with another $400 may take a lot of time in fundraising.
  - We will approach the school of engineering to request additional funding for this project
  - We will approach the athletic department that runs the gym – as the energy savings will accrue to them they may be willing to chip in on the project
  - Start this process early so that if we need to resort to other methods we will have time
- Working with facilities department – We have no experience working with the facilities department and while they have agreed to be involved we don't know how helpful they will be.
  - We will maintain regular contact with the department and set up face to face meetings whenever possible
  - We will develop a contingency plan to get part of the help we are hoping to receive from them from an outside electrician.
- Technical Knowledge – While we have an understanding of the technologies and mathematics behind the design, we are not familiar with the intricacies of the national electric code, which the project must comply with.

    - We will try to learn the basics of what is required for the work we are looking to perform
    - We will find a licensed electrician, possibly from the facilities department, who will work with us and review our designs to ensure they are code compliant
- Procurement – The time between finalizing the design and beginning installation is short. If any item is backordered or otherwise takes a long time to be delivered this could negatively impact the schedule.
    - Most likely these are the larger, costlier items, and thus will be decided on earlier in the design. We will move forward with ordering them as soon as possible.
    - We will identify two possible vendors for each critical component, if possible. If this is not possible we will identify an alternative product for each critical item.
    - We will work with our university contact for procurement to understand what the process will be, and make sure they understand what our needs are so there are no unnecessary hold ups.

Questions

- How does the timeline for the project look? Do you feel comfortable with the time available?
- How does funding for the project look? What are the broad plans for fund raising?
- What challenges has this process identified? Are you comfortable with the mitigation plans?
- This is the end of this guide until the project nears completion. What additional resources or information would be helpful in completing the project?

Resources

To be added - do you know of something that should be here?