Solar Park
Project Execution Proposal

DelftX MEP101x Program
Team 6

Luc de Goeij
Tjerk Hamstra
Stephan Heijl
Joost Kirkenier
Tobias Rooijers
Robin Versluis
Matthieu Welsink

1. Introduction

The Paris Climate Agreement was entered into force on 4 November 2016. This agreement aims to limit global warming to a rise of maximum 2 degrees Celsius this century [1]. The burning of fossil fuel is one of the main reasons for increasing temperatures [2]. There are various options for reducing the use of fossil energy. This includes wind energy, solar energy, biomass, hydropower, geothermal energy, sustainable biomass and nuclear energy. Apart from the construction and removal phases, these forms of renewable energy have no CO2 emissions. The aim of this project is to allow nature and sustainable energy to go hand in hand. Solar energy allows this because it can also serve as a mini biome, allowing plants and animals to surround it so that the horizon is not polluted. The rest of this document explains how the development and realization of a solar park, including green areas, will be set up from FEED to decommissioning.

1.1 Objective

With the realization and operation of the solar park this project aims to contribute to the Paris Climate Agreement and assist the Dutch government reaching their targets to produce clean energy. In developing the solar park the project aims to increase the ecological diversity in the direct vicinity of the solar park.

1.2 Opportunity statement

The Project Team will **design, construct and operate** a state-of-the-art **solar park** that will produce a total of 40 megawatts generated by 100.000 solar panels. Out of the 70 hectares an area of 20 hectares will be specifically reserved for **ecological development** to boost the local flora and fauna. The solar park will be fully operational in 2024 and after 20 years of operation the solar park will be decommissioned.

1.3. Detailed scope of work

The WBS , also called the Work Breakdown Structure, will consist of multiple activities that will be necessary to design, construct and operate the solar park. The following phases are identified: **Front-End Engineering Design (FEED), Engineering, Procurement, Construction, Commissioning, Operation and Decommissioning.** For an overview of the different contracts, which overlaps with the phases see figure 2.

Each WBS will consist of a problem statement, the goal of the WBS, the objective/deliverables and the timeline. Within these stages the following scope activities **will be executed**:

- Project management, including project control, project financing, project scheduling, subsidy application, legal works, contracting and procurement, risk management, Stakeholder and interface management and Health & Safety .
- Land acquisition (and legal).
- Permit and subsidy preparation and application including all required environmental impact assessments.
- Stakeholder and interface management.
- Engineering of the solar park. Including solar panels, foundation, super structure, internal electricity grid.
- Park and walkways (ecological added values).
- Grid connection.
- Planning the operation and decommissioning phases of the solar park.

The scope **will not include**:

- Energy storage capacity.
- The decommissioning of the solar park.
- After decommissioning of the solar panels no additional activities will be performed. Ecological values created will not be decommissioned.

2. Stakeholders

Stakeholder involvement and management is necessary to safeguard the interests of the project. For the efficient design and realization of the solar park it is important to represent stakeholders, show genuine interest and collect requirements and wishes. Figure 1 displays a map of the stakeholders of the solar park.

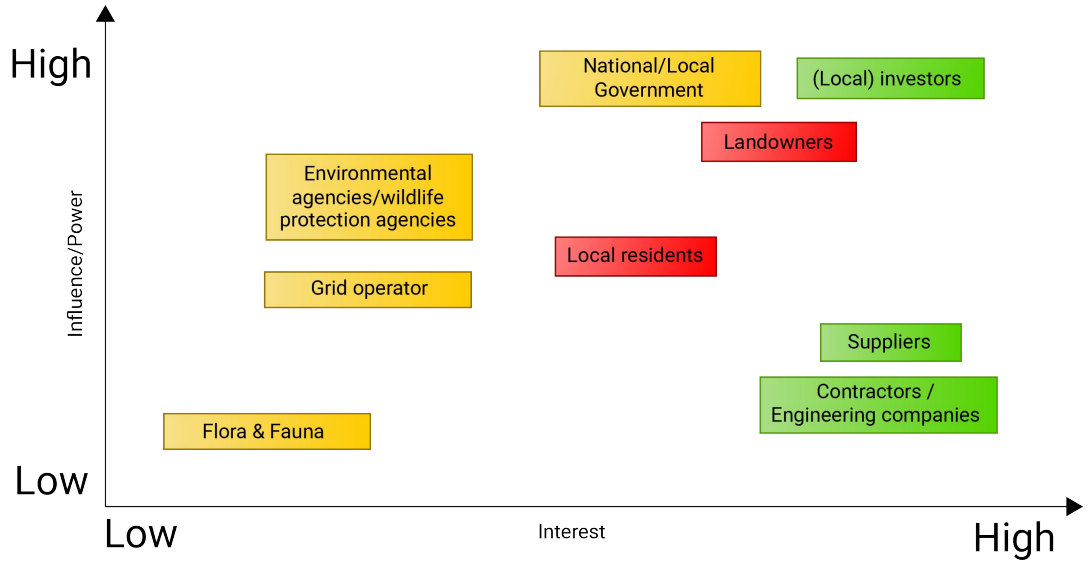


Figure 1 - Stakeholder map displaying relative interest and influence, red is negative, yellow is neutral and green is positively inclined.

- **(Local) Investors:** This stakeholder is the financial value driver of the project. The influence of these stakeholders is high, in the end they decide whether they will invest in the project.
- **National and local Government**: Grants permits (or not). This stakeholder has interest in economic growth in the vicinity of the project.
- **Landowners:** This stakeholder has to sell or rent out her land. In exchange the landowner will be compensated.
- **Environmental agencies / Wildlife protection agencies:** These stakeholders need to be taken into account concerning the environment. When something disturbs the flora and fauna, they want to protect nature.
- **Grid operator:** The energy that is generated needs to be delivered to the power grid. Project management and the grid operator need to work together in this interface.
- **Local residents:** The solar park has a direct influence on the resident's environment. They need to be considered to create support and understanding for the project.
- **Suppliers, contractors and engineering companies:** They contribute their materials, knowledge and expertise.

2.1 Stakeholder management

A PSU (Project Start Up) is organized at the start of the project with the stakeholders who have a great influence and/or great interest, together with the contractors and suppliers. A PSU is intended to introduce the project, at location, to all stakeholders and to align expectations and objectives. Due to the discussions that arise, the advantages and disadvantages of certain decisions are immediately known to everyone. During the project, multiple PFUs (Project Follow Up) will be held to realign expectations and objectives.

This means that the project team must liaise with everyone and exchange information. The project team runs the risk that information is retrieved from a stakeholder, which is not shared to all other stakeholders. Information is shared using BIM (Building Information Modeling) which acts as a single source of truth within the project. See also the chapters Monitoring & Control and Progress Reporting.

2.2 Health, safety & environmental management

The health and safety of the workers is of the utmost importance in this project. Additionally, everyone involved in the project must always comply with environmental regulations and strive to exceed expectations in environmental friendliness within the project. These goals will be achieved by implementing procedures and training that keeps all relevant stakeholders involved in at every stage of the project. Some highlights of the safety plan are described below.

Before FEED phase

The project management team will undergo EIA (Environmental Impact Assessment) training to ensure that everyone is aware of their duties and the different ways in which our project can impact the environment.

Before construction starts

An extensive safety risk plan will be set up in addition to our "normal" risk management plan. This plan will outline all the safety risks that that may be encountered and asses their likelihood and mitigation strategies. The likelihood of bombs and explosives at the project site will be assessed. If the site is in a risk area, further action will be taken. Soil investigation will take place in order to determine if there are possible contaminants in the ground that may affect the health of construction workers.

Ecological research will take place to investigate the possibility of endangered wildlife in the building area. As the solar park requires underground work, an assessment of the archaeological value of the building site will be made. Last Minute Risk Analysis (LMRA) guides will be set up for every stage of construction to ensure that workers are able to assess the safety and risks of each operation. A separate fund will be created in the budget to deal with all of the above.

During construction

Workers are required to upheld all the required standards for safety on and off site. Special consideration will be given to regulations surrounding COVID-19. Guidelines of the national institute RIVM will be followed. Our impact on the environment in terms of CO2 and other greenhouse gas emissions will be tracked so it is possible to compensate using proven greenhouse gas sequestering efforts. A separate fund will be set up to compensate for this. A portion will be sequestered by the planting of trees in the ecological park. LMRA will take place on site to ensure that at every step the appropriate precautions are being taken and everyone on site is aware of the risks and their duties.

After construction

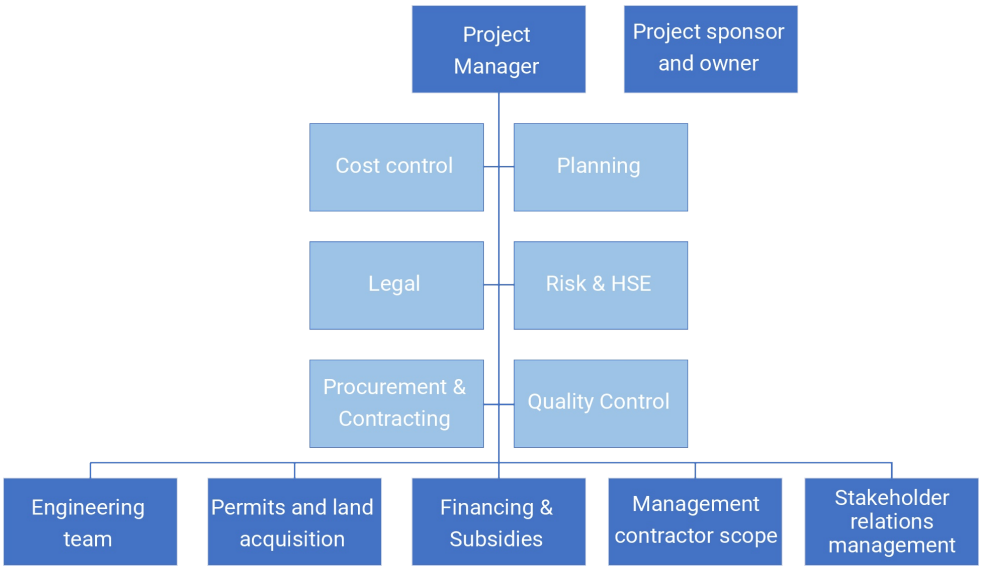
When construction has finished, all dangerous materials will be removed and disposed of in an appropriate fashion. The construction site will be left clean and safe for operation. A detailed report will be written containing all the risks that were foreseen and unforeseen, if they occurred, and if so, what the response was that was taken by the project management team.

3. The project team and its responsibilities

The project team is part of a larger owner organization from which the project team can draw the resources required for each distinct project phase. The project team organizational chart is shown in Table 1. The light blue entities (Cost control to Quality control) provide support functions for the entire project and report directly to the project manager.

The **Engineering Manager and her team** are responsible for the technical design during the FEED stage, the technical integration during the project (up to and including commissioning). They will facilitate the operational and decommissioning phases by incorporating this into the overall design. This also includes the selection of the solar panels and inverters. The **permits and land acquisition team** is responsible for obtaining the land and permits, together with the permit application specialists that will be contracted. The **financing and subsidies team** is responsible for developing the business case, obtaining subsidies if required and securing the necessary financing (debt and equity). The assistant project manager is responsible for the contractor scopes, will Tsupervise the surveys, research, landscape design and the combined civil and electrical EPC (Engineering, Procurement and Construction) works. The **stakeholder relations manager** is responsible for alignment of all stakeholders. The entire team will work closely together under the responsibility of the project manager.

Table 1: Project team organizational chart

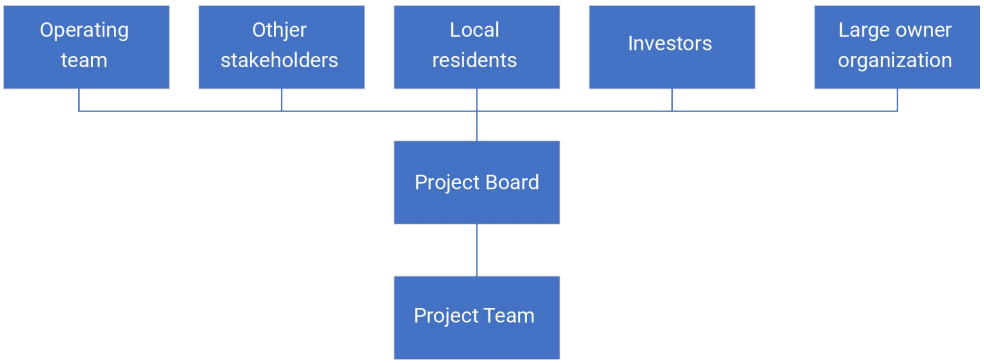


4. Project governance

Project governance is necessary to support the **decision-making processes** within the project. To do this consistently, there needs to be an overall framework. The framework of the Project Board is shown in Table 2.

A number of important stakeholders within the project are part of the Project Board to control the project. The Project Team manages the project but should report to the Project Board as described in the chapter Progress Reporting. Representatives of local residents that have bought into the project will be part of the Project Board.

Table 2: Project governance organizational chart



5. Contracting Strategy

The owner team will do all of the project management and most of the FEED, except land survey and the grid connection (very specialized and well defined, these will be contracted out). The integration of the park and walkways into the project will be done in close cooperation with a landscape architecture firm. In this way an integrated design can be made, also including the recreational/ecological areas and making sure these will not impact the solar park power output. Figure 4 shows a graphical representation of the contracting strategy.

Using the FEED package, an EPC contractor will be selected through tendering that will do the combined civil works, cables and the ground work for the park, including the installation of the panels and inverters that will be sourced directly by the owner team including a warranty. This EPC contract will be a lump sum contract (to facilitate financing of the project) with incentives and penalties to align interests.

The permits and subsidies will be acquired together with a specialized agency on reimbursable basis to improve our chances of success and reduce the time required. The land acquisition, legal work and financing etc. will be done by the owner team but specialists (such as lawyers) will be hired on a reimbursable basis when needed.

The export cable and grid connection will be completely done by a contractor, this is mainly due to the demands of the grid regulators in the Netherlands.

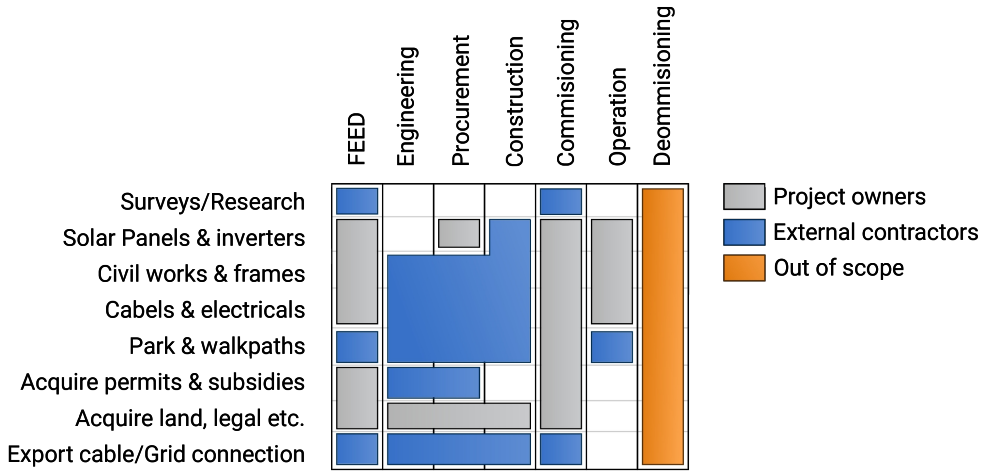


Figure 2 - Contracting strategy in different phases and work breakdown items (different blue blocks are done by different contractors)

Commissioning will be done by the **owner team** except an as-built land survey, which will be contracted out at that time.

Even though the operational phase is less complex than the phases that come before it, it has been decided to include this in our contracting scope to make sure all work focusses on complete lifecycle optimization. The operation and maintenance of the solar park will most likely be done by a **specialized team of the owner**, not the current project team. A value improving practice to be considered is to combine the main EPC contract a with contract for the maintenance of the solar park. To get a good understanding of the added benefit, **EPC contractors** will be asked to submit a bid for the maintenance phase next to their bid for the EPC, this will then be compared to estimates for carrying out the maintenance by an owner team. The maintenance of the park will be contracted out to a **landscaping company** at that time on a reimbursable basis.

The decommissioning phase is not in the scope of this project but added as a reminder of working cradle to cradle.

Interface management

In order to facilitate interface management, a single EPC contractor will be selected for all construction works on site. This means there will be only one interface during construction: between the solar park and the export cable. As the construction work does not require many different specializations it is assumed enough contractors will be able to complete the entire contract scope in-house, so that they in turn will not need to subcontract many parts. This will be one of the contract award selection criterions.

6. Risk register

In the initiation stage several risks have been identified. These cover the entire TECOPS spectrum and all stakeholders. Aggregate risk ratings range between 2 at the lowest and 20 at the highest, on a scale from 0-25. When the top risks have been mitigated, the expected risk rating reduction will be 60% for threats and the expected increase rating of opportunities will be 200-300%.

At the start of each phase, two risk sessions will be organized by the risk manager. In this meeting, known risks will be discussed and newly included. Control measures are devised, and the effort required for this (in money or time) is considered.

Through intensive cooperation between risk managers both at the owner side and the contractor side, joint risks are better managed. The risks from the contractor will be shared with the owner every quarter.

6.1 Top 4 risks with mitigations

- In order to mitigate the **risk of the required permits not arriving at the appropriate authorities in a correct and timely fashion**, a permits manager or management agency will be contracted to handle this responsibility. This will result in an additional stakeholder and increased costs but will lower the (residual) risk.
- By organizing meetings and workshops to consult with local residents to gather their insights and involve them in the project. Hopefully stopping **local residents delaying the project** and turning them into motivated, positive stakeholders.
- To reduce the risk of **not obtaining the land required for installing the panels**, multiple locations will be explored, and landowners are contracted and involved at an early stage. This will result in lower cost for acquiring land and earlier availability of the project area to start construction.
- Finally, a diverse set of suppliers will be involved early in the process to avoid the situation of **not having the required construction materials in an adequate timeframe**.

The full risk register can be found in appendix A.

7. Cost and scheduling

7.1 Cost

The costs in this project are determined in two phases. In the first phase, comparable solar park projects are analyzed in which the costs are scaled based on the amount of MW (Comparative method). The second phase is completed during the FEED stage of the project by using the work breakdown structure and costing every single aspect (Analytical method).

Comparative method

At the moment no detailed information is available, such as the designs, requirements and preconditions from stakeholders, etc. Therefore, two solar parks in the Netherlands with a comparable size have been examined:

"Zonneakker Voorst": 117.416 solar panels, 45 MW, approximately 30 million euro.
"Solar park Zeeland": 140.000 solar panels, 50 MW, approximately 40 million euro.

To estimate the costs of a 40 MW solar park, the ratio (€/Wp) of above two solar park projects have been determined. This is an average of 0.72 €/Wp. Multiplying by 40 MW results in an estimated investment of 29 million euros. To account for the **contingency costs** ((technical) variables and uncertainties in the scope), **escalation costs** such as inflation and market conditions (solar panels are dropping in price) and the addition of the ecological area, 5% is added. To account for the **risks identified** at this stage, another 5% is added. This results in an estimated investment of 32 million euro.

7.2 Scheduling

A schedule has been determined which considers the FEED stage, engineering, procurement, construction and risks. **Operation and decommissioning** are deliberately left out of this schedule as changing circumstances will affect the schedule during operation and eventually decommissioning. The operating team, mentioned in project governance, will plan and schedule operation and decommissioning.
In the FEED stage, starting early 2021, a front-end engineering design will be created, while prospecting for suitable construction sites. Because of the **identified risks** in the early phases, suitable land will be prospected before land is actively acquired. The entire phase will take approximately 3-4 months.
Permitting and financing will start in the middle of the FEED stage. This complex stage is wrought with long timelines and waiting periods, so an 9 to 11 month period is required for this to complete. Because of the **identified risks**, a longer than normal time is reserved for permits and financing.
Design consists of investigating the prospective construction site to rule out hazards and creating a detailed design for the solar park. This will take 5-6 months.

Procurement mainly consists of acquiring land, shipping of solar panels from China to the Netherlands and the offsite construction of prefabricated panel frames. It will take approximately 1 year for land acquisition to complete and 5-6 months for the materials to be procured.
Construction will take place when the construction site has been acquired, cleared for construction and the plan has been approved. It will take 5-6 months and includes commissioning.
As part of the commissioning stage a grand opening will be staged. The total time for the project to complete will be approximately 2-3 years depending on a multitude of factors. Upon completion the solar park will be at latest fully operational in the first months of 2024.

The base case planning is shown in figure 3.

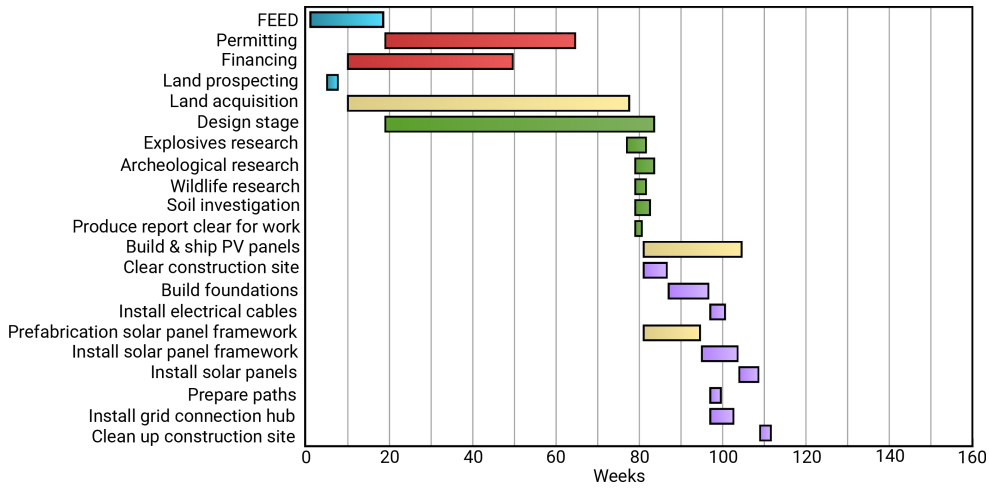


Figure 3 - Base case schedule of all phases up to commissioning of the solar park (the colors correspond to the different phases: teal = FEED, red = permitting & finance, green = construction, yellow = procurement, purple = construction & commissioning)

The following economic key data has been used for the solar park project:
Base Case:

- Total Installed Cost: 32 M Euro
- Bank loans: 27.2 M Euro (@ 2% interest): (85% typical for solar park projects in the Netherlands)
- Participants loans: 0.6 M Euro (@ 6% interest) (participating local residents)
- Required investment: 4.2 M Euro (equity, cash from owner company)
- Discount rate: 6% (3.5% WACC (Electricity Utility industry rating3) + 2.5% risk premium on forecasts)

A Dutch SDE++ subsidy can be obtained, leading to a guaranteed electricity sales price of 0.08 €/kWh for 15 years.

Income statement	**Base**	**Best**
Sale of electricity	€2.0 M	€2.0 M
Subsidy on sales of electricity	€2.0 M	€1.0 M
Operating costs (variable and fixed)	€0.45 M +	€0.39 M +
Operating income	€2.6 M	€2.6 M
Cash out: back repayments and interest	€2.6 M	€1.9 M -
Cash flow	€0.4 M	€0.7 M

	Base	**Best**
ROI	7 %	8%
PV @ 6%	€7,9 M	€10,8 M
NPV @ 6%	€3,7 M	€7,1 M
IRR	11 %	18%
PBP	15 years	6 years

Best Case: above but with 10% less cost solar park and 10% lower operating costs.
The full economic model can be found here: as PDF (link) and the original Excel file (link).

Evaluation and conclusion
To be economically viable, it is necessary for the solar park project to obtain subsidies. The best-case scenario provides a very attractive investment opportunity.

8. Project management approach

Because of the set-up of the phases, the **waterfall approach** is chosen, with each new phase beginning when the prior phase has been completed. Each phase will end with a **stage gate review** to kick off the next phase. These meetings are organized and facilitated by the project management team. Part of the gate review will be an alignment with the stakeholders and contractors of the project to make sure the stakeholders are satisfied.

The aim of this approach is to compare actual performance with planned performance and take appropriate corrective action that will yield the desired outcome of the project. It is impractical to execute this function on continuously base, as it is time inefficient. Thus, these stage gates will be treated like a hard deadline to continue the project.

9. Monitoring and control

Before each stage gate, the changes in cost, planning, execution, operation and decommissioning of the solar park will be prepared and presented in the **internal dashboard system**. In the stage gate this data is monitored and the details of what should be achieved at the next stage gate is discussed. Additionally, during these meetings the risk register will be considered to reflect how risks/opportunities develop and unanticipated risks will be discussed (including mitigation).

10. Progress reporting

All information necessary for monitoring and control will be available through **one internal dashboard system**. External communication will be based on the information on the internal dashboard system. This is detailed in table 3.

Table 3: Progress reporting overview

Stakeholder	**Reporting frequency**
Project board	At every stage gate and at halfway points of each phase.
The public	When major milestones are reached like first spade in ground or design done.
Workforce	Inform on health and safety, every morning
Locals	Involve often to avoid miscommunication or the feeling of being left out. Once every month a “light PR message”

11. Evaluation and lessons learned

After the entire project is done, it is prudent to do a review on how this process went and how to improve the monitoring and control (meta-monitoring / lessons learned). During operation (after completion of the construction and commissioning phases), monitoring and back-calculating the assumptions in the economic model will be done.

Appendix A

Risk ID	Risk title	Threat/opportunity	Identification	Cause	Event	Effect	Risk rating (0-5)	Impact rating (0-5)	Risk rate	Planned response	Residual risk rating (0-5)	Residual impact rating (0-5)	Residual risk rate	Responsible
12	Solar panel pricing	Opportunity	Commercial	Larger than anticipated panel	Price of panels decrease.	More budget.	2	1	2	Look at market patterns to buy at optimum time.	4	5	20	Acquisitions
11	Solar panel pricing	Threat	Commercial	Larger than anticipated panel	Price of panels rise	Budget overruns.	2	3	6	Buy panels in bulk at a set price.	1	1	1	Acquisitions
18	Subsidies increase.	Opportunity	Political/ Social	A more environmentalist political climate. More subsidy available.	Increases subsidies/tax benefits.	Costs are decreased.	2	3	6	Maintain good relations with environmentalist poltical parties.	5	4	20	Social relations manager
1	Lack of subsidies.	Threat	Economical	Subsidies run out of money.	Subsidies not granted to the project.	Financial shortage in the budget.	2	4	8	Start early with subsidy processes.	1	5	5	Project manager
4	More efficient technology is developed (e.g. solar panels or DC power).	Opportunity	Technical	R&D develops a more efficient and sustainable technology.	Improved technology is used in the project.	More yield because of the more efficient solar park.	2	4	8	Invest in budget to do market research (e.g. work with TENNET representatives to encourage DC adoption).	4	5	20	Company owner
10	Involve local residents.	Opportunity	Social	Local residents see the oppurtunity to start sustainable initiatives.	Local residents are involved in the project.	Investment in the project.	4	2	8	Organise meetings to talk to the local residents.	5	4	20	Social relations manager
13	Dust coats the panels.	Threat	Technical	Increase in airborne particles.	More dust settles on panels.	Decreases expected yields.	2	4	8	Hire workers to clean the panels.	1	3	3	Operating party
21	Theft or vandalism.	Threat	Technical	Equipment that thieves want to steal or that gets damaged.	Thieves steal equipment or people demolish panels.	Panels and other equipment has to be replaced.	2	4	8	Get surveilance systems and insurance.	3	2	6	Project manager
15	Protected species found.	Threat	Political	Wildlife protection agency investigates building site.	A protected animal of some sort is found.	Construction is prohibited.	2	5	10	Let biologists do a field study before construction.	1	1	1	Acquisitions manager
17	Subsidies decrease.	Threat	Political/ Social	A less environmentalist political climate.	Decreases subsidies/removes tax benefits.	Costs are increased.	2	5	10	Start early with subsidy processes.	1	2	2	Project manager
3	Bankruptcy contractor.	Threat	Economical	Contractor has debts.	Contractor goes bankrupt.	Construction is delayed. New contractor has to be found.	3	4	12	Ask for project references and bank guarantee.	2	4	8	Project manager
5	Accident at worksite.	Threat	Health & Safety	Human error.	Workplace accident.	Personnel is injured.	4	3	12	Invest in safety plans (e.g. toolbox meetings).	2	4	8	Project manager
20	Weather influences.	Threat	Technical	Hazardous weather effects.	Panels malfunction.	Panels have to be replaced.	3	4	12	Insurance.	3	2	6	Project manager
7	Contaminated subsoil.	Threat	Technical	In the last decades the site has been used as dump location for waste.	During construction the contamination is discovered.	Remediation of the soil is necessary.	3	5	15	Invest money in soil investigation. If contaminated soil is found make this known to the client.	1	5	5	Project manager
14	Work efficiency by COVID-19.	Threat	Political/ Social	New regulations for COVID-19 mitigation.	Non-efficient worker practices.	Mounting the panels takes longer/costs more.	3	5	15	Anticipate COVID-19 measures, to mitigate the impact on worker efficiency.	2	4	8	Contractor
19	Rentability of solar panels.	Threat	Technical/ Economical	Solar panels are not durable.	Energy generated is lower than calculated.	Decreases expected profitibility.	3	5	15	Require high quality panels.	2	4	8	Panel Supplier
6	Higher land costs.	Threat	Social	The project requires land from multiple owners, which is easy to block if one of the owner does not wish to sell or increases his price.	Land not sold, sold at too high value or sold at a late date.	Higher financial cost or implementation time, or no implementation possible at the identified site. Restart of land acquiring neccesary.	4	4	16	Quickly identify if locals wish to sell. Have multiple options.	1	5	5	Acquisitions manager
8	Suppliers late or insufficient panels delivered.	Threat	Commercial	Suppliers have a lot of deliverables to other client.	Not enough panels can be delivered. Suppliers can't meet demand.	Delay in project. Required wattage cannot be achieved in the first year.	4	4	16	Involve suppliers early in the process or diversify suppliers.	2	3	6	Project manager
16	Climate change increases yields.	Opportunity	Technical	Climate change.	Increases the amount of sun in the Netherlands.	Yield is improved.	4	4	16	No response planned.	4	4	16	NA
2	Permits not approved.	Threat	Economical	Government gives permits to late.	Permits not approved by government.	Delay in project. Construction is delayed.	4	5	20	Contract a permits manager.	2	4	8	Project manager
9	Resistance local residents.	Threat	Social	Local residents are not happy with the project due to pollution (noise/ visual).	Local residents try to postpone the permit process.	Permits postponed/denied.	5	4	20	Organise meetings to talk to local residents.	3	3	9	Social relations manager