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Landscaping for promoting Biodiversity and Recreation in Land-based Solar Panel Parks

- A project for IKEA Industry in Poland

Nizhuma Hasan & Rosalie Selhorst

Degree Project • 30 Credits • Landscape Architecture, Planning and Management • Master's Programme • Alnarp 2020

“But to truly transform our economy, protect our security, and save our planet from the ravages of climate change, we need to ultimately make clean, renewable energy the profitable kind of energy.” – Barack Obama, 2009 (Newton, 2015)

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Abstract

The world, because of the mass extinction of the natural species, will be doomed one day. Climate change and global warming are the prime suspects for the ongoing icecaps melting, sea levels rising, and biodiversity abolishment. Because of losing balance in the ecosystem, a listed ancient flora and fauna have already become extinct from this planet, and humans are the promoter for this devastating picture.

But if people will realize the upcoming consequential global negative impact and start to raise the question of how can they sustain for the rest of the 21st century, most societies, industries, and business policies must have to shift towards green energy with zero carbon emission and re-establish the ecosystem. This paper is about merging biodiversity with solar panel parks, which is an initiative from IKEA Industry. Create recreation facilities so that this message can be delivered to general people and make them conscious is another promotion that we added in here. But the pressing question is: can we make this happen or not?

The theory responds it is affirmative to incorporate biodiversity into solar panel parks by adding landscape parks in the surroundings. It is also possible to include local flora and fauna in the solar panel parks. In this thesis, the included design-illustrations and visualizations show the possibilities of having them together.

Briefly, the world needs to have as many solar panel parks as possible within 2030 to achieve sustainable development goals, and it is goal seven that tells renewable energy may perform a dual function: firstly, harness temperature or sea-level rise and secondly, reset biodiversity, consequentially.

Acknowledgment

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Lastly, we both are dedicating this paper to our precious assets in our life: our younger brothers Samin Hasan Bhuiyan and Arvid Selhorst.

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Chapter 1

Introduction

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The image is a visualization from the design proposal of the Plot B requirement plan that is showing an aerial view

• Solar panel park • Southern landscape park • Maintenance road • Vegetation alley

1.1 Background

In the current world, energy is inseparable from everyone's life and is necessary for economic and social development and to lead a better-quality life (Population Matters, 2020). In the 21st century, sources like fossil fuels (oil, coal, and natural gas) still persistently meet the energy demand is around 80%, but sadly they are finite and non-sustainable. Also, the consumption of fossil fuel emits GHGs (Green House Gases) and CO_2 in a substantial amount, which warms up the global atmosphere, and consequentially, there is a change in the climate (Houghton, 1997).

In the last 50 years, the global population number has increased exponentially from 3.7 billion to 7.7 billion, and by the end of this century, it will be approximately 10.9 billion. Moreover, for a 1.1% annual population growth rate (83 million), habitat destruction, overexploitation (Tragedy of the Commons), agricultural intensification, and climate change start to cause a biodiversity crisis. To mitigate necessities (food and shelter), humans already trespass into the territory of wildlife, and urbanization, industrialization, deforestation (timber extraction), industrial fishing, bushmeat hunting, wildlife poaching, and trafficking, intense cropping (using monoculture technique), artificial fertilizers and pesticides push the ecology further away from the land and water. For this reason, at present, only 1/4 of land areas and 1/3 of oceans are left untouched (Population Matters, 2020).

After five mass extinctions that wiped out numerous species, the earth again, after spending 65 million years, is approaching the next mass extinction, mostly because of humans, known as Anthropocene extinction, which will be the biggest ever. Since 1970, people have twisted and violated the biotic systems, and the world has lost 60% of its total vertebrate wildlife populations. Moreover, from 1989, the proportion of flying insects, including pollinators, has plummeted to 75%. Until 2019, there are approximately 1 million species at the edge of extinction: 41% of amphibians, 25% of mammals, 34% of conifers, 13% of birds, 31% of sharks and rays, 33% of reef-building corals, and 27% of crustaceans (Population Matters, 2020).

For temperature-sensitive species, a tiny

0.5°C temperature rise will make migration of moving species more erratic whereas, stationary species like coral reef will become extinct, and ultimately, the whole ecosystem will collapse. Monitoring this ongoing trend IPCC (Intergovernmental Panel on Climate Change) predicted by the end of the year 2100, the mean temperature will be (1-3.5)°C higher, and the mean rise in sea level will be (15-95) cm (Houghton, 1997).

How could we make up the losses in biodiversity? Research has shown the more biodiversity in any ecosystem, the less likeliness of species to become extinct. It also goes for resilience-greater biodiversity brings more elasticity of the ecosystem to the environmental changes (Mooney, 2009). So, in the forthcoming years, to stop further climate change and to reset the ecosystem as well as biodiversity, renewable energy is the ultimate option because they are infinite, sustainable, secure, and almost environment friendly.

Continuity of technological innovation in the last century and fearful expectation that one-day finite energy resource will be exhausted both inspire and compel humans to leap from hydrocarbon-based fossil fuel reliability to renewable energy (Sukhatme, 2010). In search of a solution, in 2015, 17 goals were determined by United Nations, and one of them is Affordable and Clean Energy (Goal 7), where the emphasis was given on the production of sustainable solar, wind, and bioenergy (UNDP, 2020). Having zero-carbon emission after consumption is the primary reason for which people show their tendency towards renewables. Today the world relies on 17% renewable energy (Houghton, 1997).

However, hydroelectricity has environmental impacts on altering the ecological system, precisely the life cycles of fishes in rivers. So, it cannot interlink between the present and future with its consistent energy supply (UNEP, 2011). A wind farm or wind power plant combines a group of turbines that place at a similar location to generate electricity. As they need no fuel to rotate those turbines, they have a negligible role in environmental impacts than other power generating sources. They are of two types based on their location: onshore and offshore. Therefore, the wind farm setup is totally reliant upon location. Factors that make any windfarm successful are wind condition, electrical transmission accessibility, physical access, and price of local electricity. So, faster winds are a prime factor to consider in generating cheap but more electricity.

As around $1.8\text{x}10^{11}$ MW (Megawatt), solar energy can penetrate through the global atmosphere (Sukhatme, 2010), and PV (Photovoltaic) technology forges solar power into electricity. There is an immense possibility that it can be the leading potential energy source to fulfill the global demand of the existing population, not just for today but also for tomorrow. Also, after the time of invention, the manufacturing cost of PV modules has declined from 100 USD/W to 0.3 USD/W approximately, which further supports to choose for it (Amro, 2019). Renewable energy like solar PV panel has exponential growth: in 2011, it progressively grew by 73%, and the amount increased by a factor of ten in the last five years (UNEP, 2011). From 1990 until 2018, the PV-based energy production cumulates up to 505 GW (Gigawatt) (REN21, 2019), where 2018 alone contributes 102.4 GW. Furthermore, for PV panels, sunray does not have to be its optimum level to yield electricity (Muteri, 2020). Therefore, we can expect solar will be the green weapon in the energy portfolios of industrialized countries (UNEP, 2011).

To reestablish biodiversity and adaptation of green energy demand smart planning, a revising and reprogramming of the current version of the buildings with wisdom and intelligence (Catalano, 2017). Residential or commercial buildings are the prime focus for the rooftop PV panel installation system, and the components that should take into consideration are PV models, installation systems, wires, solar inverters, etc. (Pulok, 2015). Here, PV panels are placed with a few centimeter gap and parallel to the roof surface. For horizontal rooftop panels, arrays are installed at a certain angle, and if they are mounted before the roof construction, support brackets installation must be taken into consideration. Perhaps a key to this lock is the biosolar roof, which combines diverse green roofs and PV panels for carbon-free energy. In London, at the Queen Elizabeth Olympic Park, a study conducted that affirms biosolar green roof can be integrated with solar PV panels (Catalano, 2017).

In the ground-mounted PV system, panels are placed out of reach from commercial or non-commercial buildings and shade producing structures, and racks or frames are used to support for fixing them in the ground (McPheeters, 2011). Here, as multiple rows of modules are consisting within the system, a proper space needs to be maintained so that shadow can not interfere within rows. They are massive and utility-scale solar power plants (Franklin, 2016).

Green Economy is a state-of-the-art concept that is directed to support and strengthen the economy for the purpose of "improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities… In a green economy, growth in income and employment are driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services" (UNEP, 2011). In developed countries, most companies are shifting and running their business by using this policy, and IKEA Industry is one of them. They are looking to support their power supply system with the installation of solar panel parks and enhance biodiversity to their three plots in Zbąszynek and Babimost in Poland. To do this, they reached out to SLU (Sveriges Lantbruksuniversitet/ Swedish University of Agricultural Sciences) students. Basically, from the SLU website, we found that information and got engaged in this research. But additionally, we introduce the landscape park facility, which will facilitate both wildlife and offer people to have recreational activities. We, furthermore, broadcast this information so that everyone can try to leave behind the fossil fuel dependency one day.

1.2 Aim and Purpose

The integrated objective of this thesis is to produce sustainable electricity through solar panels and promote biodiversity. Nevertheless, our immediate intention is to create recreational facilities through the establishment of landscape parks to make people more informed of our initiatives.

This assigned thesis paper could be a roadmap for the imminent projects of those who want to build a solar panel park and want to promote biodiversity. This research work will be fruitful for any industry that wants to consider biodiversity in its solar panel parks, and eventually, meet its intentions of producing sustainable biodiversity.

1.3 Research Question

How is it possible to promote and include biodiversity and recreation in solar panel parks, with the help of landscape design?

1.4 Method

The on-site visitation is compulsory, as it is a project-based study, to fetch relevant data. However, due to the pandemic situation, the site visit was not possible at the beginning because of travel restrictions. Therefore, the analysis was carried out through Google Maps and Satellite Images. Google Earth application helped to collect the data and images. The Street view tool in Google Earth helped to get precise locations and what existed there until 2013. Another supplementary tool was the measuring ruler to estimate the plot sizes, perimeter, and width of the roads surrounding the plots. After visiting the site physically, we got 90% accurate data from the digital investigation.

Combining the research question, the aim, and the thesis purpose, the literature has been outsourced from the internet. The necessary academic information about IKEA Industry, solar panels, biodiversity, and landscape parks were collected via the web search. IKEA Industry supported us with some management plan literature. Case studies regarding solar panel parks and wind-farm projects were vigorously googled. However, the proportion of information that we have on biodiversity in solar panel parks is rare. The sections in the project input and inspirations chapter except case studies described related information because of the no-go situation to those existing sites before finalizing the project.

Initially, we approach this design and innovation repeatedly. It all began with the schematic drawings by a freehand sketch. The process was modified in several phases through discussion with our supervisor. Then we devise and offer a second proposal for each plot with our distinctive research, ideas, and thoughts. So, after the final phase (function and zoning), Autodesk AutoCAD availed for 2D drawings (primarily plans and measurements). Also, relevant applications ran for the illustrations. The final resultant work of 2D plans was drawn in Adobe Photoshop. 3D drawings and final visualizations performed using SketchUp and Lumion, respectively. The post-production work again processed with Adobe Photoshop. Adobe InDesign was the tool to compile and finalize this thesis paper. To make this plan more visually understandable, based on the project requirements and our educational background, we picked only useful resources.

In the first half, we managed to attend two physical interviews with IKEA Industry, where the first one was about the general introduction and basic information. But in the next meeting, project requirements and limitations were explained and given. After the first half, interviews and supervisions were conducted through several online meetings.

1.5 Delimitations

In this paper, we are designing a project for IKEA Industry, where the primary aim is to incorporate biodiversity and landscape into the solar panel parks. We are helping to reach their goal that is sustainable energy production. However, landscape parks as a means of recreation and foraging for both human and wildlife species are our insertion into the project.

Even though we will generate solar energy as one of the renewables, we are just attempting to reduce carbon emission and climate change on a tiny scale.

Though our primary focus is on how to generate renewable energy by usable or unusable lands, we have another option that can avoid stress on these lands: rooftop solar panel. Additionally, we have wind farms to produce the same renewable energy, which we have not taken into consideration in this paper.

Except considering surrounding agricultural lands and soil types for the design purpose, we did not take into account the compensation for the existing agricultural lands, where we propose to build solar panel parks and landscape parks.

Though the PV panels specification of measuring electricity production and anatomy rate is a source, we got from IKEA Industry. We did not measure how much energy will be produced from our final proposed PV panel designs.

We are not incorporating any fauna species, but we are introducing flora species to enhance biodiversity as well as to support the existing fauna in the surrounding areas.

The assigned thesis is mainly an offline study because of the COVID-19 pandemic situation that made us delay our field research. We wanted to initiate these trips before our design finalization. Many field trips outside Sweden were planned. However, very few responses from the organizations were received, and of those respondents, the majority did not want visitors due to the current situation. But, we made some field trips inside Europe at the last phase of our thesis submission.

Since it is an original as well as an innovative concept, we have to archive information parallel to this. We explored numerous solar panel and wind farm projects, but unfortunately, few of them were interested in taking such initiatives or described in detail.

Chapter 2

Project Introduction and Site Analysis

The image is a visualization from the design proposal of the Plot B requirement plan showing autumn night

- *Front western landscape park*
- *Middle garden walkway*
- *Landmark sculptor*

2.1 IKEA Industry

Many companies are upgrading their trade policy from carbon energy to renewable energy. Among them, IKEA is one of the leading innovative industries: to run its operations, they are generating and using natural energy sources, and concurrently, they want to express themselves as a prominent model for the rest by displaying possible biodiversity at their industrial sites. In this new project in Poland, IKEA Industry yearns to build three solar panel parks in their two production facilities and promote more landscapes and biodiversity in those parks.

Representatives from IKEA Industry reached out to students at SLU with a proposal for a thesis topic that could assist them in this task. As earlier mentioned, this company wants to construct three solar panel parks and promote biodiversity, so they ask for ideas for the layout and design and how more biodiversity possibly incorporates into those landscapes.

IKEA is a multinational company that designs and trades furniture, home accessories, and kitchen appliances. It is their primary business to sell readymade

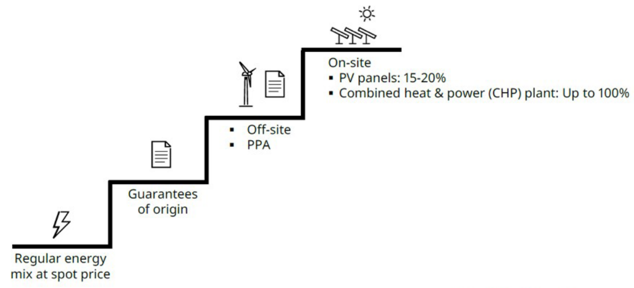


Figure 01: IKEA Industry's priority staircase for reaching 100% renewable electricity solution. Source: (IKEA, 2020)

furniture. Ready-to-assemble furniture is popular now these days globally for the consumers who are willing to set up the product on their own and collect furniture from the store (Fig 02) to save their delivery costs. All the installation instruments come along with a guidebook that is in cartons to make it simple to understand during fitting with fundamental tools. Since 2008, it is the biggest retail company in the furniture world (Forbes, 2012).

"To create a better everyday life for the many people" is the motto of IKEA, and that is the inspiration for all the employees

Figure 02: IKEA Store in Malmö, Sweden

Figure 03: IKEA Industry Strategies. Source: (IKEA, 2020)

while working: product development, ideas, usage of raw materials, and way of action (IKEA 2020).

The reason for owning its in-house production is to optimize the industrial operation in a more integrated way. Their supreme affords, productivities, and continued work of creating home decors come with better durability at an affordable price. Inputting the term 'sustainability' they are trading furniture with their 40 production units in 8 countries (Sweden, Poland, Slovakia, Hungary, Lithuania, Portugal, Russia, and China). The extent of their operations includes forestry, sawmills, wood component, and furniture production.

According to IKEA (2020), holding a mindset what they do will be positive for the people and the planet, IKEA and IKEA Industry have four strategies, where they implement them.

1. Unique capabilities and capacities

2. The integrated manufacturing system

3. Innovation, Manufacturing concepts, and knowledge transfer

4. Sustainability and circular economy

From now to 2025, they set a goal to manufacture their products by strictly maintaining their fourth idea (Fig 03).

In terms of energy production, their primary goals until 2025 are:

- Reduce greenhouse gas emissions by 80%
- Increased energy efficiency (Division Boards: 1-1.5% and Division Flatline & Solid Wood: 3-5%)
- PV studies at all sites as a basis for investment decisions

- Vehicles in use acquired after FY (Fiscal Year) 2020 are zero-emission
- Following the IKEA guidelines for electricity purchase

Their target by the end of FY-2025 is to install PV panels where there is the technical and financial feasibility. The approaches to reach these goals are:

- Conducting feasibility studies for PV panels at all sites and preparing new buildings for rooftop PV panel installations
- Investing in large PV-installations and energy storage solutions when price reductions and improves efficiency enable acceptable payback times (IKEA, 2020)

Below we are discussing the general advantages and disadvantages of rooftop and ground-mounted PV systems.

Rooftop PV system:

Advantages:

- Can be initiated in preferably urban areas, where there is no requirement of additional lands to setup and run
- Distant places where the grid connection is beyond reachable
- Prolonged shield of roofs.
- Remove the unnecessary costs like expensive batteries and generators (Pulok, 2015) (Dang Anh Thi, 2017)

Disadvantages:

- Chance of power outages if utility power cuts off until there is the battery backup
- Not possible to get rid of non-renewable energy completely
- To ensure no moisture is present on the roof that can lead to long-term consequential damage, inspection should be carried (Franklin, 2016) (Dang Anh Thi, 2017)

Ground-mounted PV system:

Advantages:

- Safe installation
- Easy accessibility provides easy maintenance
- Usability varies from small scale to large scale
- Air circulation around the array allows low cell temperatures but the maximum outcome
- Certain distance must be maintained. So, each row does not interfere with the row next to it (Franklin, 2016) (Dang Anh Thi, 2017)

Disadvantages:

- Comparatively expensive than roof-mounted panels

- Time-consuming installation
- Application is limited to even lands and not possible to setup in urban areas
- If the ground cover with gravel, it will facilitate drainage, minimize erosion, and keep the vegetation in check, but is an added cost to implement (Franklin, 2016)

As they are putting more emphasis on climate protection, the industry has begun to invest more in solar panels so that they can operate their factories partially or fully with their privately produced electricity. The primary goal of IKEA is to maintain its factory activities 365 days by using 20% of its produced solar energy throughout the year, and it will run its activities in full fledge when the weather is sunny.

The factories in Zbąszynek and Babimost are of different heights because they are built in several phases. In Zbąszynek, the factory roof area is about 300,000 m^2, excluding the areas where the roof has uneven heights and skylights. Overall, the rooftop area is not enough to meet their energy production demands. That is why they plan to install several solar panels on grounds as there are limitations to roof-mounted systems.

Reasons for why IKEA did not plan to install roof-mounted PV panels in Poland:

- The existing roofs do not have the loading capacity for PV panels, and still, if we want to reinforce, then the bearing structure will be necessary, which is costly
- The different heights in the roof can accumulate snow, thus creating the risk of roof collapse
- No water facilities are there on the roofs for fire extinction and cleaning management
- No fire alarms on the roofs leading to production risks in the factories
- Fire fighting authorities advised against a rooftop installation due to the risk of electrical shock from malfunctioning panels

However, IKEA has rooftop PV panels on its factories in Portugal and China. These factories are newly built with advanced technology and can take the extra weight. These panels are not with screws, which create holes and risk of leakage. They made an investment in a fire detecting system for their factory in Portugal (Fig 04).

They are at their initial phase of promoting more biodiversity at the manufacturing sites, with the ambition to create a new roadmap, necessity, and symbol for others. Their industrial footprints are immense, with megastructures, and extensive hard surfaces, which gave them a restriction on greeneries in the past.

It is well-known that in comparison to forest lands, agricultural lands are unlikely preferable to promote biodiversity. Also, IKEA Industry has no space to expedite biodiversity. So, to make the best use of those plots, they have decided to combine both solar panel parks and landscape parks in this project (IKEA, 2020).

Figure 04: Rooftop solar panel at IKEA Industry, Portugal. Source: (IKEA, 2020)

2.2 Site Analysis

Site analysis is thorough surveillance of the existing environment to apprehend how the site factors will influence the layout of the project. It involves inventorying the site elements and gathering relevant information regarding any site for the client, which they later will incorporate before or during the project.

In this chapter, we will discuss the issues related to the site: size, geographic location, topography, solar orientation, climate, zoning, soil conditions, and traffic conditions. Site surroundings, like, change of road designations, cultural pattern alterations, or other structural improvements, that should we consider in futuristic developments of site surroundings (Walshaw, 2018).

We have two different sites (Zbąszynek and Babimost) to analyze located in Poland, a country in central Europe (Fig 05). It is geographically located in such a direction that it acts as a connector for north-western Europe’s forested lands, Atlantic ocean’s sea lanes, and the fertile plains of the Eurasian outskirts. The continental climate is too cold in winters

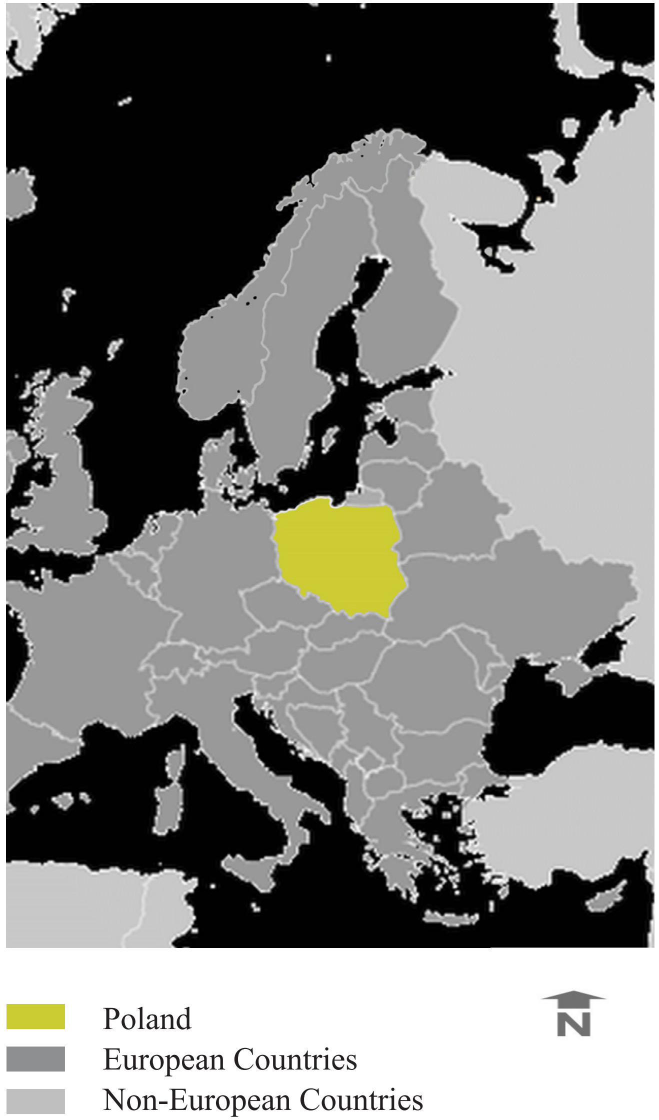


Figure 05: Diagram showing Poland in Europe

with snow. In summer (from June to August), the solar orientation is direct, and the average temperature in these three months is 25°C. Between September and November, autumn is cold and gloomy. In winter (from December to February), the average temperature is -3°C. The type of soil in these two agricultural lands is sandy.

Zbąszynek and Babimost are the two separate locations of western Poland (Fig 06), where the designed proposal will be implemented, and these two placements are roughly 110 km from the German border. The project focuses on three individual plots: two are in Zbąszynek, and one in Babimost, and there are already two established IKEA Industry factories, and most of the lands are for agricultural purposes with forests. Zbąszynek is a town located in the province of Lubusz Voivodeship, in the county of Świebodzin, whereas Babimost is located in the province but another county, Zielona Góra. The distance between the two site locations is roughly 12 km.

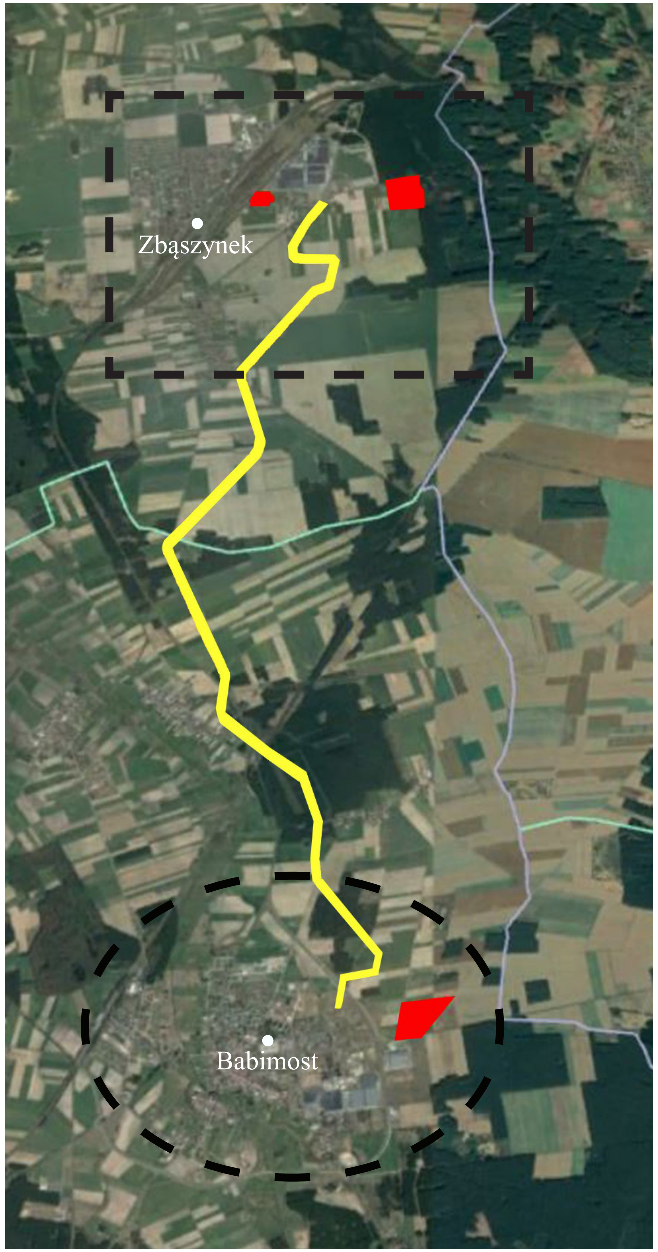


Figure 06: Project Location. Map source: Google Earth

2.2.1 Zbąszynek -

Plot A & Plot B

Zbąszynek is a town, established initially with Germanic settlers in the 1920s, located in western Poland, and has a rural-urban community at present. During the time of establishment, it was at the border station. Between the two world wars, a large modern railway infrastructure was built, and designer Friedrich Veil designed the colony according to the concept of the city-garden. In World War II, forced labor camps existed in the city, and lately, Zbąszynek became one of the major railway infrastructures from Berlin to Warsaw. These days, the largest manufacturer in that area is IKEA Industry, and the locations of those two plots are in the industrial zone (Fig 07). The topography is mostly flat with agricultural fields and forests.

Figure 07: The IKEA Industry at Zbąszynek in Poland. Left: Plot A, Right: Plot B. Source: (IKEA, 2020)

Zbąszynek - Plot A

Holding an area of 2 ha (20,000 m^2), plot A is located in the south-west of the primary IKEA Industry. In the north direction of the plot, there is parking and to the south, agricultural land. To the east, there is a residential area, and to the west, a port warehouse with railway tracks. Headed towards the north-western direction of the site, a 5 m road connects the residential area with the parking. On the southern side of the plot, there is another 3 m road connecting the residential area with the town itself. The traffic condition is light car traffic. The distance from the IKEA Industry to the plot is 1.4 km.

Figure 08: Plot A site images

Figure 09: Plot A site surroundings

Zbąszynek - Plot B

With 10 ha (100,000 m^2) area size, plot B is on the southeast side of the primary IKEA Industry. Forest is the main sight of the plot's north and east directions. There are agricultural lands to the south and west. A water stream coming from the eastern forest is at the center of the plot. On the north side of that plot, there is a 5 m road connecting itself with the residential area and factory. On the plot's north-west, there is a big parking area for cargo trucks. The traffic condition is not friendly because of cars and cargo trucks. The distance from the IKEA Industry to the plot is 1.2 km.

Figure 10: Plot B site images

Figure 11: Plot B site surroundings

The Electricity production and Autonomy rate of Zbąszynek:

90% of the PV panel produced electricity will be used in the factory, and the electricity produced by PV panels will represent 15% of the total consumption (IKEA, 2020).

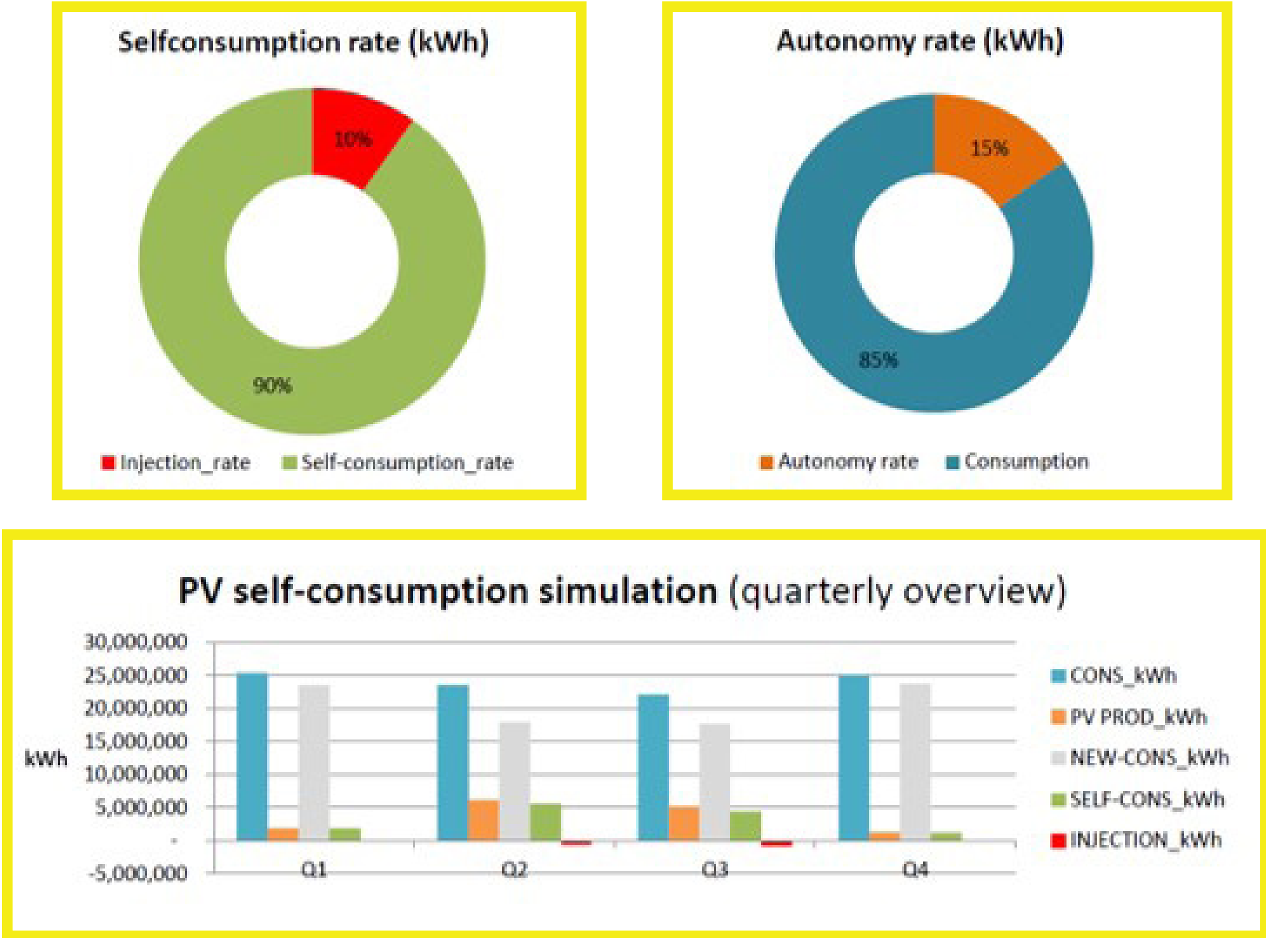


Figure 12: Zbąszynek electricity production and autonomy rate. Source: (IKEA, 2020)

2.2.2 Babimost - Plot C

Babimost is a town located just 10 km south of Zbąszynek. Early settlements had emerged in 1000 AD, and then the estate was confiscated by the Pomeranian Swienca family until 1307. But later, it became a royal town. Sweden invaded this town in the 17th century and ravaged it in 1656. In the liberation war, Poland retrieved it in 1918. However, Babimost remained within Germany. During World War II, the whole town was destroyed, and afterward, Babimost was reconstructed and reincorporated into Poland. The location of the plot is in an agricultural zone (Fig 13). The topography is mostly flat with numerous cultivable fields and urban settlements.

Figure 13: The IKEA Industry at Babimost in Poland. Plot C. Source: (IKEA, 2020)

The location of plot C is in the northwest direction of the primary IKEA Industry. This plot is 6 ha (60,000 m^2) in size, which is surrounded by agricultural fields, and on the south side, there is a 5 m road connecting the plot with the residential area and the factory. Adjacent to the east side of this plot, there is also a 4 m road that connects other villages of Nowa Wieś Zbąska, which is a village in the administrative district of Gmina Zbąszyń. To the south, there is also a production facility. Further to the west, there is the center of Babimost. The traffic condition for the plot is not friendly, consisting of both cars and cargo trucks. The distance from the IKEA Industry to this plot is 1.2 km.

Figure 14: Plot C site images

Figure 15: Plot C site surroundings

The Electricity production and Autonomy rate of Babimost:

81% of the PV panel produced electricity will be used in the factory, and the electricity produced by PV panels will represent 16% of the total consumption (IKEA, 2020).

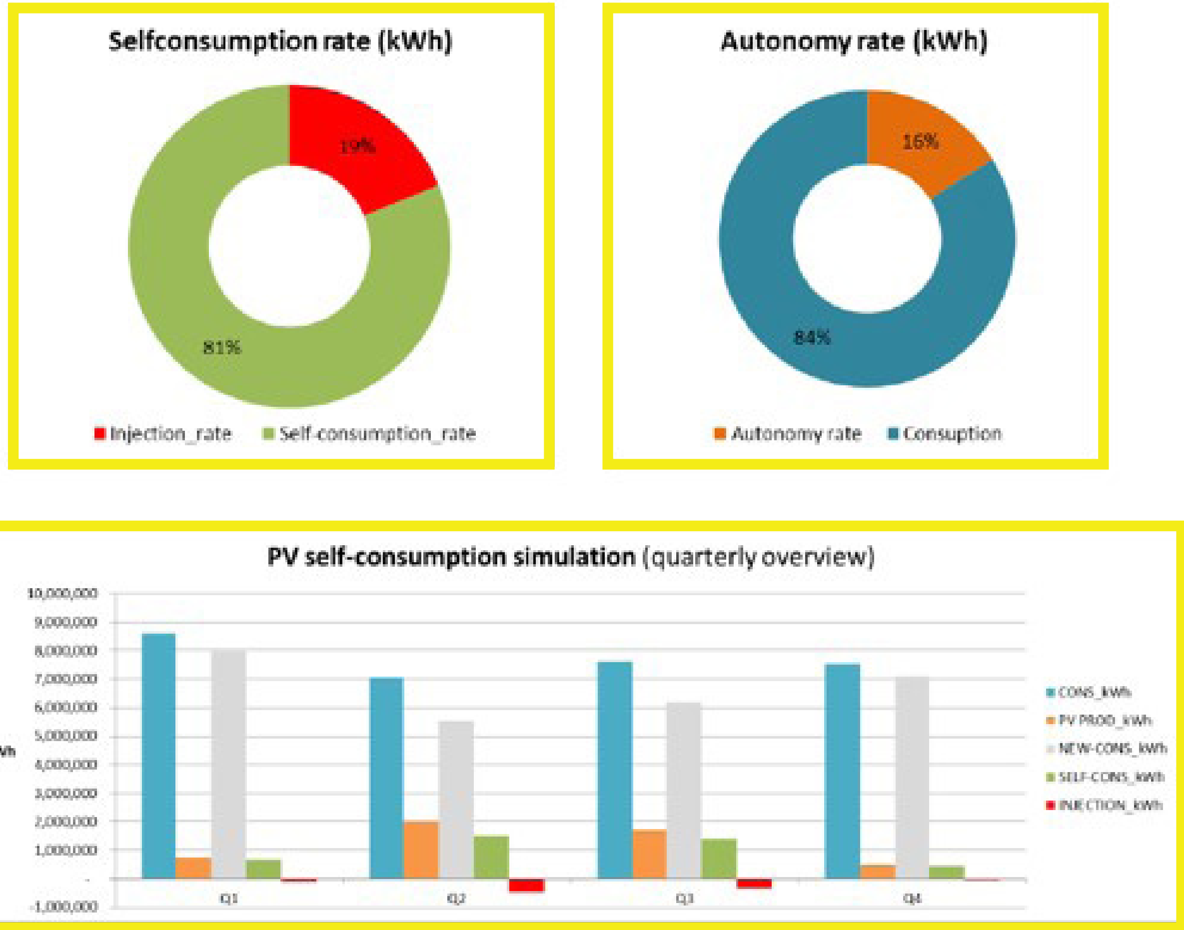


Figure 16: Babimost electricity production and autonomy rate. Source: (IKEA, 2020)

Findings in site analysis:

Though we analyzed those three plots via google earth and maps, in the beginning, there is a difference in what we experienced when we visited the place. The sandy soil that we found at the sites was different from the sandy soil in Småland and Halland, Sweden.

In Plot A, we figured out the ground is not flat: it is raised approximately 2 m above the ground towards the south. But it will have a minor impact on our proposed design for Plot A.

For Plot B, there are no changes except the surroundings developed with nearby roundabout and waterbody. However, we observed the adjacent bike path for 30 minutes that is in the northern direction and could conclude that it is used often, especially bikers from the surrounding communities use this pathway. Therefore, it will hopefully benefit our design proposal of landscape park for plot B because people can visit and experience the landscape park and solar panel park, respectively.

In plot C, the topography was more than we expected, but everything remained the same.

2.3 Present Biodiversity and Other Aspects

Biodiversity is an abbreviated form of biological diversity. Campbell (2008) describes it on three levels:

1. Genetic Diversity: it is not only intra-populace genetic variation but also an inter-populace genetic variation, which is also associated with adaptations to confined environments. The loss in genetic variation affects human welfare. For instance, if the agricultural species perish, there could be trouble in genetic resources, which can be implemented for crop quality betterment, and hybrid plants for disease resistance.

2. Species Diversity: it is the variations in species in the ecosystem of the whole planet's environment, and when it is reduced and lost or extinct, it is called Biodiversity Crisis.

3. Ecosystem Diversity: it is the community interactive network between populations of different species within an ecosystem, which means if there is a local extinction of one species, as a consequence, there will be an effect on the overall community's populace.

There are three threats to biodiversity, according to Campbell (2008): habitat loss, foreign species introduction, and overexploitation.

Habitat loss: it is the primary threat when it comes to biodiversity, which is because of human-made shifts in the habitat of species.

Foreign species introduction: when people travel the world and relocate species, deliberately and unwittingly, to a completely unfamiliar geographical region, there is a debut of non-native species.

Overexploitation: it happens when individuals are harvesting plants and wild animals at such a pace that the ability for the species to thrive again is next to impossible.

Fauna

The gradual alteration in climate and the insertion and distribution of wild creatures during the postglacial era represents today's Poland (Web, 2014). Positioning, topography, soil nature, climate, heightened social and economic awareness development, and historical background are the drivers accountable for the rich biodiversity. Mountains, lowlands, coastal, and maritime areas help the country having diverse geography. Being at the Atlantic borderline and having the continental climate make it suitable for accommodating many species reside on the border side. Numerous European migratory birds and bats meet in this country. The sensible forest initiatives and massive agricultural harvesting promote this country with enriched natural habitats for many species.

In Poland, the previous estimation gives us 60,000 existing species, among which 2,415 are spermatophytes, and 35,368 are fauna.

The following are the number of species in Poland:

Mammals: 105	Amphibians: 18
Fish: 130	Reptiles: 9
Birds: 395	

Brown bear: 164	Chamois: 334
Wolf: 1,122	Beaver: 96,658
Lynx: 308	Capercaillie: 470
Wisent: 1,361	Black grouse: 446

The above species are the highly protected ones. But due to the presence of below 447 individuals, the Porpoise living in the Baltic Sea is the most threatened one.

In Poland, permanent grasslands are the primary cloak of biodiversity. In agricultural areas, they have a percentage of 59.9, in arable lands, they have 20.7%, and in the whole country, their coverage is 12.4%. In this country, vast fragmented land areas-remaining as plots occupied by fields, trees, bushes, and natural ecosystems-conserve biodiversity and landscape.

Poland (2015) mentioning about the fauna with the inclusion of 100 bird species. Poland has 700 existing species of vertebrates. Out of these 100 bird species, only 34 live on agriculture or related to this, and they surprisingly seize the eye-catching position of the total EU bird's populace and maintain equilibrium throughout nature despite having many agricultural land transformations.

1. Aquatic warbler: 89.9%

2. White stork: 38.4%

3. Great snipe: 27.7%

4. Skylark: 21.2%

5. Corncrake: 19.8%

The country is the natural habitats of white stork (*Ciconia ciconia*), which remain as a proportion of 23 individuals. Also, in terms of the whole EU, 45% of white-tailed eagle (*Haliaeetus albicilla*) and 90% of the aquatic warbler (*Acrocephalus paludicola*) build their dens here. Furthermore, the majority of the European bison (*Bison bonasus*) prevail here without any restrain (Poland, 2014).

This place has the best-allotted sustenance to survive and breed (roaming, feeding, and grazing) 90 indigenous species, and groups of farm animals are prevalent without including the local ones. According to Poland (2014), they are:

1. Cattle: Polish red, white-backed cattle, black-white, and red-white

2. Horses: Polish konik, Hucul pony or Sztumski, and Sokolski coldblood horses

3. Pigs: Złotnicka spotted, Złotnicka white, and Pulawska

4. Sheep: Polish heath sheep and Swiniarka sheep

Flora

With a clutch of 9,600 ha area of land, Poland owns the forest, woods, and bushes in north, west, and south-east parts, which is around 30.7% of the net countrywide area (Poland, 2015). In the country, the number of unique plants is 485, and in the farming lands, around 45 plant species can be spotted.

Throughout Central Europe, the country is ahead of all for its plant's diversification. Today, this country is the homeland of 2,300 vascular plants, around 600 mosses, 250 liverworts, and 1,600 lichens. Constituting approximately 60% of the entire flora, the vascular plants are short-lived in nature because of the northeast and west directional restriction of animal migrations. Oak, Black alder, Elm (European white elm), White willow, and Small-leaved lime are some of the examples of them.

Poland (2015) states that various vascular plant species are spread out through the country:

1. Eurasian and North American plants: Red Bilberry

2. Arctic and Boreal: Dwarf Birch

3. Central European: Fir and Beech

4. West Europe: Heath

5. The Black Sea and Hungarian: Dwarf Cherry and Yellow-coloured Spring Adonis

If we head towards the north, we can observe Broad-leaved lime, European larch, and Black poplar, but to the south, we get the scope to watch Swedish Whitebeam. If we move on to the east and northeast, there is an abundance of Atlantic and sub-Atlantic plants like the Beech, Sycamore, Field maple, Sessile oak, and Crossed-leaved heath, and the presence of Dwarf birch and Lapland willow plants are in the north.

After World War II, Poland put more stress to fill their forests with pine trees onto poor sandy soils, non-productive for cereal crops, which now these days hold 57,000 km^2 of land, whereas beeches and firs own only 3,300 and 2,000 km^2, respectively

(Poland, 2014).

For the last two decades, there have hardly been any significant changes in Poland's forested territory. Coniferous plants, precisely the pine trees, and spruces cover 70% of these woods. Numerous mosses, lichens along with berry bushes, junipers undergrow these pine forests. Moreover, mosses, ferns, and berry bushes spotted in mountains and north-east also undergrow spruce, an unfavorable climactic rigid plant.

Oaks, hornbeams, or beeches are the broadleaved trees that need the ground to thrive. Bialowieza and Kampinos are suitable places for these trees to grow in abundance. Swietokrzyskie Mountains are the exact address for fir and beech trees.

Beech forests are available in the lower mountains, Pomeranian Lake District, Western Masurian Lake District, Lublin Highland, and Bieszczady. Lasy Kadynskie (Kadyny Forest) and Puszcza Bukowa are the predominant places for best beech forests (Evi Web, 2014).

Figure 17: Biodiversity at the sites

2.4 Sandy Soil

The type of soil in the project site is sandy soil. This section is about the soil types because it is an integral component of the research. Minerals, soil organic matter, water, and air are the constituting elements of soil, which upon the disparity in the ratio influence the soil's physical properties, texture, structure, and porosity. Thus, these properties affect the air and water movement in this soil. The influence of climate and living matter act upon the metamorphosis of soil properties by creating multiple distinctive layers, in terms of texture, structure, and color, termed as horizons in the soil profile. Most of the agricultural soils are assembled into four main horizons:

1. Litter layer
2. Topsoil
3. Accumulation zone
4. Parent material

Later, there is the presence of just bedrock. The texture is the cardinal physical property of any soil, and there are various soil textures. The variation in the proportion of four minerals decides the soil texture: gravel, sand, clay, and silt. Gravel particulates are more than 2 mm in diameter, sand particulates are from 0.05 to 2.0 mm, silt particulates are between 0.002 and 0.05 mm, and clay particulates are smaller than 0.002 mm in diameter. And they are invisible to the naked eye (McCauley, 2005).

Good soil management is necessary to prevent soil decay due to compression or erosion. The loss of excessive soil carbon in the form of CO_2 after the breakdown of organic material is another point to consider. The lesser the organic material, the harder it is to manage (Finch, 2014).

Sandy soils have a variant texture compared to others and must be dealt with attention to ensure the plants' healthy growth.

Soil that generally holds beyond 70% sand is considered unacceptable as topsoil material because of its low water and nutrient retention capabilities. Sand that has a below-average surface area leading to more spontaneous drainage of water and nutrients. However, sandy soil provides efficient gas diffusion around the roots of plants, even though the sand is tightly packed. The best way to improve sandy soils is to add organic matters. Since sand soil cannot hold water and nutrients sufficiently, it needs to add nutrients frequently and stay hydrated (Wagner, 2015).

Sandy soil can serve at any time without much deliberation, as they are free-draining, warm up early in spring, unstable, easily eroded by water and wind, and have little natural structure, which means that subsoiling might be needed routinely (Finch, 2014).

Irrigation on sandy soils is a prerequisite for several reasons: maintaining soil moisture to promote crop response, avoiding economic losses due to moisture lacking, maximizing the efficiency of production, minimizing irrigation-induced erosion, minimizing nitrogen leaching or uptake, managing salts in the root zone, and managing soil, air, or plant micro-climate (Alhammadi, 2013).

Land-based solar electricity generation technologies are rapidly expanding. However, people have a confined knowledge of its effect on biological carbon cycling in ecosystems. PV panels can significantly improve the local ground level climate to such an extent that the core plant-soil process cycle that governs carbon dynamics are affected. If the solar panels are installed at any location, it will affect the local distribution of rainwater because there is a disparity of rainwater in the internal and external panels (Armstrong, 2014).

Figure 18: Sandy soil examples from the sites

2.5 Project Limitations

According to the topic, the projected area is not sufficient, which offers constrained possibilities for any significant changes in biodiversity. 18 ha of land is not enough to support biodiversity promotion. In this project, the main limitation for us is the restrictions of the plots.

The project has a certain perimeter in each plot. The size of these plots is the main limitation, followed by the fixed orientation of the PV panels. Solar cells are the main component of the PV panels. A standard 72 cells PV module is 2x1 m in size. PV modules are placed in frames that need to be raised at least 1 m from the ground. PV panels orientation can only be east-west facing and south-facing (east-west in plot A & B and south in plot C), and the distance between the panel rows needs to be at least 1 m. In each row, there should be at least one string inverter. The number of transformers depends on the size of the solar panel parks. There should be 12 m wide maintenance roads and 4 m wide service isles. The whole solar panel park needs to be surrounded by security fences that have a minimum distance of 12 m from the solar panel frames. Except for the maintenance staff and project-related staff, no one is allowed inside the fence.

The limitation when it comes to biodiversity is not to have plants that are higher than 1 m in between the solar panel rows because, if the plants are taller, they will cast shade on the panels. It also means no trees in the solar panel parks. It is not suitable to plant many new vegetation in these parks since it can become a feast for rodents and other animals. Sticking with the local fauna but incorporate more diversity in those parks. Another limitation is birds since they can cast shade on the solar panels and reduce energy production.

In the beginning, we corresponded only to IKEA Industry's proposals. However, finally, for the individual plots, we ended up with some additional ideas to promote biodiversity with the landscape. Perhaps, it is feasible to welcome more biodiversity and landscape.

Chapter 3

Project Input and Inspirations

The image is a visualization from the design proposal of the Plot B requirement plan showing winter snowfall

- *Solar panel park*
- *Maintenance road*
- *East-west facing solar panel*

3.1 Solar Panel / Photovoltaic (PV) Power Station

Solar cells are electronic devices functioning by directly converting the sunlight to electricity. It was invented in 1954 at Bell Telephone Laboratories (Gielen, 2012).

Solar panels are manufactured of solar cells, which consist of semiconductor materials (Fig 19), one of them being silicone. Solar cell comes in different types, and one of them is water-based silicon cell. It prevails in 90% of the world's solar cells. Water-based silicon cells are either cut from a single crystal rod or from a block that consists of many crystals. As a result, it is also called mono-crystalline or multi-crystalline silicon solar cells.

There is another type of solar cell, thin-film solar cells, which can be made at a lower cost in large quantities. But they show lower efficiencies than water-based silicon, which means they need more surface exposure and materials (Piebalgs, 2009). Crystalline silicon cells are standard modules having high yield. The thin-film cells are cheaper to make but are less useful (Kellberg, 2015).

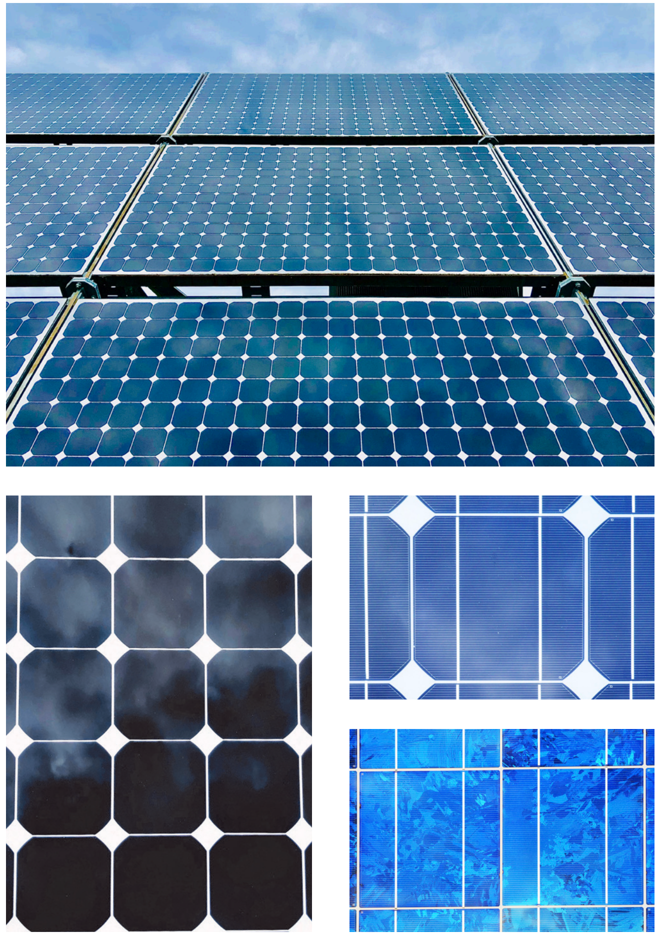


Figure 19: Solar panel and solar cells

The performance efficiency of cells will reduce over time from usage. However, the decay rate depends on the environmental conditions and modular technology. Premium quality solar cell modules can have a shelf-life of 25 to 30 years.

The solar panel modules have the facility to install on a fixed-angle frame or on frames that track the sun. Fixed structured frames are convenient to place and control (Fig 20), but the rotating frames can give 45% more yield. Solar-tracking system also facilitates a smoother power output (Fig 21). However, fixed one keeps the rows in the right order, and they are typically made of steel or aluminium. Solar-tracking systems are made of single or dual-axis systems. Single-axis can only change either orientation or tilt while the dual-axis changes both to give a more precise sun tracking. The rotation of the solar panels is oriented in such a way that they receive the maximum seasonal light and is dependent on the latitude of the site's location (Kellberg, 2015).

The core parts of a solar panel park are the solar cell modules, installation systems, inverters, and transformers.

Generally, through a series, the string modules are connected to generate a higher voltage, and by modular connection, they produce immense energy for the inverters to storage.

Figure 20: Fixed-angle frame. Left: East-West facing. Location: Vienna, Austria; Right: South facing. Location: Brandenburg, Germany

Figure 21: Sun tracking frame. Location: Bavaria, Germany

Inverters are the devices that transform and DC (Direct Current) from the solar cell modules to AC (Alternating Current), which is suitable for the central grid. This device can be constructed either by a series or central configurations. String inverters have unsophisticated maintenance, and spare kits can be kept on the site, which makes emergency repairs more manageable (George, 2012).

While selecting a site, George (2012) states that there should be some considerations that need to bear in mind, and they are:

1. Solar source

2. Available unused land

3. Local climate

4. Topography

5. Land usability (history)

6. Local legal policy

7. Geotechnical positions

8. Geopolitical uncertainties

9. Accessibility

10. Grid connection

11. Module soiling

12. Water availability

With the assistance of GIS (Geographical Information System) mapping, it is possible to select a plot easily and go for available developmental possibilities. When it comes to biodiversity, it is crucial to avoid sensitive areas, and the solar panels should preferably be built on open and barren sites, for example, on farmland or unused land.

Placement is one of the countable factors that are necessary when it comes to solar panels installations. If dust particles obstruct them, the performance of panels could not be up to the anticipated level. Hence, native weather, social movements, and wildlife activities should all take into concern while sight selection. The cleaning and repairable kits should be on-site or nearby the site, and there should be a fixed (weekly/monthly/yearly) schedule to maintain them depending on the disturbances (Kellberg, 2015).

To gain profit after subtracting all the yearly costs from any solar panel park, settings, irradiation, temperature, the sun's angle, and shading are the few prerequisites that are necessary to keep in mind.

As they are expensive, the PV modules must be safeguarded by using anti-theft bolts, anti-theft synthetic resins, surveillance cameras, alarms, and a security fence. Also, at the time of operation, professional hands and constant surveillance are required to have an impeccable performance of the panel. Plants like trees, shrubs, long grasses can cast shades on the modules. Thereby, they obstruct the performance by generating limited electricity. So, it is one of the parameters that need to be considered. Above all, if the total circumference is possible to monitor, to prevent dust, leaves, and pollen from getting onto the solar panels, then a smooth operation can be ensured (Kellberg, 2015).

3.2 Solar Panel Parks and Wind Farm Projects

This section is about some solar and wind energy projects that incorporate biodiversity measures.

In 2016, an investigated report informed when there is an establishment of a solar panel park, the range of wildlife diverseness is much extended than the similar control pasture and farmland. In this case, all the solar farms were sowed with mixed grass, including some wildflowers. With the help of bees, the management had observed that floral biodiversity had stimulated the fauna biodiversity. They even noticed that because of the richness of small prey in the grass and perching opportunities on the solar panels, there was a presence of several hunting birds in contrast to original plots. The dependency of smaller birds on grass and flowers and a protected refuge in the panel make them an easy target by other birds, which settled there building their nests. Because of the plant numbers within the panels (alleys) in comparison to beneath the panels, which were unfavorable conditions like shade and drying, the panels shade exhibited a variation in biodiversity. Nevertheless, there were more broad-leaved plants under the solar panel than in the rows. Finally, it was a proven result that solar farms could be used for multi-purposes, especially for the improvement of eco-balance, due to the availability of diverse pollinator species (Montag, 2016).

With 12.5 ha area and 18,000 ground-mounted, the solar farm outside Devon, in England, is south-facing and has the facility to roam for sheep between panels (Open Spaces, 2018). England showed another example, where it has a combined vine farm with south-facing solar panels, and again, in the solar panel area, they have included grazing animals.

A third example of a solar panel farm is a former mine site at Cornwall in England located in the center of Cornwall's historic mining areas: Wheal Jane, a 4 ha area holding 5,760 solar panels that provide 1.55 MW. The farm started to operate in the summer of 2011. After landscape and visual impact assessments, the drawn outcome was due to the extended vegetative arena, the sight that had limited scope to the distant view. An additional ecological impact assessment was also conducted and detected the likely consequence of the PV installation- the development did not have any hampering environmental effect, and contrastingly, the project would offer potential eco-friendly benefits. Since it was an old mining site, mineral safeguarding is paramount. It is for preventing the unnecessary sterilization of mineral resources (BRE, 2013).

Being a beneficent energy source, humans have always appropriated wind for their circumnavigation. From paring grains to watering crops, for more than two thousand years, wind-powered devices are helping us out.

Black Law Wind Farm

By meeting the electricity demand of 70,000 people in its initial phase 42 turbines setup, a town size like Paisley, Black Law Wind Farm has 88-turbines, which ultimately generating 18 MW power, to save about 200,000 tonnes of CO_2 emissions annually. During construction, a derelict opencast coal-mining site situated nearby South Lanarkshire transformed into shallow wetlands for this £90 million project. There had been a job opening for 200 people while constructing, and at present, there are seven permanent posts at the operational site. The installation came into succession in 2017. In 2005, it had 42 turbines, and at that time, it was the only paradigmatic onshore wind farm in the UK. In 2006, it had another 12 turbines, and in 2017 the rest. With 14 km^2 of land area, this is a sensible approach to offer sustainable energy and initiate an extended natural habitat management project to provide a healthy habitat for wildlife creatures. Because of that, the Royal Society for the Protection of Birds appreciated praise (RenewableUK, 2010).

Peñascal Wind Power Project

Holding the location in Kenedy County, Texas, the power plant consists of 168 Mitsubishi MWT-92 turbines, each of them is safe and resistant to lightning with maximum output and having the capacity to generate 2.4 MW electricity, for supplying power to approximately 70,000 households. After Phase-II construction, it was renowned for being the largest renewable energy manufacturer in the world. Phase-I and Phase-II, both had completed in two successive years by recruiting 200 people temporarily. Before starting this project, Iberdrola Renewables did a precise inspection of the weather patterns and avian movements to skip any rugged situations for the birds, wildlife, and wetlands and, for that, they deployed wildlife biologists who scrutinized the area for about 4,000 hours in three years.

The outcome from this south of Baffin Bay located Peñascal Wind Power Project has a minimum injury on the flying pattern for the annual migratory raptors, passerines, and other birds towards the central and eastern North America. Though the placement is in between the routes of migratory birds, the wind farm is equipped with avian radar that facilitates by signaling them coming at a distance of 6.4 km. Also, when flocks of birds are in proximity to the rotating blades, it automatically switches off, and when everything pacifies, it restarts again. At the end of Phase-III completion, the total power generation facility is now 605.2 MW. In Phase-III, conducted from 2013 to 2015, 101 Gamesa G97 model turbines were in use with having the capacity to generate 202 MW total electricity (The Wind Power, 2017).

Beinn an Tuirc windfarm

A Scotland-held Beinn an Tuirc is an exemplary onshore wind farm model that underwent some imperative analysis: EIA (Environmental Impact Assessment) and SEA (Strategic Environmental Assessment) before implementing the habitat management plan for local endangered wild species conservation. While under the EIA inspection, the developer, the SPR (Scottish Power Renewables), devised to relocate this further to the south, leaving the golden eagle territory unharmed. The HMP (Habitat Management Plan) offers 1,670 ha land area to them to forage, which is far from the original site. Also, the initiator continues this non-stop observation throughout the construction and existing operation. This project is now in Phase-III, but Phase-I started in 2000 and accomplished with an ability to generate 29,700 kW (kilowatt) electricity. In phase-I, the installed 45 turbine models were Vestas V47-660, with each producing 660 kW. Phase-II was commissioned in 2014 with 19 Siemens SWT-2.3-82 turbines, and the yield electricity was 43,700 kW. For Phase-III, the installed turbine number is 14, and the expected return is 50,000 kW. Because of considering the environmental matter and fulfilling the local community's expectation of building wind farms project, SPR was awarded the Queen's Award for Enterprise in 2006 (pvEurope, 2017).

Panachaiko Wind Farm

Panachaiko in southern Greece is another wind farm project in service since 2006. There is a generation of 48.45 MW power in two Phases: Phase-I produces 34,850 kW energy using 41 Vestas V52 turbines, and Phase-II produces 13,600 kW installing 16 Vestas V52 turbines. Each turbine can yield 850 kW power. Before developing this establishment, certain types of ecological studies were conducted to ensure wild animals' safety, and in the Natura 2000 site, it was a large structure in Greece. Habitually vulnerable creatures and natural forests kept at a safe distance from the infrastructure. For instance, platforms, roads, to assure there was no probable death or any unwanted events, like relocation of bird nests (pvEurope, 2017).

Figure 22: Solar panel park in Skåne, Sweden

Figure 23: Wind farm project in Småland, Sweden

Examples of some solar panel parks where incorporation of biodiversity can be possible in the future:

For Sweden, one of the biggest solar panel parks, with 1 ha sized land area and has 4,080 solar panels, located in Mossberg, just outside Arvika, named MegaSol solar panel park, which generates about 1,000 MWh per year (Teknik, 2018).

In Germany, there is an unforeseen example- individuals combine conventional waste management with solar panels. The 9.78 MW east-west facing solar panel park on the Hellsiek landfill site in Detmold functions as a seal for the landfill. The solar panels do not allow the contaminants of the landfill to mix with pure rainwater, and by that means, the contamination does keep in check. Additionally, rainwater is collected and deployed elsewhere (pvEurope, 2017).

In 2007, Bavaria Solarpark, a Germanic group, possessed 25 ha of land, where they planted three photovoltaic power stations: Solarpark Muhlhausen (capacity 6.3 MW), Solarpark Gunching (capacity 1.9 MW), and Solarpark Minihof (capacity 1.9 MW), and collectively, they generate 10 MW using 57,600 solar panels (Sunpower, 2007).

With approximately rendering 800 MW of electricity, Mohammed Bin Rashid Al Maktoum Solar Park, outside Dubai, will be a massive structure when the construction is over. This project will complete in three phases: Stage A in 2018 with 200 MW, Stage B in 2019 with 300 MW, and the final stage, Stage C in 2020 with 300 MW. Upon accomplishment, it will serve 130,000 homes with electricity and reduce carbon emissions by 6.5 million tons annually. This park will be the first to use the single-axis tracker, and it will have custom-made cleaning robots that will bypass water (Masdar, 2019). The project is now underway to phase four, where they will build the tallest concentrated solar power tower in the world. It will use heliostats to focus the sunlight on the top of that tower, where the warmth will heat a flow of molten salts. The heat will use to power steam turbines (CNNstyle, 2019).

Future visions of IKEA:

Babimost	4.6
Chlastawa	14.1
Goleniów	4.0
Lubawa	7.0
Orla	9.0
Resko	4.0
Stalowa Wola	3.5
Wielbark	8.0
Zbąszyń	0.5
Sum of the potential to install in MWp	**54.7**

Figure 24: Estimated need Poland IKEA Industry. Source: (IKEA, 2020)

Besides these locations, there is also the potential to increase existing installations.

- Pacos with plus 3.6 MW
- Nantong with plus 1.2 MW

For other locations like Lithuania, Hungary, Russia, Slovakia, and Sweden, pre-studies are yet to be conducted (IKEA, 2020).

3.3 Alley Cropping

It is an alternative concept that can be possible to enhance biodiversity. We are proposing this concept in our design proposals. Alley cropping is a state-of-the-art concept of agroforestry that involves intercropping and multi-cropping. The agricultural, horticultural, or forage crops are cultivated in the gaps between widely spaced single or multiple rows of woody plants (trees or shrubs). Based on the harvesting machinery facilities (tractor, planter, and sprayer) that are required during crop growth, the width of the alleys varies in size, which is sometimes narrow and sometimes wide (Missouri, 2015) (Trees, 2012).

Apart from the additional benefits of aesthetical enhancement, from this innovative concept, the blessings are bestowed on two main mutually inclusive sectors: socio-economical and ecological. The regeneration in vivid biodiversity is the liveliness in the about-to-be extinct living creatures. With additional avoidance in the erosion of natural resources like soil, prevention of pesticides that eventually revise water quality, and gradually developing robust crops (Huasen, 2018) (Missouri, 2015). By comparing both economic and environmental aspects, this agroforestry practice is a well-designed sustainably diversified production of crops and shrubs or saplings on the same plot where land-owners or farmers can make an immediate profit by harvesting yearly crops. But these can also get a medium to long-term income by treelike plants, such as timber and non-timber products like fuelwood, fruits, honey, and cork. (Missouri, 2015) (Lerberghe, 2017).

In the twenty-first century, the planet needs to redesign in such a creative way that challenges like global warming, food crisis, or natural habitat extinction should not come up in the first place on the challenge list. To make this possible, one of the feasible solutions is alley cropping (Huasen, 2018).

We are at the initial stage of proposing to keep alley cropping rows in between the solar panel rows, where solar panels perform as trees. Later, with the following consideration, crop and panel maintenance, fencing, and avian movements, we avert the proposition and proceed with saplings or shrubs outside the solar panel park fences for easier access and maintenance.

Once the alley cropping introduces to the parks, the reflection of vibrant biodiversity is observable sustainably in the applied domain. For instance, there will be a restoration in the habitats of wild creatures. As it involves the parallel cultivation of agricultures in between linear trees and shrubs, wild-creatures, like birds, can get cozy with this type of landscape. Because a protective shield is created between these gaps for them to move, and plentiful food is available for them to feed on (Missouri, 2015).

According to this, while projecting alley cropping, supplementary benefits are:

i. Decrease of water-mediated and sloping soil erosion:

a. The distribution of deeply entrenched tree or shrub roots along the edges protect the physical and chemical properties of soft terrestrial soils of farmlands that have an erodibility index that is greater than 8.

b. In alley cropping, implanted trees and shrubs canopy the grounded soil and obstruct them to erode during any drastic season by using their herbaceous parts, like leaves or roots. The additional aftermath will be enhanced water purity that is performed by those herbaceous tree roots by intersecting, sequestering, and decomposing the applied pesticides or agrochemicals, which is beyond the outreach of crops or grains.

ii. Modification in crop health:

a. By adjusting the wind velocity by trees and shrubs, slowing the crop evaporation from 15% to 30%, and enriching the water content with (5-15)% to the bottom layer of the soil, alley cropping strengthens the inter-crops, which have an ultimate impact on the crop health.

Before laying out this design, the focus should be on to woods and companion crop's physical attributes. Depending on this, the rest of the considerations are sunlight, water and nutrients, and allelopathy.

Figure 25: Cropping and alley cropping

Figure 26: Alley cropping before and after harvesting

3.4 Case Studies

In August 2020, we successfully completed our remaining site visits and field trips needed for the study purpose, when the corona pandemic loosens its intensity from Europe. We accomplished some study trips in Sweden, Germany, and Poland.

We had visited some places that mention below:

1. Kristianstad (Skåne, Sweden) for viewing the south-facing solar panel park (Fig 22)

2. Slageryd (Småland, Sweden) for seeing a newly built wind farm project that has six wind turbines (Fig 23)

3. Öland (Småland, Sweden) and Falkenberg (Halland, Sweden) for sampling some sandy soil (Fig 29)

4. Lomma (Skåne, Sweden) for seeing the SLU's ongoing alley cropping research work of SAFE (SITES Agroecological Field Experiment) (Fig 30)

5. Malmö (Skåne, Sweden) for viewing rooftop solar panel installation of Auguestenborg Botanical Roof Garden (Fig 31)

6. Arnstein (Bavaria, Germany) a field trip for experiencing the sun tracking system at Erlasee solar park (Fig 32)

Featuring 1,500 double-axis solar trackers, Bavaria located Erlasee solar panel park has 11.4 MW capacity to yield a 30% higher electricity. Each large panel consists of 12 individual solar panels, and each year, the park gives around 14,000 MWh of electricity. The park covers about 77 ha, and after its establishment in 2006, it became the largest double-axis sun-tracking solar panel park in the world.

There is ongoing research on alley cropping at SLU in Lönnstorp research station, Skåne. The research station has a focus on cropping system dynamics and provides research opportunities in ecology, environmental sciences, and agroecology. It belongs to the SITES (Swedish Infrastructure for Ecosystem Science) network, and a long-term field experiment, SAFE (SITES Agroecological Field Experiment), has been established.

Within SAFE, two concepts that are indeed new are the Agroecological Intensification system and the Perennial Cereal system.

SAFE is based on four cropping systems, where each replicated in four blocks: Perennial (0.48 ha divided into 2 plots), Agroecological Intensification (0.60 ha divided into 16 plots), Organic (0.48 ha divided into 4 plots), and Reference (0.48 ha divided into 4 plots).

We have had one of our field trips focused on the Agroecological Intensification system, also known as Alley Cropping. Here, in this project, one crop species that will be harvested in one season is not repeated in the next season, and this system is an eight-year rotation (Fig 27). We surveyed permanent plantings of four rows of three varieties of apple trees (*Malus pumila*), and they were: Topaz, Aroma, and Santana. Each block has three rows of hedges with trees and big shrubs in the center and small shrubs in the sides (Fig 28). The species present in the hedges are: Two varieties (Ezochi and Stubbaröd) of Blue-berried honeysuckle (*Loneicera caerulea*), Sea buckthorn (*Hippophea rhamnoides*), Vosges whitebeam (*Sorbus mougeotii*), Black elder (*Sambucus nigra*), Goat willow (*Salix caprea*), and two varieties (comomn and Cecilia) of Cherry plum (*Prunus cerasifera*). There are eight plots placed in between the apple tree rows and hedges, and several crops that intersown rotationally: Rye (*Secale cereale*), Wheat (*Triticum aestivum*), Grass/ Legume ley, Sugar beet (*Beta vulgaris L. subsp. vulgaris var. altissima*), and the intercrops of Faba bean (*Vicia faba*) with Spring wheat, Lupine (*Lupinus albus*) with Barley (*Hordeum vulgare*) and Oilseed rape (*Brassica napus*) with Hairy vetch (*Vicia villosa*). An additional plot with the same crop to keep on one side of the system in each block.

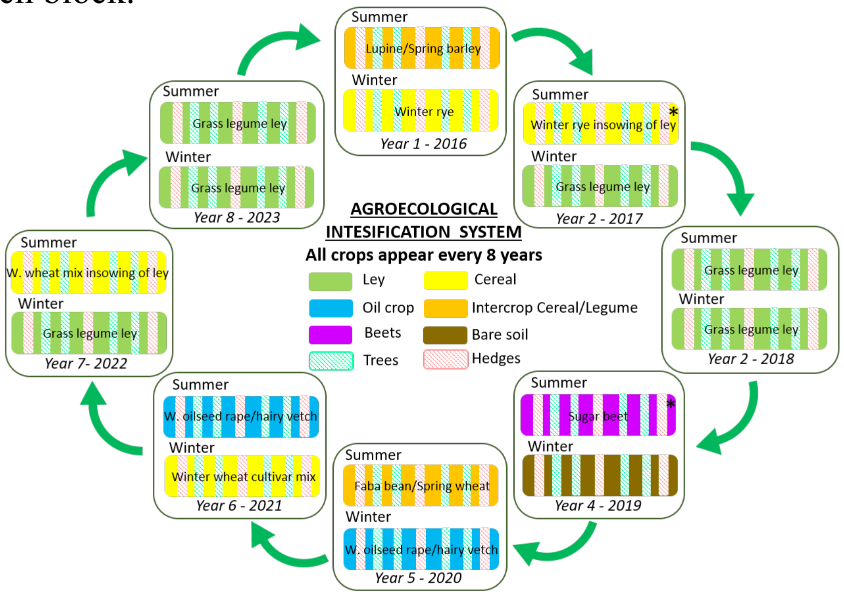


*Figure 27: Agroecological Intensification system. *Addition of fertilizer. Source: Ana Barreiro*

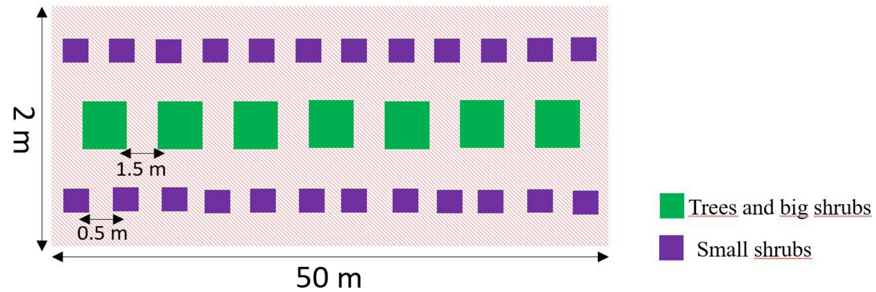


Figure 28: Detail of the distribution of trees and shrubs in the row of hedges in the Agroecological Intensification system. Source: Ana Barreiro

Figure 29 Sandy soil at Öland, Småland (Upper) and Falkenberg, Halland (Bottom)

Figure 30: Alley cropping project of SLU SAFE at Lomma, Skåne

Figure 31: Rooftop solar panel at Malmö, Skåne

Figure 32: Erlasee solar park at Bavaria, Germany

Survey on solar panel parks and wind farm projects:

During the field trips from southern Sweden to southern Germany, we surveyed and counted the number of wind farms and solar panel parks on both sides of the highway route. We approximately listed 74 wind farms and 68 solar parks. But amazingly, 60 of them are in Germany, a country that is now in the leading position in Europe in respective of renewable energy. Here, we illustrated a map that picturizes the route we took with the approximate location of solar parks and wind farms on both sides.

From this survey, we had identified the future of renewable energy usage precisely when we tripped from the previously mentioned destination. In this case, we detected developed countries like Germany are initiating this provision of shifting towards renewable power like solar or wind energy heavily. Also, by the end of 2030, we can predict that developed countries will lean more towards green energy. But after when we initiate this project, it hopefully gives other designers the aspiration to plan their projects more sustainably by promoting and incorporating biodiversity.

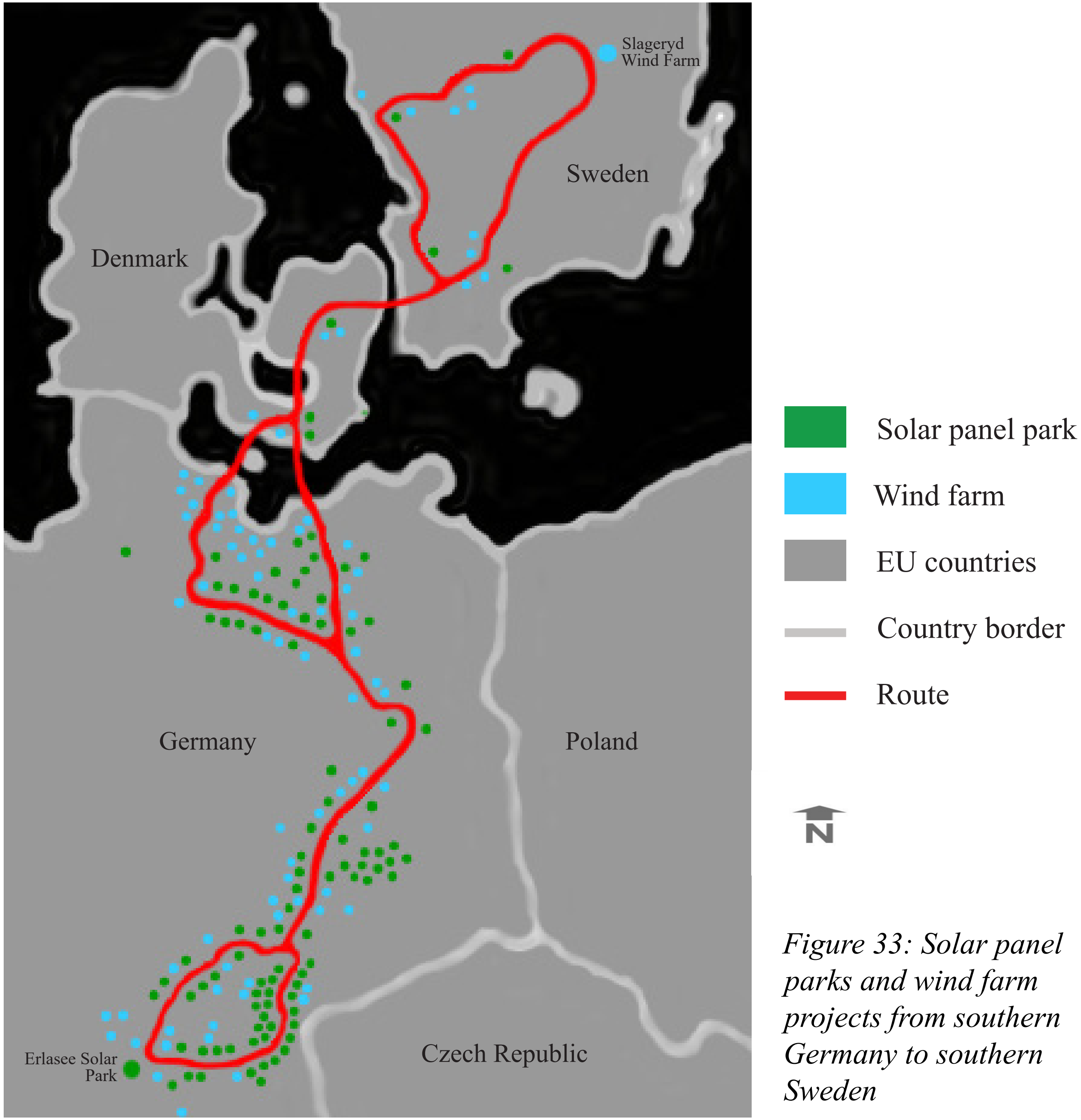


Figure 33: Solar panel parks and wind farm projects from southern Germany to southern Sweden

“Landscape as an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors” – European Landscape Convention 2000 (Stahlschmidt, 2017)

The image is a seasonal visualization from the design proposal of Plot B requirement plan showing spring and summer season

Chapter 4

Design Proposal and Aesthetical Intentions

The chapter represents visualizations with seasonal weather

The illustrations of the visualizations are representing our design concepts and proposals. However, the ideas and inspirations for the visualizations came from the requirements of IKEA. The formal aspects of our design proposal are representing spatial objects as the design proposals are made without visiting the site and without knowing the surroundings, local conditions, and culture. The official designs are retrieved from an architectural educational background. The design concepts and proposals did not have any budget restrictions.

The image is a seasonal visualization from the design proposal of Plot B requirement plan showing autumn and winter season

4.1 Design Concepts

This research topic was introduced by IKEA Industry, which is about solar panel parks considering landscape for promoting biodiversity. The primary function of a solar panel park is to convert the energy of the sun into electricity for commercial use. In this case, the electricity is generated for the primary electricity grid of the IKEA Industry factory. A solar panel park generally consists of PV panels, inverters, transformers, security fencing, surveillance cameras, maintenance roads, and service isles. The PV panels are in rows across larger areas, usually on old agricultural land.

The primary concept of this paper is to research the landscape for promoting biodiversity and recreation in land-based solar panel parks and landscape parks. The main factors to be considered in the solar panel parks are biodiversity and landscape. Inside the fence, while making the conceptual design ideas, the solution arose to introduce flora that cannot grow above the height of 1 m and wildlife such as insects, pollinators, and small rodents. As it was a challenging requirement from IKEA Industry to consider the birds as a problem, a landscape park is therefore suggested outside the fences of the solar panel park to attract birds with feeding, nesting, and breeding areas. Another use for the landscape parks can be a relaxation space for the workers from the IKEA Industry factories and the residents of Zbąszynek and Babimost. Another concept that can be considered is ‘biodiversity’ in both the solar panel parks and landscape parks with the incorporation of sheep grazing, alley cropping, water bodies, and bufferzones full of bushes and flower strips.

What is a landscape park in this case?
A standard landscape park is a concept that creates a semi-natural area usable for biodiversity like the protection of wildlife and natural habitats (resting, feeding, nesting, breeding, and roaming areas), relaxation activities by the people in its surroundings. This project consists of several landscape parks, and they are composed of grassy areas, rocks, bare soil, trees, and gardens; artifacts such as sculptures and fountains; fields for playing sports and games; benches, picnic tables, and seating areas. The majority of parks

also have trails for walking and biking etc. The waterbody is another component of one of the plots.

Solar panel parks are usually located away from main cities and populated settlements due to their large scales and utility of solar power generation. In this project, the plots are located just outside the towns of Zbąszynek and Babimost. The concept of the landscape park is, besides inviting biodiversity, also to involve the people from these two towns as they have inhabitants of approximately 5,000 and 4,000, plus the 3,000 IKEA Industry workers from each factory location.

In which way does biodiversity need to be considered in both solar panel parks and landscape parks? In solar panel parks, biodiversity should be for natural values, but in landscape parks, biodiversity should be for both natural and human values. The idea of biodiversity in these parks is to promote flowering vegetation for increasing the number of insects and pollinators. Thus increasing the diversity of flora and fauna in those parks, but also in the surrounding areas. It can function as ecosystem services when the number of insects and pollinators increases, there is a higher chance to get better yields of fruits and grains, etc.

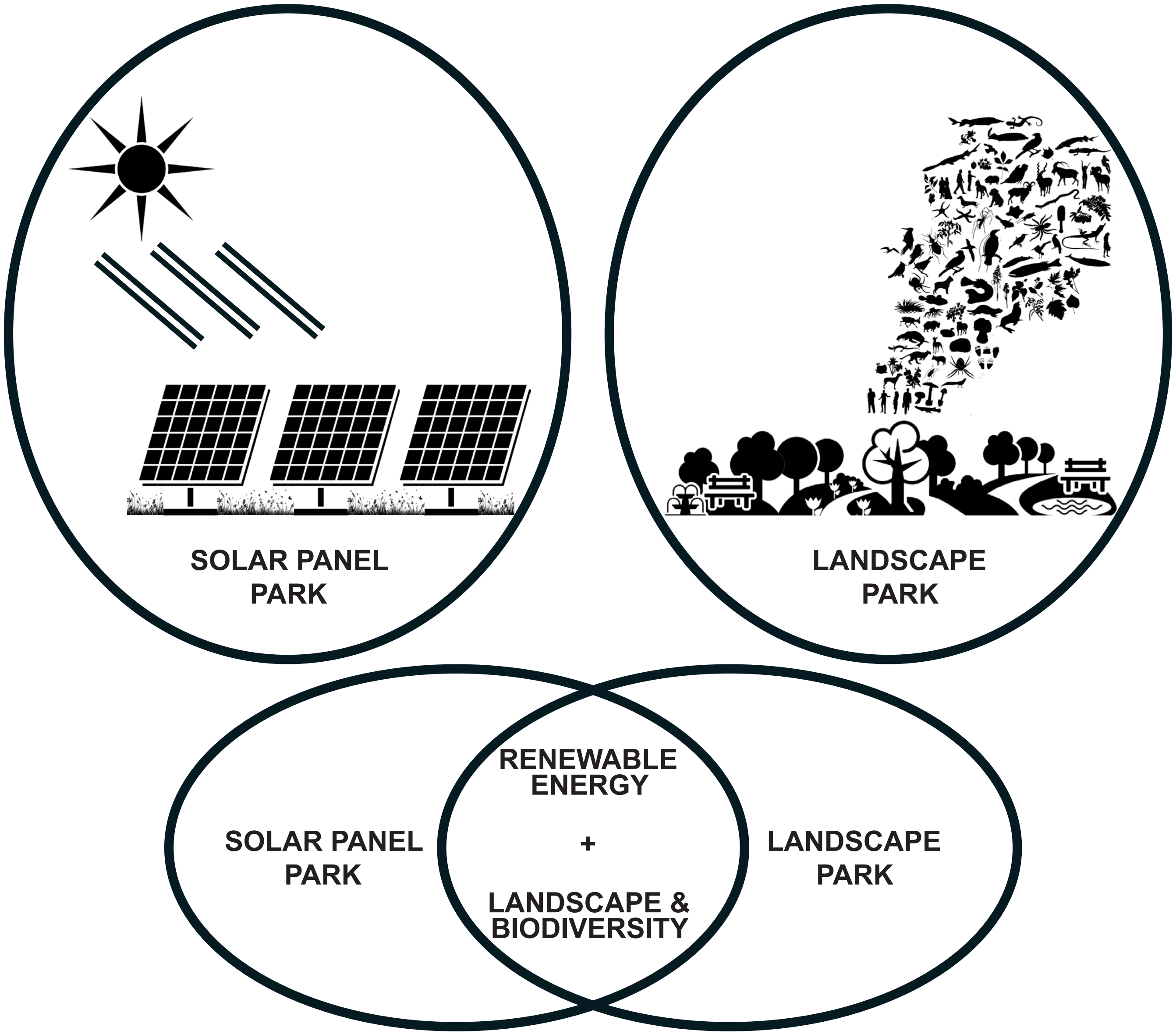


Figure 34: Conceptual diagram

The illustrations of the plans are representing our design concepts and proposals. However, we are proposing two different ideas for each plot, one we named Requirement Plan that includes IKEA Industry's requirements. The other is the Proposal Plan, where we add our thoughts, ideas, and designs.

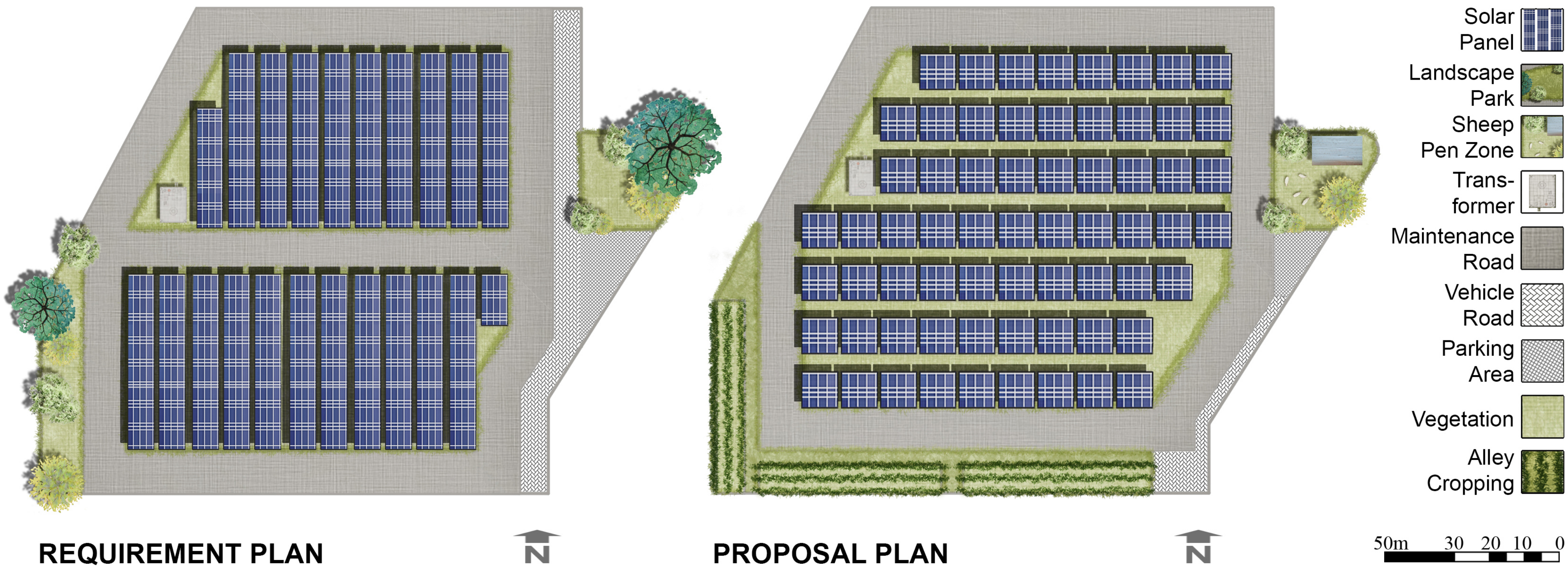


Figure 35: Plot A Plans

4.2 Design Proposal

It is always a bold strategy to research the project, site, and surroundings first and then to select the basic requirements for making a conceptual proposal. For achieving the design requirements, we conducted several meetings with the key persons of the IKEA Industry responsible for the project to determine the given requirements, ideas, and wishes. The project is about three solar panel parks for sustaining IKEA Industry factories with renewable energy.

In this research, we are presenting several proposals. IKEA Industry's wish is to produce as much energy from the plots as possible and increase biodiversity in it. However, in the other way, it is challenging to consider the main facts landscape and biodiversity without using any separate space for it. That is the reason why we are proposing two different design proposals for each plot: One from according to IKEA Industry's minimum requirements named Requirement Plan, and the other is the Proposal Plan, where we include our own thoughts, ideas, and designs, to promote biodiversity and recreational values more. Within these two facts, we are proposing the concept of landscape park in each proposal.

In our proposals, the landscape parks mainly consist of areas for the primary use of biodiversity, and partially, it can be used for human enjoyment and recreation. Alley cropping is another alternative to use in those spaces which otherwise would be unused. Alley cropping can provide food for IKEA Industry factories or provide an income for local farmers. Adding water bodies increases the biodiversity in the landscape parks, and it also increases the aesthetical attributes. By adding bufferzones with bushes and flower strips, at the setback of the sites, the biodiversity could enhance.

It is a requirement from the IKEA Industry that people cannot go inside the fence. To solve the issue and parallelly creating a place for civilian use, we decided to propose landscape parks with different features such as water bodies, alley cropping, and bufferzones outside the fence. Inside those fence of the solar panel parks, sheep grazing is an alternative to increase biodiversity inside the parks, as

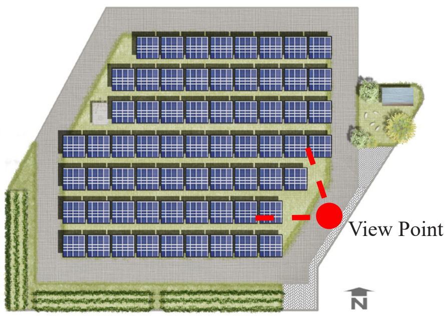


Figure 36: Plot A proposal plan showing summer noon

- *Sun tracking solar panels*
- *Sheep grazing*

well as flowers and grasses under the PV panel frames.

Another limitation is birds since they can cast shade on the solar panels as well. It is, however, hard to avoid birds since no place can be bird-free. With increasing biodiversity, there will be a chance of an increase in the number of birds. A lot of birds help with the reproduction of plants and are, therefore, important as pollinators or seed dispersers.

Design proposals for Plot A

Plot A is a small plot of only 2 ha in comparison to the rest of those plots. In the requirement proposal for IKEA Industry (Fig 35 Requirement Plan), we divided this whole plot into two segments with PV panel zones by a 12 m maintenance road in the middle. The northern PV panel zone is approximately 270 m^2, and the southern PV panel zone is 300 m^2. In this proposal, we are keeping the east-west facing PV panel frames since it was one of the requirements for the IKEA Industry for this plot. It is also required to have a 12 m maintenance road from the fence to the PV panel zones, so we have that in all design proposals. We placed a transformer zone of approximately 90 m^2 on the west side of the northern PV panel zone. We put the entrance in the middle of the east side of the plot. Beside the entrance, we propose an 8 m road that will connect the entrance of the park with the surroundings. We also propose a parking zone of 92 m^2 opposite of the entrance. North of the parking, we propose a landscape park of 100 m^2 since

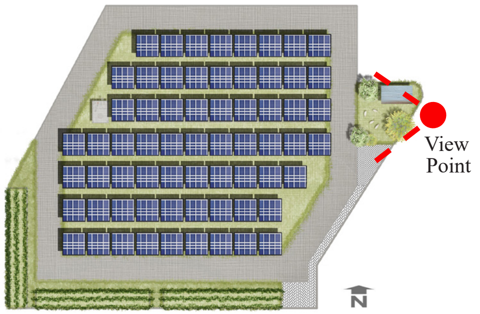


Figure 37: Plot A proposal plan showing summer morning

- *Sun tracking solar panels*
- *Sheep grazing*
- *Sheep pen zone*

that area is too small to place a reasonable amount of PV panels. In the west of the plot, we are proposing another landscape park that is 168 m^2 in size and accessible from the 3 m road running along the south side of this plot.

In our proposal for plot A (Fig 35 Proposal Plan), we propose a different kind of solar panel, with approximately 405 m^2, which has a solar tracking system that tracks the sun's path across the sky (Fig 36). Each PV panel frame has a base of 10x10 m and 5 m isles in between each row, and this for the avoidance of shading. The transformer area is in the same location as in the previous proposal. Under the PV panels, we propose sheep grazing because they cannot reach up to the solar panel at a 1.5 m height, and sheep are an easy maintenance option since they keep the vegetation short. When the land needs to rest, the sheep can stay at their mainstream farmland during that time. When the sheep are on the plot, they have a separate field with a pen and house (Fig 37), which is located east of the PV panel zone in the same position as our previous landscape park proposal. The same goes for the parking area. However, the parking area is with a 4 m road connecting it to the entrance and the road in the south. The entrance we are proposing is in the south-eastern corner of the plot. On the western side of this plot, where we previously proposed a landscape park, we are now proposing alley cropping. We also propose alley cropping in the southern part of this plot, which is adjacent to the road, proposing a total area of 380 m^2 for alley cropping outside the fence and close to the road for easy maintenance and access. In that case, we are not proposing any landscape park here, because as Plot B is near to Plot A and is five times bigger than that, we are proposing a suitable amount of area for the landscape park at Plot B.

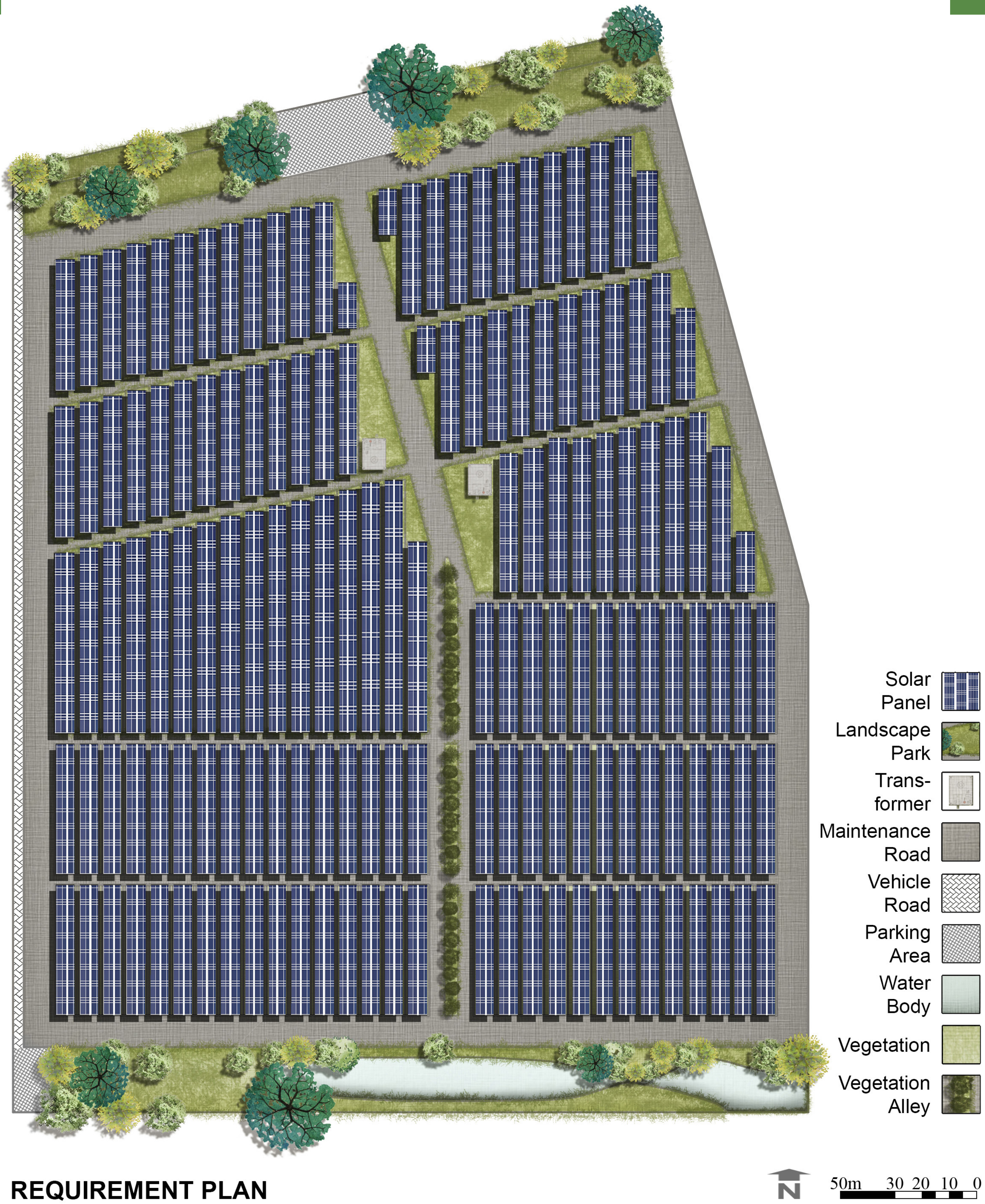


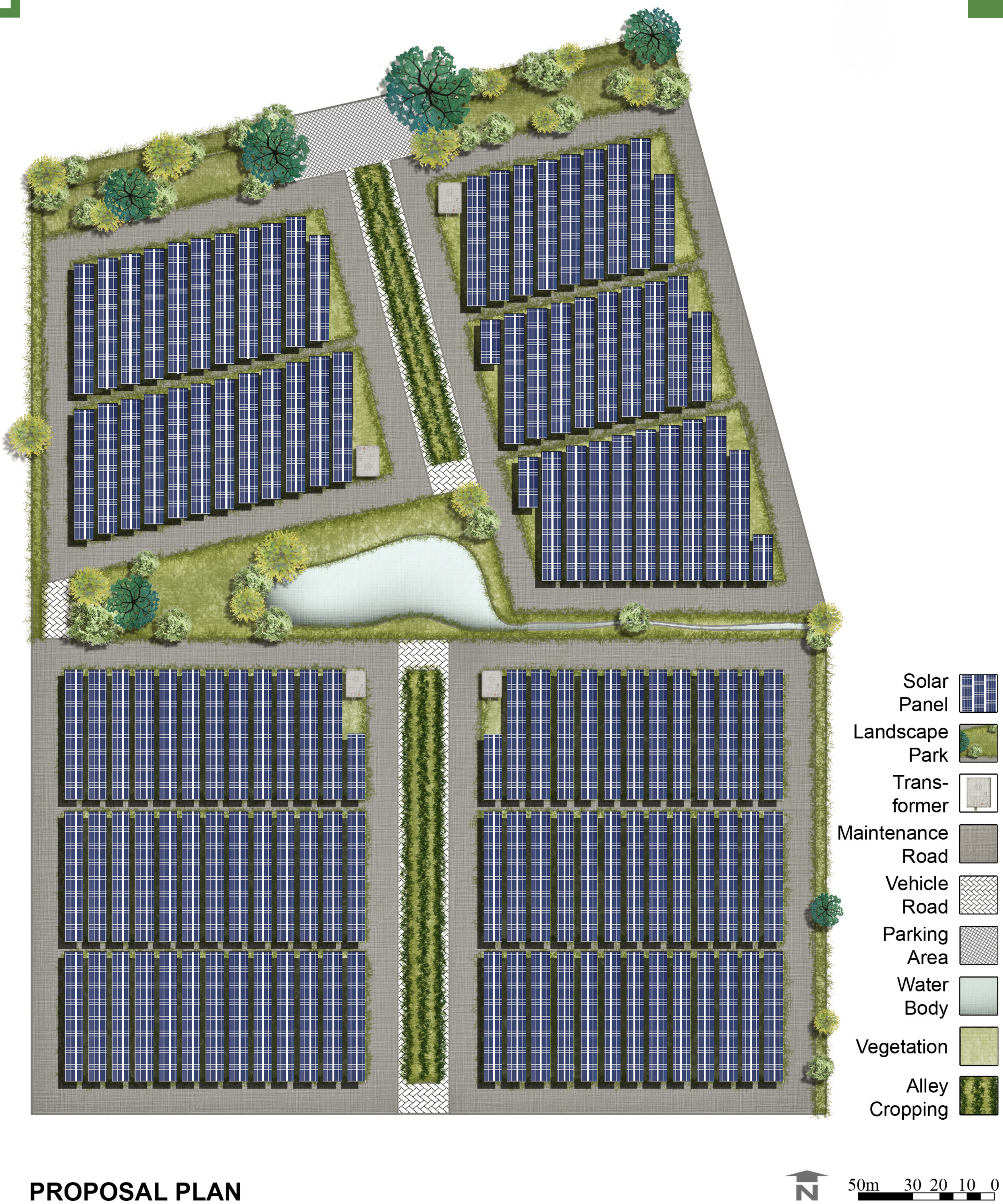
Figure 38: Plot B Plan

Design proposal for Plot B

Plot B has a size of 10 ha, and we have decided to make most of the visualizations from it among the two other plots. The reason we chose this plot as our focus for visualization is because of its possibilities to have both aspects of landscape and biodiversity. The visualization images are starting from page 74 to page 100.

In the requirement proposal for IKEA Industry, we have divided the plot into two PV panel zones with a maintenance road in the middle (Fig 38). In the southern part of this middle maintenance road, we are proposing a divider with a 5 m width, making the space between the panels a total of 18 m in width (Fig 54). The west side of the PV panel zone is approximately 830 m² in size, and the east side is about 890 m² in size, each having a transformer area of around 130 m² in the middle of the plot, adjacent to the maintenance road. We are keeping the IKEA Industry's requirement of east-west facing PV panels (Fig 43). We propose an entrance in the middle of the north side, connecting the plot with the main road (Fig 44). By the entrance, we propose a parking space of 150 m², and adjacent to the parking, we propose two landscape parks (Fig 45) (Fig 47) with a size of approximately 250 m² each. In the south of this plot, we are proposing another landscape park (Fig 57), and it has a size of 650 m², which connects a 4 m road. That road is running along the west side of the plot from the north to the south. We also propose a parking space west of the southern landscape park connected to the 4 m road (Fig 56). There is a water stream in the middle of the plot that IKEA Industry wants to move at the south end side of this plot. We change it into the proposed southern landscape park, outside the PV panel fence (Fig 58). We propose this landscape park there according to the concept of moving the water body at that place.

In our proposal, we suggest dividing the PV panel zone into four separate sections with a fence around each (Fig 39). In between the zones, where we previously



PROPOSAL PLAN

Figure 39: Plot B Plan

proposed a maintenance road, we now propose two lanes of 10 m in width, with alley cropping. One is in the north part of the plot, and the other one in the south. The size of these two proposed alley cropping lanes is approximately 140x10 m, providing a large area for farmers to cultivate crops and parallelly increase biodiversity. On each lane side, there are 4 m width roads running from north to south. Another alternative, instead of alley cropping, we propose bushes and flower strips to increase the biodiversity further. The landscape parks and the parking in the north part of the plot remain the same as in IKEA Industry's proposal. However, we are suggesting separate entrances and several gates for easier access to and between the PV panel zones. In the center of the four PV panel zones, we suggest the landscape park, which was previously in the south of the previous proposal. We also recommend the previously mentioned water body there. Here we have placed a stream running from the east side of the plot into a pond in the center of the landscape park. The whole area is accessible from all sides of this plot, making it easy for both wildlife and humans to pass through that area. The reason behind this is because we do not prefer to enclose such a large area to make it inaccessible for both wildlife and humans. After all, it is partly against the consideration of biodiversity. In our previous proposal, we have a 4 m road running entirely from north to south. In this proposal, we divide that road in half and move the southern half to the east of the plot, because we think that the eastern forest also should be accessible for all. We have a short passage of 10 m width in the middle of the plot from the east side, which we mentioned earlier as a running stream. On each side of the stream, we propose a green passage, enabling wildlife to move from the forest into the rest of the surroundings. This stream runs into the big pond in the center of the plot, which can create water-related amenities in the landscape park.

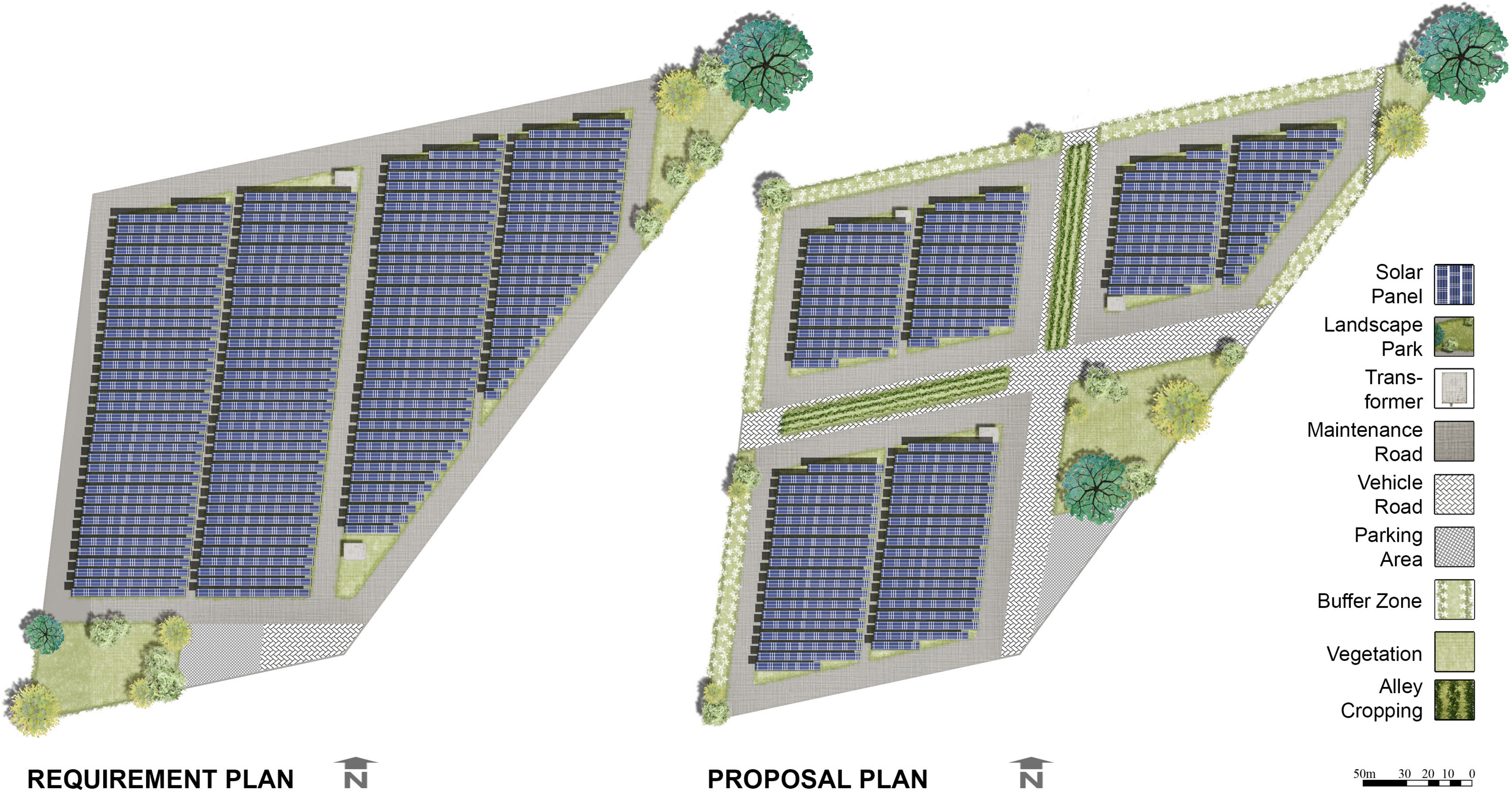


Figure 40: Plot C Plans

Design proposal for Plot C

Plot C being 6 ha in size, is a relatively challenging plot to place the PV panels as it has problematic corners. To solve this in the requirement proposal (Fig 40 Requirement Plan), we fix the zoning of this plot according to its functions. In this case, we divided this plot of solar panel parks into two segments with PV panel zones by a 12 m maintenance road in the middle of this plot. The western PV panel zone is approximately 630 m², and the eastern PV panel zone is 570 m². IKEA Industry has the requirement to place south-facing PV panels in this plot, so in this proposal, we are keeping the south-facing as their demand. It is mentioned earlier that it is required to have a 12 m maintenance road from the fence to the PV panel zones, so we have that also in our design proposal. We placed two transformer zones of approximately 100 m² in both PV panel zones. For entrance, we propose it in the bottom corner of the south-eastern side of the plot. Adjacent to the east side of this plot, there is a 4 m road. The road connects this plot with its surroundings, and that is why we are not proposing any other road outside the fence. We propose a parking zone of 150 m² just beside the west side of the entrance. West of the parking, we propose a landscape park of 220 m² since that area is close to the main road and functionally feasible to use for the factory staff and residents of Babimost. In the north-eastern corner of the plot, we are proposing another landscape park that is 270 m² in size and accessible from the 4 m road running along the eastern side of this plot. The reason for putting another landscape park in this corner is because we wanted to add more biodiversity to this plot since it is surrounded by agricultural land. We wanted to create a shelter and a safe place for wildlife. The second reason we propose a landscape park is because of the shape of the corner itself. It is not possible to place a reasonable amount of PV panels to generate a sufficient amount of energy there.

In this plot, we wanted to add more

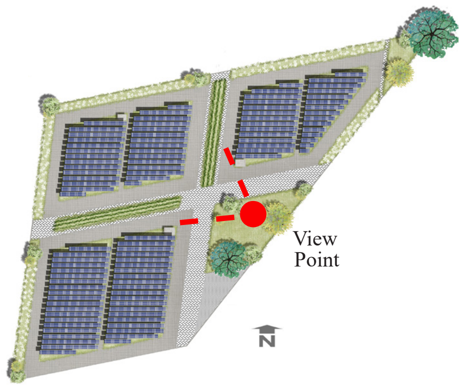


Figure 41: Plot C proposal plan showing rainy morning

- *Solar panel park*
- *South facing solar panel*
- *Alley cropping*
- *Main road*

biodiversity since this plot is in the middle of agricultural lands. In our proposal (Fig 40 Proposal Plan), we, therefore, divide this plot into four quadrants, three of them with separate PV panel zones of 530 m^2, 470 m^2, and 440 m^2, surrounded by maintenance roads and fences around each zone and fourth quadrant of 280 m^2 for our main facts, landscape, and biodiversity. We are keeping the same orientation of the PV panels as in our previous proposal. We propose a transformer area and separate entrances in each PV panel zone. In between the 18 m width of PV panel zones, we are proposing two lanes with a total of 430 m^2 for alley cropping (Fig 41). From the lane's edge to the fence, there is a 4 m wide road for easier access to the whole plot area and to create more walking trails since this area does not have many. In this way, we want to open the plot for easier access and passage for both wildlife and humans. The lanes can also be used for flower strips. We are keeping the previously proposed north-eastern landscape park at the top of the plot (Fig 42), and we are proposing another landscape park in the mid-east of this plot. Other ideas instead of a landscape park can be an energy efficiency education center where people can come and learn more about the solar panel park and its energy production system, a botanical garden for welcoming more wildlife. Because of the possibility of having an 18 m main road on two sides of this zone in this quadrant, it can be considered as a better quality to have amenities like this. We, therefore, propose an adjacent parking space of 160 m^2 in this zone so that this can work for both the solar panel park and the amenities zone.

On the outer boundaries surrounded by agricultural land, we added lanes with a width of 8 m for bufferzones full of bushes and strips of wildflowers. The reason is to create a safe space for wildlife, a contrast with the rest of the surroundings, and to break the monotony of the agricultural fields surrounding the plot.

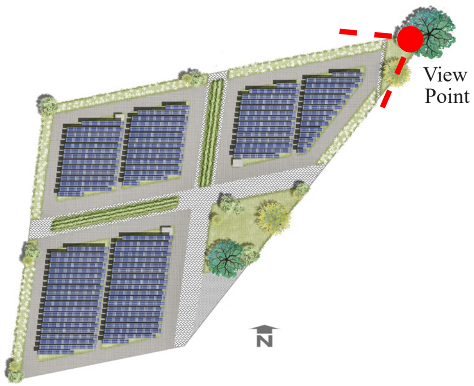


Figure 42: Plot C proposal plan showing summer noon

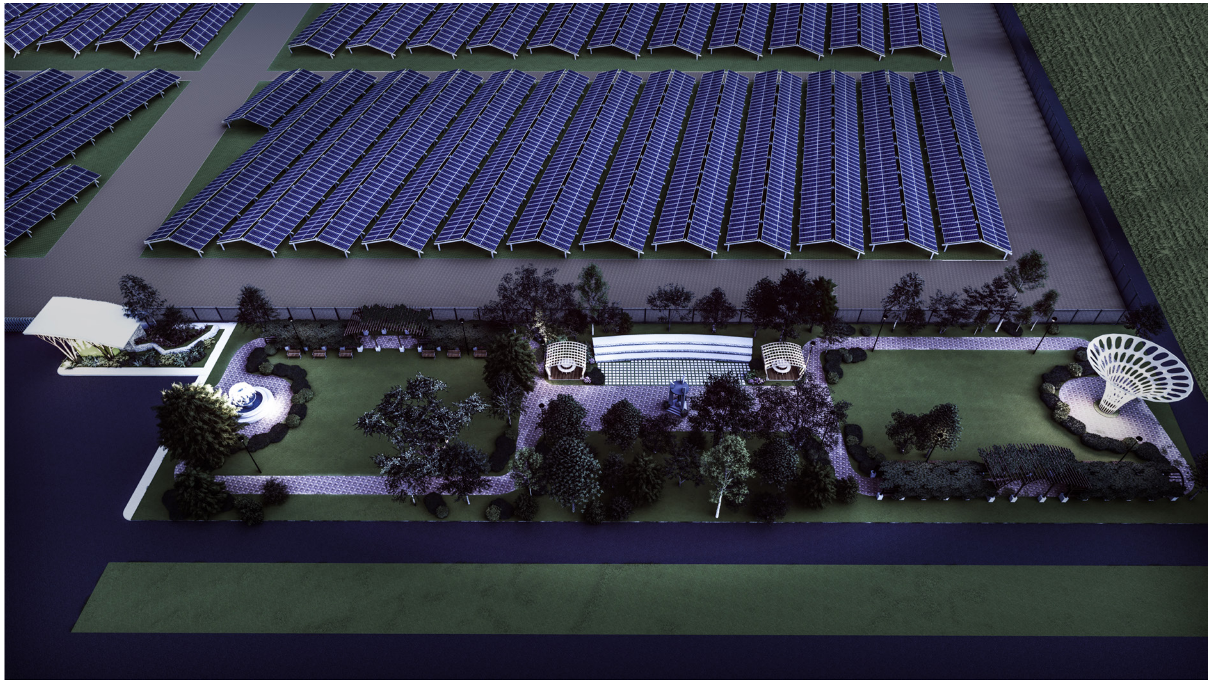
- *Solar panel park*
- *Landscape park*
- *Buffer zone*
- *Flower strips lane*

4.2.1 Aspects of the landscape park proposal

This chapter is about the landscape park proposal. What our proposal contains and the functions or components for the landscape park, we describe it here. In this paper, when we say landscape park, we mean landscape park is the concept that we have in all our six design proposals. The design concept of a landscape park consists of several facts of functions and amenities. These facts depend on the size of the landscape park and the size of the plots.

In the next chapter of the management plan, we suggest species that can be used in the landscape parks to attract biodiversity, but in this part, we are discussing the other factors that can be considered in a landscape park. Besides grassy areas, rocks, bare soil, and trees, the primary components that need to consider for these landscape parks are: different gardens, kids play zones, walking trails, walkways with vegetation canopies, benches, picnic tables, seating platforms, and seating cubicles with tables, artifacts such as monuments, sculptures, and fountains and water streams with water bodies. Every landscape park has a prominent entrance, but the parking area of the solar panel parks is also available for the users. These entrances of the landscape parks are starting with water fountains, and the concept behind this is to welcome birds and people with the soothing sound of cascading water (Fig 47). The edge of the landscape parks is ending with a tall sculpture that can work as a landmark of the whole area. Therefore, the landscape parks, which are close to the main roads (Plot B & Plot C), can work well in this concept (Fig 46). We divided the landscape parks (Plot B's northern side) into three different gardens. The first garden starts with the fountain and walkways with vegetation canopy. Here we propose a grass field in the middle where wildlife and people can use it for their multipurpose activities. This field is surrounded by walkways, which have a width of 2 m (Fig 48). The walkway is running through straight in the middle of the second garden, slicing it into two

Plot B visualization images starting from here. Scenes from the next page are sequenced in the order from start to end of a visit.



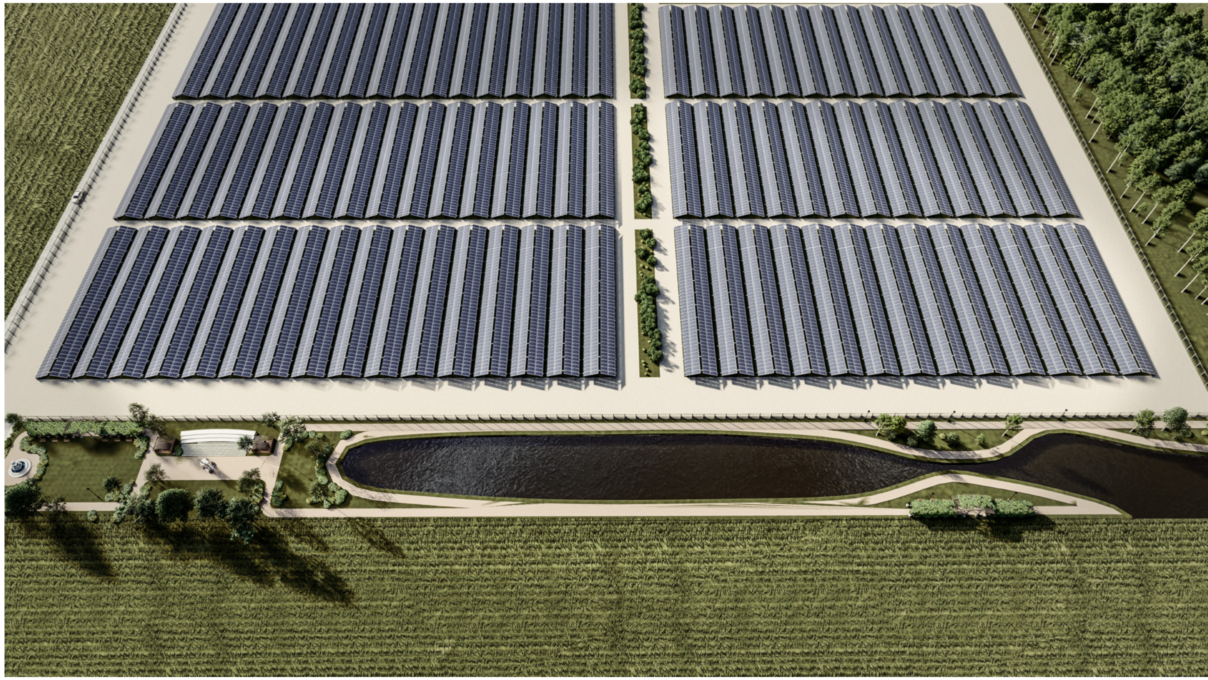


Figure 43: Plot B requirement plan showing aerial views

- *Left visualization is the rainy day from front eastern landscape park*
- *Right upper visualization is a moonlit night from front western landscape park*
- *Right bottom visualization is a sunny day from southern landscape park*

parts with 6 m of width. In the middle of this rectilinear walkway, we suggest a cross sculpture for religious purposes (Fig 49). In one part of the garden, on one side of the walkway, we propose a spiritual platform that is related to the cross sculpture. Religious people can have a pleasing time there. However, the reason for this platform can be multipurpose use like spiritual, seating, resting, and waiting zone for the kids playing, which is on the opposite side of the platform, that is on the other side of the walkway in this garden (Fig 50). From the walkway to this platform, we are placing permeable paving for allowing rainwater to run off in between paving vegetation, such as grass can grow. On two sides of the platform, we propose seating cubicles with tables for having lunch or snacks with semi-privacy facilities. Heading towards the third garden, it is similar to the first one but a little change where we suggest artifacts. Instead of the fountain from the first garden, we suggest a 6 m height sculpture that we previously mentioned for having as a landmark (Fig 51).

In the other landscape park (Plot B's southern side), we suggest a similar landscape park just like the first one (Fig 57), the difference being a pond for aquatic wildlife and a playground for kids. The walking trails of 2 m width developed around the pond according to its shape (Fig 58). The pond is mainly for wildlife, water plants, and aesthetical attributes. Currently, in the site, the existing condition of the water stream is narrow, that we are suggesting to make it bigger to welcome more water-based wildlife. In between the walking trails, some vegetation area developed, and also a walkway with vegetation canopy, we suggest in the middle of the walking trails. In every parking zone in each plot, we suggest a separate space for bike parking for the users of the landscape park.


IKEA
ZBASZYNEK
SOLAR PANEL
PARK


SOLAR
PARK

Figure 44: Plot B requirement plan showing summer night from the main road

- *Main entrance*
- *Solar panel park*
- *Parking area*

Figure 45: Plot B requirement plan showing winter morning from the main road

- *Main entrance*
- *Parking area*
- *Front western landscape park entrance*

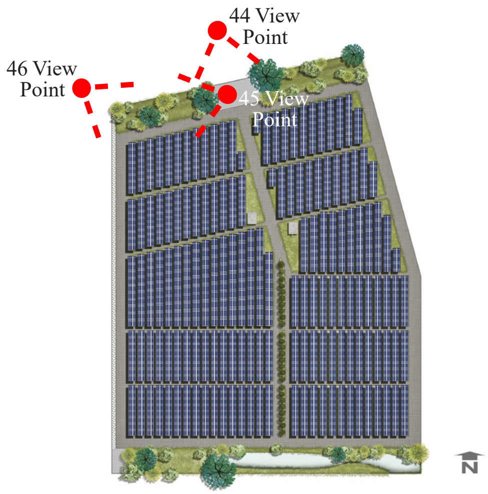


Figure 46: Plot B requirement plan showing summer noon from inside a car at the main road

- *Main road*
- *Walk and bike path*
- *Solar panel park and landscape park*
- *Landmark*

4.2.2 Management plan for promoting biodiversity

In this world, there are copious rare but delicate species that are in a constant manner contributing to human by rendering fibers, crops, and medicines, which puts them a place in the precious natural resource list. If we imbalance biodiversity, then we are not only damaging the whole world's ecosystem but also threatening our existence (Campbell, 2008).

In this project, our mission is to place side by side landscape with solar panel parks so that it can be relished by the local community and the IKEA Industry employees. But, the primary aim is to make those areas friendly to wildlife. Therefore, a general management plan is elaborately suggested below for the three individual plots.

For making an effective management plan, it is a mandatory obligation to keep in touch with clients and comprehend their management objectives, which are necessary to promote biodiversity. Engrossing together with local expertise (ecologists, biologists, and foresters) will lead to a better acknowledgment of how to preserve and enhance certain species in those landscapes. With the local conservation group's involvement, there is a chance to raise awareness and retain biodiversity (Parker, 2014).

Due to the soil property, animals like sheep will graze meadow or pasture and fertilize the area (Parker, 2014).

A Biodiversity Management Plan is a manual that identifies goals for the establishment and guidance of vegetation that supports biodiversity. The plan includes the following objectives (O), and we are answering (A) this on case-by-case basis plots and the information available at hand this time:

O: Identify the most valuable conservation in any area and ensure the plan supports them.

A: There is no major conservation in the proximity of those plots. We also have very little information on this topic.

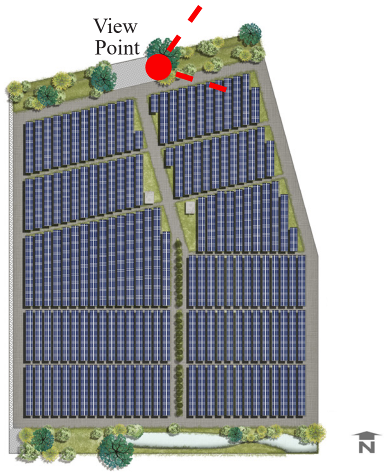


Figure 47: Plot B requirement plan showing summer morning

- *Front eastern landscape park*
- *Fountain in landscape park entrance*

However, this can discuss with regional experts like ecologists, biologists, and foresters before introducing plants and wildlife into both the management plan and the solar panel parks.

O: Detect and lessen the negative environmental impacts that arise from after the solar park installation.

A: Establishing a solar panel park on agricultural land may support biodiversity in some way. Mechanical scarification of the soils before the solar panel operation boosts the germination of seeds. Ultimately, solar farms installation could fertilize soil health on previously used agricultural land because if nutrients previously been depleted due to heavy machinery can recover vitality through the period of solar panels.

O: Create specific objectives for solar park sustainability and support prolonged biodiversity in any area.

A: By expanding local flora amid the solar panel and landscape parks could invite wildlife to be everywhere in those areas. What growers cultivate in the surrounding areas? How do the local ecosystems interact with flora and fauna present at the solar parks? What biodiversity exists in that particular area? Again, the answers to those questions could be satiated by local experts.

O: Partake in maintaining the connection with the landscape, and if possible, provide green corridors for species.

A: In our design proposals, we suggest with the founding of solar panel parks, green strips and roads will be again sparkling, allowing wildlife to revive and breed, and thus, there will be continuous wellbeing of them.

O: Recognize specific species for seeding and planting along with their sources.

A: Below, we provide a list of species-genus that possibly could serve biodiversity progression. The plants should be local to avoid invading species.

O: Supports with supplementary measurements for making the area lively

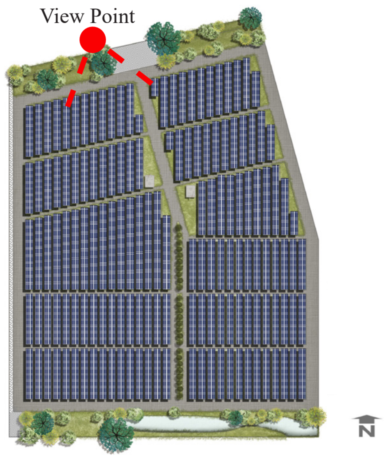


Figure 48: Plot B requirement plan showing winter snowfall

- *Front western landscape park*
- *Garden area*
- *Canopy walkway*

for wildlife such as birds.

A: Below, we submit some artificial arrangements and diverse plants that could entice wildlife to the sites.

O: Form a summary for managing the area that supports biodiversity throughout the solar panel park lifespan.

A: We list the summary below. It will be in a general perspective, not necessarily site-specific.

O: Provide a strategy for monitoring the sites during the operation and supervise the maintenance plan.

A: Under additional notes, we suggest job assignments like who does what, and we also advise how to follow-up them.

In this plan, we aim for diversified trees, shrubs, plants, and flowers that could allure insects, pollinators, and birds.

Further enhancement suggestions

Hedgerows

It is possible to trench Hedgerows around the site. These can aid good living and surviving conditions for versatile species, such as small mammals (including bats), birds, reptilians, amphibians, insects, and invertebrates. If endemic species possibly implant, it will be a smart choice. Hedgerows can also function as buffer zones to protect the solar panel park from wind, dust, and surrounding agricultural lands. Hornbeam (*Carpinus betulus*) or Blackthorn (*Prunus spinosa*) is our proposition. Hornbeam (*Carpinus betulus*) is a deciduous shrub or small tree commonly visible in gardens. This hedge needs supervision, cutting once a year during summer, to retain its shape. It has extreme tolerability, such as trimming. Blackthorn (*Prunus spinosa L.*) is also a deciduous shrub that has variable soil adaptability. It is hardy and regionally abundant in Poland. It is available on the edges of fields. In late spring, it blooms attractive, aromatic white flowers, and during summer, birds eat its Blackish

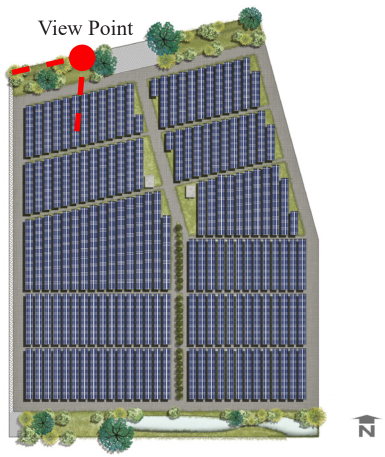


Figure 49: Plot B requirement plan showing rainy afternoon

- *Front western landscape park*
- *Walkway in the middle garden*
- *Spiritual sculptor*

purple berry fruits. As the choice of a hedgerow, Blackthorn does not need pruning or look after, and it has a natural round shape (San-Miguel-Ayanz, 2016)

Blackthorn can also a competitive plant for fencing since it is hard to penetrate, and thorns of them even discourage visitors from undesirable infiltration to the solar panel park. The Crataegus family has an extensive range for dual purposes: defense and nectar-producing flowers in early spring. It attracts insects and pollinators, and it can monitor easily. Another useful kind is from the Rosaceae family, which plants either in the buffer zones or around the fence perimeter. They provide flowers, thorns, nesting for birds, hiding for many insects, and take part in the aesthetical beauty of that area.

Out of them, the Rosaceae family can be the best fit for its flowers and protection since most species have thorns.

Wildflower strips and flower meadows

As they have the potentiality to attract multiple wild creatures, therefore, we propose wildflower strips outside the solar panel parks and flowers, meadows inside the solar panel parks.

Since the soil is sandy, diverse species perhaps suitable for both landscape parks and solar panel parks, and for that, we have a suggestion of appropriate species for those flower fields and lanes. Having heterogeneous flower species have the advantage of blooming versatile color and nectar-producing flowers that fascinate bees, butterflies, pollinators, and other insects.

- Many species, such as *Dianthus deltoides* (Maiden pink) in the Dianthus genus and, from the Caryophyllaceae family, perform well on drained, sandy soils
- *Pulsatilla vulgaris* (Pasqueflower) from the Ranunculaceae family acts well on dry sandy soils
- *Buddleja davidii*, commonly known

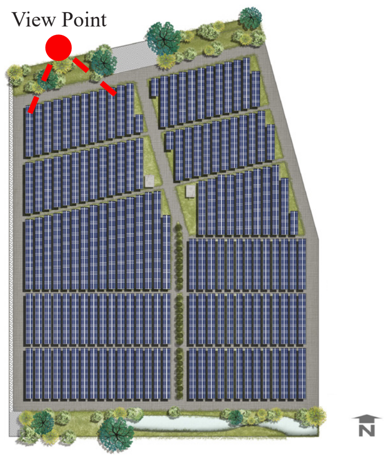


Figure 50: Plot B requirement plan showing summer noon

- *Front western landscape park*
- *Middle garden*
- *Lunch and relaxing area*

as the Butterfly bush, is beneficial for insects and pollinators. However, as it can grow over 1m, so it is wise to plant it outside the fence

- *Lavandula angustifolia* (Lavender) is also attractive for insects and pollinators. and can be grown both inside and outside the fence

- A drought-tolerant and dear-resistive, *Agastache foeniculum* (Blue giant hyssop) invites pollinators, like bumblebees, butterflies

- *Achillea millefolium* (Yarrow) thrives well in sunny weather, well-drained barren lands, and is drought tolerant. It is an insect baiter

- *Papaver rhoeas* (Common poppy) is a well-recognized flower among insects and raises fine in sandy soil

- *Neepta cataria* (Catmint) attracts pollinators and butterflies

- *Salvia pratensis* (Meadow clary) grows almost in any place and can reach up to 70 cm in height

- *Lobularia maritima* (Sweet alyssum) is fit for both inside and outside the fence and can grow on sandy soils

- *Centaurea cyanus* (Cornflower) grows well in fields

- *Leontodon hispidus* (Rough hawkbit) grows well on dry meadows and roadsides

- *Echium vulgare* (Viper´s bugloss) grows on dry open land

- *Cirsium acaule Scop.* (Dwarf thistle) grows well in dry pastures and meadows

- *Trifolium pratense* (Red clover) attracts insects and pollinators

- *Daucus carota* (Wild carrot) does well on dry open meadows, hills, and roadsides

- *Centaurea jacea* (Brown knapweed) grows well on almost all types of open land

- *Leucanthemum vulgare* (Oxeye daisy) does well on open meadows,

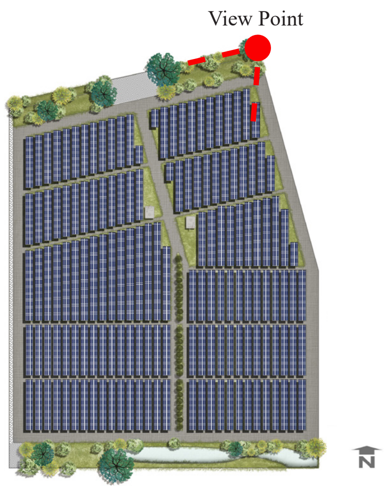


Figure 51: Plot B requirement plan showing summer dawn

- *Front eastern landscape park*
- *Sculptor as a landmark*
- *Walkway in the garden*

pastures, and roadsides

- *Hypericum perforatum* (Perforate St John's-wort) does well on poor soils and attracts insects and pollinators. (Den virtuella floran, 2017)

Our proposal for the land inside the fence is meadows. They can enhance biodiversity, especially lure insects and pollinators (Slåtterängen), and the harvests that grow here are spontaneous with its non-essentiality for further fertilizer or manure. It necessitates maintenance, but we are not discussing it further. We have another opinion: cultivate mushrooms under the PV panels. But the PV panels should be 2 m in height for the farmers to move freely below them to collect mushrooms. It brings the question of who will look after it? Will IKEA Industry let farmers enter into those parks? Harvesting mushrooms can profit local farmers, but only for a few months of the year. Though mushrooms and fungi cultivation under the panels are not possible, the presence of fungi could yet boost biodiversity since they are ecosystem protector.

A second proposal is to give the native species opportunity to raise by themselves. As nature shifts over time, pioneering species will be privileged into the areas depending on what species are desired, and management should be according to that.

Trees and Shrubs

Below we submit a list of trees, according to San-Miguel-Ayanz (2016), that are likely to grow in landscape parks and bushes that can be grown in both landscape parks and bufferzones.

Trees

- *Acer campestre* (Field maple): Tolerates most climates, shade-tolerant in earlier years, light-demanding in later years
- *Fagus sylvatica* (Beech): Shade tolerant and grows on a variety of soil types
- *Pinus Sylvestris* (Scots pine):

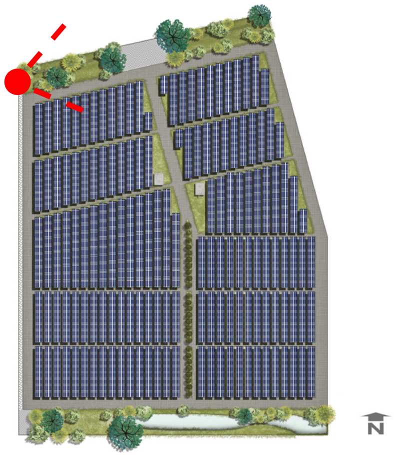


Figure 52: Plot B proposal plan showing summer day

- *Front parks*
- *Green areas instead of landscape parks*

Drought and frost tolerant

- *Prunus padus* (Bird cherry): Tolerates most types of soils and climates
- *Quercus petraea* (Sessile oak): Grows on most soil types, tolerates wind and snow well
- *Salix alba* (White willow): Tolerates most soil types but preferably sandy, silty, or calcareous soils
- *Salix caprea* (Goat willow): Tolerates most climates, light-demanding
- *Sorbus aucuparia* (Rowan): Tolerates dry summers, stress, cold and frost
- *Tilia platyphyllos* (Broad-leaved lime): Drought and frost tolerant
- *Larix decidua* (European larch): Drought and cold tolerant
- *Sorbus aria* (Common whitebeam): Can grow in all soil types except very acid and alkaline soils
- *Acer pseudoplatanus* (Sycamore): Drought and shade tolerant
- *Juniperus communis* (Common juniper): Drought and cold tolerant but needs light
- *Taxus baccata* (Common yew): Drought tolerant and can survive in extreme conditions

Shrubs

- *Cornus sanguinea* (Common dogwood) grows up to 6 m in high and does well in both shady and sunny places
- *Prunus spinosa* (Blackthorn) grows well in the sunny weather and open forest margins, meadows, and pastures
- *Crataegus* (Hawthorn) can raise between 5-15 m and make a better shelter for birds and mammals

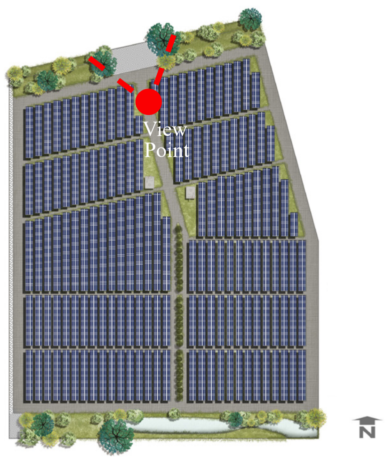


Figure 53: Plot B requirement plan showing winter blizzard

- *Solar panel park*
- *Entrance area backside*
- *Security office and storage*

Alley Cropping

In our design proposal, one of our innovative suggestions is alley cropping. In the following, we suggest some crops are plausible to cultivate in the alleys. It can provide grains or income to either IKEA Industry employees or local farmers. But the drawback is it will not offer satisfactory biodiversity due to the usable crop limitation, and grazing animals (deer, rodents, mice, and rabbits) will feed them. But the solution to this problem is fencing.

Missouri (2015) states that when selecting trees and shrubs for a specific alley cropping plantation, several criteria need to mandate before selection to get the best output. They are the following:

1. Yield miscellaneous products, such as timber, nuts, that are demanding in the market

2. Supply produces rapidly in the commercial market or moderates in terms of high valued products

3. Casting a shadow on the agricultural crops

4. Adjust with versatile soils and geographical locations

5. Avoid possible competition with their neighboring crops through deep implantation

6. Supports a secured establishment for wild birds

According to Missouri (2015), in between the trees and shrubs rows, the idea of alley cropping is to include crops in between them. So few other criteria should fulfill before crop selection. These criteria are given below:

1. Forage crops

2. Fruits

3. Biomass generating crops

Figure 54: Plot B requirement plan showing summer noon from the south side of solar panel park

- *Solar panel park*
- *Maintenance roads*
- *Vegetation alley*

Figure 55: Plot B requirement plan showing summer afternoon from the middle of solar panel park

- *Solar panel park*
- *Maintenance road*
- *Transformers*

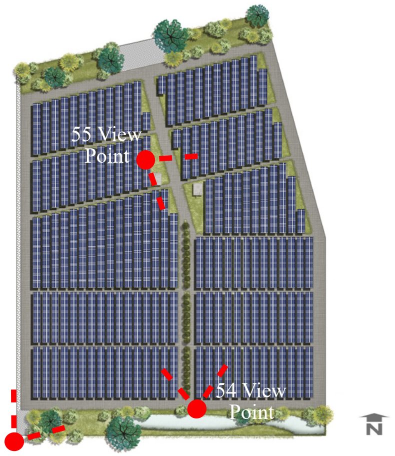


Figure 56: Plot B requirement plan showing rainy day

- *Southern landscape park*
- *4m western road*
- *Southern parking area*
- *Southern landscape park entrance*

Pasture

For plot A, we propose sheep. Sowing a mixture of wildflowers, fine grasses, and pasture is useful for evolving biodiversity. By adding more native flower species with the rest, nectar can be produced for a prolonged period, and there is an added advantage of wildflowers, which is they can allure insects and pollinators. Red clover is a better alternative option to attract pollinators, for example, bumblebees. If we introduce sheep grazing, then the flower mix needs to be replanted every 3-4 years.

Sheep has features like cost-effectiveness, and commerciality, so it is a good alternative if we introduce them to fertilize the soil. And as a consequence, it will enrich the biodiversity. However, it is less effective than flower strip alleys. In the summer, in the absence of sheep, the benefit of having insects and pollinators is they help to bloom flowers.

Ponds and watercourses

The presence of ponds and water streams will upgrade aquatic wildlife, like invertebrates, amphibians, birds, and reptiles. At the same time, they provide drinking spaces for wildlife all year round. Unmovable large water bodies may have a high risk of eutrophication. Farmers use chemicals to fertilize the agricultural fields throughout the plot that leads nutrients to penetrate the groundwater. Thus, this way, it will reach the water bodies, and algae will then form, making the water less drinkable for the usual aquatic wildlife species. So, it is essential to keep the water flow running. Smaller streams are better for biodiversity. Constructing the part with the stream will increase the water flow further. Adding water plants will help to thrive the aquatic wildlife and provide them with food and shelter.

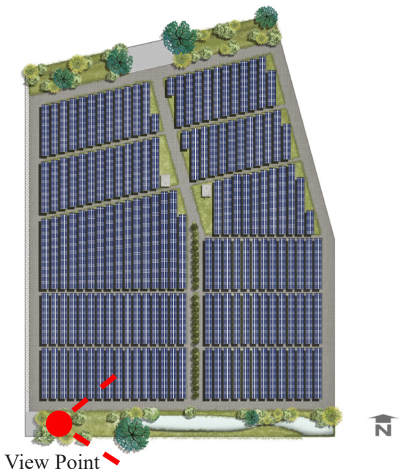


Figure 57: Plot B requirement plan showing summer afternoon

- *Southern landscape park*
- *Walkway in the middle garden*
- *Platform seating*
- *Kids play zone*

Artificial structures

To divert birds from the solar panel parks to the landscape parks, we suggest building birdhouses. We further propose putting up beehives and insect hotels to promote insects and pollinators. To support owls and bats living or resting, we recommend particular birdhouses in those landscape parks. To speed up the water stream, we can also have an artificial arrangement. We, keeping biodiversity in mind, simultaneously propose building holes for small wildlife: rodents, snakes, and amphibians. Since amphibians, like frogs, hibernate during the winter, it is mandatory to consider burrowing opportunities for frogs and other amphibians (Scientific American, 1997). Another artificial non-manmade structure is leaf stacks for the autumn, which facilitates small animals such as rodents, hedgehogs, and snakes' shelter for the winter.

Green areas instead of landscape parks

Because of the limited size of plots, there is not much room to implement biodiversity. For this, we recommend the green areas only for biodiversity instead of the landscape parks (Fig 52). Planting native trees in different alignments (linear, groups, and scattered) or sections could accommodate different wildlife habitats for various plots. Shrubs can also root in the same direction, but we have to leave small open areas surrounded by shrubs to create safe areas for wildlife. Adding flowering plants in certain areas can attract pollinators, insects, and birds there. For this angle, it is important to keep edges around the plots. Trees and bushes may enclose the area and thus, create safe spaces for wildlife.

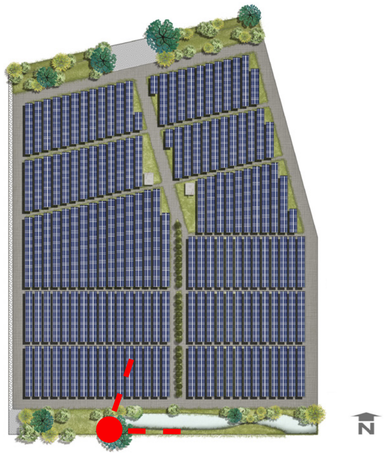


Figure 58: Plot B requirement plan showing summer dusk

- *Southern landscape park*
- *Waterbody*
- *Walking trail*
- *Canopy walkway*

Management summary

The management shall adopt the terms and objects mentioned in the plan. Keeping the areas under observation will assist further as this area and vegetation start to settle in. It will take time to adapt in the beginning. The management shall proceed per nature and plan. Regular management should also monitor to keep the grasses and other plants in check, especially between the PV panels.

Additional notes

- Raising parts of the landscape area to create dryer conditions can benefit both specific plants and biodiversity
- For biodiversity surveillance, it will be prudential decision to involve state universities because perhaps they might offer appropriate enlightenment for selecting suitable plants in those landscape parks and solar panel parks. They might also suggest the knowledge of building enriched biodiversity in those parks, which until now is relatively unexplored. They can even engage with yearly post-checkups to see how nourished the biodiversity is in those parks
- When introducing many non-invasive new species into those plots that previously plowed with crops, it is discreet to remember that it may become a sweet dish for small rodents and birds. Thus, it is wise if local seeds and plants are brought in

Chapter 5

Discussion and Conclusions

The image is a visualization from the design proposal of the Plot B requirement plan showing spring evening

• Southern landscape park • Water body • Walking trail • Canopy walkway • Seating area

From household essentials to grid-scale power generation, there has been an exponential growth in PV in the last few decades. Today the world produces and meets 3% of global renewable energy demand from solar panels. And at the end of 2050, it can hopefully be predicted that, with its 34% yearly growth, it will serve 4.7 TW (Terawatt) renewable energy by probably overtaking fossil fuel consumption.

In the last century, humans, because of their overexploitation of the common natural resources like forests, fishing, hunting, etc., made the global environment delicate, which resulted in habitat loss and extinction of numerous wild species. However, in the 21st century, through biodiversity conservation projects like species management, protected areas, and increased societal awareness, these problems start to mitigate.

To summarize, if biodiversity can be added together with solar panel parks then, it perhaps mitigates the current worry more rapidly than ever before. As it may enforce less stress on lands to preserve those sensitive wild creatures as well as there will be more lands available to crop agriculture that probably meet the upcoming food demand of 9 billion world population.

In this paper, we try to illustrate how these two concerning issues are possible to intercross and enlighten others on how to deal with the existing problem with limited resources in hand. The primary outcome is it can be achievable, with the help of landscaping, to design and incorporate biodiversity into those three solar panel parks of the IKEA Industry. It may practically inspire other countries or businesses cum environmentalists to choose for equivalent projects like this in the future, in the hope that they can sustain for at least this century.

Here, from the start, we sketched schematic drawings that are necessary. It was indeed challenging to accommodate the facilities in one place: solar energy for the IKEA Industry, greeneries, and recreations for both wildlife and humans. To do so, we require to consider zoning, orientations, etc. After reading our proposed concepts, any reasonable reader might have a fundamental understanding of why PV panel parks are necessary for developing a sustainable future. In these three separate plots, we designed three additional plans by making the utmost use of landscape and include biodiversity also. These parks will have a dual functionality: firstly, it will generate carbon-free energy, and secondly, it will be the domain for local flora and grazing land for surrounding fauna. Through the illustrations and visualizations in this paper, every person will get a general idea about how solar panel parks indirectly put an effort to protect biodiversity.

The total biodiversity that we are getting out of our hands it depends on how much biodiversity is there onto those agricultural land currently. Most of them are next to nothing in terms of existing biodiversity. Our design perhaps could facilitate to add biodiversity to the site, not lost in the presence of solar panel parks and landscape parks because agricultural lands are usually barren when it is of no use. Therefore, we may not necessarily regret biodiversity loss.

Implanting vegetables, grasses, and flowers make landscape parks more recreational and may support to preserve natural biodiversity. That is how we can consequently suppress the carbon dioxide amount and conserve our nature. The setup of this management plan for sustainable energy production by additionally placing biodiversity and recreational facility into it is site-dependent when it comes to the wild species. As mentioned earlier of the primary purpose that is to generate green energy and shield surrounding wildlife, but as the areas are not vast, it is not possible to uphold endangered species because it will not provide them suitable habitats to survive. The aim is to give protection to the surrounding wildlife. So, before planning or initiating a project like this, a complete and accurate survey of surrounded species, resources, and restrictions needs to be conducted.

If there are some changes possible to apply then, it will have some definite positive impacts. We preferred the solar panel areas to be bird-free that will enable low maintenance costs and can increase energy production. Unfortunately, it is unmanageable. We even thought about narrowing down the maintenance road to less than 12 m, but it remains withheld because of general rules and restrictions.

Due to the continuum of this pandemic situation, we have not all the options to examine. Perhaps our proposals would sound more naturalistic if we underwent fieldwork before making the decisions of design solutions. In the beginning, we could not decide, but after the site visit, it became easier for us to criticize. When we did fieldwork later, it was much easier for us to understand. Nevertheless, we made ourselves determined from the start while working with IKEA Industry, and the experience was educative. We tried to comprehend their ideas, desires, and requirements and shared the feedback, and this is what they appreciated a lot.

Critical reviews of our proposals

- The higher the height of the solar panels from the ground, the better it will be for biodiversity like we can plant different types of shrubs and include grazing animals. For example, if the panels heighten up to 2 m or more than 2 m in height, we can also include medium-sized trees and livestock.

- The fence is not necessarily a hindrance until we introduce livestock for grazing in between those panels. In the case of Erlasee Solar Gut in Germany, the fence is not installed actually for security reasons.

- If our primary goal is to promote biodiversity in the form of alley cropping in between each row of solar panels, then it will eventually force IKEA to minimize the number of solar panels. And if we do that, it perhaps will not fulfill IKEA´s primary purpose: to produce renewable energy to run their industries.

- If we have the facility to build permeable pavements for strolling and parking cars, then we don’t need to allocate parking facilities individually.

- If we have the chance to build maintenance roads by using grass for biodiversity promotion, then we shouldn’t consider sand or gravel to build these roads.

- If we minimize the extension of the solar panel area by maximizing the size of the landscape parks, it will be more informative to the general people letting them know the biodiversity necessity. The ultimate message to them is how biodiversity can be incorporated in the solar panel parks: more landscape will attract more people to deliver this vital information.

- Landscape parks should not be restricted by humans only. It is possible that we can allocate this whole area, particularly for wild species.

- If we insert water bodies into diverse places in the parks, perhaps it will benefit local wild species, but then we have to compensate for renewable electricity production.

Limitations of alley cropping

- Intensive supervision and management are required from professionals because there is a need to operate with specially designed equipment and machinery, if necessary.

- As we need to produce crops throughout the year, we need to occupy lands.

- To create a demand and supply of the produced tree products (like timber or fruits), we need a specific market.

- Before choosing trees, we need wise planning that is to categorize a particular genus. Otherwise, it can hinder operations, as well as crop growth by competing for nutrients, moisture, and sunlight.

- There is a probability that herbicides that will be used, especially for crops that may have an impact on trees (Missouri, 2015).

Importance of fencing and its consequence

- If we don't have the secured border, then wild animals can trespass and bring harm to themselves as well as damage to the panels.

- If we don't have proper fencing, there is a risk that farm animals can escape.

- If we don't have heightened borders, small or large tamed animals like cattle or goats can cause damage to the panels (Gambone, 2020) (Energy, 2020).

Awan (2020) compares rooftop and ground-mounted solar panels:

Advantages

- In contrast to the rooftop system, ground-mounted solar farms must have to go through a pile of rules and regulations with a clearance permit.

- For grid connection, rooftop projects have the facility to utilize existing transmission infrastructure, whereas solar farms need additional investment.

- In the case of local consumption, rooftop solar is prioritized because solar farms do not have that kind of facility due to its 100 % grid supply.

- There is no asking for land when it comes to the installation of rooftop panels, but ground-installed need a certain proportion of land.

- Rooftop panels can cool the external

surface of the ceiling by preventing solar radiation.

Disadvantages

- The higher the number of panels, the lower the cost will be in terms of installation, maintenance, etc.

- Ground-mounted panels have convenient accessibility, and the maintenance cost is comparatively lower than rooftop.

- Even though they require lands but it does not matter whether the land is desolated (ruined) or in seedy (Shabby and untidy) condition.

- As there are fewer complications in control transmission, solar farms are regulated by IPPs, whereas the rooftop is under supervision by residential or commercial owners.

Commercial or non-commercial establishments have already spread worldwide and will be in the future. Only after three decades, this planet will contain 10 billion of us, and 4/5 of the Europeans will have their residence in urban areas. At present, commercial and non-commercial housing hold up 33.33% share of the global energy consumption, wherein commercial spaces alone perhaps allocate 17% of the total absorption. Additionally, within the next 20 years, 48% of energy needs to be reserved for domestic purposes. Moreover, 1/5 of the GHG emission into the atmosphere are just because of infrastructures. Unsurprisingly, in the next 30 years, disastrous chaos will arise where we begin to lose our bonding with one of our biggest allies, nature: the unusual extinction rate of wilderness as well as native species (Catalano, 2017) (Awan, 2020).

As we have mentioned before, what will be the global population in the future, we need to use our resources like lands carefully. The way the world progresses, now we need to plan our settlements that can produce renewable energy and support biodiversity both in one platter. By using biosolar roofs, we can have an alternate option to generate renewable solar energy, which we do in the case of ground-mounted solar parks. In future projects, our recommendation for the IKEA Industry is they should also promote biosolar roofs into their upcoming industries.

While involved in this work, some questions mattered: who will get profit from this paper, what significance does it carry, can we contribute any role to mitigate global warming? After thinking deeply, we realized that it is achievable: promote much-needed biodiversity into the solar panel parks and landscape parks. Hence, we can play our part and contribute to society by making the planet more sustainable in an efficient way.

The project was challenging because we need to establish three individual solar panel parks for IKEA Industry. Besides, to insert biodiversity for the surrounding wildlife- an additional fundamental asking from our client- we need innovative strategies. Here, we meticulously incorporate landscape parks, where the adoption of recreational facilities provides a scope to know details about these projects. For a topic like this, it will be too naive to calculate the aftermath, but we firmly believe that in the future, it will be the only way that we will need to follow.

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Figure References:

- All of the images are from the author's, if not stated otherwise
- Site Images Photography: © Author's Nizhuma Hasan and Rosalie Selhorst
- Maps and Illustrations: © Author Nizhuma Hasan
- Plans and Visualizations: © Author Nizhuma Hasan
- Cover image is a visualization from the design proposal of the Plot B requirement plan showing IKEA Industry's solar panel park at Zbąszynek
- Back cover is a visualization from the design proposal of the Plot C proposal plan showing south-facing solar panel park at Babimost

Appendices

Preliminary concepts of general power layout and structural details for discussion purpose only.

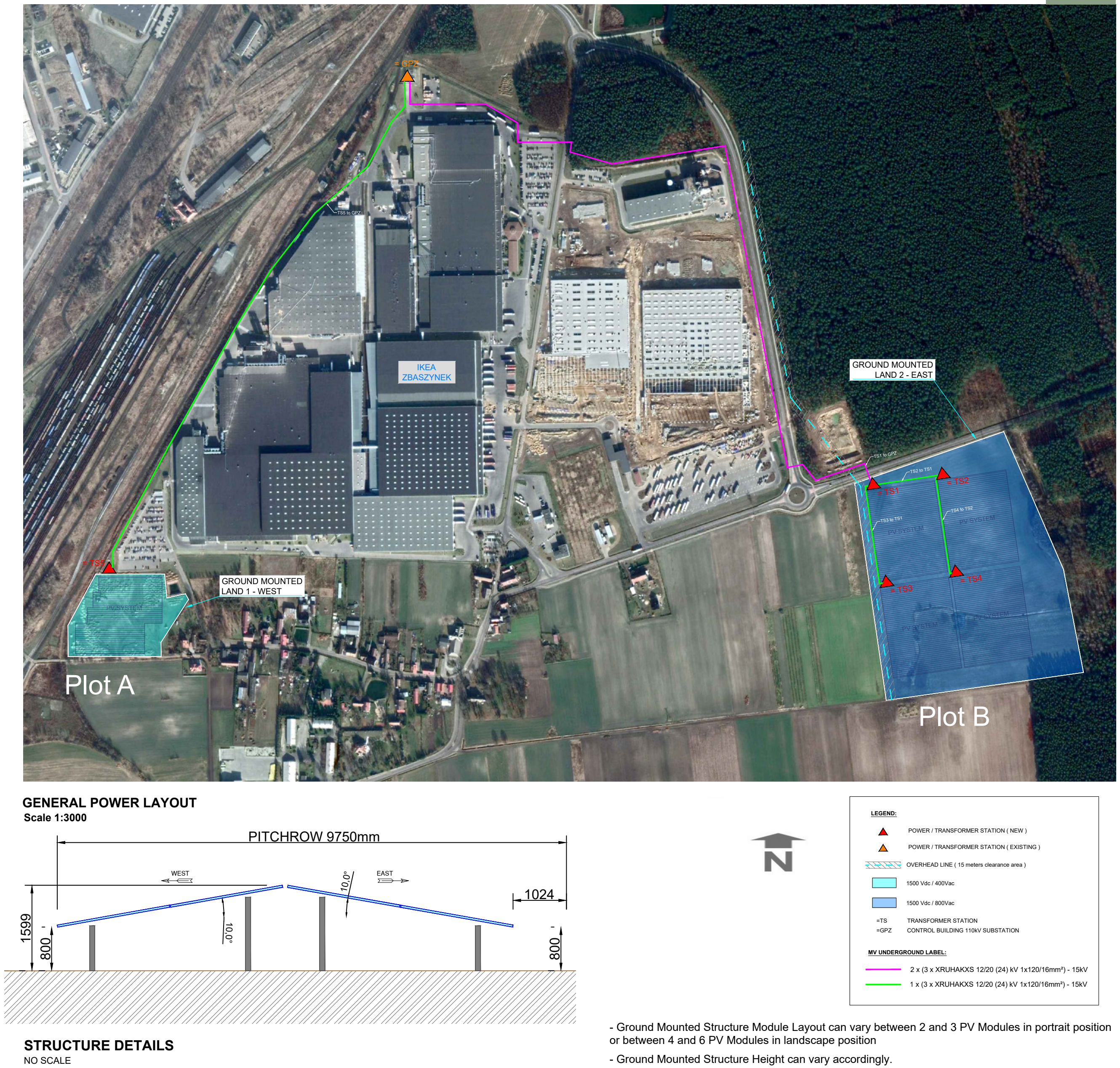


Figure 59: The general power layout IKEA Industry at Zbąszynek. Source: (IKEA, 2020)

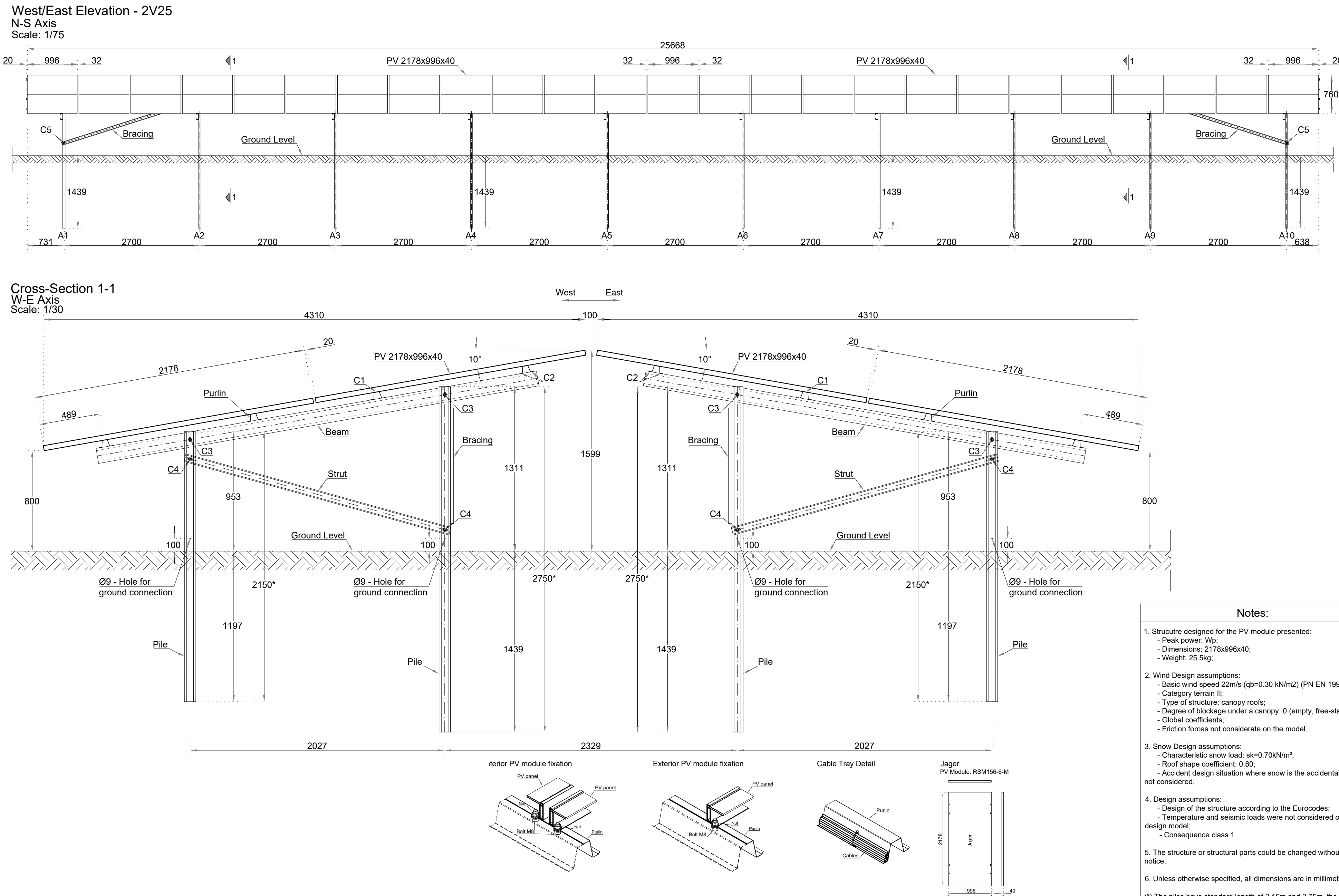


Figure 60: Structural details layout of East-west facing solar panel framing. Source: (IKEA, 2020)

Notes:

1. Strucutre designed for the PV module presented:
   - Peak power: Wp;
   - Dimensions: 2178x996x40;
   - Weight: 25.5kg;

2. Wind Design assumptions:
   - Basic wind speed 22m/s (qb=0.30 kN/m2) (PN EN 1991-1-4);
   - Category terrain II;
   - Type of structure: canopy roofs;
   - Degree of blockage under a canopy: 0 (empty, free-standing);
   - Global coefficients;
   - Friction forces not considerate on the model.

3. Snow Design assumptions:
   - Characteristic snow load: sk=0.70kN/m²;
   - Roof shape coefficient: 0.80;
   - Accident design situation where snow is the accidental action is not considered.

4. Design assumptions:
   - Design of the structure according to the Eurocodes;
   - Temperature and seismic loads were not considered on the 3D design model;
   - Consequence class 1.

5. The structure or structural parts could be changed without previous notice.

6. Unless otherwise specified, all dimensions are in millimeter.

(*) The piles have standard length of 2.15m and 2.75m, the final length of the piles will be set according to the site geotechnical survey and pull-out test.

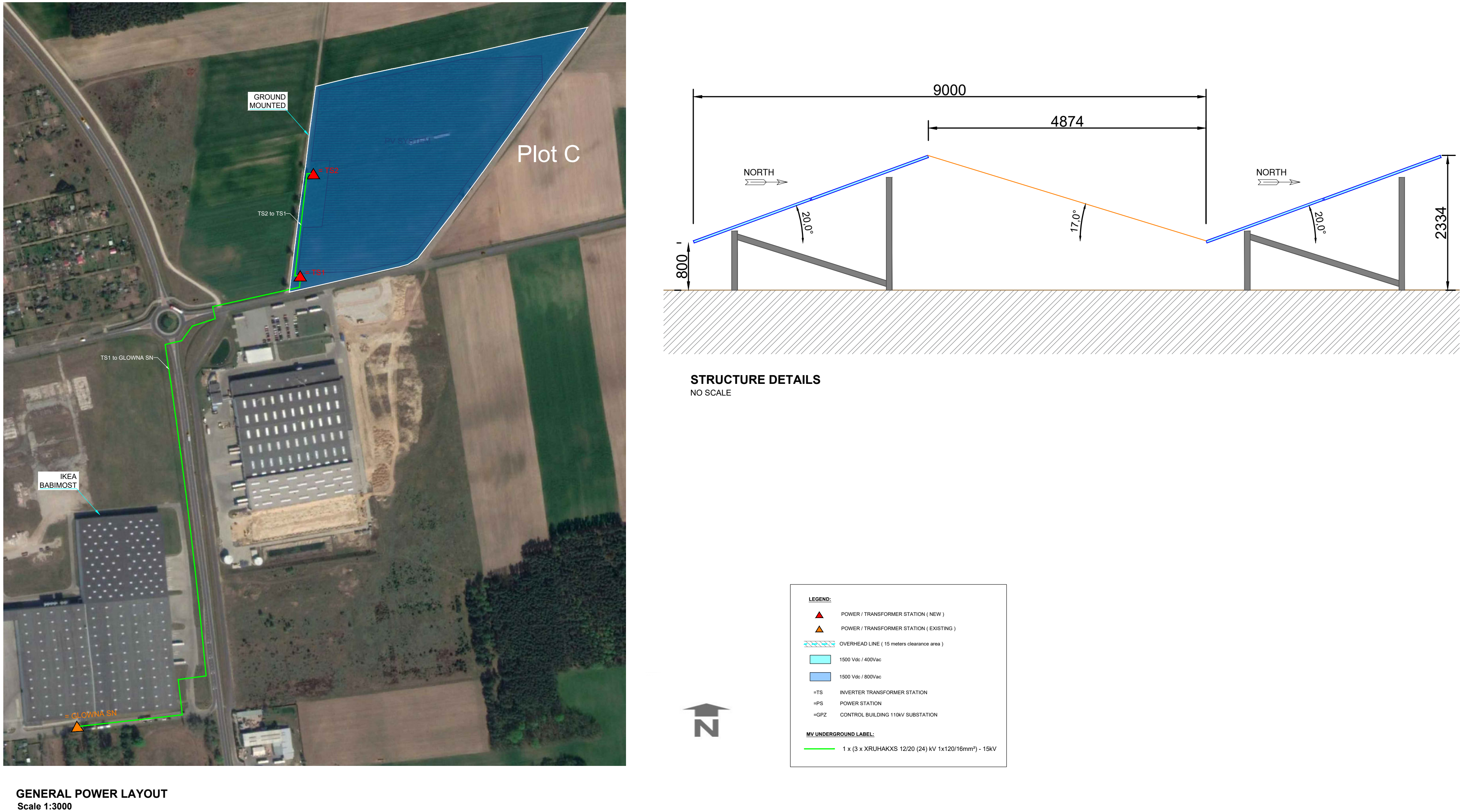
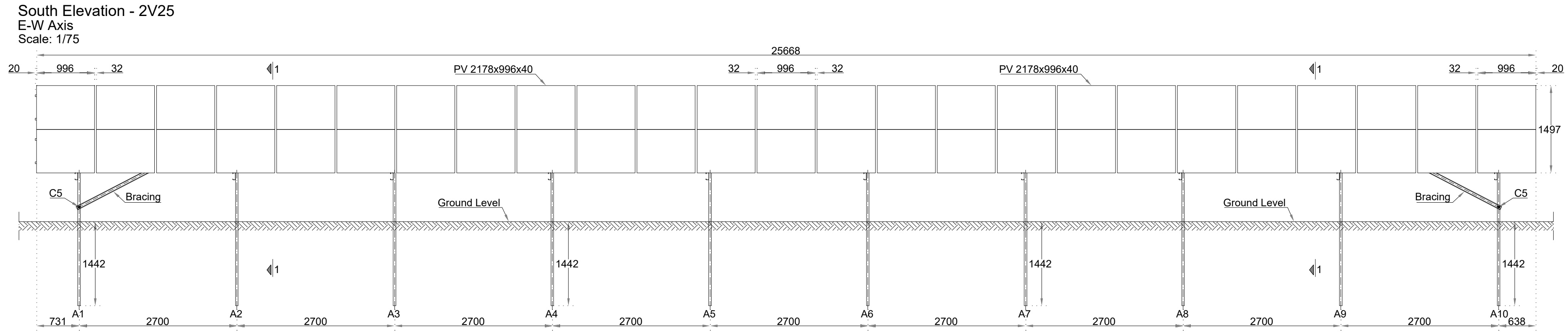
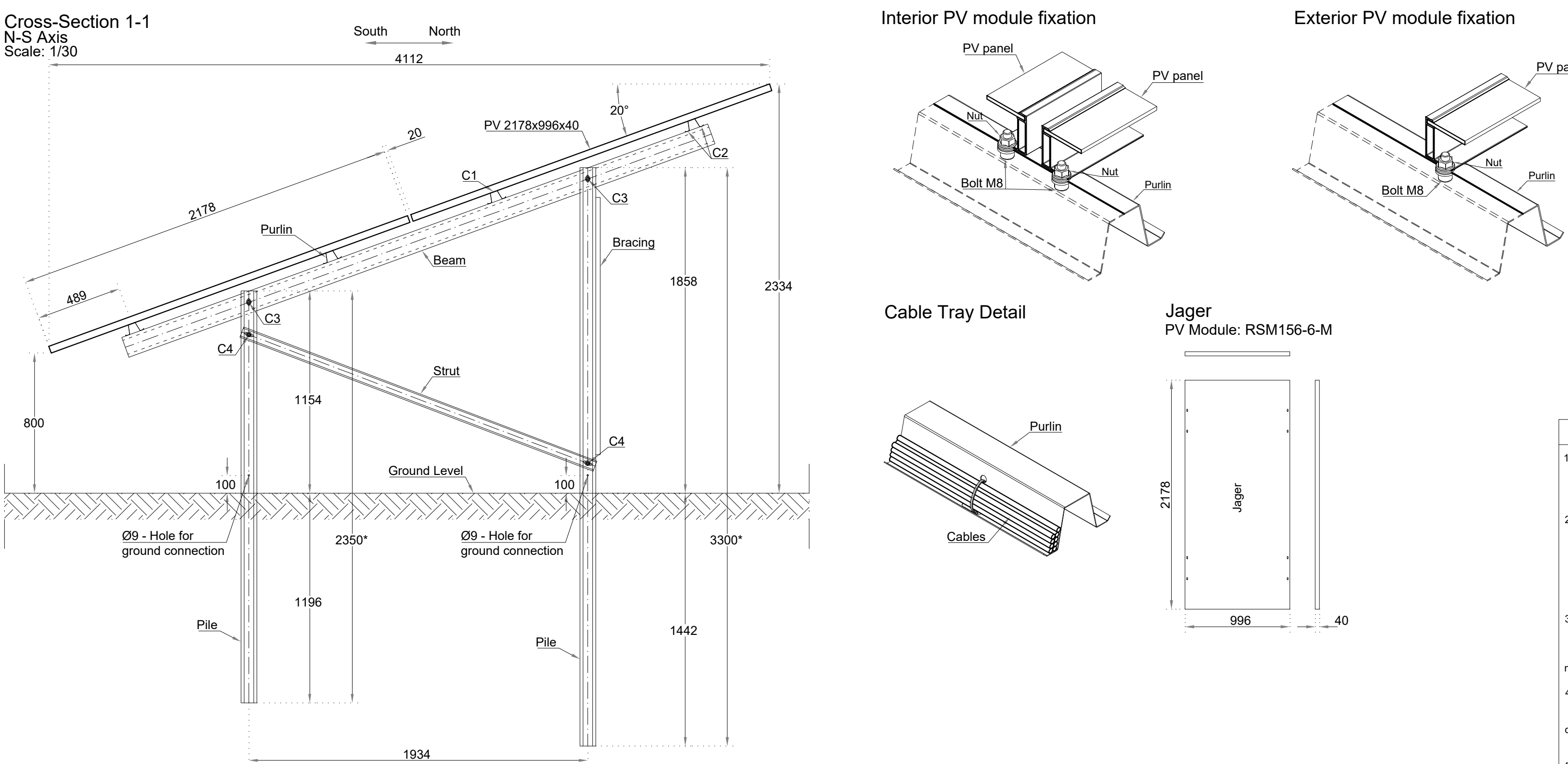


Figure 61: The general power layout IKEA Industry at Babimost. Source: (IKEA, 2020)





Notes:

1. Strucutre designed for the PV module presented:
   - Peak power: 375Wp;
   - Dimensions: 2000x1000x40;
   - Weight: approx. 26kg;

2. Wind Design assumptions:
   - Basic wind speed 22m/s (qb=0.30 kN/m2) (PN EN 1991-1-4);
   - Category terrain II;
   - Type of structure: canopy roofs;
   - Degree of blockage under a canopy: 0 (empty, free-standing);
   - Global coefficients;
   - Friction forces not considerate on the model.

3. Snow Design assumptions:
   - Characteristic snow load: sk=0.70kN/m²;
   - Roof shape coefficient: 0.80;
   - Accident design situation where snow is the accidental action is not considered.

4. Design assumptions:
   - Design of the structure according to the Eurocodes;
   - Temperature and seismic loads were not considered on the 3D design model;
   - Consequence class 1.

5. The structure or structural parts could be changed without previous notice.

6. Unless otherwise specified, all dimensions are in millimeter.

(*) The piles have standard length of 2.35m and 3.3m, the final length of the piles will be set according to the site geotechnical survey and pull-out test.

Figure 62: Structural details layout of south-facing solar panel framing. Source: (IKEA, 2020)

“The future is green energy, sustainability, renewable energy.” – Former California governor Arnold Schwarzenegger, 2012 (Newton, 2015)

Online publication: http://stud.epsilon.slu.se