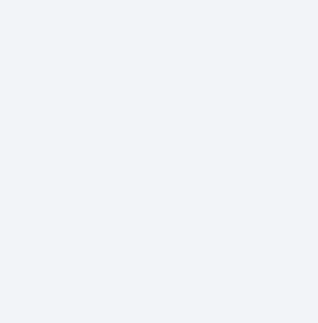





 **PRO5**

Engineering  
for good



About

## We are PRO5

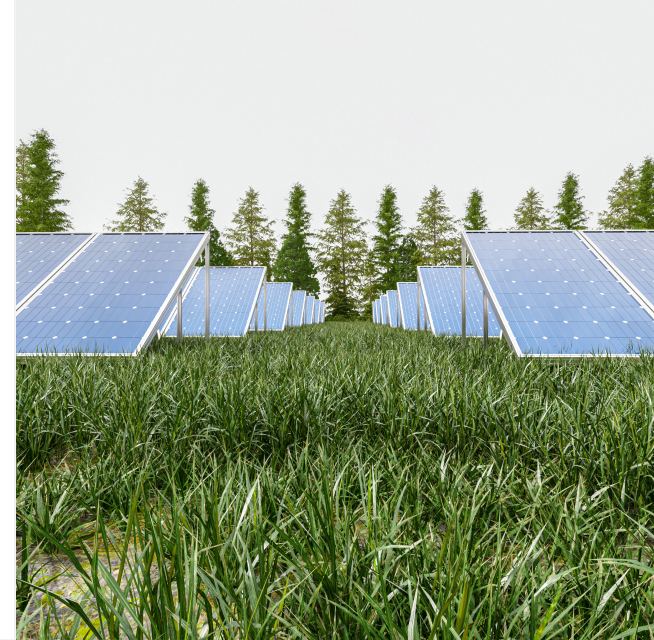
An independent engineering consultancy specialized in the design and engineering of large PV plants.

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### About us

We have been working with the leading suppliers of trackers and EPC for more than 15 years, offering a service of maximum reliability and competitiveness.

**We offer a high-quality, flexible, honest international service with the utmost confidentiality.**





About

# Mission

## Mission

Our mission is to be an international benchmark in civil and structural photovoltaic engineering, designing the best possible tomorrow for our customers and our planet.

We facilitate long-term relationships with our customers, working like their own in-house engineering teams and helping to reduce their operating costs.



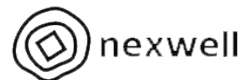
We design the best possible future for our customers and our planet.



## Our customers

We work with the leading suppliers of trackers and EPC, offering a service of maximum quality and confidentiality.

We offer our services both on an occasional basis and on an ongoing basis through long-term agreements (MSA).

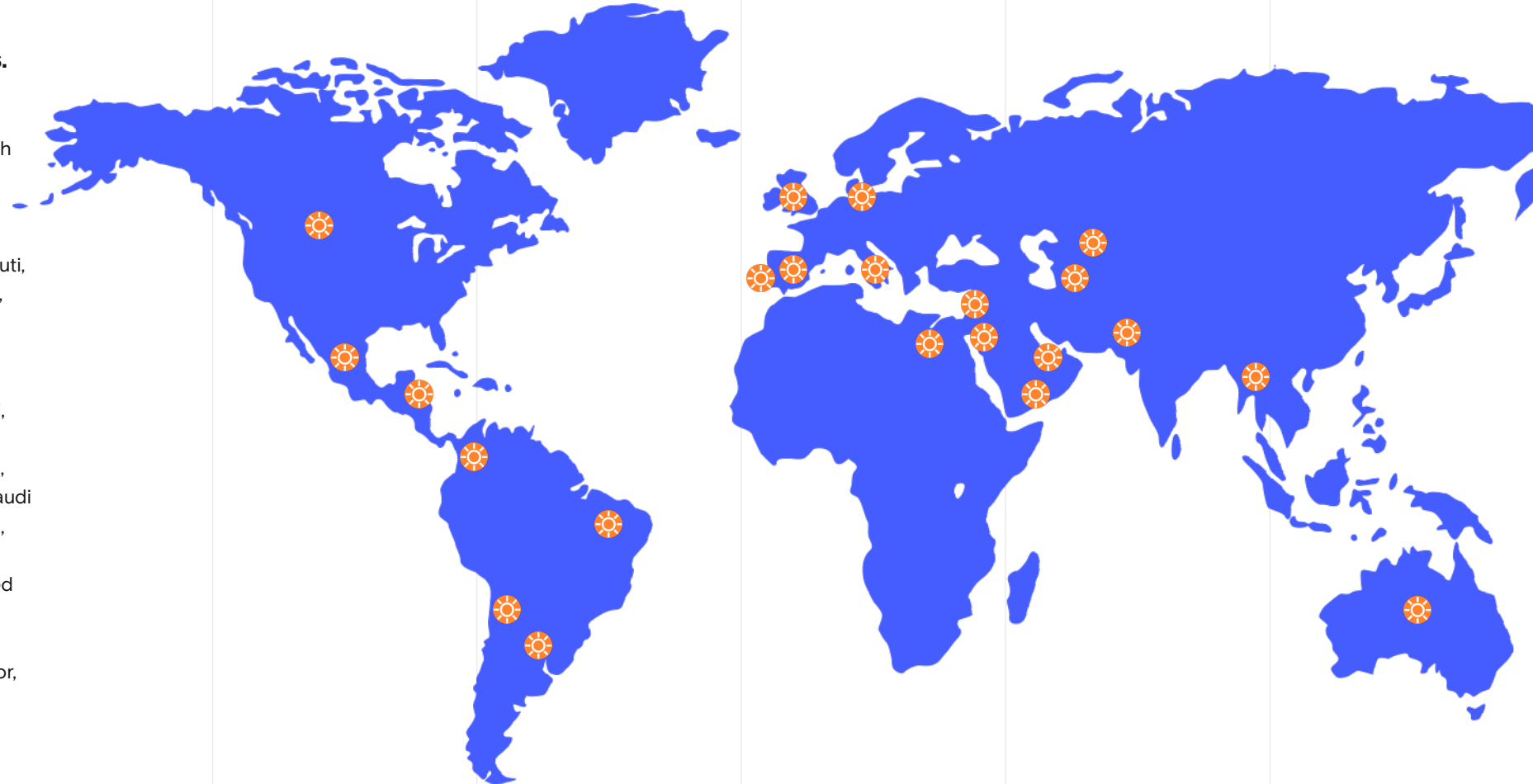


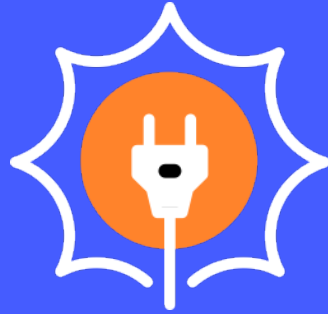


# Our work defines us

**88 countries. 5 continents.**

Australia, China, India, Indonesia, Malaysia, Pakistan, Philippines, South Korea, Sri Lanka, Thailand, Vietnam, Albania, Algeria, Angola, Armenia, Azerbaijan, Benin, Bulgaria, Burkina Faso, Chad, Cyprus, Denmark, Djibouti, Egypt, Ethiopia, France, Gambia, Georgia, Germany, Ghana, Greece, Hungary, Irak, Ireland, Israel, Italy, Jordan, Kazakhstan, Kenya, Kuwait, Lebanon, Lesotho, Lithuania, Malawi, Morocco, Mozambique, Namibia, Netherlands, Nigeria, Norway, Oman, Poland, Portugal, Qatar, Romania, Saudi Arabia, Senegal, South Africa, Spain, Sweden, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, Uzbekistan, Zambia, Zimbabwe, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay, Canada, United States of America





**+50GW**

of detail designs

**+5500**

preliminary designs

**+330**

detail designs

**+17**

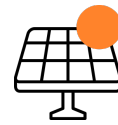
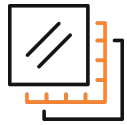
years of experience  
in solar





## Services

**We offer a high-quality, flexible, honest international service with the utmost confidentiality**

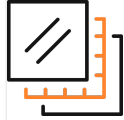


### **STRUCTURAL ENGINEERING OF SOLAR PHOTOVOLTAIC PLANTS**

- Application of structural regulations in each country
- Wind speed and snow load reports
- Structure external loads
- Analysis and application of wind tunnel result
- Calculation and verification of the superstructure
- Calculation and verification of the foundation
- Load test analysis
- Analysis of the effect of environmental and soil corrosion
- Monitoring the execution of the work
- Geological and geotechnical analysis
- Review of reports of structures and foundation of third parties

### **CIVIL ENGINEERING OF SOLAR PHOTOVOLTAIC PLANTS**

- Design and optimization of the project layout
- Fitting of the structure in the ground
- Calculation and optimization of earthworks
- Hydrology and Flood Assessment
- Design and calculation of the drainage system
- Design and calculation of internal roads and platforms
- Review of third party's calculations and design



## STRUCTURAL ENGINEERING OF SOLAR PHOTOVOLTAIC PLANTS

### Application of structural regulations in each country

We have proven experience in international projects. This has provided us with deep knowledge of each country's different regulations and codes. In addition, we have a network of local engineers who certify and validate projects with the relevant authorities.

### Wind speed and snow load reports

We carry out a study of wind speed and site-specific conditions, analyzing elements such as exposure or orography. In this way, we obtain the wind speeds for the plant's design and calculate the pressures and loads to which the structure will be subjected.

### Structure external loads

We approach the calculations of external loads according to each country's legislation, using the previous studies of the loads to which the structure is subjected, such as wind, snow, temperature, earthquakes, etc. We calculate wind loads in two ways:

#### Without wind tunnel

We use the local code and form coefficients applicable to the country regulations to obtain the loads and reactions on the piers of the structure.

#### With wind tunnel

We rely on the coefficients provided by the customer to perform the aeroelastic calculations of the structure, using the loads distributed throughout it to obtain the reactions on the foundation.



## Analysis and application of wind tunnel result

Over the past 15 years, PRO5 members have witnessed and participated in the evolution of wind tunnels, both conceptually and in terms of results. This allows us to apply the coefficients obtained to the formulation of the corresponding structural regulations with maximum reliability. In addition, we help our customers to analyze the results and optimize them for subsequent structural design.

## Calculation and verification of the superstructure

We use the loads obtained to verify the structure and the joints proposed by the customer, checking if it complies with the provisions or if it is oversized, in which case we suggest its optimization.

We calculate and verify the components of the structure above ground level with the loads previously obtained. We analyze the behavior of the different steel sections according to local regulations, validating the proposals by the customer or proposing their optimization in case they are oversized.

Thanks to our deep knowledge and continuous updating of international regulations, our calculations provide the most competitive structures according to current regulations.

## Calculation and verification of the foundation

We rely on the loads acting on the piers, the terrain conditions and the local regulations to determine the most appropriate type of foundation for the project. Then, we carry out the structural verification of the different sections used.

Our geotechnical knowledge is based on our own experience throughout the planet, as we had the opportunity to face soils with a wide variety of problems; from the expansive clays of Australia to the frozen soils of Canada, the deserts of Saudi Arabia or the peat soils of Denmark.

### **Load test analysis**

We perform a complete and thorough analysis of load testing campaigns, both for design (destructive) and for verification during execution (non-destructive).

We adjust the terrain modeled in a preliminary phase to the actual behavior of the soil obtained in the load test. In this way, we achieve the most competitive final design, based on real results of soil-foundation interaction.

We specialize in analyzing the viability of direct driving or the need for drilling to install the piers. Our experience tells us that the capacity of the terrain to be driven is one of the most delicate aspects when building. This is why we advise our customers and help them to plan the construction with all the guarantees.

### **Analysis of the effect of environmental and soil corrosion**

We analyze the possible impact of environmental factors and the chemical composition of the soil, both in the design of the foundations and the structures.

We work daily on international projects with different regulations, making estimates of corrosivity with American, Australian or European regulations, among others.

After more than 10 years of carrying out bibliographic studies on all continents, we have reached a level of differential expertise in the design of foundations consisting of steel piers.

### **Monitoring the execution of the work**

We support our customers during the execution of the design on site, solving the possible questions about the installation or possible unforeseen events related to geotechnical conditions. In this way, we offer constant support and provide a specific solution according to the loads and the terrain.



## Services

### **Geological and geotechnical analysis**

We had the fortune to face all kinds of soils throughout the planet; from marshy ground reclaimed from the sea to liquefiable soils. Almost every day, we receive and analyze geotechnical reports from around the world, assessing risks and identifying gaps to ensure the success of our customers' projects.

All this accumulated knowledge allows us to adapt the geotechnical tests to the reality of the solar plant with very high consistency and reliability.

In addition, we also develop technical specifications for pier load tests, always tailored to our customers and taking into account the characteristics of the tracker installed.

These tests facilitate the selection and final design of the foundation of the project: direct driving, pre-drilling or concrete pile.

### **Review of reports of structures and foundation of third parties**

We review the design and projects carried out by third parties to give our customers a second opinion, helping them to continue with the following stages of their projects with maximum guarantees.

Thanks to our international experience, our review processes are fast and efficient.



Services



## CIVIL ENGINEERING OF SOLAR PHOTOVOLTAIC PLANTS

### Design and optimization of the project layout

We carry out the plant's layout and general design integrating all the disciplines that make up the project: civil, structural, and electrical.

### Fitting of the structure in the ground

We calculate the height of each pier in the ground, which facilitates the installation of the structures and avoids issues or increases in costs during installation.

We provide the data in such a way that, using the current equipment, the installation of the piers is executed in the most automatic way possible. In addition, in this way, the correct installation of the rest of the structure is guaranteed.

### Calculation and optimization of earthworks

The analysis of the earthworks is carried out by taking into account the constraints of the structure, the limiting slope it supports in different directions, and the height tolerances on the ground of the different supports or piers.

Possible specifications or preferences on the part of the customer are also taken into account, such as volumetric compensation or the reduction of the difference in height between adjacent N/S trackers (north/south).

We minimize civil works costs by minimizing earthworks.

To do this, we avoid generalized leveling and thoroughly analyze all trackers and their interdependence.

Discover our new service:  
Following terrain tracker grading design

## Hydrology and Flood Assessment

- Analysis of topography, climatology, geology, types of soils, land cover, and hydrology.
- Analysis of the contributing basins/ watersheds with potential influence on the project area, identifying the watersheds in order to determine the hydrological and hydraulic parameters, as well as the catchment areas.
- Calculation of peak flows, runoffs, and hydrographs (a curve showing the streamflow versus time) construction using the Rational Method (General Method), and the SCS Curve Number Method.
- HEC-RAS 2D hydraulic models' analysis, including both stream flows and runoff generated by rainfall for the return periods of interest (usually 5, 10, 25, 50, and 100 years).
- Generation of the Flooding maps for each of the return periods, including velocity and water elevations.

## Design and calculation of the drainage system

We carry out the design and calculations of the drainage system, always taking into account the following elements:

- Size and arrangement of the ditches
- Road and internal road protections
- Measures against erosion
- Mitigation of flood areas
- Rainfall and hydrological conditions of the place
- Analysis of the drainage basins received by the plant
- Etc.

## Design and calculation of internal roads and platforms

We calculate the vertical geometry and the impact on the ground, based on the plan geometry of the general layout and the proposed type section for the internal roads. We also calculate the platforms of elements such as the substation, the inverter pads or the auxiliary buildings.





## Review of third party's calculations and design

We review the design and projects of third parties, helping our customers to continue their projects with maximum guarantees. Thanks to our international experience, our review processes are fast and efficient.







# FOLLOWING TERRAIN TRACKERS



## FOLLOWING TERRAIN TRACKERS GRADING DESIGN

### Following Terrain Trackers

Following terrain trackers is the new product developed by some of the best manufacturers in the world, consisting on a PV tracker that follows the terrain instead of the typical straight line row.

Some of the latest improvements increase significantly the ability to conform to sloping terrain, further expanding opportunities for solar development on challenging sites.

Some initial requirements are to be considered in the project, but these kind of trackers minimizes earthwork, reduces foundation steel, and keeps construction costs and schedules in check.

Depending on the supplier and model, these trackers can accept up to 1.50° TT angle change pier to pier in order to accommodate the tacker to the terrain.



### PRO5 Grading Design System

Following terrain trackers system comes with some restrictions and tolerances that need to be considered in the Civil Design activity, mainly to define two things:

 Grading Cut&Fill Design

 Pier Cut Off Elevations

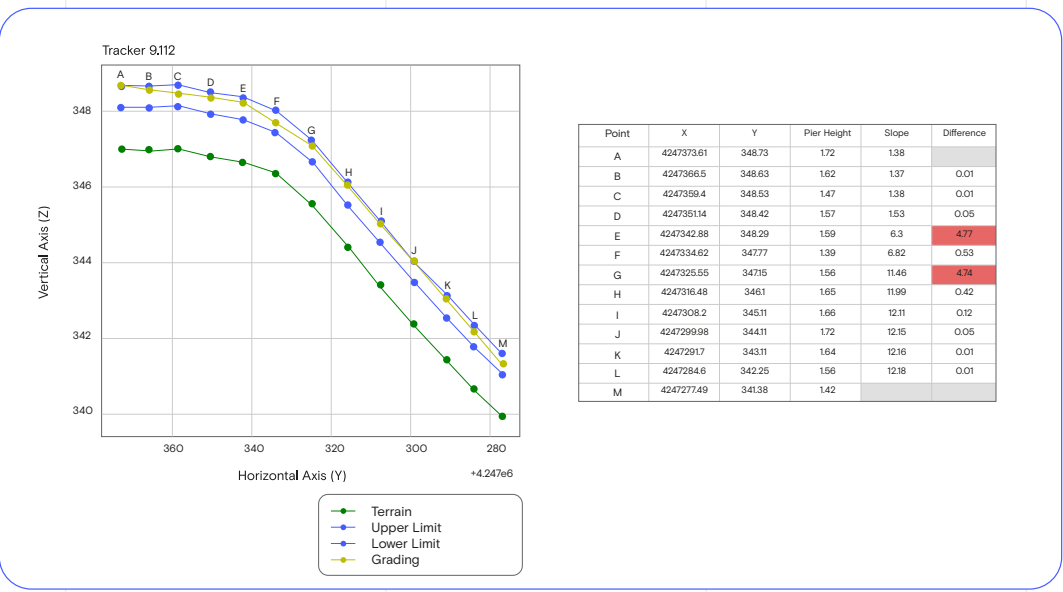
PRO5 has developed a complex process to calculate this impact on the existing terrain, and provide the information needed by the contractor to set up both, the piers cut-off elevations of every tracker to comply with the tolerances and requirements, and then, the grading operations needed to adapt the initial soil model to those requirements in case they can not be complied.

PRO5 - Tracker - Calculator

Loaded Zones: 0

Load Trackers

Total Tracker:	0	(0%)	Calculate Following T Tracker	Editor	Settings
Standard Tracker:	0	(0%)			
Following Terrain Tracker:	0	(0%)			
Earthworks Tracker:	0	(0%)	Calculate Standard Tracker		
Unedited:	0	(0%)			
Not calculated:	0	(0%)			





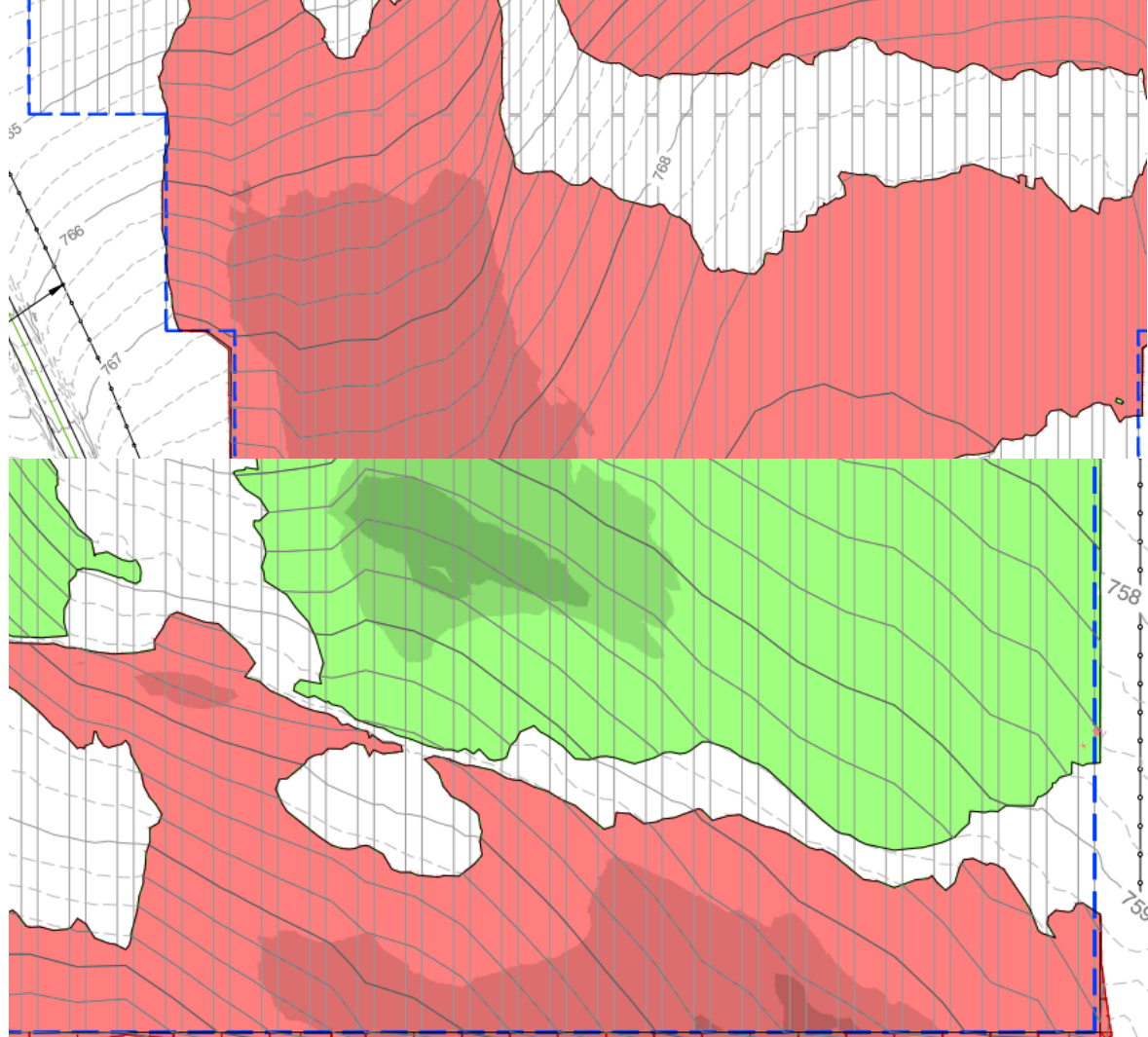
Grading Design

This process takes into consideration the civil and mechanical aspects related to any earth movement activity executed on a solar plant, producing as a final result, a realistic Digital Terrain Model that can be actually constructed.



Grading Design

Neighbour trackers interaction is always respected by not having significant steps between rows/ columns, evaluating the whole area below the PV tracker, not only the one limited by the piers. Also, the perimeter embankments are considered in the study to check the impact with the different layout elements such as internal roads, equipment pads, fences, etc..



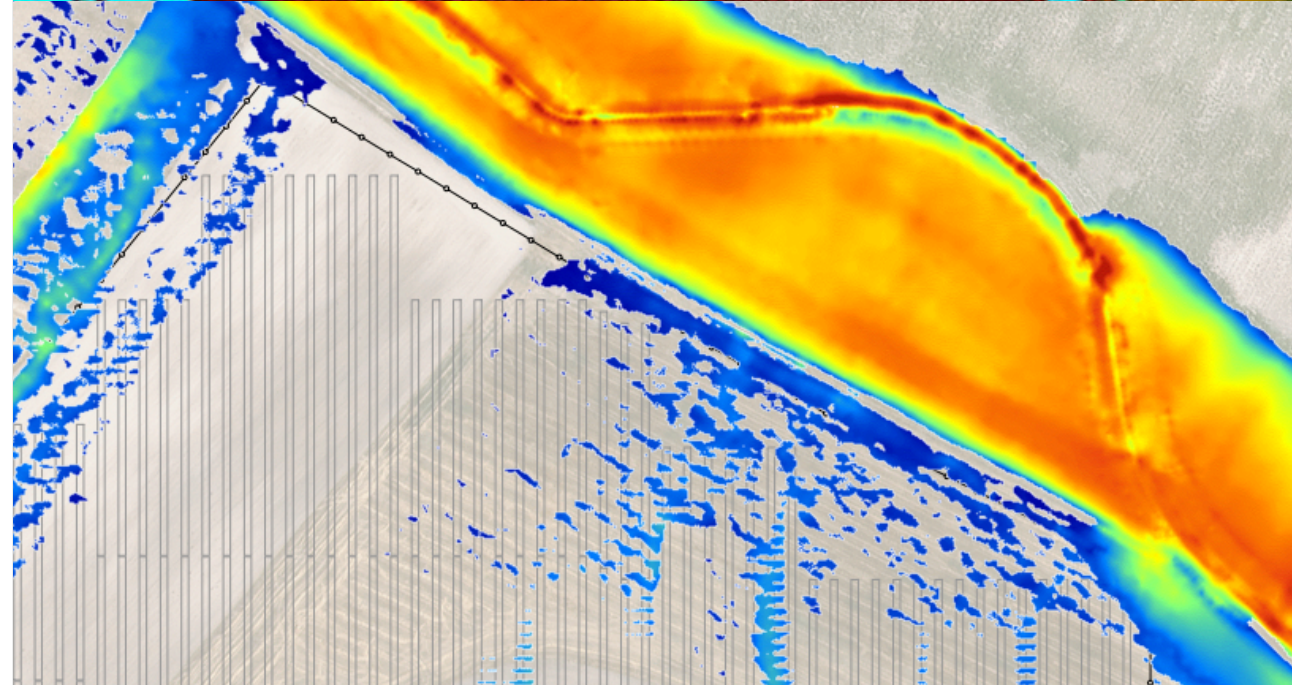
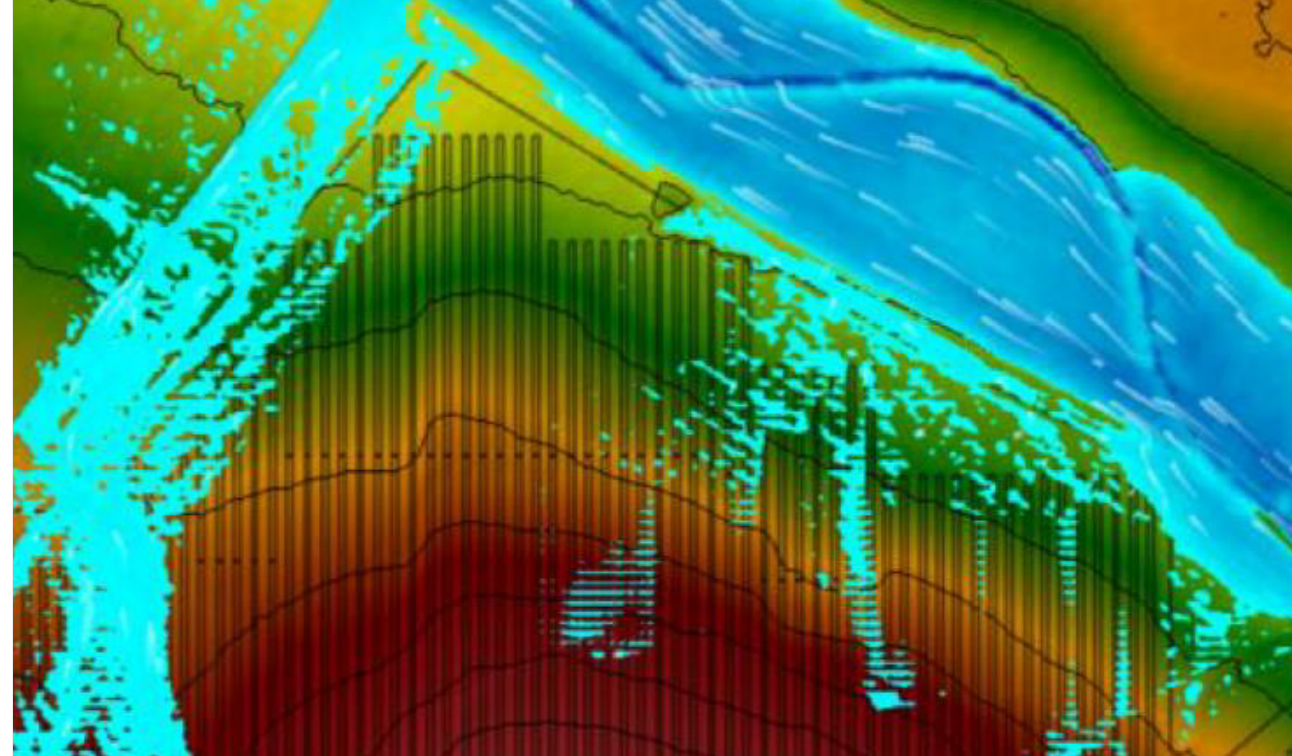
EXCAVATION INTERVAL TABLE			
	Min. Elev. (m)	Max. Elev. (m)	Color
CUT	-1.05	-0.75	Dark Red
	-0.75	-0.50	Red
	-0.50	-0.30	Light Red
	-0.30	0.00	Very Light Red
FILL	0.00	0.30	Light Green
	0.30	0.60	Medium Green
	0.60	1.00	Dark Green
	1.00	1.65	Very Dark Green

GRADING QUANTITIES - STUDINA PVPLANT				
ZONE	2D AREA m <sup>2</sup>	CUT VOLUME m <sup>3</sup>	FILL VOLUME m <sup>3</sup>	NET VOLUME m <sup>3</sup>
AREA 1	19,863.8	3,361.2	0.0	3,361.2
AREA 2	48,573.6	4,277.2	1,323.6	2,953.6
AREA 3	118,066.2	15,576.1	21,861.4	-6,285.3
AREA 4	37,459.0	3,560.9	765.0	2,795.9
<b>TOTAL</b>	<b>223,962.6</b>	<b>26,775.4</b>	<b>23,950.0</b>	<b>2,825.4</b>



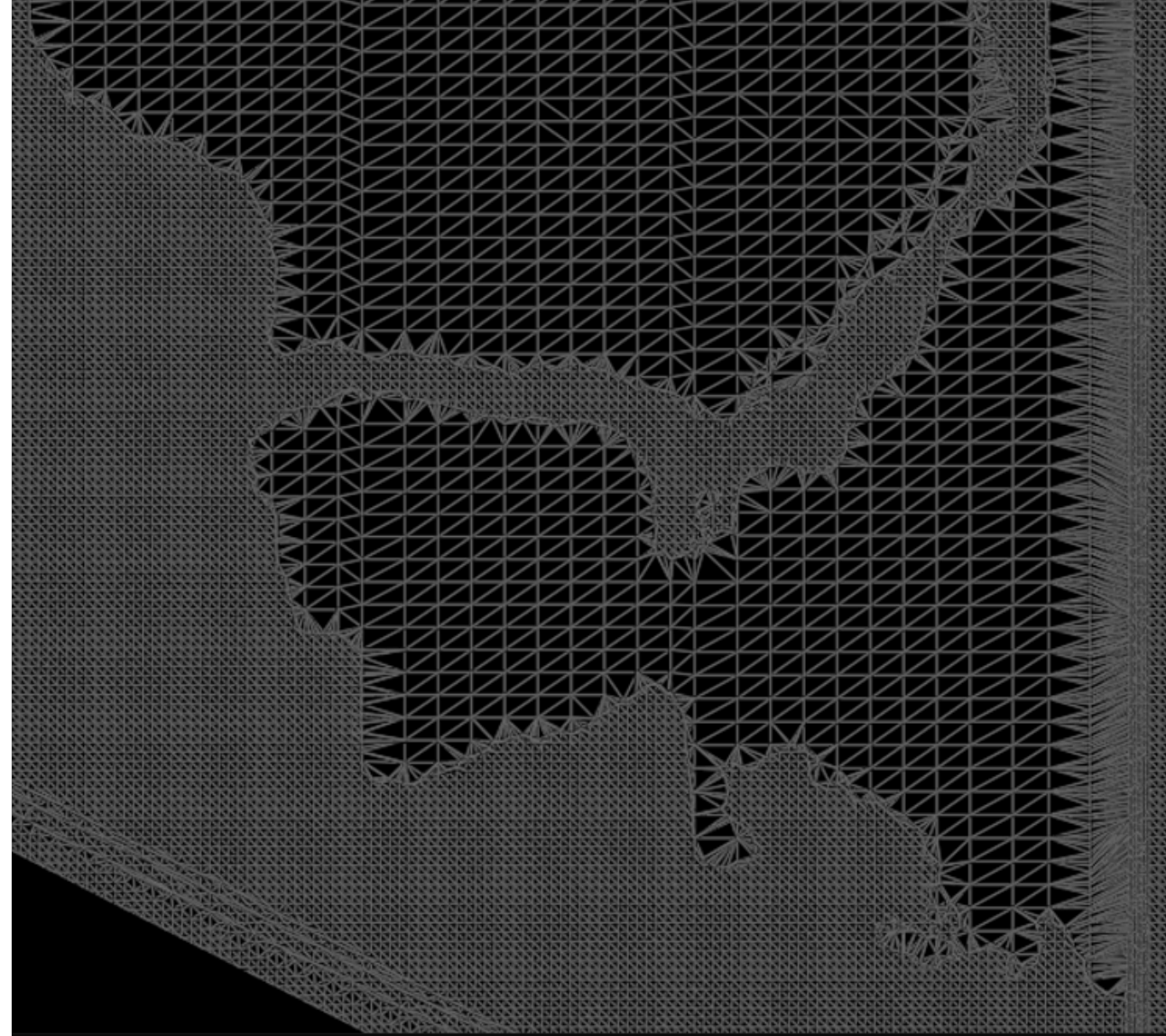
## Grading Design

Hydrological impact is analyzed to avoid future flooding issues, or to foresee a drainage level solution in case they can not be avoided.



Grading Design

Appart from the Cut&Fill Volume Summary, Setting-Out Information consisting on a detailed Digital Terrain Model in dwg/xml format, along with the pier coordinates list is provided for the Construction Phase. These formats can be easily introduced in any GPS guided system machinery to perform the grading activities on site.



ID POINT	X	Y	Z ORIGINAL GROUND	Z MODIFIED GROUND	h (m) SOIL ELEVATION DIFFERENCE	Z TOP OF PIER	h (m) PIER HEIGHT OVER THE SOIL	TRACKER TYPE	SECTION SLOPE (%)	SECTION SLOPE DIFFERENCE (%)	TRACKER ID
317	422708.650	4413989.347	505.77	505.77	0.00	507.12	1.35	All-Terrain Tracker			36
318	422708.650	4413981.088	506.05	506.05	0.00	507.40	1.35	All-Terrain Tracker	3.4%	-0.60%	36
319	422708.650	4413971.672	506.43	506.43	0.00	507.78	1.35	All-Terrain Tracker	4.0%	-0.81%	36
320	422708.650	4413962.257	506.88	506.88	0.00	508.23	1.35	All-Terrain Tracker	4.8%	-0.43%	36
321	422708.650	4413951.686	507.44	507.44	0.00	508.79	1.35	All-Terrain Tracker	5.2%	0.09%	36
322	422708.650	4413941.459	507.96	507.96	0.00	509.31	1.35	All-Terrain Tracker	5.1%	-0.81%	36
323	422708.650	4413931.233	508.57	508.57	0.00	509.92	1.35	All-Terrain Tracker	6.0%	-0.08%	36
324	422708.650	4413920.661	509.21	509.21	0.00	510.56	1.35	All-Terrain Tracker	6.0%	-0.05%	36
325	422708.650	4413911.246	509.78	509.78	0.00	511.13	1.35	All-Terrain Tracker	6.1%	0.04%	36
326	422708.650	4413901.831	510.35	510.35	0.00	511.70	1.35	All-Terrain Tracker	6.0%	1.28%	36
327	422708.650	4413893.571	510.75	510.75	0.00	512.10	1.35	All-Terrain Tracker	4.8%		36
328	422716.150	4413992.727	505.77	505.77	0.00	507.12	1.35	All-Terrain Tracker			37
329	422716.150	4413984.467	506.08	506.08	0.00	507.43	1.35	All-Terrain Tracker	3.8%	-0.18%	37
330	422716.150	4413975.052	506.46	506.46	0.00	507.81	1.35	All-Terrain Tracker	4.0%	-0.40%	37
331	422716.150	4413965.636	506.88	506.88	0.00	508.23	1.35	All-Terrain Tracker	4.4%	-0.81%	37
332	422716.150	4413955.065	507.43	507.43	0.00	508.78	1.35	All-Terrain Tracker	5.2%	-0.26%	37
333	422716.150	4413944.839	507.99	507.99	0.00	509.34	1.35	All-Terrain Tracker	5.5%	-0.73%	37
334	422716.150	4413934.612	508.62	508.62	0.00	509.97	1.35	All-Terrain Tracker	6.2%	0.13%	37



Contact

## Let's make things happen. Let's talk.

Let's see how we can help you.

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You can find us at Av. de Brasil 17,  
planta 17, 28020 Madrid (España)  
or email us at  
[admin@pro5engineers.com](mailto:admin@pro5engineers.com)

 **PRO5**