# PROJECT CASE STUDY

# SERIES OF 5MW PV FARMS IN SOUTHERN BULGARIA

## PROJECT SUMMARY

The Bridgestone Associates Team prepared a complete system design, layouts, specifications and a detailed cost estimate for a planned series of 5 MW PV solar power plants, located on reclaimed land in Southern Bulgaria. The planned total size of the facility was to be approximately 200 MW. This project was being developed to help meet some of the EU requirements for substantial increases in renewable electricity to allow Bulgaria to enter the EU.

## PROJECT STATISITICS

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| Client: | Renvision, Sofia, Bulgaria |
| Project Type: | PV Panels |
| Size: | Series of (approx.) 5 MW PV systems at interconnection point |
| Design Conditions: | 95 $^{o}$F and 40% RH/ 5 $^{o}$F Winter |
| Unit Sizes: | Series of PV panels, with 5 $MW_e$ |
| Energy Storage: | None |
| Estimated Turnkey Cost: | US$17.208 million each, without land for each 5 MW system |
| Plant Locations: | Southern Bulgaria |
| Plant Elevation: | Approx. 1,000 feet above sea level |
| Interconnection Voltage: | 11KV-230 kV (varies with the sites) |
| Dual Axis Tracker: | Inteli Track IT 2000 |
| Cooling: | Cooling Fans for Inverters for excess outdoor temp and solar load |
| Winter heating protection: | Supplemental electric heat for freeze protection |
| PV Supplier: | Helios |
| Grid-tie Inverter Supplier: | SMA Sunny Central 500 HE-11 |

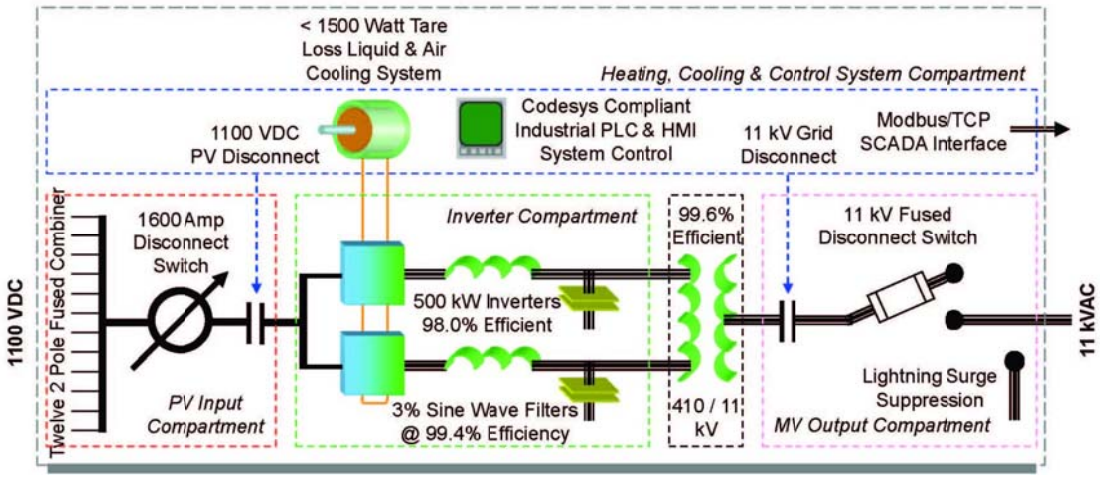
## PROJECT DESCRIPTION

A complete program design, plant specification, plant performance and cost estimate for this PV plant was developed for the client with a total first phase of about 5 MW. The plant will be located near Merichleri in South Central Bulgaria and be interconnected into the nearby 20 KV Bulgarian electrical grid. The system uses Helios PV modules and SMA 1 MW inverters, tied into an internal electrical network, with the protective relaying and 20 KV transformers upping the voltage from 480 V 3 Ph, 50 Hz A/C current.

The project uses 1 MW sealed inverter units, with built-in combiner box systems, and pre-cut and prepared cables and connectors for the PV panel arrays to reduce amount of additional skilled electrical labor required at the job site for installation and checkout.

The PV modules are mounted in an automatic tracking system to allow for periodic adjustment of elevation angle to maximize solar conversion throughout the year. Consideration was given for manual adjustment trackers made in Bulgaria, due to low cost of labor, but the available sites, and expected labor cost increases as Bulgaria gains accession to the EU indicated that dual axis tracking systems were appropriate, even though they used more land. However, at this time, the land is inexpensive.

The PV plant is connected to the local utility at 20 kV via a 700 meter long cable. This cable is buried adjacent to the nearby highway in a right of way purchased from the government. The interconnection designs for the other plants will vary slightly as each site has a different connection configuration, and the utility interconnection requirements vary slightly. However, all follow the IEEE standards with appropriate EU and Bulgarian adaptations.




A long term (up to 18 year) Power Purchase Agreement with favorable terms forms the center of the financial backing. This PPA is supported by the Bulgarian government through legislation regarding solar renewable energy required to be fed to the national grid.

The project has been developed, designed and laid out by a consortium, which consists of Bridgestone Associates, Ltd. (USA) project technical consultants; EPS Capital Corp., Inc. (USA), project engineers; Renvision (Sofia Bulgaria), project developer; and a local EPC contractor. The local EPC contractor has installed previous solar farms in Bulgaria ranging in size from 2 MW - 8 MW.

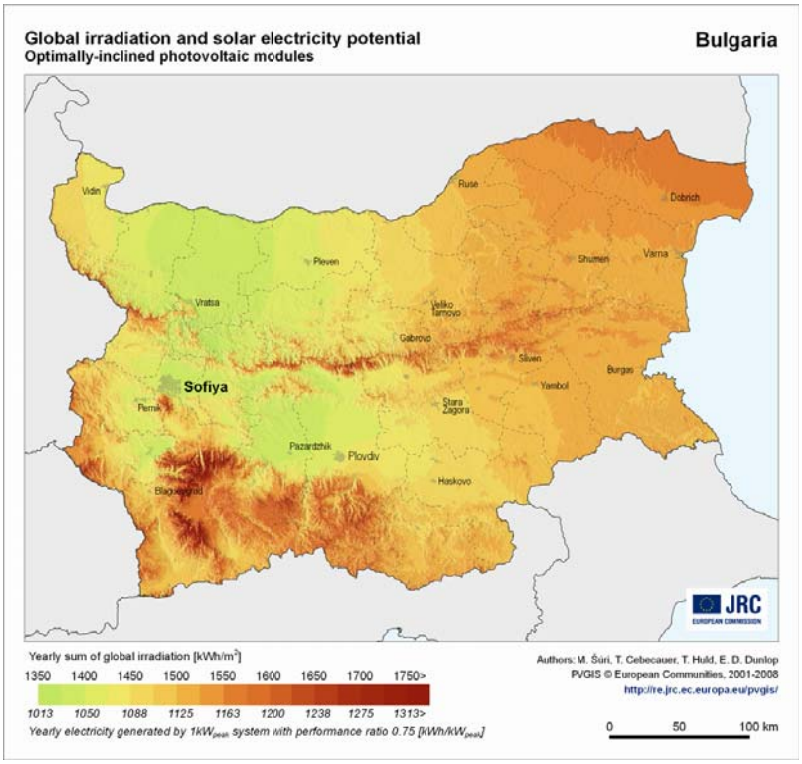
The plant does not include any energy storage capabilities. Both batteries, as well as hydrogen generation on site, and use with a biomass plant to be built nearby were considered, but rejected as not bringing appropriate economic returns. Because of the availability of selected plots of former mining lands which were reclaimed as part of EU requirements, these are being used for cost effectiveness.

The first plant site is located in a rural area. Other plants will be located in the farming areas typically outside of major urban areas. Sites already selected for other installations are all rural in nature, but co-located near major power grid connections of 20 KV to 230 KV.

Because the specific plan was for a series of 5 MW size sites located away from large urban centers, a "cookie cutter" like approach was needed in order to keep the costs down. Because solar PV is easily scalable, this approach is applicable and so a great deal of investigation was undertaken to develop the best approach and reasonable estimates of cost and performance, so as to allow for cookie cutter type implementation on a large scale. Specific activities included identification of manufacturers capable of providing the equipment, system design, estimation of system performance, system operations and maintenance, initial startup, and safety issues. For various jobs, the final mix of PV manufacturer and PV technology will vary based on price and performance, and funding rules and regulations.

Detailed performance runs were prepared for all different design scenarios, as well as full and partial loads and nighttime operation. These balances and performance runs were used as the basis for economic feasibility analysis.

A detailed capital cost estimate was prepared. This estimate was based on budget proposals and costs from equipment vendors for all major components as well as estimates based on industry data adjusted for local conditions, productivity and prevailing labor costs. Capital costs were compared against the data available in the solar industry for other similar plants.




In addition to the detailed cost estimate and performance, layout drawings, general arrangement drawings, and electrical one-line drawings were all prepared. Also prepared were a write-up of the plant design and major component specifications, an outline plan for plant operations and maintenance, an outline construction plan, a project construction schedule, and an operations and maintenance cost estimate. All was used for construction.