PHILIPPINE UTILITY-SCALE PHOTOVOLTAIC CASE STUDY

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Disclaimer

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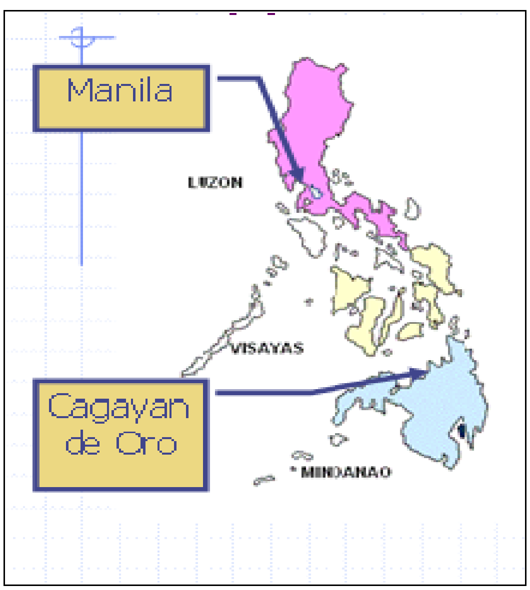
DESCRIPTION OF PROJECT – CAGAYAN DE ORO, PHILIPPINES

Cagayan de Oro was built to operate in conjunction with an existing hydropower plant, whose limited water storage capacity is being used to smooth out the fluctuations in the daily output of the PV plant. This helps convert variable solar power generation into firm energy.

Location – 5 km outside the city of Cagayan de Oro on the island of Mindanao, Philippines
Size – 950 kW (AC) photovoltaic power plant built on 1.95 hectares of land. When completed in 2004 this was the largest grid-connected PV power plant in the developing world.
Equipment – The PV array is composed of 6,480 PV panels, south facing and tilted at 10 degrees from horizontal. The modules are organized in groups of 720, with each group supplying one of nine separate DC-to-AC inverters. The separate mini-hydro project, Bubunawan Power Project, is 7 MW.
Owner – Cagayan Electric Power and Light Company Inc. (CEPALCO), an investor-owned, 100 MW power distribution company serving the city of Cagayan de Oro and three adjacent municipalities in the Province of Misamis Oriental on the northern side of Mindanao.
Off-taker – CEPALCO
Date of Operation – Testing began in June 2004; commercial operations were initiated in September 2004.
Total Cost – US $5 million
Source of Financing – The financing was provided by the Global Environment Facility (GEF), with the International Finance Corp. acting as the project executing agency on behalf of the GEF.



Location of Cagayan de Oro PV plant on the island of Mindanao

BACKGROUND

The Philippines' Energy Sector

The Philippines is a nation of many islands, with Luzon being the largest and Mindanao the second largest. Mindanao has one of three integrated electric grids, developed initially to transport hydroelectric power from plant locations to cities. At the time the CEPALCO PV project was being developed (2000-2001), Mindanao's power generation sector was dominated by hydro and geothermal sources. With the large hydro and geothermal resources fully utilized, the fast-growing demand for power in Mindanao was being supplied with diesel power generators mounted on barges.[1] Also during this period, coal-fired generation was being built on Mindanao in response to the relatively stable price of coal relative to gas and oil.

Meanwhile, regulatory policies were changing in the Philippines: government-owned generation assets were being sold (or attempts were being made to sell them) to the private sector; a competitive wholesale electric market was being developed; and new privately owned generation facilities were being encouraged by regulatory policy. During this time the price of electricity was increasing as the power market was becoming competitive. Under prior government ownership of power production, prices were based on the costs of low-cost hydroelectric power, and not on the value received for electric services. The growth in electricity demand on Mindanao, the highest in the country, was not very high in an absolute sense, but there was not enough additional capacity being built during this period. Thus, electricity demand on the island was catching up fast with the installed supply. (In 2004, when the project became operational, Mindanao wholesale electricity prices were P2.85/kWh – between US $0.057 and US$0.086/kWh. In 2008 it was P3.7 – between US $0.074 and US $0.11/kWh)

The Philippines' Experience with Solar Power

As an island nation with many islands isolated from the national power grid, the Philippines has a great deal of experience with off-grid PV systems. At the time the CEPALCO project was being developed, however, the Philippines had no experience with large, central station PV projects. PV module manufacturing was just beginning to expand into developing countries, and there were no large manufacturers in the Philippines. The solar modules for this project were provided by Sharp Corporation and manufactured in Japan. Currently SunPower, formerly a subsidiary of US-based Cypress Semiconductors but now owned by a Chinese firm, has begun manufacturing solar cells in Filipino factories that had formerly manufactured a previous generation of microchips. Most of the SunPower product is exported to wherever it can command the highest price.

[1] If a utility becomes short of power to meet demand, sometimes a privately owned barge carrying diesel oil and tens of MW of generators is towed to a harbor and connected to a local electricity grid. Such barges can charge whatever the market will bear since they can cast off and go to another port with a growing market for power that is willing to pay their price.

Quality of the Solar Resource

Unlike fossil and wind energy resources, solar energy resources are fairly evenly distributed in most densely populated areas. The main metric for solar energy resources is the average annual "insolation" on a horizontal surface, usually expressed in units of kilowatt-hours of solar radiation per square meter per year. (Alternately, this value is divided by 365 to express it in daily units.) At the lower end of the range, low elevation, cloudy, northern (or southern) locations might see only 2.5 kWh/m^2 per average day (about 900 per year) while at the other extreme higher altitude, clear desert locations near the equator might see as much as 7.5 kWh/m^2 per average day (about 2,700 kWh/m^2 per year). Energy production from a PV facility is proportional to insolation, so for any fixed-cost PV system, the price of the electricity is inversely proportional to the insolation.

At the Cagayan de Oro site the annual insolation averages about 1,840 kWh/m^2. At the time this project was constructed, on-site insolation measurements typically were collected only after a project was installed since long-term site-specific data by definition takes years to amass. However, today it is becoming more common to begin collecting such on-site solar insulation data before a project is actually installed, as well as continuing to collect the data after production has begun.

PROJECT DEVELOPMENT AND IMPLEMENTATION

History

PV power generation is clearly perceived by utilities as more expensive and more difficult to accommodate on an electric power system than coal-fired generation. This project essentially was viewed as an opportunity to ascertain if solar could generate additional value for the utility by creating synergies with a mini-hydro plant. Because the water resources were insufficient for 24-hour operation of the hydro facility, the Cagayan de Oro PV plant was designed to deliver peak load during daylight hours, while water would be stored in a reservoir to generate hydropower during the night. The GEF was interested in this project's capacity to demonstrate the role of PV plants in global CO_2 abatement, as well as the possibility of conjunctive PV-hydropower operations.

Consistent Support and Dedicated Staff

Consistent support from management at CEPALCO combined with dedicated staff contributed enormously to the success of this project. CEPALCO is a closely held company and its chairman and owners were well aware of trends in the electric power industry worldwide. They realized that in the long run economic development could not be sustained with oil- or coal-fired generation without severe and globally unacceptable environmental degradation. Through the chairman's international contacts he was able to undertake this project in a revenue-neutral way for his company, but he did invest a considerable amount of time travelling and holding meetings to bring the project together.

The financing was arranged based on a concept that CEPALCO would pay a price for the plant that resulted in a cost of power approximately equal to that of the power from the national grid, so that customers would not see a difference in their bills. In the process of creating this project, the CEPALCO chairman also developed a young, dedicated staff with the experience needed to continue the development of solar power in the Philippines. For this project, CEPALCO did not intend to make huge profits on its investment. The company simply wanted to recover its investment and the corresponding cost of capital. The benefits were to come primarily out of experience in the construction, operation and maintenance, management, and training of the staff for this kind of energy resource. CEPALCO considered these benefits to be invaluable.

Project Financing and Site Selection

The CEPALCO project was innovative not only in its design but in its financial structure. The IFC, using money from the GEF, provided debt financing through which the debt was forgiven in return for successful operation and the sharing of information.

Under the terms of its agreement with the IFC, CEPALCO operates the plant and provides data on performance, O&M, and power output, as well as CEPALCO's custom load and the cost and availability of other power suppliers. The GEF loan can convert to a grant after five years of operation if specific conditions are met. This financing structure was expected to promote timely execution and operation of the project. The forgivable GEF fund, covering around 75% of the project costs, enabled CEPALCO to put up an investment equivalent to a conventional 1 MW diesel power plant.

The project site was identified and acquired by CEPALCO. It was chosen during negotiations with the IFC lenders and before the tender for the system hardware. Criteria for the land included access for construction and proximity to an existing or planned distribution line for interconnection to the power grid, with a preference for a power line that would benefit from the daytime supply characteristic of the PV plant. In addition, the site provided dry and level land to reduce foundation costs, a regular shape that accommodates east/west running rows of solar panels (though this was not achieved ideally in the CEPALCO case), and unobstructed solar access (no shadows). No new transmission lines were required though 3 kilometers of new 13.8 kV 3 phase distribution line was added by the utility to reach the site.

Procurement Process

An international tender was used to procure the CEPALCO system. The tender included both technical and financial criteria, including testing standards and code specifications for the major components, documentation and design review stages, and guidance regarding the use of local materials and labor to the maximum extent possible. The use of the local labor was a pre-condition in the grant of project endorsement by the local government unit, which is required before an Environmental Compliance Certificate is issued by the Department of Environment and Natural Resources. The use of local materials was “preferred” – as it was stated in the contract – but was not interpreted as mandatory and it was left to the EPC (engineer, procure, construct) contractor to decide. A local crew of over 200 was used in the construction of foundations and assembly of the structural steel

The tender was advertised broadly and distributed to the PV industry. Since the time of this procurement global codes and standards for PV have improved and become more widely accepted.[2] In addition to technical and financial requirements included in this procurement, applicable local jurisdiction and national requirements such as safety and environmental laws, labor laws, duties, fees, and taxes were identified for prospective bidders.

Bidder Selection Process

The selection process used for the CEPALCO PV project involved a separate, complete review of all the criteria in the procurement documents from three perspectives: the client/owner’s; the funding agencies (IFC/GEF in this case); and engineering/technical. Top level (binary, “go/no go”) screening criteria were identified and agreed among the three parties. Each party created its own list of criteria and assigned weighted values totaling 100%. This process was translated into a spreadsheet format for judging the proposals received. More than 50 companies submitted Expressions of Intent to Bid; 12 actually bought Tender documents and 8 finally submitted a bid. A meeting was then held to review the scoring and weigh the costs of the eight proposals that were received relative to their merits.

Construction Process

Once the contractor (Sumitomo) was selected, the bid documents and winning proposal were used to develop a contract over a 12-month period that involved coordination among CEPALCO, Sumitomo, and the IFC. The project was completed within 12 months of the contract award.

Operational Experience

The CEPALCO staff was involved with the oversight of the construction and commissioning of the project, which served as a training ground for learning about this new PV technology.

The Mindanao hydro plant operates as a load follower, varying its output inversely with that of the PV plant. The saved water is stored in the hydro plant’s reservoir, to be used when PV output is not available. The PV installation is designed to meet peak power needs during the daytime and allow the dam—which has insufficient water flow to run 24

[2] While the Philippines generally looks to the United States for codes and standards governing electrical installations, the global PV industry increasingly is being guided by codes and standards development through the Worldwide System for Conformity Testing and Certification of Electrotechnical Equipment and Components (IECEE). [http://www.iecee.org/pv/html/pvcntris.htm]

hours a day—to store capacity for nighttime use. Because this hybrid project combined hydro and PV power, it is fully dispatchable. To avoid transmission and distribution losses, the PV plant was constructed just five kilometers southeast of the business district of Cagayan de Oro, which is located within CEPALCO's distribution system.

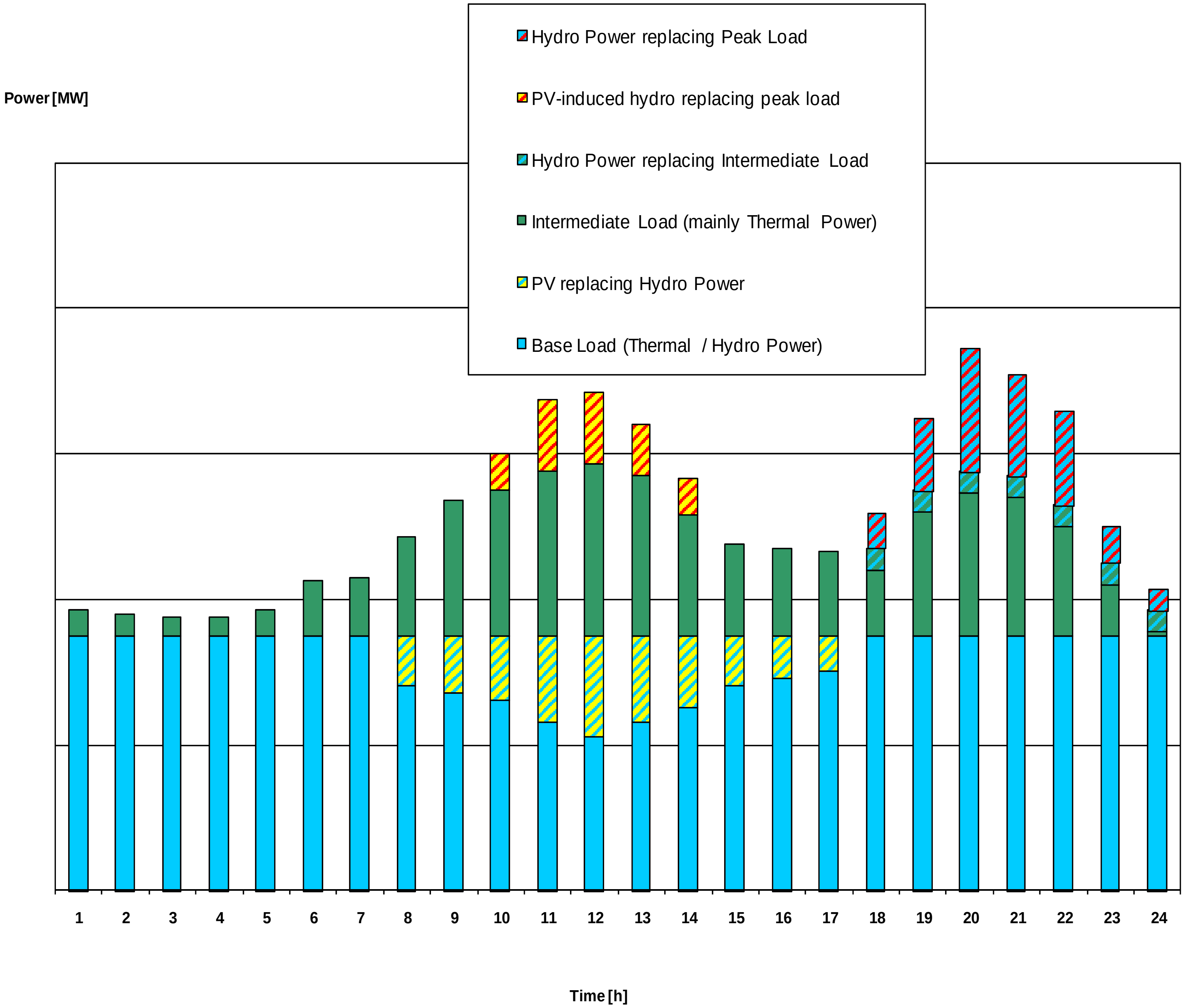
Plant operation has been as predicted in terms of power output. Module and inverter reliability has not reduced system availability in the four years since the plant has been in operation. One problem did develop in the custom DC string combiners that were manufactured for the project. Heat sinking for diodes that are included to prevent reverse current flows in the event of a DC fault (short circuit) proved inadequate and resulted in an electrical fire in one of the enclosures. Once the problem was identified and documented, the contractor redesigned and replaced the faulty equipment. CEPALCO has a 10-year maintenance contract with Sumitomo for the plant. The inverters are also guaranteed for 10 years of operation.

The utility was interested in seeing if adding PV to a mini-hydro plant would provide increased value to the utility:

- Did the hydroelectric generation have complementary daily and seasonal cycles?
- How effectively would the proposed system be able to store hydropower during the day and dispatch it at night?
- Can hydro/PV level the differences between rainy (cloudy) and dry (clear) seasons and become firm power?

Figure 1 illustrates the potential complementary nature of hydro and PV generation. The functioning of the project supported the validity of these concepts; however, the small size of the PV project (1MW) compared to the overall size of the utility system could not provide a quantitative value since it was too small to affect the operational plans of CEPALCO.

Figure 1. Hypothetical PV-hydro Conjunctive Operation



Source: Landmeyer and IFC

LESSONS LEARNED

The GEF interest in the project was based on learning about the model of operating large PV power plants to reduce CO_2 emissions associated with the expansion of electric power systems in developing countries. The IFC's interest was related to its investments in hydroelectric power plants in many developing countries and its appreciation of the synergy between solar and hydro resources, including both capturing the diurnal energy storage potential associated with dispatching hydroelectric assets during nighttime hours and mitigating the seasonal fluctuations of solar and hydroelectric resources. CEPALCO's interest was in learning about PV operation and training staff through direct participation with the project. All of these goals were accomplished.

The plant successfully demonstrated the technical feasibility of building and operating large grid-tied PV systems in developing countries as a means of reducing greenhouse gas emissions while expanding electric power generation that is needed for economic development. And it demonstrates the positive synergy between solar and hydro resources that can increase the value of both resources, even though at this level (the relative size of the project versus the size of the electrical system) it did not provide quantitative proof of the concept.

However, prior to the unbundling of the generation and transmission business of the National Power Corporation (NPC), the concept of conjunctive PV-hydro made more sense and was easier to implement and quantify in the Philippines than it is today. After restructuring, when the former NPC was split into NPC (Generation) and National Transmission Co. (Transco), the optimal financial benefit of the PV-hydro conjunctive use, or the distributed generation benefit of the PV-hydro tandem, became difficult to establish and attain. NPC charges energy (kWh) through time-of-use rates while Transco charges for capacity based on the highest registered peak (kW) during the billing period. The highest time-of-use rate of the NPC falls at around 6-9 PM while the system peak that the PV can effectively clip is between 2 PM and 4 PM. NPC has still to evaluate which is more financially beneficial: to release the stored water from 2-4 PM to take advantage of the peak clipping (at Transco pricing) or take advantage of the time-of-use rates of the NPC.

CEPALCO has been interested in building other PV projects of this type based on its experience with this plant. However since the Philippine government has been in the process of changing energy incentive policies and just enacted a new renewable energy policy structure, the utility is not likely to undertake something new until all of the rules and regulations have been finalized. As a result no other large PV projects are under construction in the Philippines at this point in time.

Another lesson learned during the permitting process is that regulatory requirements intended for conventional power plants are difficult and burdensome for solar power plants. For example, regulations pertaining to air emissions, fuel transfer and storage, and cooling water required discussions of all these issues along with public notices and hearings for full adherence to the letter of the law, even though the simple answer would seem to be “not applicable” to a PV facility. Because there was no law on renewable energy resources when the permits were processed, the PV facility was treated similarly to conventional power plants. In the years since this project was built, however, there has been a great deal of new experience in other countries with PV plants of this scale and the passage of many new laws, such as feed-in tariffs and renewable energy portfolio standards (including in the Philippines) that facilitate solar power development.

PROJECT MILESTONES

December 1998 – First IFC mission (G Schramm and group) to CEPALCO
April 1999 – Approval of the project concept by GEF Board
June 1999 – IFC pre-appraisal mission; MoU signing
July-Dec 1999 – Agreement and evaluation of technical and financial parameters
4th Q 1999 – Hiring of technical advisor
1st Q 2000 – Draft technical specs; draft Request for Proposal (RFP)
4th Q 2000 – Finalization of RFP
January 2001 – Invitation for expression of interest
February 2001 – Released invitation to bid
April 2001 – Received all bids
[June 2001 – Electric Power Industry Reform Act (EPIRA) signed into law]
October 2001 – Selection of winning bid (Joint CEPALCO-IFC)
October 01-October 02 – Contract negotiations with Sumitomo
February 03 – Signed supplemental agreement with Sumitomo
March 03 – Omnibus agreement signed (CEPALCO & IFC)
August 2003 – Construction started
July 2004 – Plant turned over to CEPALCO by contractor
August 2004 – Plant dry-run operation
September 2004 – Start of commercial operation

As indicated in this timeline, the EPIRA regulations came into effect more than two years after the initiation of the PV project activities (in fact, all bids were already received before the enactment of the new electric power regulations). However, even if the actual construction and procurement of equipment were done after the enactment of the EPIRA, the PV project did not receive any form of government incentives (there are no EPIRA provisions for this) such that the PV plant was constructed on the same footing as conventional power plants (e.g., it had to pass similar regulatory processes and permitting requirements; and pay required import duties and taxes as well as permit fees).

Photo credit: Ed Kern

REFERENCES

182. 950kW CEPALCO PV Power Plant Project History and Rationale
332. GEF - Building the Philippines’ Capacity for Grid-Connected Solar Power
333. CAPALCO - Expression of Interest for the Proposed 1,000 kW Photovoltaic (PV) Plant Turn-key Project