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GEIPP
GLOBAL ECO-INDUSTRIAL PARKS PROGRAMME

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**IMPLEMENTING
ROOFTOP
SOLAR PV IN
ECO-INDUSTRIAL
PARKS**

BEST PRACTICE SERIES





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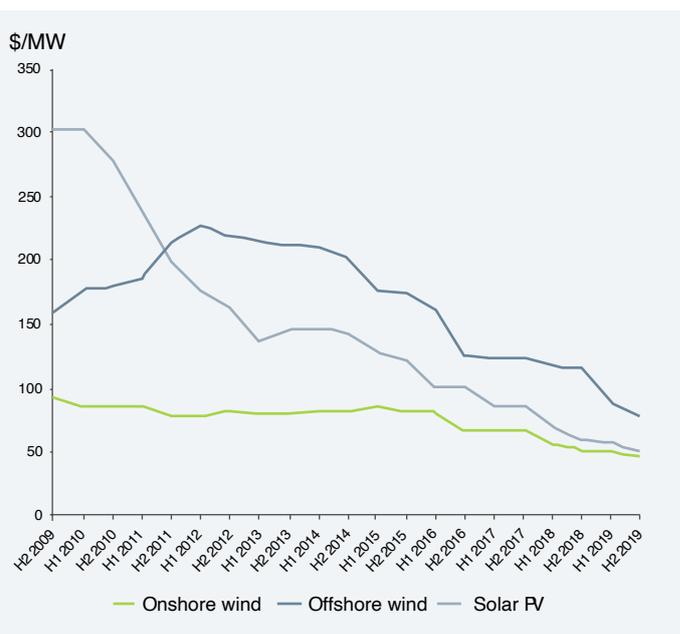
INTRODUCTION AND STATE OF PLAY

With industrial energy use accounting for 34% of global total final energy consumption and expected to grow at an annual rate of between 1.8 and 3.1 per cent over the next 25 years (UNIDO 2019), the industrial sector has come under increasing pressure to accelerate investments and adoption of various renewable energy technologies in an effort to decarbonize industrial activity. Indeed, many countries have made renewable energy commitments to that effect as part of their Nationally Determined Contributions towards the Paris Agreement. However, it is estimated that in order to fulfill those commitments, a gross addition of 2,836 GW of non-hydro renewable energy capacity will be required by 2030 (Frankfurt School-UNEP Centre/BNEF 2020). Based on the evolution of relative costs of the various renewable energy technologies available, Bloomberg NEF's New Energy Outlook 2019 projected that this would consist of 1,646 GW of new solar capacity installed in the next decade.

At the same time, private sector actors have faced growing calls to set targets to decarbonize their electricity consumption, whether from clients who expect companies to demonstrate their sustainability, to investors putting pressure to improve environmental, social and governance performance (ESG). Adopting renewables is also an increasingly important tool within wider risk mitigation strategies with energy supply chain risks and price volatility of conventional fossil fuels linked to wider ongoing global developments. It is therefore difficult to overstate the prominence of solar energy technologies and the role they will play in combatting climate change but also ensuring the ongoing competitiveness of various industrial sectors and companies.

Among various renewable technologies, wind and solar PV have shown the highest rates of growth and this trend has continued despite the COVID pandemic, thanks in part to government

Figure 1: Levelized Cost of Electricity by main renewable energy technology (2009-2019) in USD/MWh. Source: Frankfurt School-UNEP Centre & BNEF 2020



policies and recovery packages that explicitly supported renewables (REN21, GSR 2021). Solar in particular has seen a dramatic drop in cost in the last decade. Indeed, the benchmark levelized cost of solar—which factors in the expense of buying and installing the equipment, including financing, operating and maintaining it—stood at an average of USD51 per MWh in 2019, compared to USD 304 per MWh in 2009, an overall drop of 83% (Frankfurt School-UNEP Centre/BNEF 2020). This has translated into a significant growth of global investments in renewable energy capacity, with developing economies accounting for a majority of those investments since 2015.

In the solar PV segment of renewables, self-consumption continues to represent an important share of the market for new distributed systems in many countries. In fact, investments committed to small-scale solar systems (as opposed to utility-scale) jumped 37% to USD 52.1 billion in 2019, despite a drop in overall investments in solar capacity of 3% relative to the year before (IEA

2021). Distributed rooftop systems in particular have gained market share relative to utility scale projects, from around 35% in 2019 to 40% in 2020 (IEA 2020). Indeed, as the share of renewables has grown, public grid infrastructures have become a significant bottleneck in several countries as the systems were designed around conventional energy sources and require adaptation efforts that do not currently match the growth rate of renewables.

Beyond investments in the installation of solar PV capacity, several governments have tried to stimulate local production of renewable energy equipment, from modules to inverters. However, the Asia Pacific region still dominates the market, with 76% of PV modules and 71% of solar inverters installed globally having been manufactured there in 2017 and 2018 respectively (REN21 2021). China in particular continues to be the largest producer of the raw materials needed for the production of the most widely used solar cells (Kügerl and Tost 2021).

With these developments, Rooftop Solar PV systems have increasingly been deployed at industrial parks to assist with power supply and translate into savings as well as overall green transition. While Rooftop Solar PV systems are well established in the industrial park setting, they are not installed to a great extent in developing countries, including the GEIPP countries. Therefore the topic and experiences are particularly suitable for sharing as a part of the GEIPP Best Practice Series. The next section will explore how these macro-trends translate into the concrete planning and implementation of Rooftop Solar PV systems specifically in eco-industrial parks through the experiences of industrial parks in South Africa, Colombia and Indonesia. Across the case studies, the systems installed or being planned are for self-consumption, whether by park management or tenant companies. In the case of the park from South Africa, they are exploring the potential for selling electricity generated from renewables to their tenant companies.



CASE STUDY 1

Solar PV Pre-Feasibility Studies for East London Industrial Development Zone in South Africa

The East London Industrial Development Zone (ELIDZ) is a state-owned corporation and one of the first Industrial Development Zones in South Africa awarded a provision operator's license as a Greenfield industrial park in 2002. Currently, the energy needs of the park and its tenants are met through Buffalo City Metropolitan Municipality, with ELIDZ selling (wheeling) electricity to tenant companies in the park. The impetus for exploring the installation of solar generation capacity in ELIDZ came from multiple fronts. Notably, it would enable the park to better manage the load shedding that has been in place in South Africa since late 2007, where in order to deal with shortages in generation capacity, electricity consumption has been controlled by switching off the power supply to customers at given times to reduce the strain on the energy grid. In addition, there is a prevailing interest in lowering the carbon footprint of the park from both park management and its tenant companies, with tenant companies facing particular pressure to increase renewables in their energy mixes.

Consequently, the Park undertook pre-feasibility studies with support from the Global Eco-Industrial Parks Programme (GEIPP) in order to identify viable options for the generation of renewable energy within the park, bearing in mind that the preferred scenario for ELIDZ is to continue selling energy produced to tenant companies.

CONDUCTING PRE-FEASIBILITY ASSESSMENTS OF DIFFERENT SOLAR PV SOLUTIONS

The options investigated included the following solar PV setups:

- **OPTION I:** 21.8 MW Rooftop Solar PV
- **OPTION II:** 8 MW Ground-Mounted (inside ELIDZ)
- **OPTION III:** 50 MW Solar PV Farm (outside the park)

The technical pre-feasibility assessment was clustered around three overarching topics:

- **Required Capacity:** The annual consumption in ELIDZ was calculated at a value of 48.4 GWh. Disaggregated, the energy consumption of ELIDZ is 86% by leased-out buildings, 4% by estate services and 10% by privately owned buildings. Initial estimates suggested that the different solar options could meet 66% (Rooftop Solar PV), 24% (Ground-mounted inside the Park) and 150% (solar farm outside the park) respectively. It was thus concluded that a mix of Rooftop and ground-mounted solar PV can provide 90% of the required energy for the Park and the possibility of including a 2 MW battery storage solution for peak shaving was also investigated. For rooftop solar PV specifically, the required performance of the technology was evaluated based on key variables such as the strength of the roof structures, lift factor—strong winds in the area might influence installations, shading, and orientation of rooftops. For ground-mounted installations, factors such as stream and flood levels needed to be taken into account.
- **Required Quality:** The quality of potential technological solutions was evaluated through specific guidelines for rooftop installations, the Grid Connection Code for Renewable Power Plants (RPPs) etc.
- **Technology Availability:** Several companies in South Africa make solar PV panels, including ART Solar and Seraphim. However, outside of large utility-scale projects, there are few inverter producers in the country, although both modules and inverters are available internationally to import.

The pre-feasibility assessment also explored the economic feasibility of the potential PV projects. The Rooftop MW estimates were based on an

analysis of preliminary high-level rooftop space available from Google Maps with more detailed on-site investigations per rooftop still required. The rooftop energy revenue is based on the average annual municipal tariff (over the period 1 April 2021 – 31 March 2022). Other revenue projections are based on average generation rates and known wheeling tariffs. Based on these assumptions, the analysis yielded the following estimates for the economic feasibility and estimated environmental benefits of different solar options:

Table 1: Assessment of different solar PV installation options at pre-feasibility stage

	OPTION I: 21.8 MW Rooftop Solar PV	OPTION II: 8 MW Ground- mounted (inside ELIDZ)	OPTION III: 50 MW Solar PV Farm (outside the park)
CAPEX (CSIR Energy Centre estimates R10-12/ watt for rooftops and R8-9/ watt for a large scale utility plant)	R240 million	R72 million	R400 million
OPEX (R328 per kW installed according to CSIR EC)	R7.1 million p.a.	R2.6 million p.a.	R16.4 million p.a.
Energy	32 GWh p.a.	11.8 GWh p.a.	73.6 GWh p.a.
Revenue	R46.7 million p.a.	R12.7 million p.a.	R79.5 million p.a.
Simple Payback	± 6 years	± 7 years	6-7 years
Carbon Dioxide Reduction	±34 000 tons p.a.	±12 500 tons p.a.	±78 000 tons p.a.

In terms of expected job creation benefits linked to the installation of Rooftop Solar PV, it is expected that 50 construction jobs would be created for the first six months, with 2 permanent jobs for the first MW installed and 1 permanent job for every MW thereafter.

FINANCING. On the basis of this technical and economic pre-feasibility assessment, different financing options were identified using the UNIDO EIP Access-to-Finance Tool for South Africa. In total, 98 options were identified through the tool, and discussions are ongoing with the Development Bank of Southern Africa (DBSA), Infrastructure South Africa and the

International Finance Corporation (IFC). There are also some legal incentives such as Section 12B of the Income Tax Act (Act 58 of 1996) which allows for depreciation of 50% of the capital cost of solar installations greater than 1MW in the first year of commissioning, 30% in the subsequent year, and 20% in the third year.

Some of the challenges encountered during this process have been related to supply chain and procurement red tape, with bureaucratic constraints currently hampering the implementation of the project. It should be noted that given ELIDZ's status as a state-owned corporation, its procurement processes differ from parks that are privately owned. In addition, the Park is still exploring what business model to opt for, on the basis of considerations such as: who owns rooftops of leased out buildings? Or what to do with the excess energy generated?

Given that ELIDZ falls under their Municipality's license and does not have a license to act as an electrical distributor, they currently operate under the Municipality's tariffs, guidelines and rules and are in the process of trying to get a wheeling tariff approved by the national energy regulator. While the outcome of this process is still pending, it would notably allow ELIDZ to sell excess energy through the wheeling tariff. However, even in South Africa, there are different regulatory frameworks for different industrial parks and the ease of installation and wider use of the solar PV capacity depends on the framework in place and its applicability to any given park.

LESSONS LEARNT. A key lesson learnt from the process was the importance of preparatory research and information gathering, including through the help of relevant experts. For ELIDZ, this process notably involved collecting experiences and lessons learnt from other industrial parks where similar projects had been undertaken, some unsuccessfully. In addition, conducting various studies, including environmental studies upfront was seen as critical, notably in support of the procurement stage of the process to get responses from the market that would meet the exact needs and specifications of the Park.

CASE STUDY 2

Implementing Rooftop Solar PV at Tenant Company Level within Eco-Industrial Parks in Colombia

Batamindo Industrial Park has been collaborating with the Global Eco-Industrial Parks Programme—Indonesia since 2019 on the recommendation of the Indonesian Ministry of Industry. It was established jointly by private Indonesian and Singaporean companies as the first industrial estate on Batam Island and has 68 operating tenants with a collective workforce of approximately 43,000 employees. The park is managed by the Batamindo Investment Cakrawala which oversees the Park's infrastructure and services, including existing power plants, water and wastewater treatment plants, and telecommunications facilities.

Among the opportunities identified to improve the environmental performance of the park, the addition of rooftop solar PV generation capacity was evaluated, with the feasibility and attractiveness of the opportunity in part informed by the introduction of a new Ministerial Regulation on Solar Power Plants from the Minister of Energy and Mineral Resources (Regulation no. 26, 2021). In Indonesia, approval is needed to install renewable energy capacity and this was obtained by Batamindo IP. Sharing with the grid or with other consumers is also a long process but gradually there are instances where feeding into the grid is allowed. However, sharing among industries is yet to be explored. This regulatory framework consequently shapes the options considered under the feasibility assessment.

As part of this assessment, the following Solar PV options were evaluated:

- **OPTION I:** 472 kW Rooftop Solar PV (Within Batamindo IP)
- **OPTION II:** Floating Solar Farm (outside Batamindo IP)

While the floating solar farm option was explored, the location for the potential farm outside the Park made it less attractive overall.



However, the findings of the study were used by the local government of Batam, who will likely install a floating solar panel farm themselves. Ultimately, the option selected was the rooftop solar installation with 472 KW capacity for self-consumption without battery storage capacity. This capacity would supply the internal power usage of the Industrial Park's powerhouse and any excess energy would be sent to the medium voltage grid (20kW).

To support implementation, a vendor was selected that would be responsible for the financing (CAPEX), operation and maintenance of the Rooftop Solar PV system using a Build-Own-Operate business model contracted for 20 years.

PLANNING AND INSTALLATION OF THE ROOFTOP SOLAR PV SYSTEM

The initial timeline for the installation of the rooftop Solar PV system was May 2020, however, construction ultimately began in September 2021 due to delays caused by the COVID-19 pandemic.

To deal with the intermittent characteristics of solar

energy, the possibility of including a battery storage system was also explored. However, given the current state of available battery storage options which still lack long life cycles coupled with the high capital expenditures involved, the vendor advised against such a solution at this stage, recommending instead the use of a supercapacitor. The park, however, did not have the means to introduce such a supercapacitor.

Construction started in September 2021, with testing and commissioning conducted between February 2022 and March 2022. The PV system has been live since April 2022 and a remote monitoring system gives the Park visibility on daily energy production, irradiance levels etc.

It is expected that the annual GHG mitigation benefits will be 408.8 tons of CO2 avoided with average energy generation of 1,700 kWh/day.

Employment benefits are also expected from the hiring of new personnel by the implementing vendors of the installation.

Next steps for Batamindo IP will be the installation of solar power on the rooftops of the factories within the park to be used directly by each tenant. Initial estimates are that the combined solar power capacity across the various roofs would be 5000 Kwh including a potential Energy Storage system whether it is a battery or a supercapacitor. The key consideration for this planning is to understand the energy consumption needs of tenants in order to install matching capacity so that the reliability of the energy supplied is not affected.

CASE STUDY 3

Launching a Rooftop Solar PV Plant in Batamindo Industrial Park, Indonesia

In Colombia, electricity consumption represents on average between 8% and 10% of the costs of tenant companies in Industrial Parks and in the Parks collaborating with GEIPP, these costs can sometimes be as high as 30%—although assessments have shown that electricity efficiency can be improved by up to 30%. Within this context, renewables can potentially contribute up to 25% of total consumption and often feature heavily in the outcomes of RECP opportunity assessments (Resource Efficient and Cleaner Production) conducted by UNIDO.

Three prioritized Industrial Parks are working with GEIPP in Colombia: Parque Industrial Malambo, Zona Franca de Occidente and Zona Franca del Cauca. Across the three parks, a total of 22 tenant companies are working with the programme. For the tenant companies involved in GEIPP, their main objective is to improve their sustainability performance, reduce electricity costs and contribute to climate change mitigation. This case study explores the experience of planning and implementing rooftop Solar PV installations at the level of these tenant companies.

Of the companies assessed, 12 PV opportunities were identified and pre-feasibility assessments conducted. The results of the pre-feasibility assessments are captured in Table 2.

Of these, 5 PV opportunities are being explored through ongoing feasibility projects. The prioritization of the identified solar PV projects is based on the companies' objectives and the engagement by managers and stakeholders. Some barriers to adoption of PV setups at this stage included that some companies benefitted from a low cost per kWh because they already used energy from existing renewable energy systems like burning solid waste from sugar cane production.

Of the Rooftop PV opportunities that progressed to full feasibility studies, more specific information was analyzed across five categories. Full feasibility studies are ongoing and focus on the following five categories:

- 1. Available space and connection point:** the power generation and performance ratio of the photovoltaic system is estimated, considering the ideal peak power, climatic conditions of

Table 1: Snapshots from pre-feasibility assessments by Company

Company	Electricity energy savings (MWh/year)	CO2 Savings (tCO2/year)	Investment (EUR)	Annual Savings (EUR/year)	Return on Investment (years)
Agricol	51	19.5	31,344	15,251	2.06
BBRAUN	245	93.4	167,359	96,670	5.50
Forsa	488	185.4	266,370	96,670	2.76
Friomix	438	166.4	239,121	40,220	5.95
Milestone	379	144.2	204,740	33,290	6.15
Omnilife	323	123.0	196,862	32,500	6.06
Unicilindros	104	39.6	56,218	11,306	4.97
Acuapaez	513	195.2	63,516	10,515	6.04
Aceros cortados	196	74.5	105,830	19,534	5.42
Ingenio la cabaña	488	185.4	296,736	101,209	2.93
Total	3,229	1,227.12	1,628,096	390,899	4.17
Total currently under assessment	1,172	445.4	103,216	171,833	4.79

Novalene - ZFO

To define the financial mechanism **A2F Tool**
Colombia to be used

- Capacity ≈ 542 kW
- Estimated electric energy generation: 73 MWh/month
- Energy rate consumption: 20%
- Business model: to be defined
- System: On-grid
- Rol: 4.5 years
- Investment ≈ €431,613
- Barriers: green certification for the company
- Estimated CO2 savings: 121 tonnes CO2/year

Global Industrias - ZFC

Implemented in September 2017

- Capacity: 40kW
- Estimated electric energy generation: 3.7 MWh/month
- Energy rate consumption: 27%
- Business model: own resources
- System: On-grid
- Rol: less than 4 years
- Investment ≈ €19,396
- Barriers: changes in regulation that imply adequation, certifications and installation of a bidirectional meter
- Projection: 27% to 54%
- Estimated CO2 savings: 17 tonnes CO2/year (2020)

Alival - ZFC

Implemented in August 2021

- Capacity: 1.06 MW
- Estimated electric energy generation: 114 MWh/month
- Energy rate consumption: 20%
- Business model: leasing with a bank
- System: On-grid
- Rol: 3 years
- Investment ≈ €606,195
- Incentives: tax exemption and income tax discount
- Barriers: costs and suppliers
- Energy savings: 546 MWh/9 months
- Estimated CO2 savings: 651 tonnes CO2/9 months
- Estimated CO2 savings: 17 tonnes CO2/year (2020)

the site, and the orientation and inclination of the photovoltaic system. Also, the ideal peak power of the photovoltaic system according to the identified available area, the characteristics of the connection point, and the hourly load profile is calculated.

- 2. Validation of spaces and roofs:** type of covers, stability or load capacity, and connection points among others will be validated with the company and in the field.
- 3. Validation of other variables:** the distance between the proposed panels and the connection and the necessary characteristics, among others, will be validated with the company and in the field.
- 4. Financial analysis:** CAPEX and OPEX of the project will be adjusted and according to these data and others such as the applicable tax incentives. Access to Finance (A2F) tool to be used. More than 100 mechanisms have been identified through the tool and some are based on leasing or tax exemption etc.
- 5. Environmental analysis:** environmental considerations applicable to the project will be validated considering the life cycle approach and the calculation of GHG emission reduction applicable to the project.

Beyond the companies that worked with GEIPP on pre-feasibility and ongoing feasibility studies for rooftop solar PV systems, several tenant companies within the partner Industrial Parks conducted feasibility assessments independently and had either already implemented a rooftop solar PV solution or were in the process of defining the financial mechanism for implementation. More details on these companies are available in the figure above.

FINANCING. Once the feasibility studies have been completed, the tenant companies are

working with GEIPP to define appropriate financial mechanisms to apply to the projects using the UNIDO EIP Access-to-Finance Tool (A2F). For those companies undertaking their own feasibility studies, GEIPP is supporting the optimization and application of the A2F tool. The selected financing mechanisms are expected to play a large role in the selection of business model by individual companies. On the regulatory front, distributed energy systems that would allow companies to share electricity with each other via a smart grid are currently not permitted in Colombia.

Nevertheless, a number of financial incentive schemes exist in Colombia to support the installation of rooftop solar PV systems, including tax reductions, exemptions and discounts as well as benefits offered by some banks (documented in the A2F Colombia tool). However, one of the challenges encountered includes that in some cases, the tenant company is unable to get green certification for their project if they opt for a leasing model as the green certification would go to the bank rather than the company.

For one company whose rooftop solar PV systems are already operational (Global Industrias), the ROI period has already ended and they are making some profit from the installation. However, since the installation, there have been changes in the relevant regulations meaning that they would have to first seek additional certifications as a precondition before being able to increase PV capacity.

Next steps for GEIPP-Colombia partner Parks and tenant companies is the wider use of the A2F tool to accelerate the implementation of relevant EIP opportunities, both within the renewable energy sphere and beyond.

CONCLUSION

The case for the installation of renewable energy systems in Industrial Parks is only likely to get stronger as such systems contribute to the resilience of the Park in the face of external shocks linked to existing energy supplies. The three case studies presented in this Best Practice Issue show that there is strong potential for the wider mainstreaming of rooftop solar PV installations in Industrial Parks and these installations can be an important lever for improving environmental performance as part of a Park's journey towards becoming an Eco-Industrial Park.

The route taken in each country is slightly different, reflecting the importance of the local regulatory context, environmental and economic factors and the stakeholders that need to be involved in the planning and implementation phases. These differences include the level at which the rooftop solar PV installations are implemented and managed, with some installations being planned at park-level and others at tenant company level. Different business models and financial mechanisms have also been employed, from leasing roofs to electricity producing companies to Build-Own-Operate models with long-term service contracts. However, the experiences in all three countries show the factors that need to be considered in the planning phase, in particular for the pre-feasibility and feasibility assessments.

While financing remains a challenge, the business case for the installation of rooftop solar PV systems is clear, and reflected in all three case studies. However, the strength of the business case is tempered by the extent to which an enabling legal environment and regulatory framework exist. Indeed, the energy laws in many countries can create barriers to a park's efforts by limiting the size of the installation to below the potential capacity of the Park. Reasons include that there are no provisions to put in place a decentralized distributed system within a park and allow it to serve tenant companies as customers, or the

maximum size is capped for non-utilities actors. Addressing this barrier poses some challenges given the reluctance of governments to allow too many independent power producers into the market for fears of impacting the stability of the national grids in place.

The Global Eco-Industrial Parks programme is working closely with government partners in its national interventions to address these regulatory barriers and to see how these gaps can be bridged so that the parks can be supported in their transition into EIPs.





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