3. Carbon Credit Markets

a. Voluntary Carbon Markets (VCM)
Platforms for Trading: Gold Standard, Verra's Verified Carbon Standard (VCS), American Carbon Registry (ACR), Singapore Carbon Exchange (SCX), Xpansiv CBL

b. Compliance Carbon Markets (ETS - Emission Trading Schemes)
- EU Emissions Trading System (EU ETS): Requires regulatory alignment.
- China's ETS: Allows selected international projects.
- California Cap-and-Trade: Can accept foreign carbon credits with proper registration.

4. Case Study: Noor Abu Dhabi Solar Farm

- Capacity: 1.17GW
- CO_2 Reduction: ~1 million tCO_2/year
- Market: Voluntary Carbon Market
- Standard: Verra's Verified Carbon Standard (VCS)
- Buyers: Large corporations seeking carbon offsets
- Revenue: Estimated between $10M – $20M per year from carbon credit sales

Key Takeaways:
- Noor Abu Dhabi's success in Verra certification can be replicated for PNG.
- Corporations such as Google, Microsoft, and Amazon actively purchase solar-derived credits.
- Listing on Singapore Carbon Exchange (https://www.sgx.com/climate-impact-x-cix) or Xpansiv CBL (https://xpansiv.com/) will increase PNG's market access.

5. Steps for PNG Government to Monetize Carbon Credits

Step 1: Certification & Registration
- Apply for Verra (VCS) or Gold Standard certification.
- Conduct third-party validation of emission reductions.

Step 2: Market Participation & Sales Strategy
- List credits on trading platforms: SCX, Xpansiv CBL, or direct corporate sales.
- Government-to-Government (G2G) Carbon Deals: Engage with Singapore and China for ETS integration.

Step 3: Policy & Infrastructure Development
- Establish a PNG National Carbon Trading Framework.
- Integrate with regional compliance markets (EU ETS, China ETS).
- Set up a government-led carbon credit fund to reinvest revenues into clean energy.

By leveraging real-world case studies like Noor Abu Dhabi and aligning with international carbon markets, the PNG Government can generate a healthy carbon revenue per annum.

Transmissions Lines to National Electricity Grid

Household use	6.6E+06	w/yr	7.5E+02	HVDC line	800	ohm/km	0.55
People per house	2.5			Short line	20	Sag	5%
Light Industry Vs Residential	2.702702703			Med line	100	Worst Power Factor	90%
Demand factor	3			Long line	600	Substation size	6E+07
Load growth	0.2			Generator V	11000	Bus bar Amps	
Years of growth	15			Transmission V	132000	Feeders per bus	4
Transmission eff	95%			Feeder V	11000	Bus bars per substation	2
Voltage regulation	5%		Distribution V	240	Feeder Amps	400	Voltage regulation
Buffer	2		Freq	50	Feeder Length (km)	16	Buffer
Power per m² per hr	1.633333333 watts		Distribution length (km)	16			Power per m² per hr

Assumptions:
Transmission line overhead cost: $100k - $500k/km. Underground power can cost up to 5x more than above ground.
HV substation $40 - 50M.

Sustainable World Organization

CASE STUDY

Solar Farm (50MW to 3.0GW)

Project Overview

- **Components:** Solar PV panels, inverters, optional battery storage, and grid transmission infrastructure
- **Objective:** Renewable energy generation with modular scalability from 50MW to 3.0GW
- **Economic Benefit:** Energy tariffs at $0.10/kWh, making power supply affordable

Financial Feasibility

Parameter	Value (USD)
Proposed Tariff	$0.10/kWh
Proposed Development Costs	$0.80/watt
CAPEX (50MW)	$40M
CAPEX (100MW)	$80M
CAPEX (500MW)	$400M
CAPEX (1.0GW)	$800M
CAPEX (3.0GW)	$2.4B
OPEX (O&M)	1.5% - 2.5% of CAPEX/year
10-Year ROI	~18.4%
20-Year ROI	~36.5%
Breakeven Period	~6-7 years

Case Study: Noor Abu Dhabi Solar Plant, UAE

https://noorabudhabi.ae/

· Installed Capacity: 1.18GW
· CAPEX: ~$870M (approx. $0.74/W)

Solar Irradiance Data

Month	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	216.2	86.5	25.56	213.7	212.2	9219082	9086012	0.85
February	170.9	74.94	24.87	173.2	171.8	7560143	7455296	0.863
March	179.3	60.74	23.44	187.9	187.9	8261699	8165195	0.863
April	146.5	47.36	19.82	162.9	161.9	7290242	7188251	0.863
May	114.4	40.16	16.31	130.0	129.5	5997093	5907493	0.859
June	93.2	32.76	13.51	104.0	103.9	5103990	5033503	0.857
July	106.4	32.18	12.68	120.3	120.1	5033503	3722543	0.853
August	125.2	40.29	14.93	141.0	140.9	6013333	5927137	0.853
September	158.5	49.87	18.02	171.2	171.0	7695102	7613682	0.853
October	187.8	73.07	22.54	197.4	197.2	8469106	8396615	0.857
November	197.8	72.62	22.54	196.7	195.0	8507205	8386615	0.853
December	212.6	92.67	24.51	208.2	206.4	9045835	8951485	0.857
Year	1908.7	706.7	19.6	2018.4	2003.2	89412780	88161902	0.874

Revenue Projections

Installed Capacity	Annual Energy Output (MWh)	Annual Revenue (@ $0.10/kWh)	Average 10-Year Revenue	Average 20-Year Revenue
50MW	88161	$8,816,190.00	$88,161,900.00	$176,323,800.00
100MW	176323	$17,632,380.00	$176,323,800.00	$352,647,600.00
500MW	881615	$88,161,900.00	$881,619,000.00	$1,763,238,000.00
1.0GW	1763230	$176,323,800.00	$1,763,238,000.00	$3,526,476,000.00
3.0GW	5289690	$528,971,400.00	$5,289,714,000.00	$10,579,428,000.00

Reference: 50 MW solar farm in Queensland, Australia using JA Solar 620W PV module. Benchmark: 1 MW solar farm = 1,763,238 kWh / annum (88,161,902 kWh / annum ÷ [50 MW x 1,000 KW]) = 1,763.23 MWh/ Annum

CO2 Carbon Credits from Renewable Energy: Solar Farm

Proposal for Monetization of Carbon Credits from the PNG Government Solar Farm

1. Introduction

The Papua New Guinea (PNG) Government is developing a large-scale solar farm as part of its renewable energy transition. In addition to providing clean electricity, the project has the potential to generate and sell carbon credits on international markets. This proposal outlines the methodology, revenue potential, and case study-based strategies for trading carbon credits derived from the PNG solar project.

2. Carbon Credit Potential from PNG Solar Farm Assumptions

- The solar farm will offset emissions from PNG's grid, which currently relies on fossil fuels.
- According to global energy standards, each megawatt-hour (MWh) of solar power displaces approximately 0.7 metric tons (tCO_2).
- The project will be implemented in phases, with potential capacities ranging from 50MW to 3.0GW.

Estimated Annual CO_2 Offset from the Solar Farm

Capacity	Annual Energy Output (MWh)	Estimated CO_2 Reduction (tCO_2)
50MW	88161	61712
100MW	176323	123426
500MW	881615	617130
1.0GW	1763230	1234261
3.0GW	5289690	3702783

Estimated Carbon Credit Revenue (at approximate USD 7.00 per tCO_2, and USD 30.00 per tCO_2,)

Capacity	Annual Energy Output (MWh)	Estimated CO_2 Reduction (tCO_2)	Revenue at USD7/tCO_2/ annum	Revenue at USD30/tCO_2 / annum
50MW	88161	61712	$431,984	$3,702,780
100MW	176323	123426	$863,982	$18,513,900
500MW	881615	617130	$4,319,910	$37,027,830
1.0GW	1763230	1234261	$8,639,827	$111,083,490
3.0GW	5289690	3702783	$25,919,481	$3,702,780

Benchmark

1 MW = 1,763.23 mWh clean solar energy / annum
1 MWh = 0.7 tCO_2 savings / annum
1 Metric Ton of CO_2 Equivalent (tCO_2e) = 1 Carbon Credit

The carbon offset from solar energy is calculated by estimating the emissions avoided when replacing fossil-fuel-generated electricity with renewable energy. The key factor is the grid emission factor, which measures the average CO_2 emissions produced per MWh of electricity generated in a given country or region.

Global Average Grid Emission Factors (tCO_2/MWh)

- Coal-based grid: 0.8 – 1.2 tCO_2/MWh
- Oil-based grid: 0.7 – 1.0 tCO_2/MWh
- Gas-based grid: 0.4 – 0.6 tCO_2/MWh
- Global average (IEA data): ~0.7 tCO_2/MWh

Case study:

https://www.senken.io/academy/pricing-of-carbon-credits#:~:text=Carbon%20Credit%20Pricing%20forecast&text=The%20amount%20of%20lower%2Dquality,50%20per%20credit%20in%202023

Carbon credit prices are primarily influenced by the following characteristics:

- **Supply and demand**
- **Project Category**
- **Carbon credits** from Tech-based solutions price much higher than credits from Nature-based solutions, due to complex systems that are costly to engineer.
- **Quality** Verified Credits from projects with high scores.

Price

Status quo: The average price per carbon credit skyrocketed since 2021, rising by 82% from $4.04 per ton in 2021 to $7.37 in 2022, and taking a slight dip in 2023 to $6.97 - Ecosystem Marketplace (https://www.ecosystemmarketplace.com/publications/state-of-the-voluntary-carbon-market-report-2023/)

The average price of $6.97 can be misleading in terms of what companies think they should end up paying per credit. the amount of lower-quality carbon credits on the market has a significant impact on the average price, and its paramount to rather go for higher-quality credits that contain less risk. We have seen the average price of a quality credit being closer to **$30 - $50 per credit in 2023**.