Feasibility of Integrating Solar Panels into Transmission Substation Façades to Support Net Zero 2050 Objectives

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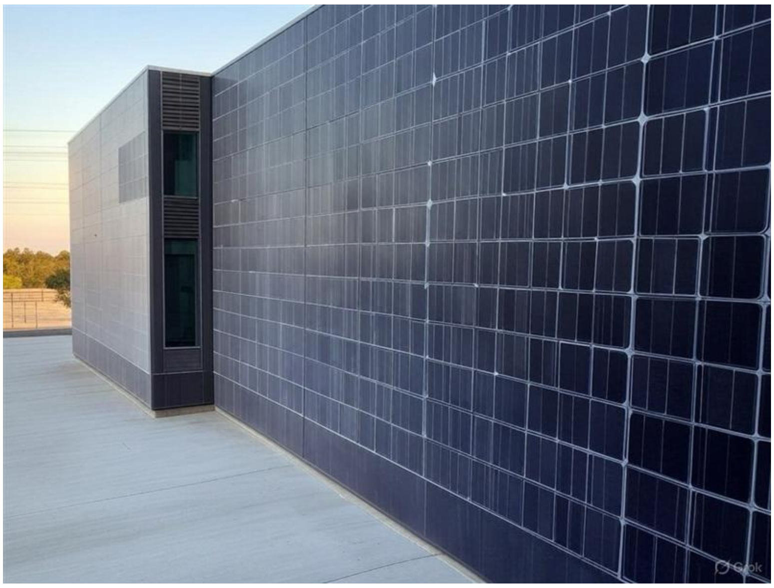
Abstract: ***This study assesses the feasibility and strategic value of integrating photovoltaic (PV) panels into transmission substation façades, transforming them from passive structures into active energy-generating assets aimed at supporting Dubai's Net Zero 2050 target (UAENetZero, 2026) by offsetting building energy demand. The initiative aligns with DEWA's sustainability vision (DEWA, DEWA Net Zero commitments, 2026), delivering technical, economic, and symbolic benefits to Dubai's energy infrastructure.***

Keywords: BAPV, solar energy, substation façade, photovoltaic system, electricity transmission

1.Introduction

Currently, rooftop PV systems are installed on 400/132 kV substations; however, these alone cannot fully meet building energy requirements. Traditionally, transmission substations prioritize functionality and reliability, with façades serving only serving primarily protective and visual functions. In line with global sustainability trends and net-zero commitments, this study explores repurposing substation façades to generate clean energy, reduce environmental impact, and enhance corporate image while contributing to Net Zero targets.



International case studies from Germany, Spain, and China demonstrate the viability of building-applied photovoltaics (BAPV) on vertical surfaces, delivering significant renewable energy and reinforcing the architectural identity of utility infrastructure.
This study is significant as it offers a scalable model for transforming passive utility infrastructure into active contributors to urban sustainability and energy independence.

Global references

- **European BIPV building case studies:** Several European utilities, such as in Germany and Spain, have piloted building-integrated photovoltaics (BIPV) on façades and roofs. These projects demonstrated that even vertical surfaces can generate significant renewable energy while improving the building's architectural identity. In Madrid, Spain, CIEMAT retrofitted its Building 42 with a 27 kWp BIPV ventilated façade (176 m² on three vertical façades). Monitoring shows ≈19 MWh/year of generation (≈700 kWh/kWp·year), covering 4.6 % of the building's electricity use before efficiency upgrades and an estimated 6.6 % after, with 100 % of PV energy self-consumed on site. (Martín-Chivelet, 2018)

Technical Feasibility of Implementation in Dubai

Currently, roof top type of installation is already in practice for 400/132kV substation, a technical feasibility study is conducted to analyse installation on façade of substation buildings namely, **132kV**, **400kV** and **Control building**.

Table 1: Generation Summary (DEWA, PVsyst - Simulation report, 2026)

S. No	Building	Type of Installation	Area m2	Tilt	DC Capacity kWp	DC capacity per m2 of area kWp/m2	No. of panel	Specific production kWh/kWp/year	Solar Generation kWh/year
1	Control Building	Façade	740	90	120	0.16	205	680	81601
2	Control Building	Roof top	805	15	69.6	0.09	119	1737	120948
3	132kV Building	Façade	1291	90	249	0.19	425	887	220,420
4	132kV Building	Roof top	2433	15	61.4	0.03	105	1735	106586
5	400kV Building	Façade	2064	90	510	0.25	871	726	370,100
6	400kV Building	Roof top	4057	15	141	0.03	241	1734	244491
	Total		**11389**	-	**1151**		**1,966**		**1,144,146**

Table 2: Savings in Cost and Co2 emissions (DEWA, DEWA Tarif Calculator, 2026)

S. No	Building	Type of Installation	Solar Generation kWh/year	Annual Saving in AED	Annual Co2 saving in kg
1	Control Building	Façade	81601	36124	34272
2	Control Building	Roof top	120948	54302	50798
3	132kV Building	Façade	220,420	100,259	92576
4	132kV Building	Roof top	106586	47667	44766
5	400kV Building	Façade	370,100	169,411	155442
6	400kV Building	Roof top	244491	111379	102686
	Total		**1,144,146**	**519,142**	**480,541**

Observations

From the table-1&2, following observations can be made,

1) Façade installations have lower specific production (680–887 kWh/kWp/year) compared to rooftop installations (1734–1737 kWh/kWp/year).
2) The 400 kV building generates the highest energy, contributing approximately 54% of the total, followed by the 132 kV building at 28%, and the Control building at about 18%."
3) The 400 kV building also contains the largest number of panels, totaling, 1,112 panels (56.6 % of the total), followed by the 132 kV building with 530 panels (27.0 %) and the Control building with about 324 panels (16.5 %).
4) Façade generates about 59% (672,121 kWh/year) V/s Roof top generates about 41% (472,025 kWh/year)
5) Energy saving results in cost saving of 519,142 AED/year and 480 Tons Co2/year. Where in 400kV bldg. is the largest contributor amongst the three buildings.
6) Façade installations exhibit a higher DC capacity density compared to rooftops because rooftop areas are often occupied by building services, limiting available space for PV modules. Although rooftops generally offer larger surface areas than façades, they remain underutilized for the same reason. However, due to vertical tilt and increased shading, façades yield lower energy per installed kWp than rooftops due to their vertical tilt and increased shading, resulting in lower specific production values.

Sustainability and Strategic Benefits

Carbon Reduction, ESG Impact, and Policy Alignment

The combined PV installations across the Control, 132 kV, and 400 kV buildings generate 1,144,146 kWh annually, resulting in an estimated 480,541 kg (≈480 metric tons) of CO_2 savings per year. This significant reduction supports DEWA's Net Zero 2050 (DEWA, DEWA Net zero commitments , 2026) commitment and strengthens its position in global sustainability rankings. Highly visible PV façades enhance DEWA's public image as a leader in green infrastructure and foster community engagement by showcasing tangible climate action. This initiative is fully aligned with the UAE Clean Energy Strategy 2050 and DEWA's vision of becoming a globally leading sustainable corporation.

Implementation Challenges and Mitigation

Category	Risks	Mitigations
Structural	Structural failure due to extra weight/wind/seismic loads.	Proper structural analysis as per DM and Dubai building code requirements.
Fire	Fire propagation; module combustibility	Use of appropriately rated PV panels and accessories, fire compartments & separation; emergency disconnect and labelling as per DRRG and UAE fire and life safety guidelines.
Electrical	Electric shock; arc flash; DC high current	Compliant wiring & isolators (IEC 60364 parts); earthing; interface protection; surge & overcurrent devices; signage; emergency disconnect as per DRRG and UAE fire and life safety guidelines.
Environmental	Dust, soiling and glare	Locate away from sensitive areas, regular cleaning, manage water & air impacts.
Operational	Falls, cuts, electric hazards during installation & maintenance	Formal risk assessment, PPE, lock-out/tag-out, training, access equipment, first aid, maintenance planning, controlled shutdown

2.Recommendations & Conclusion

From table 1&2 it is observed that roof top areas are underutilised and alone are not sufficient to offset the energy needs of the substation, creating a physical barrier to NET zero targets. Façade-mounted PV panels present an alternative to overcome this limitation by provide un-obstructed additional surface areas to install PV panels. However, it also visible that vertical installation (90º tilt) is not as efficient as roof top (15º tilt) due to shading and fractional incident solar radiation, leading to underutilisation of installed capacity and subsequently decreasing return on investment. This develops a dilemma for achieving NET zero target V/s economic feasibility.

Since façades increase PV panel installation capacity by nearly three times it is recommended that a pilot project can be undertaken to evaluate the feasibility of the installation determining an optimal balance between meeting energy demands and economic feasibility of the installation. Successful implementation will provide data for standardization and scaling across DEWA's portfolio of existing and future assets, paving the way for widespread adoption and measurable progress toward net-zero targets.

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