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CASE STUDY

Growing and Strengthening the Solar Photovoltaic Sector in Singapore with Standards

In collaboration with

Singapore Standards Council

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Standards Development Organisation

HOUSING & DEVELOPMENT BOARD

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LIST OF ABBREVIATIONS

Terms

AC	Alternating current
DC	Direct current
GWp	Gigawatt-peak
MWp	Megawatt-peak
PID	Potential-induced degradation
PV	Photovoltaic

Bodies and Organisations

EDB	Singapore Economic Development Board
HDB	Housing & Development Board
IEC	International Electrotechnical Commission
IEC TC	International Electrotechnical Commission Technical Committee
SERIS	Solar Energy Research Institute of Singapore
SSC	Singapore Standards Council
WG	Working Group

2. INTRODUCTION

2.1. About Solar PV Systems

Solar PV technology, using materials like crystalline silicon or thin film, converts sunlight into electrical energy, making it a renewable energy source. It can be deployed in various scales, from residential rooftops to utility-scale power generation installations.

Solar PV systems can be grid-connected or off-grid systems with batteries for storage. Grid-connected PV systems represent most installations around the world. Typically, the energy generated from the solar panels is DC, which is converted into AC through an inverter that acts like an interface between the PV system and the grid.

2.2. Global and Local Demand for Solar PV

Global demand for solar PV rose by 40% in 2023. The current rising demand is driven by two key factors. First, solar panels are becoming cheaper to produce, making solar PV the most cost-effective electricity generation method. Second, as a source of renewable energy, solar PV plays an important role in helping nations achieve the goals of the Paris Agreement, which is to reduce emissions and reach net zero by 2050 so that global warming is limited to 1.5°C.

In Singapore, as part of the Singapore Green Plan, efforts are ongoing to ramp up solar capacity more than seven times by 2030 and reach solar capacity of 2 GWp. This is enough to meet the annual power needs of around 350,000 households in Singapore, or about 4% of Singapore's total electricity demand today.

Local efforts in maximising space for solar PV deployment include roof-top systems; floating installations on reservoirs and other water bodies; and installations on the vertical surfaces of buildings.

3. SINGAPORE STANDARDS FOR PV SYSTEMS

3.1. Incorporating Industry Insights in PV Standards

As the national standards body, Enterprise Singapore oversees the Singapore Standardisation Programme through the industry-led SSC. Standardisation work on solar PV systems is spearheaded by the WG on Solar PV Products and Accessories, under the purview of the Electrical and Electronic Standards Committee. The WG comprises experts from government agencies, industry associations, energy solution providers and solar developers.

Singapore is a full member in IEC TC 82 on Solar PV Energy Systems since 2013 and has been contributing its expertise to the development of IEC standards, especially in the area of reliability and safety standards tests for tropical climate. An example is Singapore's active international participation in the development of a PID standard under IEC TC 82, which has also been adopted as TR IEC/TS 62804-1.

To develop the local PV sector successfully while meeting the increasing demand for PV modules and systems, the WG on Solar PV Products and Accessories reviewed the suitability of current international solar PV modules with regard to:

(1) the long-term reliability of PV modules; and
(2) the safety of PV modules.

In Singapore, the IEC 61215 series on terrestrial PV modules and IEC 61730 series on PV modules safety qualification developed by IEC TC 82 are widely used. The standards help to improve the performance, reliability, safety and competitiveness of local PV products and ensure that the products meet international requirements.

The WG reviewed and identically adopted these international solar PV standards as the SS IEC 61215 and SS IEC 61730 series of standards.

3.2. SS IEC 61215 Series

Singapore has a hot and humid climate, which can degrade outdoor systems quickly and severely. Thus, it is important for Singapore to stress-test PV modules and ensure reliability.

Testing and certification procedures are involved to ensure the quality and performance of PV modules. These procedures are carried out based on a few standards. One of the standards is the SS IEC 61215 series, which lays down the requirements for the design qualification of terrestrial PV modules suitable for long-term operation in open-air climates.

The useful service life of a qualified module will depend on its design, its environment and the conditions under which it is operated.

The objective of the tests in the SS IEC 61215 series is to determine the electrical characteristics of the PV module and to show, as far as possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure outdoors.

The SS IEC 61215 series comprises the following 3 standards:

- SS IEC 61215-1 on Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements
- SS IEC 61215-1-1 on Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules
- SS IEC 61215-2 on Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures

3.3. SS IEC 61730 Series

The safety of PV modules is a top priority in the PV sector. Potential risks to PV safety include electric shocks, fire hazards and personal injury due to mechanical and environmental stresses.

The safety standards for PV modules in Singapore is currently based on the SS IEC 61730 series.

The SS IEC 61730 series specifies and describes the fundamental construction requirements for PV modules in order to provide safe electrical and mechanical operation while listing the tests a PV module is required to fulfil for safety qualification.

In particular, the test sequence and pass criteria in SS IEC 61730-2 are designed to detect the potential breakdown of internal and external components of PV modules that would result in fire, electric shock and/or personal injury.

The SS IEC 61730 series comprises the following 2 standards:

- SS IEC 61730-1 on Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction
- SS IEC 61730-2 on Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing

4. SINGAPORE'S SOLARNOVA PROGRAMME

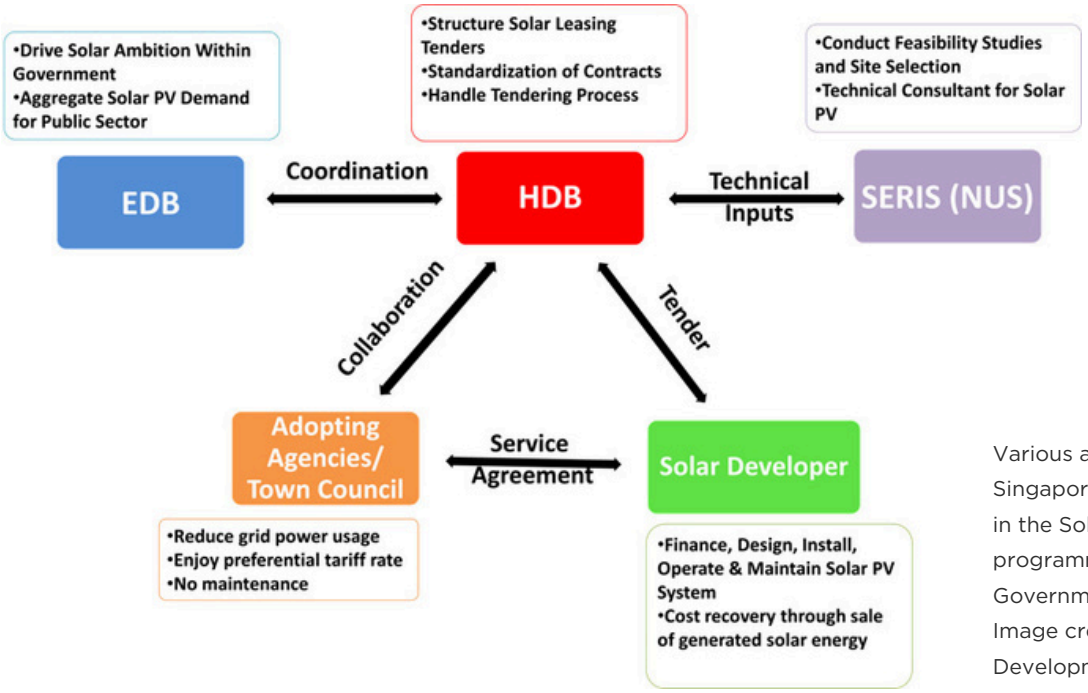
4.1. About the Programme

Singapore's tropical context and abundant sunlight present great potential to harness solar energy. The SolarNova programme, launched in 2014, is a Whole-of-Government effort led by HDB and EDB to tap this potential.

The programme has two main aims: to promote and aggregate demand for solar PV across government agencies to achieve economies of scale, as well as drive the growth of Singapore's solar industry. To meet its aims while maximising land use in Singapore, the SolarNova programme makes use of the rooftop spaces of HDB blocks for installing solar PV systems.

HDB manages the installation of solar PV systems across the HDB blocks and government sites by structuring solar leasing tenders, standardising contracts and handling the tendering process.

EDB encourages government agencies to come together to use solar power by aggregating the demand from them and providing funding for feasibility studies that determine their solar PV requirements. These studies are conducted by SERIS, the appointed technical consultant for the SolarNova programme.



Various agencies in Singapore work together in the SolarNova programme, a Whole-of-Government project. Image credit: Housing & Development Board

Solar PV installations on the rooftops of HDB blocks in Singapore.

4.2. Solar Targets

As of February 2024, under the SolarNova programme, 3,900 HDB blocks have solar PV systems installed on their rooftops. Where feasible, solar panels for the remaining HDB blocks will progressively be installed in batches over the next three years.

HDB has tendered a total solar capacity of 455 MWp across Singapore's HDB estates, which is equivalent to powering approximately 114,000 HDB 4-room flats. This is almost 85% of the SolarNova programme's target of 540 MWp by 2030.

The solar energy that is harnessed is first used to power common services such as lifts, lights and water pumps in HDB estates in the day, with excess energy channelled to the grid. On average, HDB blocks can achieve net zero energy consumption at common areas.

The SolarNova programme makes HDB the largest driver for the installation of solar PV systems in Singapore. The country's solar capacity has increased by more than nine times since 2015, in large part due to the SolarNova programme.

4.3. From Test Bed to Solar Leasing Model

HDB's solar initiative began in 2008. That year, it conducted its first solar test-bedding projects at two existing precincts in Serangoon and Wellington.

Mr Brandon Lye, Senior Engineer, Building & Research Institute, HDB, shared that the solar initiative started out small in 2008 to evaluate whether HDB rooftop spaces would be technically feasible, as well as economically viable, sustainable and worthwhile sites for solar energy generation in the long run. He added that HDB rooftops were not originally designed for solar PV installations. The test beds hence allowed HDB to gather valuable technical knowledge on the installation of extensive solar PV systems for existing HDB buildings.

In 2009, HDB commenced wide-scale test-bedding of solar PV systems in selected HDB precincts under the Solar Capability Building Programme. In 2010, Treelodge@Punggol became HDB's first solar PV-integrated HDB estate.

In 2011, HDB introduced the solar leasing model, where private developers would design, finance, install, operate and maintain the solar PV systems.

In this way, there is a win-win partnership between private developers and Town Councils: private developers are incentivised to ensure that the solar PV systems operate well to generate more electricity, which, in turn, is more profitable for them as developers, while the Town Councils, which are responsible for the day-to-day maintenance of common property in HDB estates, will enjoy electricity priced at a preferential rate not higher than the retail electricity tariff rate.

"The solar leasing model also helps us to ensure the performance of the solar PV systems," Mr Lye affirmed. "It is in the best interest of the private developers to ensure the solar PV systems operate well. The more electricity the systems generate, the more profitable they become for the developers. HDB also sets

a minimum guaranteed amount of electricity generation per annum. If this is not met for the year, the developers will have to top up the shortage in the following year."

In 2014, HDB awarded the first zero-dollar solar leasing tender, with the full cost of the solar PV systems borne by the private developers. Prior to this, part of the cost for solar leasing tenders had been funded by HDB to kickstart the solar leasing programme. With economies of scale from the wider adoption of the solar leasing model, HDB no longer needs to fund the upfront cost of subsequent projects.

In 2015, HDB called the first consolidated tender under the SolarNova programme. Since 2015 and as of February 2024, HDB and EDB have conducted eight successful rounds of tenders awarding a total of 455 MWp solar power capacity, including HDB's own efforts prior to the SolarNova programme. This is the equivalent of powering 114,000 HDB 4-room flats.

4.4. Adoption of PV Standards

Since the start of the SolarNova programme, HDB has included the IEC 61215 and IEC 61730 series of standards in tender specifications, where private developers must adhere to the standards when installing solar PV systems.

Mr Lye shared that incorporating IEC 61215 and IEC 61730 in the SolarNova programme's tender specifications helps ensure that solar PV installations are on par with international standards. "Since the SolarNova programme is taking the lead in driving solar PV deployment in Singapore, we want to expose the industry to global best practices. In addition, when private developers meet the IEC standards, they can participate in the local and global solar PV marketplace. This encourages a healthy growth of Singapore's solar PV industry," said Mr Lye.

The commercial success of the solar PV systems in the SolarNova programme is also based on their long-term reliability. "By adopting IEC 61215, we can better ensure that the solar PV systems under the SolarNova programme last a long time," said Mr Lye. "Because we cannot wait for years to evaluate if the solar PV systems are reliable, the accelerated stress tests set out by IEC 61215 come into the picture. They allow the private developers to identify design, materials and process flaws early on and anticipate any potential failures."

Public and operational safety are also key considerations when deploying solar PV systems in HDB estates. IEC 61730 adequately addresses these concerns. Mr Lye highlighted that the IEC 61730 series of standards lists out the fire resistance and fire rating requirements for safe solar PV system operations.

The SolarNova programme emphasises Design for Maintainability, a practice where operations and maintenance considerations are integrated into project planning and design to achieve effectiveness, safety and economy of maintenance tasks during the lifespan of a facility. Mr Lye explained that developers should carry out maintenance works easily without having to dismantle the solar PV system. Hence, the solar PV installations on HDB rooftops include a compulsory 1.6 m buffer between the primary roof and the underside of the solar PV modules, where workers can access the solar PV system for maintenance works.

4.5. Impact of the Programme

The SolarNova programme has created a market in Singapore for solar PV systems. Before the launch of the programme in 2014, few industry players wanted to take on the risk of investing in solar PV systems in Singapore. Between 2014 and 2019, the installation of solar PV systems grew by nine times in Singapore, driven by the SolarNova tenders.

The SolarNova programme offers certainty to private developers in terms of the scale of solar PV system installations and helps them to drive costs down and generate excess electricity to sell back to the grid.

The growing domestic market also leads to increasing experience of the local installation workforce, which lowers the cost of deployment. Today, solar PV systems cost eight to 10 times less than in 2008, the year that HDB first began exploring the technology.

The SolarNova programme also ensures that solar PV systems in Singapore are of international standard. By including IEC 61215 and IEC 61730 in the tenders, the SolarNova programme encourages the industry to adopt the standards and be aligned when it comes to solar PV reliability

The SolarNova programme creates a market in Singapore for solar PV systems. Image credit: Housing & Development Board

and safety. Solar PV solutions that adopt the standards can also enter the global marketplace more easily.

Importantly, the SolarNova programme increases solar capacity and the adoption of solar energy. Before the programme, users paid for solar PV installation, or signed a hire purchase agreement where they assumed full ownership of the solar asset. This high burden of cost on users was a deterrent to the adoption of solar energy. The SolarNova programme coordinates efforts to aggregate rooftop solar PV demand to achieve economies of scale.

With HDB acting as the government's central procurement agency for solar PV systems, users with a smaller demand benefit from the economies of scale and enjoy solar energy at a lower cost. Changes were also made to enhance the market and regulatory framework to facilitate solar deployment. This includes streamlining the registration process for solar consumers to sell their excess solar electricity to the grid and reviewing metering requirements to reduce cost.

In addition, the SolarNova programme drives innovation in solar PV technology. By opening private sector opportunities up to enter and compete in the energy market through the solar leasing model, the SolarNova programme encourages competition to produce cost-efficient, innovative and sustainable solar PV solutions.

Today, the SolarNova programme uses more efficient solar panels that can convert around 20% of sunlight into electricity, compared with 16% in the past. This has enabled some previously unsuitable rooftop spaces such as point blocks and partially shaded areas to now be installed with solar panels.

5. BROADER BENEFITS OF PV STANDARDS FOR SINGAPORE

In the global market, there are very few standardised solar PV rooftop systems. This presents a great opportunity for Singapore to take the lead in developing such systems for urban solar applications worldwide. By adopting solar PV standards, local developers can create reliable and replicable blocks of solar PV system components for rooftops more quickly and manufacture them in larger quantities at higher economies of scale.

As of end 2022, Singapore has a solar capacity of over 820 MWp. Singapore's goal is to achieve at least 2 GWp of installed solar capacity by 2030 and meet the annual electricity needs of around 350,000 households. Solar PV standards, by boosting the productivity of solar PV deployment and performance of solar PV systems, are helping Singapore reach its solar target efficiently – this can be witnessed in the SolarNova programme. PV standards are thus an important part of Singapore's strategy to fulfil its climate change ambitions.

About SSC
www.go.gov.sg/ssc

SSC facilitates the development, promotion and review of Standards and Technical References in Singapore. This work is done through partnerships with the industry, academia and government organisations, under the national standardisation programme overseen by Enterprise Singapore.

About IEC
www.iec.ch

IEC is a worldwide organisation for standardisation comprising all national electrotechnical committees. The objective of IEC is to promote and facilitate international co-operation on areas concerning standardisation in the electrical and electronic fields.