# Promoting Digital Solar Resource Maps and Management Technologies in Advancing Renewables Growth in APEC

**APEC Energy Working Group**

**May 2025**

APEC
Asia-Pacific Economic Cooperation

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APEC Project: EWG 01 2023A

Produced by
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# Content

# 1 Background

Climate change poses an existential threat to the entire world. APEC, comprising 38% of the global population and 55% of the GDP, is responsible for 60% of worldwide greenhouse gas emissions and 65% of carbon emissions. Due to their varied locations and geographic diversity, APEC economies are highly vulnerable to climate change, experiencing over 70% of global natural disasters. To address environmental challenges, APEC focuses on renewable energy as a key strategy in combatting climate change. Renewable energy lies at the core of the energy transition required to tackle ecological issues. The development and utilization of renewable energy sources, notably solar energy, are crucial in increasing renewable power generation and expanding capacity within the energy mix.

Emerging digital technologies have the potential to enhance the mapping and management of solar resources, aiding in both distributed and concentrated generation as well as direct consumption. Through innovative technologies, digital solar resource maps can assess the feasibility of solar energy generation. Digital solar energy management systems, incorporating technologies like artificial intelligence and digital twins, enable the consolidation of renewable information and data for analysis, benchmarking, and improvement exploration. These allow for effective territory-wide monitoring and management of operations. These technologies empower policymakers in shaping renewable energy policies, assist businesses in making informed industrial decisions, aid academia in developing innovative technologies, and enable the market to create green jobs along the transition to sustainable energy.

APEC economies can chart their energy transition policies and roadmaps by leveraging solar energy data and information obtained from solar resource maps and energy management technologies. In alignment with these efforts, Hong Kong, China (HKC) conducted the project "Promoting Digital Solar Resource Maps and Management Technologies in the APEC Region (EWG 01 2023A)" to advance digital solar resource mapping and management technologies across the region.

# 2 Objective

## 2.1 Project Objectives

This project aimed to foster APEC's renewables growth by disseminating study results, leading the discussion on a workshop, and conducting a workshop summary as a reference for APEC economies supporting policies to progress towards APEC's doubling the share of modern renewables goal and attain carbon neutrality.

## 2.2 Event Objectives

The workshop "APEC Workshop on Promoting Digital Solar Resources Maps and Management Technologies" that came alongside this project with one day session on 8 July 2024 aimed to encourage member economies to improve the utilization of digital solar resources maps and management systems in the APEC region, so as to accelerate APEC's move towards its goals of doubling the share of modern renewables goal and attain carbon neutrality.

The workshop provided a direct dialogue platform for building capacity on developing, deploying and operating of digital solar resource maps and management technologies among APEC members, international organisations and academia. More than 30 delegates and experts from 6 APEC member economies attended the workshop to exchange views on the best practices, challenges, and the application of innovative technology in digital solar resources maps and management systems.


Photo of the Workshop on Promoting Digital Solar Resources Maps and Management Technologies of the Asia-Pacific Economic Cooperation was held in Hong Kong, China on 8 July 2024

# 3 Workshop Summary

## 3.1 Welcoming Remarks of Workshop

Presenter: Mr TSE Chin-wan, Secretary for Environment and Ecology, Hong Kong, China

Mr TSE Chin-wan emphasized the significance of solar energy in achieving a sustainable energy transition, noting its critical role in combating climate change and enhancing its share in the energy mix.

Hong Kong, China (HKC) aimed to achieve carbon neutrality before 2050 and to halve carbon emissions from 2005 levels by 2035. The Climate Action Plan includes strategies for net-zero electricity generation, energy-saving initiatives, green buildings, green transport, and waste reduction.

The Government is actively developing renewable energy systems on government premises, with a notable project being a 150-kilowatt solar energy system at Jordan Valley Landfill. Since 2017-18, HKD3 billion (USD384 million) has been allocated for small-scale renewable energy systems, with HKD2 billion (USD269 million) approved for 240 projects generating 25 million kilowatt-hours annually. The government is also launching a Pilot Scheme on Building-Integrated Photovoltaics.

Private sector and community involvement is crucial for the energy transition. The Feed-in Tariff (FiT) Scheme, launched in 2018, incentivizes distributed renewable energy development, generating over 300 million kilowatt-hours annually from 24,000 approved systems, a significant increase from just 200 private renewable energy systems before the scheme.

Achieving carbon neutrality within 26 years necessitates policy support and cross-sectoral collaboration. Emerging digital technologies, such as AI and digital twins, are essential for advancing solar energy. Digital solar resource maps and management technologies can evaluate solar potential, facilitate data sharing for analysis, and enable remote monitoring and management. These tools support policymakers, industry decisions, academic innovations, and green job creation, assisting APEC economies in planning energy transition policies.

At the end of his speech, Mr TSE encouraged collaboration among academia, experts, and practitioners for promoting renewable energy. The workshop aims to explore digital solar resource maps and energy management technologies to drive this transition.

## 3.2 Opening Remarks of Workshop

Presenter: Mr Raymond POON, Director of Electrical and Mechanical Services, Hong Kong, China

Mr Raymond POON delivered the opening remarks at the workshop, commencing with the ancient Chinese proverb "靠山吃山，靠水吃水." He underscored HKC's dedication to aligning with APEC's objective of doubling the proportion of renewables by 2030. The city aims to elevate the share of renewable energy in electricity generation to 7.5-10% by 2035 and 15% by 2050 through local initiatives and regional collaborations.

Despite geographical challenges, HKC maximized solar energy utilization through financial incentives like the Feed-in Tariff (FiT) scheme and the "Solar Harvest" initiative for PV system installations at educational institutions and welfare organizations. Efforts also encompass disseminating optimal practices for solar systems and endorsing research ventures, including a pilot program for Building Integrated Photovoltaic systems at the EMSD Headquarters.

Mr POON provided a global overview, highlighting the surge in global solar PV capacity from 1.2 TW in 2022 to 1.6 TW in 2023. China contributed over 60% of the new capacity in 2023, with a cumulative capacity of 662 GW. The worldwide stock of PV modules was around 150 GW, with prices decreasing significantly, presenting a favorable window for expanded PV system installations.

Discussing the role of digital solutions, Mr POON accentuated that digital solar monitoring systems enable real-time supervision and optimization of solar energy production and usage, aiding enterprises in attaining peak energy efficiency and reducing dependency on conventional sources.

Introducing the integrated Self-sustained Renewable-energy Explorer (iSEE), Mr POON outlined its comprehensive approach to data collection, sharing, and quality enhancement. Diverging from traditional models, iSEE gauges on-site climate parameters and employs AI for output analysis, performance monitoring, and potential issue prediction. Real-time data access via mobile applications ensures immediate alerts and maintenance notifications.

In conclusion, Mr POON underscored the imperative of advancing and deploying renewable energy resources, particularly solar power, to bolster renewable energy production. He urged all APEC member economies to embrace innovative technologies for a seamless transition towards sustainable energy practices.

## 3.3 Summary of Pre-Workshop Findings

Presenter: Ms Elaine YIP, Engineer, Electrical and Mechanical Services Department, Hong Kong, China

Ms Elaine YIP's presentation aimed to report progress findings from the APEC-funded project focusing on the deployment of innovative technology in renewable energy, particularly solar. Ms YIP shared the strengths, limitations, importance, and best practices of the deployment of innovative technology (I&T) in solar energy.

She shared Digital Solar Resource Maps as crucial tools for evaluating solar energy generation potential. The research assessed 17 existing maps from international organizations and APEC member economies, evaluating them based on eight parameters. These maps varied in spatial resolution, ranging from detailed (1 meter) to broader scales (1 km). While most maps allowed for tile angle adjustment, they often overlooked shading effects from surrounding structures, impacting prediction accuracy. Advanced maps also featured financial analysis elements to assist in investment decisions. Common frameworks comprised six layers, from data collection to GIS integration and map visualization.

The research also included the assessment of Digital Solar Energy Management Systems, which focused on advancing both distributed and concentrated generation. These systems utilized artificial intelligence and digital twin technologies to facilitate effective monitoring, benchmarking, and exploration of improvements in renewable energy operations. A total of 15 software solutions were evaluated, including those from government agencies, private sectors within APEC economies, and major electrical suppliers outside the APEC region, based on parameters such as data collection, fault alarm, and prediction functions.

In conclusion, enhancing solar resource maps and energy management systems through higher resolution, real-time data, and advanced features could significantly enhance the accuracy and efficiency of solar energy deployment, aiding in accelerating the growth of renewable energy through innovative technologies.

## 3.4 Session 1 - Data Requirement from Solar Energy Systems

### Sharing 1.1: Essential solar-related data for energy modeling and forecasting

Presenter: Dr Alexander IZHBULDIN, Senior Researcher, Asia Pacific Energy Research Centre

Dr. Alexander IZHBULDIN's presentation offered a detailed overview of the essential data and limitations required for accurate energy modeling and forecasting, specifically focusing on solar energy generation.

He explained the generation of electricity from diverse primary sources like fossil fuels, nuclear energy, hydropower, geothermal, wind, and solar irradiance, outlining the conversion process into secondary energy forms utilizing technologies such as turbines, generators, and inverters in photovoltaic (PV) systems. Key metrics like capacity factor and efficiency were deemed critical in assessing performance.

Modeling electricity generation necessitates inputs like electricity demand predictions, load profiles, and data on existing power plant fleets. Demand forecasts anticipate future energy requirements, while load profiles reveal consumption patterns, notably with intermittent renewable sources. The modeling process incorporates current and future power plants, alongside performance metrics, to predict capacity growth and energy use.

Solar generation potential is influenced by factors such as location, solar irradiance, technology, and system size. Location determines solar radiation availability, technology choice impacts project feasibility, and system size affects efficiency. Integration into energy grids demands an understanding of existing infrastructure and expansion plans.

Constraints affecting solar energy modeling encompass resource availability, logistics, and infrastructure. Solar PV considers factors like irradiation, weather, and geography. Efficiency affects input needs for traditional technologies and output for solar systems, potentially leading to capacity limitations concerning materials, grids, and installation space.

Dr. IZHBULDIN stressed the impact of geography and topography on solar PV installations, exemplified by Japan's terrain challenges and Germany's flat landscape advantages. Weather and seasonal variations affect irradiance and panel efficiency significantly.

Effective energy modeling mandates consideration of on-ground constraints such as geography, topography, and public sentiment. While solar irradiance data is accessible, integration constraints information is often lacking, posing modeling obstacles. Understanding these elements is pivotal for precise forecasting and optimizing solar energy system potential.

### Sharing 1.2: AI and Digital Twinning enabled Intelligent Solar Energy Management and Performance Assessment

Presenter: Prof. XU Zhao, Chairman of IEEE PES/IES/PELS/IAS Joint Chapter in HKC Section, BEAM Society; Professor, the Hong Kong Polytechnic University, Hong Kong, China

Prof. XU Zhao delivered a presentation titled "AI and Digital Twinning Enabled Intelligent Solar Energy Management and Performance Assessment." His focus was on how these technologies can enhance the management and performance assessment of solar energy systems in high-density urban environments.

He began by discussing the motivation behind developing intelligent solar energy management systems, emphasizing the urgent need to combat climate change and achieve zero carbon emissions by 2050 as outlined in Hong Kong, China's Climate Action Plan 2050. To stimulate investment in renewable energy, particularly solar, the government has introduced a feed-in tariff scheme offering significant subsidies.

To address practical challenges faced by solar PV systems, such as component failures and shading issues, the Integrated Solar Energy Performance Management System was developed. This cloud-based system connects multiple PV systems using flexible communication protocols like 4G, WiFi, and LoRa, providing functions such as real-time operation monitoring, asset management, system measurement, and predictive maintenance, all powered by AI and digital twinning.

Data management plays a crucial role in the system's effectiveness. The system integrates data from local sensors, GIS information, and weather forecasts to improve predictive maintenance. Power prediction relies on data from electrical circuits and weather conditions, processed through a Long Short-Term Memory (LSTM) neural network. For fault diagnosis, digital twin models simulate PV operations, comparing simulated data with actual measurements to identify and predict faults.

Prof. XU also addressed broader data challenges relevant to smart grids, which involve large-scale data measurement and complex operational tasks. He highlighted the necessity for advanced architectures and compliance with industry standards like IEC 61850 to manage these challenges effectively. He concluded by sharing successful outcomes from their research, including patents and accolades from the Geneva International Exhibition of Inventions, and expressed gratitude for EMSD's support.

## 3.5 Section 2 - Deployed technologies for Solar Resources Maps and Management Systems

### Sharing 2.1: Digital resource maps for solar potential analysis and solar asset management

Presenter: Dr Thomas REINDL, Deputy CEO, Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS), Singapore

Dr. Thomas REINDL discussed the use of high-resolution digital resource maps for solar potential analysis and asset management, focusing on optimizing solar energy deployment in urban settings.

He introduced SERIS as an institute dedicated to practical problem-solving and solar industry advancement, covering the entire solar value chain, from cells to systems, including building-integrated PV and floating solar technologies.

Dr. REINDL stressed the necessity of detailed solar irradiance data for precise solar potential analysis, especially crucial for urban solar deployment in land-constrained areas like Singapore and HKC. In Singapore, there was a network of 25 irradiance stations for real-time solar data collection, facilitating detailed 3D modeling of solar potential. This modeling involved assessing individual buildings and surroundings for accurate shading and irradiance evaluation, aiding in identifying suitable locations, notably in industrial zones with ample rooftops for PV installations.

Techno-economic analysis plays a vital role in evaluating solar project feasibility, with the Levelized Cost of Electricity (LCOE) as a key metric. In Singapore, where solar energy resource costs are minimal, solar projects are economically attractive.

Solar forecasting is crucial for managing solar energy variability, particularly in tropical climates with unpredictable weather. A real-time solar forecasting system was developed for forecasting every five minutes up to seven hours ahead, aiding grid operators in ensuring stability and effective solar energy integration.

Dr. REINDL concluded by highlighting the importance of high-quality solar resource data and advanced modeling techniques in optimizing solar energy deployment and encouraging collaboration between industry and government stakeholders to further advance solar energy solutions.

### Sharing 2.2: Designing, Monitoring and Maintenance Solar in Viet Nam

Presenter: Mr LE Cong Doanh, Representative from the Electricity and Renewable Energy Authority (EREA), Ministry of Industry and Trade, Viet Nam

Mr LE Cong DOANH presented on the design, monitoring, and maintenance of solar systems in Viet Nam. He began by outlining the power structure in Viet Nam, noting that by the end of 2023, the economy had achieved a total power capacity of approximately 80,555 MW, with renewable energy sources, particularly solar and wind, contributing significantly. Solar power alone accounted for over 25,000 MW from 147 solar power plants and more than 103,000 rooftop systems.

In designing solar power plants, Mr DOANH emphasized the importance of considering construction location, connectivity to the domestic electricity system, and project progress. He detailed the use of photovoltaic technology directly connected to the grid, using polycrystalline and monocrystalline PV modules, inverters, and transformers. The layout of solar panels, electrical control, communication design, and adherence to international standards such as IEC 61215 for PV modules and IEC 61683 for power conditioners were also highlighted. Auxiliary equipment like UV-resistant connectors, DC cable systems, and meteorological stations were essential for ensuring optimal plant operation.

For monitoring and control, he discussed a distributed system structure that integrates various independent operating systems into a unified data storage and monitoring system, facilitated by high-speed LAN networks. This system allows for effective data exchange and monitoring between different plant systems and operators.

In terms of operations and maintenance (O&M), Mr DOANH outlined a structured approach that includes regular monitoring, damage assessment, and implementation of maintenance plans. Periodic and non-routine maintenance activities were described, along with specific requirements for general upkeep, inspection of modular rack frames, cables, inverters, and protective devices. He stressed the importance of regular cleaning of solar panels to prevent power losses due to dust and other pollutants, recommending methods such as specialized robots, automatic spray systems, and manual cleaning.

Mr DOANH concluded by highlighting Viet Nam's significant achievements in solar energy, with a total capacity surpassing 20,000 MW by the end of 2023. Looking forward, Viet Nam aims to reach 10,836 MW by 2030. To support this growth, the economy is developing mechanisms like Direct Power Purchase Agreements (DPPA) and self-producing and self-consuming rooftop solar power systems, focusing on optimal design solutions for solar power plant monitoring, technology design, and maintenance to ensure high performance, cost savings, and system stability.

## 3.6 Section 3 - Innovative technologies for Digital Solar Energy Systems

### Sharing 3.1: Residential PV market pain points and solutions

Presenter: Dr HE Yu Fei, Representative from the Huawei Digital Power Technologies Co., Ltd., China

Dr. HE Yu Fei of Huawei underscored the company's dedication to delivering reliable PV solutions for channel partners, with a strategic focus extending beyond solar panel manufacturing and installation.

Addressing prevalent challenges faced by installers and homeowners, such as fire risks, shading issues, and high operational costs hindering solar energy adoption, Dr. HE introduced Huawei Brain. This innovative platform offers a holistic solution for poly-electronic systems, featuring versatile inverters and an intelligent backup power safeguard. The 1+4+X residential solution optimizes module performance, ensuring enhanced user revenue, system safety, and reliability. Components include cloud integration ('1'), optimizers, inverters, energy storage systems, and smart chargers ('4'), as well as support for various electrical loads ('X'). Huawei's products meet global safety standards and have seen successful deployment worldwide in residential and commercial sectors.

A core focus was Huawei's optimizer technology, employing a buck converter topology to enhance solar panel efficiency through module-level MPPT, surpassing traditional string-level systems. The optimizer includes rapid shutdown capabilities for emergencies, monitors panel voltage and current, and transmits data for real-time cloud monitoring, with plans for AI diagnostics to further boost performance.

Huawei's advanced hardware platform supports AI algorithms to optimize residential solar systems, integrating with diverse communication protocols and third-party devices. Online tools like an intelligent design tool and the Fusion Solar app streamline commissioning processes.

Dr. HE emphasized Huawei's all-encompassing solar solution, prioritizing efficiency, safety, and user-friendly operation. By providing a unified approach, customers benefit from diverse products from a single supplier, tailored to various residential and solar panel scenarios. The presentation highlighted Huawei's commitment to innovation and safety, backed by a successful track record with over 1.2 million deployed battery packs without significant incidents.

## 3.7 Section 4 - Innovative technologies for Solar Industry

### Sharing 4.1: Demonstration of the Integrated Solar Management System

Presenter: Prof. XU Zhao, Chairman of IEEE PES/IES/PELS/IAS Joint Chapter in HKC Section; Professor, the Hong Kong Polytechnic University, Hong Kong, China

Prof. XU outlined the framework of the ISMS, which is a web and cloud-based platform that allows for real-time monitoring of multiple photovoltaic (PV) systems across Hong Kong, China (HKC) and beyond. The main interface features a map of HKC, displaying icons representing the various PV systems connected to the platform. This connectivity enables the system to receive real-time data on energy generation and performance metrics. Additionally, the ISMS can integrate data from other sources, such as the map and local weather data, through application programming interfaces (APIs).

To enhance functionality, the ISMS employs advanced technologies, including artificial intelligence (AI) and digital twin modeling. These technologies facilitate sophisticated features such as fault diagnosis and performance analysis, allowing for proactive management of the solar systems By leveraging these tools, users can gain insights into system performance and identify issues before they escalate.

Following the introduction of the ISMS framework, Prof. XU provided a detailed demonstration of its implementation at PolyU. He explained that several PV panels are installed on the rooftop of the university’s laboratory, converting solar energy into electricity. The generated power is fed into the university’s power grid via inverters. In addition to the electrical components, various sensors, including irradiation and temperature sensors, are strategically placed on the rooftop to gather crucial environmental data.

This data is transmitted to the Huawei Cloud-based ISMS for processing and analysis. The analyzed information is then accessible through both web and mobile app interfaces, providing users with a comprehensive view of the solar energy system’s performance. Prof. XU emphasized that this integrated approach not only optimizes energy management but also contributes to the university's sustainability goals.

In conclusion, Prof. XU highlighted the transformative potential of the Integrated Solar Management System in enhancing solar energy utilization and monitoring, paving the way for smarter energy management solutions.

### Sharing 4.2: Prof. LI Gang, Chair Professor, Department of Electrical and Electronic Engineering, the Hong Kong Polytechnic University, Hong Kong, China

Presenter: Prof. LI Gang, Chair Professor, Department of Electrical and Electronic Engineering, the Hong Kong Polytechnic University, Hong Kong, China

Prof. LI Gang provided a detailed overview of advancements in solar cell technology, focusing on silicon and organic solar cells. He highlighted the pivotal role of solar energy in addressing global energy needs sustainably and reducing greenhouse gas emissions. Noting significant investments in solar energy in the United States and China, Prof. LI underscored its importance for energy security and economic development amid environmental challenges and fossil fuel dependence.

The presentation delved into the fabrication process of silicon solar cells, emphasizing single-crystal silicon technology's efficiency and reliability. Prof. LI elucidated steps like Czochralski pulling to grow silicon ingots, followed by wafer slicing and junction formation crucial for electricity generation. He discussed the purity and crystallinity requirements for efficient silicon wafers and the emergence of tandem solar cells that combine materials to boost energy conversion efficiency. While silicon remains prominent, he introduced organic solar cells utilizing conductive polymers, offering flexibility and cost advantages.

Prof. LI highlighted the remarkable efficiency enhancements in organic solar cells, soaring from 4% in 2005 to over 20% recently due to molecular engineering advancements. Transparent organic solar cells were noted for maintaining efficiency while permitting visible light transmission, catering to urban applications' aesthetic concerns. Nanoscale tuning of molecular structures has boosted charge transport and reduced energy losses, paving the way for solar technology integration into buildings and electronics.

In conclusion, Prof. LI stressed the potential of synergizing silicon and organic materials to elevate solar cell efficiency and expand applications in urban and agricultural contexts. He expressed optimism about these technologies fostering a sustainable energy landscape and enhancing the solar industry's profitability. The presentation encapsulated the transformative impact of solar energy technologies, offering valuable insights into their promising future.

### 3.8 Closing Remarks of Workshop

Presenter: Mr Boris YIU, Assistant Director/Electricity and Energy Efficiency of the Electrical and Mechanical Services Department; Project Overseer of Hong Kong, China

Mr Boris YIU delivered the closing remarks. In his closing remarks at the APEC Workshop on Promoting Digital Solar Resources Maps and Management Technologies, Mr Boris YIE expressed heartfelt gratitude to all participants and speakers, including representatives from The Pacific Energy Research Centre, Hong Kong Polytechnic University, National University of Singapore, Electricity and Renewable Energy Authority of Viet Nam, and Huawei Digital Power Technologies. He emphasized that their contributions were vital to the workshop's success. The event highlighted the promotion of digital technology and capacity building in solar power innovation, aligning with APEC's goal of doubling renewable energy and advancing the Putrajaya Vision for a sustainable energy transition.

Mr YIU recapped key insights from distinguished speakers: Alex underscored the significance of geographical and meteorological data for energy modeling; Prof. XU discussed the integration of AI and digital twinning with power grids; Dr. REINDL emphasized the role of digital resource maps in solar potential analysis; Mr DOANH shared insights on solar system design and maintenance in Viet Nam; Dr. HE presented solutions addressing market challenges; and Prof. LI introduced advancements in third-generation solar cells.

He called for continued collaboration among APEC member economies to leverage today's knowledge in combating climate change. Mr YIU expressed eagerness to explore further carbon neutrality measures and share valuable experiences in future gatherings, concluding with an invitation to enjoy the upcoming session at the Hong Kong Polytechnic University.

# 4 Summary of Discussion

## (i) Session 1 - Data Requirement from Solar Energy Systems

Q1: What suggestions do you have for developing photovoltaic systems in high-density cities like HKC?

Mr Alexander IZHBULDIN acknowledged that HKC is making significant strides in addressing the challenges posed by limited space and the potential for solar energy capture. He emphasized that while HKC enjoys ample sunlight, the primary constraint lies in effectively capturing solar radiation. He identified shadow management as a substantial challenge, suggesting that artificial intelligence could play a role in mitigating this issue.

Furthermore, Mr IZHBULDIN stressed the importance of understanding the limitations of the existing grid infrastructure. It is essential to evaluate whether the current grid can accommodate extensive rooftop solar panel installations. He also highlighted the necessity for storage solutions in high-density urban areas. To facilitate the integration of variable solar generation, identifying suitable locations for battery installations is critical, and these should be incorporated into planning maps. Such batteries would help manage variability and ensure a stable energy supply.

Q2: Could you share insights on the challenges of improving accuracy in AI and digital twin systems and how you address them?

Prof. Zhao XU explained that the success of AI and digital twin technologies is heavily reliant on data quality. He noted that significant challenges arose when the outputs of their digital twin or AI modules diverged from expected results, prompting frequent checks of their database for underlying issues. A key lesson learned was the critical importance of data quality control. To address this, they implemented various detection criteria to ensure the reliability of the data utilized in their management systems.

## (ii) Session 2 - Deployed technologies for Solar Resources Maps and Management Systems

Q1: How do you process different sensor data for AI-driven predictive operation and maintenance?

Dr. Thomas REINDL highlighted that the success of AI-driven predictive operation and maintenance is fundamentally tied to the quality of the input data, encapsulated in the saying "garbage in, garbage out." He explained that SERIS has amassed over 12 years of high-resolution data from 25 irradiance stations throughout Singapore, along with monitoring data from 30 to 40 photovoltaic (PV) systems over the same period. Their asset management platform incorporates more than 150 input parameters derived from real-world PV installations.

Dr. REINDL emphasized the importance of having a diverse array of input parameters and extensive time series data for effective machine learning and AI model development. He noted that smaller, varied systems tend to provide more valuable learning opportunities compared to large, uniform installations, as they present a broader range of configurations and conditions. The crux of effective algorithm training lies in the availability of high-quality, diverse data.

### (iii) Session 3 (No Q&A)

### (iv) Session 4 - Innovative technologies for Solar Industry

Q1: What is the current size of your organic solar cell device?

In response to this inquiry, Professor Gang Li provided valuable insights. He noted that the current laboratory-scale devices measure approximately 0.1 $cm^2$. These small cells are primarily utilized in research settings to validate various concepts. Professor Li anticipates that as technology progresses, the size of these devices will increase.

Q2: Among the existing materials, which is the most suitable for applications?

Professor LI emphasized that the suitability of materials largely depends on their intended application. He highlighted the importance of achieving high efficiency while ensuring compatibility with existing technologies. For instance, while the first part of Pro-Skater 2 employed a single-junction cell made from gallium arsenide, he pointed out that this approach may not be sustainable long-term. In contrast, silicon offers advantages such as cost-effectiveness and longevity. He elaborated that if the industry is valued at 100 billion, there is potential for a 20% increase in profits by avoiding excessive spending, particularly in urban areas like HKC. The commitment to maximizing efficiency remains paramount, with a focus on securing farmland for future applications. Professor LI also expressed enthusiasm for integrating photovoltaic (PV) systems into buildings and exploring their use in agricultural settings, noting these as key areas of interest.

Q3: There are reports indicating that previous efficiencies were about 50% lower than those of current technologies. Are there any advancements in this area?

In addressing this question, Professor LI clarified the benchmark for efficiency comparisons, revealing that the efficiency has improved from 26.7% two years ago to 27.1% today. This progress showcases the capabilities of laboratory technologies. He acknowledged the considerable efforts being made to leverage modern technologies and artificial intelligence in this field. However, he emphasized that the focus on efficiency and organic photovoltaic (OPV) technology is not intended to compete with the direct sunlight absorption of traditional solar farms. Instead, the goal is to excel in innovative applications such as building-integrated photovoltaics (BIPV) and transparent components, where their technology may offer superior solutions.

# 5 Conclusion

In this workshop, various international scholars and engineers shared their professional points of view and investigation on the digital solar resource maps and management technologies. From their expertise in analysing the solar resource maps and management systems development in the APEC region, they introduced the background of solar resource maps and management systems and emphasized the importance of the solar resource maps and management systems. At the same time, they pointed out the problems and challenges that solar resource maps and management systems are currently facing and envisioned future goals.

This workshop provided an opportunity for APEC member economies to learn about solar resource maps and management systems. APEC member economies shared best practices for converting knowledge into practical action. The workshop is for promoting digital solar resource maps and management technologies in the APEC regions and provides a direct dialogue platform for building capacity on developing, deploying and operating of digital solar resource maps and management technologies among APEC members, international organisations and academia. In addressing environmental challenges, promoting renewable energy is one of the concerted efforts in APEC to tackle climate change and is at the centre of the energy transition to address ecological challenges. We are making enduring efforts to progress towards APEC's doubling the share of modern renewables goal and attain carbon neutrality.

## Appendix A – Agenda

Date: 8 July 2024
Time: 09:00am-17:20pm (GMT+8)
Venue: Eaton Hong Kong Hotel

| Time slot (HKT) | Sessions / Topics |
|---|---|
| 07:00 – 08:30 | Setup |
| 08:30 – 09:00 | Rehearsal |
| 09:00 - 09:30 | Registration |
| 09:30 – 09:40 | Welcoming Remarks – SEE (Pre-recording) |
| 09:40 – 09:55 | Opening Remarks – Mr. Raymond POON, Director of Electrical and Mechanical Services, Hong Kong, China |
| 09:55 – 10:05 | Photo Taking |
| 10:05 - 10:15 | Summary of Pre-Workshop Findings |
| 10:15 -10:45 | Break |
| | **Session 1: Data Requirement from Solar Energy Systems** |
| 10:45 - 11:05 | 1.1 "Essential solar-related data for energy modeling and forecasting" By Dr Alexander IZHBULDIN, Senior Researcher of Asia Pacific Energy Research Centre (APERC) |
| 11:05 - 11:10 | Session 1.1 – Q&A |
| 11:10 - 11:30 | 1.2 "AI and Digital Twinning enabled Intelligent Solar Energy Management and Performance Assessment" By Prof. XU Zhao, Chairman of IEEE PES/IES/PELS/IAS Joint Chapter in HKC Section; Professor, the Hong Kong Polytechnic University, Hong Kong, China |
| 11:30 - 11:35 | Session 1.2 – Q&A |
| | **Session 2: Deployed technologies for Solar Resources Maps and Management Systems** |
| 11:35 - 11:55 | 2.1 "Digital resource maps for solar potential analysis and solar asset management" Dr Thomas REINDL, Deputy CEO, Solar Energy Research Institute of Singapore (SERIS), National University of Singapore (NUS), Singapore |
| 11:55 – 12:00 | Session 2.1 – Q&A |
| 12:00 - 12:10 | 2.2 "Designing, Monitoring and Maintenance Solar in Viet Nam" Mr. LE Cong Doanh, Representative from the Electricity and Renewable Energy Authority (EREA) – Ministry of Industry and Trade, Viet Nam |

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|---|---|
| 12:00 – 12:15 | Wrap up of morning session |
| 12:15 – 14:00 | Lunch |
| 14:00 – 14:10 | Registration |
| | **Section 3: Innovative technologies for Digital Solar Energy Systems** |
| 14:10 – 14:30 | 3.1 "Residential PV market pain points and solutions"<br>Dr HE Yu Fei, Huawei Digital Power Technologies Co., Ltd., China |
| 14:30 – 14:35 | Session 3.1 – Q&A |
| 14:35 - 14:40 | Closing Remarks – Mr. Boris YIU, Assistant Director/Electricity and Energy Efficiency of the Electrical and Mechanical Services Department; Project Overseer of Hong Kong, China |
| | **Section 4: Innovative technologies for Solar Industry** |
| 14:40 – 15:20 | Travel to the Hong Kong Polytechnic University |
| 15:20 – 15:30 | Registration and Group photo |
| 15:30 – 15:45 | 4.1 Demonstration of the Integrated Solar Management System<br>By Prof. XU Zhao, Chairman of IEEE PES/IES/PELS/IAS Joint Chapter in HKC Section; Professor, the Hong Kong Polytechnic University, Hong Kong, China |
| 15:45 – 16:00 | Travel within campus |
| 16:00 – 16:15 | Break |
| 16:15 – 16:50 | 4.2 "Recent Progress in Printable Solar Cells" at CD634 with demonstration of production facilities<br>By Prof. LI Gang, Chair Professor, Department of Electrical and Electronic Engineering, the Hong Kong Polytechnic University, Hong Kong, China |
| 16:50 – 17:20 | Travel to hotel |
| 17:20 | End of workshop |

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