



NUS
National University
of Singapore



Solar Energy System Cluster

The "PV System Doctor"

Real-Time Monitoring of PV Systems

Advanced On-Site Diagnostics

Climate-Specific Testing of PV Modules and Systems

Owner / Lender's Engineer Services

Technical & Financial Feasibility Studies

Verification of RE Certificates for Sustainability Reporting

NATIONAL RESEARCH FOUNDATION
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SINGAPORE



EDB:
SINGAPORE

SERIS is a research institute at the National University of Singapore (NUS). SERIS is supported by NUS, the National Research Foundation Singapore (NRF), the Energy Market Authority of Singapore (EMA) and the Singapore Economic Development Board (EDB).

THE “PV SYSTEM DOCTOR”

A smart and innovative O&M service that provides a comprehensive health check for photovoltaic (PV) systems. It consists of three “health choices” which can be booked individually or as a package:

- Real-time monitoring of PV systems
- Advanced on-site diagnostics
- Independent financial assessment

REAL-TIME MONITORING OF PV SYSTEMS

Using our state-of-the-art proprietary monitoring system, which includes smart sensors and big data analytics coupled with an intuitive graphic user interface (GUI) enables continuous measurement of actual PV system parameters down to the individual string level. We provide:

- Independent power output measurements, inverter readings, weather sensor readings
- Specialised sensor readings (e.g. motion sensors for Floating PV)
- Real-time irradiance measurements
- Ambient and module temperature measurements
- Performance ratio (PR) calculations
- Live streaming of Fast Data (1-second) and Regular Data (1-minute) of weather and PV Systems parameters from various types of energy meters, inverters, including string level monitoring
- Submission of live power and irradiance data compliant with requirements from power system operators (PSO), e.g. Singapore’s Energy Market Authority (EMA)
- Tight time synchronisation of +/- 150ms
- Early fault detection by continuous benchmarking of:
 - String performance against each other
 - System performance against simulated behaviour under optimal conditions
 - Plant performance against peer installations



Example of the graphic user interface (GUI) of SERIS’ real-time monitoring solution

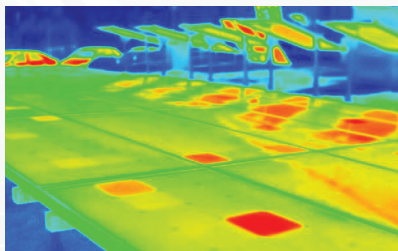
ADVANCED ON-SITE DIAGNOSTICS

We offer an integrated diagnostic package to accurately locate PV defects in the field down to module level, using non-destructive techniques. It includes:

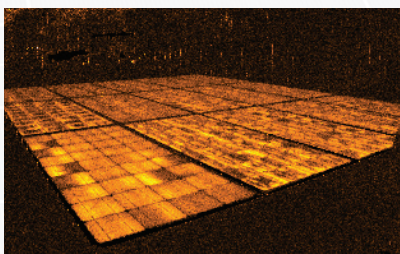
- Field inspections according to the latest IEC standards
- Electrical assessments on string level (including I-V curve evaluation)
- The following advanced imaging techniques (all applicable in daylight conditions):



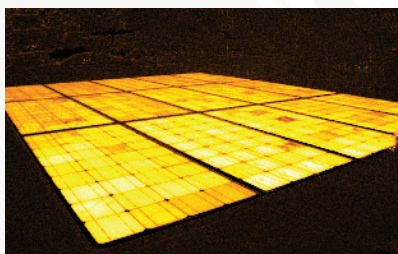
Optical imaging (OI)



Thermal imaging (IR)



Daytime electroluminescence imaging (DEL)

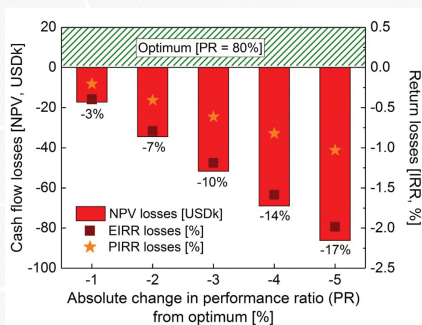


Daytime photoluminescence imaging (DPL)

INDEPENDENT FINANCIAL ASSESSMENT

An under-performing PV system results in revenue losses and reduction of expected returns. Even small deviations from the optimal performance ratio can negatively impact a project's financial return and cash flow. Our financial service team offers:

- Financial impact analysis of the under-performance
- Life-cycle cost/benefit analysis of required rectification works needed to bring the system back to its optimum performance



An example of net present value (NPV) losses and equity & project internal rate of returns (EIRR, PIRR) impact for a 1 MW_p rooftop system

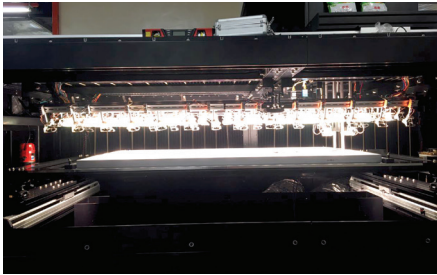
CLIMATE-SPECIFIC TESTING OF PV MODULES AND SYSTEMS

TruePower™ Alliance

Advanced combination of extended indoor and outdoor PV module & system testing across major climate zones.

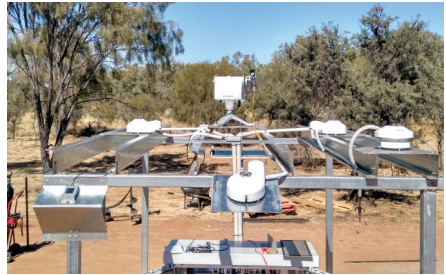
Advanced & flexible indoor test facility

- Wide range of intensities and module temperatures, long pulse I-V measurement equipment
- Module-level spectral response measurements



360° Solar irradiation measurement

- State-of-the-art meteorological sensors including albedo measurements
- > 5 years experience in monitoring with very high data quality



Cross-climatic outdoor testing

- Using high-precision equipment to measure realistic annual energy yield
- Identical module and system testing setup across four climatic zones



SERIS' Outdoor Module and System Testing facility in Alice Springs, Australia (desert climate)

Scientific interpretation and data intelligence

- Big Data analysis
- Revise the standard set of indoor measurements representing real outdoor performance



SERIS' Outdoor Module and System Testing facility in Friedenshall, Germany (temperate climate)



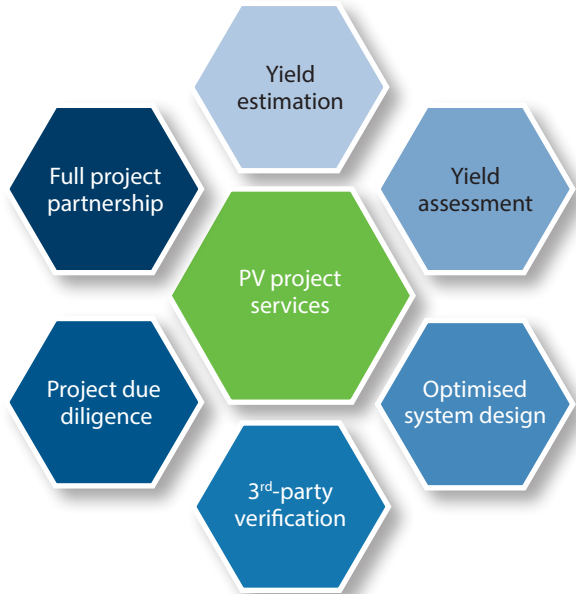
SERIS' Outdoor Module Testing facility in Singapore (tropical climate)

OWNER / LENDER'S ENGINEER SERVICES

SERIS can assist project owners and developers in the design of their PV systems for performance optimisation and to meet the highest quality standards, in particular for installations in the tropics. SERIS' project services start from initial yield estimations until the systems are fully operational and perform as originally planned.

SERIS also works with lenders on the technical and financial evaluation of a proposed solar project.

Typical PV system services offered by SERIS are illustrated by the image on the right.



FLOATING SOLAR

SERIS has special expertise in the area of "Floating Solar" where it operates the World's largest testbed of Floating PV installations and carries out technical and financial assessments around it.



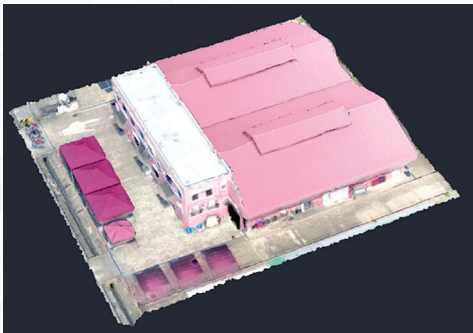
The floating PV system at Tengah reservoir Singapore comprises different types of floating structures and PV modules of approximately 100 kW_p each

TECHNICAL & FINANCIAL FEASIBILITY STUDIES

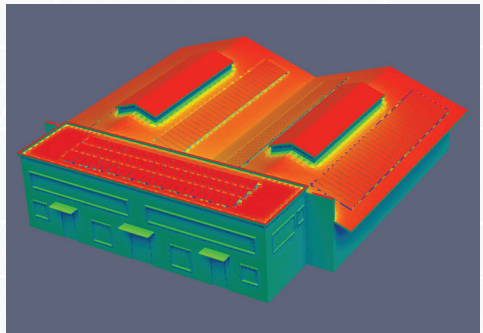
We offer a wide range of feasibility studies, from specific technical questions to comprehensive studies including commercial and regulatory aspects, for example:

- Technical and economic feasibility of solar projects of any size and any deployment option, e.g. ground-mounted, floating PV, or roof-top.
- Commercial and regulatory feasibility of large-scale PV projects in Asia
- Analysis of solar PV potential for cities and regions
- Solar PV roadmaps

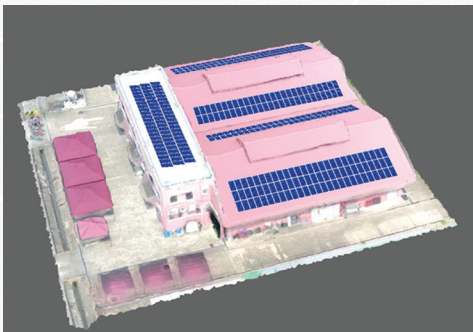
SERIS also offers an integrated techno-economic assessment that combines PV capacity estimation, energy yield projection and economic evaluation. This service blends innovative UAV (unmanned aerial vehicle) surveying techniques, specialised in-house modelling capabilities and know-how to produce visually engaging evaluations for optimised solar PV installations.



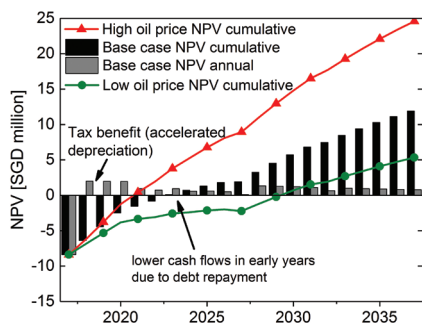
3D building model after UAV surveying



Detailed irradiance modelling to assess maximum solar energy harvest



Optimum PV system layout for maximising solar energy generation throughout the year, including shading analysis

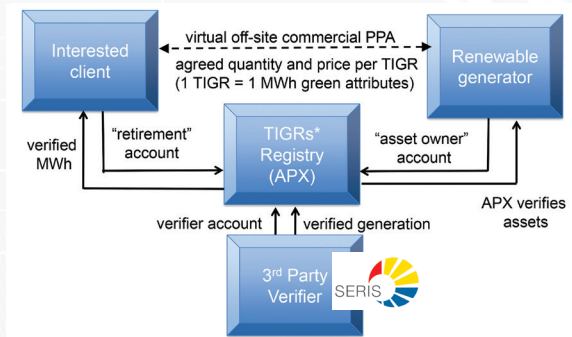


Detailed economic viability assessment (NPV = net present value)

VERIFICATION OF RENEWABLE ENERGY CERTIFICATES FOR SUSTAINABLE REPORTING

As multi-national companies move towards sustainable goals and climate-friendly policies, the need for a platform to transact renewable energy certificates (RECs) becomes more evident. SERIS was instrumental for the launch of the Tradable Instruments for Global Renewables (TIGRs) platform in 2016, supporting Singapore's move to become the regional hub for renewable energy.

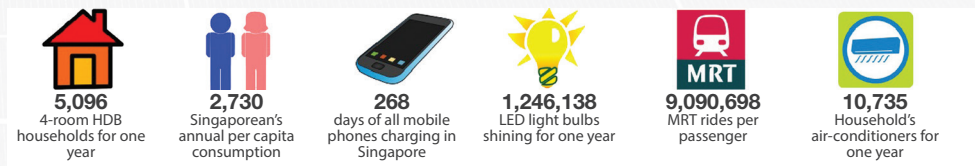
SERIS acts as the so-called "independent verifier" to assess actual PV generation data and reduces the risk of double-counting of solar electricity within TIGRs, but also within the eco-system (e.g. whether the "green attributes" have been used to obtain other benefits such as the Green Mark scheme for buildings).



Schematic of the TIGRs/RECs ecosystem

ENVIRONMENTAL ATTRIBUTES ASSESSMENT FOR RENEWABLE ENERGY PROJECTS

SERIS has developed an Environmental Attributes Calculator (EAC) available under www.eac.seris.sg where clients can download Environmental Attributes Assessment reports for renewable energy projects with country- or region-specific features. The tool enables clients to visualise equivalencies of the amount of green electricity generated and avoided carbon emissions throughout the economic life span of a project.



Singaporean equivalencies for the annual green electricity produced by a 1 MW_p system

NATIONAL SOLAR REPOSITORY (NSR) OF SINGAPORE

One of SERIS' key goals is to "solarise" Singapore and help to disseminate solar information to the public. The NSR website (www.solar-repository.sg) contains many features, such as a dynamic Solar Economic Handbook which is regularly updated, a LCOE calculator, PV system database, real-life irradiance map, and more.

ABOUT THE SOLAR ENERGY SYSTEM CLUSTER AT SERIS

The Solar Energy System (SES) Cluster focuses on making solar power a cost-effective and trusted source of electricity. The SES cluster offers a wide variety of services, which span from remote monitoring to novel PV system deployments such as Floating Solar and forecasting of irradiance for better grid integration management.

The SES cluster drives several “targeted leadership” areas of SERIS:

- High-performance PV systems for the tropics
- Variability management of PV grid integration
- Solarisation of Singapore / “Urban Solar”
- PV quality assurance

The SES cluster comprises five R&D groups which also offer professional services:

R&D Groups:

Solar System Technology

PV Quality Assurance

Digitisation of Energy

Urban Solar Solutions

Smart O&M



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