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AT SERIS 10TH ANNIVERSARY CELEBRATION
THURSDAY, 5 APRIL 2018
SHAW FOUNDATION ALUMNI HOUSE AUDITORIUM

Professor Tan Eng Chye, NUS President

Emeritus Professor Joachim Luther, Founding CEO of SERIS

Professor Philip Liu, Chairman of the SERIS Supervisory Board

Professor Eicke Weber, Member of SERIS' International Advisory Panel

Distinguished Guests, Colleagues, Ladies and Gentlemen,

1. Good morning and thank you very much for joining us today to celebrate the 10th anniversary of the Solar Energy Research Institute of Singapore, or SERIS, here at NUS.

2. These are exciting times for renewable energies, and solar energy in particular. The costs of solar photovoltaic electricity have been reduced by about 85% in the last 10 years, and are now competitive with fossil fuel based power in many countries, including Singapore.

3. This anniversary is thus a good opportunity to look back at how SERIS has developed in the past 10 years, and to present to you some of the research results that SERIS has achieved in recent years. This is part of the exhibition which we have set up for you.

4. SERIS started its operations on 1st April 2008, as Singapore's national institute for applied solar energy research. This was part of a government initiative to stimulate the establishment of a clean technology, or "cleantech", sector as one of the future pillars of the Singapore economy. As such, collaborations with industry are an integral part of SERIS' genetic code.

5. The mission of SERIS has been to conduct research and development for a sustainable energy supply based on solar resources.

6. The main research and development areas of SERIS in the past 10 years have been:
- Silicon solar cells and modules
- Nanostructured solar cells
- PV module performance analysis
- PV system technology, and
- Solar and energy efficient buildings

7. The institute has grown strongly in the past 10 years and now comprises 220 personnel, including 116 scientists, engineers and technicians, 56 postgraduate research students, 25 technical infrastructure and administration personnel, and 23 adjunct professors from NUS.

8. During its 10-year life, SERIS has taken in 110 PhD students. Of these, 52 have already graduated, and all of them have found good jobs in the solar energy sector, including management positions in industry, group leaders in research institutes, or they have founded their own start-ups.

9. In parallel to training manpower and growing its headcount, SERIS has established more than 3,000 sqm of state-of-the-art laboratories. These include:
- a 1,400 sqm lab that houses a pilot line for industrial high-performance silicon solar cells,
- a 300 sqm pilot line for industrial silicon solar modules, and
- an 800 sqm PV Module Testing Lab that is accredited under ISO 17025 for the provision of high-precision PV module testing according to international standards.

10. SERIS has been using its laboratories for conducting cutting-edge research on low-cost high-performance solar cells, modules and systems. Often, this research was performed in collaboration with companies from Singapore or abroad.

11. For example, in 2012, as part of an industry-funded project, SERIS developed the world's first all-back-contact silicon solar cell with low-cost screen-printed metallisation. The solar cells had efficiencies of over 20% and the technology was successfully transferred to the company.

12. From 2014 to 2016, SERIS supported Singapore-headquartered REC Solar in the development of its award-winning TwinPeak solar module. TwinPeak is a new, high-performance, high-power solar panel with 120 or 144 half-cut cells that transforms more of sunlight into electricity compared with standard panels. Based on multicrystalline silicon PERC technology, half-cut cells and a novel cell connection design, TwinPeak panels have at least 7% more power than standard panels. The world-class efficiency of up to 18% makes it the world's highest-performing multicrystalline silicon solar panel, with power outputs of up to 355 Watt in the 72-cell format.

13. In the past 3 years SERIS developed several low-cost high-performance PV modules, including the world's first full-size bifacial module with IBC solar cells. Such cells have all their metal contacts on the rear surface, which gives higher cell efficiency and a perfectly black appearance of the front surface. We also developed bifacial PV modules for sound barrier applications in urban environments, for example along MRT tracks.

14. In 2017, SERIS developed a 21.5% efficient n-type monocrystalline silicon solar cell that represents one of the world's best compromises between high performance and low-cost processing. N-type silicon has higher solar cell efficiency potential than p-type silicon, and thus such cells are expected to gain significant market share in the coming years.

15. SERIS also developed a novel surface texturing method for diamond-wire sawn multicrystalline silicon wafers. This invention paves the way for the market entry of this much cheaper and cleaner wafer manufacturing method. Several companies are showing strong interest in licensing our technology.

16. Another recent example is "SolarEYE", an all-in-one solar cell characterisation, analysis and simulation tool based on artificial intelligence. This technology has already been licensed to two solar companies.

17. In 2017, SERIS commercialised and licensed an advanced tool design and layer formation method - called "monoPoly technology" - for silicon solar cells with passivated contacts to a large European photovoltaic equipment manufacturer.

18. SERIS has also bundled its comprehensive characterisation and assessment tools into services which we call the “Solar Cell Doctor”, the “PV Module Doctor” and the “PV System Doctor”. Our “hospital services” provide a unique set of value propositions for the PV industry to improve efficiencies, optimise designs and increase energy yields. It is not that we want to compete with the School of Medicine here on campus, but this example describes nicely that SERIS tries to solve “pain points” of our industry partners, which keep them awake at night and affect their bottom lines.

19. Another highlight of the last 10 years was the design and implementation of a PV system in Singapore with 90% performance ratio. The performance ratio describes how well a PV system operates in real-world conditions relative to its module performance in standardised indoor test conditions. This SERIS developed system is one of the best-performing PV systems in the world – despite the tougher climatic conditions here in the tropics, with constant high temperatures and high humidity.

20. After this PV system was installed in 2011, we did not immediately write a scientific paper about it. Instead, we went out and held 8 workshops with the local PV system integration community to bring the messages and clues across about how to optimise the system design and maximise energy yields in space-constraint Singapore. This is another good example of how SERIS operates and helps the industry to grow sustainably.

21. SERIS has also developed a proprietary and award-winning real-time monitoring system with very high reliability and availability. This is the backbone of the well-known “Live irradiance map of Singapore**”**, which is also shared with the general public on the National Solar Repository website, or NSR for short. Singapore is the only country in the world which has such a live irradiance map!

22. The NSR website is a one-stop shop for solar PV in Singapore that contains a large amount of useful information for the general public. For example, it hosts the Solar Economics Handbook of Singapore, which consists of more than 90 pages describing the global solar market, the Singapore energy landscape, the current solar deployment rate in Singapore, and the economic viability of solar PV for various types of roof-top owners and investors.

23. The real-time monitoring of the solar resource is of paramount importance for assessing the impact of the variable output from solar PV systems on Singapore’s electric power grid. It is also the base for SERIS’ solar forecasting activities, which are well respected internationally, and recently contributed to the award of a large grant by the Energy Market Authority of Singapore, or EMA, to integrate solar forecasting into the actual power system operation in Singapore. The research is conducted jointly by SERIS, the Electrical and Computer Engineering Department of NUS as the project lead, the Centre for Remote Imaging, Sensing and Processing at NUS, A*STAR’s Experimental Power Grid Centre, and Met Services Singapore.

24. In parallel to developing advanced or novel solar technologies, the other key mission of SERIS has been to serve the national needs for solar adoption and industry growth. SERIS is therefore a pillar of Singapore’s efforts towards reducing greenhouse gas emissions and lowering its carbon intensity.

25. The solar industry in Singapore has developed well in the past 10 years, and there are now more than 80 solar companies with operations in the city state. Starting from a humble base in 2008, Singapore is now an important player in the global solar sector, including R&D, manufacturing, deployment, as well as financing and project development of solar PV systems in Southeast Asia and beyond.

26. In the R&D sector, Singapore has established SERIS, which is now one of the 10 largest solar laboratories in the world.

27. Similarly, in the manufacturing sector, Singapore hosts one of the world's largest and most advanced vertically integrated manufacturing facilities for silicon wafers, solar cells and PV modules. The $2.5 billion factory in Tuas, established, owned and operated by REC Solar, produces 1.3 GW of solar modules per year, representing about 1.5% of the global production. To put this into perspective, REC's factory produces about as many solar panels each year as there are inhabitants in Singapore. Thus, on a per-capita basis, Singapore is the largest PV panel producer in the world!

28. In terms of deployment of solar systems, Singapore's highly urbanised landscape poses some challenges, as there is no space for large land-based systems. However, there are tens of thousands of rooftops that can potentially be used.

29. Singapore's solar market has grown strongly in the last 5 years and presently consists of rooftop PV systems with a capacity of about 140 MW-peak, which corresponds to an area of about 230 soccer fields.

30. Supported by visionary Government programmes such as SolarNova and the world's largest Floating PV testbed, Singapore is on track to host solar PV systems with a peak capacity of several hundred MW-peak by 2020. Beyond 2020, Singapore is expected to deploy 1 GW-peak of solar PV systems.

31. In the area of Floating Solar, Singapore is now widely recognised as the global leader, as can be seen from the cover story of the latest PV Tech Magazine or the fact that SERIS is presently writing the first guidebook on Floating Solar, funded and commissioned by the World Bank in Washington DC.

32. SERIS has also strongly been supporting the SolarNova initiative of the Singapore government, by providing technical expertise and economic viability assessments, but also through developing innovative tools for evaluating the suitability of buildings for solar deployment using drone-based 3D modelling and proprietary ray-tracing algorithms.

33. In the next 10 years, in collaboration with partners from industry, SERIS will conduct innovative R&D programmes that will lead to strongly improved solar cells, modules and systems, providing further drastic reductions of the levelised cost of electricity (or LCOE) from PV systems.

34. Furthermore, SERIS will continue to play an important role in the solarisation of Singapore and the creation of a diverse solar industry.

35. Going forward, there will be 3 new flagship R&D projects at SERIS:
- The first is the development of a 30% efficient thin-film-on-silicon tandem solar cell, in a collaborative project with NTU and CREATE;
- The second is the development of low-cost high-efficiency building-integrated PV, or BIPV, modules and systems to replace parts of the building envelope with PV, including the facades;
- The third is the development of a multi-purpose floating PV system, which is also suitable for off-shore applications in sheltered waters like Singapore.

36. Other major R&D projects at SERIS will target international leadership in the areas of:
(1) Industrial silicon wafer solar cells,
(2) Industrial PV module development and testing,

(3) “Urban solar”, meaning innovative deployment of PV systems in an urban environment, such as in facades, in walkways or as fences or sound barriers,
(4) Variability management for PV grid integration, and
(5) PV quality assurance.

37. SERIS is optimistic that its R&D activities will contribute significantly to further drastic reductions of the cost of solar electricity, as well as the growth of new market segments such as BIPV and Floating PV. In combination with distributed and grid-scale electric energy storage, this will make solar power highly competitive in the Singapore market.

38. Ladies and Gentlemen, as you can see, solar technologies are progressing rapidly and their future looks very bright. If research institutes such as SERIS and the solar industry keep innovating, then solar will gain an ever increasing share of the power generation mix. This in turn will help Singapore to achieve its carbon emission targets, and at the same time will provide a clean, green and healthy environment for future generations.

39. In conclusion, I would like to thank all SERIS staff, adjunct professors and students for their many contributions and achievements throughout the last 10 years. SERIS sincerely thanks all its industry partners and supporters over the past decade, especially the National Research Foundation, the Economic Development Board, the Building and Construction Authority, the Energy Market Authority, the Housing and Development Board, the National Climate Change Secretariat, the National Energy Transformation Office, the National Environment Agency, the Public Utilities Board, the Sustainable Energy Association of Singapore, the National University of Singapore, our Supervisory Board, our International Advisory Panel, and other collaborators in the public and private sectors.

40. Thank you very much.