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Solar Energy Strategy for Sri Lanka: The Solar Village Solution for Sustainable Development and Poverty Reduction

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Abstract

This paper will first summarise few relevant projects for energy production using solar energy for Sri Lanka. Amongst these projects, the "Solar Village" will be the main focus of this paper. This will include a brief history of the development of this project through an HE-Link programme in the 1990s. The pilot project started in 2008 in Kurunegala District and its tremendous impacts on social development will be discussed. Solar village concepts used to empower village communities, combat climate change issues and find solutions to social problems like kidney diseases due to non-availability of clean and drinkable water will be presented. There are 13 out of 17 SDGs (sustainable development goals as highlighted by the United Nations) embedded in this particular project by channelling new Science and Technologies towards Social development. With the help of two charity organisations {APSL-UK (Association of Professional Sri Lankans in the UK) and Helasarana}, another few Solar Villages are commencing soon as a replica of the pilot project.

1.0 Introduction

This paper summarises the keynote speech given by the author at Science and Technology for Society Forum Sri Lanka 2016, held in Colombo during 7-10 September 2016. Although the paper focuses on sustainable development of Sri Lanka, it is equally valid for developing countries in the sun-belt. The Forum discussed the role of Science and Technology in Society especially in achieving the 17 Sustainable Development Goals (SDGs), set out by the United Nations Development Programme, last year. The event was attended by over 1000 participants, and well organised by the National Science Foundation and the Ministry of Science and Technology. The opening ceremony was held at Nelum Pokuna theatre, and graced by His Excellency the President, Hon. Prime Minister and Hon. Science and Technology Minister. This is an excellent initiative to create numerous projects to develop a knowledge-based economy in Sri Lanka. The presentation given and this paper summarise the author's efforts devoted over the past 20 years with Sri Lankan Universities to build capacity in solar energy research and applications in the society.

2.0 Current Status of Solar Energy

Although photovoltaic (PV) solar energy conversion was first discovered in 1839 by Henry Becquerel, the PV devices were not fabricated until the 1950s, due to the availability of fossil fuel at low prices. The PV devices were first used for satellite applications by 1960s, and the real interest in terrestrial energy conversion started after the first oil crisis in the early 1970s. The cost of PV solar energy was expensive at the beginning at ~100 US$/W and drastically reduced because of scientific research in the field. This cost reduction is shown in Figure 1 as a function of time. At present the cost of solar panel is ~0.60 US$/W and it is interesting to know that grid parity has been achieved in some sunny countries. This cost reduction is continuing due to worldwide scientific research and development in the field.

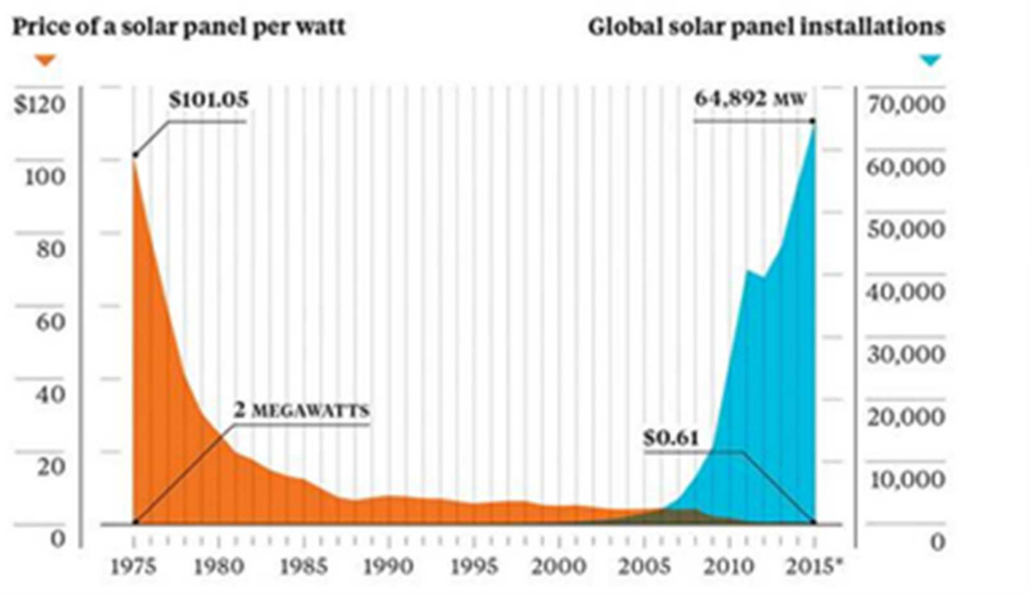

Figure 1: Change of solar panel cost and Global solar panel installations as a function of time. Note the drastic cost reduction and exponential increase in solar energy application between the 1980's and at present.

The global solar energy applications started in the 1990s and showed a rapid growth exceeding exponential growth. In the year 2015, ~65 GW of solar panels were installed making the total solar power production capacity to ~300 GW. This is also shown in Figure 1, and this trend is going to accelerate in the future.

3.0 Solar Energy Strategy for Sri Lanka

As a result of gradual increase in the global population, energy demand is going to increase, and this demand cannot be provided by the conventional fossil fuels due to their gradual depletion and increase in the prices. Pollution already created by burning fossil fuels is a real concern today. The solution is to introduce clean energy technologies to fill this gap while

improving the efficiency of conventional energy production in order not to further pollute the environment. The use of renewables such as solar energy is extremely important and advantageous in sun-belt countries like Sri Lanka.
In order to move towards energy independence and sustainable development, Sri Lanka should develop a technology-mix using available indigenous energy sources (Hydro, Solar, Wind, Bio-mass etc.), and reduce the use of imported fossil fuels. Hydro-power is already well established in Sri Lanka, and solar energy is at the top of renewables list and following five areas are crucial.

3.1 Use "Solar Home Systems" for house-holds not connected to the National Grid

Complete electrification target using the National Grid (NG) is noble but economically not viable in a country like Sri Lanka with scattered households. Therefore, Solar Home Systems (see Figure 2) should be used to help the poorest community in the country, not connected to the NG. These systems are widely used in many parts of the world including Sri Lanka. These systems will provide power for few lights, radio and the television. These systems cost between Rs 40,000 to 60,000 depending on the size, but not attractive when the grid is available. Limitation can arise due to energy storage using batteries, but lighting can be improved using bulbs based on Light Emitting Diodes (LEDs).

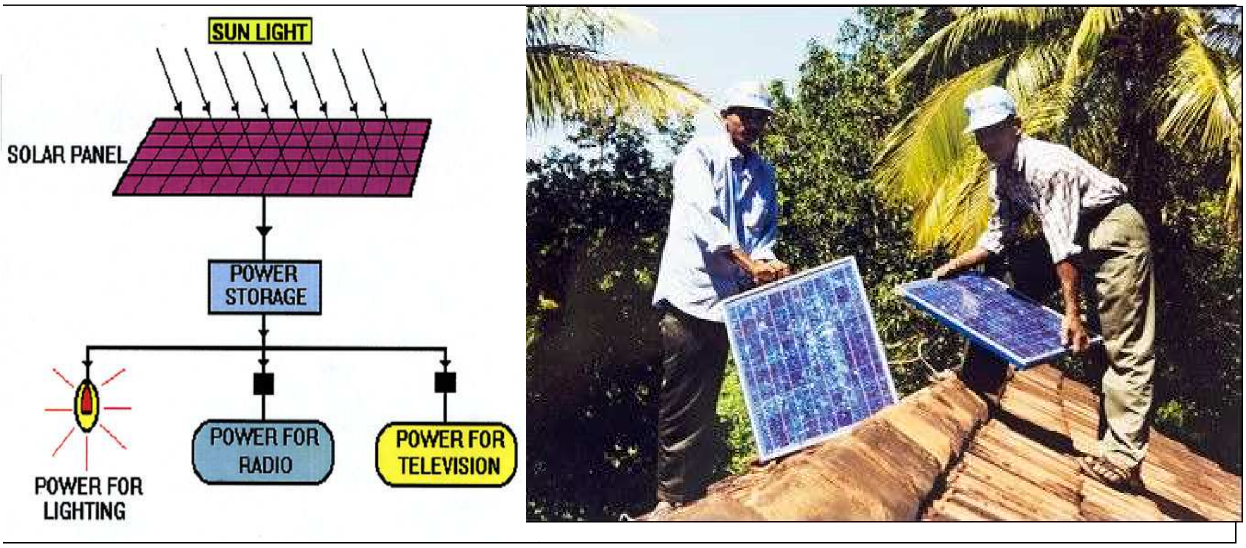

Figure 2: Schematic diagram of a Solar Home System and an example of a real system in Sri Lanka.

3.2 Establish "Solar Villages" in Sri Lanka to develop every corner of the country

Approximately 80% of the Sri Lankan population live in villages and their livelihood depends on agricultural products. Therefore, it is necessary to "Empower" these communities to develop themselves via projects like "Solar Villages". The main aim of the STS-Sri Lanka 2016 presentation and this paper is to brief on the "Solar Village" project.

Figure 3: About 85 final year students with five staff members from Sri Jayewardenepura University taking part in the opening of the pilot Solar Village in 2008.

3.3 Introduce "Solar Roofs" for production of power and feed the National Grid

The introduction of solar roofs for middle-income families and connect to the NG via net metering, payment for excess energy produced & fed to the grid, and unlocking people's personal savings for this purpose is economically viable. The recent announcement on one Million Solar Roof project by the Power and Energy Ministry is applaudable as a move in the right direction. As proposed, providing financial assistance to low and middle-income families will help in their economic development contributing to clean energy production. One Million, 3.0 kW roofs will be equivalent to 3 GW power production capacity during the day time for industries to use, and save water in reservoirs to use during the night time. Combination of solar roofs and hydro-power is an excellent way of energy production and storage. Meanwhile, the NG should be upgraded continuously to move towards a "Smart Grid".

Figure 4: Typical solar roofs appearing around the Globe as a result of Solar Revolution which started at the beginning of the 21st Century.

Incentives introduced by the UK Government in 2010, by paying 43.5p per energy unit produced by solar energy led to mushrooming of solar roofs in the country. Even the pensioners used their funds to install solar roofs and within a 2-3 year period, 5 GW of power was produced using solar roofs. If this number of solar roofs appears in Sri Lanka, the output could be doubled or trebled this amount due to strong sunshine available in Sri Lanka. In fact, these types of incentives will unlock personal savings from the general public, and the Government doesn't have to borrow money increasing the country's debt. UK Government is working to increase this power production to 15 GW by the year 2020. It is pleasing to see one in five roofs in Germany becoming a solar roof. The new scheme announced recently in Sri Lanka will also have a great impact in helping many aspects of the sustainable development.

Decisions taken in the recent past to go for imported and polluting coal fuel as the main energy source in Sri Lanka is damaging and cannot be understood. However, using already established coal plants to provide a breathing time, a technology-mix should be established within the country and later, it is sensible to allow the coal burning to phase out as soon as possible.

3.4 Develop Very Large Scale-PV systems (VLS-PV) to feed the NG

PV solar technology has rapidly developed to a stage that solar farms in which a few hundred MW can be generated have been built. Large solar farms are appearing in many countries (see Figure 5) producing large amounts of energy and feeding the NG. Sri Lanka also has established approximately 500 kW size two solar farms and these are useful in training electrical engineers and performance monitoring purpose. In these projects, covering fertile lands should be avoided.

The most sensible and profitable solar farms can be developed in arid lands and desert areas. Japanese scholars Kurokawa and Komoto have edited books on "Energy from Deserts". Now the practical and very large scale-PV systems (VLS-PV) of 50, 100 and 200 MW size solar farms are appearing in many countries. Energy from desert has numerous benefits like preventing desertification and food production through drip irrigation using un-cultivated shaded land areas, in addition to the power production. China is currently building a 200 MW solar farm in Gobi desert.

Sri Lankans need to realise the slow desertification is taking place in Jaffna peninsula. Sand and Palmira trees (Palm trees) are the early signs of desertification and it is high time for people to recognise this at the early stages and take right actions. Once the palm trees are gone the land becomes a complete desert and then starts slow expansion. Currently experiencing Global warming and Climate Change could only accelerate this process. Solar technology will provide the solution by slow water pumping, tree planting and food cultivation through drip irrigation. Mannar Island is an ideal place to build a large solar farm and grow vegetables on shaded land.

Figure 5: Examples of solar farms in Germany and in desert areas. Energy from desert provides additional benefits like stopping desertification and food production using previously unused lands.

3.5 Build Capacity through Scientific Research and Establish solar panel manufacturing in Sri Lanka.

To carry out all the above projects, human capacity should be built within the country. This is essential for a knowledge-based society and higher education institutes should take this responsibility. The Higher Education Link programme (HE-Link) continued in the 1990s, initiated and coordinated by the author was mainly aimed at this aim. This ~8 year programme was funded by the UK-DFID (UK-Department For International Development) and managed by the British Council. The network developed focussed on establishing solar energy research in local universities producing graduates with MSc and PhDs, and promoting clean energy technologies for social development and poverty reduction. Young academics from local universities also benefitted from several scholarship opportunities opened up through this HE-Link programme. This work is now self-sustaining and continuing with some universities in Sri Lanka.

Establishing solar panel manufacturing in Sri Lanka is also essential to reduce import costs of solar panels, and create local jobs. The best way forward is for local companies to link up with established solar panel manufacturing companies and start joint ventures, with the support from the Government. Developing countries like Sri Lanka should avoid long process of Spin-Out company formation in this field due to the complexity of the subject. This time consuming and expensive process should take place in developed countries with available funds. For example, the Apollo project to develop CdTe thin film solar panels started by British Petroleum Company, where the author was also a member of the development team of 26 scientists, continued for ~15 years to manufacture ~1.0 m^2 solar panels. This process is extremely heavy for developing countries like Sri Lanka.

4.0 Solar Villages For Sustainable Development & Reduction of Poverty

During the HE-Link programme continued about 8 years in the 1990s, over 40 senior academic visits were completed between collaborating universities in Sri Lanka and the Author's solar energy research group at Sheffield Hallam University. In addition to scientific research, the author spent half of his efforts to promote Renewables by delivering public understanding of science lectures in schools, universities, social events and Government Ministries in both countries. An annual local conference series was also organised to cover both scientific research and applications. Later this local network expanded to SAREP (South Asia Renewable Energy Programme) and established and international "Solar Asia" conference series. This conference series started from Sri Lanka (2011) and held in Malaysia (2013) and in India (2015). The aim of this conference series is to accelerate solar energy research and applications in the South Asia region. The author's main aim was to design a project (Solar Village) to use clean energy technologies to develop deprived communities in developing countries, in addition to his scientific research in this field.

4.1 Design Stage During a HE-Link Program

Figure 6 shows a picture visualised and drawn by a child in ~2000 after listening to a presentation on solar villages. It contains many possible activities like street lighting, solar home systems, solar roofs, planted trees, animal & vegetable farming and small industries like brick making.

Figure 6: A child's drawing of a Solar Village containing some features discussed during the design stage.

4.2 Beginning of the Pilot Solar Village

The design stage was turned into reality in September 2008, when the diesel powered water pump was replaced by a solar water pumping system at Kaduruwewa village cluster in Kurunegala District. All other infrastructure was built by the Government supported by the World Bank project. After this, the project entered into a guiding and monitoring period.

Figure 7: The pilot Solar Village started in 2008 by replacing a diesel water pump by a solar water pumping system.

Figure 8: Official opening of the Solar Village project in the village Temple with the village community attending with the visiting university students and staff.

4.3 Aims & objectives of the Solar Village

- To **empower** rural communities by introducing clean energy technologies, and guide them to escape from poverty traps
- To improve water & food security in deprived communities, while uplifting their living standards
- To find solutions to climate change, improve environment and reduce the burning of fossil fuel
- To take new technologies from laboratory to the society for sustainable development.

4.4 Activities Taking Place in the Solar Village

With the guidance from project initiators, village community involves in various projects such as Tree planting, Organic farming, Beekeeping, Improvement of the Village School, Temple, Nursery and the Library. **13 out of 17 UN SDGs are embedded within this particular project.** Community members work together in various development projects to improve their living standards reducing poverty within that community.

Figure 9: Various activities taking place within the pilot solar village.

4.5 Main Impacts of the Solar Village

The primary school was mainly built by the villagers and was running for 50 years without tap water or electricity from the grid. Since this area is dry and modern facilities are low, it was hard to retain the teachers in the school for a reasonable length. As a result, the number of pupils was reduced to ~20 and the Government decided to close the school in 2007. The prompt action by the Head Teacher, Mr. Lansakara contacted the Author and established the first solar village in this cluster of villages, and all meetings were held in this primary school or in the Temple. As a result of the initiation of the pilot solar village, the school received free tap water and electricity from the grid. The temple also received free water from the solar water pumping system. With this initiation many other facilities improved, with the financial support from the Education Department and some of the main impacts noted are given below.

- The village school earmarked for closure in 2007, after applying Solar Village ideas, now has Electricity, Free running water, Few computers, and the student number increased from ~20 to 85
- The same school now ranking 4th out of 255 primary schools in the region, with an added new building
- The environment of the school has improved tremendously, and teachers do not want to leave the school
- Village Temple shows rapid development and all households show rapid economic development.

Figure 10: Impressive development that took place in the village school after starting the solar village project ideas.

4.6 Replication Plans of the Solar Village Project

This is a tried and tested project with successful outcomes, and therefore current efforts are towards replication of this project within and outside Sri Lanka. A recent short presentation in an APSL-UK meeting in London attracted interests from two charity organisations, APSL-UK and Helasarana to establish few Solar Villages in different parts of Sri Lanka as indicated by Figure 11. The author continuously presents the high impact of this project in international conferences, and initial work is taking place to initiate such projects in countries like Malaysia and Nigeria. Taking new Science & Technology to develop needy communities has tremendous impact on sustainable development.

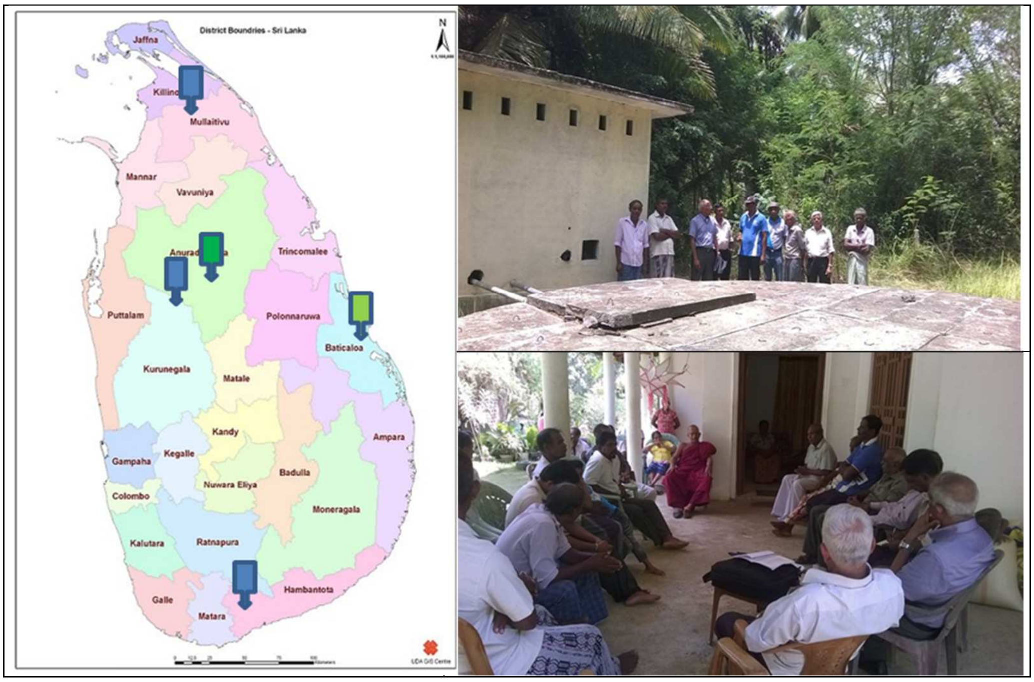

Figure 11: The initial meeting of APSL-UK and Helasarana representatives with community leaders at Nochchiya village to establish a new solar village.

Several Solar Villages will be established with funding from Charitable Organisations and personal funds from interested and generous donors. Figure 11 shows the initial discussions held at Nochchiya village community in August 2016, to start and apply Solar Village concepts to develop over 1000 people living in that village cluster. We hope, when the Professionals design, pilot, monitor and start replication of successful projects like these, the local Governments will pick-up and widely establish for sustainable development.

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   https://dharmesblog.wordpress.com/

About the Author

The author is currently working at Sheffield Hallam University in the UK as a Senior Staff Grade Professor and Head of the Electronic Materials & Sensors Group. He is a graduate of the University of Peradeniya in Sri Lanka, and completed his postgraduate research in University of Durham on Electronic Materials & Devices and Solar Energy conversion, by winning an open commonwealth scholarship in 1977.

Since then, he has continued his research work and professional activities in Sri Lanka and the United Kingdom, in both academia (Peradeniya, Cardiff and Sheffield) and in Industry (BP-Research Sunbury). He was involved in the commercialisation of CdTe thin film solar cells within BP-Apollo project. In his subsequent research and development programme, he has successfully supervised 20 PhD theses to date and currently supervising 3 PhD candidates. He is currently a referee for 12 learned Journals and one of the Editors of the Journal of Material Science; Materials in Electronics. In the past, he has served six years each as an Assessor/panel member for EPSRC (UK-Engineering & Physical Sciences Research Council), DTI (UK-Dept. of Trade & Industry) and the British Council. He currently serves as an expert for Solar Energy panel in European Commission, and a member of the academic advisory board for the Commonwealth Scholarship Commission in the UK. His single-authored book on "Advances in Thin Film Solar Cells" was released in September 2012. In addition to his Lecturing and R&D work at Sheffield Hallam University, he has been involved actively in public understanding of science work on "clean energy technologies" over the past 25 years. The "Solar Village" project was born as a result of this continuous effort to help needy people.