SERIIUS at the Indo-US Energy Dialogue

The Indo-US Ministerial Energy Dialogue was held on September 21, 2015, at the U.S. Department of Energy, Washington. The Indian delegation was led by Mr. Piyush Goyal, Minister of State (Independent Charge) for Power, Coal, New and Renewable Energy and U.S. was led by Dr. Ernest Moniz, the U.S. Secretary of Energy.

Dr. Ernest Moniz and Mr. Piyush Goyal at the U.S.-India Energy Dialogue. The PACE-R consortium, including SERIIUS, gave presentations at the event.

During the dialogues, the Minister and Secretary reviewed the progress made by the six Working Groups of the Energy Dialogue including the new PACE-R Working Group.

Mr. Goyal stressed on the objective of the Government of India to provide 24x7 power across India by 2019 and to accomplish this he emphasized that India was committed to pursue a green path to growth. He also elaborated on India's plans for deployment of 175 GW Renewable Power capacities by 2022, including 100 GW of solar and 60 GW of wind.

To achieve the goals of the joint dialogue, activities on four separate levels include:

1. PACE: Established in 2009, the Partnership to Advance Clean Energy (PACE), which continues to be a cornerstone of cooperation, is on track to help the Indian government achieve its energy and development related missions. So far, it has mobilized $2.4 billion for clean energy finance, helping India meet the first gigawatt of its ambitious 100 gigawatt solar energy target.
2. JCERDC: The Joint Clean Energy R&D Center (under PACE-R) is encouraging technological innovation in solar energy, biofuels, and energy efficiency for buildings. There are plans to expand this research partnership into the critical areas of smart grids and energy storage for grid applications. This is where SERIIUS operates.
3. PEACE: Through the Promoting Energy Access through Clean Energy (PEACE) initiative, launched in 2013, we are working together in support of India's goal to bring electricity access to roughly 300 million people (nearly the population of the United States). This initiative supports the development and deployment of innovative off-grid technologies and business models.
4. PACESetter Fund: The Energy Dialogue was particularly exciting because of the recently launched PACESetter fund, which will provide $8 million in partnership with the Indian Government to support innovation in energy access delivery.

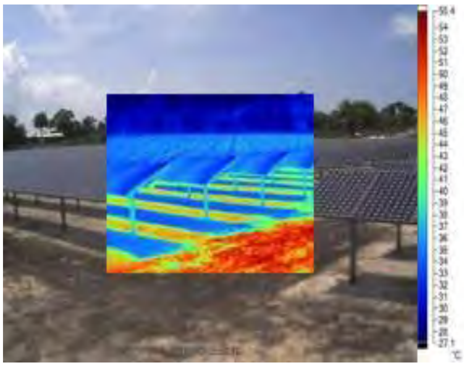
During the dialogue, there were presentations made on the progress under various joint research programs like Partnership to Advance Clean Energy - Research (PACE - R), including in the field of solar energy, energy efficient buildings and biofuels. The Solar Energy Research Institute for India and the US (SERIIUS) presented (David Ginley and Kamanio Chattopadhyay co-directors) on its three-pronged approach to develop new deployable solar technologies. This includes low-cost photovoltaics (PV), multi-scale concentrated solar power (solar thermal), and a detailed understanding of the applicability and bankability of the systems. Particularly the need for multi-scale solutions for India and the U.S. going from individual homes to mega-cities was highlighted.

SERIIUS reported on the progress in developing new thin-film PV technologies based on roll-to-roll processing and using Corning's Flexible Willow glass as a substrate.

This approach targets producing low-cost routes to high-performance PV in systems including CIGS, CZTS, polymer-based photovoltaics and the new perovskite-based materials. Coupled to this is the development of atoms to modules modeling, benefiting both the new technologies and the established Si technologies.

New approaches to solar cell processing using roll-to-roll flexible glass currently being developed under SERIIUS PV thrust

The SERIIUS consortium is also evaluating and mitigating the effects of dust and the hot and humid climate on the reliability of solar panels in India.



Developing ways to assess reliability in hot and humid environs – thermal imaging of arrays

In the Concentrated Solar Power (CSP) area, SERIIUS reported on the development of scalable CSP technologies going from kilowatts to megawatts using supercritical CO_2 Brayton cycle for high temperature power conversion in solar tower and Organic Rankine cycle for low-temperature parabolic trough systems.

The CSP efforts have resulted in a new technology including new low cost heliostats and parabolic troughs that can affect both the U.S. and India.

Field testing of new parabolic trough designs

The Solar Energy Integration (SEI) efforts are to understand technology to market, resource assessment and bankability vs scale issues, which are critical for defining the context of the new systems. The thrust reported on the feasibility of making solar-grade Si in India and also, on the improvement of the power output quality by geographical smoothing of solar PV plants in Gujarat.

SERIIUS Reception and All-Hands Workshop, New Orleans, LA June 2015

A SERIIUS reception and Meeting for Business was organised in conjunction with the IEEE Photovoltaic Specialists Conference on June 17 at New Orleans where various SERIIUS activities currently under progress were show cased through overview talks, posters and discussions. The meeting was attended by stakeholders in solar domain across academia, Industry and government from within and outside SERIIUS. This was followed by SERIIUS All-Hands internal review meeting held on June 19-20 at the same location. The detailed meetings across PV, CSP and SEI thrusts helped to refine the current goals and brought the various teams together to work on the integrated SERIIUS project plans. The teams also reviewed the activities planned in the remaining two years of SERIIUS programme in context of the Indo-US solar initiatives and targets.

Joel Ager (LBNL), Bala Kavaipatti (IIT-B) and Cynthia Lo (WuSTL), during the SERIIUS poster session at the IEEE PV Conference at New Orleans on June 18, 2015

SERIIUS researchers in the All-Hands internal review meeting at New Orleans on June 20, 2015

Dr. Nettem Choudary and Dr. Peddy Rao of Hindustan Petroleum Corporation Limited (SERIIUS Industry partner) with Marisa Howe of NREL during their June 2015 visit to NREL.

Rajiv Sharma, Sanjay Bajpai, Vandana Nath of IUSSTF-DST team visiting NREL, June 2015

MAGEEP-SERIIUS Intern Scholarship Highlights

Jesus Daniel Ortega from Sandia National Laboratories (SNL), US worked with the SERIIUS team at the Indian Institute of Science (IISc) on the modeling and analysis of supercritical carbon dioxide (s-CO2) receivers as part of the CSP activities. The team developed tools for undertaking structural analyses required for the evaluation of the receiver components. Jesus also participated in the analysis of the receivers being developed by IISc and Indian Institute of Technology (IIT) Bombay. Based on this work, the team has planned one journal and three conference papers as joint publications.

SNL Mentor- Dr. Cliff Ho

IISc Mentor- Dr. Vinod Srinivasan

Jesus calibrating the test setup used at IISc for receiver tests

Oluwatobi A. Oluwatola from RAND Corporation, US worked at the Center for Study of Science, Technology and Policy (CSTEP) under SEI thrust on a project titled "Green Industrial Policy in India's Solar Industry" as part of his dissertation. The study aims to lay out the political issues as well as economic costs and benefits of supporting solar PV manufacturing growth in India. Oluwatobi spent time in India by talking to about 25 experts in solar manufacturing and development, government, and research. His findings show that while the economics of domestic manufacturing in India may not be net positive as of now, many experts agree that there is strategic value in maintaining a threshold level of manufacturing domestically particularly in the interest of energy security and domain learning.

RAND Mentor: Dr. Aimee Curtright

CSTEP Mentor: Dr. Sharath Rao

Oluwatobi with SERIIUS-SEI team members at CSTEP, Bengaluru

SERIIUS Select Project Highlights

1) PV: Soiling Losses for Commercial PV modules

Team Members: Arizona State Univ., NISE (MNRE), NREL, IISc-Bangalore and IIT-Bombay

With the global installed PV capacity nearing 200 GW, many countries are scaling up their PV installations almost exponentially. Many of the countries that are rich in solar energy may also see a huge loss (sometimes above 50%) in PV performance due to dust accumulation. One of the project objectives is to address the concerns of the PV community regarding the reduction in PV system performance due to dust accumulation on PV modules, especially in the Indian context.

One major challenge faced by the PV industry is to estimate the severity of the soiling for a given geographical location. Evaluation of soiling loss on PV modules in a geographical location involves collecting performance and soil data from a fielded PV system of that location. This is usually a time consuming, operation intrusive and expensive undertaking. Hence, we have proposed collecting dust samples from various location of interest, preferably from the module surface, and use them for conducting performance loss experiments due to soiling in laboratory. In this work, based on the Sandia's approach, researchers from IIT Bombay and Arizona State University have collaborated to develop a low-cost artificial dust deposition technique. This could be used to deposit dust on a module or coupon surface in a controlled manner, which helps in predicting soiling loss associated with various dust properties including densities, chemical compositions, and particle sizes. The soil samples covering six different geographic locations in India with diverse climatic conditions were collected and soiling loss at the same dust density of 1.8 g/m^2 is shown in Figure 1. The large variations in loss are attributed to the sediment type and chemical composition of the dust. We have also estimated the soiling losses for various commercial PV module technologies and the results are shown in Table 1.

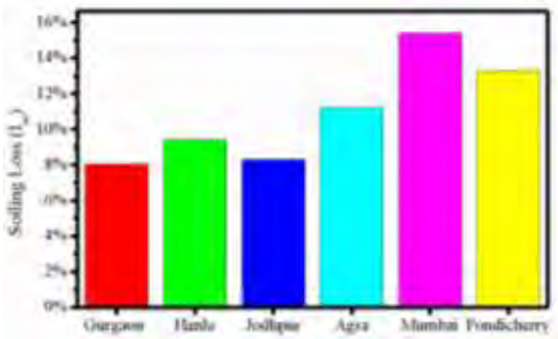


Figure 1: Comparison of I_{SC} (soiling loss) for crystalline silicon technology due to dust of same gravimetric density (1.8 g/m^2) from various locations

TABLE 1
SIMULATED SOILING LOSS OF DUST SAMPLES (1.8 G/M^2) FROM 6 LOCATIONS

Soil Samples collected from	Soiling loss (%) of PV Module Technologies			
	a-Si	CdTe	CIGS	c-Si
Mumbai	17.7	15.7	15.4	14.5
Pondicherry	15.5	13.8	12.7	12.4
Jodhpur	9.2	8.5	8.4	7.9
Hanle	10.2	9.5	9.5	8.9
Gurgaon	8.4	7.8	8.3	7.5
Agra	11.9	11.1	11.4	10.6

The artificial soiling technique can also be used for rapid testing of the efficacy of anti-soiling coatings. This SERIIUS Indo-US joint work has been accepted in the IEEE Journal of Photovoltaics.

2) CSP: Pressurized high-temperature receivers for solar powered s-CO_2Brayton cycle

Team Members: Sandia National Lab, IISc-Bangalore, IIT-Bombay, BHEL-Bangalore

Objective: The objective of the project is to design, optimize, fabricate, and test suitable solar receivers that can be used to provide heat to a high temperature supercritical CO_2 (s-CO_2) Brayton cycle. The major challenges in implementing solar receivers with s-CO_2 power cycles include high fluid pressures (~20 MPa) and temperatures (~700 °C).

Receiver Configurations: After a detailed review of alternate receiver configurations, tubular and volumetric receivers were identified as potential configurations for direct heating of s-CO_2. Indirect receiver designs using a different heat transfer fluid in the receiver were also considered. These require an additional heat exchanger to heat s-CO_2. Volumetric air receivers, tubular and falling particle receivers are candidates for indirect heating of s-CO_2. The heat-transfer media employed by indirect receiver designs can be air, molten salts, liquid metals, or solid particles. Three design concepts were chosen for an extensive analysis at small scales (~kW, for testing and demonstration), as well as at large scales (~MW, for power generation).The tubular receiver consists of modular panels. Each panel employs straight, parallel metallic tubes connected to a common header. A large number of panels can be arranged adjacent to each other depending on the concentrator arrangement. The incoming concentrated radiation impinges on the tubes, while simultaneous flow of s-CO_2 through the tubes convects the heat away from the receiver.

In the helical coil receiver, the hot, pressurized s-CO_2 flows inside the coiled metallic tubes. Depending on the concentrator, the receiver maybe irradiated on the inside and act like a cavity, or the receiver might be exposed to a heliostat field where heat impinges on the outside of the cylinder-like surfaces created by the coils.

The volumetric receiver has an absorber placed inside a pressurized chamber with a window. The absorber gets heated due to irradiation from the concentrator. The absorber may consist of a tortuous porous media or a structured one (like a straight channelled one in helical coil receiver), and can be made with high temperature ceramics such as silicon carbide. The incoming radiation penetrates the volume of the absorber. Simultaneous flow of heat transfer fluid through the absorber cools it. While direct use of s-CO_2 at pressures ~20 MPa presents a humongous challenge with this configuration (due to the glass window), heating air (at a moderate pressure ~1.5 MPa) as a heat transfer fluid prior to transferring heat to the s-CO_2 through a separate heat exchanger is an option.

Simulation & Analysis: The team has also undertaken a coupled optical-thermal-fluid-structural analysis of these receiver designs for various scales of heat input and heat transfer fluids. An in-house MATLAB code has been developed for direct mapping of the heat flux from a ray-tracing tool (SolTrace). This has yielded more realistic heat flux and temperature distributions (Figure 2). A more accurate prediction of the thermal stresses in addition to the static stresses due to pressurized fluid has thus been obtained. Coupled creep-fatigue analyses for cyclic and constant loading conditions have also been studied in detail for the designs.

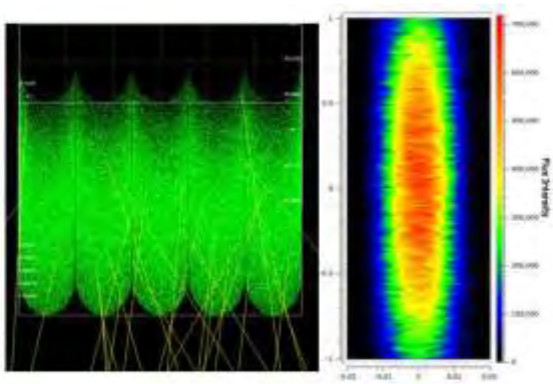


Figure 2: *SolTrace ray intersections and heat flux distribution on a tube surface*

Testing: A single axis tracking test rig (Figure 3) using a 1.1 m diameter Fresnel lens as a concentrator has been constructed and testing of small-scale modules with air as the working fluid is underway. The test rig can give very high concentrations (average concentration ratio ~1500), and can be used to test receiver as well as other materials requiring high temperatures.

Figure 3: *Single axis tracking test rig for testing at small scales*

Small modules of the volumetric receiver and the helical coil receiver (Figure 4) are currently being tested and testing at larger scales will follow soon.

In addition to having co-authored a number of joint publications, preparation of a document named 'Design Requirements' which will serve as a guideline for design, manufacturing and operation of pressurized high temperature receivers is also underway. Recently, the team has also successfully submitted a Concept Paper for a novel receiver configuration.

Figure 4: *Small-scale helical coil receiver*

To facilitate this collaborative effort, two SERIIUS-MAGEEP exchange fellows, one each from IISc-Bangalore and SNL, have completed their visits successfully.

MAGEEP-SERIIUS scholar Sagar Khivsara from IISc, India visiting SNL, US

MAGEEP-SERIIUS scholar Jesus Ortega from SNL, US with Prof. Kamanio Chattopadhyay at IISc, India

Interview

Dr. Phyllis Yoshida (DoE) is the Deputy Assistant Secretary for Asia and the Americas at the Office of International Affairs at the U.S. Department of Energy (DOE). She works on administrative policy implementation and supports the development of international cooperation on issues pertaining to science, technology, and energy policy. She has to her credit over 40 publications related to industrial science and technology, including widely cited work on the globalization of R&D and on government-industry relations. She responded to the interview questions posed by Dr. Sharath Rao of CSTEP SEI team.

Q: *What are the key takeaways from the recently concluded US-India Energy Dialogue? Can you also highlight the areas/activities of relevance to solar energy?*

A: We have a broad portfolio of energy collaboration between our two countries – which we discussed in detail during the U.S.-India Energy Dialogue. We had the opportunity to discuss the progress made in identifying paths for bringing down the cost of clean energy technology and finance by both the teams. We heard from the three PACE-R consortia on their progress, the road ahead, and discussed joint work to support India's ambitious goals for off-grid clean energy access. This presents tremendous potential for advanced off-grid technologies to address energy poverty and spur economic development.

Energy efficiency is another key priority for our two countries. Over the next 15 to 20 years, peak electricity demand from the top ten most electricity consuming appliances and equipment in India is projected to be more than 300 GW. This is equivalent to the output of nearly 600 large power plants. We are already working together under the U.S.-India Collaboration on Smart and Efficient Cooling and on super-efficient appliance standards through the Clean Energy Ministerial to help address these challenges. We also discussed on-going collaboration between DOE and India's National Institute of Solar Energy (NISE). This is to enhance the accuracy of India's solar resource maps and data, and plan for an online platform for sharing them.

Q: *In the on-going Indo-US bilateral partnership on energy, what are the areas that need further strengthening? On a short and long-term basis, which of the research areas/collaboration have larger relevance?*

A: The United States and India are already working together both bilaterally and multilaterally (through the Clean Energy Ministerial) across a range of activities that support these goals (which you can read more about in the latest PACE progress report: http://www.pace-d.com/wp-content/uploads/2015/10/PACE-Annual-Report.pdf). In both short and long-term research areas, we need to make use of the deployable outcomes of our joint research and help find a way to commercialize the technologies that are being created through joint collaborations. Moving forward we are excited about the upcoming launch of the new research stream on smart grid and energy storage for grid application. These areas will help enhance the ability of both the countries to manage RE grid integration, and make use of emerging efficient appliances.

Q: *The Joint Clean Energy Research and Development Center (JCERDC) is in its fourth year* *of operation, what according to you is the road ahead? Which of the research area/activity needs to be bolstered?*

A: The SERIIUS consortium has made tremendous progress in the last few years with breakthroughs that could be deployed in the near future. The same is true of our building energy consortium, which has helped advance research on energy efficiency technologies. The second generation biofuels research consortium is beginning to make progress on discovering high-yield and stress tolerant crops that can be processed for biofuels. They have made progress on increasing efficiency in the process of converting crops into biofuels. All these areas are moving us towards being able to manage an energy landscape that has large amounts of RE and supports smarter, more efficient technologies. We also announced last January that we would extend our joint research for another five years in the existing areas of solar energy, building energy efficiency and advanced biofuels at the end of the initial five years in fall 2017. In the future, we would look at addressing the translational phase between the research side and the deployment side.

Q: *Globally, the price of solar system has declined at 15% CAGR since 2007. Given this trend, how close is solar in becoming a mainstream energy?*

A: Let me start by saying that by 2012, rooftop solar panels cost about one percent of what they did 35 years ago, and between 2008 and 2014, the total cost of utility-scale PV systems fell from $5.70/W to $2.34/W – a decrease of 59%. This has helped solar come within reach of cost parity with traditional electrical generation from natural gas and coal in parts of the United States. As of mid-2015, there were more than 27,000 MW of utility-scale solar projects under development, across the United States. Finally, on distributed generation, as of the summer of 2015, there have been nearly 800,000 cumulative rooftop PV installations across the United States. This is equal to almost 10,000 MW, rivalling the capacity of utility-scale installations. In India, SunEdison recently won an auction bid to build a 500 MW power plant in the southern state of Andhra Pradesh and sell power at Rs. 4.63 per kilowatt-hour, bringing it below the maximum price of producing power from coal in the country (Rs. 5 per kilowatt-hour). Based on this I would say that solar is becoming more and more mainstream.

Q: *What in your opinion needs to be done to move towards an energy infrastructure that has significant share of RE?*

A: We need to have a smarter, more resilient grid that can handle the dynamic flow of energy that renewable sources provide at different times of the day and times of the year. In addition, advancements in energy storage technology could help us store the larger amounts of energy that renewable sources provide at off-peak times that we may then use at peak times on demand. These two things would make the energy infrastructure better able to handle the integration of a large amount of RE. The United States Government is already collaborating with the Indian Government on grid integration through the recently announced Greening the Grid initiative led by USAID. Much of India's grid infrastructure is being built today. The Greening the Grid Initiative seeks to build a grid that allows for the integration of high-levels of RE, which will assist the Government of India achieve its RE plans. Under the US DOE, National Renewable Energy Laboratory has an Energy Systems Integration Facility (ESIF), which undertakes projects that seek to understand how energy sources and demand response systems can optimally work together as a system. Specifically, projects under the Integrated Network Test-bed for Energy Grid Research and Technology Experimentation (INTEGRATE) initiative will address the challenge of enabling the nation's electric grid to handle increasing amounts of RE.

Journal Publications (April-September 2015)

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3. **Improvement in PbS-based Hybrid Bulk-Heterojunction Solar Cells through Band Alignment via Bismuth Doping in the Nanocrystals**, Saha SK, Bera A, Pal AJ: *ACS Applied Materials & Interfaces*.**7**, 8886-8893 (2015): http://dx.doi.org/10.1021/acsami.5b01521

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9. **Performance comparison of controllers for solar PV water pumping applications**, Yadav K, Sastry OS, Wandhare R, Sheth N, Kumar M, Bora B, Singh R, Renu, Kumar A: *Solar Energy*.**119,** 195-202 (2015): http://dx.doi.org/10.1016/j.solener.2015.06.050

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11. **Quantification and Modeling of Spectral and Angular Losses of Naturally Soiled PV Modules,** John J, Rajasekar V, Boppana S, Chattopadhyay S, Kottantharayil A, Tamizhmani G: IEEE Journal of Photovoltaics, **5**, (2015):http://dx.doi.org/10.1109/JPHOTOV.2015.2463745

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13. **Phase and stress evolution in diamond microparticles during diamond-coated wire sawing of Si ingots**, Yang J, Banerjee S, Wu J, Myung Y, Rezvanian O, Banerjee P: *Int J AdvManuf Technol.* Springer London, 1-8 (2015): http://dx.doi.org/10.1007/s00170-015-7446-y

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16. **Effects of instability and coherent structure on the performance of a thermocline based thermal energy storage,** Deepu P, Anand P, and Basu S: Physical Review E Statistical, Nonlinear, and Soft Matter Physics; Phys. Rev. E 92, 023009 (2015) http://dx.doi.org/10.1103/PhysRevE.92.023009

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18. **Geographic smoothing of solar PV: Results from Gujarat,** Klima K, Apt J: Environmental Research Letters, **10**, 104001 (2015): http://iopscience.iop.org/1748-9326/10/10/104001

19. **Techno-economic review of rooftop photovoltaic systems: Case studies of industrial, residential and off-grid rooftops in Bangalore, Karnataka,** Ghosh S, Nair A, Krishnan SS: Renewable and Sustainable Energy Reviews, **42**, 1132-1142, (2015): doi:10.1016/j.rser.2014.10.094

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23. **Theoretical prediction of a highly conducting solid electrolyte for sodium batteries: Na10GeP2S12,**Kandagal VS, Bharadwaj MD, Waghmare UV: *Journal of Materials Chemistry A.***3,** 12992-12999 (2015):http://dx.doi.org/10.1103/PhysRevE.92.023009

Solar News (April-September 2015)

[Novel low-cost solar cell without silver](#), pv magazine, August 2015

Natcore technologies has paved the way for the decrease in solar cell cost by eliminating use of silver

- Silver contributes about 11 % of total raw cost of a cell and could be eliminated using laser processing techniques
- The new cell uses an aluminium all-back-contact instead of silver for its silicon hetero-junction.

[Solar-powered railway coach rolled out](#), Firstpost, June 2015

The Indian Railways inaugurated a non-AC coach lit by solar panels on the roof, which can generate about 17 units of power a day, with an equipment cost of around INR 3.90 lakh per coach.

- This will reduce diesel consumption and save about INR 1.24 lakhs per year for a coach
- This could be extrapolated to INR [11 crores of diesel savings](#) per year for more such installations
- The rollout is part of a plan by the railways to install 1000 MW solar power in the next five years under various zones, railway office buildings, as well as level crossings.

[NCEF reaches INR 17000 crores but lying unused](#), Business Standard, July 2015

The National Clean Energy Fund (NCEF) has crossed INR 17000 crores (2.5 billion USD), after a recent increase of coal cess to INR 200 per tonne. Even though grid connected Renewable Energy (RE) has grown to about 25 % in the past decade, not much has been allocated to RE sector from NCEF. The need to make these funds immediately available to RE projects was deemed important for a quick deployment of RE.

[Dollar linked tariff to push solar industry](#), Livemint, June 2015

The Government of India (GoI) has asked the National Thermal Power Corporation (NTPC) and PTC India Limited to charge dollar-linked tariffs for new solar projects on a pilot basis.

- This is aimed at lowering solar costs by making cheap dollar-based financing easier to access
- However, there is a need for a hedging mechanism to cover the risk of depreciation of rupee in comparison to dollar.

More details available at:
http://www.thehindubusinessline.com/companies/ntpc-ptc-india-allowed-dollarlinked-tariffs-for-new-solar-projects/article7389364.ece

[Solar Cities for India selected](#), Greentech Lead, April 2015

The Ministry of New and Renewable Energy (MNRE) has chosen 50 cities for its flagship solar cities program

- This will reduce the projected demand for conventional energy in the selected cities by 10% over 5 years
- A master plan for 44 cities is ready and stakeholder committees have been constituted
- A total of INR 66.5 crore (9.9 million USD) has been sanctioned for master plans, solar city cells, promotional activities, and installation of RE projects.

More details available at:
http://mnre.gov.in/file-manager/UserFiles/Status-Note-on-Solar-Cities.pdf

[Details of 100 GW solar energy targets](#), Press Information Bureau, GoI, June 2015

The National Solar Mission (NSM) target has been scaled up by five times to reach 100 GW by 2021-2022

- Target comprises 40 GW rooftop and 60 GW large and medium-scale grid connected solar power projects. The total investment will be to a tune of INR 6, 00,000 crores (~ 90 billion USD)
- Capital subsidy will be provided for rooftop solar projects. Viability gap funding-based projects to be developed through Renewable Energy Corporation of India (RECI) and decentralized generation through small solar projects
- There is a strong push from the Prime Minister's Office (PMO) to various state and central government ministries to initiate supporting interventions for the solar industry.

SoftBank Investment in India's solar market, Livemint, June 2015

A Japanese telecommunications company- SoftBank decides to invest 1.3 lakh crore (20 billion USD) in India's solar energy sector along with Bharti Enterprises Ltd. and Foxconn Technology through a joint venture named SBG Cleantech Ltd. A private sector investment of such huge scale will help drive growth in India's NSM.

WTO backs US in solar dispute with India, Reuters India, August 2015

The US had raised an issue against India at WTO, related to unfair trade practices in mandating domestically manufactured solar panels.

- Both India and US had filed petitions at the World Trade Organization (WTO)
- US claimed that India violated rules under General Agreement on Tariff and Trade (GATT) and Trade Related Investment Measures (TRIM)
- WTO has recently ruled against India

Note: This is an integrated issue and covers important events and landmarks, dated upto September 2015.

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Indian Institute of Science, India &National Renewable Energy Laboratory, USA

Research Thrust Leadership

Indian Institute of Technology-Bombay, Center for Study of Science, Technology and Policy, Sandia National Laboratories, RAND Corporation

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