CSIR-NPL establishes facility for efficiency validation of solar cells

In India, the research on solar cells is being pursued in various scientific laboratories and industries; however, there is no facility for the validation of solar cell efficiency. Globally there are three recognized centers available for validation of solar cell efficiency, namely National Renewable Energy Laboratory (USA), Fraunhofer Physikalisch-Technische Bundesanstalt (Germany) and Institute of Advanced Industrial Science and Technology (Japan). In order to validate the efficiency of the fabricated solar cells, these have to be sent to one of the above-mentioned centers and this process is not only expensive but also time consuming. For the validation of efficiency of such devices, it requires calibration of various individual parameters involved in measurement of efficiency, such as, light source, current/voltage source-meter, temperature sensors and active area of device. Constructing a system meeting all the required criteria for any standard solar simulator is difficult and expensive, moreover, such systems require periodic calibration to maintain the standard. Even the commercially available highest class solar simulators (these are classed from most to least accurate as A, B or C) require careful setting up, so that measurement be performed at an accurate estimation of a solar cell's efficiency. Being 'National Metrology Institute' (NMI) of India, CSIR-National Physical Laboratory (NPL) has standards and traceability to all units used in solar cell efficiency measurement. Thus, CSIR-NPL has taken up an initiative for setting up a 'National Facility' for validation of solar cell efficiency with the maximum possible accuracy. The facility will be a potential service to nation, including the academic institutions and research laboratories and industries across the country. CSIR-NPL is in the process of establishing efficiency validation facility for all kinds of solar cells. The individual parameters involved in the efficiency measurement of a solar cell have been traced. To begin with, CSIR-NPL dedicated the efficiency measurement facility of organic and other excitonic solar cells to nation on World Metrology Day, i.e. 20 May 2016. The major source of error in estimating the efficiency of these solar cells mostly comes from a large uncertainty in the measurement of active area. The area of solar cell is measured using displacement laser interferometer with associated measurement uncertainty of 0.1 micron. Thus, it is important to have protocols of a laboratory to adopt good measurement practice and verify their measured efficiency of a solar cell by an external party.

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Technology Vision 2035

Technology Information, Forecasting and Assessment Council (TIFAC), the Government of India's autonomous technology think-tank under the Department of Science and Technology (DST) directs technology trends and makes an effort to delineate possible technology trajectories that India needs to take. TIFAC has made significant contributions to the Indian S&T system by bringing out technology vision documents, technology assessment and foresight reports besides supporting technology innovation, technology infusion in the micro, small and medium enterprises sector and patent facilitation.

Recently, TIFAC has been engaged in a vast consultative exercise of formulating the Technology Vision 2035 (TV 2035) document, an outcome of an extensive visionary exercise involving about 5000 people across 12 key sectors of national importance. The Prime Minister of India released the document on 3 January 2016 at the 103rd Indian Science Congress held in Mysuru.

The document captures the needs and aspirations of Indians in the year 2035 and enunciates them in the form of 12 prerogatives – six individual and six collective – in addition to a set of 10 grand challenges. Several technologies at different stages of evolution have been identified as enabler in this context in order to achieve these prerogatives. The document generates 12 sectoral roadmaps, a brief of which is captured as 'Technoscape'.

To create public understanding of TV 2035, a conference was organized to facilitate interaction between the TIFAC think-tank team and selected stakeholder groups for diffusion and dissemination of the essence of the document. In this one-day event, four sectoral areas – education, information and communication technologies (ICT), energy, and medical sciences and health care were discussed.

Suhas B. Naik-Satam (National Centre for Science Communicators, Mumbai) coordinated the event. Shivaprasad Khened (Nehru Science Centre, Mumbai) and A. P. Deshpande (NCSC) welcomed the guests A. P. Jayaraman (NCSC) delivered the opening remarks. He gave an insider view about how the idea to hold the conference was conceived.

India needs to give highest priority to technological growth in the coming years to increase its gross domestic product (GDP), according to nuclear scientist Anil Kakodkar (TIFAC and mentor TV 2035). Kakodkar pointed out that in AD 1700, India had the highest GDP in the world and expressed confidence that

*A report on the National Conference 'Technology Vision 2035', jointly organized by the National Centre for Science Communicators, and Technology Information, Forecasting and Assessment Council and the National Council of Science Museums on 18 April 2016 at the Nehru Science Centre, Mumbai.

the country has the potential to lead the world in terms of GDP by 2035. He said that the key ingredients of GDP are raw materials, human resources, technology and innovation. Although technology empowers citizens, societies and nations, it is a double-edged sword. There is a need to ensure responsible use of technology. Also, technology enables strategic autonomy against restrictive regimes driven by political, economic and military interests.

Kakodkar added that there has to be robust decision-making while applying technology to avoid vulnerabilities. He emphasized the need to give priority to research and development (R&D). In spite of India's expenditure on research and development being much more than countries like China, Israel, Canada, Sweden and the UK, the investment in R&D by the industry is low. Investments in R&D need to grow proportionately to the size of the country. It is imperative to evolve and nurture innovation ecosystems and respond to technology development demands. A mindset change across all domains – political, society, academia, industry and bureaucracy is a must, stressed Kakodkar.

Prabhat Ranjan (TIFAC) outlined the goals of the document – to ensure security, enhance prosperity and strengthen identity of Indians in 2035 using technology as both enabler and driver to scale the growth. He cited the example of guar gum. India produces 80% of guar gum in the world; yet we have only 1% of the 11,000 guar gum-related patents.

Due to a culture that looks down upon working with hands, the manufacturing sector has suffered. According to Ranjan, there is hardware-based work in college, which limits innovation. He regretted that engineers today do not work in the factory, which is affecting manufacturing. He urged the academicians amongst others to reverse the trend. Ranjan called for a change in the mindset on issues like physical labour. He listed 10 grand challenges before the nation, the first and the foremost being assuring nutritional security and eliminating anemia in both women and children. Other challenges include ensuring quantity and quality of water in river and aquatic bodies, securing critical resources commensurate with the size of the country, providing learner-centric, language-neutral holistic education to all and understanding national climate pattern and adapting to it.

The effort that went into the making of the document was narrated by Gautam Goswami (TV 2035). T. Ramasami (formerly with DST) conceived the exercise. Twelve Advisory Committees were formed to provide sectoral perspectives and foresights for this definitive document.

Bal Phondke (one of the authors of the document) outlined its salient features. He said that while the only certainties of the future of India are the size; diversity of its population, the needs of this population would continue to evolve.

The plenary sessions began with the education sector, in which Varun Sahani (one of the authors of document and Jawaharlal Nehru University, New Delhi) suggested that the document is as good as breaking away from the Lord Macaulay-influenced paradigm of education in India and creating a new one that would meet the needs of new demographics of India in 2035.

H. C. Pradhan (formerly with Homi Bhabha Centre for Science Education, TIFR, Mumbai) speculated on how the document could help ordinary schools and help improve teacher-training programmes. He stressed that with the help of technology one can vocationalize education. TV 2035 can complement IIT/IISER-level institutions for teacher education that contributes to short-term training, Master's or doctoral programmes. Technology-based vision can lead to world-class educational research and develop high-quality audio visual and software aids for teachers.

B. M. Bhanage (Institute of Chemical Technology, Mumbai) stressed on the need for transformation in the Indian higher education system. According to him, the undergraduate sector in India is huge; currently 14.6 million (86%) students are enrolled in undergraduate courses compared to 2 million (12%) in postgraduate courses. Bhanage stressed that state universities can be an excellent source of manpower for centrally funded institutions belonging to CSIR, ICMR, DAE, BARC and DRDO.

The situation regarding arts and humanities education is grim because of the lack of institutional collaborations. Low admissions can lead to depleted departments and fewer opportunities leading to lesser research output. Bhanage suggested that the reforms should be made at the state university level. Teaching in state universities and colleges can be improved using digital learning technologies.

In the session on ICT, Ashok Jhunjhunwala (IIT Madras, Chennai) spoke about ICT development in India. According to him, Indians contribute substantially to ICT-driven growth worldwide and India excels in ICT services but not in ICT products. Indian expertise in design, development and intellectual property rights (IPR) should match the expertise in ICT services eventually making ICT products. His recommendations included affordable on-line shopping and services, making ICT products, better infrastructure and better industry–academia links to help research beyond mere paper publishing.

Devesh Rajadhyax (Cere Labs, Mumbai) commended the Vision document and emphasized the attainment of the 12 prerogatives for each and every Indian by 2035. He said that TV 2035 gives a view of what Indians would ask for with regard to security, prosperity and identity after 20 years. The technologies are classified into four stages – technologies that are readily available, those that need to be moved from lab to field, those on which more research is required and the technologies that are still in imagination. Document focuses on the actors who can actually bring these technologies to life, and what activities should be done to ensure that they are able to do their jobs.

Rajadhyax stressed on the fact that individual actors such as students and entrepreneurs are the forces behind early-stage technology. Such principal actors are identified for each stage of the timeline. The actors have certain motivations. These stem from their background and upbringing, and drive their actions. It is extremely important therefore to align the priorities of TV 2035 with these motivations. He also highlighted the prerogatives and technologies that are important for the 'left out or left behind' segment of the population and discussed why the technologies related to this segment are usually not preferred by implementers and what can be done to change the situation.

Ranjan Banerjee (IIT Bombay, Mumbai) dealt with the energy sector. Even with one-sixth of the world population, India consumes only 6% of world's energy. He mentioned that in the past decades the proportion of power generated from renewable sources has shrunk in the country.

There is a correlation between the UN Human Development Index (HDI) of a country and its electricity consumption and cost–benefit parameters for various sources of energy. Amongst the goals of TV 2035, Banerjee stressed upon an increased dependence on hydroelectric and renewable sources of energy, a small proportion of nuclear energy and an insignificant percentage of coal-based energy. Developing power generation capacity of 1000 GW, minimizing power loss, pilferage and focusing on technological areas, are the other goals specified in the document. Stating the energy goals of TV 2035, Banerjee recommended policies like developing an enabling ecosystem for the energy sector and energy services.

S. P. Sukhatme (IIT Bombay) spoke about estimating India's future needs of electricity. The present mean annual per capita supply of electricity in India is only around 800–900 kWh. This is a low value and it is accepted that it will have to increase in the future. Sukhatme suggested working out the per capita energy needs for domestic use, infrastructure, manufacturing of essentials, including clothing, processed foods, public amenities, etc. This is an approach that yields estimates higher than 1000 GW for the scale at which power generation capacity must grow.

His talk concerned with two aspects, which could find a mention in TIFAC's energy sector in the TV 2035 document – one was to lay down the future goals, which India must eventually strive to achieve in terms of the value of the mean annual per capita supply of electricity in order to become an economically developed nation, and the other regarding the nature of distribution of the supply with respect to population. It is imperative that an equitable distribution of generated power is required – mean annual per capita electricity consumed to be positively correlated with HDI to improve the quality of life as envisioned in TV 2035.

Ravi B. Grover (Homi Bhabha National Institute, Mumbai) commented that India's energy installed capacity is only 298 GW, while the envisioned increase was around 236% within just 20 years. He also mentioned about the worrisome problem of energy storage and skyrocketing prices of lithium, the storage medium primarily used. He lauded the TV 2035 document for pinpointing various challenges to the R&D community in India.

In the session on medical sciences and health care sector, W. Selvamurthy (formerly with Defence Research and Development Organization, New Delhi) gave a detailed overview about India's health care status. He spoke about maternal and infant mortality, which form the focus of TV 2035. There is an imbalance in health care services; 70% of which is being concentrated in urban areas.

Selvamurthy addressed the recommendations provided in the document to improve life by providing nutritional interventions, improving public health and hygiene awareness. The future in medical care rests in equipping every panchayat with a primary health centre, every taluka with a specialty hospital and every district with a super specialty hospital with air ambulances, which could transport patients to a higher facility.

Bal Inamdar (Obstetrician and Gynaecologist) put forward his concern regarding maternal and infant mortality rates in India. According to him, more than 20% of all such deaths worldwide occurred in India. This is a direct consequence of 48% of live births in the absence of skilled personnel. India is the 18th lowest spending country on health in the world. He revealed startling figures – 79% of children under 5 years and 50% of women suffering from anemia, 67% of the population with no access to proper health care, 84% of medical expenses out-of-the-pocket and 40% of sick people borrowing money or selling assets to pay for medical bills.

He stressed that health care should be a right, and charity and public spending on health care cannot help. In addition, he advised focusing on health care in remote villages. He cited the example of Jawahar, a village in Maharashtra, where infant and maternal mortality have been eliminated within a span of three years with nutritional intervention, providing iron and sucrose supplements to all the deficient individuals.

Bijoy Kutty (Icon Heart Centre and Platinum Hospitals, Mumbai) asserted that nothing can undermine the importance of a healthy India. According to him, the probability of death for people under 15 years is as high as 22%. Due to the vast population of India and poor health care, non-communicable diseases alone cost US$ 2.58 bn annually, an amount equivalent to the entire GDP of India, and the productivity loss due to cardiovascular disease is 17.9 man-years.

Kutty suggested improvements in health care such as installation of effective equipment like the intra aortic balloon pump, which can save lives and cost-effective procedures such as beating heart surgery. In addition, he mentioned the use of nanotechnology in targeted pharmacological approach, an example of a developing field that will revolutionize future health care.

Kakodkar summed up the day's proceedings. In his concluding remarks he stressed that technology development is an inherent cultural issue for India and hence only a change in mindset would facilitate research that creates technology. He urged the audience to become ambassadors for the ambitious endeavour, TV 2035.

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