Each participant was asked to provide feedback on the workshops. They were excited about how earth processes could be demonstrated using inexpensive and easily available materials. It was a radically new experience which the teachers said they would use in their teaching. At the end of the Goa workshop, the teachers gave a written request to the State and Central governments to periodically organize such workshops, which would help to equip them to teach earth science concepts better to their pupils. A teacher participant from Goa was subsequently able to convince the principal of her institution to initiate steps to start the earth science stream for 11th standard.

We summarize in Table 2 the main findings of the three workshops conducted in India, the steps that should be taken to improve the earth science education scenario and the benefits that would accrue by pursuing the suggested steps.

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MEETING REPORT

Plant molecular farming*

The third United Kingdom–India Education and Research Initiative (UKIERI)-sponsored international biennial workshop on plant molecular farming was held during 27–28 July 2016. The objective was to introduce the use of plant expression systems for recombinant pharmaceutical protein, to explore its potential for the production of valuable and complex therapeutics, and to provide hands-on training in basic techniques to early career researchers in India.

Twenty-five participants from research organizations across India were selected from among 46 applications. They were Ph D scholars and early investigators, usually but not necessarily already working in plant science. The two-day workshop comprised a series of lectures, case-study discussions, short technical talks and four hands-on practical laboratory sessions. The inaugural ceremony was presided over by P. S. Mohan (Bharathiar University, Coimbatore) who described plants as bio-factories and discussed the urgent need for more research into plant science for a better understanding of its full potential. He appreciated the organizers for taking the effort to disseminate knowledge in their respective specializations and recent techniques to the emerging young researchers. Julian Ma (St. George's University of London) delivered the inaugural address, emphasizing the role and importance of international collaboration in modern science. He shared his memories of the 7-year collaboration with R. Sathishkumar (Bharathiar University) and remarkable achievements in plant-based chikungunya vaccine development project through UKIERI funding since 2007.

The workshop introduced the field of molecular farming and highlighted latest developments in glycoengineering, plant expression system and protein purification from plants. The programme addressed all the major issues from gene design to manufacture and downstream processing. A particular highlight was the presentation by K. Sumathy (Bharat Biotech, Hyderabad), who gave an in-depth account of the pharmaceutical industry's perspective of recombinant vaccine development in India. She highlighted the importance of a bridge between university research and its scope in Indian vaccine industries. Other keynote talks were delivered by Waranyoo Phoolcharoen (Chulalongkorn University), Gina Webster (St George's University of London) and Gowtham Iyappan (Bharathiar University). Plant molecular farming is the most advanced area of plant science which mainly focus on the production of protein therapeutics, including vaccines, antibodies and other proteins in plants systems. According to Ma, even though plants are safe and economic, they have some limitations such as post-translational modification and transgene containments. The advent of technologies in plant science eliminates these limitations by engineering the plants with glycosylation machinery, and environmental concerns have been addressed by following good manufacturing practices in plant molecular farming through transient expression. A case study involving molecular farming of rabies antibodies in the plant system was discussed by Phoolcharoen. A similar kind of study carried out at Bharathiar University, DRDO-BU CLS was briefly discussed by Gowtham, which involves making plant-based recombinant vaccine for staphylococcal food-poisoning agents. Webster discussed about various recombinant protein purification strategies for purification of antiviral peptides from

*A report on the third UKIERI-sponsored Indo-UK joint workshop on 'Plant Molecular Farming' held at the Plant Genetic Engineering Laboratory, Department of Biotechnology, Bharathiar University, Coimbatore.

plants. Individual sessions started with a lecture, followed by laboratory-based hands-on sessions which mainly focused on recent techniques (agroinfiltration, vacuum infiltration, and gene gun-mediated transformation and antibody purification from plant crude extract) and their compatibility for vaccine research. For these sessions, the participants were divided into four groups; each led by a plant molecular farming expert either from UK or India. The programme provided opportunities for informal as well as one-on-one discussions between the participants and workshop instructors. Group activities were also designed to identify research areas of common interest among the participants and gave them an opportunity to make individual presentations of their short- and long-term research goals. Feedback from participants suggested additional workshops on similar topics of longer duration to learn more. The Indo-UK partners have committed to make efforts to sustain this successful biennial workshop in future.

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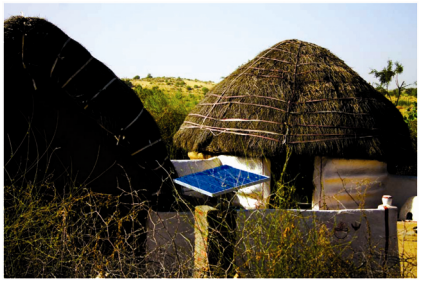
Solar-DC inverterless: an Indian technology bags IEEE Spectrum 'Technology in the Service of Society' Award 2017

With over one billion homes in the world living off-grid, and over half a billion with poor grid, Governments and different levels of national and international organizations have been trying to electrify these homes with newer targets set every year. While rooftop solar was an obvious choice for powering such decentralized and difficult locations, this was not being implemented; DC power of the renewables and batteries was not directly exploited and converted to conventional AC power, resulting in large losses and inefficiencies. The status-quo mindset would not allow a major change. Ashok Jhunjhunwala and his team at IIT Madras realized that this scenario is not going to change in the near future without technology disruption. The modern developed market showed the way itself by offering DC appliances in almost every segment and promising higher efficiency and economics compared to AC counterparts. In order to leverage this market trend, the team took two bold steps. First, departing from the norms, the power-line inside homes was conceived to be DC, powering all DC appliances, and hence avoiding all AC to DC conversions that are done at each point of connect when we install these appliances. Second, all possible powering sources in the system were kept DC to create the synergy between DC sources and DC loads, without conversions. This made the system highly efficient, deriving its name as Solar-DC 'Inverterless'. No conversions help in weaving-in associated benefits in terms of reduced battery sizing and reduced solar panel sizing. The whole system thus becomes economically viable and affordable to even low-income homes. The reliability and efficiency of the system add to the choice of decentralized installation at remote, unelectrified locations. This technology offers a promising solution for homes that want uninterrupted power or want to go green and own their power-generation facility.

Inverterless is fitted with a remote monitoring module and energy metering app for users to regularly manage their energy consumption patterns. The system adds modularity for the convenience of house owners to scale their power generation capabilities and backup duration as and when they can afford to do so. The system supports generation from 125 Wp to 500 Wp and storage ranging from 500 Whr to 5 kWh, and thus becomes suitable for very low income as well as upper middle class homes.

The system needed a whole ecosystem around it for deployment in a home, which encouraged the development of a variety of DC appliances at affordable prices. Several industries, including start-ups joined hands to standardize the DC voltage as 48 V, build and integrate this whole system to be installed at various locations. Today, this system is deployed at 4000 homes in Rajasthan, India with a package containing 125 Wp solar panel, 1 kWh battery pack, Inverterless, a fan, one tube light, a bulb and a cell-phone charger. The loads and sources can be increased according the requirements of a home. Another 7200 homes are getting electrified in Assam, with the support of the Government of India. Small clusters of varying sizes between 20 and 350 on-grid and off-grid homes have also been powered with this system in various states of the country. It replaces an inverter and provides power backup, reduces power consumption by half and enables rooftop solar to provide electricity at a cheaper rate than the grid. The system is being planned for a commercial launch soon.



An off-grid home in Bhom ji ka Gaon, Jodhpur, Rajasthan, India deployed with inverterless.

Fan and tube light inside the home deployed with inverterless system.

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