

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 pro-

vided 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 com-

mitted 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

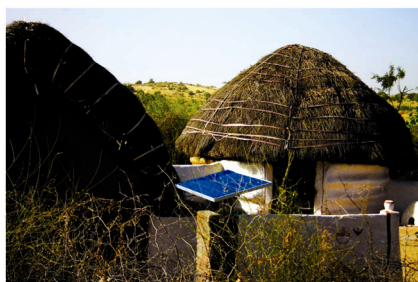
With over one billion homes in the world living off-grid, and over half a billion with poor grid, Governments and different levels of national and international organizations have been trying to electrify these homes with newer targets set every year. While rooftop solar was an obvious choice for powering 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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