Hugh Rudnick

access to electricity

making the expansion worldwide

IN JULY 2013, U.S. PRESIDENT Barack Obama pledged US$7 billion to help provide access to electricity to Sub-Saharan Africa, where two-thirds of the population lacks access to electricity, including more than 85% of those living in rural areas. When making this pledge, he said, "Access to electricity is fundamental to opportunity in this age. It's the light that children study by, the energy that allows an idea to be transformed into a real business. It's the lifeline for families to meet their most basic needs, and it's the connection that's needed to plug Africa into the grid of the global economy."

This commitment illustrates an awareness in the developed world of electricity's role in providing a fundamental path for economic and social progress and a way out of poverty in continents like Africa and Asia. In effect, as the World Bank indicates, about 1.2 billion people do not have access to electricity worldwide. The Bank indicates that, although 1.8 billion people obtained connections to electricity between 1990 and 2010, the rate was only slightly ahead of the population growth of 1.6 billion over the same period. Electricity expansion growth will have to double to meet a 100% access target by 2030, and getting there would require an additional US$45 billion invested in access every year, five times the current annual level.

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With these challenges in mind and with 2014 marking the start of the United Nations Decade of Sustainable Energy for All (SE4ALL), an international effort to bring sustainable energy to everyone on the planet, we invited a selected group of world experts to share their diverse views on ways to proceed to expand electricity access worldwide. They all agree that the technical community, including IEEE, can make a significant contribution to that expansion.

First, we invited a recognized specialist in the field, Adriaan Zomers, author of the book *Rural Electrification: Utilities' Chafe or Challenge?* (Twente University Press, http://doc.utwente.nl/38683/1/t0000008.pdf), to provide an overview of the context, challenges, and obstacles of access to electricity. He emphasizes that there is a rather large difference between the challenges regarding electrification in countries with a mature electric infrastructure and in developing economies. In most countries with a mature electric infrastructure, access to electricity is taken for granted, although utilities are grappling with the challenge to connect a variety of distributed generators to existing distribution grids while maintaining security of supply. The efforts of power utilities and other stakeholders in countries in the developing world are directed toward providing access to reliable electricity services in non- or poorly electrified areas and to cope with the affordability problems of poor communities. The potential benefits of electrification, apart from the benefits related to the improvement of the living conditions, are socioeconomic, sociopolitical, and environmental. He calls attention to the fact that access to electricity in these countries is an essential, but not sufficient, condition for socioeconomic development: rural markets and adequate credit facilities are just as important for rural industrialization.

The second article, by Hugh Rudnick, Joseph Mutale, Debabrata Chattopadhyay, and Robert Saint, shares with us the electrification experiences of three distinctly different countries, the United States, India, and Zambia, which illustrates that different approaches that have been or are being taken to overcome the challenge. The rural electrification experiences of the three countries, despite their major differences, have some elements in common. Rural electrification will not take place on its own unless there is a clear direction or support by the government, either in creating the institutional framework for it to take place or in supplying the necessary basic funding or subsidies for it to develop. Having said that, it is important that this takes place without political interference but based on clear socioeconomic objectives. They indicate that rural electrification is not just one of supplying rural households with basic electricity but also looking at the economic impact that electricity may have on poor communities.

A businesslike approach in electrification is presented in the contribution by Marcus Wiemann and Ling Ng, who argue that access to energy lies in business innovation. In the developing world, like everywhere else, there is not a one-size-fits-all energy solution. Nonetheless,

if private companies are willing to take a chance and invest in the extraordinary potential of these countries, there is no telling what that market might become. Few realize that business innovation and appropriate modeling is key, and only then can renewables in these countries become a long-term solution. Several case studies are presented as examples of how renewable energy can bring small but significant changes to rural communities. They demonstrate how the latest innovations and affordable rural electrification solutions are able to serve the market needs by offering a competitive range of products with breakeven periods that at times may be fewer than two years.

In addition, we wanted to illustrate in depth the challenges in providing access to electricity to isolated communities, which often only have access to simple and inexpensive local energy sources, such as biomass for cooking and kerosene lamps or candles for lighting. Some more sophisticated locations generate electricity using fossil fuel-based generators, a mature, simple, and reliable technology but often with high operating costs, environmental impacts, and complex fuel logistics.

We first asked Mariano Arriaga, Claudio A. Cañizares, and Mehrdad Kazerani to assess the challenges of approximately 200,000 people who live in 280 remote, isolated communities across Canada, not connected to the North American electric grid and solely generate electricity using fossil fuels, often with very high costs, needing important government subsidies. The energy-related challenges of these communities encompass economic, technical, social, and environmental issues that need to be collectively analyzed. The article describes efforts from different stakeholders to address some of the issues, with pilot projects developed to further understand and assess the challenges, including hydro-hydrogen storage, wind diesel systems, and photovoltaic diesel systems, among others. Indeed, the perception of diesel fuel being the sole alternative for such communities is slowly changing, but there are still significant challenges to change the existing energy mix to include considerable contributions from renewable sources.

Another view of access by isolated communities is provided by Guillermo Jiménez-Estévez, Rodrigo Palma-Behnke, Diego Ortiz-Villalba, Oscar Núñez, and Carlos Silva Montes, who discuss different ways of achieving community engagement with a microgrid system to promote the long-term sustainability of power supply systems for isolated locations. These concepts and applications foster community participation in the

system's development and operation. A "social SCADA system" is introduced, which gathers and stores data about both the microgrid's operation and the community component, including sustainability indicators. The proposals were tested together with the community in a small isolated village in desert-like northern Chile, with the majority of its inhabitants approving the project after one year of operation. Resilience development and microgrid monitoring are identified as key challenges for future developments.

A third article, by authors Henry Louie, Peter Dauenhauer, Michael Wilson, Adriaan Zomers, and Joseph Mutale, related to isolated communities assesses the ingredients for sustainable off-grid energy development. They report that small-scale, off-grid systems require less upfront capital and shorter implementation time frames and can be strategically located. But they warn that whereas many organizations expend effort on fundraising, technical design and implementation of a system, few thoughtfully plan for a project's long-term viability. They propose a holistic design approach, considering technical, environmental, economic, social, and organizational aspects of sustainability that must be considered and planned for.

Finally, this issue's "In My View" column offers a contribution from Sudeshna Ghosh Banerjee, Mikul Bhatia, Elisa Portale, Ruchi Soni, and Nicolina Angelou from the World Bank Group's Sustainable Energy Department. They report that the 1.2 billion people without electricity are concentrated mostly in Sub-Saharan Africa and South Asia. In fact, Sub-Saharan Africa alone constitutes half of the access deficit. India is home to the largest nonelectrified population of more than 300 million people, followed by Nigeria and Bangladesh. They call for a new way of thinking about access to electricity and emphasize that achieving universal access by 2030 will require ambitious action by numerous stakeholders including governments, the private sector, nongovernmental organizations, and civil society.

We thank the authors for their time and dedication to produce these articles and to *IEEE Power & Energy Magazine* for the opportunity to analyze and reflect on such relevant matters for the well-being of people worldwide. Thanks to Adriaan Zomers for his valuable help in identifying experts to invite to contribute as well as with the paper reviews. Special acknowledgements to Editor-in-Chief Mel Olken for his continuous support.