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EDITORIAL

Off-grid appliances and smart controls for energy access

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Energy access is an essential condition to economic growth, human development, and environmental sustainability. IEA estimates that the number of people without access to electricity was about 1.1 billion in 2016, mostly in sub-Saharan African countries, and expects that number to decline to less than 700 million by 2030. Eighty-four percent of the population who do not have modern energy access are living in rural and remote areas of developing countries. Since the loads are far from the grid and providing the connection by extending from the main grid requires a high investment associated with long and costly transmission and distribution lines, addressing this challenge in a timely and cost-effective way requires innovative solutions.

Therefore, off-grid microgrid systems, using distributed renewable electricity generation (namely using solar photovoltaics) and energy storage systems, supplying very high-efficiency appliances, integrated with smart controls, are a promising solution to supply energy for rural and remote locations in areas that lack access to the electric grid. Recent technology developments, both in the demand and supply side, are ensuring the economic viability of the above-mentioned solutions to ensure the availability of sustainable energy services to the populations lacking modern energy access.

The objective of the Special Issue "Off-grid Appliances and Smart Controls for Energy Access" is to present the state-of-the-art of the impact of off-grid appliances to ensure the objectives of energy access. The focus of this issue is on topics such as follows: super-efficient off-grid appliances; DC microgrids for rural electrification; integration of renewable distributed generation with storage and load controls; and policies, financing, and governance for promoting the above technologies and solutions.

As introduction to the topic, "Energy Efficient Off-Grid Systems – Review" (de Almeida et al., 2019) presents an overview on microgrid systems, using solar photovoltaic and storage systems, integrated with very high-efficiency appliances, for off-grid systems including the most recent plug and play solutions. A characterization of the most common strategies used for control, communication, metering, security, and protection of microgrids is presented, as well as the recent evolution of the associated component technologies. An overview of the main off-grid appliance market evolution and efficiency trends, in terms of energy efficiency, is also addressed, as well as a set of recommendations to promote cost-effective systems.

"Off-Grid Appliance Performance Testing: Results and trends for early-stage market development," (Lai et al., 2019) provides a glimpse into the current status, efficiency and cost trends, and remaining challenges gleaned from the off-grid television, fan, and refrigeration market—top three appliances with significant

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potential to scale. The assessment shows efficiency improvements and prices drop. However, the assessed off-grid appliances have not yet reached a level of affordability for many low-income off-grid consumers in Africa and South Asia.

"State of play and innovations in off-grid refrigeration technology: lessons learned from current initiatives" (Abagi et al., 2019) explores off-grid refrigeration, presenting the findings of a baseline product testing effort used to establish a foundational understanding of the field performance of commercially available off-grid refrigerators. The paper further explores the role of innovation cash prizes in catalyzing technology innovation and market expansion of off-grid refrigeration, analyzing them through the lens of the Global Lighting and Energy Access Partnership Off-Grid Refrigerator Competition.

"Design and Optimization of Grid-Tied and Off-Grid Solar PV Systems for Super-Efficient Electrical Appliances" (Ghenai and Bettayeb, 2019) describes a renewable energy system to serve the electric load of super-efficient appliances with high penetration of renewable resources and low greenhouse gas emissions and cost of energy. Hourly calculations using optimization methods are used to study the daily and yearly performance and the cost of the renewable energy systems. A comparison between the performance of the grid-tied and off-grid solar PV systems using conventional and super-efficient appliances in Dubai is presented to conclude about the potential of super-efficient appliances powered with the grid-tied solar power system to reduce the electricity cost and greenhouse gas emissions.

"Stochastic load profile construction for the multi-tier framework for household electricity access using off-grid DC appliances" (Narayan et al., 2018) used a stochastic, bottom-up methodology to construct load profiles at the household level for each tier of electricity access as set forth by the multi-tier framework for measuring household electricity access. The loads comprise dedicated off-grid appliances, including super-efficient appliances. The resulting load profiles for different tiers shed significant light on the technical design directions that current and future off-grid systems must take to satisfy the growing energy demands of the un(der)-electrified regions.

"Integration of Renewable Distributed Generation with Storage and Demand Side Load Management in Rural Islanded Microgrid" (Azeem et al., 2018) proposes a novel approach to overcome challenges such as affordability and accessibility in a rural microgrid. A proactive load control and prioritized smart load curtailment is proposed in real-time using local system parameters and human activities load demand. The objective is to reduce blackouts and ensure maximum load supply without using conventional backup sources, computational forecasting, scheduling tools, and sophisticated communication architectures.

"Rural Electrification in Kenya. A Useful Case for Remote Areas in Sub-Saharan Africa" (Hansen and Xydis, 2018) presents the modeling, computer simulation, and optimization of a hybrid-powered mini-grid for a remote area in Northern Kenya. The solar photovoltaic and wind turbine are considered as the two renewable resources for generating electricity coupled with a battery and a diesel generator as a backup system.

"Viable Residential DC Microgrids Combined with Household Smart AC and DC loads for Underserved Communities" (Palaniappan et al., 2018) analyzes a residential DC microgrid in an urban, underserved area that enables the sharing of renewable and stored energy resources between dwellings. The goal of the residential DC microgrid is to drive down to fixed costs of utility-provided electricity to all participants, such that the percentage of utility cost to total household income comes can be made comparable with that of more advantaged communities. The distributed installation of solar panels and battery storage among dwelling locations are optimized based upon varying consumption patterns. Each dwelling has a DC interface to the residential microgrid, and a progressive insertion of DC loads is considered.

"Analysis of Solar and Battery Requirements for Hybrid DC/AC Powered Households in the United States" (Veerapaneni et al., 2019) presents as a goal to make installed cost benchmarks for residential solar photovoltaics with energy storage costs more affordable for an average-income homeowner in the USA. In order to achieve that goal, the power consumption can be reduced by converting a portion of household electrical loads such as LED lighting, air conditioning, ceiling fans, and electronic loads to DC supply. Secondly, the optimal size of the solar panels and of the battery capacity is ensured, while ensuring that the costs and savings of different system architecture can be adaptable based on the type of the house, location, savings, and affordability.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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