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Research Project

Low-cost energy technologies for Universal Access

EXECUTIVE SUMMARY:

Preliminary candidate list of appropriate technologies, business models and enabling environment for Universal Access to Electricity

Lily MWALENGA[1], Reja AMATYA[1], Andres GONZALEZ-GARCIA[2], Robert STONER[1], Ignacio PEREZ-ARRIAGA[1, 2]

[1] Massachusetts Institute of Technology, USA

[2] IIT Comillas University, Spain

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Executive Summary

This Working Paper 1 (WP1) is the first outcome of the *Low cost energy technologies for Universal Access* project by the Massachusetts Institute of Technology (MIT), acting through the MIT's Energy Initiative (MITEI) and funded by the Fondazione Centro Studi Enel (Enel Foundation). The project is developed in collaboration with Comillas Pontifical University – Institute for Research in Technology (IIT-Comillas) under the scope of the Comillas University – Massachusetts Institute of Technology Electricity Systems (COMITES) Program. WP1 focuses on assessing the existing knowledge and successful experiences in access to electricity, reviewing the main technological, business and political approaches.

The UN Secretary General's Advisory Group on Energy and Climate Change defines Universal Access as "access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses." Electricity supply, according to the International Energy Agency (IEA), is the most critical energy carrier for development. 1.3 billion people lack access to electricity in 2010, according to IEA. 84% of them live in rural areas, with the majority in sub- Saharan Africa and South Asia. Without additional dedicated policies, by 2030 the population without access to electricity drops only to 1.0 - 1.2 billion.

Achieving a minimum basic Universal Access to electricity for 2030 would require an average additional investment of $32B per year, or $640 billion cumulative additional investment. 90% of the people without access to modern energy already spend so much in traditional alternatives and batteries that they could afford modest electricity consumptions with modern options such as solar kits, household systems and even access to the power grid. It is clear that a problem of this magnitude cannot be seriously approached without private capital and, most likely, with the serious involvement of energy companies, although decentralized approaches –either transitory or not– cannot be ruled out and they are already taking place.

Obviously this will happen only if an attractive business model can be defined. This model must include: the definition of the appropriate (low cost) technologies to be used; a regulatory framework that clearly establishes the rights and obligations of all parties involved and, specifically, the rules of remuneration for the provision of the service; and the sources of finance for this activity. Such considerations are central to this research project and represent a considerable challenge, especially for rural areas.

The Sustainable Energy for All (SE4all) initiative has established a widely accepted taxonomy of 6 access levels, so that policy targets and business model pathways can be set properly to enable the further development of the communities supplied with electricity. Tier 0 represents no access to modern electricity supply (except for disposable batteries). Tier 1 supplies 4 hours of light for task lighting and phone charging or radio. Tier 2 provides general lighting and enough power for a high efficiency TV or fan. Tier 3 extends the supply for 8 hours including low-power appliances and a minimum quality of service. Tier 4 can power medium-power appliances for up to 16 hours while Tier 5 reaches up to high-power appliances. Accordingly, different technologies can satisfy different access levels for different household, community and productive electricity uses. A number of technology choices can provide different levels of service for different Tiers. WP1 analyses four electrification modes in detail, as well as their appropriate applications to satisfy this diversity of needs, according to the suitability of each solution for different environments.

Moreover, the initial choice of technology sets a pathway that will determine the future ability of the system to provide more advanced energy services up the energy ladder. It will also restrict future options concerning cost of the technological upgrades, fuel expenses, carbon emissions, safety, reliability or pollution. Therefore, adequate technology decisions should not only take into account present needs and capabilities, but also the future evolution of the system.

In this context, adapting products and services to the needs of low-income groups requires significant innovation and research. Within the limits of cost restrictions, electrification agents need to tailor their products to different customer demands and priorities, from lighting, charging cell phones or powering small radios to productive agriculture, manufacturing or commerce, and to community services such as street lights, health and education. Low-income groups also require innovative business solutions that overcome the cultural barriers, in terms of distribution channels, customer relationships, risk aversion, raising awareness of customers and gaining their trust.

1 .1 PICO AND SMALL LIGHTING SYSTEMS

Pico and Small Lighting Systems (SPLS) make available a clean, affordable, portable and reliable technology for basic energy services, especially for in and outdoor lighting, charging of communication devices as cell phones, powering radios or even small TVs, as well as low power community and productive uses. The contribution of these systems to development is limited by their low storage capacity and power, but still represents an important leap from candle or kerosene lighting, home wood fires and dependency from disposable batteries.

The low cost of SPLS allows the emergence of new business models for a provision of energy services, similar to the retailing of IT and other mobile technologies, radically different from traditional grid supply. The nature of these business models makes them more robust in weak regulatory frameworks in many developing countries. Nevertheless, they would benefit from appropriated regulatory measures in terms of quality of service, and technical standards. The high up-front costs of these technologies, compared to traditional energy sources, require the establishment of appropriate financing mechanisms. These mechanisms should be tailored both for the users in the base of the pyramid, and for the service providers along the value chain, assisting the final consumers and the intermediaries in reduging their risks, and in attaining their economic sustainability in the long term. Energy policies for universal access should consider these solutions as an initial step for the electrification process, as it would allow un-electrified people to experience the hands-on convenience, benefits and uses of electricity. However this stage should always be considered as previous to other electrification modes, because of its limited capability to enable further development opportunities.

1 .2 STAND-ALONE- SYSTEMS

Stand-Alone-Systems (SAS) are probably the most flexible and common off-grid electrification mode for the achievement of multi-tier universal access (from Tier 1 up to 5). SAS present also a variety of energy supply options, from solar to hydro, wind, biomass or diesel power, favoring hybrid configurations for higher efficiency and system performance.

The multiplicity of business models matches also this large set of user service levels and appliances, from pay-as-you-go systems at the low-end to rental, community or cooperative exploitation and fee for service tariffs. Investment costs are higher than SPLS, therefore, increasing the need for appropriate financing mechanisms for customers, retailers, distributors and manufacturers, in order to provide suitable and innovative solutions for the base of the pyramid market. Continuous operation and maintenance is necessary for long-term sustainability of SAS systems. The users themselves, or local technicians, can perform most of these activities. This has favored the creation of ancillary jobs and auxiliary businesses at local level, with especially high incidence in the empowerment of female entrepreneurs.

1 .3 ISOLATED MINI-GRIDS

Isolated Mini-grids provide a proper multi-tier low-cost solution for villages. Mini-grids may serve from a limited group of a few houses to large populations of thousands.

Economies of scale are achieved because of the aggregation of customers, both from the point of view of the size of the systems and regarding management and operation. They can provide higher quality of service both because improved generation and storage efficiency, especially in hybrid configurations, and because of the possibility of smart grid operation and active demand management.

Mini-grids have a higher technical complexity, thus requiring a higher effort in maintenance and operation activities at a mini-utility level, requiring the participation of skilled technicians and more advanced business layouts. User education is critical to prevent overconsumption, but innovative, low-cost metering and energy controls may be set in place to provide for a smooth system performance, also giving the customers appropriate signals about their energy consumption.

1 .4 GR ID EXTENS ION

Connection to the existing, typically national, grid should include well-known advantages, such as reliability, economies of scale, scalability and equitability of energy supply. However close attention must be paid to the costs. Equitable network access assumes the same tariff for all the national users of the network, despite the fact that the costs of urban, rural and isolated users are dramatically different. Therefore, grid extension establishes de-facto cross subsidies between users.

Grid extension increases the demand of energy generation in countries where there is usually a lack of generation and transport capacity, especially to satisfy peak demand periods. Many users receive grid service only a limited number of hours each day during the demand valley, and will be disconnected in favor of users with a higher priority at peak time every day. Blackouts and brownouts are also common. Therefore, grid extension must be accompanied by an investment in generation capacity or otherwise it will reduce further the quality of service.

Grid extension in populated areas usually receives higher attention from companies and policy makers, because of its higher impact and faster results. Nevertheless, specific governmental planning that considers both grid and off-grid complementary approaches is needed, so that agents and consumers outside the scope of grid-extension plans know that alternative electrification modes will be available for them.

Keywords: *Universal Access, off-grid electrification, grid extension, rural electrification, isolated areas, modern heat, business models, regulation, energy policy, enables environment, decision support models.*

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Corresponding Author

Andres Gonzalez-Garcia

Institute for Research in Technology (IIT) – Comillas Pontifical University

C/ Sta. Cruz de Marcenado 26.

28015 Madrid, Spain

Email: andres.gonzalez@iit.comillas.edu

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