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Research Project

Low-cost energy technologies for Universal Access

EXECUTIVE SUMMARY:

Appropriate technologies, business models and enabling environment for Universal Access to modern energy services

With high-level descriptions of modeling and analysis tools

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EXECUTIVE SUMMARY

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". Access to modern energy services is a key element for human development and is central for achieving the Millennium Development Goals. The International Energy Agency (IEA) establishes that achieving a minimum basic Universal Access to electricity and providing clean cooking facilities for 2030 would require around $1 trillion cumulative investment. Compared to the energy-related investment estimated by the IEA new policies scenario for 2030, the amount required for this minimum level of Universal Access represents only an increment of about 3%, less than 1.95% of current electricity tariffs in OECD countries[1]. IEA also highlights electricity as the most critical energy carrier for development while the use of biomass in inefficient stoves remains one of the main causes of premature deaths. It is clear that a problem of this magnitude cannot be seriously approached without private capital and, most likely, with the serious involvement of major 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 with the participation of the concerned communities. This model must include: the definition of the appropriate (low cost) technologies to be used; a regulatory framework that clearly defines 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 for rural areas. The purpose of this project is to contribute to the development of Universal Access strategies and tools for policymakers, global businesses and practitioners. This Working Paper 3 finalizes Phase I of the Low-cost energy technologies for Universal Access project by the Massachusetts Institute of Technology (MIT) acting through MIT's Energy Initiative (MITei) and in collaboration with Fondazione Centro Studi Enel (Enel Foundation). The project is developed in collaboration with Comillas Pontifical University – Institute for Research in Technology (COMILLAS – IIT) under the scope of the Comillas University Massachusetts Institute of Technology Electricity Systems (COMITES) Program.

Phase I of the project comprises the analysis of the State of the Art technologies, strategies and business models for electrification (Working Paper 1) and modern heat (Working Paper 2) as well as the proposal of a methodology to develop country studies for the establishment of roadmaps to universal access (Working Paper 3).

[1] The International Energy Agency makes clear in their reports that this is under the assumption that those people with new Access to electricity will stay below a limit of 750kWh per person and year, half the household consumption per capita of developed countries like Spain or Italy, nearly seven times less than residential per capita electricity use in US or Canada, and between seven and fourteen times less energy than the average EU or US consumption if we include the productive, commercial and community power needs of modern societies. Under this assumption, the impact of Universal Access on climate change would be also negligible, but it is hard to believe that for the time range considered in the typical climate change analyses (2050 or for the end of this century) the consumption of those with Access to electricity will remain so low (Brazilian & Pielke, 2013; Wolfram, Shelef, & Getler, 2012).

Phase II includes the application of this methodology to different countries, starting with a report for two case studies, Kenya and Peru, as well as a preliminary analysis for other countries as Brazil, Nigeria or India.

This Working Paper 3 starts framing the challenge of Universal Access in order to propose a comprehensive methodology for the assessment of the appropriate modes of electrification, heating and cooking for specific

countries or regions. The methodology covers the collection of data, the logic processes and the potential use of software tools that make possible the development of a proposal including the different choices of technologies, business models, financial, regulatory and policy strategies that could lead to the provision of universal access to modern forms of energy services.

A successful strategy towards Universal Access requires assessing carefully the diverse energy services from the perspective of the beneficiaries, the impact on their economic and social development and the environmental consequences. Establishing properly both the targets to be achieved and the mechanisms and effort to apply require grounding them in the final user present and future needs. Understanding the end-user need is one of the critical aspects of our methodology, for which gathering relevant information about the enabling environment and characterizing current access to modern energy are essential tasks. SE4All framework of multi-tiered energy services[2], for both heat and electricity will be taken as the basis for evaluating various technology solutions. The framework allows for determining the technical performance of the primary energy services for heat and electricity. The overall access to modern heat and electricity can be determined based on the total number of households at various tiers of service. The establishment of sustainable business models for universal electrification needs a proper identification of the conditions under which different electrification modes are more suitable than others for the satisfaction of the present and future needs of the un-electrified or under serviced population. The focus of this approach is on making use of a geographic information systems (GIS) methodology to assess the size, scope and geographic location of the potential consumer base for different modes of electrification and to enrich this geographic information with demographic, socio-economic, environmental, technical and contextual information required to support decision making planning tools at both the national and individual project level.

GIS is a useful way of structuring, storing and handling data, and can provide compelling, accessible visualizations of quantitative results to answer strategic spatial questions about the types of places best suited to different electrification strategies, or where to site potential electrification projects – useful for government planners, practitioners, and off grid electrification entrepreneurs.

Electrification design tool can help specifically design a near-optimal power system to provide electricity access to a region (either small or state-sized) including the type, size and locations of electricity generation, storage and distribution assets. The model requires, as an input, the location and load profile for all customers. The GIS methodology can provide these inputs based on gathered data such as the household census data, satellite images, income level, and current service tiers etc. This model

[2] (ESMAP et al., 2013)

could be used by planners to estimate electrification cost and appropriate electrification models at a regional level.
Additionally, the tool could be used to design electrification schemes for a specific area appropriately balancing level of service and costs.
Finally, the *MASTER4all* model can help evaluate the future macro level impact of different energy access strategies in a specific region or a country as a whole, taking into account various business scenarios and regulatory policies. The *MASTER4all* model optimizes the energy resources of a region while considering the energy generation, conversion, transportation, distribution and supply to fulfill the final energy services demand. Within the *MASTER4all* mode, used for an environmental impact study, CO_2 emission of various technology choices can be considered within the optimization options. The tool is designed for providing useful insights about the trade-offs between different technological, financial, environmental and energy policy alternatives specifically focused on energy poverty reduction and energy transition to modern supply.
The methodology for the selection of business models is built bottom-up focusing first on the user needs and favoring the approaches with a higher impact in development and reduction of energy poverty (Step 1), then focusing on the business model planning choices according to the conditions of the customer base (Step 2). At the macro level the business model must take into account the available enabling environment (Step 3) to finally pay close attention to the analysis of the institutional ecosystem of stakeholders for energy access. (Step 4). Finally at the business model level the decision-making must first analyze the actual value proposition (Step 5) and the future conditions for sustainability and advancement of the delivery model (Step 6).