INTRODUCTION

Decentralized electrification and development: initial assessment of recent projects

Jean-Claude Berthélemy and Victor Béguerie - Coordinators

Jean-Claude Berthélemy is Professor of Economics at Paris 1 Pantheon-Sorbonne University and former Dean of its School of Economics, and is co-director of the school's "sustainable development economics" research area. He is also Senior Fellow of the FERDI, where he heads research on access to electricity as part of the "Environment, climate and development" program, and a corresponding member of the Academy of Moral and Political Sciences (ASMP) of the Institut de France.

Victor Béguerie is research officer of the program "Environment, climate and development" at FERDI. His work focuses on access to modern energy and electricity, on their impacts on household living conditions and on their reliability. He holds a PhD in development economics of CERDI – Université d'Auvergne. His PhD brought him to Burkina Faso to analyze the impact of the Multifunctional Platform program on woman and child living conditions.

Recent years have seen the development of a great many initiatives to increase access to electricity in under-served regions. And yet, despite these actions and a growing awareness in the international community of the important part access to electricity can play in driving down poverty (DFID, 2002; ECOWAS and UEMOA, 2006), much work remains to be done if we are to meet Sustainable Development Goal 7: ensure access to affordable, reliable, sustainable and modern energy for all. Some 1.2 billion people remain without electricity (IEA, 2015), i.e. 17% of the global population. Of these people, 97% live in sub-Saharan Africa or developing Asian countries (Ibid.). There are significant regional disparities in electrification rates. The goal of universal electricity access is close to achievement in North Africa, the Middle-East and South America, where electrification rates are 99%, 92% and 95% respectively (Ibid.). Most of the problems in access to electricity are concentrated in rural areas of sub-Saharan Africa and developing Asian countries, where rural electrification rates are 17% and 78% respectively, as illustrated in Figure 1.

EXTENDING UTILITY GRIDS AND DECENTRALIZED ELECTRIFICATION: TWO COMPLEMENTARY APPROACHES

Until recently, initiatives looking to drive up access to electricity were focused on the major utility grids, which also dovetailed with in-house expertise at the major development financing institutions. But some of the more recent initiatives (Power Africa and New Deal on Energy for Africa in particular) also include off-grid electrification projects. Many NGOs of all sizes and companies from the private sector have been involved in off-grid projects for a number of years.

There are several reasons that argue in favor of this heightened interest in decentralized solutions, at least for areas of the world where electrification rates lag, i.e., sub-Saharan African and South-East Asia.

Extending major utility grids is extremely expensive as inhabitants are spread out over vast distances and transmitting electricity over long distances is very costly. As an example, in 2015 the Association for the Development of Energy in Africa (ADEA) costed at USD 884 billion Jean-Louis Borloo's plan for universal electrification across Africa by 2040. The plan is essentially based on upgrading the generating and distribution capacities of major utility grids, with over half the total amount corresponding to electricity transmission and distribution infrastructure.

CHRONOLOGY OF THE MAIN RECENT INITIATIVES TO PROMOTE ELECTRIFICATION

2016
- Electrification Financing Initiative (European Commission)
- Africa Power Vision (African Union Commission, New Partnership for Africa's Development, Nigerian ministry of finance, United Nations Economic Commission for Africa, African Development Bank)

2015
- New Deal on Energy for Africa (African Development Bank)
- Energy Africa campaign (DFID)
- African Energy Leaders Group (Heads of State and business leaders)
- Energy Access Ventures Fund (Schneider Electric, CDC Group, DFID, European Investment Bank, FISEA, PROPARCO, OFID and AFD-FFEM)
- Énergies pour l'Afrique (Jean-Louis Borloo)

2013
- Power Africa (Obama presidency)

2012
- Sustainable Energy Fund for Africa (African Development Bank)
- Access to Energy Initiative (World Business Council for Sustainable Development)
- Global Electricity Initiative (initiative supported by the World Energy Council)
- Global Lighting and Energy Access Partnership (inter-governmental initiative)

2011
- Sustainable Energy for All (United Nations)

2008
- Africa Electrification Initiative (World Bank)

2007
- Lighting Africa (World Bank)

It is interesting to note that even where potential customers live close to a utility grid ("under grid") they do not always connect to it. Lee et al. (2014) used Kenyan data to show that half of all households not connected to the grid live less than 200 meters from a low voltage power line. Connection costs account for part of this phenomenon, but to understand its true significance it is important to remember how unreliable electrical grids are in regions where electricity supply remains under-developed.

Decentralized solutions, whether individual or collective (micro-grids and kiosks) offer a partial response to the challenges posed by the very high cost and poor reliability of the major utility grids. This phenomenon has long been observed among industrial users in sub-Saharan Africa, where most companies whose output relies on electricity use standalone generators to compensate for outages in the utility grid supply, which they are also connected to, even though using generators to produce electricity is expensive.

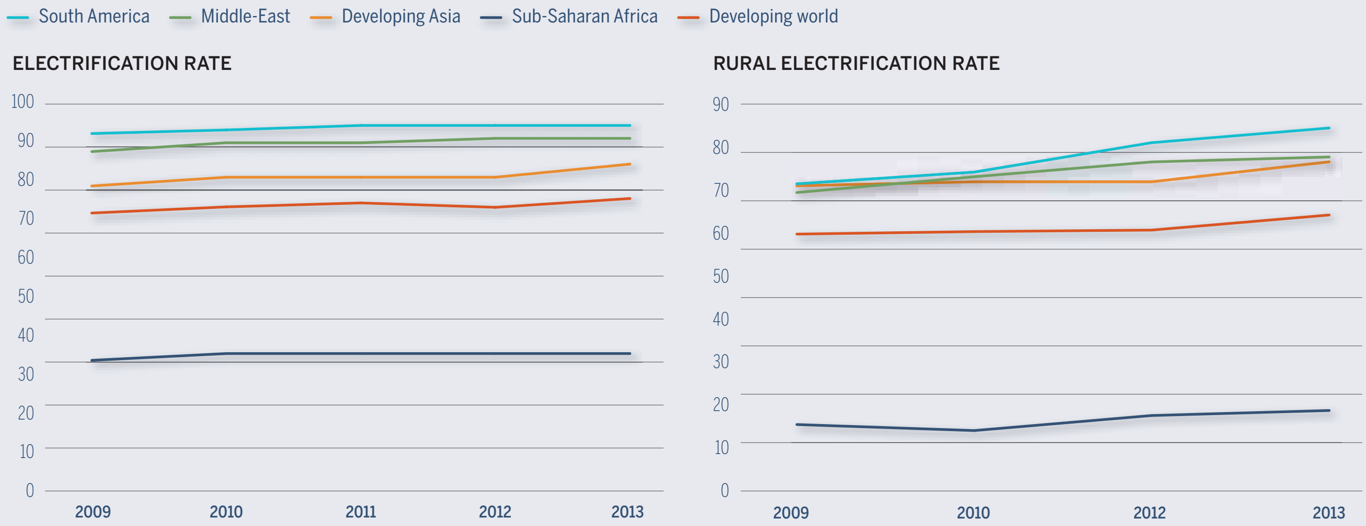
Decentralized solutions for access to electricity offer more limited supplies of electricity than would be available from a utility grid, particularly in terms of the amount of power available. However, none of the farming and small-scale service or craft activities that could develop in these rural areas (lighting, refrigeration, irrigation and use of small electrical tools) require a high-power electrical supply. Furthermore, according to the World Bank (2014), these are some of the types of activity that have had the biggest impact in driving down poverty in sub-Saharan Africa. So, the development of decentralized electrification might be a realistic option as part of a development policy focused on poverty eradication.

The quest for renewable energy sources (mainly solar, but also wind, hydro, biomass and geothermal) is fully compatible with off-grid projects. In the current context, where sustainable development and climate change are central to the challenges facing our planet, it is vital that efforts to close the energy gap focus on mechanisms that are sustainable and environmentally friendly. This is something that can be achieved with decentralized solutions that rely wholly or partially on renewables. Technical solutions employing renewable energy exist and have already proved their worth, such as micro-hydroelectric, solar, wind and hybrid power plants, kiosks, solar kits and lamps. In addition, with prices for solar panels falling by as much as 67% between 2011 and 2020, the cost of PV-generated electricity will by then be comparable to the cost of electricity from conventional sources (de la Tour et al., 2014).

The many initiatives and the lack of coordination between them make it impossible to identify and evaluate the many decentralized electrification solutions that have recently been developed or are emerging. This makes it impossible to have a clear vision of the respective merits of the various solutions on offer, which may also be wholly dependent on the geographical and institutional contexts that they are deployed in.

"EXTENDING MAJOR UTILITY GRIDS IS EXTREMELY EXPENSIVE AS INHABITANTS ARE SPREAD OUT OVER VAST DISTANCES AND TRANSMITTING ELECTRICITY OVER LONG DISTANCES IS VERY COSTLY."

Rate of electrification in the developing world



Source: IEA, World Energy Outlook annual reports

Figure 1

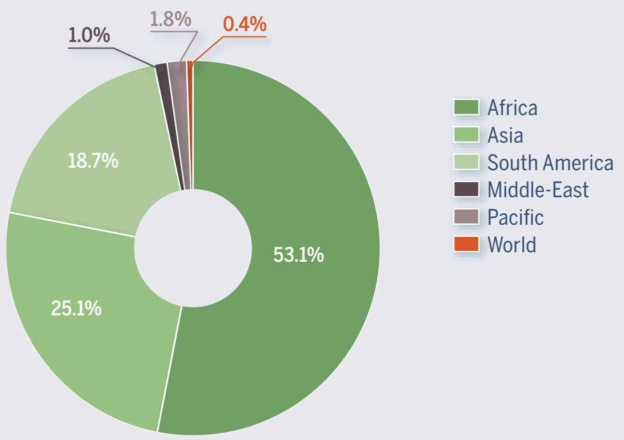
OVERVIEW OF RECENT PROJECTS

The only initiative we are aware of to gather data on these energy access initiatives is the database developed by World Access to Modern Energy (WAME) & EXPO 2015 . WAME & EXPO 2015 is a non-profit created by eight major European energy companies (A2A, Edison, Enel, Eni, Eon, Gas Natural Italia, Engie and Tenaris) in collaboration with the organizers of World Expo 2015 in Milan, Italy. The idea is to raise public awareness about the issues and consequences of the lack of access to modern energy sources facing a large percentage of the global population. The organization exists to help eradicate the "modern energy gap" by supporting, developing and multiplying actions in the field that help to tackle this issue. WAME's database lists energy access projects, policies, case studies and publications that have helped to increase access to energy services for households, collective bodies and businesses, almost exclusively in Asia, Africa and South America. The initiatives listed in the database are often, but not always, focused on renewable sources and cover a very broad range of participants (bilateral and multilateral donors, public institutions, governments, NGOs, private businesses and charitable foundations). Even though it is not exhaustive, using this database does provide us with an initial overview of the current status of decentralized electrification projects.

By concentrating on data on accurately documented projects (location, year, energy source and technology used), 606 electrification projects and case studies carried out between 2000 and 2015 were identified. Of these projects, 481 (79.4%) were off-grid electrification initiatives, 99 (16.3%) were on-grid electrification initiatives, and 26 (4.3%) were electrification initiatives that combined densifying or extending the national utility grid with deploying off-grid systems.

The geographic spread of decentralized electrification projects, or projects with dual centralized and decentralized dimensions, is as follows:

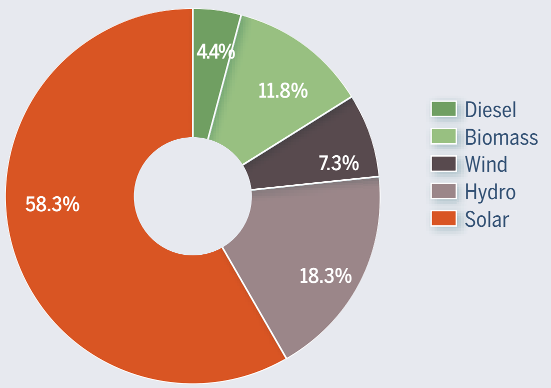
Geographic distribution of projects identified



Source: WAME modified by the authors

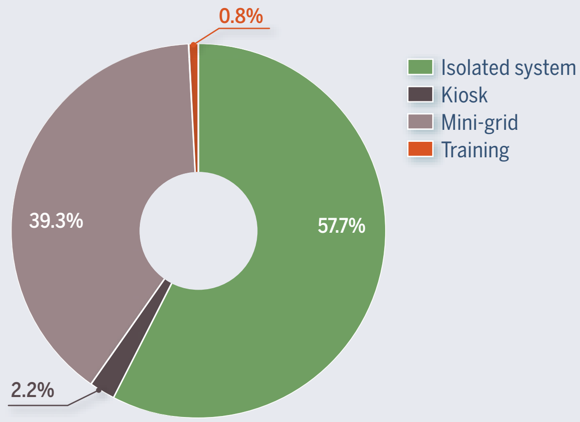
Figure 2

Breakdown of energy sources



Source: WAME modified by the authors *Figure 3*

Breakdown of the different solutions offered



Source: WAME modified by the authors *Figure 4*

Unsurprisingly, Africa and Asia are home to almost 80% of electrification projects identified in the database between 2000 and 2015.

These decentralized electrification projects use a very varied range of energy sources: fossil, solar, hydro, wind and biomass. A total of 15.9% of initiatives identified directly involve several energy sources, and 4% of them combine energy sources via a range of hybrid technologies, from basic solar-fossil power plants to more complex solutions combining solar, wind and diesel, for example. Solar is the most widely used energy source, used in close to 60% of the off-grid electrification projects identified.

Three major families of technical solutions can be identified:

- mini-grids powered by electricity generating plants (fossil, solar, hydro, hybrid, etc.);
- energy kiosks offering a range of energy services to communities;
- isolated systems that provide access to electricity for households and collective structures (schools, health centers, water pumps, etc.). These technical solutions may take the form of solar lanterns, solar kits, pico turbines, pico wind turbines, home biodigesters, etc.

In total, 20.6% of projects identified concern several families of technical solutions.

Most of the projects identified include a capacity-building dimension. A minority provide training only.

The large majority of decentralized electrification initiatives identified in the database concern isolated systems (57.7%) and mini-grids (39.3%).

EXPECTED EFFECTS OF DECENTRALIZED ELECTRIFICATION PROJECTS

It is impossible to assess the actual effects of these initiatives from the WAME database. At best, it provides information on the expected effects, which are wholly dependent on the nature of the solutions deployed.

Low-power individual installations provide lighting and can be used to recharge mobile phones. We have no data on the impacts on people's well-being and so we can only conjecture: lighting in the evening should help children to improve their schoolwork; the ability to recharge a mobile phone saves time that could be used for productive activities. However, timesaving in these ways remains a potential effect. We can add to this the fact that people living without electric lighting use primary energy sources that damage their health and the environment as well as being expensive (kerosene, candles and wood), or else they use a number of individual solutions that pollute over the long term (small battery-powered torches and lanterns), but the harmful health effects of these traditional solutions are not generally measured.

Installations offering greater amounts of power can help to trigger a process of development through contributing to the economic transformation of the communities concerned, the creation of new small-scale businesses and

"THE SUCCESSFUL DEPLOYMENT OF A MINI-GRID DEPENDS ON THE GRID'S QUALITY OF GOVERNANCE."

the use of water pumps for irrigation. They can also contribute to improving vital public services such as dispensaries and schools. Mini-grids have to be designed, scaled and organized (sharing the resource, bill payment methods) in ways that promote the development of these enterprising uses of electricity.

Constraints relating to the intermittent nature of the primary sources used for renewable production (wind and solar) impose additional constraints on the structures of mini-grids, which are all the more severe in cases where users require a set amount of power. This means that the successful deployment of a mini-grid depends on the grid's quality of governance. Compared with major interconnected utility grids, which in developing countries suffer from chronic outages related to the inability of the grid operators to meet demand, local governance of mini-grids is potentially more efficient. Elinor Ostrom (1999) suggests this in her work on local governance rules for coping with the tragedy of commons.

CONTEXTUALIZED FEEDBACK

This special issue of FACTS Reports does not claim to answer every question. Instead, it showcases a few real-life examples of decentralized electrification and suggests a few initial conclusions. The case studies are presented by the project leaders themselves. There are already a number of encouraging responses to questions of how to evaluate the impact of these field actions, although they remain mostly highly qualitative. Looking in detail at some of these experiments also highlights several key factors for the success of these endeavors. Identifying the technology most appropriate to the circumstances is far from the only factor and many other questions arise, such as prior identification of local people's needs and requirements, alterations to the institutional and legislative framework, deployment of innovative finance and payment solutions for users (pay-as-you-go, microcredit), and the need to train the energy entrepreneurs who will carry out the installation and then provide maintenance and after-sales services. Mini-grids require a mode of governance, for what is a local public good, that is appropriate to the context and enables collective maintenance management and conflict resolution in the event of disputes about how this common resource is to be shared.

This special issue features presentations of experiments from the field, arranged into the three categories described above (mini-grids, kiosks, individual solutions), that correspond to the varying degrees of ambition for the development of decentralized electricity offerings. These different solutions cannot be assessed according to a single set of criteria, but they must all, in one way or another, meet the needs of the communities concerned.

The first section looks at mini-grids. In areas without access to an interconnected national utility grid, mini-grids can provide electricity to households, small businesses and public services (schools, dispensaries, etc.). In some cases, mini-grids constitute a viable alternative to electrification by extending major interconnected grids, providing comparable services to those offered by major utility grids, particularly in terms of matching available power to demand. We examine four mini-grid experiments:

- hybrid mini-grids in Mauritania, a delegated public service managed by CDS (article from David Munnich);
- mini-grids in Mali, built as part of a rural electrification program supported by GERES (interview with Benjamin Pallière);
- a project in Laos to develop pico turbines, run by Électriciens sans frontières (article from Gérard Descotte);
- the Rhyviere rural electrification project in Madagascar, developed by GRET (article from Julien Cerqueira).

The first section also contains two articles examining electrification via the national utility grid, but are of particular interest for the governance and management of mini-grids:

- an article on Light Recicla, a social scheme in Brazil that helps with access to electricity in poor neighborhoods (article from Eleanor Mitch and Fernanda Mayrink);
- an article on the constraints limiting the inclusion of intermittent energy sources within the electricity grid on the Seychelles, as identified by Energynautics (article from Tom Brown, Nis Martensen and Thomas Ackermann).

The second section looks at energy kiosks, which offer local people services that require a source of electricity (solar in these cases) rather than access to an electrical connection. For outlying or poor villages where it would not be economically viable to build a mini-grid, these solutions can bring the first benefits from modernizing economic and social life specifically provided by electricity, such as refrigeration or the use of modern computer and communication technologies:

- the development of solar kiosks in Madagascar by HERi, a social enterprise (article from Louis Tavernier and Samy Rakotoniaina);
- the development by the SELCO Foundation of integrated energy centers for people living in informal settlements in Karnataka, India (article from Adritha Subbiah, Sahar Mansoor, Rachita Misra, Huda Jaffer and Raunak Tiwary).

The third section examines individual solar solutions. Often limited to providing a low-power supply for lighting and recharging mobile phones, individual solutions are nonetheless very popular in developing countries thanks to their ease of deployment and the emergence of appropriate financing solutions (pay-as-you-go). Such is the extent of their popularity that today their spread is increasingly the work of private commercial initiatives rather than of projects funded by NGOs or aid agencies. However, the maturity of the market for individual solutions remains conditioned by the existence of market infrastructure, particularly distribution and maintenance networks and specific financing solutions such as microfinance institutions, which are still largely dependent on collective initiatives. Several articles examine these issues:

- two articles illustrate the spread of purchases using pay-as-you-go financing. One describes the experiences of Azuri Technologies, which sells home solar installations in Rwanda with the backing of USAID (article from Simon Collings and Anicet Munyehirwe); the other looks at lessons learned by Village Power's Light Lwengo project in Uganda (article from Annie von Hülsen, Thomas Huth and Simon Koch);
- two articles explore microcredit for financing the purchase of individual solar solutions, one on the work done by Fondation Energies pour le Monde in Burkina Faso (article from Sarah Holt), and the other on the partnerships PAMIGA has built with local microfinance institutions in Cameroon, Ethiopia and Kenya (article from Marion Allet);
- an article describing PAMIGA's experience of training energy entrepreneurs to help grow the energy solutions market in Cameroon and Ethiopia (another article from Marion Allet).

Lastly, the final section features two articles summing up the current situation, setting out a few initial conclusions drawn from recent experiments in decentralized electrification. As the large majority of initiatives use off-grid solar equipments as their energy source, these last two articles concentrate on this type of solution. These are:

- an article that looks at lessons learned from projects that have won an Ashden Award for their work to develop access to sustainable electricity (article from Anne Wheldon, Chhavi Sharma and Ellen Dobbs);
- an article setting out recent trends in the market for solar products in Africa (article from Jörg Peters and Michael Grimm).

"THE ARRIVAL OF ELECTRICITY MUST HAVE A TRULY TRANSFORMING EFFECT ON BEHAVIORS AND PRODUCTION METHODS."

CONCLUSION

This special issue of FACTS Reports on decentralized electrification does not claim to offer any definitive answers to the – perfectly legitimate – questions of the appropriateness of developing decentralized electrification projects. It does, however, show that many solutions have emerged that are capable of tackling the problems encountered, particularly for increasing uptake of individual solar solutions, but also for setting up more ambitious projects such as mini-grids. There are still many practical obstacles to overcome, technical and economic, financial and organizational, and this is something that the growing volume of experience feedback, such as presented here, should help to resolve. Other questions remain to be explored regarding the reality of the social and economic impacts. Although impacts are sometimes verified, impact assessment methods are far from systematic. In the future, better assessments must be made of the economic, social and environmental impacts of these types of projects. In conclusion, we submit that, in order to bring about significant impacts on development, the arrival of electricity must, whatever the geographical or economic conditions and whatever the profile of the target groups, have a truly transforming effect on behaviors and production methods.

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