SMART VILLAGES

New thinking for off-grid communities worldwide

Electricity for off-grid villages: an overview of the current state-of-play

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Smart Villages

We aim to provide policy makers, donors and development agencies concerned with rural energy access with new insights on the real barriers to energy access in villages in developing countries - technological, financial and political - and how they can be overcome. We have chosen to focus on remote off-grid villages, where local solutions (home- or institution-based systems, and mini-grids) are both more realistic and cheaper than national grid extension.

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1. Introduction

This technical report provides a review of the literature relating to the issues around provision of electricity to off-grid villages. It summarises key challenges associated with the provision of electricity to off-grid villages (Section 2), and views set out in the literature on the opportunities and required framework conditions to address those challenges (Section 3). Also, two particular topics are reviewed in more detail: how to ensure that electricity provision acts as a catalyst for development (Section 4), and the complementary roles of government, the private sector etc. (Section 5). A bibliography of the literature informing this review is provided at the end.

2. Challenges

Taking a global view, the International Energy Agency (2011) has estimated that providing universal modern energy access by 2030 will require a cumulative investment of US$1 trillion: an average of US$48 billion per year, which is five times the 2009 rate of investment in extending access to modern energy services.

Specific challenges in respect of off-grid energy access are discussed under the following five headings:

- Government and donor policies.
- Affordability and financing.
- Viable markets and business models.
- Technical and expertise issues.
- Cultural and attitudinal issues.

These various issues are interdependent, their relative importance depending on the specific context, and a systemic approach is needed in their evaluation (Watson et al 2012).

Government and donor policies have tended historically to emphasise large energy infrastructure projects to drive macro-economic growth, at the expense of initiatives to provide energy access to the rural poor (Practical Action 2009; GVEP International 2011; Wilson et al 2014). Particularly in countries where energy access rates and service quality to urban and industrial areas are low, governments may find it difficult to prioritise rural energy access (Shanker 2012). Economic imperatives may favour intensification of access in dense populations close to the grid (Pueyo et al 2013). An additional factor is that energy access cuts across sectoral policies and hence does not sit well with traditional development planning (Sokona et al 2012).

Subsidies to fossil-fuels and grid-electricity can be counter-productive, channelling

resources to the relatively well-off at the expense of extending energy access to the poor, and undermining the financial viability of utilities and private sector and community providers and the economics of off-grid options (GVEP International 2011; Pachauri et al 2013).

Lack of clear regulatory/policy frameworks for off-grid provision and of available information on government plans for grid extension act as barriers for developers who fear being left with stranded assets, particularly if mini-grid design and/or financial arrangements do not provide for incorporation into the national grid system (GVEP International 2011; Schnitzer et al 2014). Similarly, lack of quality standards for energy goods, or inadequate enforcement of these standards, can lead to markets being swamped by poor quality goods, user confidence consequently being undermined, and reputable suppliers being driven out of the market. More generally, governance problems can include unstable policy environments, weak policy implementation, and political interference (Kirubi et al 2009; Watson et al 2012).

With regard to international donors, concerns have been expressed that many small, uncoordinated initiatives result in duplication of effort and lack of critical mass (IED 2013). Shifting donor priorities may undermine the longer term initiatives necessary to make substantial inroads to the energy access challenge (Watson et al 2012).

Problems of **affordability and financing** are cited as the most pervasive and important of the barriers to the provision of rural electricity services (Watson et al 2012). Low income countries with low electrification rates do not have a critical mass of taxpayers and consumers that can make electrification financially sustainable (GVEP International 2011). Problems of financing are particularly acute in Sub-Saharan Africa as low population densities and low household incomes reduce the returns on electrification projects, lending institutions tend to be risk averse, and technical and non-technical (e.g. theft) losses are on average 30-35% (GVEP International 2011; Kirubi et al 2009; RECP 2014). There may be a lack of appropriate mechanisms and institutions to channel finance to low income consumers and to SMEs (Wilson et al 2014). Insufficient access to working capital is cited by SMEs providing energy services as an impediment to their ability to scale up their businesses (Ashden 2014).

For both project developers and households, up-front costs are consistently cited as the key barrier, whereas the literature reports mixed experiences of the ability of customers to afford the operational costs of electricity provision (Watson et al 2012; Glemarec 2012). Up-front costs may be exacerbated by import duties on generating plant and standalone systems and appliances (GVEP International 2011). Poor people in rural communities are typically engaged in subsistence agriculture with seasonal income streams (Chaurey et al 2012; Wilson et al 2014). They lack collateral and credibility to repay loans reliably: local banks are consequently reluctant to lend to them (Practical Action 2009). Higher income households benefit more from village electrification initiatives than poor households, as the latter can find the connection fees prohibitive (Greenstone 2014).

Moreover, rural communities are often dispersed, resulting in high per household or enterprise costs of distribution. They have low initial levels of energy demand, and it tends to be highly time-concentrated, resulting in low system load factors (World Bank 2008; RECP 2014). Users connecting to mini-grids, installing standalone systems or buying standalone appliances do not benefit from the cross-subsidies inherent in a large grid system where established consumers in high-density communities effectively support more dispersed, newly connected users as they utilise the opportunity of improved energy access for activities which grow demand and enable them to move further up the energy ladder.

In part because of these factors, private sector developers are often deterred by long (8-10 year) payback periods and high project risks (IED 2013). Banks financed by short term customer deposits find it difficult to make the necessary long term (10 year +) loans, and are reluctant to invest in what they see as a low-profit and high risk sector (IED 2013; Shanker 2012). Additional impediments for banks are lack of experience of lending to off-grid village energy projects, high transaction costs associated with small projects, and concerns that policy and regulatory frameworks may not be stable over the required time periods (IED 2013; Shanker 2012; Wilson et al 2014).

Even where pilot and demonstration projects are successful, the absence of **viable markets and business models** that can be scaled-up prevents their promulgation (Chaurey et al 2012; Glemarec 2012). The extension of schemes is hindered by the absence of supplementary programmes dealing with issues such as access to markets, development of small and medium sized enterprises, and working with local financing institutions (GVEP International 2011). Retail tariff regulation can undermine the viability of business models if prices are set too low (Schnitzer 2014), and even where higher tariffs are allowed, subsidies to, and constraints on, grid-based utility tariffs may make off-grid energy costs appear unattractive. If village-based businesses are competing with those in towns who are receiving subsidised grid-based energy, they will be facing an uphill task.

With regard to the overall shortfalls in financing discussed above, potential barriers to scaling up the financing instruments provided by multilateral and bilateral sources for energy access include (IEA 2011):

- The regulatory and financial sector reforms necessary to enable some countries to absorb increases in development financing.
- The need to satisfy multiple criteria in order to apply much of the available development assistance to energy access projects, particularly those related to renewable sources and climate change;.
- The reordering of development priorities that may be required of organisations (and the governments behind them) in order to increase the share of energy-access projects within their portfolios.

Technical and expertise issues include the operational and perception problems caused by poor quality products and exaggerated claims for their performance (GVEP International 2011; Watson et al 2012). Inadequate maintenance can exacerbate quality problems (GVEP International 2011). Another manifestation of the quality issue arises from poor assessment of local physical parameters and of peak demand levels in the design of projects, affecting the power outputs, number of customers who can be served and economics of renewable energy systems (GVEP International 2011).

An often cited problem is shortfalls in skills and capacity for the design and operation of energy systems, and their financial management (Alliance for Rural Electrification 2013; Glemarec 2012; GVEP International 2011; Practical Action 2009; Watson et al 2012). If individuals in villages are given training they often leave for the cities where job prospects may be better (Watson et al 2012). SMEs concerned with energy provision cite finding the right staff and high staff turnover as impediments to progress (Ashden 2014).

Concerns have been expressed that energy technology research, development and transfer do not respond to the energy needs and capacities of the poor (Practical Action 2009). Also, that there has been an undue focus on solar photovoltaic technologies, and consequently other viable local energy technologies such as small scale wind, micro hydro and biomass

have received insufficient attention (Practical Action 2009).

Hardware failures and poor performance are manifested in **cultural and attitudinal issues** as negative perceptions and mistrust of particular technologies and of energy access initiatives (Practical Action 2009; Watson et al 2012). In the absence of clear and well-enforced quality standards, households and enterprise owners are unable to distinguish the good from the bad (Bailey et al 2012; Watson et al 2012). But different technologies, for example solar home systems and grid connection, may be seen as status enhancing or the opposite depending on circumstances (Watson et al 2012).

Lack of community involvement from the early stages of project appraisal, through design, construction and operation can result in lack of buy-in and ownership (Chaurey et al 2012). Education and training of the local community is needed in order to build their trust and ensure that they get the most from, and maximise the prospects of success of, energy schemes (Chaurey et al 2012). Theft of power and equipment can be a problem: community involvement and ownership may help to ameliorate such problems.

3. Overcoming the Challenges

An overarching consideration is the need to mobilise an additional investment in energy access of US$34 billion per year in order to meet the 2030 target of energy access for all (IEA 2011). Although this is a large amount, it is still only 3% of the projected global investment in energy infrastructure to 2030 (IEA 2011). The poor, and developing countries, have a limited ability to contribute to closing the funding gap (Practical Action 2009), and such countries may find it difficult to mobilise the political will to support the diffusion of new energy technologies (UNEP 2011c).

A key aim, therefore, must be to harness new sources and mechanisms of international finance. An important enabler would be the recognition of a right to energy access alongside other rights such as access to education, healthcare etc., and that energy access must be of a sufficient level to support all of a community's needs (Practical Action 2009).

Mirroring the presentation of challenges above, the necessary framework conditions and initiatives to address the challenges proposed in the reviewed literature are presented under five headings:

- Policy and regulation.
- Affordability.
- Viable and scalable businesses.
- Capacity and skills.
- Stakeholder engagement.

Finally, opportunities arising from technology developments, and considerations in ensuring that energy systems are fit for purpose, are briefly reviewed.

3.1 Policy and regulation

Policy and regulation need to create an enabling environment, designed to support bottom-up approaches (UN Energy 2013), and which de-risks and enables profitability for investors in energy schemes (UNEP 2011c). Above all, investors look for a policy and regulatory environment which is predictable and stable (UNEP 2011c) and can be trusted (RECP 2014).

Governments need to give greater priority to energy access, making clear and consistent statements to that effect, setting out staged targets, and putting measures in place to deliver them (Glemarec 2012; IEA 2011; Practical Action 2010). Energy access is a responsibility of government requiring pro-poor strategies: it cannot just be left to the market (Practical Action 2009). Plans need to

include the criteria and geographical priorities for energy access through grid extension and through off-grid approaches, including mini-grids, and standalone systems and appliances (Kirubi et al 2009; RECP 2014). (It must be recognised that even in communities where a mini-grid provides the most economic energy access solution for many, there will be some who live on the physical periphery of the community, or who cannot afford mini-grid access, that will need to rely on standalone solutions. Their needs too must be addressed). An integrated combination of measures is thus needed given that the barriers are interrelated (UNEP 2011c; Watson et al 2012).

That integration should link energy access initiatives with other development programmes and institutional mechanisms, so that communities are able to take advantage of the improved energy access and there is a positive impact on other development goals such as education, healthcare and livelihoods (Bellanca and Garside 2013; Chaurey et al 2012; Pachauri et al 2013). It will also provide positive synergies and multiplier effects, reducing transaction costs and minimising conflicts with other societal goals (Ahuja and Tatsutani 2009; Kirubi et al 2009).

Regulatory processes and decisions should be transparent and free from arbitrary government interference (EUEI PDF 2013; IEA 2011). The private sector looks for strong and predictable governance and regulatory frameworks which define the rights and obligations of private investors and developers, and protect consumers, while favouring new projects and not imposing an undue burden on developers (ARE 2011; IEA 2011). Coherent policy and regulatory frameworks are of particular concern to investors, who seek a streamlined implementation process (UNEP 2012b).

Governments should give more preference to private sector participation, for example through public-private partnerships, and support national utilities to cooperate with the private sector and share information on the market and consumers (EUEI PDF 2013). Consequently, regulatory frameworks and economic incentives need to be put in place to mobilise the private sector (which brings key skills, not just money), establishing stable conditions, a level playing field, easy market access, and mitigating political and regulatory risk (UNEP 2011c; UNEP 2012; RECP 2014). Specific measures include output-based aid subsidies, advance market commitments and long-term concessions (GVEP International 2011).

It is also important to reduce transaction costs for developers, for example through streamlined legal procedures to approve schemes, standardised administration procedures to set tariffs and light-handed regulation (GVEP International 2011; Tenenbaum et al 2014), and for financiers, for example through establishing aggregation mechanisms (IIED 2013). Bilateral and multilateral aid institutions should use their funding to lever private sector involvement, concentrating on the more difficult areas of energy access which may not offer adequate commercial returns (IEA 2011).

In designing financial measures, it must be recognised that improved energy access provision particularly through mini-grids may often not initially be financially viable on a purely commercial basis as the economic benefits of improved access will take time to develop. Combinations of private and public funding will be needed, as will public support to de-risk private investment (RECP 2014). Radically innovative ways must be found for international agencies and the international community more widely to support governments of developing countries who themselves lack the financial muscle to provide this funding support.

3.2 Affordability

A strong message from experience to date is that to enhance the affordability of energy to rural communities, schemes for energy provision

should be associated with initiatives to create income generating activities and promote entrepreneurship. This generates revenues and boosts incomes, enabling consumers to pay for their energy (ARE 2011; Chaurey et al 2012; Glenarec 2012; Pueyo et al 2013). At the same time increased economic activity, and the higher energy demand that comes with it (especially if this demand is spread more evenly through the day and so increases load factors), will reduce per unit energy costs. Such initiatives should facilitate the establishment of businesses and complimentary infrastructure such as roads and water supply (Haanyika 2006).

Improved access to finance is needed for project developers and for end users (IEA 2011; Practical Action 2010). Financing instruments should be adapted to developers' business models and to the cash flow profiles of poor people, enabling them to overcome the initial capital barrier of energy access (EUEI PDF 2013; Glemarec 2012; GVEP International 2011). Initiatives may be needed to establish local networks of lenders (local banks, microfinance institutions etc.) with the required understanding of energy projects (IEA 2011).

Risk mitigation is an important concern of investors (Averchenkova 2014; RECP 2014). Support to local financial institutions may be necessary to reduce their perception of risks associated with loans to energy projects and end users. Such support may take the form of credit enhancement through partial risk guarantees provided by donors, or supporting partnerships between financial institutions and energy companies (Cabraal 2012; GVEP International 2011).

In order to make energy projects financially viable for developers, and energy access affordable to villagers, some form of subsidy may be necessary (Haanyika 2006; Pachauri et al 2013; Pueyo et al 2013; Yadoo and Cruickshank 2010; RECP 2014). Such subsidies need to be carefully designed and targeted as they may otherwise be regressive, favouring wealthier people over the poor, and should provide for being phased out if applied to consumption tariffs as they can otherwise be 'addictive'(Ahuja and Tatsutani 2009; GVEP International 2011; Pachauri et al 2013; Pueyo et al 2013).

Subsidies to up-front costs (market development, development of distribution networks, connection costs, initial capital cost etc.) which can otherwise act as barriers to market entry, and to "public goods" such as information on renewable resource availability and energy demand levels and user awareness campaigns, are preferred to subsidies to operating costs and consumption (Glemarec 2012; GVEP International 2011; Haanyika 2006; Kirubi et al 2009). The latter may not, in any case, be needed as there is often a high willingness to pay given the high costs of prevailing alternatives (Pueyo et al 2013; RECP 2014). Conversely, locally generated electricity often costs more than that from the national grid: cost-reflective tariffs may therefore lead to resentment from rural populations and inhibit rural development opportunities (RECP 2014; Tenenbaum et al 2014). In some circumstances, 'lifeline' tariffs, in which an initial tranche of electricity consumption is available at a lower cost, may play a useful role in enabling poorer people to have energy access (Pachauri et al 2013).

Governments should set up one coherent mechanism in which donors participate, rather than have a proliferation of donor-led schemes (EUEI PDF 2013). And improved approaches are needed to enable village-level projects to access global funds such as the Clean Development Mechanism, Global Environment Facility etc. (Practical Action 2009).

Considerations of affordability should take a long-term rather than short-term view of financial sustainability (ARE 2011). The lifetime costs of the project should be the

focus, not minimisation of up-front costs, determining the choice of technology and favouring products of appropriate quality (ARE 2011; Bellanca and Garside 2013; Cabraal 2012; GVEP International 2011; Sovacool 2012). Good operational management and maintenance is another key factor in ensuring that costs are minimised in the long term (ARE 2011).

3.3 Viable and scalable businesses

Viable and scalable businesses need to sit within a functioning network (an 'ecosystem' (Practical Action 2010)) of local companies and financial intermediaries (ARE 2011). Necessary functions include the provision of spare parts, maintenance and repair services, and access to energy generating and using equipment (Cabraal 2012; GVEP International 2011). For products used in the home such as solar lights, retailers are needed who understand the market, and systems need to be in place for product return and repair. It may be possible to make use of existing supply chains for other products (Hirmer 2014).

Business models need to be replicable and scalable, but also adaptable to different contexts (Bellanca and Garside 2013). Risks should be borne by those most capable of managing them (Cabraal 2012). In some circumstances, viable micro/mini-grid projects can be founded on 'anchor tenants' - existing businesses or public institutions - from which energy access can be extended to private households, provided that the scheme is appropriately sized from the outset (ARE 2011; Schnitzer et al 2014).

Smart subsidies may attract private developers by enabling economically viable projects to be established which might not be viable if left just to free market forces. They may take the form of tax credits, low import duties on energy equipment, support for site surveys and market studies, and capacity building (ARE 2011; Glemarec 2012). To the extent that government policies and regulation constrain tariffs, they must be set at a level that enables financially viable schemes to be developed, including provision for expansion to meet increases in consumer demand (GVEP International 2011; Pueyo et al 2013). Effective mechanisms need to be in place for payment collection from customers (GVEP International 2011; IEA 2011).

3.4 Capacity and skills

Developing the necessary capacity and skills (the 'energy literacy' (Practical Action 2009)) to ensure off-grid energy projects are successful is recognised as a key factor, and applies to all stakeholders and each point in the value chain (ARE 2011; Practical Action 2010; Tenenbaum et al 2014). Institutional capacity needs to be developed along with human capacity, and may prove to be the more challenging outcome to achieve (Sovacool 2012).

For households, training and awareness raising initiatives need to explain the benefits of, and opportunities arising from, modern energy, how to use electricity and modern appliances safely, and how to obtain and pay for supplies (ARE 2011; Hirmer and Cruickshank 2014). Being clear on the 'rules' should help to reduce conflicts and electricity theft (GVEP International 2011). Training on the relevant issues associated with energy projects is needed for financial institutions, and on operation and maintenance for power plant operators and electricity distributors (GVEP International 2011). Raising awareness of the merits and potential problems of alternative technologies, business models etc. may also be useful at the national level (GVEP International 2011).

Typically, energy entrepreneurs lack information on what has worked or failed elsewhere (United Nations Foundation 2012): potential project developers need information on existing projects and possible local partners, and consumer research (EUEI PDF 2013).

Donors are in a unique position to facilitate learning between projects, markets and countries, and to support tailored capacity development (EUEI PDF 2013).

3.5 Stakeholder engagement

Stakeholder engagement should be inclusive, involving the public and private sectors and end-users, with the aim of developing a common definition of objectives and agreement on the approach to meeting them (Bellanca and Garside 2013; Haanyika 2006; EACI 2011). Rural energy users and local communities should be viewed not as passive consumers but as active participants in energy projects (Haanyika 2006; Sovacool 2012). They should be involved from project inception in identifying energy needs, monitoring progress, organising the community, enforcing rules, supporting value-added enterprises and so on (ARE 2011; RECP 2014). Local leaders need to be on board, otherwise they may see the project as a threat to their position (GVEP International 2011).

The local community may take a financial stake in the project, and may be involved in the operation and maintenance of the system. This requires much preparation, and in particular social and technical capacity building (ARE 2011). End-users should be able to control their monthly bills, for example through meters or pre-payments (Pueyo et al 2013).

3.6 Technology developments

Rapid technology developments, for example the sharp falls in solar PV costs, more efficient appliances, and the availability of smart technologies for controlling mini-grids, are changing the technological landscape and introducing new opportunities for off-grid village energy provision, particularly against oil-based schemes where operating costs have escalated dramatically (Craine et al 2014; Glemarc 2012; United Nations Foundation 2012). Innovative payment technologies, for example pay-as-you-go and real-time monitoring technologies, are also contributing to increased access (Wilson et al 2014).

There are opportunities also to reduce 'balance of system' costs, which can account for up to 50% of project costs, for example through standardisation of ancillary equipment (Glemarc 2012) and through anticipated reductions in battery costs (Carbon Tracker 2014). But the cost of distribution systems and of the energy storage needed when primary energy resources are intermittent, remain significant factors. It is important to draw on knowledge and expertise from across the world, transferring and adapting appropriate technologies, and supported by long-term partnerships between universities and research institutes in the North and South (Practical Action 2010).

For each installation, a careful choice is therefore needed between technologies, the preferred choice being customised to the specific needs of the community (Chaurey et al 2012). The selection and design of the system must be founded on careful analysis of local resources and demand patterns (GVEP International 2011), and the chosen technology needs to be capable of being locally operated and maintained (Bellanca and Garside 2013). Certification schemes for energy equipment such as solar lights and solar home systems which may be purchased directly by households can play an important role in enabling customers to make informed choices (Hirmer 2014; United Nations Foundation 2012).

4. Catalysing Development

Bazilian and Pielke (2013) criticise the lack of ambition in current thinking which focuses on energy access based on low threshold limits – a 'poverty management' approach – rather than to take seriously the development aspirations of people living in developing countries. Whereas the energy access thinking reflected in the International Energy Agency's 2012 World Energy Outlook (IEA 2012) projects the need for one trillion US$ to be invested over the period to 2030 to achieve universal energy access, 17 times more investment would be needed to achieve world-wide access equivalent to South Africa's or Bulgaria's current rates of energy consumption.

These concerns are echoed by other authors who indicate that, to date, there has been too much emphasis on minimalist approaches, for example the provision of solar lanterns or solar home systems, which tend to result in consumptive rather than productive uses of electricity (Bhattacharyya 2012; Pachauri et al 2013). There needs to be much more focus on energy provision for productive uses, linking initiatives to poverty reduction and livelihoods programmes, if poor people are to escape the poverty trap and 'viscous' cycles are to be transformed to 'virtuous cycles' (Chaurey et al 2012; Sokona et al 2012; World Bank 2008). Provision of rural energy access is a necessary, but not sufficient condition to trigger development (Kirubi et al 2009).

While the reliability, cost and quality of energy are all critical success factors, in order to enhance livelihood prospects energy access must be coupled with access to markets, creation of social networks and business propositions with sufficient demand (Practical Action 2012). Business development support services should focus on establishing sustainable opportunities to generate surplus income (Watson et al 2012) and establishing enterprises which generate new and decent jobs, particularly for workers with low skill levels (Pachauri et al 2013). Initiatives to encourage the productive use of energy may target areas with inherently high potential (for example, with the required infrastructure and access to markets) or focus on deprived areas, in which case complementary initiatives will be needed to create the necessary environment (Pueyo et al 2013).

Various minimum standards to characterise 'total' rather than minimalist energy access have been proposed (Practical Action 2012), as have multi-tier frameworks to characterise a progression through improving levels of energy access for education, health care, households and productive use (Practical Action 2013). Similarly, the United Nations Secretary General's Advisory Group on Energy and Climate Change has proposed an incremental energy access matrix reflecting progression through basic needs, to productive uses, and then modern needs such as the use of domestic appliances, cooling and space heating, hot and cold water, and private transportation (Sovacool 2012c).

Providing the conditions discussed above are met, energy access can enable people to increase their income through new earning opportunities, improving the productivity of existing activities, and reducing opportunity costs by enabling necessary household tasks to be completed more quickly, so freeing up time for income-generating activities (Practical Action 2010). Experience has shown that if households have access to electricity they are more likely to have an income from micro-businesses (Pachauri et al 2013).

Financing of mechanical power is often one of the most cost effective ways to support poor people as some of the most fundamental services required for reducing poverty and promoting human development involve mechanical energy and increasing the productivity of human labour (Sovacool 2012c). Mechanical power enables activities such as pumping, transporting, and lifting water, irrigating fields, processing crops, small-scale

manufacturing, and natural resource extraction. It helps alleviate drudgery, increase work rate and substantially reduce the level of human strength needed to achieve an outcome, thus increasing efficiency and output productivity, producing a wider range of improved products, and saving time and production costs.

While provision of mechanical power has a direct impact on opportunities to increase incomes, energy services which facilitate education and healthcare have an indirect impact as healthy and educated people have greater potential for income generation (Cabraal et al 2005). Access to telecommunication services in developing countries, made possible by access to electricity, can unlock entrepreneurship, promote economic development, lead to greater political empowerment, and provide tax revenues for governments (Glemarec 2012).

Care must be taken to ensure that energy access initiatives provide for the poorest members of the community whose insolvency means that they cannot take advantage of the availability of electricity to escape the poverty trap (Shanker 2012; Cook 2010). They may be unable to afford the required appliances, farm tools and equipment for micro-enterprises, and face the bottlenecks of inaccessible markets and capital (Pachauri et al 2013).

5. Roles: governments and the private sector

A substantial increase in funding is needed from all sources in order to deliver energy services to rural communities in developing countries (IEA 2011). In its scenario exploring actions necessary to achieve universal energy access by 2030, the International Energy Agency (2011) projects annual funding requirements of US$18 billion from multilateral development banks and bilateral aid, US$15 billion from developing country governments and US$15 billion from the private sector.

State co-financing is considered necessary to make energy provision to remote and under-developed areas sufficiently profitable to attract the private sector, particularly in the early stages when public funds may need to support a significant proportion of the costs (Ahuja and Tatsutani 2009; Shanker 2012). Sustained government investment is needed over a significant period to create a market for energy access (Glemarec 2012). A parallel is drawn with the US rural electrification programme in the last century where there was 30 years of government funding before significant capital investment was attracted from the private sector (Glemarec 2012).

Government subsidies and support need to be well-targeted, simple, competitive and time limited (Ahuja and Tatsutani 2009; Haanyika 2006), and should aim to establish effective markets for energy access (Practical Action 2009). In particular, public funding is likely to be needed for “public goods” such as information and users’ awareness of benefits (which individual market actors are reluctant to fund since they may not capture the economic benefits), and for the super-costs of market entry such as establishment of last-mile distribution networks and early stage operation while demand is low (Tenenbaum et al 2014).

A key role for governments is also to put in place a supportive legal/regulatory and institutional framework, which establishes a rural electrification agency and independent regulator, and sets effective ground rules for utilities, both public and private (Haanyika 2006). Governments may usefully also fund business incubation initiatives and demonstration projects which show that a new concept or business model is commercially viable and attractive to private investment (UNEP 2012b; STEPS Centre 2014; Wilson et al 2014). And they need to conduct and publicise market and technological research, raise awareness of consumers and investors to reduce perceived risks and build shared visions, and build networks that link diverse stakeholders (STEPS Centre 2014).

A key challenge for governments in developing countries is that their capacity to provide the necessary funding is limited: they also face substantial needs for funding in areas such as education, health, social services, food and human security, basic infrastructure, and disaster risk management (Chaurey et al 2012; Glemarec 2012). Innovative mechanisms are therefore needed to catalyse private sector involvement and investment (Glemarec 2012; IEA 2011; UNEP 2012), which will also bring to bear the private sector's experience of appropriate innovative technologies and organisational solutions (Shanker 2012). A better understanding is needed of hoe alignment between business and development objectives can be constructed and incentivised by donors, governments and NGOs (Humphrey et al 2014).

Mechanisms and support for de-risking of investments can play an important role (IEED 2013). The United Nations Environment Programme is launching a programme to demonstrate viable and scalable business models for mini-grids to address these issues (UNEP 2014). Within the private sector it is considered important also to mobilise small private resources and local capital, for example from small farmers and local traders (Practical Action 2009).

Pro-poor public-private partnerships are considered to be an attractive mechanism for involving the private sector, and can in principle effectively allocate project risks between the public and private partners (Chaurey et al 2012). Local cooperatives, operating with some form of government assistance, can also be an effective model, enabling the ownership and active involvement of the local community (Yadoo and Cruickshank 2012).

International support should build on national ownership and should complement local efforts and fiscal resources (UN Energy 2013). To date, access to funding from the Clean Development Mechanism (CDM) has been impractical for small rural electrification projects: rigid rules leading to long, uncertain and expensive approval processes have made transaction costs unaffordable (Glemarec 2012; IEA 2011). But current CDM reforms may make these funds more available. Another route for governments to free up resources is to reform existing subsidies, for example to agriculture, fisheries, forests and water as well as energy. Subsidies to fossil fuels are a significant barrier to renewable energy technologies (Glemarec 2012).

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