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Expanding access to electricity

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Chapter II

Expanding access to electricity

Grid and centralized sources

- Traditionally households connected to centralized power plants
- Advantage of economies of scale; disadvantage of high up-front costs during expansion

→ Disadvantage: Challenge to address climate change and advances in renewable energy technologies drive focus on electricity through distributed sources

Distributed sources

- Households connected to distributed sources
- Proximity to the point of consumption, largely renewable, not connected among sources
- Advantage of being able to reach poor and remote populations quickly and cheaply, while simultaneously mitigating carbon emissions

Source: (Bhattacharyya & Palit, 2016; Deshmukh et al., 2013; TERI- GNESD, 2014; Terrapon-Pfaff et al., 2014; Alstone et al., 2015)

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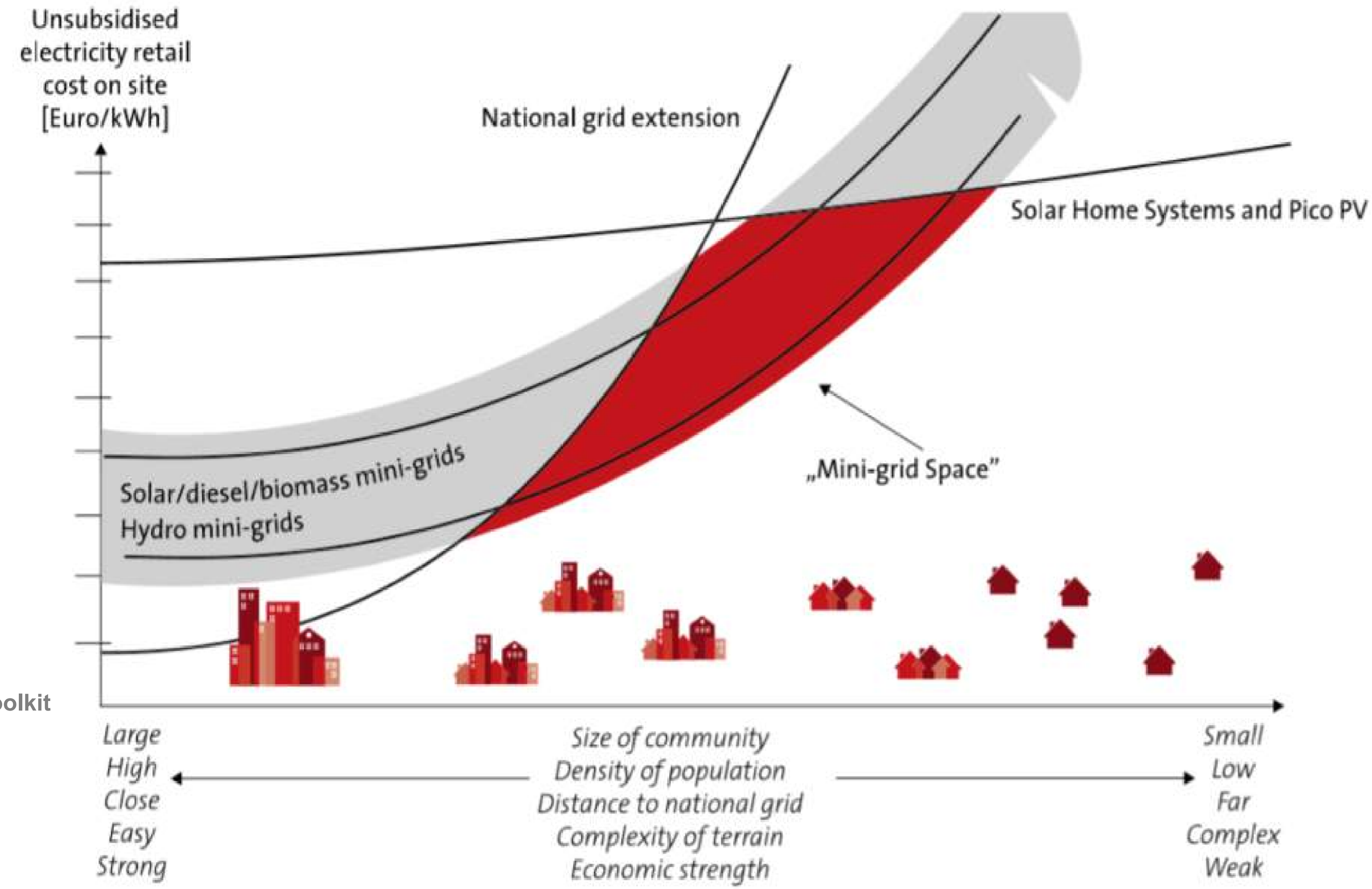
- Grid vs. Mini-grid as small-scale electricity generation (10kW to 10MW) in isolation supplying relatively dense settlements with electricity at grid quality level



Source: Mini-Grid Policy Toolkit

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Four dominant approaches

- Connecting households by expanding the grid
- Providing electricity via mini-grids
- Providing electricity via solar home systems (SHSs)
- Providing energy services via the sale of solar appliances

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→ Expanding the grid

Advantages

- Economies of scale, many people to a single piece of infrastructure
- Lowest retail price of all technologies bc shared by all customers
- Feasible to provide for large quantities (industry)
- Well understood / blue prints - finance, construction, retail market, institutional req's

Challenges

- High up-front costs, high connecting costs
- Densely populated areas, people must afford connection and large quantities of el
- Poorly suited in poor, remote areas, small amounts of electricity, challenging terrain where infrastructure difficult to build and maintain

  → Much of sub-Saharan Africa's rural population: challenging characteristics of low density, low incomes, low levels of demand, current extent of the grid limited

Expanding access to electricity

→ Expanding the grid

Challenges continued…

- Grid infrastructure reliable and sufficient capacity?
- Expansion of an unreliable grid, without addressing capacity problems, places greater demands on the system and makes the grid less reliable for everyone (overall infrastructure vulnerable to localized impacts)
- Approximation of a perfect monopoly (high capital costs, low marginal costs): not amenable to competition, best managed by regulated utility

Solutions

- Bring down connection costs
- Commercialisation and private competition: but not proven to bring down costs

  → Cost of expanding the grid, sparse and remote population, unresponsiveness of many African utilities led to recent push to focus on distributed generation - private sector involvement, bypass the need to engage an unresponsive utility

Expanding access to electricity

→ Mini-grids

Characteristics

- Variety of electricity generation systems drawing on a variety of sources (solar photovoltaic, wind, small-scale hydropower, biomass, fossil fuels, and combinations)
- Number of households and/or services connected to a generation point
- Power in various amounts and over various time intervals during a day
- Stand-alone or connected to the grid for smoothing out problems
- Systems can initially be built with limited generation capacity and then add capacity as demand for electricity increases
- Costs vary by generation source available and demand
  - Micro-hydropower lowest-cost if river runs all year
  - Wind cost effective too, site specific wind assessment important
  - PV ubiquitously available and relatively predictable (greatest promise for mini-grids)

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→ Mini-grids

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Challenges

- Up-front costs significantly lower than in grid expansion, but still high for local population
- Small extent of mini-grids means requirement for storage, few economies of scale
- Storage requirement drives cost
- In remote and hard-to-reach locations maintenance costs go up

- Costs of components and labour vary across countries, size of the system, source of the energy, pattern of demand placed on the system
- LCOE of PV-diesel mini-grids: \$0.24–\$0.35/kWh or €/0.18– €/0.25kWh (Source: Huld et al., 2014)

Expanding access to electricity

→ Mini-grids

Challenges continued…

- Electricity from mini-grids generally higher cost than from the grid
- Creates challenges for using mini-grids to drive energy access and human development
  - high cost limits the extent to which mini-grids are accessible to the poor
  - households tend to limit services they are willing to access to those requiring only small amounts of electricity (lighting, cell phone charging), not use electricity for productive purposes
  - mini-grid profitability challenge limits interest of the private sector
- Operating a mini-grid comparable to operating a mini-utility, requires considerable economic, financial and technical skill (lack of trained installers, technicians, and trainers)
- New technology as a “risky business environment due to unknown consumer characteristics and unfamiliar business activities, weak institutional arrangements

Expanding access to electricity

→ Mini-grids

An example

In Africa, grid tariffs so high that considered an impediment to development, grid retail prices are about \$0.13/kWh (World Bank, 2013), though can be much higher in cases

- IEA definition of energy access suggests urban household needs at least 500 kWh of electricity annually to meet its basic energy requirements for lighting, communications, and some cooling, while a rural household needs at least 250 kWh
- 2008 average income of an African household of \$7626 (Lakner & Milanovic, 2013), 10 percent of that household budget (the income threshold for energy poverty) would provide \$76.20 for spending on energy
- mini- grid prices \$0.34/kWh, average African household could afford only 224 kWh/year
- at average African grid prices (\$0.13/kWh), the average household could afford about 586 kWh annually

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Expanding access to electricity

→ Mini-grids

An example continued…

→ All of this together means that the average African household could not afford to purchase the basic electricity required for a rural household even if it spent as much as 10 percent of its annual budget on electricity obtained from a relatively large-capacity mini-grid

→ Such a household could only just meet the needs of an urban household when buying electricity from the grid. When we consider that this 10 percent budget share excludes energy for cooking, it becomes clear just how large a challenge energy costs present for improving energy access among poor, rural households

Expanding access to electricity

→ Mini-grids

Solutions

- High tariffs stem from high capital costs, focus to keep down capital costs
- Stand to benefit greatly from advances in renewables technology, lower costs of energy system and storage options
- Low watt appliances
- Opportunity to address energy poverty requires consideration of future prices

- Keep the system as small as possible while still meeting people's energy needs
- Requires exhaustive analysis of likely system demand prior to project (Deshmukh et al., 2013)
- Build demand-side management into any mini-grid system (Deshmukh et al., 2013)
- Unelectrified rural households know how much electricity they will use?

Expanding access to electricity

→ Mini-grids

Solutions continued…

- Yet hybrid diesel-PV systems also pose challenges
  - introduction of diesel results in carbon emissions
  - import dependency and emissions lead to unstable costing/electricity prices
- Expert advice has begun to suggest eschewing hybrid systems in favor of purely PV generation, despite the increased costs (M. Lee et al., 2014; Murphy et al., 2014)
- Proper battery management is essential to the longevity of mini-grids
- Issue of (1) financing, (2) lack of technical staff to support mini-grid operation and maintenance, and (3) challenges associated with first-generation technologies

  → development of tools for financing local entrepreneurs; training of personnel involved in mini-grid siting, installation, operation, and maintenance; support for data sharing and learning for effective business models (Alstone et al., 2015)

Expanding access to electricity

→ Mini-grids

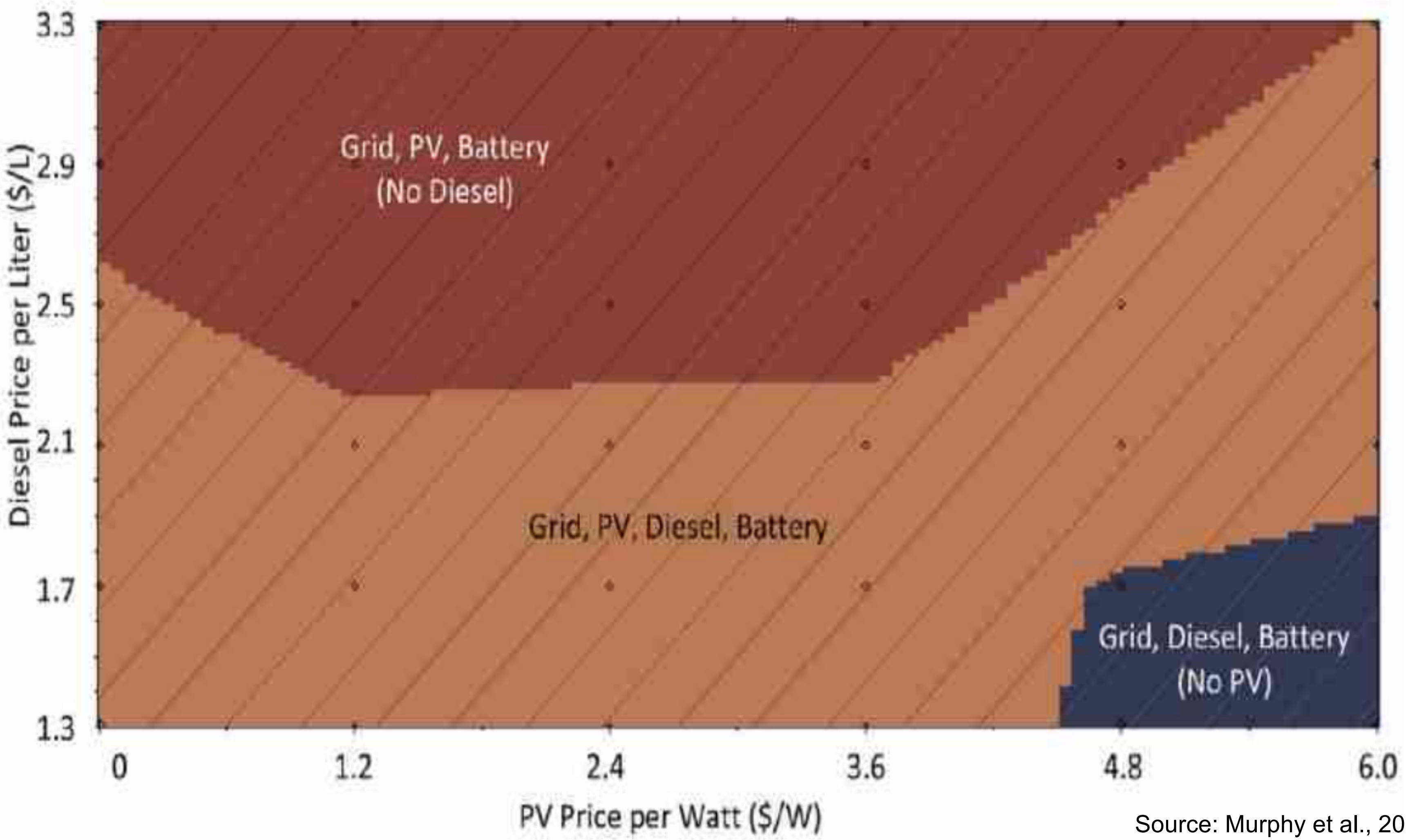
Solutions continued…

- Even under supportive conditions the private sector has been known to refuse to deliver mini-grids to certain areas if they are considered too remote, too poor, or too small to offer serious potential for growth in demand (Bhattacharyya & Palit, 2016)

- Even though distributed energy technologies are intended to improve energy access among the poor, reviews show that they continue to benefit the relatively well-off (Bhattacharyya & Palit, 2016)

Expanding access to electricity
→ Mini-grids

Price points at which PV-only, hybrid, and diesel-only mini-grids produce the lowest-cost electricity



Source: Murphy et al., 2014

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→ Mini-grids

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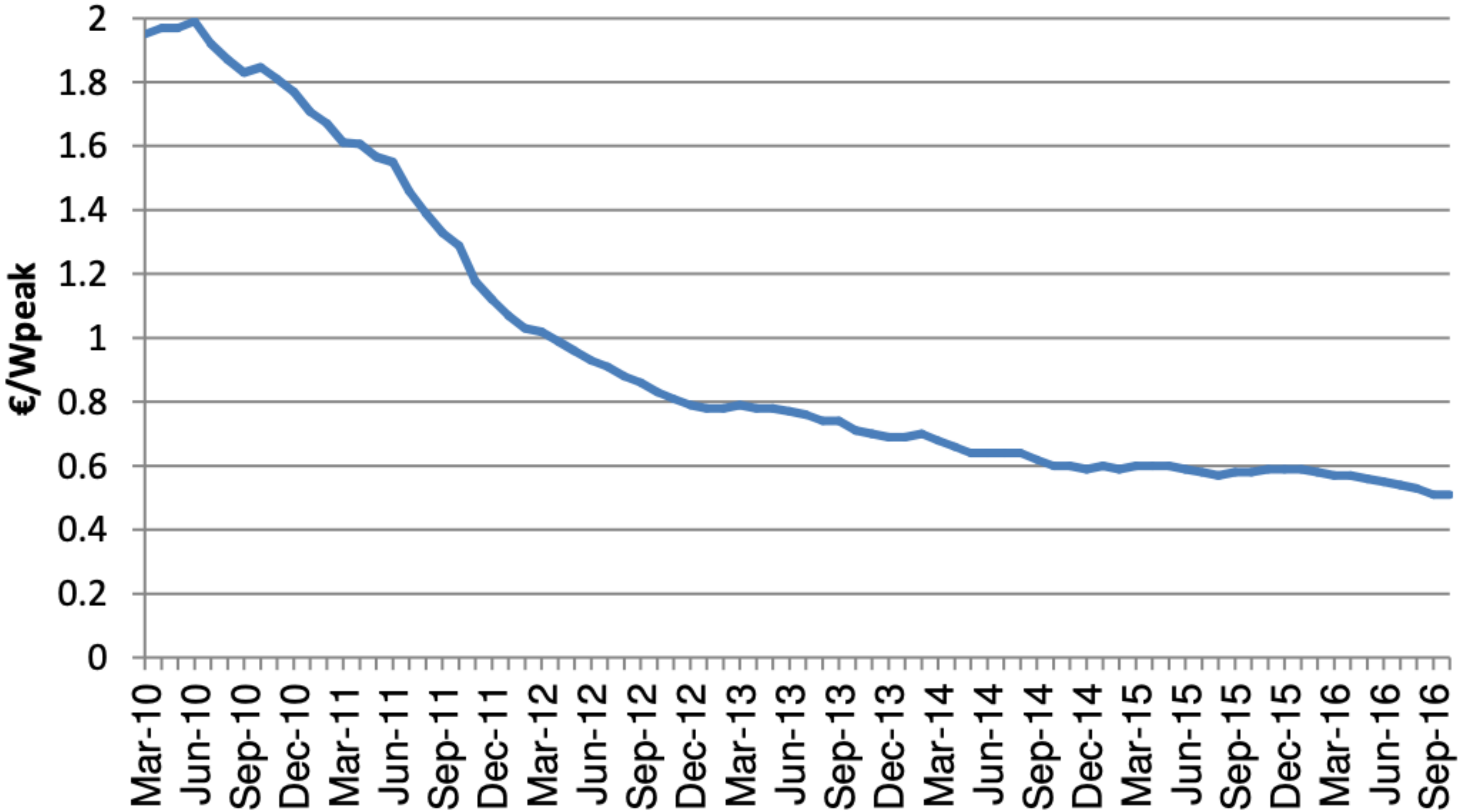
The falling price of solar panels: March 2010–October 2016

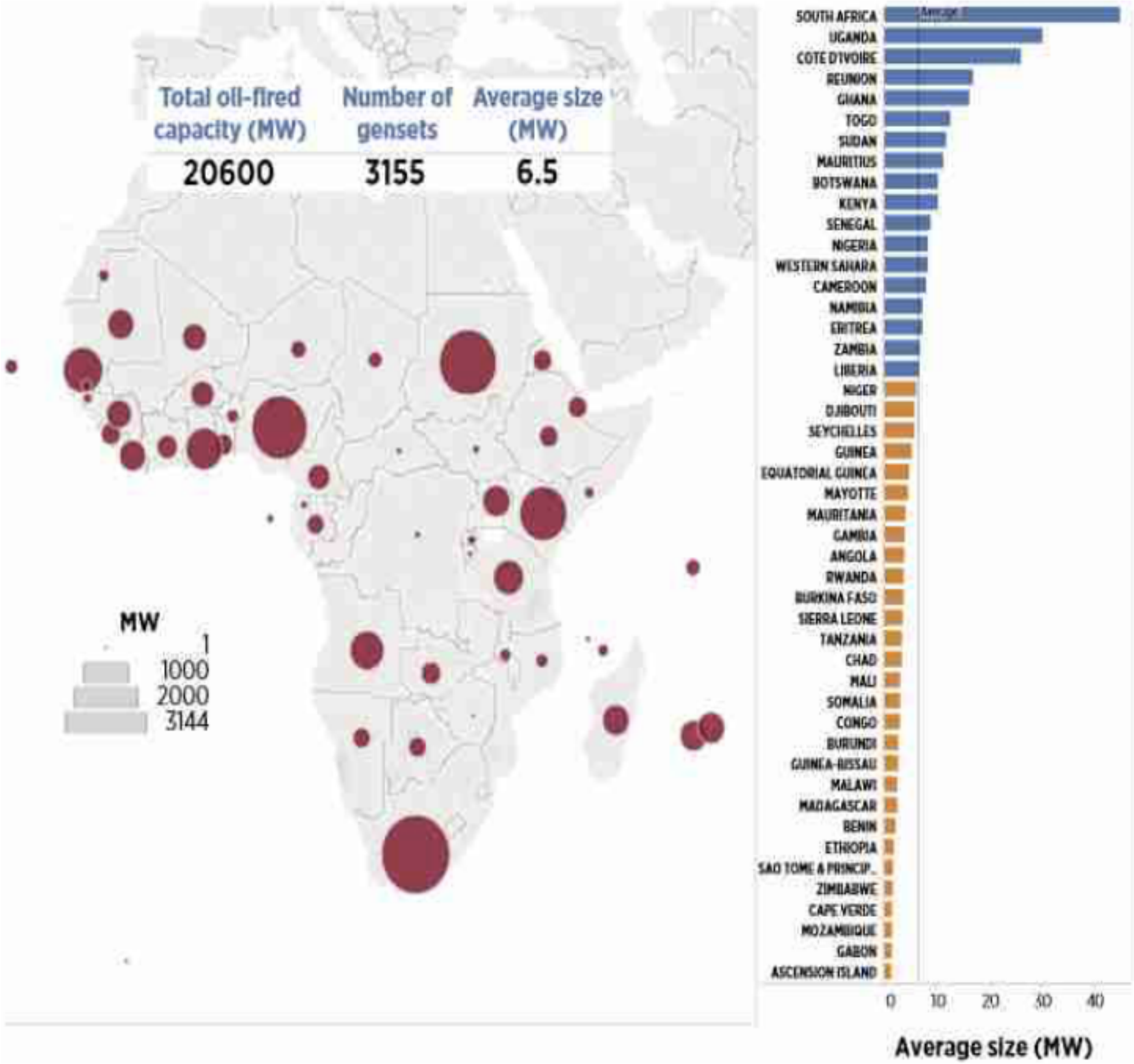


Source: PVXchange

Expanding access to electricity

→ Mini-grids

Distribution of existing oil/diesel generator capacity in sub- Saharan Africa



Source: IRENA, 2016b, p. 59

Expanding access to electricity

→ Mini-grids

Comparing different costs of generation sources

Generation source	LCOE ($/kWh)		Total energy average African household - 10% budget (kWh/yr) (IEA basic: rural - 250, urban – 500)
	Small system	Large system	
Hybrid PV-diesel mini-grid	0.47	NA	162.1
PV mini-grid	NA	0.34–0.37	205.9–224.1
SHS	0.72	NA	105.8
Grid in Bangladesh (retail price)	0.04	0.04	1905[7]
Grid in Africa (avg. retail price)	0.13	0.13	586.2

Source: Oxfam research backgrounder on energy poverty and access

Expanding access to electricity

→ Solar home systems

Definition

- Solar home systems are generation systems designed to provide electricity to a single household using solar panels and a small battery
- Major advantage of SHSs is that they can be used to provide electricity to isolated households

Challenges

- Small size of these systems can only provide small amounts of electricity (suitable for lighting, entertainment, charging a cell phone, and cooling)
- Limited hours a day
- Unable to supply energy for heating or cooking, not sufficient to provide motive power to support small industry
- Lowest tiers of energy access

Expanding access to electricity

→ Solar home systems

Challenges continued …

- Stand to gain from likely future advances that reduce the cost of renewable generation and storage components and from the arrival of new low-watt appliances on the market
- Theft of solar panels: Locked steel cages or removed panels from their roofs can change set up and decreases generation capacity (Azimoh et al., 2014)
- Truly unable to take advantage of economies of scale
- Electricity from an SHS is usually more expensive than that provided by a mini-grid that provides the same level of services (Bhattacharyya, 2015)
- Even with relatively low capital costs, many poor households remain unable to afford the up-front costs of SHS installation

Expanding access to electricity

→ Solar home systems

Solutions

- Subsidies or credit schemes needed to support affordability of the technology
- Risk of theft can be reduced by using mobile racks, hold the solar panels off the ground and at an appropriate angle, yet allow households to move them inside
- Many of the challenges with SHSs can be addressed if the communities receiving the technology are engaged, understand the capacity of the system and the challenges to sustainability posed by system mismanagement
- Overall SHSs provide an important means for providing access to electricity, but the general success or failure of a program depends on the specific context. In many cases households have been satisfied with the service they receive from SHSs despite the costs

Expanding access to electricity
→ Solar appliances

Definition

Solar appliances refer to individual appliances (torches, radios, cell-phone chargers, lanterns) that run on solar power and provide energy service

Advantages

- very low capital requirements
- have supply chains that can be established relatively easily
- offer a big market for the private sector
- rapid and significant impacts on domestic energy systems, replacing dry-cell batteries as well as solid and liquid fuels for illumination purposes (Turman-Bryant et al., 2015)

Expanding access to electricity

→ Solar appliances

Challenges

- only small quantities of electricity and have limited storage capabilities
- useful for meeting the lowest tiers of energy access and do not supply motive power to support livelihood diversification or help meet thermal energy service needs
- new technology, uptake can be slow

Solutions

- Future gains possible from the development of low-watt appliances and cheaper solar components
- To improve uptake, it is thought that providing guarantees of the quality of the devices, as well as socializing their advantages over solid fuels, can increase households' willingness to spend relatively large sums of money on untested technologies (Turman-Bryant et al., 2015)

Expanding access to electricity

→ Solar appliances

Solutions

- Solar appliances can play an important role in providing people with the lowest tiers of energy access
- Efforts thus need to be focused on promoting these technologies and then incorporating them into a process that delivers energy systems capable of more completely meeting people's energy needs

Relative strengths and challenges
→ Four approaches

Expanding the grid	Success in providing electricity to populations around the word Advantage of economies of scale Large role for the state	Can sell electricity at low cost Can provide large quantities of electricity Essential for increasing overall penetration of renewables Known technology	Very expensive to build State bureaucracy and unresponsiveness Currently heavily reliant on fossil fuels
Mini-grid	Very limited economies of scale New technology Amenable to future reductions in price of solar and storage	Very large scope for renewables Can provide large quantities of electricity Lower capital costs Quick to deploy Some role for the private sector	Relatively expensive electricity Relatively high capital costs (for local investors) Requires resource-intensive, bespoke approaches to make electricity affordable Current lack of supply chains and relevant skilled personnel First-order challenges to new technology
SHSs	No economies of scale Amenable to future reductions in price of solar and storage	Large role for private sector 100% renewable Relatively established technology	Expensive electricity Limited quantities of electricity Novel challenges around system management
Solar appliances	No economies of scale	100% renewable Large role for the private sector Potential to drive rapid changes in household fuel use	Very limited quantities of electricity Very expensive electricity Difficult to exercise quality control over different appliances

Source: Oxfam research backgrounder on energy poverty and access

Electricity and energy poverty

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Chapter III

Electricity and energy poverty

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Significant experimental challenges to test this relationship - I

- When areas receive electricity (especially grid electricity), they also tend to be undergoing other changes - significant economic and/or population growth - also likely to be experiencing other changes in terms of resourcing and infrastructure

- Difficult to disentangle the impacts of electrification on development from the effects of other processes taking place in a population (Burlig & Preonas, 2016; Dinkelman, 2011; Khandker et al., 2009a)

Electricity and energy poverty

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Significant experimental challenges to test this relationship - II

- A host of novel and sophisticated methods to resolve this challenge

  → Methods include panel data, control groups (Khandker et al., 2009b), instrumental variables (Dinkelman, 2011; Khandker et al., 2009a), regression discontinuity (Burlig & Preonas, 2016), propensity score matching (Khandker et al., 2009a), and simple qualitative impact assessments

- Worth keeping in mind, all cross-sectional analysis have their shortcomings, impacts of electrification may be short-term - patterns observed today may not hold in the future (Khandker et al., 2009, p. 22)
- Nonetheless, multiple works on electrification show a recurrent features regarding their impacts on household energy poverty, economic development, and services

Electricity and energy poverty

→ Impacts on household energy poverty

Access to electricity

- principally used for lighting, entertainment and ICTs, and cooling
- results are increased use of appliances, reduced candle and kerosene use, increased access to lighting, and less time spent collecting fuels (Azimoh et al., 2015; Bhattacharyya & Palit, 2016; Broto et al., 2015; Dinkelman, 2011; Prasad & Visagie, 2006)
- changes household fuel choices and reduces use of some solid fuels (Dinkelman, 2011)

- BUT: generally does not cause households to shift away from using predominantly solid fuels for cooking and heating (Bailis et al., 2005; Broto et al., 2015; Gebreegziabher et al., 2012; Khandker et al., 2009b; Madubansi & Shackleton, 2006; Malla & Timilsina, 2014; Masera et al., 2000; Prasad & Visagie, 2006; World Bank, 2008)

Electricity and energy poverty

→ Impacts on household energy poverty

Access to electricity and heating and cooking

- pattern persists even when electrification rates are high (Bailis et al., 2005; Broto et al., 2015) and long after electricity access has been established (Bailis et al., 2005; Cowan & Mohlakoana, 2005; World Bank, 2008)
- relationship holds among very wealthy households (Hiemstra-Van der Horst & Hovorka, 2008; Khandker et al., 2010), including those in the 90th income percentile17 (Bacon et al., 2010)
- holds when access to fuelwood decreases (Madubansi & Shackleton, 2006) and when electricity is the cheapest available fuel source (Hosier & Kipondya, 1993)
- pattern largely holds across rural and urban areas (Broto et al., 2015), though urban areas have seen greater use of electricity for cooking (Bacon et al., 2010; Cowan & Mohlakoana, 2005)

Electricity and energy poverty

→ Impacts on household energy poverty

Access to electricity has impact on well-being

- Despite the failure to transition energy-poor households toward using electricity for cooking and heating, electrification has a significant impact on people's well- being
- illumination provided by SHSs in South Africa was found to be used effectively to improve safety and scare away reptiles from people's dwellings
- entertainment has been noted to improve people's quality of life (Azimoh et al., 2015; Prasad & Visagie, 2006)
- positive impacts on education by increasing study hours (Azimoh et al., 2015; Khandker et al., 2009a; Prasad & Visagie, 2006)
- school enrolment rates go up (Khandker et al., 2009b)? - study involving 30,000 Indian villages, showed no evidence of increased school enrolment as a result of households' being provided with access to electricity through the grid (Burlig & Preonas, 2016)

Electricity and energy poverty

→ Impacts on household energy poverty

Access to electricity and increased consumption

- newly connected areas are repeatedly found to experience a subsequent increase in demand, households' slowly purchasing appliances that they have had to save up for (Khandker et al., 2009b)

- trend is so common that it is considered good practice to oversize mini-grid installations in order to cope with the subsequent increases in demand that are likely to take place

Electricity and energy poverty

→ Impacts on economic development

Evidence

While the evidence on the impact of electrification on household energy poverty is clear, on the economic impacts of electrification is much more ambiguous (Cook, 2011)

- literature agrees that access to electricity in rural areas does not drive industrialization (Dinkelman, 2011; Khandker et al., 2009b; World Bank, 2008), findings on the impacts on small business development, livelihood diversification, household incomes are mixed
- no particularly noticeable impacts on economic development, generally thought to be uncertain and largely anecdotal (Schillebeeck et al., 2012; Terrapon-Pfaff et al., 2014)
- mixed results suggest that while electrification matters for economic development, by itself it is insufficient to drive development, and other factors likely matter in determining economic outcomes (Cook, 2011)

Electricity and energy poverty

→ Impacts on economic development

Evidence continued…

- only a few households use electricity for productive purposes
- the focus is on a few small business owners who use electric lighting to extend their business hours (Azimoh et al., 2015; Bhattacharyya & Palit, 2016; Broto et al., 2015) or the small number of households that use electricity to start new businesses, such as hairdressing salons (Broto et al., 2015; K. Lee et al., 2014) and cold storage facilities (Broto et al., 2015)
- electrification has been shown to favour the creation of sectors that provide electronic services (such as showing TV, charging phones, and playing music)
- there is limited evidence of households using electricity for productive purposes involving motive power (such as carpentry or milling) (Khandker et al., 2009b; K. Lee et al., 2014)

Electricity and energy poverty

→ Impacts on economic development

Evidence on the limited effects

- at best, electrification leads to only small changes in economic outcomes in the medium term, three to five years (Burlig & Preonas, 2016) – urban and rural areas
    - in Cape Town's informal settlements, for example, electrification was found to have almost no discernible impact on economic activity (Cowan & Mohlakoana, 2005)

- women's income opportunities have been observed to increase in urban areas as a result of access to electricity
    - Support of commercial activities such as dressmaking, washing, ironing, and hairdressing (Clancy, 2006)
    - KwaZulu Natal Province, South Africa, female employment found to rise significantly, electrification increased the number of jobs in rural KwaZulu Natal, and also increased the hours women worked, with most of this work thought to come through the creation of cottage industries (Dinkelman, 2011)

Electricity and energy poverty

→ Impacts on services

Little research available

impact of electrification on the availability and quality of services (Practical Action, 2014)?

What do we know?

- street lighting to be important for safety, for making it easier to run errands after dark in informal settlements, and for creating a welcoming neighborhood (Broto et al., 2015)
- Although expanding access to electricity has been used to improve the cold chain (which is important for vaccines) questions have been raised about whether this translates into increases in immunization rates (World Bank, 2008)
- largest impacts of electricity on service provision are thought to result from a greater willingness on the part of health and education workers to remain in rural areas once they are electrified (World Bank, 2008).

Electricity and energy poverty

→ Summary - I

- Energy is necessary for a host of services that can have profound impacts on human well-being, simply providing electricity, whether from the grid or from distributed sources, does not guarantee that people will start consuming those energy services
- Newly electrified households tend to use electricity for lighting, communications, entertainment, and cooling. They do not, for the most part, use electricity for cooking or heating
- In terms of the economic impacts of electricity access, the results are decidedly mixed
- Many studies indicate that economic impacts are small and limited to a few individuals, with the deployment of electricity for motive power being extremely limited
- At the same time, other studies point to large, generalizable positive effects on income through improved access to irrigation and the creation of cottage industries

Electricity and energy poverty

→ Summary - II

- Predictions that rural electrification would lead to large-scale improvements in well-being among poor populations in low-income countries, fuelled by a huge diversity of small-scale industries, do not appear to have been borne out in the empirical literature to date

- While the evidence base is limited, access to electricity does appear to have improved access to services

Electricity and energy poverty

→ Bridging to thermal services

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From electricity to thermal services - I

- Access to electricity shows benefits on income and well-being
- But users' failure to use electricity for thermal services, and ambiguous findings on the economic impacts, present real challenges to efforts addressing energy poverty

- In developing countries, cooking and heating are responsible for more household energy than any other activity - as much as 90 percent (Bhattacharyya, 2012; Malla & Timilsina, 2014)
- Using solid fuels for these activities drives the most severe negative health outcomes (Africa Progress Panel, 2015)

Electricity and energy poverty

→ Bridging to thermal services

From electricity to thermal services - II

- The limited use of electricity for productive purposes not only suggests a failed opportunity to stimulate development gains, but also strains the financing of energy projects
- This is because exclusive domestic energy use causes peak loads to concentrate in the early evening, increasing the cost of the overall system
- failure to increase household incomes threatens the long-term sustainability of electricity access efforts because poor populations remain unable to afford the tariffs that are required to cover the full costs of generating the electricity (Terrapon-Pfaff et al., 2014)
- As a result, efforts to address energy poverty need to go well beyond simply providing access to electricity. They need to account for the persistent use of solid fuels for meeting people's thermal needs, and they need to integrate better with the factors driving economic development

Beyond electricity: broaden energy access

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Chapter IV

Beyond electricity: broaden energy access

→ In addition to improving access to electricity, any serious effort to address energy poverty will need to pay greater attention to questions of energy for cooking and heating

→ To understand why efforts at electrification have failed to address household energy poverty, it is useful to begin by discussing the paradigm that informed the strong focus on electricity

Beyond electricity: broaden energy access

→ Energy ladder

Hope that access to electricity would address household energy poverty stems from a particular conception of how households make choices about fuels - known as the "energy ladder" (Agbemabiese et al., 2012; Hiemstra-Van der Horst & Hovorka, 2008; Masera et al., 2000). Households:

- expected to purchase the most sophisticated fuel they can afford / have available
- expected to choose less-polluting, more efficient fuels, and so to substitute dung for wood, wood for charcoal, charcoal for kerosene, and kerosene for LPG or electricity

→ each fuel representing a higher, rung on the energy ladder

→ wood is the fuel of the poor, and people's fuel choices are determined by constraints related to access to fuels and low incomes (Hiemstra-Van der Horst & Hovorka, 2008)

→ focus on electricity has been based on the assumption that households have a natural preference for electricity and will use it based on the savings to be had from using a more efficient, less locally polluting fuel

Beyond electricity: broaden energy access

→ From the Energy ladder to fuel stacking

The energy ladder has been criticized for ignoring human agency in fuel choices and for doing a poor job at predicting them (Hiemstra-Van der Horst & Hovorka, 2008)

→ subsequent empirical studies looking at fuel use have suggested that a more effective conceptualization of fuel choices is the idea of “fuel stacking” (Bacon et al., 2010; Hiemstra-Van der Horst & Hovorka, 2008; Masera et al., 2000)

→ rather than simply exchanging traditional fuels for modern ones, households make deliberate choices to use specific fuels to meet particular needs (Hiemstra-Van der Horst & Hovorka, 2008; Madubansi & Shackleton, 2006)

Beyond electricity: broaden energy access

→ Fuel stacking

Considerations

Choices regarding which fuels to keep in the household and when to use them are based on assessments of both needs and opportunities – complex household economies

- availability and price of different fuels
- cultural preferences for using certain cooking methods
- opportunity cost of acquiring those fuels considering the resources available to the household

→ accounts for the complex fuel choices that households have been observed to make

(Bacon et al., 2010; Gebreegziabher et al., 2012; Khandker et al., 2010; Khandker et al., 2009b; Malla & Timilsina, 2014; Meikle & Bannister, 2003)

Beyond electricity: broaden energy access

→ Fuel stacking in practice

persistent use of solid fuels for cooking and heating, even when electricity and LPG are available, is explained by the fact that collected fuelwood has no monetary cost and because household-labor is often abundant

- Charcoal, which must be purchased, has the advantage of being available in small quantities that match households' limited access to cash (Bacon et al., 2010)
- In contrast, LPG must be bought in a large canister (a problem referred to as "lumpiness" in the literature), and many households are unable to afford it at any one point in time (Cowan & Mohlakoana, 2005)
- In regards to concerns around reliability mentioned earlier, households continue to use solid fuels because of cultural preferences regarding how different fuels affect the flavour of food and because the individuals preparing food know how to use them

Beyond electricity: broaden energy access

→ Fuel stacking in practice

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- households have been observed making highly strategic choices about using different fuels for different foods—for example, making "modern foods" such as tea, coffee, and macaroni on an electric hotplate while using fuelwood to prepare traditional foods that require long simmering times (and that are also vulnerable blackouts if prepared on an unreliable grid) (Cowan & Mohlakoana, 2005; Hiemstra-Van der Horst & Hovorka, 2008).

- Research on the complex energy economies apparent within households has also found that households will maintain fuels such as kerosene and candles in the home for illumination even when they have access to electricity (K. Lee et al., 2016)

➢ Grid is liable to suffer blackouts, and SHS/mini-grid connections may not provide sufficient energy to cover illumination needs for the whole household

Beyond electricity: broaden energy access

→ Energy ladder and fuel stacking

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Overall

- introducing modern fuels into households drives changes in how households access energy services (such as reducing the kerosene used for lighting), but it does not lead to the complete substitution of those fuels
- households gain access to modern fuels and further diversify the fuels they use, adding electricity and/or LPG to the mix (Madubansi & Shackleton, 2006; Masera et al., 2000)

- Abundant literature criticizing the concept of the energy ladder, but still omnipresent in discussions about energy access
- In contemporary conceptions rungs of the energy ladder refer to extent to which households use modern fuels to access an increasing number of energy services – essentially conflating the notion of a ladder rung, with tiers of energy access

Beyond electricity: broaden energy access

→ Energy ladder and fuel stacking

Overall continued…

- The first rung of the ladder, for example, is the use of electricity for lighting, communications, and entertainment (see, e.g., Lee et al., 2016; Africa Progress Panel, 2015)
- New usage still focuses on the idea that people will increasingly move toward using modern fuels to meet more of their energy service needs and failure to do so is driven primarily by constraints on their ability to choose their fuels

➢ conception still generally fails to account for the agency of households in choosing fuels (Hiemstra-Van der Horst & Hovorka, 2008)

➢ should be pointed out that the fuel-stacking model too, despite its advantages, fails to effectively explain why and when households begin to abandon solid biomass fuels and use modern fuels to meet all of their energy service needs

Beyond electricity: broaden energy access
→ Energy ladder and fuel stacking

Wrap up with limitations of both

Models have focused heavily on the potential role of

- fuel price and
- income

as constraints on fuel choice

- As such these two factors have received particular attention in the literature