Leapfrogging to smart grids: How startups can help developing countries roll out modern electricity networks

As many developing countries are still in the process of rolling out electricity networks, they have an opportunity to leapfrog to smart grid technology. Less than 50% of people in the least developed countries have meaningful access to electricity and it is a priority of many governments to extend grid access to those missing out. Instead of being upgraded later, these grid extensions could be made smart from the outset.

Smart grids could bring significant economic and social benefits to developing countries. Advanced metering infrastructure can help crack down on electricity theft, which costs utilities in developing countries tens of billions of dollars annually, reducing their ability to provide reliable and affordable electricity. Smart grids can also help prevent the blackouts that plague many developing nations, at an estimated economic cost of billions of dollars each year.

However, the upfront cost of smart grid technology is a major barrier for developing countries. While the benefits of smart grid projects – if executed properly – can be considerably higher than costs, a lot of those costs need to be paid upfront. This is a problem for many developing countries who have limited access to debt and budgets that are already stretched thin.

Startups can help overcome this barrier by finding low-cost solutions. Startups have the tendency to develop goods and services at lower costs than previously possible. One way they often achieve this is by leveraging existing assets. In the smart grid context, this might involve coordinating appliances such as air conditioners to provide demand management services.

There is a lot that governments and other organisations can do to encourage entrepreneurs to focus on smart grid problems. Governments that wish to leverage startups in this area can extend smart grid tendering practices and establish relevant price signals. Funders, NGOs, multilateral organisations and existing businesses can use their resources and local knowledge to help overcome the lack of information, contacts and reputation that might otherwise hold back startup activity.

(Energy)Lab

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About EnergyLab
We are Australia's leading platform for launching new energy businesses. Our Acceleration Program was the first in Australia to focus on energy startups and is currently operating in four cities. To find out more visit energylab.org.au.

About EnergyLab's research
EnergyLab prepares discussion papers such as this to help facilitate productive conversation around clean energy innovation, and to promote and support clean energy entrepreneurship.

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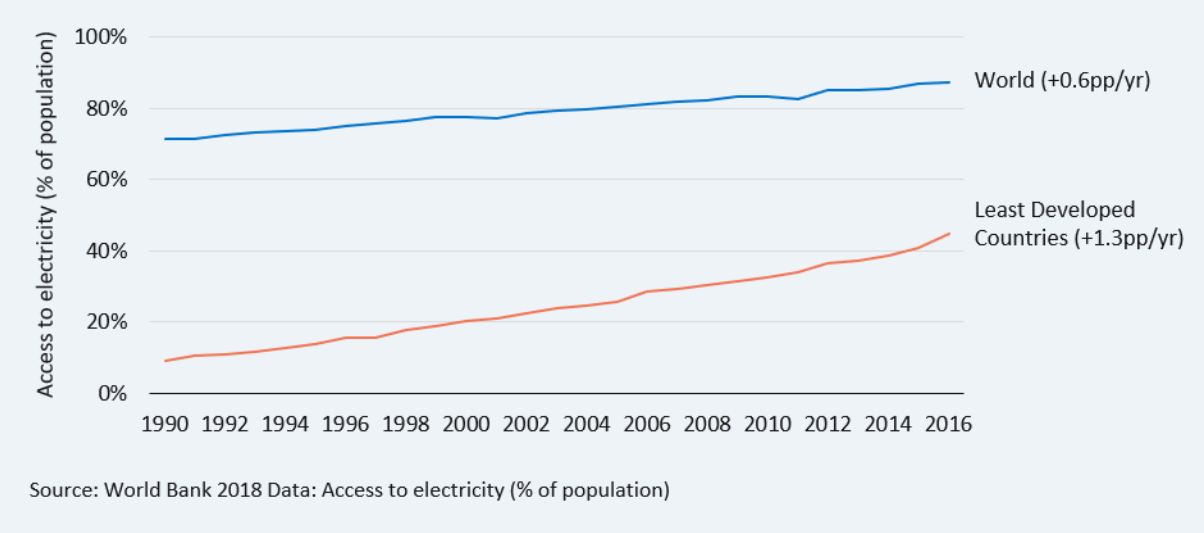
Introduction

Recently at EnergyLab, we have expanded our focus to Australia's neighbours in the Asia-Pacific region. Earlier in the year, we established an office in Phnom Penh, Cambodia, building on our team's experience in international development and entrepreneurship in South East Asia. In partnership with EMPRI, we also ran our first hackathon in India, which focussed on how electric vehicles can help solve Delhi's transport problems. With any luck, this will be just the start of our work in the region.

One of the roles we believe we can play in developing countries is in assisting other organisations to work with startups to achieve social and environmental objectives. There is a lot of interest in working with the private sector to achieve development outcomes. The US$10 billion Green Climate Fund has a strong focus on private sector engagement,[1] as does Australia's aid program.[2] Startups are an important part of the private sector and clean energy startups, in particular, can generate significant social and environmental benefits. We hope to leverage our experience with such startups in Australia to contribute towards development outcomes abroad.

In this discussion paper, we explore how startups can help developing countries in their efforts to extend affordable and reliable electricity access to all members of their population. Despite steady progress, there is still much work to be done to achieve the seventh sustainable development goal of universal access to affordable, reliable, sustainable and modern energy.[3] Less than half the population of the least developed countries have meaningful access to electricity and the current rate of progress is only about 1.3 percentage points per year (Figure 1). This paper will focus on how energy startups can help accelerate progress towards 100% electrification.

Figure 1: Proportion of the population with access to electricity



Source: World Bank 2018 Data: Access to electricity (% of population)

[1] McDonald 2017 Australia and the Green Climate Fund: Supporting new climate investments; GCF 2016 Annex I: Initial Strategic Plan for the GCF
[2] DFAT 2018 Australia's aid program
[3] UN 2017 Sustainable Development Goal 7; World Bank 2018 SDG7 Tracking: The Energy Progress Report

In particular, we explore how startups can help developing countries leapfrog traditional electricity grids to more cost-effective and reliable smart grids. Many developing countries have already skipped straight over copper wire telecommunications networks to satellite, fibre-optic and mobile phone technology.[4] It's possible they will now be able to leverage this technology and similarly roll out electricity grids that are smart from the outset, avoiding the retrofitting task facing developed countries.[5]

> *"Free from the patchwork systems that mature cities in the U.S. and Europe have hacked together over the last century, [developing countries] can leapfrog outdated technology and start from scratch at the cutting-edge."*
> – Siemens

For this discussion, we will focus on national grids, as opposed to mini-grids or off-grid solutions. While decentralised approaches have an important role to play in increasing electricity access, the focus of many developing countries is on rolling out centralised networks. The Lao PDR is targeting 90% electrification by 2020, primarily through a centralised grid[6] and grid extension is the main focus of the Cambodian Government's Rural Electrification Strategy.[7] Other countries such as Vietnam and Ghana also focus heavily on grid extension to electrify all areas of their countries.[8] As a result, we will predominantly focus on centrally-controlled electricity networks in this discussion paper and leave alternative solutions for a future paper.

The following sections provide background information on smart grids and a discussion of the role of startups and what can be done to make the most of their potential. We'll discuss the advantages startups have in addressing the current barriers to smart grid deployment and provide examples of companies that are already achieving success in this domain. We'll also make some suggestions for governments and other organisations that wish to encourage more startup activity in this space. But first, we'll attempt to demystify what exactly a smart grid is.

[4] Davison et al 2000 Technology Leapfrogging in Developing Countries - An Inevitable Luxury?; Lam & Shiu 2010 Economic growth, telecommunications development and productivity growth of the telecommunications sector: Evidence around the world
[5] IRENA 2015 Smart Grids and Renewables: A cost-benefit analysis guide for developing countries; Levin & Thomas 2016 Can developing countries leapfrog the centralized electrification paradigm?
[6] World Bank 2012 Lau PDR – Power to the People: Twenty Years of National Electrification; Susanto 2012 Limits of grid extension in the Lao PDR: A financial perspective
[7] Ministry of Industry Mines and Energy 2009 Cambodia Rural Electrification Strategy and Implementation Plan
[8] World Bank 2018 Access to Energy is at the Heart of Development

Smart grids – features, benefits and barriers

For all the hype around smart grids, many are still unclear what they are, why we want them, and why our grids aren't smart already. In this section we set out to answer these questions, starting with an attempt at a definition. We'll then discuss the benefits and explore whether they outweigh the costs before wrapping up with the main reason developing country electricity grids aren't as smart as they could be.

A smart grid can be defined as an electricity network integrated with sensing, communication and control technology.[9] There are many competing definitions of smart grids, but most have those three elements in common. Of course, traditional grids also have a degree of sensing, communication and control capability. For example, sensors measure frequency and communicate that information back to grid operators, who have a level of control over large generators and some large consumers of electricity to ensure the frequency stays within safe limits. Therefore, rather than ask if a grid is smart, it may make more sense to ask *how* smart it is.

> *"…put simply, smart grids bring computer technology to a standard electricity grid…"*
> – Origin Energy

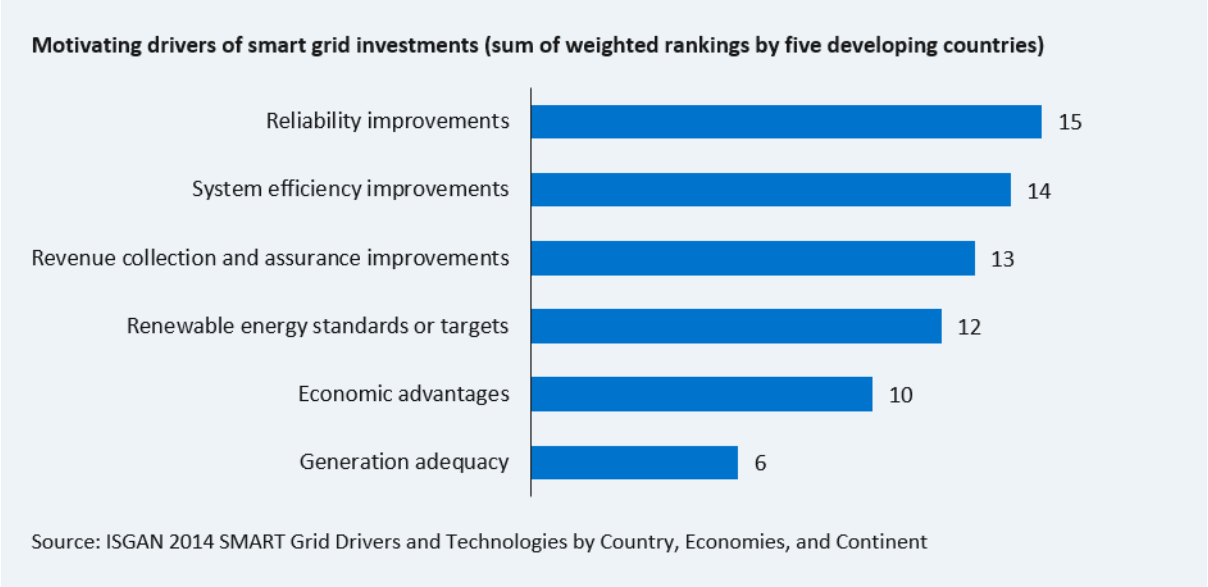
A defining feature of smart grids is that (unlike traditional grids) they have as much control over demand as supply. Operators of traditional grids largely take the demand for electricity at any moment as a given and then use various means to match the supply of electricity to that demand. Smart grid operators, on the other hand, have more tools at their disposal. By utilising communication and control technology, they can choose whether to change consumption or generation, depending on what is cheaper. For example, instead of instructing a backup power station to start generating to meet the demand of people returning home from work and turning on the air conditioning, they can instruct EVs to hold off charging until later in the evening.

This control is made possible by various smart devices connected to the grid. Smart meters are generally the first technology to be deployed in a smart grid program and are considered the backbone of a smart grid. To be considered smart, a meter generally needs to collect consumption data on at least an hourly basis and periodically send that information to utilities to assist in monitoring and billing. More advanced smart meters will measure and communicate consumption in much smaller increments, enabling more smart grid applications. Combined with communication and data management systems, smart meters are an integral part of the 'advanced metering infrastructure' that is the largest cost component of smart grids.[10] The next largest cost component is the 'distribution automation system', which includes advanced field devices such as monitors, fault indicators, automated feeder switches, capacitors and voltage regulators, and smart relays.[11] Depending on who you ask, consumer appliances such as electric vehicles, solar batteries and smart fridges are also part of the smart grid. Regardless of the definition, these assets have the potential to provide grid operators with considerable control over electricity consumption.

[9] IEA 2015 How2Guide for Smart Grids in Distribution Networks; Güngör et al 2011 Smart Grid Technologies: Communication Technologies and Standards; Fang et al 2012 Smart Grid – The New and Improved Power Grid: A Survey
[10] Padmini, Omran & Chatterjee 2017 Cost benefit analysis of smart grid: A case study from India; Smart Grid Consumer Collaborative 2013 Smart Grid Economic and Environmental Benefits: A Review and Synthesis of Research on Smart Grid Benefits and Costs
[11] US DoE 2016 Distribution Automation: Results from the Smart Grid Investment Grant Program

There are two key advantages for developing countries to integrating the grid with all this technology: increased reliability and reduced costs of electricity delivery. According to an ISGAN survey (summarised in Figure 2), the top three reasons developing countries are interested in smart grids is for improvements in reliability, system efficiency, and revenue collection and assurance (largely, reducing electricity theft). The last two of these benefits can be summarised as lowering the net cost of delivering electricity, as less energy needs to be generated in a more efficient system and electricity theft is a major expense for electricity providers.

Figure 2: Why developing countries are interested in smart grids



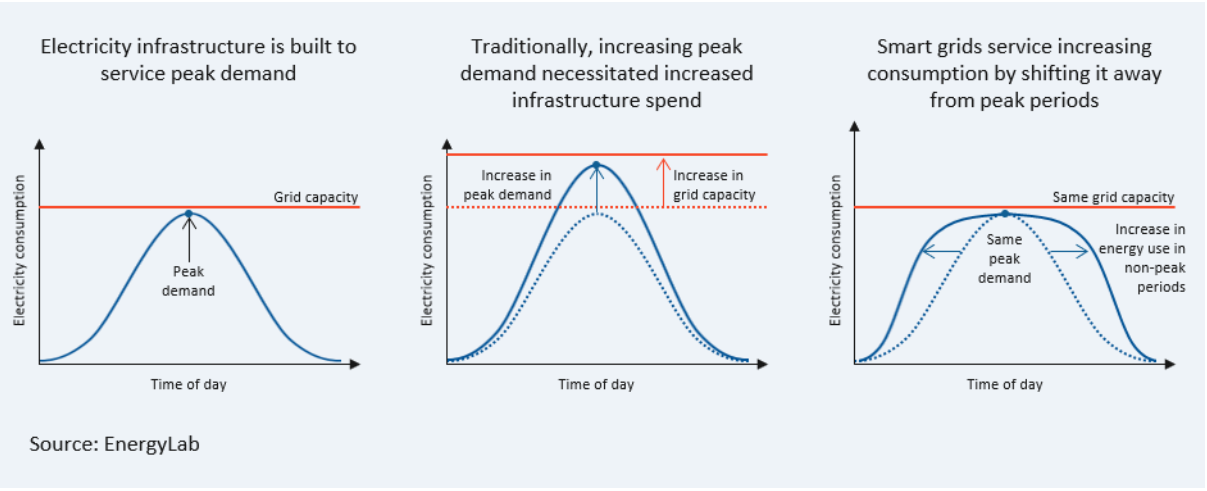
Smart grids improve reliability by providing grid operators with increased information, control and automation. The more information and control that operators have, the greater their ability to keep the grid humming along, especially if they're aided by automation. Faulty equipment can be detected and replaced before failure. Sensors can also detect stress on system assets which operators can, with the control that smart grids provide, reduce by diverting power or reducing consumption as necessary. Much of this work can also be automated, with smart switches diverting power or islanding microgrids and then reconnecting them. Automated systems can react more quickly than human operators, quickly isolating parts of the grid that are experiencing issues before problems can spread and affect more customers. As such, smart grids reduce power outages and reduce the number of customers impacted by any outages that do occur.[12]

With increased reliability, smart grids can also handle much higher levels of intermittent renewable energy generation. Renewable energy increases the grid operator's challenge of matching supply and demand as sources such as solar and wind vary significantly throughout the day. Traditionally, grid operators would largely counter these variations with generation sources that were quick to dispatch such as gas turbines. However, this is an expensive approach and can only accommodate a certain level of variability. Smart grids are much better able to deal with the intermittency of renewable sources because they come with a much larger toolkit of options for dealing with the variation.

[12] NETL 2010 Understanding the Benefits of the Smart Grid

Smart grids can help keep electricity costs down by mitigating the need to upgrade infrastructure as consumption increases. In general, electricity infrastructure is built to service peak demand but most of the time consumption is well below this point. By reducing consumption during peak periods and deferring it to periods of lower demand, increasing amounts of consumption can be serviced with the same assets, as illustrated in Figure 3. Similarly, smart grid devices allow greater peak utilisation of existing assets. For example, the amount of electricity that can be transported on a transmission line is dependent on ambient conditions such as temperature. As traditional grids have limited information on these conditions, conservative assumptions are used to calculate the line capacity or 'rating'. Smart grids, on the other hand, use sensors, communication devices and software to calculate real-time, dynamic line ratings, allowing grid operators to squeeze 5-15% more usage out of the same infrastructure.[13]

Figure 3: How smart grids help avoid the need for increased grid infrastructure spend



Source: EnergyLab

Another way smart grids can reduce costs in developing countries is by helping reduce electricity theft. Almost US$100 billion is lost each year due to 'non-technical losses' of electricity. While some of that is due to non-malicious factors such as billing errors, most of it is due to theft.[14] Developing countries are hardest hit by this problem,[15] further burdening under-resourced utilities and governments. Smart grids, particularly smart meters, can help identify and reduce electricity theft and its economic cost.[16]

The economic benefit to developing countries of the increased reliability and reduced cost of electricity delivery made possible by smart grids is highly significant. Estimating smart grid costs and benefits is a challenging task and will vary widely by country but, as an example, one study estimated that upgrading the US grid would cost about US$400 billion and deliver about US$1,600 billion in benefits.[17] About a third of the benefit to US consumers is expected to come from increased energy efficiency made possible by advanced voltage optimisation.[18] However, in developing countries, the main benefit may come from a

[13] EPRI 2011 Estimating the Costs and Benefits of the Smart Grid; NETL 2010 Understanding the Benefits of the Smart Grid; Energy Sector Planning and Analysis 2014 Dynamic Line Rating Systems for Transmission Lines: Topical Report
[14] Northeast Group 2017 Electricity Theft and Non-Technical Losses: Global Markets, Solutions, and Vendors
[15] PR Newswire 2014 World Loses $89.3 Billion to Electricity Theft Annually, $58.7 Billion in Emerging Markets
[16] The Brookings Institution 2016 A developing country's perspective of the Smart Grid; IRENA 2015 Smart Grids and Renewables: A cost-benefit analysis guide for developing countries; Northeast Group 2017 Electricity Theft and Non-Technical Losses: Global Markets, Solutions, and Vendors
[17] EPRI 2011 Estimating the Costs and Benefits of the Smart Grid
[18] McKinsey 2010 U.S. smart grid value at stake: The $130 billion question; Smart Grid Consumer Collaborative 2013 Smart Grid Economic and Environmental Benefits: A Review and Synthesis of Research on Smart Grid Benefits and Costs

reduction in electricity theft and an increase in reliability. Economic costs of power outages are difficult to estimate but have been placed at about US$3 billion in Zambia in 2015 and US$1 billion in Zimbabwe in 2009.[19] Across all African countries, the impact has been estimated at 1-2% of GDP.[20] While smart grids can't guarantee 0% theft and 100% reliability, the data points to the smart grid having substantial benefits for developing countries.

Figure 4: Electricity theft is a strain on utility budgets in many developing countries

Despite all these benefits, developing countries struggle to justify the upfront cost of smart grid technology. Grid investments are typically financed by raising tariffs but there is a limit to how much developing countries can deploy this tactic while keeping electricity affordable for the majority of its population. This shouldn't be a deal breaker, as many smart grid investments pay for themselves through reduced costs and increased revenues. However, many utilities are capital-constrained with limited access to low-cost debt for upgrades. Governments can subsidise upgrades but may find it hard to justify spending more on the grid in areas where it exists when so many in rural areas aren't connected yet.[21] In the next section, we will discuss how startups can help overcome these challenges.

[19] Samboko et al 2016 The Impact of Power Rationing on Zambia's Agricultural Sector; Kaseke 2014 A Comparative Cost Assessment of Electricity Outages and Generation Expansion in Zimbabwe
[20] CDC Group 2016 Development Impact Evaluation: What are the links between power, economic growth and job creation?
[21] IRENA 2015 Smart Grids and Renewables: A cost-benefit analysis guide for developing countries; Energypedia 2017 Smart Grids for Improved Grid Performance in Developing Countries; University of Ontario 2015 Are smart grids in developing countries a reality?; Zaglago, Craig & Shah 2013 Barriers to Nationwide Adoption of the Smart Grid Technology in Ghana

The role of startups in building smart grids

Startups are uniquely placed to help address the upfront cost challenge facing smart grid deployment in developing countries. As discussed in the previous section, one of the main barriers to deploying smart grids is the high upfront cost of the investment – utilities have limited access to capital and governments have a limited ability to provide funding. Startups can help avoid the need for some of that investment by developing low-cost solutions and by finding business models that avoid the need for funds to be invested upfront.

The ability of startups to provide low-cost solutions in general is the subject of Clay Christensen's theory of disruptive innovation. According to Christensen, established companies typically focus on providing solutions of increasing sophistication to their most demanding and highest-paying clients because that is what they believe will lead to greatest profitability. As a result, incumbents eventually end up producing products and services that have more features and a higher price-tag than would suit customers with more modest budgets. This provides an opportunity for startups to develop low-cost solutions that may be inferior to that provided by incumbents but still sufficient for many customers. Such an opportunity can be attractive to startups as it provides a foothold from which they can continue to improve their offering and eventually compete with incumbents for higher-paying customers.[22]

Applied to the energy sector, Christensen's framework suggests a unique role for startups in providing affordable smart grid solutions in developing countries. Incumbent companies in developed countries are built on providing solutions to wealthy populations in an environment of strict regulation – solutions that might be considered over-engineered by developing countries. Theoretically, they could develop low-cost alternatives but often have more profitable opportunities to pursue, such as expanding into adjacent markets like smart home services. In contrast, startups and other innovative organisations may be able to initially offer basic, low-cost products and services in developing countries and then expand their offering as the needs of grid operators in those countries grow. It's conceivable such startups would eventually be able to expand to developed countries where they might then have a cost advantage.

SparkMeter is one startup taking such an approach to metering solutions for developing countries. SparkMeter was spun off from the non-profit EarthSpark in 2013 to focus on developing smart meter hardware and software for developing countries. Their solution (shown in Figure 5) is a low-cost, pay-as-you-go smart meter. This approach provides low-income households with control over their electricity costs and increases revenue certainty for utilities.[23]

Figure 5: SparkMeter's product

Source: EarthSpark International 2015 Six Months of Solar-Powered Smart Grid

Startups commercialising smart meters for personal use in developed countries may similarly find a niche in providing low-cost meters to developing-country grid operators. Australian startups Wattwatchers and Symbiot provide smart meters that also enable remote, circuit-level control of a building's energy consumption. Such a solution may be attractive to developing country utilities who may want to incentivise their customers to provide them with control over loads such as air conditioning. Other Australian startups are developing

[22] Christensen, Raynor & McDonald 2015 What Is Disruptive Innovation?

[23] Carnegie Mellon University 2014 Press Release: Carnegie Mellon's Daniel Schnitzer Wins Grant From US Agency To Provide Affordable Electricity in Haiti; SparkMeter 2015 SparkMeter brings smart grid functionality to underserved utility customers; SparkMeter 2018 Our Solution; Start Up Energy Transition 2018 SparkMeter, Inc., USA

simple, low-cost smart meters that are easy to install, which could possibly be adapted for developing-country needs.

Just as startups can provide low-cost smart grid hardware, they may also have an advantage in providing smart grid software at a lower cost than incumbents. Established companies often charge grid operators in developed countries millions of dollars for seemingly simple alterations to software. Staff at these companies may identify cheaper solutions but struggle to get internal support as such solutions could threaten existing revenue streams. Startups, who face no such constraints, could provide these low-cost alternatives. Zepben is one Australian startup providing smart grid software solutions for electricity distribution networks. Their product helps to visualise, forecast and control the impact of distributed energy resources on the grid.[24] While Zepben is currently focussed on Australia, there might be an opportunity for other startups to provide developing country grid operators with similar services at a lower cost than offered by existing businesses.

One of the main ways that startups provide low-cost services is by developing software and business models that leverage existing assets. The classic examples are Uber and AirBnB who use software and the internet to connect the owners of cars and spare bedrooms with those who need a ride or place to crash. By utilising existing assets and, in the case of AirBnB, doing away with a lot of the bells and whistles (such as expensive hotel foyers), these services can be provided cheaper than taxis and hotels. Incumbents rarely develop these offerings themselves for various reasons, including the fact that such solutions threaten the return they receive on their existing assets.

In Australia, startups are working to leverage existing energy assets to provide grid services. Australian startup Reposit Power create smart devices (shown in Figure 6) that increase the return on household batteries by selling electricity back to the grid when prices are high.[25] By partnering with electricity retailers, such as Powershop, Reposit have used their technology to create a 'virtual power plant' that enables thousands of household batteries to be discharged to the grid at the same time, acting just like a traditional power plant.[26] Reposit claim a similar approach could also be used to help restart the grid after a blackout.[27] While early attempts at virtual power plants have focussed on batteries,[28] any energy consuming, generating or storage asset could theoretically be aggregated in such a manner. GreenSync (another Australian startup) and Energy Queensland are working together to connect large HVAC equipment and diesel generators used by large businesses to create what is to be Australia's largest virtual power plant.[29]

Figure 6: The Reposit Box

Source: Solar Choice 2018 Reposit First energy monitoring system reviewed

The energy assets controlled by energy startups may be different in developing countries, but the approach remains the same. In countries where rooftop solar and batteries are yet to take off, other energy consuming devices may be aggregated instead. For example, air conditioners in urban areas may be connected to the internet and remote control given to grid operators. Or perhaps operators will be given control to remotely deactivate karaoke machines to relieve stress on the grid (and anyone within hearing range).

[24] Zepben 2018 Home Page
[25] Reposit Power 2018 Frequently Asked Questions
[26] RenewEconomy 2018 Powershop to tap customer battery storage in new virtual power plant; AFR 2018 Powershop, Reposit Power join 'virtual power plant' stampede
[27] Solar Choice 2017 Could distributed battery systems 'blackstart' the grid?
[28] ARENA 2017 AGL Virtual Power Plant; ARENA 2018 Simply Energy to build 8MW virtual power plant in Adelaide
[29] The Fifth Estate 2018 GreenSync to create huge virtual power plant in Queensland; Queensland Government 2017 Energy Queensland delivers Australia's biggest 'virtual power plant'

The rise of electric cars, motorbikes, tuk-tuks and rickshaws in developing countries provides an opportunity to integrate these assets into a smart grid. India is one of the countries leading the developing world in electric vehicle uptake with the Indian Government aiming for annual sales of electric vehicles to hit at least 6 million by 2020.[30] Startups are also playing a significant role, with Ola (Uber's main rival in India) announcing in April 2018 a plan to roll out 10,000 electric rickshaws (such as in Figure 7) within 12 months and 1 million electric vehicles in total by 2021.[31] All these electric vehicles could be connected with software and smart devices, similar to how Reposit connect household batteries, to deliver grid services when the vehicles are plugged in for charging. Nuvve is one startup that could take advantage of this opportunity – they develop software that can remotely control a diverse range of electric vehicles when they're plugged into the grid for the benefit of grid operators and vehicle owners.[32]

Figure 7: One of Ola's electric rickshaws

Source: TechCrunch 2018 Ola will add 10,000 electric rickshaws to its India fleet over the next year

As well as addressing a lack of capital, startups are also good tools for solving difficult problems that are specific to expanding electricity access in developing countries. It is well known that established companies struggle with innovation due to barriers such as risk avoidance, internal bureaucracy and short-term incentives.[33] Setting up a startup isn't without its challenges, but those challenges are different to those faced by existing companies and therefore lead to a different focus. Startups and existing businesses also face different options and opportunity costs. As already discussed, incumbents may not innovate in a certain area because they can make more money by investing in another area. Startups may not be able to pursue the same opportunities because of barriers to entry (that may have been put up by incumbents). Instead, startups may need to get a foothold in less profitable areas before pursuing bigger opportunities. Therefore, a problem that may be difficult or unattractive for an existing company to solve can be an attractive and tractable opportunity for a startup.

Senergy represents a successful story of a startup solving a difficult challenge before better-resourced incumbents. In 2011 electricity theft was costing Brazil billions of dollars in lost revenue. Siemens engineer Sergio Jacobsen searched for smart grid solutions to this problem but uncovered little of use as most smart grid applications at the time were in the US and Europe, where electricity theft was less of a problem. He eventually found the answer in a local startup called Senergy. This small band of engineers had created software that pulled in data from multiple sources and pinpointed where electricity was likely being stolen. When we think of electricity theft, the slum-dweller illegally hooking a wire over a distribution line may come to mind. But in Brazil, the main culprit turned out to be small-to-medium businesses like ice factories that were tampering with their meters to reduce their overheads. In 2012 Siemens acquired Senergy and to this day continues to use their technology to detect electricity theft.[34]

[30] CNN 2017 India to sell only electric cars by 2030
[31] CNN 2016 India's Ola wants to put a million electric vehicles on the road
[32] Forbes 2017 See How This Clean Tech Start Up Plans To Turn Electric Vehicles Into Virtual Power Plants; Greentech Media 2017 EDF Renewable Energy Leads Series A Round in Vehicle-to-Grid Startup Nuvve
[33] IBM 2006 Five barriers to innovation: Key questions and answers; HBR 2017 Why Big Companies Can't Innovate
[34] Siemens 2017 How smart tech ended Brazil's power theft crisis; Interview with Sergio Jacobsen on 7 June 2018

Startups can't solve every problem facing smart grid deployment in developing countries, but they have a unique and valuable contribution to make. There are many barriers to smart grid deployment and it will take the efforts of many different actors to overcome them. Startups are an important part of that equation and have unique strengths that are relevant to overcoming the difficulty in financing smart grid investments. Startups can also be an effective tool for solving the myriad of problems that will need to be solved to help developing countries leapfrog to smart grid infrastructure while at the same time extending it to reach all residents. In the next two sections, we'll discuss how governments and other organisations can tap the full potential of smart grid startups.

How developing country governments can leverage smart grid startups

If a government wishes to encourage more startup activity within their borders, they can do so by expanding the range of commercially viable opportunities available for startups to pursue. Startups are by their very nature unpredictable – and that's a good thing. One of the contributions startups make in society is to solve problems we didn't know we had with products and services that are better and cheaper than we thought possible. Therefore, it can be unproductive for governments to try to identify with too much specificity which particular startups they want to be created. However, governments can direct more startup activity in areas they desire (such as smart grid products and services) by increasing the options for startups to achieve financial viability in those areas. Startups will naturally seek profitable opportunities within their markets so increasing the range of business models possible in an area should generally result in more startup activity.

Approaches to creating good conditions for smart grid startups could be grouped into two categories: tendering for products and services or introducing price signals. The former approach is typically used to engage startups in deploying smart grid infrastructure up to and including the meter. Price signals, on the other hand, can be particularly effective at encouraging the uptake of 'behind-the-meter' smart grid assets such as solar batteries and smart appliances. Either approach can then be used to encourage startups to utilise these assets to provide smart grids services.

Tendering for related products and services is a common approach taken by governments wishing to engage the private sector in smart grid deployment. For example, in May 2017 the Australian Renewable Energy Agency and the Australian Energy Market Operator put out a call for demand management solutions. In October of the same year, ten projects were approved for funding, to be delivered by a range of small and large businesses.[35] These initiatives were later found to provide capacity support at one fifth the price of diesel generators.[36] It is also common for governments to tender for physical smart grid infrastructure, particularly smart meters, which make up a large proportion of the upfront cost of smart grids.

The Indian smart meter rollout is a recent example of a smart grid tender. In July 2017 the Indian Government launched a tender to procure five million smart meters, which was awarded to ITI Limited in October that year. By going out to tender the government was able to procure smart meters for Rs 2,503 each (~AU$50), half the market price at the time.[37] In this instance, the contract was awarded to an established company, but ITI subcontracted to several other companies, including startup ZenMeter who will supply 250,000 smart meters.[38] With some changes in the tender approach, startups could play an even bigger role in future smart grid initiatives.

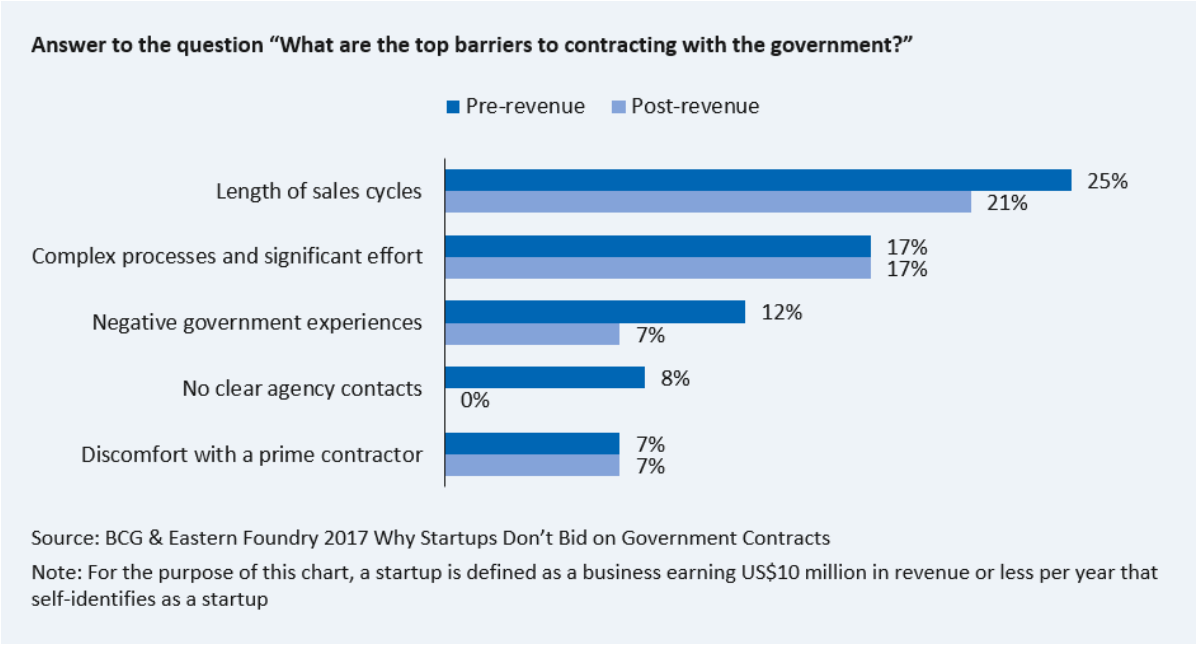
Startups don't tend to feature heavily in tender processes but there are several steps government can take if they wish to change that. One study found that less than 3% of UK government spending went to

[35] ARENA 2017 AEMO and ARENA demand response trial to provide 200 megawatts of emergency reserves for extreme peaks
[36] RenewEconomy 2018 AEMO, ARENA want to expand demand response trials; ARENA & AEMO 2018 ARENA/AEMO joint response to AEMC Directions Paper Section 5: Wholesale Demand Response
[37] PowerLine 2018 Smart Meter Roll-out: Expected to pick up pace after a slow start
[38] Business Standard 2017 Companies upset over smart meter tender; IndiaCatalog 2018 Tender for 10 mn prepaid meters attracts 12 bidders, large players keep out

small companies less than five years old, and less than 0.5% of spending went to companies in their first two years of operations.[39] The reasons for the low level of spending on startups appears to involve a mismatch between the timeframes, levels of complexity and risk that startups and government departments operate under. This can be addressed by making changes to tender timing, requirements and structure, and government incentive and communication.

One of the most important considerations is ensuring timelines are startup-friendly. Time seems to flow differently in the hallowed halls of government than within the walls of a startup office; a multi-year tender process that seems quite normal for a government department can seem like an eternity for a startup. This is because startups typically operate at a loss and have less than a year before they need to achieve profitability or receive another cash injection from investors. In the US, this difference in pace is considered by startups to be the biggest barrier to contracting with the government, as shown in Figure 8. Consequently, governments can go a long way towards encouraging startup activity by reducing the time between receiving bids and awarding a contract.[40] Singapore has achieved this by providing accredited startups with access to a 'fast track' that avoids lengthy procurement cycles, with startups only being accredited if they can deliver and achieve fast growth.[41] Once the contract has been awarded, it may be necessary to pay a proportion of the project costs upfront, as the startup may need that cash to purchase the equipment necessary to successfully deliver the project.

Figure 8: Barriers to startups contracting with the US government



Source: BCG & Eastern Foundry 2017 Why Startups Don't Bid on Government Contracts

Note: For the purpose of this chart, a startup is defined as a business earning US$10 million in revenue or less per year that self-identifies as a startup

The second-most important step is to simplify tender processes. Startups are typically under-resourced and struggle to fill out the extensive paperwork often requested by government tenders. By reducing the documentation required to the essentials, government departments can help level the playing field between startups and larger companies. Similarly, it is important to ensure that the supporting documentation required is not prohibitively difficult for a startup to provide, such as audited accounts

[39] The Guardian 2015 Startups get less than 3% of government spend, this must change
[40] BCG & Eastern Foundry 2017 Why Startups Don't Bid on Government Contracts
[41] GovInsider 2016 Inside Singapore's Startup Laboratory

spanning back longer than the startup has existed. It can also help to provide contractors with guidance on how to submit tenders as startups may be unfamiliar with certain terms or lacking in knowledge gained by established competitors with more government experience.

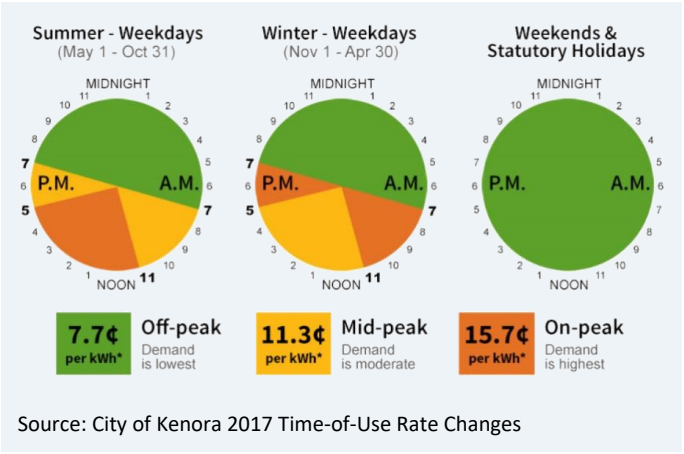
In addition to reducing the barriers to entry just discussed, altering the tender structure can increase the potential for highly innovative solutions. By specifying outcomes rather than specific solutions, startups will have more scope for coming up with innovative approaches to solving problems. Israel is trialling such an approach by inviting startups to propose solutions to problems in the city with 'challenge-style tenders'.[42] It may also help to break large projects into sub-components. Startups often initially commercialise very specific solutions and may not have the breadth to deliver on larger projects. By tendering for a larger number of smaller contracts, a variety of startups might be attracted, each uniquely suited to each component of the overall project. Similarly, large projects like the tender for five million smart meters mentioned previously could be broken down into regions with smaller numbers of smart meters to be delivered to each region. Such an approach could also reduce the contract risk, as less funding will be invested in any one startup, and the entire project won't be reliant on their performance.

Where governments wish to work more extensively with startups, modifying internal incentive structures may make it easier to do so. Due to the way they are evaluated themselves, government officials evaluating bids may – quite justifiably – be biased towards more established companies. They may have more to lose by taking a risk on a startup than they would have to gain by that startup performing better than a safer, more established contractor. As such, it could be beneficial to assess the selection criteria for tenders and the incentives placed on those evaluating bids against those criteria.

Finally, a government wishing to gain the full benefit from these initiatives should ensure they are visible to the startup community. Due to the barriers explored in this section, most startups don't actively monitor announcements of new tenders. Therefore, it may be important to notify the startup community of developments designed to overcome these barriers and actively encourage them to apply for new opportunities.

The second key approach for governments wishing to incentivise startup activity is the use of price signals. This takes the concept of tendering for solutions a step further as price signals can be created to achieve desired outcomes. In the case of electricity markets, this might come in the form of varying the price of electricity at different times of day depending on when more or less consumption or generation is desired. The market can then be left to discover profitable ways to influence generation and consumption accordingly.

Figure 9: Example northern hemisphere time-of-use pricing



Source: City of Kenora 2017 Time-of-Use Rate Changes

Time-of-use pricing is one price signal that can incentivise behind-the-meter smart grid solutions. This typically involves setting a different tariff for electricity consumption during peak, shoulder and off-peak periods, as illustrated in Figure 9. Such pricing can

[42] GovInsider 2017 Exclusive: How Israel's smart cities will work with startups

help shift consumption of electricity in a way that reduces the need for upgrading grid infrastructure. For example, time-of-use pricing was introduced in Vietnam in 1998 at a cost of $2.3 million, which was mostly the cost of installing smart meters. This initiative is estimated to have avoided the need for $46 million in new capacity investments.[43] Startups can help achieve these savings by developing products and services to help households and businesses save money by shifting their energy consumption from peak to off-peak periods.

Time-varying feed-in-tariffs can further improve the business case for smart grid startups. Feed-in-tariffs are usually set at a fixed price but, with the use of smart meters, different rates can be paid depending on the value of the electricity exported at different times. For example, in Australia, the Victorian State Government has specified minimum feed-in-tariffs that vary according to the time and day. Rates for off-peak, shoulder and peak periods are 7.1, 10.3 and 29.0 c/kWh, respectively, to reflect the varying wholesale price of electricity expected during those periods.[44] Household feed-in-tariffs are typically put in place to incentivise rooftop solar uptake but can be used to encourage the purchase of other energy assets too, such as household batteries and electric vehicles. Startups can then come up with creative ways to help households and businesses consume electricity when it's least valuable and export it when it's most valuable.

Implementing additional price signals, such as through ancillary services markets, could encourage even greater startup activity. As developing countries continue to open their electricity sectors to competition and private investment, they may introduce additional price signals that will incentivise further activity from smart energy startups and innovative businesses. For example, the spot market and frequency control ancillary services market in Australia are both an integral part of making projects like the Tesla big battery commercially viable. However, for many countries, such markets take some time to establish. Bid-based power pools with spot pricing are considered to be particularly unfeasible for all but the most advanced developing countries.[45]

All these initiatives can build upon one another as startups are likely to 'stack' different incentives to make new smart grid solutions viable. For example, a startup might initially sell a service to help households utilise their electric vehicles to arbitrate time-of-use tariffs. They might then tender for a government contract to provide demand response services using those same electric vehicles, sharing the benefits with the households. If ancillary services markets are later introduced, that could provide yet another revenue stream. In this way, government initiatives to encourage smart grid startup activity can complement each other and build momentum in startup activity.

[43] Charles River Associates 2005 Applications of Dynamic Pricing in Developing and Emerging Economies
[44] Essential Services Commission 2018 Minimum Electricity Feed-in Tariffs to Apply From 1 July 2018: Final Decision
[45] World Bank 2002 Global Electric Power Reform, Privatization and Liberalization of the Electric Power Industry in Developing Countries; Joskow 2008 Lessons Learned From Electricity Market Liberalization; Wolak 2003 Designing Competitive Wholesale Electricity Markets for Latin American Countries

How other organisations can support and make the most of smart grid startups

If other organisations, such as funding bodies, NGOs and multilateral organisations wish to leverage or support smart grid startups, there are several interventions that might prove particularly effective. As with developing country governments, many of these entities may be seeking to leverage the private sector – including startups – to assist in addressing the problems within their mandates. An idealised pathway for an entrepreneur exploring a startup idea could be characterised as identifying a potential business opportunity, conducting desktop analysis and customer research to assess it, establishing a business if all is looking good, and then working to generate their first dollar of revenue. Many entrepreneurs might start down this path but only a fraction will make it to the end of the road. In our experience, there are several ways other organisations with an interest in encouraging startup activity can help improve these odds, increasing the number of startups that are successfully launched.

Figure 10: One of the mobile money providers in Cambodia (Metfone, not the cows)

One of the biggest levers for supporting startups in developing countries is also the hardest to pull: ensuring adequate financial and telecommunications infrastructure. Cheap and ubiquitous access to the internet (and the cloud services available on it) have been credited for the apparent explosion in the number of startups around the world.[46] It's not hard to believe that spreading internet access in developing countries is also a necessary pre-condition for many startup ideas to become viable. Many developing countries are quite a way down this path already, with widespread mobile phone and at least low-speed internet coverage, although there are often gaps that need to be filled. Phone coverage has also led to the spread of financial infrastructure through mobile money, which is arguably even more fundamental to fostering business innovation. Mobile money can be particularly useful for startups as it creates opportunities to automate payment collection, enabling businesses to scale more rapidly.

However, having access to financial infrastructure is not enough in itself; people also need to be accustomed to using the associated financial services. For example, most Cambodians have heard of at least one mobile money provider and a high percentage have used mobile money, but a very small proportion of the rural population use mobile money to pay for anything. The reason for this is that many just use mobile money to *receive* funds from family, perhaps from a daughter working in a garment factory in the city. That means that a startup cannot rely on the mobile money system to receive payment. Existing large businesses can help overcome this problem by incentivising their customers to pay with mobile money instead of cash. Those customers will then be more willing to use mobile money to pay for other services, reducing one barrier for the startups offering them.

[46] The Economist 2014 The startup explosion

An easier way to support entrepreneurs may be to provide market data. Having access to information on where households and business are, how much energy they are using and their willingness to pay, enables entrepreneurs to more readily explore potential business ideas. For startups already operating, this information can help better target their sales forces. This level of information might seem basic to those in developed countries. However, in developing contexts it can often be the case that the entrepreneur has no up-to-date information about where people live, whether they have electricity access, and how much they pay for it. As a result, they might make decisions based on outdated or incomplete information, reducing their chances of success. Village Infrastructure is one organisation working to overcome this problem by providing data on factors such as electricity access and population for free.[47]

When an entrepreneur has identified a potential business opportunity, funders and existing organisations on the ground may be able to speed up the process of market validation. Learning about the market and their potential customers is a key early task for entrepreneurs but may be more challenging for those working across jurisdictions. Entities such as multilateral organisations and NGOs often have wide networks of contacts that can make this process easier. For example, having a local guide and translator familiar with the communities concerned is highly useful in speeding up the process of interviewing customers, especially if the entrepreneur does not speak the local language. NGOs often know individuals who can play this role and can sometimes identify community members willing to assist a startup interested in local problems. For both local and overseas entrepreneurs, existing organisations can also provide valuable assistance by introducing the entrepreneur to potential customers to interview. This is particularly valuable for entrepreneurs trying to solve problems for customers they do not have links to, such as established businesses.

Assistance with the ins and outs of establishing a business can also be valuable, particularly for foreign entrepreneurs entering a developing market. In our experience, Australian entrepreneurs find it hard enough to navigate the forms and procedures required to establish a business in Australia. Setting up a business overseas often adds the additional complication of having to navigate unfamiliar systems and a maze of unspoken local norms. As a result, it can take over a year for some startups to complete the registration process. Foreign entrepreneurs may also face the barrier of needing a local organisation to vouch for them to register a business. By providing a bit of guidance and support during these stages, existing organisations can significantly speed up and de-risk this process.

Finally, helping startups secure their first customer can be incredibly useful. The first dollar of revenue is always the hardest dollar any startup will earn as few are willing to take a risk on a new business that doesn't have a single customer yet. Therefore, one of the easiest ways an existing organisation can help a business get started is to agree to be their first customer. This provides the startup with experience and credibility to pursue additional customers. When this route is not appropriate local organisations with aligned missions can play a valuable role in helping startups gain their first customers by associating themselves with the startup and making introductions.

[47] Village Infrastructure Angels 2018 Services and Tools

Conclusion

While this discussion paper was inspired by our experience in Cambodia and India, we hope it will be helpful for those in other developing countries as well. Having recently established an office in Phnom Penh, Cambodia, and run our first hackathon in Delhi, India, we are turning our attention to the role of – and opportunity for – energy startups in countries outside Australia.

In our opinion, the global movement towards smart grids provides one of the greatest opportunities for startups in developing countries. This may be the case for developed countries as well. However, the fact that many developing countries are still rolling out electricity networks provides an opportunity to ensure that those grids are smart from the outset, rather than being upgraded at a later date.

As we have discussed in this paper, startups possess some advantages that can help overcome the challenges facing smart grid deployment in developing countries. In particular, startups are good at doing things cheaply – whether by inventing new approaches to delivering exactly what is needed and nothing more or by leveraging existing assets to provide low-cost services. As they face different constraints than other types of organisations, startups may also have a competitive advantage in solving certain problems facing smart grid deployment.

Where startup engagement is identified as valuable, various stakeholders can play a role in helping startups to achieve the impact they're capable of. Governments can modify their existing tender processes to make it easier for startups to win contracts for smart grid initiatives such as smart meter rollouts. Governments can also make new smart grid supportive business models viable by introducing time-of-use pricing and time-varying feed-in-tariffs. Other interested organisations can do a lot to stimulate smart grid startup activity in developing countries by providing on-the-ground information, resources and support to help startups get started and secure their first customers.

We look forward to working with other stakeholders to further the state of knowledge in this area and support the startups working in it. Like all our discussion papers, this document is meant to summarise our current understanding of an important topic and encourage productive conversation. There are many areas that could be explored further, such as the need to remove distortionary fuel subsidies, and provide more mentorship and financing to help energy startups in developing countries grow. However, we have focussed on what we believe are some of the most important and tractable factors that need to be considered for startups to play a significant role in smart grid deployment. We look forward to working with existing and potential partners to further explore how, together, we can support clean energy startups in developing countries and possibly help enable those countries to leapfrog to smart grids.