Ambitions versus concrete policy design: Addressing issues of the Power Africa initiative's quantitative targets

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Abstract Alarming energy access figures in sub-Saharan Africa have given rise to over 60 international electrification initiatives in the region. The US-led Power Africa initiative is one of the largest such efforts. Its central targets are to install 30 GW of additional capacity and create 60 million new connections to double electricity access by 2030. While Power Africa has received praise for its early achievements, focusing an analysis on its targets and the rationale behind them reveals attributional, developmental and technical issues. Power Africa lacks a clear definition which criteria have to be met before African electrification projects can be counted towards fulfilling Power Africa's targets. Furthermore, the targets themselves appear to be too low to deliver on Power Africa's promises, as well as exhibit several inconsistencies. Crucially, this paper argues that contrary to the Trump administration's decision to reduce its funds, Power Africa's targets and efforts need to be increased to meet the initiative's own ambitions.

Keywords: Foreign aid; African electrification; socio-economic development; international electrification initiative; public service provision; sub-Saharan Africa.

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1. INTRODUCTION

Energy poverty in sub-Saharan Africa (SSA) constitutes one of the most significant obstacles to achieving the UN Sustainable Development Goal No 7 of providing access to modern energy for all. The region is home to roughly 640 million or half of the earth's un-electrified people (International Energy Agency, 2016). Having realised the necessity of external assistance, over 60 foreign initiatives have emerged to support African electrification (Tagliapietra and Bazilian, 2017). In terms of scope and contributed finance, the Power Africa initiative, launched in June 2013 and led by the US Agency for International Development (USAID), is the largest such initiative (Power Africa, 2016a). It intends to double electricity access in SSA and increase installed capacity by 30 GW by 2030. The initiative includes over 130 public and private sector actors, including the World Bank, the African Development Bank, the African Union, the European Union and the UN (Power Africa, 2017a). Roughly 75% of its 54 billion USD investment commitments originate from the private sector.

Power Africa has been praised for its scale (Taliotis et al., 2016), its progress during its first four years of existence (Moss and Bazilian, 2018), its success in finance acquisition and private sector involvement (Gualberti et al., 2014), its positive societal implications (Bazilian et al., 2017), as well as its proclaimed focus on renewables (Otieno, 2015). These factors have been argued to constitute important success factors for large-scale electrification in SSA (Trotter et al., 2017b). Power Africa's approach features capacity building efforts, case-specific ownership structures and multilateral co-operations, which is in line with what has been called a "'sustainable energy' approach" to providing energy access ((Sovacool et al., 2016), p.4). At the same time, however, different critiques have been raised. Moss and Bazilian (2018) question Power Africa's institutional setup which requires direction and support from the White House. Their concerns appear to be justified, given the administration of President

Donald Trump has revealed it intends to cut funds for the Power Africa initiative. This move could have significant implications for African electrification given the current importance of external finance. Furthermore, several large-scale international electrification initiatives including Power Africa have been found to focus heavily on creating business opportunities for international energy companies from their own countries, turning African electrification into a business case for Western companies (Trotter and Abdullah, 2018). As a consequence, know-how transfer to African companies is limited, and addressing the issue of large-scale rural electrification through the advocated market-based approach in areas where roughly half of the population lives in poverty appears unlikely to work.

This paper does not aim to dispute Power Africa's benefits for electrification in Africa. It rather intends to highlight and discuss several design issues of Power Africa's quantitative targets. Goal-setting theory and social-cognitive theory have long demonstrated the crucial importance of setting adequate targets to enhance performance and efficacy (Locke and Latham, 2002; Otley, 1999). This paper argues that Power Africa's targets exhibit considerable attributional, developmental and technical issues (section 2). Most importantly, while being described by the initiative as both "ambitious" and "critical" for Africa's electrification success ((Power Africa, 2016b), p.2,8), the targets fall short of what would be required to fulfil Power Africa's stated ambitions. To overcome these issues, section 3 of this paper suggests to unambiguously define how African electrification projects are attributed to Power Africa, introduce end-user focused TWh-type generation and capacity range targets to overcome its technical issues, as well as to increase Power Africa's targets to double access without compromising system reliability. A brief conclusion is offered in section 4.

2. ISSUES OF THE POWER AFRICA TARGETS

Power Africa introduces its main targets as follows ((Power Africa, 2016b), p.8):

> “Power Africa has set two ambitious targets to expand access to power across sub-Saharan Africa by 2030:
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> • Increase installed power capacity by 30,000 MW; and
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> • Create 60 million new connections to double electricity access.”

Drawing from recent Power Africa policy documents and the electricity planning literature, the following three sub-sections critically analyse these targets and their rationale, addressing attributional, developmental and technical problems, respectively.

2.1 Attributional issues

2.1.1 Extensive selection of electrification projects to count towards targets

While Power Africa’s targets are formulated in clear and quantitative terms, the way how Power Africa attributes projects towards the fulfilment of its capacity and connection targets appears to be ambiguous. Power Africa’s setup allows a wide variety of generation projects in SSA to be included in the initiative’s Power Africa Tracking Tool (PATT) and counted towards its capacity target. To be registered in the PATT, projects neither have to be at a certain development stage, in a certain location, of a certain technology, nor, crucially, do they have to be actively supported by Power Africa (Power Africa, 2016b). Power Africa only requires that one of its numerous partners has "helped facilitate" a project ((Power Africa, 2017a), p.4,5), without quantifying what this facilitation help has to entail. As a consequence, no precise boundary emerges to indicate which type of African electrification project cannot be counted towards Power Africa's targets. In 2017, the PATT featured over 800 capacity addition transactions in at least 27 countries which are home to over 80% of the region's population (Power Africa, 2017b).

For example, Power Africa tracks all 17 renewable energy electrification projects totalling 157 MW of the German GET FiT initiative in Uganda, 9 of which are already part of Power Africa's self-reported accomplishments to date (Power Africa, 2017a). Yet the GET FiT initiative was launched in May 2013, i.e. slightly before Power Africa. Neither Power Africa, USAID nor the US are mentioned in any of GET FiT's annual reports or official communications. The UK and Norway, both Power Africa partners, finance a minor share of some of GET FiT's projects. This constitutes the only identifiable, albeit indirect link between GET FiT and Power Africa, raising the question to which extent counting all 17 GET FiT projects towards Power Africa's capacity target is justified. As the German development bank KfW rightfully lists the GET FiT projects as part of their contribution to African electrification, Power Africa's attributional vagueness can lead to double-counting of achievements on an integrated scale as KfW is not a Power Africa partner. On a more broader scale, while it may be a coincidence, it is noteworthy that the 2016 Power Africa roadmap document quantifies the projects where the initiative is solely "Maximizing Value from Existing Transactions" ((Power Africa, 2016b), p.17) with the exact same interval of 18 – 21 GW which it used to quantify the total amount of capacity it expects to be online by 2030 (Power Africa, 2016a) (see section 2.1.2 for a discussion of the latter).

With regards to Power Africa's connection target, Moss and Bazilian (2018) point to concerns about Power Africa's decision to count the distribution of solar lanterns towards its connection target. As of 2017, solar lanterns account for the majority of new connections Power Africa reports (Power Africa, 2017a). While they may be capable of transforming a household's quality of life, solar lanterns without additional storage and fitted outlets do not provide electricity access. Therefore, they are not suitable to be counted towards electricity access goals.

2.1.2 Reporting financial close versus actual generation for target fulfilment

Power Africa states that it aims to physically "increase installed generation capacity" by 2030 ((Power Africa, 2016b), p.8). Yet the 7.2 GW capacity addition labelled as the "Achievements to Date" in Power Africa's 2017 annual report relate to financially closed rather than operational projects. Subsequent construction and commissioning processes, which are required before a plant can generate electricity, can take several years to complete. Thus, using the 7.2 GW figure as a bases for an extrapolation until 2030 which concludes that Power Africa is on track (see Moss and Bazilian, 2018) is questionable, especially given the ambiguous way Power Africa attributes projects to its own efforts (section 2.1.1). Although not clearly labelled, the projected achievement run-up Power Africa provides in its 2017 annual report suggests that by 2030, 29.6 GW will have reached financial close. Yet the report fails to mention how much of this capacity will be operational in 2030, i.e. how much of its actual target it projects to fulfil. In 2016, Power Africa estimated that only 18 – 21 GW of the projects it is tracking will be online by 2030 (Power Africa, 2016a), implying a 35% gap between target and projected achievement.

2.2 Developmental issues

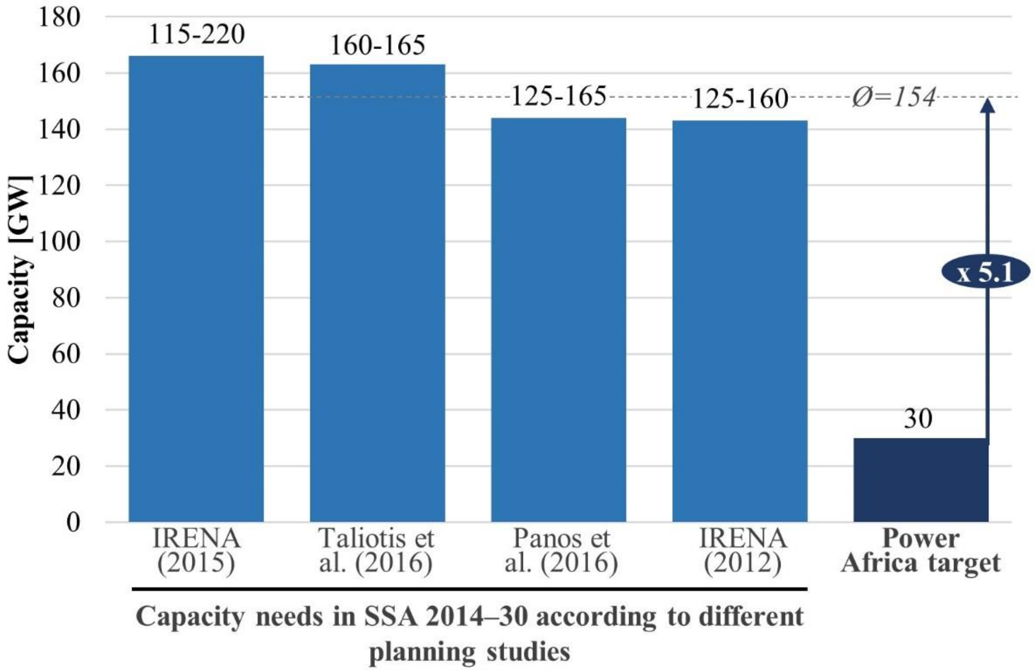
2.2.1 Too low capacity target to deliver on developmental promises

Power Africa is driven by an aspirating vision of its impact in SSA. Its central roadmap document states that

> "[t]he Roadmap offers a tangible plan for how to make our common vision of an economically vibrant sub-Saharan Africa a reality by developing Africa's rich and abundant energy resources … By increasing access, Power Africa will drive economic growth and reduce poverty across the continent" ((Power Africa, 2016b), p.4,8).

Analysing SSA's current state and future demand of electricity indicates, however, that the 30 GW target appears to be considerably too low to double access and reduce poverty across SSA. In 2014, the region used roughly 90 GW to electrify 350 million people (World Bank, 2018). SSA's installed capacity per electrified person was below 8% of per capita capacity in the US. By aiming to double access through the addition of 30 GW, Power Africa would effectively reduce the available installed capacity per electrified person by 33% compared to the current level in SSA which is already causing an average 7 outages for firms in SSA per month due to severe undercapacities (World Bank, 2018). This issue becomes more severe when considering the smaller capacity factors of newly added solar and wind plants (see section 2.3.1).

Addressing electricity requirements for economic growth and poverty reduction, several planning studies have analysed additional capacity needs in SSA to meet demand. On average, they recommend net additions of 154 GW between 2014 and 2030, more than 5 times the Power Africa target during this timeframe (Figure 1). The requirements for the twelve countries of the Southern African Power Pool alone have been estimated to be between 50 and 120 GW (Trotter et al., 2017a). It is important to bear in mind that Power Africa currently only tracks electrification projects in countries home to 80% of the region's population, and is unlikely to track all generation projects in the countries where it is active. Yet given its extent and its encompassing approach of counting projects towards its targets (see section 2.1.1), the over 500% gap between demand and Power Africa's target to double access and drive economic growth across the continent appears to be significant. This gap further increases when considering that Power Africa's targets relate to new instead of net additions. To calculate SSA's actual installed capacity in 2030, plant retirements of roughly 6 – 8 GW have to be subtracted (International Renewable Energy Agency, 2013). Hence, a certain share of Power Africa's new additions will not constitute net but substitutional additions with no positive economic growth effect. To put Power Africa's capacity target into perspective, it roughly matches SSA's historical generation capacity growth: mainly financed by African taxpayers and infrastructure users rather than international funds, SSA has increased its net capacity by roughly 28 GW between 1997 and 2013, the 17 years before Power Africa's 2014 – 2030 timeframe (Foster and Briceño-Garmendia, 2010; International Energy Agency, 2014).



Note: Capacity needs were interpolated to match Power Africa's timeframe

Figure 1: Power Africa capacity target versus projected requirements in SSA between 2014 - 2030 [Sources: (International Energy Agency, 2014; International Renewable Energy Agency, 2012, 2015; Panos et al., 2016; Taliotis et al., 2016)]

2.2.2 Too low connection target to 'double access'

Power Africa intends to double electricity access. In 2014, the year Power Africa first declared its intention to double access, World Bank figures suggest that not 300 million but 350 million people were electrified in sub-Saharan Africa (World Bank, 2018). Following Power Africa's assumption of an average household size in SSA of 5 people ((Power Africa, 2016b), p.47), doubling access would require 70 million new household connections (assuming 'doubling access' means to double the amount of electrified people). The initiative further intends to electrify businesses to drive economic growth, as well as health centres and schools ((Power

Africa, 2016b), p.2). Between 2008 and 2012, in the 19 of the 49 countries in SSA where data are available, 1.7 million new businesses were founded (World Bank, 2018), most of which are likely to benefit from an electricity connection. Extrapolating this number to 17 years and across SSA indicates that connecting businesses, clinics and schools requires over 10 million new connections on top of the 70 million for households.[2] Hence, the target of 60 million new connections appears to be at least 33% too small to meet Power Africa's own ambitions.[3]

2.2.3 Lone capacity target favours urban over rural electrification

Power Africa intends to provide electricity access "particularly in the lowest-income communities that are often located in rural areas" ((Power Africa, 2016b), p.8). While Power Africa plans 25 million of its new connections to be supplied by electricity from off-grid and micro-grid technologies, the initiative does not formulate specific off-grid or micro-grid capacity or generation targets. Instead, it solely defines one overall capacity target. Pursuing such a target in the context of limited finance availability favours centralised over de-centralised generation infrastructure: due to economies of scale, simpler logistics and the option to construct large-scale fossil fuel plants, centralised electrification is considerably cheaper per

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[2] If Power Africa means doubling the electricity access rate by its "doubling access" target, i.e. an increase from 36% to 72%, a figure which is still 4 percentage points below that of India's current electricity access, a total of 1020 million people would need electricity access in SSA in 2030. This translates to over 140 million new connections for households only.

[3] Furthermore, similarly to capacity additions, Power Africa's new planned connections would not increase the historic electrification rate growth. Adding 60 million new household connections would translate to an electrification rate increase from 36% to 46% given the population growth in SSA. While the absolute number of electrified people would increase markedly, in the prior 17 years, the access rate has grown by 11 percentage points from 25% in 1997 to 36% in 2013.

MW installed (International Renewable Energy Agency, 2013), easier to monitor and possess shorter amortisation times. They electrify the urban population more cost-effectively than rural areas as a close-by grid infrastructure usually already exists and per-connection transmission and distribution (T&D) losses are smaller.

This issue is reflected in Power Africa current project support structure. As of 2016, of the tracked 27 GW for which data is publicly available, only roughly 0.25 GW or less than 1% constituted beyond-the-grid solutions (Power Africa, 2017b). This number conflicts with the 25 million beyond-the-grid connections target. Power Africa fails to define in detail what kind of average appliance usage it intends to enable by an average connection it intends to add. The UN's Sustainable Energy for All initiative defines 5 consecutive tiers of household electricity access (Mentis et al., 2017). Tier 1 type consumptions implies that electricity usage is limited to lighting and phone charging with roughly 40 kWh per household and year. Tier 3 includes light appliances such as food processing and a washing machine (roughly 800 kWh per household and year), tier 4 adds medium appliances such as ironing, rice cooking and refrigeration (roughly 2100 kWh per household and year), while tier 5 also includes heavy continuous appliances such as air conditioning (3000 kWh per household and year). To at least rhetorically not fall into the trap of what Monyei et al. (2018) call "energy bullying (by industrialized nations on developing countries mostly in SSA)" ((Monyei et al., 2018), p.68), Power Africa has repeatedly stated the goal of driving economic transformation in Africa. Hence, to allow for sufficient electricity mobility towards higher energy levels, it can be assumed that at least a Tier 3-type to Tier 4-type of electrification is envisioned to be enabled to allow for productive use of electricity which is required to drive said economic transformation. For the purpose of this exercise, hence, an average of roughly 4 kWh per household and day is assumed to be sufficient for basic productive use of energy, similar to previous estimations in the literature (Deichmann et al., 2011; Parshall et al., 2009). Using this interval's lower end and optimistic assumptions of a 35% capacity factor (cf. (International Renewable Energy Agency, 2013)), no T&D losses for beyond-the-grid capacity, and no extra demand from rural businesses, the 0.25 GW tracked off-grid capacity could meet the long-term demand required for productive use of energy of less than 0.7 million rural households (versus the target of 25 million).

2.3 Technical issues

2.3.1 Coupling capacity addition with new connection target

The Power Africa roadmap document states that "[c]reating new generation capacity is not an end unto itself. New MW are only important if they can be delivered to homes and businesses" ((Power Africa, 2016b), p.18). Its central target definition intends to "expand access to power" ((Power Africa, 2016b), p.8). Technically, these formulations are imprecise and relate to a more general problem of Power Africa's targets. Appliances run on electricity, measured in Joule (or kWh), which constitutes the unit of interest for end-users. Installed capacity or power, both measured in Joule per second (or kW), are the time derivative of energy, and therefore can neither be delivered nor accessed. Power Africa's quantitative target of new connections by 2030 implies meeting a certain corresponding electricity demand. A single capacity target, however, does not map onto such an electricity demand target as it can yield significantly different amounts of consumable electricity. Table 1 shows ranges for capacity factors of different generation technologies. For instance, a modern 1 GW natural gas power plant can produce more than 4 times as much electricity as a 1 GW onshore wind park with a 20% capacity factor. The difference in resource volatility further increases this difference due current conversion and storage losses. The growing projected importance of grid-connected solar energy in Africa further exacerbates this issue (Trotter et al., 2018). Academic generation planning research thus often provide capacity ranges rather than a fixed value (Figure 1).

Table 1: Common capacity factor ranges for different newly constructed generation technologies in sub-Saharan Africa [Sources: (International Renewable Energy Agency, 2012, 2013]

Technology	**Capacity factor range for sub-Saharan Africa**[a]
Solar PV	0.20 – 0.25
Onshore wind	0.20 – 0.40
Hydro	0.25 – 0.70
Geothermal	0.50 – 0.80
Coal	0.70 – 0.85
Natural gas	0.70 – 0.90
Oil/diesel	0.30 – 0.80

[a] Large ranges are due to the potential occurrence of droughts (hydro) or where an application may not be designed for full load usage (de-centralised diesel).

2.3.2 Inconsistent temporal prioritisation of targets

Power Africa's targets relate to a 2030 timeframe. The initiative's legal foundation in the US, the Electrify Africa Act (EAA), was passed by US congress in 2016 and features capacity as well as electrification targets up to 2020. The official EAA report to US congress states that "Power Africa's goals also align with the goals of increasing access by 50 million people and at least 20,000 MW by 2020 as articulated in the Electrify Africa Act" ((US Agency for

International Development, 2016), p.2). Power Africa's 60 million connections target to households translates to 300 million people (Power Africa, 2017a). Hence, 50 million people are to be electrified while adding 20 GW generation capacity in 7 years, and subsequently, at least 250 million people are to be electrified while adding 10 GW in 10 years. Given the significant undercapacities currently present in much of SSA and assuming a constant generation mix when adding capacity, people connected to electricity between 2021 and 2030 through Power Africa could therefore demand no more than 10% of the electricity demanded by people connected between 2014 and 2020. Hence, the EAA and Power Africa appear to be inconsistent in their temporal prioritisation of their capacity and connection targets.

3. IMPLICATIONS AND POTENTIAL TARGET ADJUSTMENTS

Setting too low and inconsistent targets can have adverse implications for the direction and the success of any initiative (Locke and Latham, 2002; Otley, 1999). Most crucially, Power Africa's targets of doubling access by adding 30 GW and 60 million new connections create too low aspiration and motivation levels for the many stakeholders of Power Africa to address the actual size of the problem. Already, Power Africa is "working with our partners to help us identify new viable projects to fill the gap of 9,000 – 12,000 MW to reach our 30,000 MW goal" ((Power Africa, 2016a), p.5), rather than focusing on raising additional funds to address the much larger capacity gap to double access or meet demand by 2030 through a reliable electricity supply. A significant part of the 18 – 21 GW estimated in 2016 to be online by 2030 can be assumed to stem from Power Africa accelerating existing transitions rather than funding new ones from scratch. Hence, a significant fraction of the 54 billion USD raised through Power Africa is likely to still be available. With installation costs of 1 – 4 billion USD per GW, depending on technology (International Renewable Energy Agency, 2013), adding 9 – 12 GW does not appear insurmountable with the funds Power Africa has already gathered. The resulting decreased incentives to raise further finance for the actual, much higher capacity requirements in SSA, however, constitute a significant missed chance for electrification in SSA given Power Africa's remarkable success of accumulating finance commitments.

Table 2 lists implications and potential solutions for Power Africa's target issues discussed in detail in section 2. It addresses two different levels of ambitions both present in Power Africa reports. First, to double access, roughly 80 million new connections would be required. Using current estimates of household demands and residential versus non-residential consumption splits, SSA would need to generate roughly 350 TWh of additional electricity by 2030 to ensure reliable access for the new connections. Using an average capacity range interval between 35% and 55%, informed by recent IRENA planning studies on Africa, this translates to adding 80 – 110 GW (rather than 30 GW) of additional net capacity between Power Africa's 2014 – 2030 timeframe.[4] The lowest average capacity factor of 34% would mean a power system with a considerable amount of wind and solar PV resources backed-up by gas turbines, and the highest average capacity factor of 55% would imply a power system which relies more heavily on fossil fuels, hydro and other renewable baseload technologies). Second, Power Africa's developmental narrative across SSA is most likely to manifest itself if the projected demand of the region is met. Planning studies have indicated that roughly 500 TWh new generation would be required to meet demand, a number that exceeds the requirements for doubling access by two thirds. Using the same capacity factor interval assumption of 34% - 55%, this would

[4] Despite current undercapacities, doubling access can be achieved by doubling the current installed capacity. This is due to Power Africa's assumption that 40% of the newly electrified people will be served through autonomous beyond-the-grid technologies which can electrify more people per MWh generated than if electricity is fed into the national grid subject to unmet demand from industry, services and previously electrified households.

require 130 – 180 GW additional capacity (Figure 1), enabling roughly 125 million new reliably served connections by 2030. In either scenario, with urban versus rural electrification inequality in SSA being the highest in any world region (Trotter, 2016), it appears paramount to translate Power Africa's goal of achieving 40% of its new connections through beyond-the-grid technologies into concrete generation targets. Given a demand of 4 kWh per household per day, roughly 45 TWh beyond-the-grid generation for the 'double access', and 70 TWh for the 'meet demand' aspiration would be required.

Furthermore, Table 2 suggests how Power Africa could overcome the attributional and technical issues with its targets. The initiative could introduce a number metrics to clarify the meaning and impact of achieving its targets. This entails a definition what its minimum contribution to an electrification project must be before it can be counted towards its targets, reporting fully operational rather than financially closed generation capacity, as well as introducing a total and rural TWh-generation target combined with consistent electricity demand per connection estimates.

Table 2: Implications and potential solutions of Power Africa target issues for a 'double access' and a 'meet demand' scope

		Potential solutions		
Issues of Power Africa targets	**Implications**	**Description**	**'Double access' needs[a]**	**'Meet demand' needs[a]**
Extensive selection of electrification projects (section 2.1.1)	- Uncertainties regarding Power Africa's impact - Potential double-counting of capacity by different international initiatives	- Define verifiable metrics which indicate when an electrification project can be counted towards Power Africa's targets	-	-
Reporting financial close as achievements (section 2.1.2)	- Difficulty to track Power Africa's degree of target achievement - Lessened focus to achieve timely construction and commissioning	- Exclusively report fully operating capacity towards target fulfilment	-	-
Too low capacity target (section 2.2.1)	- Risk of reduced socio-economic gains - Increased grid instability - Lowered motivation to achieve instalments beyond 30 GW	- Add an adequate additional generation target and a maximum T&D loss target	- 350 TWh (T&D loss ≤ 20%)	- 500 TWh (T&D loss ≤ 20%)
		- Define adequate net capacity range to meet generation target	- 80 – 110 GW	- 130 – 180 GW
Too low connection target (section 2.2.2)	- Risk of reduced socio-economic gains - Required re-orientation of beneficiaries of Power Africa	- Make amount of new non-household connections explicit and increase connection target	- 80 million new connections	- 125 million new connections
Urban over rural electrification (section 2.2.3)	- Danger of exacerbating urban versus rural electrification inequality in SSA	- Define concrete beyond-the-grid generation targets	- 45 TWh and 15 – 20 GW	- 70 TWh and 25 – 35 GW
Coupling capacity with connection target (section 2.3.1)	- Uncertainty how much electricity is available per connected household - Focus on capacity versus ensuring adequate operation and maintenance	- Combine connection with generation rather than capacity target	- 4 kWh demand per day per household connection	- 4 kWh demand per day per household connection
Inconsistent temporal prioritisation (section 2.3.2)	- Increased capacity stress between 2020 and 2030	- Use consistent per capita demand throughout planning horizon	-	-

[a] 'Double access' means to double the number of electrified people in SSA from 350 million in 2014 to 700 million in 2030. In addition, 15% of new connections are assumed to electrify businesses, health care facilities and schools. 'Meet demand' means to supply enough electricity between 2014 and 2030 to meet projected demand in SSA (Figure 1). For both scenarios, following Power Africa's goal, 40% of new connections are assumed to be beyond-the-grid and serve households and small businesses only, the remaining connections are grid-connected. Households are assumed to require an average 4 kWh per day if basic levels of productive use of energy are to be enabled, a necessary condition to deliver on Power Africa's ambition to drive economic development through electrification. Total T&D losses for grid-connections are assumed to be 20% (Electricity Regulatory

Authority, 2016; International Energy Agency, 2014).[5] The range of overall system capacity factors is taken from (International Renewable Energy Agency, 2012, 2015). Capacity requirements are defined as net increases against the 2014 baseline. The share of grid-connected electricity consumption by households is assumed to remain at the current 27% (International Energy Agency, 2014), a figure close to current EU levels.

4. CONCLUSION AND POLICY IMPLICATIONS

Power Africa is an important initiative to address several crucial barriers for large-scale electrification in SSA. By alleviating financial shortages, increasing private sector involvement and providing broad technical and non-technical assistance, it aims to foster sustained economic growth, reduce energy poverty and depart towards a cleaner energy future across the continent. However, this paper has suggested that the initiative's targets feature attributional, developmental and technical issues which make it unlikely to meet its aspirations. This paper has suggested to introduce clear, quantitative requirements which define at which point Power Africa's support for an electrification project renders its tracking towards Power Africa's target justified. Furthermore, its capacity target of 30 GW and its connection target of 60 million are too low to double reliable access to electricity in SSA. To do so, this paper has quantified a

[5] While reliable data is scarce, total T&D losses in sub-Saharan Africa have been estimated to be around 18% (International Energy Agency, 2014) outside of South Africa, where losses are roughly 10%. The World Bank provides a lower figure of 12% for sub-Saharan Africa which includes theft and pilferage. However, this figure appears to be too low as data for many low-income countries with poor transmission and distribution networks is missing. For instance, in Uganda, which is not included in the World Bank database and has a comparably well-managed power sector, total T&D losses were roughly 23% in 2015, 4 percentage points of which are transmission losses, 19 percentage points occur via distribution, with roughly a third of which due to theft (Electricity Regulatory Authority, 2016). Hence, 20% total transmission and distribution loss is assumed here.

connection target of 80 million and related capacity requirements of 80 – 110 GW to generate roughly an additional 350 TWh by 2030. For the ambition of meeting demand, the values increase to 130 – 180 GW generating roughly 500 TWh, enabling 125 million new connections. To manifest the initiative's rural focus, roughly 15% of the TWh generation targets should be achieved through beyond-the-grid technologies.

While these requirements represent a significant increase from Power Africa's current targets, it is important to note that 75% of Power Africa's timeframe is still ahead. Its rate of raising funds has not slowed down between 2013 and 2016, and, in fact, its targets have been increased twice before in 2013 and 2014 to arrive at its current levels. Lead times between initial project conception and production are considerably below 10 years for all generation technologies other than large-scale hydro. Hence, in contrast to the Trump administration's decision to cut funds for the initiative, Power Africa should use the time it has left to increase the capacity and connection targets, couple it with adequate overall and beyond-the-grid generation targets, and intensify fundraising, technical assistance as well as knowledge transfer efforts to do justice to its ambitions of driving economic growth and reduce poverty across the continent.

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APPENDIX

The below Table 3 lists the assumptions how the 350 TWh target was derived for the "double access" goal. For the "meet demand" target, the 500 TWh were taken as an average from the previous planning studies which have assessed African demand projections in detail (see Figure 1). The associated required capacity range follows by applying a lower and upper bound on the power system's average capacity factor as described in section 3.

Table 3: Breakdown of 350 TWh target for "double access" scenario

Item	Value	Calculation / assumptions	Relevant sources
Number of connections required to double access	80 mn.	Matching the current number of roughly 80 mn. connections (currently roughly 70 mn. connected households and an assumed 10 mn. connections for businesses, schools, health facilities and other public sector institutions)	(World Bank, 2018), *this paper*
- of which household grid connections	42 mn.	Assuming the same 40% ratio of household connections to come from off-grid used by Power Africa	(Power Africa, 2016b)
- of which household off-grid connection	28 mn.	Assuming the same 40% ratio of household connections to come from off-grid used by Power Africa	(Power Africa, 2016b)
- of which non-household grid connections	10 mn.	Doubling the assumed current number of non-household connections	*(this paper)*
Electricity required for household grid connections	~80 TWh	42 mn. connections times average 4 kWh[a] per household per day times average household size times days in a year, all divided by (1-20%) to account for T&D losses	(Deichmann et al., 2011; World Bank, 2018)
Electricity required for household grid connections	~50 TWh	42 mn. connections times average 4 kWh[a] per household per day times average household size times days in a year, all divided by (1-20%) to account for T&D losses	(Deichmann et al., 2011; World Bank, 2018)
Electricity required for non-household grid connections	~220 TWh	Household share of consumption remains at 27% to ensure proportional rise in business consumption and sufficient purchasing power to pay for electricity	(International Energy Agency, 2014)
Sum	**~350 TWh**		

[a] The 4 kWh assumption translates to roughly 250 kWh per person per year which would represent an electrification usage pattern between Tier 3 and Tier 4 on a standard Tier 1 (light and phone charging) to Tier 5 (heavy, continuous appliances such as air conditioning) demand interval as presented by (Mentis et al., 2017).

REFERENCES

Bazilian, M., Sovacool, B., Moss, T., 2017. Rethinking energy statecraft: United States foreign policy and the changing geopolitics of energy. Global Policy 8, 422-425.

Deichmann, U., Meisner, C., Murray, S., Wheeler, D., 2011. The economics of renewable energy expansion in rural Sub-Saharan Africa. Energy Policy 39, 215-227.

Electricity Regulatory Authority, 2016. The Least Cost Generation Plan - 2016 - 2025, Kampala, Uganda.

Foster, V., Briceño-Garmendia, C., 2010. Africa's Infrastructure - A Time for Transformation. World Bank, Washington, DC.

Gualberti, G., Bazilian, M., Moss, T., 2014. Energy investments in Africa by the US, Europe and China. International Association for Energy Economics.

International Energy Agency, 2014. Africa Energy Outlook - A focus on Energy Porspects in sub-Saharan Africa. International Energy Agency, Paris, France.

International Energy Agency, 2016. World Energy Outlook 2016, Paris, France.

International Renewable Energy Agency, 2012. Prospects for the African Power Sector - Scenarios and Strategies for Africa Project. International Renewable Energy Agency, Abu Dhabi, UAE.

International Renewable Energy Agency, 2013. Southern African Power Pool: Planning and Prospects for Renewable Energy. International Renewable Energy Agency, Abu Dhabi, UAE.

International Renewable Energy Agency, 2015. Africa Power Sector - Planning and Prospects for Renewable Energy. International Renewable Energy Agency, Abu Dhabi, UAE.

Locke, E.A., Latham, G.P., 2002. Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. American psychologist 57, 705.

Mentis, D., Howells, M., Rogner, H., Korkovelos, A., Arderne, C., Zepeda, E., Siyal, S., Taliotis, C., Bazilian, M., de Roo, A., 2017. Lighting the World: the first application of an open source, spatial electrification tool (OnSSET) on Sub-Saharan Africa. Environmental Research Letters 12, 085003.

Monyei, C.G., Jenkins, K., Serestina, V., Adewumi, A.O., 2018. Examining energy sufficiency and energy mobility in the global south through the energy justice framework. Energy Policy 119, 68-76.

Moss, T., Bazilian, M., 2018. Signalling, governance, and goals: Reorienting the United States Power Africa initiative. Energy Research & Social Science 39, 74-77.

Otieno, G., 2015. Harnessing the UN's SE4All Initiative: How ECAs and Multilateral Partners Support Projects in Sub-Saharan Africa. Global Policy 6, 318-320.

Otley, D., 1999. Performance management: a framework for management control systems research. Management accounting research 10, 363-382.

Panos, E., Densing, M., Volkart, K., 2016. Access to electricity in the World Energy Council's global energy scenarios: An outlook for developing regions until 2030. Energy Strategy Reviews 9, 28-49.

Parshall, L., Pillai, D., Mohan, S., Sanoh, A., Modi, V., 2009. National electricity planning in settings with low pre-existing grid coverage: Development of a spatial model and case study of Kenya. Energy Policy 37, 2395-2410.

Power Africa, 2016a. Power Africa annual report September 2016, Washington, DC.

Power Africa, 2016b. The Roadmap - A Guide to Reaching 30,000 Megawatts and 60 Million Connections, Washington, DC.

Power Africa, 2017a. Power Africa annual report August 2017, Washington, DC.

Power Africa, 2017b. Power Africa Tracking Tool (PATT).

Sovacool, B.K., Bazilian, M., Toman, M., 2016. Paradigms and poverty in global energy policy: research needs for achieving universal energy access. Environmental Research Letters 11, 064014.

Tagliapietra, S., Bazilian, M., 2017. The role of international institutions in fostering sub-Saharan Africa’s electrification.

Taliotis, C., Shivakumar, A., Ramos, E., Howells, M., Mentis, D., Sridharan, V., Broad, O., Mofor, L., 2016. An indicative analysis of investment opportunities in the African electricity supply sector - Using TEMBA (The Electricity Model Base for Africa). Energy for Sustainable Development 31, 50-66.

Trotter, P.A., 2016. Rural electrification, electrification inequality and democratic institutions in sub-Saharan Africa. Energy for Sustainable Development 34, 111-129.

Trotter, P.A., Abdullah, S., 2018. Re-focusing foreign involvement in sub-Saharan Africa's power sector on sustainable development. Energy for Sustainable Development 44, 139-146.

Trotter, P.A., Maconachie, R., McManus, M.C., 2017a. The impact of political objectives on optimal electricity generation and transmission in the Southern African Power Pool. J Energy South Afr 28, 27-42.

Trotter, P.A., Maconachie, R., McManus, M.C., 2018. Solar energy's potential to mitigate political risks: The case of an optimised Africa-wide network. Energy Policy 117, 108-126.

Trotter, P.A., McManus, M.C., Maconachie, R., 2017b. Electricity planning and implementation in sub-Saharan Africa: A systematic review. Renewable and Sustainable Energy Reviews 74, 1189-1209.

US Agency for International Development, 2016. Electrify Africa Act of 2015 - Report to Congress, Washington, DC.

World Bank, 2018. World Development Indicators. World Bank, Washington, DC.