Norad

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Knowledge Base for Norad's Clean Energy Portfolio

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Authors
Stockholm Environment Institute
Dr. Daniel Duma daniel.duma@sei.org
Maximilian Bruder maximilian.bruder@sei.org
Annika Hilgert annika.hilgert@sei.org

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www.norad.no
postmottak@norad.no

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List of Abbreviations

Asian Development Bank	ADB
African Development Bank	AfDB
Commercial and Industrial	C&I
Capital Expenditure	CapEx
Challenge Fund	CF
Development Finance Institution	DFI
Development Policy Operations	DPO
Economic Community of West African States	ECOWAS
Energy data and intelligence system for off-grid networks	EDISON
European Investment Bank	EIB
Energy Sector Management Assistance Programme	ESMAP
Dutch Entrepreneurial Development Bank	FMO
Gross Domestic Product	GDP
Global Energy Transfer Feed-in Tariffs Programme	GET.Fit
Global Energy Transformation Programme	GET.pro
Hard Currency	HCY
Hybrid Renewable Energy Systems	HRES
International Development Association	IDA
International Energy Agency	IEA
International Finance Corporation	IFC
International Monetary Fund	IMF
Independent Power Producer	IPP
International Renewable Energy Agency	IRENA
Independent Transmission Project	ITP
Local Currency	LCY
Low and Lower-Middle Income Countries	LLMICs
Liquefied Petroleum Gas	LPG
Multilateral Development Bank	MDB
Multilateral Investment Guarantee Agency	MIGA
Megawatt	MW
Nationally Determined Contributions	NDCs
Operations and Maintenance	O&M
Overseas Development Institute	ODI

Organisation for Economic Co-operation and Development	OECD
Off-grid systems	OGS
Private Infrastructure Development Group	PIDG
Power Purchase Agreement	PPA
Public Private Partnership	PPP
Peer Review and Learning Network	PRLN
Solar Photovoltaic	PV
Results-based Financing	RBF
Regional Liquidity Support Facility	RLSF
Risk Mitigation and Transfer	RMT
Sustainable Development Goal	SDG
Sustainable Energy Fund for Africa	SEFA
Sustainable Energy for All	SE4ALL
Solar Home Systems	SHS
Swedish International Development Cooperation Agency	Sida
Sub-Saharan Africa	SSA
Transmission and Distribution	T&D
Technical Collaboration Framework	TCP
Theory of Change	ToC
United Nations Economic and Social Commission for Asia and the Pacific	UNESCAP
United Nations Secretary General	UNSG
Utility Performance and Behavior in Africa Today initiative	UPBEAT
United States Agency for International Development	USAID
US Dollar	USD
World Bank	WB
Willingness to Pay	WTP

Executive Summary

The Norwegian Agency for Development Cooperation (Norad), represented by the Department for Climate and Environment, Section for energy commissioned an analysis of the evidence base relevant for Norad's clean energy development cooperation portfolio. The clean energy portfolio aims to achieve increased access to affordable, clean energy and strengthened public management, to ensure economic and social development. The purpose of this report is to provide an updated basis for Norad's management of the clean energy portfolio through a review of academic and practitioner literature in order to assess in which areas Norwegian grant funding can provide the greatest added value. The focus was on energy development in low- and lower middle-income countries (LLMICs) in Sub-Sahara Africa, covering Norad's intervention areas (generation, transmission, access on-and off-grid, clean cooking, knowledge production/sharing and policy reform).

To this end, relevant data was obtained through a mixture of systematic and purposeful sampling of literature. Subsequently, the literature was synthesised and structured along a theory of change (ToC), to outline both operational advice on how to achieve immediate results (inputs to outputs) and longer-term development effects (outputs to outcomes/impacts). For both stages of the ToC, available evidence is described along Norad's intervention areas. For the first stage (inputs to outputs), the state of the evidence concerning factors enabling successful implementation of energy interventions is outlined and key takeaways formulated. For the second stage (outputs to outcomes/impacts), the effects of the interventions are described both on the macroeconomic and microeconomic levels.

Evidence on the input to output level

On utility scale **generation**, interventions have become generally successful at overcoming the various challenges. Thanks to the accumulated experience of pioneering projects, there are now best practices on procurement, project development and financing. Countries are at different levels of readiness and require tailored interventions. More attention needs to be given to planning, avoiding system integration issues and overburdening the offtaker and the government with unsustainable levels of debt. Generation interventions tend to be more suitable for systems that have high cost of back-up power and frequent/lengthy outages and should not be expected to directly contribute to improving access to underserved communities.

Transmission and distribution (T&D) may require greater focus going forward, but the challenges may be even higher than generation, as the success of interventions depends directly on the utility. Of the private sector participation models, the independent transmission projects model seems the most promising.

On **energy access on-grid**, the challenges stem from the high cost of new connections and low consumption and willingness-to-pay from prospective customers. There are solutions to both sides, including explicit and justified subsidies, which are effective when coupled with comprehensive interventions for improving utility performance.

On **energy access off grid**, while more flexibly usable and cheaper than on-grid connections, costs remain a challenge. Companies active in LLMICs often face difficulties accessing (affordable) financing, which increases costs of doing business that get passed on to end-consumers. This is due to the risk inherent to the business models, catering to a poor customer base with highly volatile ability and generally low willingness

to pay. Further, the macroeconomic conditions of the countries where off-grid energy solutions could yield significant impact further increase the perceived investment risk. Off-grid development therefore continues to depend heavily on development partners. Market conditions for these businesses need to be improved, for example, through higher capital subsidies, enhanced access to early-stage equity and medium-to-longer-term debt finance and hard currency, support with regulatory matters, and capacity building as well as bottom-up design interventions that incorporates the preferences of the user base.

For **clean cooking**, on aggregate, interventions do not consistently deliver the intended health and other co-benefits. The literature primarily suggests that impacts do not manifest beyond the short-term due to low adoption rates and inconsistent usage by the intended beneficiaries. Hence, funding for this intervention area should aim to address challenges such as high prices of initial acquisition as well as running costs of fuel, inappropriate technological design, lack of a supportive ecosystem and lack of awareness of benefits and proper usage by the intended users.

On **knowledge sharing and capacity building**, the effectiveness of interventions is particularly difficult to measure. Such interventions have had limited documented success in increasing local capacity and access to financing, policy adoption and technology deployment. Based on the available evidence, offering advisory services, spaces for learning and exchange, support for policy outputs like regulatory frameworks and sector plans, knowledge products, international learning events, and training programmes are promising activities in the energy sector. However, knowledge sharing and capacity building interventions are unlikely to present impacts in the short term and they must be funded, implemented, and assessed systematically and sustainably in the long-term and rooted in the local context.

On **policy reform**, there is similarly limited evidence for the effectiveness of interventions and reported difficulty in achieving significant policy objectives in a sustainable way. Yet, reforming the power sector is seen as the only way to ensure that investments in generation and transmission generate the benefits they are designed for and that the system is able to sustain them in the long term. Understanding the political economy behind the drivers of weak performance, including subsidies, imprudent cots, losses and low collection rates is crucial for interventions to be effective.

Other overarching findings are on finance, the role of donors, and the private sector. On **finance**, there are now adequate instruments that have proven effective for different types of interventions and country contexts. Risk mitigation instruments like guarantees have also been successful, as have innovative RBFs or challenge funds. At the same time, for currency risk, there does not seem to be a credible solution in use, at scale, which creates a major vulnerability for offtakers.

The **role of donors** is evolving, as more work now entails collaboration with the private sector. Taking an integrated view within and between portfolios, pursuing a more risk-tolerant approach and maintaining strong channels to gather local input are seen as critical success factors. On the **role of the private sector**, the prospects for commercial viability is the cornerstone of any intervention that expects contributions from for-profit firms of any size. Countries have different levels of readiness and companies are at different stages, and these differences need to be acknowledged when designing interventions. The reality that most of the revenues that these private entities rely on to survive is expected to come from people living in poverty also needs to be acknowledged. The numerous failures in the off-grid and clean cooking space should be accepted as an implicit risk in the given context.

Evidence on the output to outcome/impact level

At the **macroeconomic** level, there is enough evidence that energy access does lead to economic growth and employment, particularly through two channels: lowering energy costs (by displacing expensive fossil back-up generation) and reducing outage times. There are countries where the causal link has not been confirmed, but, it is generally believed that energy is a necessary but not sufficient condition for growth. For clean cooking interventions, there are

few analyses estimating macroeconomic effects. Rather, correlations are established that show that clean cooking is positively correlated with other key development variables such as economic growth and GDP per capita.

At the **microeconomic level**, the evidence suggests **positive but modest effects** on households in terms of economic outcomes, education, health, and gender equality. However, there exists **considerable heterogeneity across studies**, stemming partly from observable characteristics of the studies, such as study design, the type of outcome evaluated, the way variables were measured, location, method employed, or length of follow-up. This finding underlines **the importance of local, specific contexts**. With the high degree of heterogeneity, understanding and assessing how context determines adoption and use of electricity infrastructure is key for yielding impacts. Without appropriately considering these factors, beneficiaries may not take up electricity, use electricity at a much later date than anticipated, or consume sub-optimal levels of electricity for basic energy services, for short periods. Further, unexpected outcomes and negative externalities need to be more explicitly measured and counteracted. In the context of clean cooking, impact is lacking because of inconsistent adoption and usage by the intended users.

Photo: **Ken Opprann**

1

The impact of energy interventions – difficult to measure but a ‘no-regrets’ development strategy

Energy is an enabler of a variety of processes potentially affecting an extremely wide range of outcomes through lengthy, complex and non-linear causal chains, making the estimation of impacts exceptionally difficult (ADB, 2019). The difficulty of finding significant economic impacts from energy access interventions is well known and sometimes compared to the productivity paradox experienced in industrialized economies, whereby the introduction of electric machinery or the computer and information technology did not result in significant productivity improvements (Lenz *et al.*, 2017; Toman and Peters, 2017). It is now accepted that impacts occur over decades and are difficult to trace.

All donors and DFIs/MDBs struggle with this issue. Independent evaluations acknowledge that the attribution of results to the respective interventions is uncertain, difficult to either prove or dispel (Trotter, 2019; Social Impact, 2022; Independent Evaluation Unit, 2024). For example, the GCF evaluation recommends better measurement of intermediate indicators to be able to discern any causal pathways. The AfDB evaluation on its energy interventions concludes that calculating the efficiency of interventions is extremely challenging and that 'the results of the economic appraisal of investment projects are uncertain because they are based on the future values of variables' (Independent Development Evaluation, 2020).

In general, evidence tends to focus on the macro level using forceful behavioural assumptions that are difficult to test accurately at the micro level. With energy interventions having more and more objectives beyond energy including income, education, health, gender equality, environment, there are more untested assumptions about the behavioural changes induced by energy access (ADB, 2019).

Impact evaluations rely on fewer assumptions, as they build, through different methods, a counterfactual: a control group to compare with the treatment group, with the difference being considered as the result of the intervention and not of anything else.

However, according to the ADB review (ADB, 2019), there is a shortage of impact evaluations on energy interventions due to:

- Selection bias
  - Community level: interventions may take place in communities that are already on a growth trajectory: more accessible, densely populated
  - Household level: take-up of the intervention can be higher in households with particular characteristics that can confound the effect
- Data collection is expensive and complex both for the baseline study and follow-up
- Random assignment is difficult or impossible for some interventions
- Large spillover – an energy intervention has economy-wide effects and the spillover to 'non-treated' communities makes the impact hard to discern

For this reason, there are so many counterintuitive results. For example, an evaluation of off-grid solar electrification in Kenya found that post electrification the expenditure on firewood increased for which no explanation has been found, leaving the authors no option but to attribute it to measurement errors

during data collection (Trinomics, 2018). In addition, there are many potential impacts that are very difficult to measure and rely on subjective perceptions and (potentially misleading) self-reported attitudes of beneficiaries. An evaluation by FMO finds that 'households might experience, and sometimes mention impacts in the field of security, leisure, health, or woman empowerment but such impacts are very hard to measure quantitatively' (APE, 2017).

Besides the inherent difficulty of measuring impacts, there is also a clear evidence gap (ADB, 2019). More work can be done on impact evaluation at the microeconomic level, with richer contextualization, especially when complex social goals are pursued. This will require better use of theoretical and applied research, but also better data collection. A good example of improved data collection is the EDISON platform, that Sida developed for some of its off-grid interventions (Nordic Consulting Group, 2021). EDISON connects to the monitoring systems of off-grid service providers and extracts real time information on payments, jobs created, female customers, quality of service, faults and others. This can enable better learning on how the intervention is performing.

To sum up, there are limits to what can be measured in terms of impact, particularly in the short term. Both the outputs (electrification) and impacts (economic growth or wellbeing) are phenomena that most often take decades to materialize. For example, the WB recognizes that the transition from low to high electricity access in a country can occur in two decades if conditions are right (IEG, 2016; Toman and Peters, 2017). However, the impacts can take even longer. At the same time, there is no country that achieved a good level of prosperity that does not utilize significant amounts of electricity (Moss and Kincer, 2023). This means that interventions that aim at improving access to energy for businesses and households should be seen as a 'no regrets' strategy for development. However, the focus needs to be more on the 'how' than the 'why'.

The 'how' is no trivial matter either. Improving access to modern and sustainable energy proves to be difficult, even when ignoring its final impacts. For example, an evaluation by AfDB concludes that 'the achievement of high-level objectives of the Bank's assistance to the energy sector is unsatisfactory in terms of access to electricity and clean cooking solutions' (Independent Development Evaluation, 2020). More learning on what works in actually providing people with energy is needed even if the exact impacts of energy on economic and social development are difficult to measure.

Taking a more global policy view, energy is at the intersection between climate and development goals and the focus has only grown in recent years. Momentum increased with the launch of the United Nations Secretary General's (UNSG) initiative on Sustainable Energy for All (SE4All) in 2011 and the UN SDGs (SDGs) in 2015. SDG 7 is dedicated to access to energy for all by 2030 and SDG 13 is dedicated to climate change – with major energy implications. The Paris Agreement and the Nationally Determined Contributions (NDCs) confirmed sustainable energy as a major global priority.

In conclusion, the impact of energy access is extremely complex and thus difficult to evaluate. At the same time, energy is such a fundamental service with implications for wellbeing, economic activity, and the environment, that the challenge is equally to identify the types and specificities of interventions that lead to energy being available and used, and to evaluate the impact it creates.

2

Methodology

This document summarizes the evidence from both academic and gray literature on energy interventions in LLMICs along Norad's intervention areas. It does so by looking at both the input-output level as well as the output-outcome-impact levels of the ToC. The document also reflects the experience of SEI in research and engagement on this subject. The document presents findings and discusses some unresolved dilemmas on clean energy finance in LLMICs, particularly in SSA.

The reviewed evidence focuses on the major areas of energy interventions in development contexts

i. hard infrastructure provision and

ii. soft interventions that can enable them.

The hard infrastructure can be divided into: generation, transmission and distribution, on and off-grid solutions and clean cooking. The soft interventions include policy improvements and knowledge exchange with various stakeholders.

First, a search was performed in the bibliographic database SCOPUS, testing for the presence of keywords. A preliminary search using different variations of key terms for each intervention area brings up a number of results for each.

TABLE 1

Preliminary search strings and results by thematic area in SCOPUS

	Scopus v1	Scopus v2	Scopus v3	Scopus v4	Scopus v5	Scopus v6	Scopus v7
Theme	Renewable energy generation	Transmission	Access on-grid	Access off-grid	Improved cooking solutions	Knowledge production/ data/synthesis	Institutional capacity building, technical assistance, energy sector reforms
Search Query	TITLE-ABS-KEY ("energy generation" OR "energy production" OR "renewable energy development" OR "renewable energy power generation")) AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")	TITLE-ABS-KEY ("energy") W/10 ("transmission") AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")	TITLE-ABS-KEY /" Electricity access") AND NOT ("Off Grid")) AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")	TITLE-ABS-KEY ("Electricity access" AND NOT ("Off Grid")) AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")	TITLE-ABS-KEY ("clean cooking")) AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")	TITLE-ABS-KEY ("energy")) AND ("knowledge production" OR "knowledge sharing" OR "Data production" OR "Data collection" OR "data synthesis") AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")	TITLE-ABS-KEY ("energy")) AND ("institutional capacity" OR "capacity building" OR "technical assistance" OR "energy sector reform") AND ("Project" OR "Intervention" OR "initiative" OR "Support" OR ("development cooperation")) AND ("Financ*" OR "Invest*" OR "Risk" OR "Portfolio" OR "Funding")

Inclusion and exclusion criteria were then defined. Specifically, all articles that do not explicitly aim to analyse the impact of energy interventions on a sustainable development goal (either quantitatively or qualitatively) were not considered.

Further data was then collected from the second type of data source, namely documents from development cooperation actors, international organisations and MDBs/DFIs as well as private sector actors and civil society organisations not found in academic databases. As there is no centralized database for these types of practitioner literature, a purposive sampling approach has been applied. Within the gray literature, a snowball approach was taken to scan for further data.

The data is subsequently synthesised, triangulated and structured along the lines of Norad's intervention areas and their theory of change.

3

Variants of the theory of change

All organizations working with energy interventions in development contexts have put forward a theory of change (e.g. IEG, 2016; FMO, 2017; ADB, 2019; ICF, 2020; Independent Development Evaluation, 2020; Nordic Consulting Group, 2021; Greencroft Economics, 2022; Wörlen *et al.*, 2023; Independent Evaluation Unit, 2024). While some differences exist, they tend to follow broadly similar lines from inputs to outputs, to outcome and impact. All of them rely on strong assumptions. The following demonstrates a collection of interventions typically included in the ToCs of the different organisations. In the subsequent sections, we use this generic ToC to structure the evidence found in the literature.

Inputs to outputs

- Inputs include:
  - Capital, derisking instruments
  - Transaction facilitation
  - Technical assistance, capacity building, knowledge sharing
  - Incentives for service providers
- Desired outputs include:
  - Better planning
  - Improved policy and regulation
  - Better capabilities for system integration
  - Power capacity

Outputs to outcomes/impact

- Households and businesses have greater access to energy which leads to:
  - Substitution of more expensive or polluting energy sources (kerosene, firewood) with positive impacts on livelihoods and health
  - Improved lighting translating into:
    - Changes in use of time
      - More education
      - More socialization and entertainment
    - More perception of safety
    - More autonomy for women
  - Electric power translating into:
    - Better access to information through radio, TV, internet, communication with friends
    - Expanded use of appliances with impacts on:
      - Health: refrigeration, information
      - Productivity: firms using devices to improve production or profitability (information, comfort for customers, refrigeration)
      - Productivity in agriculture: milling, grinding, irrigation, refrigeration
    - Comfort:
      - Reduced physical labour
      - Fans for cooling with potential impact on learning and productivity as well
    - Enhanced services in education and health using all of the above
- Overall increased welfare, subjective wellbeing, improved livelihoods and reduced poverty.

The problem with assumptions

However, each step of the ToC depends on major assumptions which may or may not hold in particular interventions, cases, regions or periods of time (ADB, 2019). Even at the primary output level, the assumption that access to energy is achieved does not always hold. The service may be unavailable due to technical faults, inability to pay for the connection works, the bills, or for appliances that actually use it. Even if the power is available, the assumption that it is used right away is also shown to be only partially valid.

Further along in the ToC, there are assumptions on the changes that energy access induces in the behaviour of people. This includes the predicted interactions with the services enabled by electricity that should lead to greater wellbeing through various channels like reduced costs, substitution of dirtier fuels, education through better lighting, information and connectivity, health, socialization, gender empowerment, perceptions of safety and comfort, and increased economic activity leading to reduced deprivation. At the public facility level, schools and hospitals are expected to improve their services thanks to energy, while at the business level, energy access is expected to determine small businesses to improve productivity by mechanizing work or by enhancing their services. The literature is ambivalent on all these assumptions, showing that they sometimes hold fully, partially or not at all, depending on study design, the time from the intervention, and the region (ADB, 2019; Bayer *et al.*, 2020; Eberhard and Dyson, 2020; Lee, Miguel and Wolfram, 2020).

Other assumptions play important roles in anticipating effects at the system level. One is that adding comparatively lower-cost capacity to the grid reduces end-user tariffs or improves the financials of utilities or the government. This assumption has been shown to hold in some contexts, but not in all, as there are known cases of countries where adding capacity, even at low costs, lead to unsustainable levels of debt for the utility and the government (KfW, 2020).

Another relevant assumption is that poor management or policy-making is the result of lack of capacity or knowledge and can be addressed with technical assistance and capacity building. These assumptions have also been challenged, as the drivers of poor management may be the political economy and vested interests behind the status quo rather than poor information (Auriol and Blanc, 2009). A lot of work goes into identifying the conditions under which technical assistance is effective over given time horizons and to account for some of the pathologies that render them ineffective.

Finally, assumptions on the role of the private sector, financial instruments, and market solutions are also fundamental to the ToC of most donor organizations. One assumption is that creating the enabling conditions will help markets develop and cater to previously unserved populations in a sustainable way. This assumption has been challenged, with many private sector initiatives struggling to maintain profitability as consumers at the base of the pyramid cannot afford to make regular payments for the service in the long run (Nordic Consulting Group, 2021; Wörlen *et al.*, 2023). Finally, another assumption states that private for-profit capital can be deployed with the help of blended finance tools, with public entities taking over the excess risk while allowing private capital to earn their rightful return (Convergence, 2024). The assumption only holds for contexts and projects where the prospect of commercial viability is credible and blended finance can provide enough comfort to investors to deploy capital (Duma and Muñoz Cabré, 2023). But blended finance is not a substitute for commercial viability, which means the assumption only holds where a rich market analysis confirms that commercial demand is robust (with or without subsidies).

4

Evidence along the theory of change

In this section, the evidence found in academic and gray literature is presented. While different factors lead to successful implementation of interventions at output and outcome levels across generation, transmission and access, the impact of electricity is always the final result of the chain. Therefore, output and outcome levels of the ToC are discussed for each intervention area (generation, transmission and distribution, energy access on-grid, energy access off-grid, clean cooking, knowledge sharing and policy reform) separately in section 4.1, whereas the impact-related evidence of electricity and clean cooking is discussed for all areas in section 4.2.

Photo: **Espen Røst**

4.1 Input to output

4.1.1 Generation

4.1.1.1 Evidence

Utility-scale generation of electricity is a part of the sector that has seen progress. Investments from MDBs and DFIs have resulted in expanded power capacity (Attridge *et al.*, 2019; Independent Development Evaluation, 2020). For example, an ODI report finds that DFI finance has led to increased provision of energy, a higher installed capacity with reduced energy prices and improved reliability (Attridge *et al.*, 2019). SEI research shows that most countries in SSA now have one or more utility scale project operational or in advanced development (Duma, Muñoz Cabré and Kruger, 2023). The reason why the success is not duly recognized is because of the way targets have been set, i.e. either in absolute terms or in multiples of billions of USD (Trotter, 2019). In reality, adding utility-scale renewable capacity to the small grids of SSA under extremely challenging circumstances of macroeconomic imbalances (debt, inflation, currency depreciation) and political instability is remarkable. There are projects that added significant percentages to the existing grid (for example Salima and Golomoti added almost 20% to the Malawi grid).

However, a disappointment stems from the limited role of the private sector in financing such projects. This comes from the belief that poor countries can absorb unlimited 'private investment'. In reality, any capital committed by the private sector to a project and country needs to be recovered with a decent return, which means either the government or customers have to be able and willing to pay the right price that solves that equation. Research shows that the vast majority of the people without access to energy are living in poverty (IEA, 2023b) and cannot afford to pay even modest amounts to access and use energy (Nordic Consulting Group, 2021). Thus, misrepresenting the addressable market in terms of need, not in terms of willingness and ability to pay, is another source of disappointment.

At the same time, the fact that expanding capacity has very little if any consequence on improving access (providing connections to previously unserved households) also needs to be well understood. Expanding generation capacity is aimed at improving availability and service quality to existing customers and especially to growing businesses (Steward Redqueen, 2017). Improving access is the result of different interventions including extending distribution grids (or installing off-grid technologies) and ensuring support to enhance usability and affordability (IEG, 2016; APE, 2017).

However, there is a growing body of evidence on enablers of success in expanding clean energy generation capacity, but also on barriers, pitfalls and unintended consequences. All will be discussed along the project development cycle.

Planning and demand assessments

The importance of planning and credible commitments is emphasized in the literature (Trotter, McManus and Maconachie, 2017; McPherson *et al.*, 2018; Trotter, Cooper and Wilson, 2019). Ensuring that a comprehensive energy system plan is in place and is accepted by all stakeholders is a critical success factor. Conversely, its absence is a major source of risk. In 2020, 90% of countries in SSA lacked an updated comprehensive long term generation plan (Cornieti and Nicolas, 2023). Two major risks have been identified (and have materialized) stemming from inadequate planning.

The first is system integration. Within the small power systems that are common in SSA, even

modest additions of variable generation can affect grid stability, in the absence of adequate mitigation strategies. Several papers from development agencies and MDBs mention the issue of grid integration as critical but too often overlooked (Eberhard and Dyson, 2020; Independent Development Evaluation, 2020). System integration also pre-supposes the availability of grids to evacuate the power, which sometimes is lacking. The AfDB evaluation identified challenges in the actual utilization of the power produced due to inadequate T&D infrastructure, absence of storage technologies and system instability (Independent Development Evaluation, 2020).

The second risk is overcapacity – contracting energy services in excess of the country's ability to consume and/or pay (Andersen and Pedersen, 2023). This risk has materialized in a number of countries with significant consequences. Ghana is an example of a country that responded to an energy deficit with a poorly planned series of bilaterally negotiated Power Purchase Agreements (PPA)[1] with various Independent Power Producers (IPP) resulting in overcapacity, a massive burden of liabilities for the utility and the government who need to pay for energy that is not utilized (Ackah *et al.*, 2021). The inability to pay by different actors has led to a paradoxical state of continued unreliability of the power service despite overcapacity. The situation constitutes one of the causes behind Ghana's sovereign default in 2022 (IMF, 2023). To tackle it, the government is working with the IMF and other actors on reviewing the standard 'take-or-pay' PPA clause. This situation is not unique to Ghana. After a number of successful IPP investments that expanded its capacity significantly, Kenya resorted to creating a Presidential Taskforce to review PPAs that were creating a heavy burden of liabilities. Reviewing the standard 'take or pay' clauses, changing them into 'pay-when-taken' (AfDB, 2023).

Hence, more generation capacity does not always have positive impacts on the economy but could actually be detrimental to growth including to the growth of the power sector. Other countries are likely going to experience overcapacity in the short run, including Uganda, Rwanda and Cote d'Ivoire (Independent Development Evaluation, 2020; Andersen and Pedersen, 2023). In Uganda, while the successful GetFit procurement program was being implemented for small hydro and PV capacity, two extra Chinese-funded hydropower projects have been initiated, which are likely going to result in overcapacity and financial difficulties for the utility. The evaluation of KfW confirms that 'power sector planning is critical to ensure that power generation capacity financed through additional private sector capital can be integrated into the grid and absorbed by the economy. This can otherwise worsen the domestic utility's balance sheet substantially and drive up sovereign debt' (KfW, 2020, p. 14).

Andersen and Pedersen (2023) discuss the paradox of overcapacity in some African countries and identify three main explanations: the quality of planning and management in the power sector, national ideology and political economy interests, and the role of donors and private investors. The first involves planning that is not thorough enough and relies on optimistic demand and export scenarios, implying that 'demand will follow supply'. The second describes the importance of energy capacity in ideological narratives of development but also the lack of transparency and potential corruption in contracting projects in excess of need. The final explanation traces the pressure on donors to show palpable development results and to involve the private sector that can lead to contracts that the countries may not be prepared to honour in the medium term.

To avoid this problem, generation, transmission and demand planning is paramount. Various tools for least cost sector-level planning including interconnections are available and have been applied in many countries in SSA. However, planning must be performed in parallel with a deep understanding of political economy risks that may otherwise render it ineffective. While valid for all interventions, a deep understanding of power dynamics and risks of corruption is particularly relevant in avoiding onerous contracting of additional

1 Based on the Ghana cautionary tale, the Energy for Growth Hub started a PPA watch, a transparency tool that holds the government accountable for the number and terms of the bilaterally negotiated PPA that they sign that create long term liabilities for the utility and, implicitly, the state (*About PPA Watch*, no date).

capacity that a country cannot afford (Rahman, 2020). Realistically assessing demand is also crucial for a correct estimation of costs, with deviations potentially resulting in large cost increases (Egli *et al.*, 2023).

Enabling conditions

Renewable energy projects can only emerge after a number of minimal enabling conditions are met by a country. The task of promoting these conditions or even identifying them through experience tends to be performed by the first project in the country, as illustrated by the Mocuba project in Mozambique (Duma, Muñoz Cabré and Kruger, 2023). This varies from country to country, but can include work on exemptions from import duties, the legal clearance for certain standard PPA clauses, the very legality of private actors owning and operating power infrastructure in the country, access to land, and others. As most countries in SSA now have at least one project in the operational phase or in advanced development, the pioneering work has largely been completed, with subsequent projects focusing more on gradual improvements.

The critical success factor in establishing the enabling conditions is government political commitment (Independent Development Evaluation, 2020). This can be achieved by seizing windows of opportunity, such as power shortages from droughts and expensive fossil solutions. This has been the driver behind significant power sector reforms in Uganda, Zambia and others (KfW, 2020). However, as illustrated by Ghana, the urgency for action should not overlook the importance of planning, otherwise the state of the power system can actually deteriorate after bridging the acute crisis by adding too much capacity compared to the system's ability to consume and pay.

Structuring

The IPP model with PPAs under a project finance structures has proven successful and has been replicated throughout SSA (Duma and Muñoz Cabré, 2023). Other models, such as financing on corporate balance sheets have been seen in the case of bankable utilities like NamPower in Namibia but also with C&I dedicated utilities. For example, the Copperbelt Energy Corporation in Zambia financed on its balance sheet a 33 MW PV plant to service the lucrative copper mines in the north of the country (Kruger and Eberhard, 2019). Another successful model implemented recently is a vesting-leasing contract for modular re-deployable utility-scale solar, first implemented by Eneo in Cameroon with ReLease by Scatec (IFC, 2023). Other C&I models are developed but tend to be self-sustaining and to require much less development assistance.

Procurement

Evidence shows that well-designed[2] competitive procurement tends to be successful at attracting reputable developers, reducing lead times, and at obtaining low PPA tariffs (Kruger and Alao, 2024). They are, however, not without their problems. Even the relatively successful and carefully planned procurement programs have experienced problems. For example, Scaling Solar, a program led by the World Bank Group, with technical assistance for competitive procurement, stapled IFC financing, and IDA and MIGA risk mitigation, has only been implemented in a few countries (Zambia, Senegal, Madagascar). The evaluation of the program in Zambia showed that the projects have been built at low tariffs thanks to concessional finance and risk mitigation. However, even with the integrated approach, there have been delays, perverse incentives (post award re-negotiation, reopening after financial close), little access for local players, and the PPAs ended up burdening the utility and the government (USAID, 2018).

Another important program that included a competitive procurement component is GetFiT[3]. GetFiT was seen as successful in Uganda, but less so in Zambia, for reasons that have less to do with the program, but with the country context (Zambia entered sovereign default), which confirms the importance of a thorough understanding of the macro and political context and

2 The design parameters vary and are crucial in ensuring the auction is well adapted to the context and generates sustainable outcomes. The criteria are discussed in more detail in Kruger and Alao (Kruger and Alao, 2024).

3 The REIPPP program in South Africa is also a relevant example but the country itself is seen as economically developed enough to sustain programs with less support from development partners. The Proler program supported by the EU in Mozambique is also underway but it is still early for an evaluation of its success.

of the right timing (and the undeniable role of luck) (Kruger, Eberhard and Swartz, 2018; Duma, Muñoz Cabré and Kruger, 2023)

Even well-designed competitive procurement that results in record low PPA tariffs can sometimes be problematic. The PPA price tends to be a function of various project-specific features such as the resource (e.g. solar irradiation), land costs, or taxes, and, crucially the country risk and the cost of capital. With many projects being financed via concessional debt by MDBs/DFIs in foreign currency (and thus well below market interest rates), the resulting PPA prices tend to be low. This can have two potentially negative consequences. One is that the high competition can lead to the 'winner's curse', well known in auction theory, whereby the winner's bid is below the level that would ensure commercial viability and thus can determine the entity to seek re-negotiation. The second is that the low price creates a false benchmark for other countries or projects who will now expect similar prices (despite different fundamentals). Hence, PPA prices that are above these benchmarks can become a political vulnerability for incumbents and also can become the subject of renegotiations, increasing the perception of risk.

Project preparation

This stage is the one that faces the most complex risks and most projects that enter early development never actually get built. Grants for resource measurement, land surveys and interconnection studies and equity injections in early project companies would greatly bolster the chances of projects getting to the advanced development stage (IRENA, 2016; DBSA, 2021). The IEA finds that early stage financing is often too risky for the private sector and therefore constitutes one of the important ways of using development assistance money, critical for building up the project pipeline (IEA, 2023a, p. 40). Yet supporting this stage also needs to come with the acknowledgement that the project may never materialize, which is well known and accepted in the private sector, but more difficult to tolerate in the public sector (and development agencies).

Financing

There is now enough of a track record in financing renewable energy projects in SSA to allow for the identification of the major success factors (IRENA and CPI, 2020; SE4ALL and CPI, 2020; KFW, GIZ, and IRENA, 2021; IRENA and AfDB, 2022; Buchner *et al.*, 2023). According to the AfDB evaluation, they are: 'the level of experience of project developers; familiarity of equity and debt providers with developing country risk; bankability of power purchase agreements, appropriate risk mitigation and security measures, such as escrow accounts, letters of comfort, partial or full guarantees, and political risk insurance' (AfDB, 2023). Each of these success factors implies great complexities and addressing them in a manner that is satisfactory requires significant effort and improvisation, but the solutions tend to be known. Once all project components are in place, risks are managed and fairly allocated, and the return prospects are adequate, finance is no longer a major issue (Cornieti and Nicolas, 2023), especially when DFIs/MDBs are highly incentivized to lend at concessional rates. In this context, based on the accumulated experience and the wealth of instruments available, donors must simply ensure that developers are experienced, facilitate access to providers of finance, guarantees and insurance. Even so, financial close can take years to reach. More details on financing will be offered in the dedicated subchapter (4.1.8).

Construction and O&M

For mature technologies, construction and O&M tend to be based on standard procedures and reputable suppliers with good track records. The relatively frequent issues with delays and cost overruns tend to affect the efficiency of interventions from the donor perspective (AfDB, 2023) and are generally caused by structural problems related to supply chains and logistics (customs clearance), access to land, or conflicts (Duma, Muñoz Cabré and Kruger, 2023). Strictly related to construction and O&M, experienced project developers are generally well equipped to allocate risks effectively, as they incur large losses in case of delays and failures. Issues such as local content requirements or difficulties around procurement should be dealt with well in advance, and donor could help navigate such complexities, based on

their accumulated experience from previous projects and via their bilateral channels with the government.

Social and environmental considerations

A major source of risk that affected projects in SSA has been securing land rights. With most land being under customary administration with complex layers of traditional authority, access to land is not under the complete control of the state but requires careful consideration of local sources of traditional authority (Lund, Odgaard and Sjaastad, 2006; Pueyo, 2018). Careful preparation and meaningful local engagement are crucial for project success. On the environmental side, the footprint of energy infrastructure tends to be significant and mitigation requires careful adaptation to the variety of potential risks in SSA. The IFC standards for social and environmental performance are generally accepted but tend to require significant amounts of time to complete in a thorough manner.

4.1.1.2 Key takeaways

- In most countries, there is enough of a track record for utility scale clean energy projects to enable future projects
- The major areas of concern are the financial viability of the system and the risk of overcapacity
- More generation is not always beneficial, on the contrary, it can add to a country's problems by adding short term debt
- When the main project components are in place (land, resource, transmission, offtaker, tax), finance tends to follow.

4.1.2 Transmission and distribution

4.1.2.1 Evidence

Transmission and Distribution (T&D) is identified as a major vulnerability in SSA. A number of MDB evaluations conclude that T&D has been overlooked and that energy sector interventions should shift their focus to T&D (IEG, 2016; Independent Development Evaluation, 2020; AfDB, 2023). Moreover, interventions in this sector are seen as even more challenging than generation (KfW, 2020). Correspondingly, there is less evidence on the effectiveness and impact of T&D interventions (Eberhard and Dyson, 2020). One important reason behind the lack of evidence is the difficulty in isolating the effect of the intervention, given the fact that potential impacts occur through multiple channels.[4]

Many sources describe the challenges faced by T&D infrastructure throughout SSA: obsolete and poorly maintained equipment, large technical and commercial losses, frequent and long interruptions (World Bank, 2020). Expensive diesel backup generators are routinely used to cope with the numerous technical faults. The assets tend to be owned and operated by integrated utilities that are chronically underperforming (see section on 4.1.6 on knowledge sharing and reform). Hence, financing and implementing grid extension, maintenance, modernization, and digitalization (SCADA, smart metering) are extremely challenging.

Overall, interventions in T&D contribute to increasing the supply of electricity by enabling electricity generation and cross-border exchange, but they rarely result in the overall improvement of reliability of power services, nor do they lead to lowering end-user tariffs (Independent Development Evaluation, 2020). The AfDB evaluation concludes that none of its cross-border T&D interventions that enable a country to access a neighbour's relatively cheaper electricity, including the ones part of the Western African Power Pool, has resulted in lowering utility tariffs.[5] A cluster evaluation of AfDB interconnection projects confirmed that the interventions did not result in improved reliability or affordability, but that they did contribute to increased availability of electricity for importing countries and increased cross-border trading (Independent Development Evaluation, 2018). The same evaluation found that interconnection projects underestimated a number of risks, including the availability of sufficient

4 A new or improved transmission line does not automatically or always lead to measurable improvements in overall reliability nor does it lower tariffs, especially when regulation or utility management are not granular enough to allow for the impact to be well defined.

5 Tariff design for regulated utilities is highly complex, isolating the effect of a transmission line on tariffs is likely to be difficult if not impossible. The AfDB evaluation finds that the overall operational inefficiency of utilities is passed on to consumers and that additional interconnection capacity can lead, at best, to 'slowdown in tariff growth rate'. Therefore, utilization of the line is likely a better indicator of effectiveness.

power in the exporting country to meet both domestic and export demand, the utility's ability to operate and maintain the assets effectively, insufficient tariffs to adequately cover the costs of the new project, and political tensions between neighbouring countries. A comparative study of African power pools also found that they resulted in increased cross border trading (Elabbas, de Vries and Correljé, 2023).

Grid extension is challenging in general, due to the poor financial health of the utility, but extending coverage to the rural areas is particularly challenging (Toman and Peters, 2017; Bos, Chaplin and Mamun, 2018; Greencroft Economics, 2022). They tend to be remote, and thus expensive to build and maintain, and they serve customers with extremely low consumption levels (if they can even afford to be customers), which results in large losses. T&D tends to be a bottleneck for the generation side as well. A case in point for the vulnerability of transmission, one of the largest wind projects in Africa – Turkana in Kenya was completed in 2019 but the transmission line took longer to finalize, which led to the government having to pay for deemed energy to the wind park even though the energy could not be utilized (AfDB, 2023).

Modernizing existing grids and close-to-viable grid extensions is a worthwhile endeavour as it directly impacts service reliability and the prospects for enhanced access (Steward Redqueen, 2017). The impacts can be relatively high even from minor interventions, given the general level of technological obsolescence. Relying on the integrated or unbundled utility to plan and execute the required interventions is challenging, given their poor financial state and chronic lack of resources, and thus requires complementary interventions such as technical assistance for increased utility performance. As with all energy interventions, because of the complexity of causal chains but also of the political economy around the energy system, progress tends to be slow.

Private sector participation models and financing

Most T&D investment is performed by state-owned utilities funded directly by the government, or through MDB loans with sovereign guarantees (Eberhard and Dyson, 2020). With both utilities and the sovereign facing massive debt problems, the model does not seem adequate to generate the required progress, making T&D a bottleneck for expanded access but also for deployment of clean energy.

Models for private sector participation in T&D frequently used in other parts of the world could be applicable to Africa (World Bank, 2017; RES4Africa, 2021; US Department of Commerce, 2021; Attia, 2022; Gridworks, 2023). The four main models are: whole of network concessions, independent transmission projects (ITP), privatization (selling shares in corporate entity that owns the assets), and merchant lines. Of the four models, the one that is believed to have the greatest chances of success in SSA is ITP. This model entails a contract (a transmission purchase agreement) between the public utility (or, preferably the unbundled transmission company) and a project company selected to build and operate a specific line or set of lines. The selection can be made through an auction ensuring competitive pricing. A relevant component of the contract is an availability payment that ensures that the project company can honour its liabilities irrespective of the quantity of energy that passes through its lines (Gridworks, 2023). The ITP model has been successful in Brazil, Peru, Chile and India and is believed to be flexible enough to fit the various conditions in SSA. Projects based on this model are already under development in Uganda and Mozambique.

Compared to generation, new T&D assets are difficult to carve out from existing networks, thus sharing responsibilities and allocating risks between a private entity and state-owned utility can be more difficult. Grids also tend to be seen as strategic by governments and are planned centrally, which makes third-party participation seen as a loss of control. The ITP model is able to overcome some of these issues in similar ways that the IPP model did, but will require trial and error to find the right risk allocation for each specific country. Donor resources could be dedicated to supporting this initial process of structuring, identifying and pursuing the enabling conditions, and consolidating the offtaker's capabilities of entering and executing such complex contracts.

4.1.2.2 Key takeaways

- T&D investments are even more challenging than generation, for many reasons, including political economy and the difficulty of carving out projects.
- T&D represents a significant bottleneck to further clean energy expansion, to overall viability (due to large losses) and to the economy (due to reliability issues).
- T&D projects including cross-country interconnectors have been found to increase availability of power and cross border trade, but they rarely lead to reliability or affordability improvements, due to structural problems of the utility.
- Conventional grants and loans can be complemented with private sector participation models, particularly ITPs.

4.1.3 Energy access interventions (on-grid)

4.1.3.1 Evidence

Energy access interventions on-grid include extensions of different magnitudes but also initiatives to support households to connect to an existing grid. For both, there are obstacles both on the supply and the demand side. With utilities and grid companies (where unbundled) struggling with cost recovery, high losses, outdated equipment and poor maintenance, adding new T&D lines, especially over long distances, is difficult both to finance and operate efficiently (Wörlen *et al.*, 2023).

On the demand side, households who are lacking access may have low consumption and may not afford connection (Golumbeanu and Barnes, 2013), appliances and bill payment. For example, a rural electrification study in Kenya found that the cost of supplying the selected households was much higher than the willingness to pay even with significant subsidies (Lee, Miguel and Wolfram, 2016b). The counterintuitive finding that energy access is not increasing welfare is explained by nuances both at the demand and the supply side. For households, bureaucracy, the low reliability of the service and the lack of access to credit is what constrains willingness to pay (a proxy for the value the households places on the electricity service). This determines low take-up and consumption which are confirmed by studies in Botswana, Ethiopia, Tanzania and others (Bos, Chaplin and Mamun, 2018; Sievert and Steinbuks, 2020).

On the supply side, it is found that costs are higher than optimal due to leakage, which is common in public works and may explain the high costs of rural electrification confirmed by the literature in Kenya, Tanzania, and Uganda (Bos, Chaplin and Mamun, 2018). Overall, electrification is likely to be beneficial over the longer run through social effects (access to information, education, social capital) but requires careful consideration of different variables for it to be enhancing economic welfare in the short run as well (Lee, Miguel and Wolfram, 2016b).

These overall findings are consistently reiterated in the literature. Eberhard and Dyson (2020) survey the existing literature and find that few new connections present enough power demand to the system, which means that adding connections may further decrease the financial viability of the utility. Donor evaluations also finds that the connection cost is larger than the willingness to pay (WTP) of potential customers, and that the cost is not expected to be recovered for many years, even if payments would occur regularly (Greencroft Economics, 2022; Wörlen *et al.*, 2023). As such, subsidies are required in the long term, to be able to maintain the services to newly connected households in a way that does not negatively affect the utility (ICF, 2023). Some studies found that connected

households that are relatively well-off are heavily subsidized as well (Auriol and Blanc, 2009) which makes the subsidies quite regressive (Bos, Chaplin and Mamun, 2018).

In a study conducted for Finnfund, the consultancy Steward Redqueen found that on-grid interventions are more impactful in countries with large manufacturing sectors, frequent power outages, and better rates of existing grid connection (Steward Redqueen, 2019). At the same time, the evaluation of the USAID Power Africa Southern Africa program finds that in many countries, the low hanging fruit of 'connecting densely populated areas where the potential income from new customers may cover the costs of grid extension, is largely complete' (Social Impact, 2022). Whether this finding can be generalized to all SSA is difficult to establish and data confirming or denying this finding is not available. If this finding holds, the implication would be that further on-grid access is becoming marginally more difficult and requires better interventions, both at the project level (subsidies either for the consumer or the service provider) or wider interventions to improve the reliability of the service. Indeed, the distribution of the population is key in establishing the strategy for on-grid expansion. For example, a study in Kenya found that a majority of households were located in relative proximity to the grid and could be connected at a reasonable cost (Lee, Miguel and Wolfram, 2016a). In this case, the effectiveness of the intervention is based on correctly estimating the WTP and the operational performance of the utility.

4.1.3.2 Key takeaways

- Energy access interventions through grid extensions or connection of new households to existing grids are challenging for both demand and supply side reasons.
- On the demand side, willingness to pay tends to be low due to low incomes, low perceived benefits, bureaucracy, unreliability of service, and lack of credit.
- On the supply side, the cost of service is too high to extend grids to households that are likely going to have very low consumption (or to not connect at all).

4.1.4 Energy access interventions (off-grid)

4.1.4.1 Evidence

The high cost of extending electricity grids into rural areas with low population density and low demand for electricity explains why off-grid systems (OGS) are pertinent for remote and impoverished populations that main utilities do not serve (Eberhard & Dyson, 2020). As the costs of solar photovoltaic (PV) systems and batteries decline, off-grid solutions are becoming increasingly attractive, particularly in regions where grid electricity is both expensive and unreliable (ESMAP, 2021).

In 2022, the World Bank estimated that approximately 48 million people were connected to 21,500 mini-grids, with approximately half of installed mini grids are solar or solar hybrid, followed by those powered only by hydro (35%), fossil fuels (10%), and other generation technologies such as wind or fuel cells (5%) (ESMAP, 2022). The most commonly used off-grid solution is a solar lantern (50 %), followed by solar home systems (17 percent), mini-grids (13%), generators (12%), and rechargeable batteries (10%) (ESMAP, 2022).

There is an ongoing debate about which type of off-grid renewable solution delivers the most impact. Different studies offer varying perspectives. Berthélemy and Millien (2018) conducted a meta-analysis that finds

larger mini-grids tend to have more positive impacts on sustainable development compared to solar home systems. This includes greater economic benefits and enhanced quality of life for connected communities. In line with this, Sida (2020) asserts that microgrids are the best energy supply solution. Conversely, the EIB concludes in a report that SHS are the most cost-effective solution to provide full Tier 1 electricity access for most unserved segments in SSA (2021). USAID (2022) posits that SHS are least-cost for settlements with low demand (<10 kW) or in sparsely populated areas, whereas mini-grids are optimal in settlements further from the grid with denser populations. Comparing the impact of off-grid solutions depends on the targeted population and outcomes. 60 Decibels (2020; 2024) has found repeatedly that solar lanterns are the most impactful off-grid solution. While not providing comprehensive energy access, they have the highest marginal effect because they tend to be the users' first step on the energy ladder, moving from having no access to electricity to the lanterns.

Since stand-alone renewables systems are variable, power generation is often suffering from instabilities (Rinaldi *et al.*, 2021; Zebra *et al.*, 2023). Therefore, the application of alternative energy configurations, in particular hybrid renewable energy systems (HRES) with a storage device and backup power supply of diesel generators, are sometimes seen as the most appropriate options to overcome the intermittency challenge and meet the energy demand in terms of affordability and reliability in developing countries (Zebra *et al.*, 2023).

While having successfully scaled up activities in certain market segments, thanks in part to business model innovation such as pay-as-you-go, energy-as-a-service or carbon credits, the sector is still struggling to provide services to the poorest populations, segments which are considered below the "commercial frontier" (Nyarko, Whale and Urmee, 2023). The lack of a business case for serving some customer segments is due to a number of structural challenges facing the off-grid sector. It is therefore crucial for donors to provide substantial and long-term subsidies to ensure affordability for the poorest segment of the population. While concrete drivers and obstacles to achieving impact through off-grid solutions need to be identified within their specific contexts, there are a number of over-arching key factors that ought to be addressed.

Underdeveloped enabling environment

Countries typically lack a combination of necessary incentives to encourage private sector investment, including foreign direct investment (e.g., restrictions on investors/capital controls, policy limitations). This can include macroeconomic factors such as political instability and corruption. Often, there is lack of coordination among government agencies, and complex licensing procedures are creating an unstable environment for off-grid electrification initiatives (Nyarko, Whale and Urmee, 2023). These key barriers can be due to an inadequate long-term electrification strategy, which is often not based on hard data. Countries often lack the necessary geospatial data and key potential consumer information to enable effective energy access planning (USAID, 2022). As a result, information for market participants regarding the market and the policy environment are lacking. Even in Kenya, a relatively mature off-grid sector in SSA, firms noted that the regulatory framework is only "somewhat clear" (Jeuland *et al.*, 2022). Consequently, the literature emphasizes the need for both light touch regulation on the one hand, and clear institutional and regulatory frameworks as well as incentives on the other, two aspects which can clearly conflict (Jeuland *et al.*, 2022).

Insufficient local knowledge base

New and less-knowledgeable energy access companies often face significant operational and capacity challenges in scaling their business and effectively building out their sales force networks. Governments also have limited capacity to effectively monitor, oversee, and enable private sector actors to increase energy access (60 decibels, 2024). Beyond the companies themselves, oftentimes there is insufficient knowledge about local conditions. Poor community involvement during the planning stages, insufficient human resources to operate and manage systems, and social acceptance issues can also impede off-grid project implementation (Nyarko, Whale and Urmee, 2023). Issues such as fluctuating resource

supply, incompatibility of components with local conditions, and operation and maintenance challenges limit the effectiveness of off-grid systems (Nyarko, Whale and Urmee, 2023).

The lack of implementing suitable solutions has led to low customer satisfaction for off-grid energy interventions. 60 Decibels (2024) reports that for mini-grids, 37% of customers are experiencing challenges with using mini-grid products or services. For solar home systems the rate is 33%, for appliances 30% and for solar lanterns 21%. Issues tend to centre on reliability, customer service, and the high cost of energy.

Commercial viability challenges

Companies in the off-grid sector often face low margins and return on investment, due to the low and volatile incomes of end customers, which impede reliable revenue streams due to the inability to make regular payments, (EIB, 2021). Additionally, the WTP of consumers may be significantly lower than what is commercially viable. Involvement of the financial sector therefore remains limited, such that off-grid development continues to depend heavily on development partners (Jeuland *et al.*, 2022). Increasing risk coverage and providing financial support for early-stage and growing businesses can attract further private-sector investment (EIB, 2021). Additionally, an underdeveloped payments landscape, and currency mismatch (i.e. revenues in local currency, balance sheet funding in hard currency) leads to high collateral requirements and high costs for financing (USAID, 2022).

Due to these inherent risks to their business models, many smaller energy access companies face significant barriers to obtaining financing. These can be exacerbated by a lack of credit records, weak balance sheets, and high local currency interest rates, impeding the ability of these firms to grow their businesses and reach economies of scale (Jeuland *et al.*, 2022). High upfront capital costs as well as insufficient long-term subsidies/funds are therefore significant obstacles for the sector (Nyarko, Whale and Urmee, 2023).

Thus, the literature suggests the need for a battery of interventions to grow the sector and achieve countries' energy access goals. However, differing needs are apparent in the fact that different policy solutions are preferable to different actors. Addressing these barriers requires collaboration among various stakeholders, including governments, donors, local financing institutions, civil society organizations, and private sector players (EIB, 2021). Policies must be tailored to the specific challenges and contexts of different countries, focusing on creating conducive environments for investment and innovation in off-grid technologies (ITPEnergised, 2019).

4.1.4.2 Key Takeaways

Different off-grid solutions can be suitable in different contexts and a detailed suitability analysis is paramount before implementation. There are a number of over-arching factors determining successful implementation of off-grid solutions:

- Access to information and data for planning
- Local environment
- Local and managerial knowledge
- Commercial viability and resultant challenges in accessing financing

4.1.5 Clean Cooking

4.1.5.1 Evidence

Clean cooking can be defined as various technological options such as improved solid biomass stoves, biogas systems, liquefied petroleum gas (LPG) stoves, electric cookers, ethanol stoves, and solar stoves, all of which either do not use solid biomass or use it more efficiently compared to traditional stoves (Karanja and Gasparatos, 2019).

The lack of access to modern fuels is recognized in the 2015 SDGs. Indicator 7.1.2 refers to the "proportion of population with primary reliance on clean fuels and technology" (UN, no date). The world is not on track to achieve universal access to clean cooking by 2030. In 2021, only 71 percent of the global population had access to clean cooking fuels and technologies. While progress has been made, across LLMICs, some 2.3 billion people use polluting fuels and technologies for most of their cooking. In Sub-Saharan Africa, the clean cooking trend has been negative, as access to clean cooking has failed to keep pace with growing populations (WHO, 2023). Globally, cooking with open fires or simple stoves fuelled by kerosene, coal, biomass such as wood, dung and agricultural residues leads to an estimated 3.2 million deaths per year in 2020, including over 237 000 deaths of children under the age of 5 (UNESCAP, 2021; WHO, 2023). Women and children are disproportionately affected by biomass combustion because of their prolonged exposure at the hearth. Additionally, the procurement of firewood can impose significant economic and opportunity costs, where again women and children bear the brunt of the burden by being limited in their economic mobility or pursuit of education (Lindgren, 2020). Lastly, the combustion of residential solid fuels is responsible for a significant proportion of greenhouse gas emissions (Mazorra *et al.*, 2020) and environmental degradation (Rosenthal *et al.*, 2018). Due to the multi-faceted benefits of clean cooking, the challenge has for decades been a priority for development actors (UN, 2023).

The literature points to a set of factors that collectively effect stove adoption and use.

Affordability and financing

On the **demand side**, costs substantially influence the adoption and sustained use of clean cooking fuels and stoves (Karnja and Gasparatos, 2019). Both the upfront cost of the stoves and the continued cost of the fuel need to be considered. Within the contexts of low, irregular and unpredictable income for many potential beneficiaries, liquidity constraints are often the major challenge for households to afford the stoves (Shankar *et al.*, 2020; Gill-Wiehl, Ray and Kammen, 2021).

Lowering operational costs is especially important for households that depend on buying fuel from markets (Karanja and Gasparatos, 2019; Pye *et al.*, 2020). On the other hand, fuel/cost savings are of less importance for households that procure their fuel for free or at low costs, due to their proximity to forests (Dohoo *et al.*, 2013), as households may not count the labour associated with collection as a cost (Gill-Wiehl, Ray and Kammen, 2021). The stability of prices for clean fuels are similarly crucial, with fuel stacking often used as a hedge against fluctuations (Pye *et al.*, 2020).

Thus, high capital and maintenance costs of stoves can become a barrier to clean cooking adoption by poor households. Access to credit or subsidies by government or international actors can lead to increased affordability (IOB Evaluation, 2013). Many studies point to the correlation between subsidy levels and the percentage of households that made a purchase, suggesting that users were interested in purchasing the new technologies once the economic barrier was removed (UNESCAP, 2021).

Additionally, the **supply side** of clean cooking markets has adopted new approaches leading to improved affordability, for instance by providing frugal "no frills" solutions. As the lack of liquidity for the consumers is another crucial issue, businesses increasingly employ daily rather than monthly payments or pay-as-you-go solutions, making cooking solutions increasingly available for households (Clean Cooking Alliance, 2023). This allows users to enrol without a large upfront deposit.

Such business model innovations have helped the sector becoming more profitable and scaling up activities (Stritzke *et al.*, 2023). Furthermore, traditionally, in the context of clean cooking, grants have played an outsized role in enterprise financing, posing the risk that companies cater to the donor preferences, rather than to those of users. This suboptimal incentive structure may be partially to blame for the development of products and services that are too costly relative to their value proposition. This dynamic has shifted, and enterprises now increasingly recognize that business models are sustainable only when products are adopted and used regularly. Hence, the clean cooking industry is maturing and moving away from donor-based models to more fully-fledged profit-driven business models. Reflecting this, clean cooking industry revenue grew to US$ 104 million in 2022 – more than double pre-pandemic highs (Clean Cooking Alliance, 2023). The increased attractiveness of clean cooking business models is evidenced by a rapid increase in investment in clean cooking enterprises, which grew to an all-time high of US$ 215 million in 2022. Return-seeking capital (debt and equity) dominated the picture, accounting for 97% of the investments recorded in 2022.

Carbon finance is a key driver behind this trend, with clean cooking enterprises issuing carbon credits in addition to their core business activities of selling cookstoves and fuel. Carbon finance generated by clean cooking enterprises is stimulating latent demand for clean cooking solutions. Enterprises with access to carbon finance are using carbon revenue to reduce local prices for improved and clean cooking solutions to levels at which consumers are willing to buy these products or services, helping to drive sales. Hence, leveraging carbon finance can play a key role in making clean cooking investments financially viable if the downside risks are carefully managed (Clean Cooking Alliance, 2023).

However, due to volatility in the carbon markets, this business model is no failsafe. The average carbon credit spot price for household devices (which includes cookstoves) in 2023 fell to US$ 5.90 per tCO2e, which is 38% below the average price for 2022 (Clean Cooking Alliance, 2023). The drop in demand has been partly caused by extra buyer scrutiny on carbon credits to avoid accusations of "greenwashing" and supply-side problems with over-crediting from some projects. This is a big concern, with one study indicating that clean cookstove projects overestimate their carbon removal benefits by nearly 1,000%, leading to excessive issuance of carbon credits compared to actual performance (Gill-Wiehl, Kammen and Haya, 2024).

To mitigate the risks posed by market volatility as well as to close the still remaining funding gap, action is necessary. An increase in public investment in clean cooking to leverage private investment, including via climate finance, is needed to complement the funding efforts by traditional multilateral development banks (UN, 2023). Blended finance approaches, mixing private and concessional public finance, as well as results-based financing can reduce financing costs for companies supplying clean cooking solutions, leading to more affordable products for end-users (IRENA, 2024).

Cookstove design and fuel characteristics

Stove characteristics significantly affect both the adoption and sustained use of clean cookstoves. For instance, stoves that allow for high time savings through improved heat transfer, energy efficiency, and the ability to simultaneously cook different dishes are more likely to be adopted (Karanja and Gasparatos, 2019). Additionally, stove designs that cater to user needs and enable the preparation of local dishes with traditional cooking utensils are more likely to be used. Conversely, stove designs that fail to accommodate specific cooking styles, fuels, and available resources for maintenance and renovation might not be adopted in certain local contexts (Gill-Wiehl, Ray and Kammen, 2021). Furthermore, traditional cooking can provide co-benefits beyond food preparation, such as heating and pest control (Karanja and Gasparatos, 2019). Thus, it is crucial to develop a deep understanding of local conditions and needs and for clean cooking solutions to be adaptable and attuned to the local context in order to truly provide added value compared with traditional cooking modes (Shankar *et al.*, 2020).

Socioeconomic and demographic household characteristics such as size, income, education, and gender dynamics can influence decisions over the adoption of clean bioenergy stoves. In relation to the above-mentioned importance of costs, household income is a particularly important determinant of initial stove uptake (Ang'u *et al.*, 2023). Intra-household gender dynamics are also crucial for stove adoption, as households where women cannot make independent or consensual decisions over household budget allocation, stove purchase may not be prioritised (Pye *et al.*, 2020).

Cultural practices, traditions, and beliefs can similarly hinder stove adoption. Concerns such as fear of fire or explosion, and a lack of awareness about safety and long-term health benefits, are prevalent (Pye *et al.*, 2020). Thus, enhancing awareness about the health, safety, hygiene, and environmental benefits of clean cooking is important for promoting the widespread adoption of clean cookstoves.

Therefore, the design of cooking stoves and fuels should be approached from a bottom-up perspective, explicitly considering the needs and wants of the local population. Several studies suggest that inclusive planning is crucial to ensuring that clean cooking solutions meet the cooking needs of users at all levels – individual, household, and communal – through proactive consultation with end-users at all stages, including programme design, planning, and implementation. Comprehensive educational initiatives, as opposed to mere training or simple information provision, are essential components of a behaviour change strategy that can promote the sustained use of clean cooking technologies (Lindgren, 2020). Such initiatives should aim to provide in-depth understanding and practical knowledge to ensure long-term engagement and adoption of these technologies. They can be facilitated through promotional campaigns including community meetings, cooking demonstrations and household visits, as integrating techniques that foster social relations and facilitate behavioural change can significantly influence the adoption and diffusion of clean cookstoves by creating social multiplier effects among peers (Jeuland *et al.*, 2020).

Market development

Barriers to accessing fuel, such as the distance to the distributor, significantly limit the adoption and continued use of clean cooking technologies. Establishing robust supply chains and ensuring the reliable availability of fuels are crucial to overcoming these barriers (Shankar *et al.*, 2020).

Stable markets, well-developed consumer strategies, and reliable supply chain infrastructure can positively impact the adoption of clean stoves. Market development enhances marketing efficiency, distribution, and sustained adoption of clean cookstoves. Infrastructure must be improved, as poor rural infrastructure can adversely affect the distribution, accessibility, availability, and pricing of stoves.

4.1.5.2 Key takeaways

- Clean cooking technology is inconsistently adopted and used
- High costs of stoves, fuel and maintenance hinder adoption
- The stoves often do not offer a relative perceived advantage to the users, as they do not match existing usage patterns and preferences
- There is a shift in clean cooking supply from donation-based to profit-driven businesses

4.1.6 Knowledge sharing and capacity-building

Innovations aimed at knowledge sharing and (institutional) capacity aim to remove barriers and create enabling environments for renewable energy development. This includes on the one hand knowledge sharing and technical assistance to facilitate access to research, technology, and 'know-how' for clean energy and energy efficiency. On the other, it involves capacity-building to enable scaling up, coordination and management of renewable energy and energy access, as well as increased local ownership of these processes. Taken together, these are expected to enable increased investment in and successful implementation of projects related to energy access, renewable energy, and energy efficiency (Rahman *et al.*, 2016; Stritzke, Trotter and Twesigye, 2021). Further, knowledge-sharing and capacity-building interventions aim to create enabling conditions for the effective and efficient management of and planning for the energy sector, including environmental and social concerns (this is closely linked to policy reform efforts and further explored in section 4.1.7). These kinds of interventions are cross-cutting and often form a component of other interventions that target a specific energy sub-sector (G-20 Development Working Group, 2015; Downing *et al.*, 2021).

For the purposes of this evidence assessment, interventions related to knowledge sharing and capacity development have been separated from those targeting energy sector reform. This is done to account for the somewhat different logics and desired outputs of these two kinds of interventions. However, there remain substantial overlaps between them, and policy sector reform interventions often include knowledge-sharing and capacity building activities.

Lack of institutional capacity, lack of knowledge and data, and a lack of coordination and clear guidance within the sector are frequently identified as barriers to the upscaling of renewable energy in Sub-Saharan Africa (OECD, 2015; Aly *et al.*, 2019; Independent Development Evaluation, 2019, 2020). Crucially, the presence of institutional capacity to maintain an efficient sector and skilled staff who can maintain and develop infrastructures and business models has been identified as a key enabler for the longer-term sustainability of intervention outputs after projects have come to an end (Independent Development Evaluation, 2020; Wörlen *et al.*, 2023; Greencroft Economics, 2024). In light of this, SDG 7.4 specifically calls for efforts to promote access to research, technology and investments in clean energy. Beyond this, efforts to develop capacity and share knowledge have been positively linked to SDG4 on education, specifically 4.3 developing relevant skills for financial success (Colenbrander *et al.*, 2015; Eberhard and Dyson, 2020), and SDG5 through enabling training programmes and capacity building especially for women (Hattori, Nam and Chapman, 2022; Greencroft Economics, 2024). Further, knowledge-exchange and capacity-building efforts that are bilateral and aim to strengthen national institutions and authorities, such as Norad's 'Energy for Development' program, are linked to SDG 16.6, to 'develop effective, accountable and transparent institutions'.

4.1.6.1 Evidence

Knowledge and capacity activities as part of larger interventions

When knowledge-sharing and capacity-building activities are part of larger interventions, the impacts of providing advisory services and capacity building efforts (through international events, mentoring and training) are best documented, though evidence is still limited. In these cases, there is some evidence of the effectiveness of interventions for policy adoption, improved access to finance, and increased capacity (Independent Development Evaluation, 2019, 2020; Stritzke, Trotter and Twesigye, 2021; Larkin, Gardiner and Gulati, 2023; Greencroft Economics, 2024).

An evaluation of the technical support for early-stage projects provided as part of the Climate Investor One finance facility found that it was effective in building capacity of project developers to produce good quality projects and increased the speed of project development for renewable energy infrastructure projects (Larkin, Gardiner and Gulati, 2023). Additional

positive impacts recorded include reduced cost of development, additional funding attracted and overall, more favourable financing arrangements for projects (Larkin, Gardiner and Gulati, 2023).

On the other hand, the evaluation of the 'Beyond the Grid Fund' for Zambia indicates that while advisory support contributed to identifying risks and organisational capacity weaknesses and supported business strategy development, it did not lead to any changes in operations of the energy service providers and challenges persisted (Greencroft Economics, 2024). Similarly, the stakeholder platform established through the fund was found to be useful for cross-stakeholder engagement and coordination but it was not a main driver of government reforms and failed to engage substantially with the private sector (Greencroft Economics, 2024).

For more general capacity-building and technical assistance activities, two evaluations of the African Development Banks' work in the energy sector found that capacity building and technical assistance were somewhat effective when employed, though activities were partial and inconsistent (Independent Development Evaluation, 2019, 2020). The evidence indicates a limited effect on outcomes in the sector and that issues such as weak regulatory frameworks and a lack of institutional coordination have persisted despite programme efforts.

When knowledge sharing and capacity building activities are part of larger interventions, focusing these activities in the development phase of projects as means to 'set the stage' for subsequent interventions through trainings, pre-feasibility studies or sector planning seem promising to maximise their impact (Independent Development Evaluation, 2019; Larkin, Gardiner and Gulati, 2023).

Standalone knowledge and capacity efforts

Dedicated standalone capacity-building and knowledge sharing activities make up only a small portion of 'Technical Assistance' interventions (Cox and Norrington-Davies, 2019). There is stronger evidence that standalone capacity building and knowledge sharing activities contribute to improved decision-making, policy and technology deployment, increased access to financing and local capacity building compared to combined interventions. However, this is likely affected by a bias in the literature as outcomes of standalone programmes for knowledge-sharing and capacity-building are usually better documented and evaluated.

Most prominently, the ESMAP programme of the World Bank has been largely successful in their mission to "assist low- and middle-income countries in growing their know-how and institutional capacity to formulate environmentally sustainable energy solutions for poverty reduction and economic growth" (ICF, 2020, p. vii). Through their own knowledge products, like reports, workshops, datasets and analytics, and their support for the development of strategies and implementation plans, such as conducting pre-feasibility studies and technical reports, they have informed USD26.6 billion in funding between 2017-2019 "which is expected to provide more than 76 million people with access to electricity" (ICF, 2020, p. 66).

Similarly, the Power Africa 'Southern Africa Program', which works to "incentivize, facilitate, and enable investments through technical assistance, policy reform, capacity development, and transaction facilitation" has been evaluated to be highly impactful (Social Impact, 2022, p. 69). Between 2013 and 2021, the programme's activities have produced 33 new policies for the energy sector and completed training for over 2,000 people in five different intervention countries, which in turn have informed the installation of 5,771MWs of renewable energy capacity (Social Impact, 2022).

For academic knowledge building activities in the energy sector, the evidence has been more mixed. Colenbrander *et al.* (2015) assess renewable energy doctoral programmes in Sub-Saharan Africa that aim to build in-country capacity for the renewable energy sector, including technical, business and regulatory skills. They highlight that while PhD students develop these skills and frequently find employment in the renewable energy sector after completing their studies, there is a strong bias in investment and

research towards large energy infrastructure which align with donor interests but fail to address pressing local needs in rural electrification (Colenbrander *et al.*, 2015). Instead, these local needs would benefit from community and local scale and often off-grid energy projects, which are not a major focus of these educational capacity building programmes. At the same time, Haselip *et al.* (2017), reflecting on the outcomes of the Global Network on Energy for Sustainable Development (GNESD), highlight that academic cooperations contributed to multiple regional plans and national policies related to energy and energy access, including energy access targets for the Rural Electrification Agency in Kenya and the National 'Luz Para Todos' (Light for All) Plan in Brazil.

More generally, technical collaboration frameworks (TCPs) aimed at knowledge sharing and capacity building in the energy sector, often beyond a bilateral focus, have seen substantial increase in activities and have been able to demonstrate some impact (International Energy Agency, 2019, 2021). Knowledge-sharing and peer-learning interventions between state agencies in donor and recipient countries have seen some success in developing policy and regulatory products through peer-to-peer assessments and site visits and through training, though the evidence base is limited (Norad Evaluation Unit, 2012; Effective Institutions Platform and National School of Government International, 2018; GDSI limited, 2019; Ryan and Mazzilli, 2023; Norad, 2024) (Effective Institutions Platform and National School of Government International, 2018; GDSI limited, 2019; Ryan and Mazzilli, 2023). Results from evaluations of Norad's bilateral institutional capacity-building and technical assistance interventions within the 'Oil for Development' and 'Energy for Sustainable Development Programme' highlight positive impacts on the development of economic models, revenue management, and regulatory frameworks (Norad Evaluation Unit, 2012; Norad, 2021, 2024). At the same time, a critical review of capacity development for the power industry indicates that donors are often reluctant to fund stand-alone capacity building programs, citing the difficulty of measuring their impact relative to their cost as a key reason for this reluctancy (Independent Development Evaluation, 2020).

Intervention activities

There is evidence that some activities for knowledge sharing and capacity development are more successful than others. Hattori *et al.* (2022) analyse the International Energy Agency Technology Collaboration Programmes and find that international events and training programmes are significantly associated with policy adoption and technology deployment. Overall, however, combining different output channels rather than conducting them in isolation (such as stakeholder dialogue, design of roadmaps and sector plans, and technology policy analysis) was significantly associated with achieving technology deployment, economic benefits and social acceptance.

There is further evidence that cross-stakeholder knowledge exchange and dialogue has had some positive impact on the development of policy reforms in the energy sector in Uganda and Zimbabwe (Stritzke, Trotter and Twesigye, 2021) and across AfDBs interventions in the energy sector (Independent Development Evaluation, 2019). Additionally, Thillairajan *et al.* (2012) find that interventions related to increasing transparency in the energy sector had a positive (yet limited) effect on the outcomes of energy infrastructure projects. Similarly, cross-stakeholder knowledge exchange and network building have been identified as success factors for the Americas Competitiveness Exchange on Innovation and Entrepreneurship (ACE) program, to build capacities amongst decision-makers in the energy sector (Global Partnership Initiative (GPI) on Effective Triangular Co-operation, 2019).

Some of the literature highlights the need for a minimum level of flexibility and responsiveness in intervention activities to ensure the continued relevance (Cox and Norrington-Davies, 2019; Hagelsteen and Becker, 2019; Hagelsteen, Becker and Abrahamsson, 2021). Social Impact (2022) note that participants in the Power Africa program identify the responsiveness of technical assistance and advisory services as a success factor for accessing financing. Larkin *et al.* (2023) highlight that rigid expectations

of non-financial support activities have limited the potential for local capacity development. Similarly, the evaluation of ESMAP suggests that the lack of flexibility and room for local input in programming for these activities could be a barrier to the sustainability of project outcomes (ICF, 2020).

At a more general level, scholars caution that capacity development programmes tend to overfocus on the 'visible' aspects of capacity, like formal processes and structures, at the expense of 'less visible' factors like networks and legitimacy, which can limit the impact and sustainability of interventions (Keijzer, 2020).

Coordinating intervention activities

Across the literature, the need for strong coordinating capacity for activities relating to knowledge sharing and capacity building is emphasised as it positively affects intervention outcomes (Colenbrander *et al.*, 2015; Independent Development Evaluation, 2019; Lundsgaarde and Keijzer, 2019; Hattori, Nam and Chapman, 2022).

Greencroft Economics (2024) outline the coordinating role of the platform for market change (developed as part of the Beyond the Grid Fund for Zambia) as key to securing policy and regulatory reforms. These reforms relate to tax exemptions for lithium-ion batteries, development of minigrid regulations, and a new national energy policy, though the evaluation questions how much of this can be directly attributed to the coordinating efforts. Similarly, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) led the coordinated approach towards the regional implementation of the SE4ALL initiative (Quitzow *et al.*, 2016). This process resulted in each country in the region preparing a set of interconnected reports and policy documents, including a National Renewable Energy Action Plan (Quitzow *et al.*, 2016).

In the same vein, the lack of capacity for coordination activities, including communication and other miscellaneous activities, was identified as a barrier to impact in Haselip et al's (2015) analysis of the African Rural Energy Enterprise Development Programme and the evaluation of the Power Africa Off-grid project, limiting the uptake and deployment of knowledge shared and capacities developed (Wörlen *et al.*, 2023).

Beyond coordinating activities within individual programs, some literature also highlights that the lack of coordination of different donor activities related to knowledge-sharing and capacity-building limits the impact of activities, particularly when activities overlap or contradict each other across different energy sub-sectors (Gualberti, Singer and Bazilian, 2013; Cox and Norrington-Davies, 2019; Lundsgaarde and Keijzer, 2019; Kablan and Chouard, 2022; Jain and Bardhan, 2023) This situation is further complicated by the changing landscape of development actors with the growing role of the private sector and philanthropies increasing the heterogeneity of actors in the sector (Lundsgaarde and Keijzer, 2019).

In light of this, Lundsgaarde and Keijzer (2019) highlight the promising role of the Sustainable Energy for All initiative (SE4ALL) as a coordination and convening platform for capacity development activities in the energy sector. SE4ALL aims to mobilise both public and private stakeholders and provides evidence on gaps and opportunities for capacity development interventions, including cross-cutting issues around climate change, economic development and poverty reduction in the energy sector (Lundsgaarde and Keijzer, 2019).

Further, lack of coordination related to differences in processes and donors' institutional and legal frameworks for interventions taking place at the same time can limit their impact. To ensure coordination of activities, co-financed activities as well as regional initiatives, such as the 'Team Europe' or 'Working Better Together' approaches or coordination at the Nordic level, can be useful starting points (Lundsgaarde and Keijzer, 2019; San and Karim, 2022).

Intervention modality

The structure and timeline of interventions is a key variable for the success of knowledge sharing and capacity building interventions, acting either as a barrier or an enabler. Generally, more long-term (at least 3 years) financing that is programmatic, i.e. where interventions are coherent, phased across time, and

strategically linked, are identified as enabling impact for capacity and knowledge interventions. This is highlighted across recommendations for improvements for different programmes, including Power Africa and African Development Bank activities (Independent Development Evaluation, 2020; Social Impact, 2022).

Given that capacity-building and knowledge activities are often a component of larger interventions, these components often have more limited resources allocated to them which has been highlighted as a barrier to their effectiveness. While Hattori *et al.* (2022) identify more resource-intensive knowledge sharing activities like international events and formal workshops are most influential for policy adoption and the deployment of new low-carbon technologies, these activities were constrained by limited funding. Colenbrander *et al.* (2015) identify overworked staff and outdated facilities in doctoral training programmes as barriers to local capacity development in the renewable energy sector.

Further, some literature indicates that limited financial resources have negatively affected the technical assistance and advisory services offered through the interventions (Independent Development Evaluation, 2020; Social Impact, 2022; ICF, 2023; Wörlen *et al.*, 2023). In AfDB activities in the energy sector, some participants identified a lack of relevant expertise and capacity to address more niche challenges as limiting the usefulness and impact of the programme (Independent Development Evaluation, 2019, 2020). In a similar vein, the evaluations of the Power Africa Southern Africa Energy Programme, ESMAP and the Southern African Energy Program highlight the programmes' ability to meet partners' specific needs, even for niche technical expertise, and a hands-on relationship with participants as key factors for quicker project development and increased commercial viability (Kim, 2018; Social Impact, 2022; ICF, 2023; Wörlen *et al.*, 2023). Thus, the capacity of those implementing programme activities is itself a requirement for successful knowledge sharing and capacity building activities directed at others. Further, an evaluation of Norad's 'Oil for Development' programme which focuses on institutional cooperation, demonstrates largely positive impacts, but highlights the appropriate matching between the skills and capacity of institutions in Norway and the needs in intervention countries as a limitation (Norad Evaluation Unit, 2012).

Finally, capacity development activities at large are often focussed on a simple 'one-way' transfer of knowledge and 'filling assumed gaps' rather than engaging in more communicative learning and a sharing of knowledge that accounts for the need to transpose and adapt knowledge to the local context (Keijzer, 2020; Ørnemark, 2020). A case study of an intervention to implement off-grid renewable energy technologies in El Salvador, Honduras and Nicaragua highlights that a mechanistic division of labour between partners and a simplistic North-to-South knowledge transfer approach has limited intervention outcomes (Kruckenberg, 2015). Instead, open engagement and negotiation of knowledge beyond 'teachers' and 'learners' can enable impact (Kruckenberg, 2015).

In light of this, some scholars suggests a need for donors to adopt a 'brokering' role to enable genuine peer-learning, facilitate dialogue among local stakeholders and draw out synergies and opportunities aligned with local priorities (Effective Institutions Platform and National School of Government International, 2018). A promising modality for this role is the use of Technical Assistance Facilities, such as in the case of the Climate Investor One financing facility, which can provide more flexible resources guided by local needs (Cox and Norrington-Davies, 2019; Larkin, Gardiner and Gulati, 2023).

The role of donors

A lack of alignment between programme activities and local priorities and needs in the energy sector has been identified as a key barrier to successful knowledge and capacity related interventions, both due to their lack of relevance and potential targeting of areas that governments are unwilling to change (NSGI 2018, Cox and Norrington-Davies, Keijzer and de Lange). Summarising lessons learnt from institutional capacity building interventions in energy governance in Uganda and Zambia (Stritzke, Trotter and Twesigye,

2021) and from technical collaboration programmes through the International Energy Agency (Hattori, Nam and Chapman, 2022), activities not aligned with local priorities had a negligible impact on capacity development and policy adoption. Similar barriers were identified in the Power Africa Southern Africa Energy Programme evaluation report, highlighting that a misalignment between programme priorities and those of partners had led to limited outcomes (Social Impact, 2022).

This issue of aligning priorities is sometimes linked to larger concerns about the relationship between donor organisations and participants, particularly for unilateral North to South knowledge exchanges or technical assistance (OECD, 2015; Hagelsteen, Becker and Abrahamsson, 2021). Stritzke et al (2021) highlight that a feeling of disempowerment among national stakeholders contributed to the limited impact of the regulatory frameworks developed with donor input. Similarly, Colenbrander et al (2015) highlight that the bias in research and investment towards large-scale renewable projects in doctoral programmes is linked to strong donor interests and is fundamentally misaligned with local needs for rural electrification on a small and community-based scale. Further, scholars highlight that capacity development interventions have been largely supply-driven rather than based on local demand, which bears the risk of displacing domestic initiatives, often taking their point of departure from where donors would like partners to be rather than where they are (Effective Institutions Platform and National School of Government International, 2018; Keijzer, 2020). Allocating sufficient time and resources to assess local capacity needs has been suggested as one way to mitigate this (Zapf, Refaeil and de Leon, 2019).

External factors

The role of external factors on the effectiveness of knowledge and capacity building interventions is a red thread throughout the literature, in particular the presence of strong political will and motivation among local stakeholders and the government as enablers for impact. For example, Kennedy and Basu (2013) highlight the importance of strong political will and stakeholder buy-in in an intervention aiming to 'bridge the gap' between low carbon project developers and investors in Mozambique and Uganda. The intervention provided advisory services and guidance in project development which resulted in a significant reduction of the perceived obstacles to the mainstreaming of financing for clean energy projects and implemented projects that installed over 240 MW of clean capacity (Kennedy and Basu, 2013).

On the flipside, a lack of political will and weak government ownership of capacity building initiatives has been identified as a barrier, for example for knowledge sharing and capacity building interventions aimed at increased off-grid connectivity (Wörlen *et al.*, 2023). Further, difficult relations between energy-related agencies, such as Ministries of Energy, utilities, and regulators (ICF, 2020) and with non-government stakeholders like trade unions (Haselip, Desgain and Mackenzie, 2015) have been identified as barriers. These barriers are compounded by frequent high staff turnover in local governments, limiting the ability to generate institutional knowledge (Wörlen *et al.*, 2023) and the general political economy situation in-country.

More generally, Kim (2018) suggests that funding for technical assistance activities in the energy sector contribute more strongly to local capacity in least developed-countries compared to lower-middle-income recipients, based on analysis of technical assistance aid in the energy sector between 2002 and 2015.

Finally, while capacity has been identified as a bottleneck in the energy sector, Cox and Norrington-Davies (2019) caution that this is not always the primary constraint on organisational performance. It is therefore important to assess why an institution is not performing well before designing a capacity-building intervention.

4.1.6.2 Key takeaways:

- The evidence base for the impact of knowledge-sharing and capacity building interventions is limited but available evidence indicates that those interventions have had a positive effect.
- Impacts of knowledge sharing and capacity building

interventions are both hard to capture in indicators and difficult to isolate from the impact of other activities they are usually combined with

- Knowledge sharing and capacity building interventions are unlikely to present impacts in the short term, so a long-term and holistic approach is necessary
- Knowledge-sharing and capacity-building interventions need to be demand-led and aligned with local needs and priorities

4.1.7 Policy reform

Similarly to knowledge-sharing and capacity-building interventions, the need for reform to enable effective and efficient governance of the energy sector that allows for scaling up and coordination of renewable energy and energy access has been highlighted in the literature (OECD, 2015; Independent Development Evaluation, 2020; World Bank, 2020; Greencroft Economics, 2024). As Toman et al. summarise: "Changing longstanding institutional forms, regulatory norms, and management practices is always fraught with political economy issues. However, efforts to increase power sector investment and make use of innovative technology will in themselves accomplish little without progress also in sector governance. Such efforts also can take advantage of innovation in designing regulatory systems, and in understanding of organizational behaviour" (Toman *et al.*, 2018, p. 2).

At a high-level, energy sector reforms often aim to provide guidance and support for policy development and sector planning, as well as for improving the structure, management and efficiency of relevant agencies in the sector (Independent Development Evaluation, 2020; World Bank, 2020). These efforts are expected to allow for a more effective and efficient energy sector, improved markets and regulatory mechanisms, and improved access to financing. Reform interventions are often a component of larger efforts in the energy sector (World Bank, 2020).

4.1.7.1 Evidence

While the literature highlights the importance of policy reform in the energy sector, the evidence for their impact is limited (Imam, Jamasb and Llorca, 2019). A number of evaluations of development agency energy portfolios find that policy reform efforts have been ineffective, and the literature acknowledges the difficulty in achieving significant policy objectives in a sustainable way. Further, the literature highlights the challenges of attributing results to policy reform interventions (Social Impact, 2022). Nonetheless, some scholars highlight that interventions can generate 'pockets' or 'islands' of capacity when tasks are limited and well-defined and in settings that are relatively independent from political pressures, for example in central banks, national audit organisations, or regulators (Department of International Development *et al.*, 2018; Cox and Norrington-Davies, 2019).

A key focus of efforts has been systematic sector reform with a market mindset, corporatization, unbundling, reducing state interference, establishing independent regulators, tariff design, and utility reform. According to the literature, results have been modest and even attributing them to interventions is challenging. Indeed, a systematic review of market-based reforms on access to electricity in developing countries (Bensch *et al.*, 2016) concluded that interventions (including regulation, liberalization and private sector involvement reforms) did not have an impact on intervention outcomes and highlight their complex nature "at the intersection of the technological, economic and political sphere" (Bensch *et al.*, 2016, p. 84).

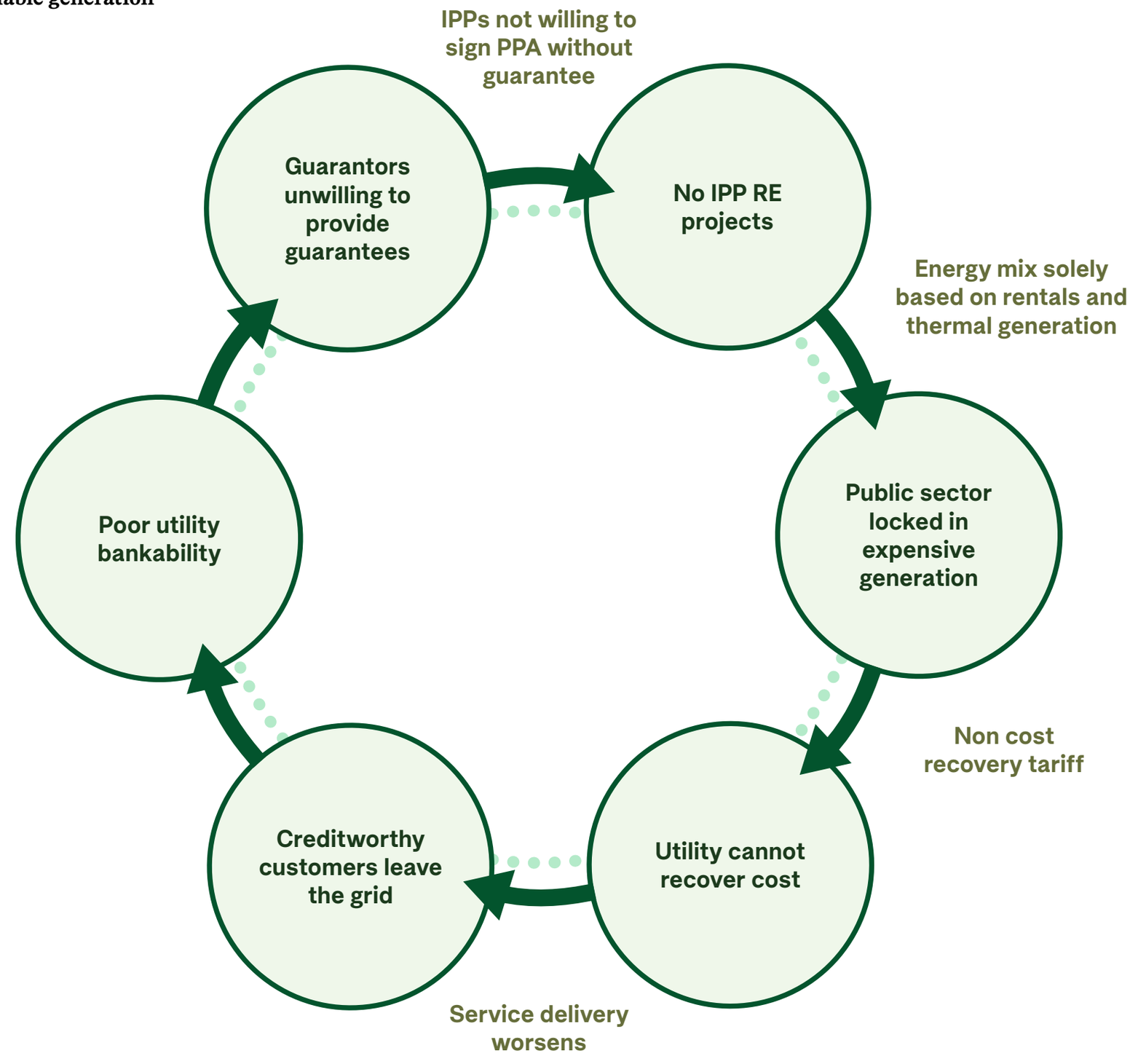
Concretely, despite more than a decade of work on this front, the AfDB finds that power, where available, is often billed to end consumers at well below cost. High commercial and technical losses and poor collection rates (some public entities rarely pay their electricity bills), difficulty in ensuring costs are prudent, all result in utilities that are not financially viable and are unable to invest in network infrastructure. Cross subsidies are thus needed to keep them working, which affects the whole sector. A World Bank study form 2016 concludes that only Uganda and the Seychelles had viable electricity sectors and described the challenges of improving utility performance and removing

subsidies (Trimble *et al.*, 2016). The UPBEAT platform collects a dashboard of data on utility performance and presented its first findings up to 2018. A follow up with data up to 2020 shows that the overall trends in electric utility performance are improving, albeit not materially. UMEME, the Ugandan utility continued to be the only one that meets all the operational performance criteria. The explanation is believed to be in the incentives set by the regulatory agency, ranked first in the regulatory agency index of Africa and by the concession agreement with private investors and the financial discipline implied by stock exchange listing (Twesigye, 2023). In this context it is worth mentioning that UMEME's concession is set to expire in 2025 and the government decided not to renew it.

Cornieti and Nicholas (2023) discuss the importance of a thorough system 'diagnosis' before any energy intervention, including policy reform. They describe a vicious cycle that tends to be at play in many countries in SSA (Fig. 1). The reliance on expensive and inefficient fossil-based capacity (or unreliable hydro in draught-prone environments that requires emergency diesel back-up) leads to high generation costs that are rarely recovered from customer tariffs. This leads to poor maintenance and unreliable services which prompt anchor consumers to build their own generation capacity and further reduce the revenue base of utilities. This puts them in a weak financial position, unable to operate efficiently, invest in cheaper generation, maintain grids to reduce losses and improve reliability. Finding the right point to intervene and break this vicious cycle is not trivial. For example, adding lower-cost renewable based generation (assuming that the creditworthiness problems is overcome with guarantees) translates into PPA payments that may add to the utility's short term liquidity problems and make things worse, without other, complementary interventions. The authors argue that breaking the cycle should start from greater use of grant and highly concessional loans to make additional capacity as affordable as possible, to cover costs of reducing losses and interruptions in grids, and to improve management and operational efficiency of utilities. They recommend Viability Gap Funding, through CAPEX or tariff buy-downs for the generation side, and grants and low cost debt for the other segments.

FIGURE 1

Many countries face a vicious cycle of dependence on expensive and unsustainable generation



Source: *Cornieti and Nicholas, 2023*

Nonetheless, Stritzke *et al.*'s (2021) analysis of energy governance in Uganda and Zambia indicates that donor-backed interventions led to successful implementation of new regulatory frameworks for electrification and rural development as well as increasing cross-stakeholder engagement in the sector through engagement platforms. However, relatively weak horizontal governance links have persisted and resulted in a continued lack of clarity regarding roles and responsibilities, which has limited effectiveness. Further, the policy reform activities of the GET.Transform project have had some success, for example through their Peer Review and Learning Network (PRLN). PRLN facilitates the exchange of best practices between different electricity regulators, and has contributed to greater regional harmonization as well as accelerated the pace of electricity regulation (GET.Transform, 2024). Finally, an evaluation of EU twinning projects in the energy sector in Ukraine and Jordan aimed at electricity market reform suggests that these programmes have been largely successful in supporting reform activities and capacity development in national electricity utilities and regulators, using templates from EU countries (GDSI limited, 2019). However, the broader impact on effectiveness of the energy sector had not yet materialised (GDSI limited, 2019). In general, successful twinning programmes are demand-driven by the recipient, have a clearly defined operational need, tend to operate in the long-term, and bring together two agencies which share (or have shared) similar contexts and problems (GDSI limited, 2019; Ryan and Mazzilli, 2023).

Another, relatively more successful line of work has been more ad-hoc and project-driven reform. Under the pressure of getting to financial close, developers with the help of DFIs have been able to achieve progress on import duties for PV panels, land status, rights for foreign entities, public finance, grid connection, with some of the results being relevant for subsequent projects as well (Duma, Muñoz Cabré and Kruger, 2023).

Key enablers for successful policy reform interventions in the energy sector, particularly related to energy utilities, are flexibility in intervention activities and medium-term planning. Both the three-year structure of the World Bank Development Policy Operations (DPOs) and the holistic or portfolio approach taken in ESMAP interventions have been identified as contributing to the success of their reform activities (ICF, 2020; World Bank, 2020). Further, an evaluation of DPOs of the World Bank in the energy sector, which aim at policy and institutional reforms, identified a strong political commitment to the reform process as the key enabler for programme success (World Bank, 2020). To ensure this, one of the criteria for selecting countries for interventions for policy reform are whether there are strong prior relations with the government and a sense of trust, which have been identified as keys to ensuring high political commitment.

More broadly, Bensch *et al.* (2016) suggest that independent regulators that operate efficiently increase the likelihood of positive effects of further electricity sector reforms, highlighting the importance of well-functioning regulators themselves as a key enabler for further policy reform. Linked to this, reform activities aimed at independent regulators may provide a promising setting for developing 'islands' of good practice and capacity as they can be comparatively isolated from political pressures (Department of International Development *et al.*, 2018).

Similarly to interventions aimed at knowledge sharing and capacity building, there is a risk for policy reform to focus on 'form over function', where interventions lead to a focus on formal markers of reform (policies, processes, and institutional structures) without acquiring the functions and being suited to the local context (Cox and Norrington-Davies, 2019).

Despite these challenges, reforming the power sector is seen as the only way to ensure that investments in generation and transmission generate the benefits they are designed for and that the system is able to sustain them in the long term. Thus, a long-term perspective on the impact of policy reform, especially given the strong effects of external factors like political stability and economy, is a crucial starting point for policy reform interventions. In line with this, policy reform activities that are part of longer term and programmatic interventions which allow for the establishment of trust

and local authority buy-in may be productive avenues to ensure the internalization and implementation of reform processes.

The evidence highlights the importance of regulation and the role of regulators both as targets of reform interventions but also as enabling reform in the sector to further increase efficiency and effectiveness.

As indicated above, reform interventions require substantial buy-in from relevant stakeholders, including politically. Reform interventions need to be integrated holistically into and linked across governance structures and stakeholders to be effective and to be sustained beyond the timeframe of the intervention itself. The obstacles to reform may stem from vested interests that may be difficult to discern without a significant local presence. The dynamics between agencies, ministries, utilities, regulators, the market and consumer groups that benefit from the status quo need to be well understood for interventions to be effective (Auriol and Blanc, 2009; Kojima, Bacon and Trimble, 2014). Thus, when selecting contexts for policy reform interventions, considering existing relationships and trust with the targeted authority, as well as other interventions in similar areas, is crucial.

4.1.7.2 Key takeaways

- Reforming the power sector is seen as the only way to ensure that investments in generation and transmission generate the benefits they are designed for and that the system is able to sustain them in the long term.
- Trust and buy-in from local authorities are key for sector reform.
- Independent regulators can both be targets of reform interventions to develop 'islands of good practice' while also enabling further reform in the sector to further increase efficiency and effectiveness.

4.1.8 Overarching issues in energy interventions

4.1.8.1 Blended finance

Financing energy interventions can take many forms, from grants to the government or the utility to procure equipment or turnkey projects, to concessional or market-rate loans and guarantees with public or private beneficiaries to equity contributions into project companies (IEA, 2023a; IRENA and CPI, 2023). In general, a greater role is expected from private finance to inject capital into energy projects, but this is limited by the prospects of commercial viability (see dedicated subsection). As such, as far as the private sector involvement goes, innovation on financing vehicles and structures becomes meaningful when an underlying strategy of commercial viability is possible, i.e., the project generates enough revenue to cover costs and an expected return.

If the latter condition holds, clean energy finance becomes highly suitable for the blended finance approach, which modifies the risk-return parameters and can make an investment marginally more attractive for a private entity (Duma and Muñoz Cabré, 2023; Convergence, 2024). Given the fact that the interventions can be structured around a service that is revenue-generating, the blended finance tools are well fitting. Using the Convergence definition, blended finance tools include technical assistance (for enabling conditions), grants (for viability gaps, project preparation), concessional debt or equity, and risk mitigation instruments like guarantees. All have been shown to work well when adapted to their context. This is confirmed by the fact that energy is the most relevant sector for blended finance and SSA has been the most successful region at using these instruments (Convergence, 2024).

Independent evaluations of development agencies or MDBs confirm that finance has kept up with the progress in the sector, by offering support to new instruments and structures (APE, 2017; Independent Development Evaluation, 2020; Nordic Consulting Group, 2021; Greencroft Economics, 2022).

SEI research also found that risk mitigation and transfer instruments have been instrumental in getting projects to financial close, specifically by offering lenders the comfort they need to commit capital long term to projects with a long useful life that rely exclusively on the Power Purchase Agreement with a (typically) struggling counterparty. The research also confirmed however that the role of RMT instruments is to push almost-viable projects into the feasibility zone, and thus they are not a substitute for fundamental commercial viability (Duma and Muñoz Cabré, 2023).

A particularly successful instrument, used by development agencies, DFIs and MDBs, has been guarantees (World Bank, 2016; RES4Africa, 2020; Nordic Consulting Group, 2021). They transfer a portion of the risk to a third party and thus provide comfort to investors to deploy capital under challenging conditions, especially unsustainable sovereign debt and counterparties (utilities) that are not creditworthy. Instruments that have been applied successfully, helping projects get to financial close, include standard or custom guarantees such as partial credit or partial risk guarantees by MDBs such as the WB or AfDB, liquidity instruments such as the RLSF or stand-by Letters of Credit from commercial banks covering a few months of PPA payments and backed by a guarantee, tenor extension guarantees and others (Frisari and Micale, 2015; IRENA, 2016; Duma, Muñoz Cabré and Kruger, 2023). They have been designed and adjusted for Public-Private Partnerships (PPP) in the infrastructure sector and are seen as successful (Independent Development Evaluation, 2020) generating a leverage factor close to six, while having relatively high transaction costs (KfW, 2020).

Sida has accumulated significant experience with the use of portfolio guarantees (Convergence, 2022). In the evaluation of Sida Power Africa, a number of findings related to guarantees are presented (Nordic Consulting Group, 2021). Firstly, the guarantee can only be useful if a financial institution is willing to extend credit in the first place and take at least a part of the risk. This is not a given, since Sida's objectives are for capital to be extended to entities that are expected to provide multiple development outcomes and thus are unlikely to be commercially viable, nor attractive for financial institutions. This means Sida needs to accept being reactive rather than proactive, responding to demand from financial institutions. To respond to this challenge, Sida also started offering portable guarantees, whereby certain borrowers are issued a letter of commitment for a Sida guarantee that they can take to a bank. In addition, the evaluation finds that financial institutions are not always interested in working with Sida guarantees, due to the cumbersome approval procedures, the risk-weighting implications (Basel criteria), and the cost of the guarantee itself that may turn their financial product uncompetitive.

While generally seen positively, risk mitigation can also have unintended consequences. The AfDB evaluation of the renewable energy portfolio finds that 'sub-optimal risk sharing can impose long-term financial burdens on governments, adding to sovereign debt stress and hampering further development of critical infrastructure', including infrastructure relevant for renewable energy (AfDB, 2023). Equity investors typically use Political Risk Insurance that covers non-commercial risks such as expropriation or civil unrest, while also using the halo effect of MDBs, especially the World Bank Group, as a deterrent to hostile action on the part of the government. The evidence points to such instruments being successful, as they enable positive investment decisions, and are rarely triggered (Duma and Muñoz Cabré, 2023).

A major residual risk where the experience with risk mitigation and transfer (RMT) instruments has not been as successful is currency risk (see section 5.2 "Unresolved Dilemmas") (Climate Investment Funds, 2024). There is often a mismatch between the revenue side of any power project (normally in local currency (LCY)) and the debt service (often in hard currency (HCY)). With LCY generally depreciating against HCY, the risk of committing to long term HCY payments is enormous (Donovan and Corbishley, 2016; Hirschhofer, 2022). This risk is generally passed to the utility and implicitly the government (APE, 2017). There is ongoing work on mitigating this risk either by enabling local currency financing, which has the downside of being much more expensive, or by currency hedging (which is also expensive for non-standard currencies). The work

of GuarantCo (part of the PIDG) and TCX (a currency hedging fund) deserves mention, but their portfolio is still small.

In the smaller scale segment, like off-grid and mini-grids, the business models are vastly different and, consequently, the financing instruments also differ. Sida finds that many of the service providers have insufficient equity and retained earnings which limits the working capital and contributes to a low capital base. This constrains subsequent debt financing and makes it very difficult to scale up (Nordic Consulting Group, 2021) Equity contributions are seen as crucial in this segment and can be enabled through guarantees as well.

Sida has also been implementing two other instruments, in addition to guarantees: results based financing (RBF) and challenge funds (CF). CFs select and fund early stage ventures that propose an innovative or promising solution to a defined challenge involving energy access or productive uses. RBFs select more mature entities through a competitive procurement process whereby different service providers commit to achieving certain results (in terms of connections, or productive uses) at the least cost. Both can be combined with the other Sida tools such as guarantees, transaction advice and technical assistance. The evaluation of Sida's Power Africa Project found CFs and RBFs to be successful, acknowledging the high rate of failure to be expected of service providers that serve customers living in poverty, as well as their natural tendency to target better-off segments of the population (Nordic Consulting Group, 2021).

4.1.8.2 The role of the donors

The role of donors (development agencies) is covered especially by the gray literature.

As for areas of focus, the literature seems to point toward the need for donors to take system views and design their interventions with enough consideration for all of the moving parts (IEG, 2016). There is a need to move away from a project-by-project approach and closer toward 'a sector-wide organizing framework and process for mainstreaming the sustained engagement needed for implementing' projects (IEG, 2016; Nordic Consulting Group, 2021; Greencroft Economics, 2022). The literature acknowledges the difficulty of intervening at different points along the value chain while creating the enabling environment and stimulating and supporting demand, yet this is the role that donors have to pursue for the interventions to be impactful. For example, Sida's Power Africa project includes 5 areas of intervention: 1) funding (grants, loans, guarantees); 2) transaction advice and technical assistance; 3) support for project development; 4) innovation activities at technological or business model levels; and 5) sectoral reform and organizational development. USAID's Power Africa program also includes a wide range of interventions, such as power sector reform, transaction facilitation, and bridging financing gaps.

For example, the Sida Power Africa evaluation recommends extending focus to the integration of different technologies such as hydro, wind, and biomass, with productive uses, including mechanized agriculture and forestry with the reutilization of waste for energy (Nordic Consulting Group, 2021). Donors could also pursue riskier innovative and transformational technologies and business models including storage, offshore wind, green hydrogen, or digitalization (Independent Evaluation Unit, 2024) while leaving more commercially mature segments to the private sector.

When dealing with the private sector, one major challenge is the different organizational culture, with donors tending to have lengthy processes that do not always match with timelines and restrictions in the private sector (Larkin, Gardiner and Gulati, 2023). To mitigate this problem, improvements and simplification in internal processes such as approvals or reporting, and a better understanding from the donor of the different constraints and operational models of private entities are recommended (Larkin, Gardiner and Gulati, 2023).

Other critical areas that affect the effectiveness of energy interventions are high staff turnover, lack of continuity, inconsistency in local presence, and

ineffective channels to gather local input into the design of interventions (Social Impact, 2022).

Energy is an input to most economic processes and interacts in different and complex ways with the people's lives. As such, energy interventions must be designed in coordination with other portfolios. Energy is connected to other high-stakes global policy sectors such as security, environment and climate, agriculture, water, health and education. As Sida finds in its evaluation, 'it is impossible to solve energy problems with traditional approaches to innovation which tend to focus on a single, or just a few aspects, of the problem. Instead, analysis of challenges and creation of solutions need to address entire systems' (Nordic Consulting Group, 2021).

Another important task of donors is to set priorities. For example, whether to focus efforts on improving energy access and reliability in higher consumption areas that host manufacturing facilities, mining or services, or to target access to unserved or underserved groups in rural and remote areas (Toman and Peters, 2017). The two options require different tools and capabilities and the literature seems to point toward the former as a priority because of its higher feasibility, prospects for consumption, and economic impact. One group of experts recommends to "focus initially more effort on locations where expanding access can have significant economic developments for larger-scale productive uses" (Toman *et al.*, 2018).

Finally, coordination among donor activities is a key factor for successful interventions. A lack of coordination amongst different donor activities can lead to inconsistent or contradictory interventions and contribute to a high administrative burden among recipient governments, which in turn limit the impact of interventions (Gualberti, Singer and Bazilian, 2013; Cox and Norrington-Davies, 2019; Kablan and Chouard, 2022; Jain and Bardhan, 2023). Further, aid is often driven by bilateral interests and strengths rather than an international division of labour (Lundsgaarde and Keijzer, 2019). This is particularly important in light of the increasing heterogeneity of donor aims, activities, reporting, and funding requirements through the increased role of the private sector and philanthropies. Further, there are some coordination and convening platforms for donors in the energy sector, such as the Sustainable Energy for All initiative (SE4ALL), which are promising channels for coordinating donor activities in the sector (Lundsgaarde and Keijzer, 2019; San and Karim, 2022).

4.1.8.3 The role of the private sector

The role of the private sector is increasing with many development actors trying ways to involve them at various stages of interventions (Independent Development Evaluation, 2020; KfW, 2020; Nordic Consulting Group, 2021). This is in response to global calls for greater involvement on the private sector in development activities, illustrated by the UN's Addis Ababa Action Agenda or the World Bank's cascade approach (UNGA, 2015). This movement is based on the assumption that for-profit private entities could complement the state as a source of finance but also in service delivery, while still earning adequate returns for their shareholders. Simplifying, the role of private sector could be divided into two categories: finance and service delivery (real economy).[6]

On finance, the energy sector is one of the most suitable for private sector investment, as it constitutes a relatively functioning market in many countries. There are several ways for private finance to contribute to energy interventions ranging from bond investors extending debt at the sovereign or utility level, to pension funds investing in a utility scale renewable energy project or banks or microcredit institution offering loans to end users so that they can purchase appliances or connection equipment.

On the delivery side, private entities can range from a multinational corporations acting as project sponsors and selling electricity as Independent Power Producers through a Power Purchase Agreement, to off-grid or minigrid companies that sell services to final C&I customers or to households. Both are bound by the

6 Entities that export standard goods or services like PV panels or wind turbines, electrical equipment, construction, consulting or legal services are also important, but their challenges are less relevant in a development context. However, they can be important actors with deep knowledge of the context, important distribution channels, and may work closely with banks or Export Credit Agencies, and thus they may bring important contributions to making projects more sustainable.

same conditions: generating a return higher than the cost of capital (Donovan and Corbishley, 2016).

The demand side of finance – the companies that sell power services – can be profitable only if the prospective customers are willing and able to pay a price that covers the costs and generates some level of return. Alternatively, they need to receive a subsidy to continue to offer those services.

The evidence points to significant challenges for service providers to reach or maintain profitability, despite efforts to make their offering as affordable as possible (Independent Development Evaluation, 2020; Nordic Consulting Group, 2021; Greencroft Economics, 2022; Social Impact, 2022; ICF, 2023). As profit-seeking entities, service providers tend to shift their target away from the most remote and vulnerable customers and toward comparably well-off customers that have more disposable income and can make payments. In many cases, these customers no longer match the donor's poverty definitions and thus deviate from their initial goals (Trinomics, 2018). Some development agencies recognize this and face the dilemma of whether to encourage the upmarket segment to grow, or to rethink the offering for the base of the pyramid, by including different appliances, especially productive ones and different financing terms (Greencroft Economics, 2022).

KfW (2020) classifies countries by their level of readiness for private sector participation using the World Bank's Regulatory Indicators for Sustainable Energy (RISE). On the one hand, this is helpful both to inform private sector actors who may need to adapt their strategy to different country contexts and avoid failures. On the other hand, development agencies should also ensure that vulnerable countries are not exposed to strategic behaviour from private sector actors who can, in certain contexts, be better prepared and exploit the vulnerabilities by extracting rents, while leaving the country worse off (Independent Development Evaluation, 2020).

In the KfW framework, countries with low readiness should be offered support for pilot projects using grants and standard concessional loans with structures like GetFiT establishing procurement procedures and support through feed in tariffs. For countries with medium readiness that already have one or more projects in the operational phase, the energy development toolbox should include risk mitigations (such as the RLSF), equity and debt at concessional rates, and policy-based lending (support conditional on implementing certain reforms). For high readiness countries where renewables are an established market and there is adequate liquidity, support should focus on innovation, advanced technologies (including digitalization and storage) and more complex financial instruments such as securitization.

Across SSA, taking a value chain approach, Probst et al. (2020) find that the segments that are suitable for private sector participation, both as providers of finance and service delivery, are generation, off-grid and minigrids, while transmission, distribution and retail are not seen as ready.

The stage of the private entity is also relevant when designing interventions. The most critical finding applies to early-stage ventures, where the development support needs to be 'innovative and flexible, joining early rounds and staying in to bring the investee through to commercial scale, bridging the pioneer gap, including continuing to offer small ticket direct equity investments' (Greencroft Economics, 2022).

A recurring theme in the grey literature is the difficulty of maintaining profitability in the off-grid-minigrid sector and the necessity of using and maintaining subsidies (APE, 2017; Nordic Consulting Group, 2021; ICF, 2023). It is expected for many of the funded service providers to face challenges and for some to default. According to USAID, the underlying assumption of the Power Africa model is that 'underserved communities can be served with a private sector-based model without subsidies' by entities 'that are well equipped with management skills, financing, and an understanding of market conditions, where enabling environments are established through government policies' which in turn will ensure that contributions to energy access and economic growth will ensue. This assumption is found to be only partially correct (ICF, 2023).

An issue to keep in mind is the potential for crowding out (see unresolved dilemma). FMO finds that 'there is a potential risk of crowding out some commercial investment as FMO competes with other investors to provide capital to the same small number of companies, including, sometimes, competing with the specialized sector funds that it has helped to capitalize' (Greencroft Economics, 2022).

4.1.8.4 Key takeaways

- Finance has been able to develop adequate tools for different country contexts, project size, and step in the value chain but not so successful on managing currency risk.
- Risk mitigation, particularly through guarantees, has been successful, but can sometimes hide risks that can materialize and hurt the government's debt sustainability.
- The role of donors is becoming increasingly complex as it must deal holistically with policy, planning, regulation, capacity, market operations, fiscal implications, and several types of different actors.
- The role of the private sector is more relevant in energy than other sectors, due to the clear path to revenue, both for the finance and the real segment. However, all are constrained by the requirement of commercial viability, which may only be achieved in certain segments.

Photo: **Ken Opprann**

4.2 Outcome and impact

4.2.1 The causal chain and major assumptions

As discussed in the chapter dedicated to the Theory of Change, the impacts of energy rely on certain assumptions. The first and simplest assumption is that energy is available to households and business after the intervention and that it is being used. Even this assumption should not be taken for granted, as in many cases, the beneficiaries deal with:

- Affordability issues – the service is above the users' willingness to pay (WTP). Further, an economic shock such as illness, a drought, loss of income – can suddenly render the service unaffordable.
- Availability issues – the service or equipment can experience faults or require changing parts which may be not affordable. For example, some impact evaluations found that about a tenth of the lights provided through the intervention were broken after 7 months (Trinomics, 2018) and many clients experienced problems with the functioning of the device in the past 12 months (Rom, Günther and Harrison, 2017).
- Usability issues – the service may not be tailored to the needs of people who may simply choose not to use it.
- Adequacy issues – the service may not be enough for the uses they require. For example, an FMO evaluation finds that 'of the total 40 million people reached with their intervention, 35 million are below or around the threshold of Tier 1 energy access, while just five million have access to a system that would provide full Tier 1 energy access for the whole household' (Greencroft Economics, 2022).

More complex assumptions include:

- Substitution – replacing more expensive, less reliable, more polluting or dangerous, socially or environmentally deleterious sources, with comparatively better sources provided by the intervention
- Specific use cases
  - For productive purposes generating income
    - Through mechanized work, or value-added services (fans, etc)
  - For changes in use of time
    - More learning for children and adults
    - More information helping with better decision making in social, political, or economic terms
    - Changes in use of time in socially relevant ways (more socialization with neighbours of friends) or more autonomy for women and girls

The assumption is that through these intermediate outcomes, people will have higher incomes, more comfortable lives, will experience less deprivation and oppression, will be healthier and educated, and ultimately will experience more wellbeing.

The assumptions are strong and difficult to assess, but even on an intuitive level, one can easily imagine that not all of them will hold in all contexts. Some may be valid under certain circumstances, may change over time, may oscillate and interact with each other. It's no surprise that the literature focusing on impact evaluation is not vast and sometimes presents contradictory results. These results are not conclusive in terms of providing a definitive answer as to the impact of energy interventions but are informative for promising ways in which such interventions may be made more effective.

4.2.2 Macro level impacts

4.2.2.1 Energy

At the macro-level, energy interventions are aiming to contribute to several impacts such as economic growth, increased employment and skills, better productivity but also climate change mitigation, reduced pollution, reduced deforestation, and others. The focus will be on economic performance, since the other potential impacts are addressed through the energy intervention itself (prioritizing clean energy technologies and using high environmental performance standards).

Identifying causality and its direction between energy interventions and macro impacts such as GDP growth is difficult. The studies that attempt establishing such relationships are using abstract modelling techniques that rely heavily on assumptions. For example, the development consultancy Steward RedQueen produced several studies for various DFIs looking at two major pathways for impact: reduction in the cost of power (mainly by displacing expensive back-up fossil-based generators) and reduced outage times (Steward Redqueen, 2016, 2017). Both pathways are believed to lead to businesses having greater productivity, to increases in aggregate demand and employment in the economy. They use combinations of outage times from the utility, simulated power prices with additional capacity, firm-level data on production, and input-output models to estimate the impact on the economy. They consistently find significant impacts, including a 1.7% GDP increase associated with 70MW of expanded capacity in Senegal and a 2.6% increase in GDP from a 250 MW hydroelectric plant in Uganda and associated energy reforms. However, they acknowledge that the results depend on a number of significant assumptions and the quality of statistical data (Steward Redqueen, 2017) which severely limits the extent to which they can be generalized. In a literature review performed for Finnfund, the same consultancy find that the two pathways (decreased cost and increased reliability) are at work in many countries helping firms produce more, while mentioning that 'the benefits are not equally shared across the economy, with more energy intensive sectors benefiting the most' (Steward Redqueen, 2019).

The constraint on the operations, productivity and growth of firms imposed by power outages is one of the most convincing research results. Evidence from various countries including Nigeria and Ghana and others points to significant loss of production and direct losses stemming from the unreliability of the grid (Cole *et al.*, 2018; Osei-Gyebi and Dramani, 2023). Hence, interventions that improve reliability in already electrified regions may have the most direct impact on expanded production and economic growth (Toman *et al.*, 2018).

Another comprehensive review of the macroeconomic effects of electricity provision concludes that indeed GDP growth and electricity use go hand in hand, and that electricity access is an important enabler of economic growth, while acknowledging that convincing econometric evidence is hard to find due to the methodological intricacies (Stern, Burke and Bruns, 2019). The experience of different countries suggests that electricity is necessary but not sufficient for sustained and diversified growth. Ethiopia is a country where electricity capacity seems to have been a direct enabler of growth, while Chad is a counterexample, with growth largely coming from the oil sector, in almost complete absence of electricity capacity expansion (Stern, Burke and Bruns, 2019). Another review of the evidence finds that three quarters of the reviewed studies point toward a strong statistical correlation between energy and growth, while half of them indicate a direction of causality from energy to growth (Lemma *et al.*, 2016). The review also confirms that evidence is convincing for a relationship between energy use and growth in Sub-Saharan Africa and identifies poor reliability and high cost of energy services as a major constraint to business growth, confirmed by survey data of business leaders. However, there are also countries where the evidence does not confirm a causal link between energy and growth (Wolde-Rufael, 2009).

ODI reviews evidence on the impact of energy investments by DFIs on growth and employment

(Attridge *et al.*, 2019). There is credible evidence that the additional generation capacity of 3866 MW related to the Proparco portfolio is estimated to have led to a GDP increase of 1 billion euros and 218,000 jobs (with a corresponding fraction being attributable to the Proparco investment). Similarly, FMO finds that its energy portfolio led to the creation of 106,000 jobs between 2009 and 2014 (APE, 2017).

At the same time, in all analysed documents of development agencies and DFIs/MDBs, the availability of energy is seen as a precondition for growth. While growth does not automatically, predictably or measurably follow after the addition of capacity, it almost certainly cannot happen in its absence. As the Energy for Growth Hub puts it, there are no high growth low energy countries (Moss and Kincer, 2023).

4.2.2.2 Clean cooking

On the macroeconomic level, no relationship has been found that indicates a direct causal link between clean cooking interventions and macroeconomic development. Rather the correlations found in studies can be seen as indicative for favourable pre-conditions for clean cooking.

An analysis of solid fuel use rates in 69 countries indicate that increasing GDP is by far the strongest determinant of reduced solid fuel use and a reduction in solid fuel use rates (McLean *et al.*, 2019). Furthermore, access to clean energy is influenced positively by income, foreign direct investment, political regime (strength of democratic institutions) and employment, while inflation has some negative effect on its accessibility (Kwakwa *et al.*, 2021).

Transition to clean cooking is a function of income, energy prices, and urbanization in LLMICs. Widespread modern fuel adoption in households cannot be observed for countries with a GDP per capita under $12,000. Similarly, in countries with high degrees of income inequality, poor households are excluded from access (Schunder and Bagchi-Sen, 2019). Further, high degrees of population density and urban population are associated with lower solid fuel use rates. Indeed, most studies point towards an urban-rural divide, with urban areas showing higher access rates to modern fuels than rural regions (e.g., in sub-Saharan Africa 42% of urban compared to 5% of rural residents have access) and show a higher likelihood of sustained use (McLean et al., 2019; Puzzolo & Pope, 2017).

4.2.2.3 Key takeaways

- The evidence on macroeconomic impacts of energy interventions is mixed. Some studies confirm a positive causal relationship between energy and economic growth and employment, while others are rather inconclusive.
- The availability of energy (particularly electricity) seems to be a pre-condition for growth in many countries, but does not guarantee it.
- These findings, corroborated with the experience of overcapacity in some countries, confirms that financing (through loans) more energy does not automatically translate into higher growth or budget revenues, and could instead bring sovereign debt to unsustainable levels.
- There is not enough evidence to prove macroeconomic impacts of clean cooking interventions.

4.2.3 Micro level impacts

4.2.3.1 Energy

Access to electricity or improvements in its quality are expected to generate numerous impacts at the household level, in accordance with the ToC. There are numerous studies confirming such impact through the expected channels such as change in the use of time, improved education, health, and wellbeing. At the same time, there are numerous studies that fail to provide the expected evidence, despite similar interventions. The divergence of results is also explored in the literature and the most likely explanations are the different methodologies, the different design of the electricity service itself, the difference between countries or even regions or neighborhoods. Another confounding factor can be to ascertain the actual use rate of novel devices and applications. This can lead to counterintuitive study results, for example, a study in Kenya found that households that had a higher WTP for electricity experienced greater economic benefits than the ones that only accessed the service when it was provided for free.

Thus, the causal relationship between electricity use and economic development at household level is complex and depends on contextual details that can be difficult to capture in data, much less generalise between countries and regions (Riva *et al.*, 2018; Eberhard and Dyson, 2020).

Time use

Access to electricity significantly alters household daily routines by extending lighting hours, providing entertainment options, and freeing up time from household chores. Electrification allows households to engage in more productive and leisure activities, extending their waking hours.

In Rwanda, following the rollout of a national electrification program, households in electrified communities spent an average of 50 minutes longer awake compared to non-electrified communities, primarily due to extended lighting hours and increased use of entertainment devices such as TVs and radios (Lenz *et al.*, 2017; UNESCAP, 2021). In Tanzania, electrification reduced the time spent by adults and children collecting fuel and water, and men spent less time preparing food. Again, this led to a significant increase in time spent on watching television and socializing, ranging from 1.15 to 1.45 hours daily (UNESCAP, 2021). The increase of leisure activities through electrification as well as an increased feeling of safety often improves overall subjective wellbeing (Aevarsdottir, Barton and Bold, 2017).

However, electrification can also have unintended effects on time use. The "Energy for the Poorest" intervention in Kenya, which provided solar equipment to households benefiting from cash transfers, led to changes in time use. Some of these changes included an increase in household chores for young girls, which reduced their hours for rest and sleep (ADB, 2019). Overall, while electrification generally leads to positive changes in household time use by freeing up time from labour-intensive chores and extending productive hours, the impact on leisure and unpaid work varies, and there can be unintended negative consequences for certain household members.

Economic outcomes

Electricity access is assumed to produce benefits across multiple areas. These benefits are expected to arise through a number of different mechanisms, such as increased income and consumption possibilities, increased productivity and employment. Potential increases in household and firm wealth may produce positive externalities, for example by increasing demand for local services and attracting residential and commercial migration, resulting in increased labour supply.

Income & consumption

A core debate within the literature on the effects of electrification surrounds whether households increase their incomes after obtaining access to electricity. Studies have found incomes gains from energy access are because, with electricity, people have to perform less domestic labour and also can switch remaining domestic activities to the evening hours. Both factors free up time for income generation activities (Khandker, Barnes and Samad, 2009; Aevarsdottir, Barton and Bold, 2017; Steward Redqueen, 2019).

Studies in India, Bangladesh, and Vietnam show electrification correlated with income gains ranging from 25% to 36%, with similar positive effects observed in Latin America (Lipscomb, Mobarak and Barham, 2013; Van De Walle *et al.*, 2013). However, the applicability of these findings across all contexts is contested, with for instance Peters and Siever (2015) suggesting that income impacts from interventions are limited in SSA due to challenges such as poor market access and a lack of adoption of electricity for income-generating activities among rural households.

There exist also heterogeneous effects depending on household income. For instance, spending on off-grid technologies are correlated with household income levels based on the size of solar home systems purchased though the direction of causality is not clear. Research from Uganda underscores the disparity in household income between electrified and non-electrified areas, although causality often reflects that higher incomes precede electricity access rather than vice versa (Steward Redqueen, 2016).

Overall, while electrification consistently shows potential to boost incomes and improve economic conditions, the degree of impact varies significantly across regions and depends on factors such as local economic conditions and the availability of supportive infrastructure and markets.

Employment

Meta studies have shown a strong correlation between energy consumption and employment, principally through higher household employment following electrification. Notably, most studies show that household employment increases only for women (World Bank, 2017; UNESCAP, 2021).

Business outcomes

The impact of electrification on business performance appears varied and context-dependent. According to the ADB (2019), improvements in business performance due to electricity access show mixed results across different studies. For instance, manufacturing firms in Myanmar that located in areas with high electricity access experienced increased profits. In contrast, electricity interventions in India did not significantly affect the number of business ownerships. Overall, business productivity saw only marginal improvement, with several studies noting no improvement, and some notable gains observed in agricultural activities, while non-agricultural enterprises showed no significant changes.

In contrast, a study on rural electrification in Bangladesh highlighted significant enhancements in enterprise productivity. Electrification enabled businesses to operate extended hours into the evening, thereby increasing daily sales and profitability. Additionally, businesses could adopt more efficient and productive machinery and tools compared to their non-electric counterparts (Samad and Portale, 2019). These findings underscore how electrification can positively influence business operations and productivity, particularly in contexts where businesses can leverage extended operational hours and improved technology facilitated by electricity access.

Gender equality

Electricity usage can contribute to gender equality through a shift in time use such as: (i) less time spent on tasks within the households and therefore increased employment opportunities outside the home and (ii) enhanced education and study possibilities for children. In addition, the health and wellbeing, particularly of women, benefit when health clinics are electrified and maternal health services are expanded.

The productive application of electricity can significantly reduce gender disparities by increasing women's involvement in economic activities and enabling systemic changes in gender norms and household roles (Pueyo and Maestre, 2019). Women in electrified households may spend fewer hours per day on fuel collection, enabling them to engage more in productive activities. By saving time on such household labour, electrification can facilitate women's participation in the labour market, allowing them to generate their own income. Also for businesses in the energy sector, employing women can yield outsized benefits and lead to a virtuous cycle. For instance, in the off-grid solar sector, including women as

consumers, employees, and entrepreneurs enhances service delivery, financial performance, employee retention, and innovation (ESMAP, 2022).

Moreover, exposure to electronic media via electricity access can increase women's access to education and information, exposing them to more opportunities and strengthening their agency in economic, social, and political affairs. It is associated with a lower acceptance of intimate partner violence, suggesting a potential reduction in domestic violence (Sievert, 2015) and increase in intrahoushold bargaining power (ESMAP, 2022).

Additionally, women in electrified households are more likely to make independent decisions regarding their children's health, family planning and economic management (ADB, 2019). A study by Duke University found a positive association between a women's empowerment index and energy access at the household level in most countries (Chandrasekaran *et al.*, 2023).

Lastly, electrification may be associated with a reduction in fertility rates. For example, women from electrified households in Ghana had, on average, three fewer children than those from non-electrified households after 13 years of the national rural electrification program (Akpandjar, Puozaa and Quartey, 2018).

Health

Access to reliable energy can impact health outcomes through several mechanisms. Improved household energy access can reduce indoor air pollution, support clean water supply systems and effective sanitation. Beyond the household, electrification of medical facilities can improve their functionality.

According to the UN (2021), electricity can improve health conditions in homes through refrigeration for food preservation and nutrition, and via fans and air conditioners for personal comfort and safety.

In a meta study, the ADB (2019) finds positive correlations between access to electricity and the use of contraception and social benefit from lower fertility, access to health information (e.g., on vaccination), and positive health outcomes (e.g., increase in life expectancy, decrease in mortality rates, and fewer incidences of low birth weights). However, statistical significance in the impact assessments is mixed (ADB, 2019).

The UN (2021) points out that the greatest contribution of electricity access comes through medical facilities, e.g. by powering lighting, medical devices, and refrigeration prolonging night-time service provision and attracting and retaining skilled health workers to provide faster emergency response, including for childbirth deliveries.

However, again, the evidence base is mixed. For example, studies in Tanzania show that on-grid electricity access does not affect health whereas off grid technology does (Aevarsdottir, Barton and Bold, 2017; Chaplin *et al.*, 2017). The ADB (2019) points to the complexity of aggregating results of various studies analysing the impact of energy on health outcomes, as these studies have very heterogeneous study design and focus on many different outcomes while also defining the outcomes of interest differently.

Education

Access to electricity can have implications for education outcomes. New or improved lighting can extend the effective school day and permit more flexible home study. Further, increased use of electrical devices and digital aids can also attract and retain high-quality teaching staff, improving the educational process and enabling learners to invest more in their education both at school and at home.

A meta-analysis conducted by the Asian Development Bank (ADB) in 2019 found that electricity access interventions have a positive but small effect on pooled education outcomes. The analysis indicated significant improvements in study time, particularly at night, with minor enhancements in years of schooling and school enrolments, but no significant effects on grade progression and literacy rates. Interventions that expanded access alone had a reduced effect size, whereas combining affordability with system and

policy management components increased the effect size (ADB, 2019). Similarly, UNESCAP (2021) found that providing households with an electric connection had a positive impact on educational outcomes, with a small but significant increase in study time and years of schooling.

In Peru, grid access increased children's study time by 1.6 to 2.3 hours (Aguirre, 2017), while in Uganda, children in households with mini-grid connections spent 10-35 minutes more on education than those without electricity (Steward Redqueen, 2016). Additionally, off-grid technology has been reported to increase study time overall (Gogla, 2018), with studies in Sub-Saharan Africa showing increases in study times ranging from 1.7 to 3.2 hours per night (Scott *et al.*, 2016). Contrastingly, in a study by Karumba and Muchapondwa (2017), children in electrified households were found to devote 43 minutes less to evening studies compared to those in non-electrified households.

Furthermore, the comprehensiveness of interventions seems to be highly relevant for impact, with those interventions that aim to expand access alone – both on- and off-grid – resulted in decreased effect size, while combining affordability with system and/or policy management components were associated with increased effect size (ADB, 2019).

Overall, the evidence suggests that while the impact of electrification on education is generally positive, the extent of these benefits can vary significantly based on regional, gender-specific, and implementation factors.

Moderators

Income

Many studies examined how equitable electrification programmes were. For studies with a focus on nation-wide on-grid electrification, empirical evidence suggests that on average, groups with higher initial economic endowment often benefit more from electrification programmes. However, there exist cross-country differences between the outcomes. Also, depending on the study horizon differences exist, with some proposing that over time, the rate of return from electrification declines among richer households, while poorer households catch up by diversifying their electricity use (UNESCAP, 2021).

Rural-urban

Examining the urban-rural divide Kumar (2020) found that an "electricity connection" increased monthly per capita consumption for urban areas by 78% compared with only 56% for rural areas. This suggests that electrification results in greater economic benefit in urban areas, possibly due to higher baseline income or access to resources.

Farm – non-farm income

Electrification can increase farm income by facilitating the automation of agricultural practices through adoption of technology, thereby increasing farm productivity. In addition, it can encourage households and/or individuals to seek new nonfarm business opportunities (UNESCAP, 2021), suggesting that electrification can lead to diversification of economic activity. According to a meta analysis by UNESCAP, rural electrification tends to increase non-farm income more than farm income (2021).

Gender

Economic impacts by gender are highly heterogeneous – some studies demonstrate that electrification had a larger effect on men (Dasso and Fernandez, 2015; Rathi and Vermaak, 2018) and others on women (Barron, 2020). In a number of studies, more women were brought into the fold of employment as a result of electrification. Inversely, men were working longer hours (UNESCAP, 2021).

The benefits of energy access on education can also differ by gender. For instance, in Vietnam, on-grid electrification improved enrolment rates more for boys than girls, raising enrolment rates by 11% and increasing schooling years by 0.7 years (Khandker, Barnes and Samad, 2009). Conversely, in India, similar improvements were observed predominantly for girls (Van De Walle *et al.*, 2013).

4.2.3.2 Clean cooking

Relevant literature underscores that clean cooking technologies in LLMICs have the potential to contribute to multiple SDGs. Specifically, they have been linked to SDG 3 (Good health and well-being), as the cleaner-burning stoves or fuels reduce illnesses and premature deaths caused by indoor air pollution (Rosenthal *et al.*, 2018; Gill-Wiehl, Ray and Kammen, 2021). Moreover, the shift to clean cooking fuels such as LPG and biogas can advance SDG 13 (Climate action) by mitigating climate impacts through reduced emissions (Simon *et al.*, 2014). Through reduced use of woody fuels, SDG 15 (Life on Land) can be contributed to due to a reduction in deforestation and resultantly reduced land degradation and desertification (Karanja and Gasparatos, 2019). Contributions to SDG 5 (Gender equality) can result from reduced time spent on biomass collection, which allows women to engage in more productive economic activities (Nussbaumer, Bazilian and Modi, 2012; Pachauri and Rao, 2013). Similarly, when children partake in the collection of biomass to fuel their cooking, more efficient technologies can lead to contributions to SDG 4 (Quality Education), as children using the saved time to pursue education instead (Stritzke *et al.*, 2023).

Thus, there is significant overlap between the factors driving potential impact of clean cooking interventions and energy interventions more generally. The impact of clean cooking interventions hinge on two factors:

1. The novel technology actually being cleaner than what is currently in use
2. The adoption and sustained use by households

The effectiveness of different clean cooking solutions varies (JPAL, 2020). While lab-based studies generally support the health benefits of modern clean cookstoves compared to traditional methods, field evaluations suggest more modest improvements in air quality and health outcomes (Rosenthal *et al.*, 2018). Some novel stove designs, while reducing pollution, still do not adhere to WHO health standards (World Health Organization, 2014). Hence, if the stoves themselves are incapable of burning cleanly, no significant health impacts can be achieved (UNESCAP, 2021). There is therefore a case for testing stoves or interventions that help people switch to cleaner fuels (e.g., liquid petroleum gas (LPG), electricity) to reduce exposure to indoor air pollution, rather than relying on cleaner-burning biomass stoves.

Even if stoves and fuel burn significantly cleaner if used, additional discrepancy between laboratory conditions and real life application arises from challenges in achieving widespread purchase, adoption and consistent usage of these technologies within LLMIC households, as outlined in the section on outputs (Rosenthal *et al.*, 2018; Lindgren, 2020; Gill-Wiehl, Ray and Kammen, 2021). Appropriate technology design and creation of an enabling ecosystem is a crucial supply-side prerequisite for adoption (Ramani *et al.*, 2023). This adoption is crucial for realizing the potential co-benefits across various SDGs. "Adoption" of clean cooking practices in this case is defined as the increased and sustained use of clean fuels/technologies, the decreased use of dirty fuels/technologies, and the correct and sustained use of clean fuels and technologies. Also, while clean cooking technologies are often grouped together, studies have demonstrated that different types of clean cooking solutions offer different types of benefits and challenges (Rosenthal *et al.*, 2018).

Further, while the literature frequently speaks of cookstove or fuel usage in absolute terms, it is important to note the heterogeneity in fuel use found at the household level, as most households add clean cooking practices to the traditional methods of cooking resulting in combined use, commonly referred to as stove "stacking".

Thus, despite long ongoing efforts by development actors, there is little evidence that clean cooking solutions are consistently delivering their intended health and other benefits. Due to the large potential impact, these interventions should not be given up on, but rather need to be approached more holistically. The literature primarily suggests that impacts do not manifest beyond the short-term due to low adoption rates by the intended beneficiaries. Hence, funding for this intervention area should aim to address demand

side-challenges, including:

a. high prices
b. inappropriate technological design,
c. lack of support services and
d. lack of awareness

The findings suggest that price discounts are critical for the diffusion of clean cooking solutions. Innovative business models and subsidies to directly reduce costs for the beneficiaries is therefore of utmost importance. Further, both debt and equity investment ought to be mobilized for building a pipeline of scalable businesses capable of delivering affordable cooking products.

Second, there is no single stove, fuel, or business model that can be applied universally. Solutions must be context specific and appropriate for the intended userbase. Thus, while the cooking technology is crucial, donors must ensure that technical solutions are rooted in a holistic approach, designing solutions from the bottom-up, by practitioners deeply embedding themselves into local contexts and including the intended beneficiaries into the design process, thereby co-designing holistic solutions that go beyond the stove itself. Thus, more focus is needed on the whole value chain or system rather than solely on technology for more transformational impacts.

Third, an enabling ecosystem around the clean cooking technologies needs to be created. Accessibility of both stoves and fuels needs to be strengthened through robust supply chains and delivery mechanisms. Stove maintenance must be made possible either by the users themselves or by experts who are easily available. Creation of such an ecosystem and fostering an enabling environment for the growth of relevant industry must be facilitated through donors advocating for effective and predictable policies.

Fourth, consumer demand must be increased by supporting behaviour change and awareness-raising interventions through education campaigns that are relevant and continuous.

Lastly, to determine which types of interventions work, more monitoring and evaluation along with longitudinal study designs are necessary. Donors ought to mobilise patient capital, as such complex interventions can take time to bear fruit. An iterative process of piloting and refining interventions is necessary for success.

4.2.3.3 Key takeaways

- The evidence on microeconomic impacts of energy interventions is mixed. Some studies confirm a positive causal relationship between energy and various impact dimensions (time use, economic outcomes, gender, climate action, life on land) while others show mixed or no impact.
- Mixed results of energy interventions are due to varying methodologies, service designs, and regional contexts.
- The evidence on microeconomic impacts of clean cooking interventions is also mixed and effectiveness varies; lab studies show health benefits, but field results are modest. Co-benefits arise only sporadically.
- Adoption and consistent use of clean cooking technologies remain the primary challenges, with many households struggling to purchase cookstoves at market rates and if they do, combining its use with traditional cooking methods.

5

Unresolved dilemmas

1. Currency risk continues to be a chronic problem with energy investments and the existing solutions (such as the ones offered by GuarantCo or TCX), despite being promising, are not being used at scale. Local currency finance is scarce and hedging is expensive for many currencies. In the meantime, exposure to currency risk continues to be major vulnerability for offtakers and, implicitly, the government.

2. The role of private finance, the cost of capital and the potential crowding out is another puzzle. This stems from the fact that the cost of capital is a cost for the demand side of finance but actually represents the return for the provider of capital. Reducing the cost of capital by extending concessional credit and risk mitigation makes the sector unattractive for private finance. Private equity or debt funds are complaining that they are crowded out by DFIs who get funding at rates they cannot compete with. If the sector is going to be attractive for private investors, it must generate adequate risk-adjusted returns. At the same time, this translates directly into higher prices of power. This dilemma is unlikely to be resolved any time soon.

3. Is targeting the poor with energy interventions the best way to reduce poverty? As shown by many off-grid interventions, service providers are gradually and naturally moving toward more affluent segments of society, in search for more revenues. Serving the base of the pyramid is challenging, as their take-up is hesitant due to low perceived benefits, consumption is low, and the overall impacts uncertain. Further, there is the question if harm can befall the users if interventions are not carefully planned and targeted, e.g. through additional debt burdens or faulty technology.

4. Finding the right role for the private for-profit sector is still work in progress. Pursuing multiple social goals such as poverty alleviation, reducing gender disparities, education, health, the environment while maintaining profitability from delivering a service to the most vulnerable customers is immensely challenging. It should not be surprising that most of these providers struggle to maintain profitability. The interplay between grants, subsidies and risk mitigation to keep these companies afloat while they deliver desirable outcomes will require time and experimentation.

5. The relationship between infrastructure and growth is difficult to disentangle even for OECD countries where research is not lacking. Assuming that LLMICs will take the same pathways for development, while avoiding all the downsides of growth that OECD countries experienced (environmental damage, social inequality, etc) does not seem credible. The reality is that the exact route to development is highly uncertain and will require patience, learning and experimentation, as well as adaptability as results unfold.

Photo: **Christopher Brandt**

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Bibliography

60 decibels (2024) *Why Off-Grid Energy Matters 2024: An impact performance report.*

About PPA Watch (no date) *PPA Watch.* Available at: https://ppawatch.org/about/ (Accessed: 6 August 2024).

Ackah, I. *et al.* (2021) *A case study of Ghana's Power Purchase Agreements.* Institute for Economic Affairs and Energy for Growth Hub. Available at: https://energyforgrowth.org/wp-content/uploads/2021/03/A-Case-Study-of-Ghanas-Power-Purchase-Agreements.pdf.

ADB (2019) *Impact Evaluation of Energy Interventions: A Review of the Evidence*. 0 edn. Manila, Philippines: Asian Development Bank. Available at: https://doi.org/10.22617/TCS190113-2.

Aevarsdottir, A.M., Barton, N. and Bold, T. (2017) 'The impacts of rural electrification on labor supply, income and health: experimental evidence with solar lamps in Tanzania'.

AfDB (2023) *Evaluation of the AfDB's Support for Renewable Energy (2012-2021)*. Available at: https://idev.afdb.org/en/document/evaluation-afdbs-support-renewable-energy-2012-2021.

Aguirre, J. (2017) 'The Impact of Rural Electrification on Education: A Case Study from Peru', THE LAHORE JOURNAL OF ECONOMICS, 22(1), pp. 91–108. Available at: https://doi.org/10.35536/lje.2017.v22.i1.a5.

Akpandjar, G., Puozaa, C. and Quartey, P. (2018) 'Explaining Fertility Variation in Rural Communities: The Role of Electricity in Ghana', *Economies*, 6(3), p. 40. Available at: https://doi.org/10.3390/economies6030040.

Aly, A. *et al.* (2019) 'Barriers to Large-scale Solar Power in Tanzania', *Energy for Sustainable Development*, 48, pp. 43–58. Available at: https://doi.org/10.1016/j.esd.2018.10.009.

Andersen, O.W. and Pedersen, R.H. (2023) 'The paradox of overcapacity in African energy sectors', *Energy for Sustainable Development*, 72, pp. 83–87. Available at: https://doi.org/10.1016/j.esd.2022.11.011.

Ang'u, C. *et al.* (2023) 'Determinants of the sustained use of household clean fuels and technologies: Lessons from Vihiga county, Kenya', *Energy Reports*, 9, pp. 1990–2001. Available at: https://doi.org/10.1016/j.egyr.2023.01.026.

APE (2017) *Evaluation FMO Access to Energy Fund*. FMO. Available at: https://www.fmo.nl/l/library/download/urn:uuid:c2e9f418-219c-4e1c-9e40-8b2d82719a86/final+report+evaluation+aef_24+mar2017-exsum.pdf?redirected=1719829621.

Attia, B. (2022) 'Business models to unlock private investment in sub-Saharan Africa's electricity transmission sector'. Available at: https://energyforgrowth.org/article/business-models-to-unlock-private-investment-in-sub-saharan-africas-electricity-transmission-sector/.

Attridge, S. *et al.* (2019) *The Impact of Development Finance Institutions*. London: Department for International Development. Available at: https://assets.publishing.service.gov.uk/media/5d1232bee5274a066ad2cf79/DFI_Impacts_REA_Report__June_2019.pdf.

Auriol, E. and Blanc, A. (2009) 'Capture and corruption in public utilities: The cases of water and electricity in Sub-Saharan Africa', *Utilities Policy*, 17(2), pp. 203–216. Available at: https://doi.org/10.1016/j.jup.2008.07.005.

Barron, M. (2020) 'Household Electrification and Labor Supply: Experimental Evidence from El Salvador'. Available at: https://doi.org/10.1257/rct.5535-1.0.

Bayer, P. *et al.* (2020) 'The need for impact evaluation in electricity access research', *Energy Policy*, 137, p. 111099. Available at: https://doi.org/10.1016/j.enpol.2019.111099.

Bensch, G. *et al.* (2016) *Effects and mechanisms of market-based reforms on access to electricity in developing countries: a systematic review*. 2016th edn. International Initiative for Impact Evaluation. Available at: https://doi.org/10.23846/sr51232.

Berthelemy, J.-C. and Millien, A. (2018) 'Impact of Decentralized Electrification Projects on Sustainable Development: A Meta-Analysis', *Documents de travail du Centre d'Economie de la Sorbonne* [Preprint]. Available at: https://ideas.repec.org//p/mse/cesdoc/18039.html (Accessed: 1 July 2024).

Bos, K., Chaplin, D. and Mamun, A. (2018) 'Benefits and challenges of expanding grid electricity in Africa: A review of rigorous evidence on household impacts in developing countries', *Energy for Sustainable Development*, 44, pp. 64–77. Available at: https://doi.org/10.1016/j.esd.2018.02.007.

Buchner, B. *et al.* (2023) *Global Landscape of Climate Finance 2023*. Climate Policy Initiative. Available at: https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2023/.

Chandrasekaran, M. *et al.* (2023) 'Gender empowerment and energy access: evidence from seven countries', *Environmental Research Letters*, 18(4), p. 045003. Available at: https://doi.org/10.1088/1748-9326/acc2d3.

Chaplin, D. *et al.* (2017) 'Grid Electricity Expansion in Tanzania by MCC: Findings from a Rigorous Impact Evaluation, Final Report', *Mathematica Policy Research Reports* [Preprint]. Available at: https://ideas.repec.org//p/mpr/mprres/144768f69008442e96369195ed29da85.html (Accessed: 1 July 2024).

Clean Cooking Alliance (2023) 2023 *Clean Cooking Industry Snapshot*. Clean Cooking Alliance. Available at: https://cleancooking.org/wp-content/uploads/2023/12/CCA-2023-Clean-Cooking-Industry-Snapshot.pdf (Accessed: 8 July 2024).

Climate Investment Funds (2024) *Managing Foreign Exchange Risk for Transformational Climate Solutions*. Available at: https://www.cif.org/sites/cif_enc/files/knowledge-documents/tcf_foreign_exchange_rates_apr11-compressed.pdf.

Cole, M.A. et al. (2018) 'Power outages and firm performance in Sub-Saharan Africa', *Journal of Development Economics*, 134, pp. 150–159. Available at: https://doi.org/10.1016/j.jdeveco.2018.05.003.

Colenbrander, S. *et al.* (2015) 'Renewable energy doctoral programmes in sub-Saharan Africa: A preliminary assessment of common capacity deficits and emerging capacity-building strategies', *Energy Research & Social Science*, 5, pp. 70–77. Available at: https://doi.org/10.1016/j.erss.2014.12.010.

Convergence (2022) *Profiling Sida's Guarantee Programme*. Available at: https://www.convergence.finance/resource/profiling-sidas-guarantee-programme/view.

Convergence (2024) *State of Blended Finance 2023*. Available at: https://www.convergence.finance/resource/state-of-blended-finance-2023/view.

Cornieti, S.M.I. and Nicolas, Claire Marion (2023) *How to Unlock Pipelines of Bankable Renewable Energy Projects in Emerging Markets and Developing Countries?* ESMAP. Available at: https://www.esmap.org/Pipelines-of-Bankable-RE-Projects.

Cox, M. and Norrington-Davies, G. (2019) *Technical Assistance: New Thinking on an Old Problem*. Agulhas Applied Knowledge.

Dasso, R. and Fernandez, F. (2015) 'The effects of electrification on employment in rural Peru', *IZA Journal of Labor & Development*, 4(1), p. 6. Available at: https://doi.org/10.1186/s40175-015-0028-4.

DBSA (2021) *Insights on Project Preparation and Development Capital in Africa and the ASEAN region*. Available at: https://www.dbsa.org/sites/default/files/media/documents/2021-03/DBSA%20SDIP%20insights%20into%20Project%20Preparations%20in%20Africa%20and%20ASIAN%20regions.pdf.

Department of International Development *et al.* (2018) *Turning Aid Delivery on its Head Fast-Tracking Institutional Development Through Peer-to-Peer Support*. Available at: https://gpgovernance.net/wp-content/uploads/2021/02/Conference-Report-NSGI-DFID-TBIFP.pdf (Accessed: 1 August 2024).

Dohoo, C. *et al.* (2013) 'Impact of biogas digesters on wood utilisation and self-reported back pain for women living on rural Kenyan smallholder dairy farms', *Global Public Health*, 8(2), pp. 221–235. Available at: https://doi.org/10.1080/17441692.2012.758299.

Donovan, C. and Corbishley, C. (2016) *The cost of capital and how it affects climate change mitigation investment*. Briefing paper No 15. London: Imperial College London, p. 16.

Downing, C. *et al.* (2021) 'The role of knowledge exchange in energy demand policy innovation', in. *European Council for an Energy Efficient Economy Summer Conference*. Available at: https://www.creds.ac.uk/publications/the-role-of-knowledge-exchange-in-energy-demand-policy-innovation/ (Accessed: 28 June 2024).

Duma, D. and Muñoz Cabré, M. (2023) *Risk mitigation for renewable energy investments in Sub-Saharan Africa: a review.* Stockholm Environment Institute.

Duma, D., Muñoz Cabré, M. and Kruger, W. (2023) *Risk mitigation and transfer for renewable energy investments: case studies in the Southern Africa Development Community.* Stockholm Environment Institute. Available at: https://www.sei.org/publications/risk-mitigation-renewable-energy-sadc/ (Accessed: 10 July 2023).

Eberhard, A. and Dyson, G. (2020) *What is the impact of investing in power?* CDC. Available at: https://assets.bii.co.uk/wp-content/uploads/2020/01/30151049/Whats-the-impact-of-investing-in-power.pdf (Accessed: 28 June 2024).

Effective Institutions Platform and National School of Government International (2018) *The future of peer-to-peer learning and partnerships in the new development agency.* Available at: https://www.effectiveinstitutions.org/files/The_Future_of_Peer_to_Peer_Partnerships_in_the_New_Development_Agenda.PDF (Accessed: 1 August 2024).

Egli, F. *et al.* (2023) 'The cost of electrifying all households in 40 Sub-Saharan African countries by 2030', *Nature Communications*, 14(1), p. 5066. Available at: https://doi.org/10.1038/s41467-023-40612-3.

EIB (2021) *Commercial & Economic Feasibility Study for Enhancing Off-Grid Solar Inclusion in Sub Saharan Africa*. Available at: https://www.eib.org/attachments/press/eib-ogs-finance-report-14062021.pdf (Accessed: 1 July 2024).

Elabbas, M.A.E., de Vries, L. and Correljé, A. (2023) 'African power pools and regional electricity market design: Taking stock of regional integration in energy sectors', *Energy Research & Social Science*, 105, p. 103291. Available at: https://doi.org/10.1016/j.erss.2023.103291.

ESMAP (2021) *Energy Sector Management Assistance Program Annual Report 2021*. World Bank. Available at: https://doi.org/10.1596/37888.

ESMAP (2022) *Mini grids for half a billion people: MarketOutlook and Handbook for Decision Makers*. International Bank for Reconstruction and Development / The World Bank. Available at: https://openknowledge.worldbank.org/server/api/core/bitstreams/32287154-1ccb-46ce-83af-08facf7a3b49/content (Accessed: 1 July 2024).

Frisari, G. and Micale, V. (2015) *Risk Mitigation Instruments for Renewable Energy in Developing Countries: A Case Study on Hydropower in Africa, CPI*. Available at: https://www.climatepolicyinitiative.org/publication/risk-mitigation-instruments-for-renewable-energy-in-developing-countries-a-case-study-on-hydropower-in-africa/ (Accessed: 1 December 2022).

G-20 Development Working Group (2015) 'Scaling Up Knowledge sharing for Development - A Working Paper for the G-20 Development Working Group'. Task Team on South-South Cooperation; UNDP; OECD; World Bank Institute. Available at: https://hdl.handle.net/10986/22985.

GDSI limited (2019) *Evaluation of the Twinning instrument in the period 2010-2017*. Available at: https://neighbourhood-enlargement.ec.europa.eu/document/download/0754c987-946c-483d-93c2-cfaad9d62a81_en?filename=final_report_-_volume_i.pdf (Accessed: 1 August 2024).

GET.Transform (2024) 'Introducing GET.transform'.

Gill-Wiehl, A., Kammen, D.M. and Haya, B.K. (2024) 'Pervasive over-crediting from cookstove offset methodologies', *Nature Sustainability*, 7(2), pp. 191–202. Available at: https://doi.org/10.1038/s41893-023-01259-6.

Gill-Wiehl, A., Ray, I. and Kammen, D. (2021) 'Is clean cooking affordable? A review', *Renewable and Sustainable Energy Reviews*, 151, p. 111537. Available at: https://doi.org/10.1016/j.rser.2021.111537.

Global Partnership Initiative (GPI) on Effective Triangular Co-operation (2019) *Triangular Co-Operation in the era of the 2030 agenda: Sharing evidence and stories from the field.*

Golumbeanu, R. and Barnes, D. (2013) 'Connection charges and electricity access in Sub-Saharan Africa', *Policy Research Working Paper Series* [Preprint]. Available at: https://ideas.repec.org//p/wbk/wbrwps/6511.html (Accessed: 30 June 2024).

Greencroft Economics (2022) *FMO's Contribution to the Off-Grid Electricity Sector*. FMO. Available at: https://www.fmo.nl/off-grid-sector-evaluation.

Greencroft Economics (2024) *Ex-post Evaluation of the Beyond the Grid Fund for Zambia (BGFZ)*. Available at: https://reeep.org/wp-content/uploads/2024/06/Ex-post-avaluation-of-BGFZ-Full-report-June-2024.pdf.

Gridworks (2023) *Private investment in transmission. Four business models for emerging markets*. Available at: https://gridworkspartners.com/wp-content/uploads/2023/05/Investment-in-Transmission-Gridworks.pdf.

Gualberti, G., Singer, C.E. and Bazilian, M. (2013) 'The capacity to spend development funds in the energy sector', *Utilities Policy*, 26, pp. 36–44. Available at: https://doi.org/10.1016/j.jup.2013.05.001.

Hagelsteen, M. and Becker, P. (2019) 'Systemic problems of capacity development for disaster risk reduction in a complex, uncertain, dynamic, and ambiguous world', *International Journal of Disaster Risk Reduction*, 36, p. 101102. Available at: https://doi.org/10.1016/j.ijdrr.2019.101102.

Hagelsteen, M., Becker, P. and Abrahamsson, M. (2021) 'Troubling partnerships: Perspectives from the receiving end of capacity development', *International Journal of Disaster Risk Reduction*, 59, p. 102231. Available at: https://doi.org/10.1016/j.ijdrr.2021.102231.

Harrison, K. et al. (2020) *Why off-grid energy matters: An impact performance report*. 60 decibels. Available at: https://60decibels.com/wp-content/uploads/2022/11/60-Decibels-Why-Off-Grid-Energy-Matters-1.pdf (Accessed: 6 August 2024).

Haselip, J., Desgain, D. and Mackenzie, G. (2015) 'Non-financial constraints to scaling-up small and medium-sized energy enterprises: Findings from field research in Ghana, Senegal, Tanzania and Zambia', *Energy Research & Social Science*, 5, pp. 78–89. Available at: https://doi.org/10.1016/j.erss.2014.12.016.

Haselip, J.A. *et al.* (2017) 'Reflections on experience with the global network on energy for sustainable development as a South–South global knowledge network', *Energy for Sustainable Development*, 36, pp. 37–43. Available at: https://doi.org/10.1016/j.esd.2016.11.002.

Hattori, T., Nam, H. and Chapman, A. (2022) 'Multilateral energy technology cooperation: Improving collaboration effectiveness through evidence from International Energy Agency Technology Collaboration Programmes', *Energy Strategy Reviews*, 43, p. 100920. Available at: https://doi.org/10.1016/j.esr.2022.100920.

Hirschhofer, H. (2022) *Four ways to make development finance fairer and more effective, Development Matters*. Available at: https://oecd-development-matters.org/2022/12/08/four-ways-to-make-development-finance-fairer-and-more-effective/ (Accessed: 11 January 2023).

ICF (2020) *External Evaluation of the Energy Sector Management Assistance Program (ESMAP): Final Evaluation Report.* Available at: https://www.esmap.org/sites/default/files/Documents/ESMAP%20Final%20Evaluation%20Report_2March2020.pdf.

ICF (2023) *External Performance Evaluation of the Power Africa Off-Grid Project*. USAID. Available at: https://arepoconsult.com/wp-content/uploads/2023/09/Evaluation-PAOP.pdf.

IEA (2023a) *Financing Clean Energy in Africa*. Paris: International Energy Agency. Available at: https://www.iea.org/reports/financing-clean-energy-in-africa.

IEA (2023b) *Scaling Up Private Finance for Clean Energy in Emerging and Developing Economies*. Paris: International Energy Agency. Available at: https://www.iea.org/reports/scaling-up-private-finance-for-clean-energy-in-emerging-and-developing-economies (Accessed: 10 January 2024).

IEG (2016) *World Bank Group Support to Electricity Access, FY2000-2014.* World Bank. Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/416421468196746577/main-report.

IFC (2023) *IFC Partners with Release by Scatec to Boost Clean and Affordable Power Generation in Africa, International Finance Corporation.* Available at: https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=27929 (Accessed: 26 March 2024).

Imam, M.I., Jamasb, T. and Llorca, M. (2019) 'Sector reforms and institutional corruption: Evidence from electricity industry in Sub-Saharan Africa', *Energy Policy*, 129, pp. 532–545. Available at: https://doi.org/10.1016/j.enpol.2019.02.043.

IMF (2023) *Ghana: Request for an Arrangement under the Extended Credit Facility.* International Monetary Fund. Available at: https://mofep.gov.gh/sites/default/files/basic-page/Ghana-2023-IMF-ECF-Programme.pdf.

Independent Development Evaluation (2018) *Powering Africa Through Interconnection: Cluster Evaluation Report.* Available at: https://idev.afdb.org/sites/default/files/Evaluations/2020-03/Power%20Interconnection%20project%20cluster%20evaluation%20EN.pdf.

Independent Development Evaluation (2019) *Evaluation of the African Development Bank's Program Based Operations: Energy Governance Cluster.* African Development Bank. Available at: https://idev.afdb.org/sites/default/files/Evaluations/2020-03/PBO%20-%20Energy%20Governance%20Cluster%20Evaluation-EN-%20Web.pdf.

Independent Development Evaluation (2020) *Evaluation of the AfDB's Assistance to the Energy Sector (1999-2018): Refocusing Support for Improved and Sustained Energy Access in Africa.* African Development Bank. Available at: https://idev.afdb.org/sites/default/files/documents/files/Energy%20Sector%20Evaluation%20-%2029-03-2021%20-%20Eng%20-%20Web.pdf.

Independent Evaluation Unit (2024) *Independent Evaluation of the Green Climate Fund's Energy Sector Portfolio and Approach.* GCF. Available at: https://ieu.greenclimate.fund/evaluation/ES2023.

International Energy Agency (2019) *Energy Technology Innovation Partnerships.* Paris, France. Available at: https://iea.blob.core.windows.net/assets/5809baaa-ebf4-4160-93d3-0f5d29602fad/Energy_Technology_Innovation_Partnerships.pdf (Accessed: 12 July 2024).

International Energy Agency (2021) *Expanding the global reach of the TCPs: A handbook for TCPs and other clean energy initiatives*. Paris, France: OECD Publishing.

IOB Evaluation (2013) *IOB Study - Renewable Energy. Access and Impact. A systematic literature review of the impact on livelihoods of interventions providing access to renewable energy in developing countries. - Report - Government. nl.* Ministerie van Algemene Zaken. Available at: https://www.government.nl/documents/reports/2013/03/01/iob-study-renewable-energy-access-and-impact (Accessed: 1 July 2024).

IRENA (2016) *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance.* Abu Dhabi: International Renewable Energy Agency, p. 148.

IRENA (2024) *Advancing renewables-based clean cooking solutions: Key messages and outcomes.* Available at: https://www.irena.org/Publications/2024/Mar/Advancing-renewables-based-clean-cooking-solutions-Key-messages-and-outcomes (Accessed: 1 July 2024).

IRENA and AfDB (2022) *Renewable Energy Market Analysis: Africa and Its Regions.* Abu Dhabi and Abidjan: International Renewable Energy Agency and African Development Bank. Available at: https://www.irena.org/Publications/2022/Jan/Renewable-Energy-Market-Analysis-Africa.

IRENA and CPI (2023) *Global Landscape of Renewable Energy Finance 2023.* IRENA. Available at: https://www.irena.org/Publications/2023/Feb/Global-landscape-of-renewable-energy-finance-2023.

IRENA and CPI (2020) *Global Landscape of Renewable Energy Finance 2020.* Abu Dhabi: International Renewable Energy Agency, p. 88.

ITPEnergised (2019) *Off-Grid Electricity in Africa Market Review and Opportunities for the UK and Japan.* Available at: https://www.itpenergised.com/wp-content/uploads/2019/08/Off-Grid-Electricity-Access-in-SSA-Japan-and-UK-Opportunities.pdf (Accessed: 1 July 2024).

Jain, P. and Bardhan, S. (2023) 'Some factors of energy aid volatility across developing countries: A special focus on renewable sector', *Energy Policy*, 178, p. 113596. Available at: https://doi.org/10.1016/j.enpol.2023.113596.

Jeuland, M. *et al.* (2022) *Barriers and Policy Solutions for Off-Grid Energy Development: Evidence from a Comparative Survey of Private Sector Developers in Eastern Africa.*

Jeuland, M.A. *et al.* (2020) 'Adoption and impacts of improved biomass cookstoves in rural Rajasthan', *Energy for Sustainable Development*, 57, pp. 149–159. Available at: https://doi.org/10.1016/j.esd.2020.06.005.

JPAL (2020) *Biomass cookstoves to reduce indoor air pollution and fuel use, The Abdul Latif Jameel Poverty Action Lab (J-PAL).* Available at: https://www.povertyactionlab.org/policy-insight/biomass-cookstoves-reduce-indoor-air-pollution-and-fuel-use (Accessed: 1 July 2024).

Kablan, S. and Chouard, V. (2022) 'Does climate aid matter for reducing CO2 emissions? The case of foreign aid for renewable energy', *Applied Economics,* 54(46), pp. 5357–5372. Available at: https://doi.org/10.1080/00036846.2022.2044995.

Karanja, A. and Gasparatos, A. (2019) 'Adoption and impacts of clean bioenergy cookstoves in Kenya', *Renewable and Sustainable Energy Reviews*, 102, pp. 285–306. Available at: https://doi.org/10.1016/j.rser.2018.12.006.

Karumba, M.M. and Muchapondwa, E. (2017) 'The Impact of Micro Hydroelectricity on Household Welfare Indicators'. Available at: https://gupea.ub.gu.se/handle/2077/66053 (Accessed: 1 July 2024).

Keijzer, N. (2020) *Cooperation Opportunities in a Knowledge-Intensive World.* UNDP. Available at: https://www.undp.org/sites/g/files/zskgke326/files/migration/seoul_policy_center/Knowledge-Sharing-Paper-Final.pdf.

Kennedy, M. and Basu, B. (2013) 'Overcoming barriers to low carbon technology transfer and deployment: An exploration of the impact of projects in developing and emerging economies', *Renewable and Sustainable Energy Reviews*, 26, pp. 685–693. Available at: https://doi.org/10.1016/j.rser.2013.05.071.

KfW (2020) *Mobilising private capital for grid-connected renewable power in developing countries – Lessons learnt.* Kreditanstalt für Wiederaufbau. Available at: https://www.kfw-entwicklungsbank.de/PDF/Evaluierung/Themenbezogene-Evaluierungen/Nr11_Evaluation-update_Mobilising-private-capital_E.pdf.

KFW, GIZ, and IRENA (2021) *The Renewable Energy Transition in Africa: Powering Access, Resilience and Prosperity.* Frankfurt am Main, Eschborn, Abu Dhabi: KfW Development Bank, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, IRENA.

Khandker, S.R., Barnes, D.F. and Samad, H.A. (2009) 'Welfare Impacts of Rural Electrification: A Case Study from Bangladesh'. Rochester, NY. Available at: https://papers.ssrn.com/abstract=1368068 (Accessed: 1 July 2024).

Kim, J.E. (2018) 'Technological capacity building through energy aid: Empirical evidence from renewable energy sector', *Energy Policy*, 122, pp. 449–458. Available at: https://doi.org/10.1016/j.enpol.2018.07.003.

Kojima, M., Bacon, R. and Trimble, C. (2014) *Political Economy of Power Sector Subsidies : A Review with Reference to Sub-Saharan Africa.* World Bank. Available at: https://openknowledge.worldbank.org/entities/publication/429bb0ae-3a95-5e08-bcbc-aa1cb6365eba.

Kruckenberg, L.J. (2015) 'North–South partnerships for sustainable energy: Knowledge–power relations in development assistance for renewable energy', *Energy for Sustainable Development*, 29, pp. 91–99. Available at: https://doi.org/10.1016/j.esd.2015.10.003.

Kruger, W. and Alao, O. (2024) *Driving Growth: Effective Renewable Energy Tendering in Africa.* Get.transform. Available at: https://www.get-transform.eu/wp-content/uploads/2024/05/Effective-RE-Tendering-in-Africa_May24.pdf.

Kruger, W. and Eberhard, A. (2019) *Zambia Country Report.*

Kruger, W., Eberhard, A. and Swartz, K. (2018) *Uganda Country Report.* University of Cape Town Power Futures Lab. Available at: https://www.gsb.uct.ac.za/files/Uganda_Auction_Report.pdf.

Kumar, N. (2020) 'Social Business Model and its Efficacy: A Case Study on Agroforestry in the Indian Context', *Journal of Entrepreneurship and Innovation in Emerging Economies*, 6(1), pp. 195–219. Available at: https://doi.org/10.1177/2393957519899568.

Kwakwa, P.A. *et al.* (2021) 'Towards the attainment of sustainable development goal 7: what determines clean energy accessibility in sub-Saharan Africa?', *Green Finance*, 3(3), pp. 268–286. Available at: https://doi.org/10.3934/GF.2021014.

Larkin, J., Gardiner, M. and Gulati, M. (2023) *Mid-Term Evaluation of Climate Investor One: Final report.* SQ Consult. Available at: https://www.fmo.nl/l/en/library/download/urn:uuid:26c8b96d-a562-43bb-b5c7-5b57964154d5/cio+mte+final+report+sq+consult+v2+10-23.pdf (Accessed: 28 June 2024).

Lee, K., Miguel, E. and Wolfram, C. (2016a) 'Appliance Ownership and Aspirations among Electric Grid and Home Solar Households in Rural Kenya', *American Economic Review*, 106(5), pp. 89–94. Available at: https://doi.org/10.1257/aer.p20161097.

Lee, K., Miguel, E. and Wolfram, C. (2016b) 'Experimental Evidence on the Demand for and Costs of Rural Electrification'. National Bureau of Economic Research (Working Paper Series). Available at: https://doi.org/10.3386/w22292.

Lee, K., Miguel, E. and Wolfram, C. (2020) 'Does Household Electrification Supercharge Economic Development?', *Journal of Economic Perspectives*, 34(1), pp. 122–144. Available at: https://doi.org/10.1257/jep.34.1.122.

Lemma, A. *et al.* (2016) *What Are the Links between Power Economic Growth and Job Creation.* London: CDC. Available at: https://assets.cdcgroup.com/wp-content/uploads/2016/01/25150848/Links-between-power-economic-growth-and-job-creation.pdf.

Lenz, L. *et al.* (2017) 'Does Large-Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program', *World Development*, 89, pp. 88–110. Available at: https://doi.org/10.1016/j.worlddev.2016.08.003.

Lindgren, S.A. (2020) 'Clean cooking for all? A critical review of behavior, stakeholder engagement, and adoption for the global diffusion of improved cookstoves', *Energy Research & Social Science*, 68, p. 101539. Available at: https://doi.org/10.1016/j.erss.2020.101539.

Lipscomb, M., Mobarak, A.M. and Barham, T. (2013) 'Development Effects of Electrification: Evidence from the Topographic Placement of Hydropower Plants in Brazil', *American Economic Journal: Applied Economics*, 5(2), pp. 200–231. Available at: https://doi.org/10.1257/app.5.2.200.

Lund, C., Odgaard, R. and Sjaastad, E. (2006) *Land Rights and Land Conflicts in Africa: A review of issues and experiences.* Danish Institute for International Studies. Available at: https://pure.diis.dk/ws/files/68278/Land_rights_and_land_conflicts_in_Africa_a_review_of_issues_and_experiences.pdf.

Lundsgaarde, E. and Keijzer, N. (2019) 'Development Cooperation in a Multilevel and Multistakeholder Setting: From Planning towards Enabling Coordinated Action?', *The European Journal of Development Research*, 31(2), pp. 215–234. Available at: https://doi.org/10.1057/s41287-018-0143-6.

Mazorra, J. *et al.* (2020) 'A comprehensive analysis of cooking solutions co-benefits at household level: Healthy lives and well-being, gender and climate change', *Science of The Total Environment*, 707, p. 135968. Available at: https://doi.org/10.1016/j.scitotenv.2019.135968.

McLean, E.V. *et al.* (2019) 'Country-level analysis of household fuel transitions', *World Development*, 114, pp. 267–280. Available at: https://doi.org/10.1016/j.worlddev.2018.10.006.

McPherson, M. *et al.* (2018) 'Planning for variable renewable energy and electric vehicle integration under varying degrees of decentralization: A case study in Lusaka, Zambia', *Energy*, 151, pp. 332–346. Available at: https://doi.org/10.1016/j.energy.2018.03.073.

Moss, T. and Kincer, J. (2023) *How does energy impact economic growth? An overview of the evidence, Energy for Growth Hub.* Available at: https://energyforgrowth.org/article/how-does-energy-impact-economic-growth-an-overview-of-the-evidence/ (Accessed: 1 July 2024).

Norad (2021) *Oil for Development Annual Report 2020.* Available at: https://www.norad.no/publikasjoner/2021/oil-for-development---annual-report-2020/ (Accessed: 5 September 2024).

Norad (2024) *Energy for sustainable development annual report 2013.* Available at: https://www.norad.no/publikasjoner/2014/energy-for-sustainable-development---annual-report-2013/.

Norad Evaluation Unit (2012) *Facing the Resource Curse: Norway's Oil for Development Program.* Available at: https://www.norad.no/publikasjoner/2013/facing-the-resource-curse-norways-oil-for-development-program/ (Accessed: 5 September 2024).

Nordic Consulting Group (2021) *The Power Africa Project at Sida: Innovative investment mobilisation for fossil-free electrification. A Mid-Term Evaluation 2015-2019.* Sida. Available at: https://www.sida.se/en/publications/the-power-africa-project-at-sida-innovative-investment-mobilisation-for-fossil-free-electrification-a-mid-term-evaluation-2015-2019.

Nussbaumer, P., Bazilian, M. and Modi, V. (2012) 'Measuring energy poverty: Focusing on what matters', *Renewable and Sustainable Energy Reviews*, 16(1), pp. 231–243. Available at: https://doi.org/10.1016/j.rser.2011.07.150.

Nyarko, K., Whale, J. and Urmee, T. (2023) 'Drivers and challenges of off-grid renewable energy-based projects in West Africa: A review', *Heliyon*, 9(6), p. e16710. Available at: https://doi.org/10.1016/j.heliyon.2023.e16710.

OECD (2015) *Policy dialogue, knowledge sharing and engaging in mutual learning.* OECD Working Paper. Available at: https://web.archive.org/web/20221006201729/https:/www.oecd.org/knowledge-sharing-alliance/OECD-Post-2015_Policy-Dialogue-Knowledge-Sharing-and-Engaging-in-mutual-learning.pdf (Accessed: 28 June 2024).

Ørnemark (2020) *Lessons harvesting: Learning from P2P engagements.* Available at: https://www.effectiveinstitutions.org/files/EIP_Lessons_Harvesting_Final_Version.pdf (Accessed: 1 August 2024).

Osei-Gyebi, S. and Dramani, J.B. (2023) 'Firm performance in sub-Saharan Africa: What role do electricity shortages play?', *Cogent Economics & Finance*, 11(2), p. 2251822. Available at: https://doi.org/10.1080/23322039.2023.2251822.

Pachauri, S. and Rao, N.D. (2013) 'Gender impacts and determinants of energy poverty: are we asking the right questions?', *Current Opinion in Environmental Sustainability*, 5(2), pp. 205–215. Available at: https://doi.org/10.1016/j.cosust.2013.04.006.

Peters, J. and Sievert, M. (2015) 'Impacts of Rural Electrification Revisited: The African Context', *Revue d'économie du développement*, 23(HS), pp. 77–98. Available at: https://doi.org/10.3917/edd.hs03.0077.

Probst, B. et al. (2020) *Attracting Private Solutions and Participation in the Power Sector in Sub-Saharan Africa: Findings from a Survey of Investors and Financiers.* World Bank. Available at: https://openknowledge.worldbank.org/entities/publication/0e051617-3463-521f-b6a0-13e632fa377f.

Pueyo, A. (2018) 'What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana', *World Development*, 109, pp. 85–100. Available at: https://doi.org/10.1016/j.worlddev.2018.04.008.

Pueyo, A. and Maestre, M. (2019) 'Linking energy access, gender and poverty: A review of the literature on productive uses of energy', *Energy Research & Social Science*, 53, pp. 170–181. Available at: https://doi.org/10.1016/j.erss.2019.02.019.

Puzzolo, E. and Pope, D. (2017) 'Clean Fuels for Cooking in Developing Countries', in *Encyclopedia of Sustainable Technologies*. Elsevier, pp. 289–297. Available at: https://doi.org/10.1016/B978-0-12-409548-9.10153-8.

Pye, A. *et al.* (2020) 'Drivers of the Adoption and Exclusive Use of Clean Fuel for Cooking in Sub-Saharan Africa: Learnings and Policy Considerations from Cameroon', *International Journal of Environmental Research and Public Health*, 17(16), p. 5874. Available at: https://doi.org/10.3390/ijerph17165874.

Quitzow, R. *et al.* (2016) *Mapping of Energy Initiatives and Programs in Africa.* European Union Energy Initiative Partnership Dialogue Facility. Available at: https://africa-eu-energy-partnership.org/wp-content/uploads/2020/04/01_mapping_of_initiatives_final_report_may_2016.pdf (Accessed: 28 June 2024).

Rahman, K. (2020) *Anti-corruption in the renewable energy sector.* Transparency International. Available at: https://www.u4.no/publications/anti-corruption-in-the-renewable-energy-sector.pdf.

Rahman, Md.M. *et al.* (2016) 'Multicriteria-based decision aiding technique for assessing energy policy elements-demonstration to a case in Bangladesh', *Applied Energy*, 164, pp. 237–244. Available at: https://doi.org/10.1016/j.apenergy.2015.11.091.

Rathi, S.S. and Vermaak, C. (2018) 'Rural electrification, gender and the labor market: A cross-country study of India and South Africa', *World Development*, 109, pp. 346–359. Available at: https://doi.org/10.1016/j.worlddev.2018.05.016.

RES4Africa (2020) *Scaling up Africa's renewable power: the need for de-risking investments and the case for RENEWAFRICA.* Rome.

RES4Africa (2021) *Private Sector Participation in African Grid Development.* Available at: https://res4africa.org/wp-content/uploads/2023/04/PrivateSectorParticipationinAfricanGridDevelopment-RES4AfricaNovember20212.pdf.

Rinaldi, F. *et al.* (2021) 'Economic feasibility analysis and optimization of hybrid renewable energy systems for rural electrification in Peru', *Clean Technologies and Environmental Policy*, 23(3), pp. 731–748. Available at: https://doi.org/10.1007/s10098-020-01906-y.

Riva, F. *et al.* (2018) 'Electricity access and rural development: Review of complex socio-economic dynamics and causal diagrams for more appropriate energy modelling', *Energy for Sustainable Development*, 43, pp. 203–223. Available at: https://doi.org/10.1016/j.esd.2018.02.003.

Rom, A., Günther, I. and Harrison, K. (2017) *The Economic Impact of Solar Lighting: Results from a randomised field experiment in rural Kenya.* ETH Zürich. Available at: https://ethz.ch/content/dam/ethz/special-interest/gess/nadel-dam/documents/research/Solar%20Lighting/17.02.24_ETH%20report%20on%20economic%20impact%20of%20solar_summary_FINAL.pdf.

Rosenthal, J. *et al.* (2018) 'Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals', *Energy for Sustainable Development*, 42, pp. 152–159. Available at: https://doi.org/10.1016/j.esd.2017.11.003.

Ryan, H.E. and Mazzilli, C. (2023) 'Twinning and development: a genealogy of depoliticisation', *Journal of International Relations and Development*, pp. 1–20. Available at: https://doi.org/10.1057/s41268-023-00289-z.

Samad, H. and Portale, E. (2019) 'Have Improved Cookstoves Benefitted Rural Kenyans?', *World Bank Publications - Reports* [Preprint]. Available at: https://ideas.repec.org//p/wbk/wboper/32122.html (Accessed: 1 July 2024).

San, B. and Karim, K. (2022) *Enhancing coordination between European donors, development agencies and DFIs/PDBs: insights and recommendations.* European Think Tanks Group. Available at: https://ettg.eu/wp-content/uploads/2022/09/Enhancing-coordination-between-European-donors-ETTG-brief-september-2022.pdf (Accessed: 11 July 2024).

Schunder, T. and Bagchi-Sen, S. (2019) 'Understanding the household cooking fuel transition', *Geography Compass*, 13(11), p. e12469. Available at: https://doi.org/10.1111/gec3.12469.

Scott, A. *et al.* (2016) *Accelerating access to electricity in Africa with off-grid solar*. ODI. Available at: http://cdn-odi-production.s3-website-eu-west-1.amazonaws.com/media/documents/10246.pdf.

SE4ALL and CPI (2020) *Energizing Finance: Understanding the landscape*. Sustainable Energy for all and the Climate Policy Institute. Available at: https://www.seforall.org/system/files/2020-11/EF-2020-UL-SEforALL_0.pdf (Accessed: 17 May 2022).

Shankar, A.V. *et al.* (2020) 'Everybody stacks: Lessons from household energy case studies to inform design principles for clean energy transitions', *Energy Policy*, 141, p. 111468. Available at: https://doi.org/10.1016/j.enpol.2020.111468.

Sida (2020) 'Africa-a-market-for-energy-services.pdf', *Africa – a market for energy services*. Available at: https://cdn.sida.se/app/uploads/2020/12/16072414/Africa-a-market-for-energy-services.pdf (Accessed: 1 July 2024).

Sievert, M. (2015) 'Rural Electrification and Domestic Violence in Sub-Saharan Africa', *SSRN Electronic Journal* [Preprint]. Available at: https://doi.org/10.2139/ssrn.2706469.

Sievert, M. and Steinbuks, J. (2020) 'Willingness to pay for electricity access in extreme poverty: Evidence from sub-Saharan Africa', *World Development*, 128, p. 104859. Available at: https://doi.org/10.1016/j.worlddev.2019.104859.

Simon, G.L. *et al.* (2014) 'Current debates and future research needs in the clean cookstove sector', *Energy for Sustainable Development*, 20, pp. 49–57. Available at: https://doi.org/10.1016/j.esd.2014.02.006.

Social Impact (2022) *Southern Africa Energy Program Evaluation Report.* USAID.

Stern, D.I., Burke, P.J. and Bruns, S.B. (2019) *The Impact of Electricity on Economic Development: A Macroeconomic Perspective.* UC Berkeley: Center for Effective Global Action. Available at: https://escholarship.org/uc/item/7jb0015q#author.

Steward Redqueen (2016) *What-is-the-Link-between-Power-and-Jobs-in-Uganda.pdf.* Available at: https://www.stewardredqueen.com/wp-content/uploads/2019/01/What-is-the-Link-between-Power-and-Jobs-in-Uganda.pdf (Accessed: 1 July 2024).

Steward Redqueen (2017) 'What is the link between power and economic development?', *Steward Redqueen*. Available at: https://www.stewardredqueen.com/insights/blogs/what-is-the-link-between-power-and-economic-development/ (Accessed: 30 June 2024).

Steward Redqueen (2019) *Power Investments & Welfare Benefits. Describing Pathways to Impact from a Literature Review.* Finnfund. Available at: https://www.finnfund.fi/wp-content/uploads/2019/08/Power-and-Welfare-Literature-Review-July-2019.pdf.

Stritzke, S. *et al.* (2023) 'Impact Financing for Clean Cooking Energy Transitions: Reviews and Prospects', *Energies*, 16(16), p. 5992. Available at: https://doi.org/10.3390/en16165992.

Stritzke, S., Trotter, P.A. and Twesigye, P. (2021) 'Towards responsive energy governance: Lessons from a holistic analysis of energy access in Uganda and Zambia', *Energy Policy*, 148, p. 111934. Available at: https://doi.org/10.1016/j.enpol.2020.111934.

Thillairajan, A., Deep, A. and Gómez-Ibáñez, J.A. (2012) *Impact of changes in the transparency of infrastructure procurement and delivery on infrastructure access, costs, efficiency, price and quality: a systematic review of the evidence in developing countries.* EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Toman, M. *et al.* (2018) 'Electricity Access and Economic Development in Africa: Options for Accelerating Progress', in. Available at: https://www.iaee.org.

Toman, M. and Peters, J. (2017) *Rural electrification: How much does Sub-Saharan Africa need the grid?, World Bank Blogs.* Available at: https://blogs.worldbank.org/en/developmenttalk/rural-electrification-how-much-does-sub-saharan-africa-need-grid (Accessed: 22 June 2024).

Trimble, C. *et al.* (2016) *Financial Viability of Electricity Sectors in Sub-Saharan Africa.* World Bank. Available at: https://openknowledge.worldbank.org/server/api/core/bitstreams/55677998-2cdf-5ebf-a866-dd45b8e5cfd1/content.

Trinomics (2018) *Off-grid solar in Kenya: Market potential and development impacts.* Available at: https://www.fmo.nl/technical-assistance-energy-resources.

Trotter, P.A. (2019) 'Ambitions versus policy design: Addressing issues of the Power Africa initiative's quantitative targets', *Energy Policy*, 128, pp. 900–906. Available at: https://doi.org/10.1016/j.enpol.2019.01.035.

Trotter, P.A., Cooper, N.J. and Wilson, P.R. (2019) 'A multi-criteria, long-term energy planning optimisation model with integrated on-grid and off-grid electrification – The case of Uganda', *Applied Energy*, 243, pp. 288–312. Available at: https://doi.org/10.1016/j.apenergy.2019.03.178.

Trotter, P.A., McManus, M.C. and Maconachie, R. (2017) 'Electricity planning and implementation in sub-Saharan Africa: A systematic review', *Renewable and Sustainable Energy Reviews*, 74, pp. 1189–1209. Available at: https://doi.org/10.1016/j.rser.2017.03.001.

Twesigye, P. (2023) 'Understanding structural, governance and regulatory incentives for improved utility performance: Learning from Umeme Ltd in Uganda', *Energy Research & Social Science*, 95, p. 102900. Available at: https://doi.org/10.1016/j.erss.2022.102900.

UN (2023) *Achieving universal access and net-zero emissions by 2050.* Available at: https://www.who.int/publications/m/item/achieving-universal-access-by-2030-and-net-zero-emissions-by-2050-a-global-roadmap-for-just-and-inclusive-clean-cooking-transition (Accessed: 1 July 2024).

UN (no date) *Goal 7 | Department of Economic and Social Affairs.* Available at: https://sdgs.un.org/goals/goal7#targets_and_indicators (Accessed: 1 July 2024).

UNESCAP (2021) *Systematic-Review-of-the-Socio-economic-Impacts-of-Rural-Electrification 26 Feb. pdf.* Available at: https://www.unescap.org/sites/default/d8files/knowledge-products/Systematic-Review-of-the-Socio-economic-Impacts-of-Rural-Electrification%2026%20Feb.pdf (Accessed: 1 July 2024).

UNGA (2015) 'Resolution A/RES/69/313 - Addis Ababa Action Agenda of the Third International Conference on Financing for Development'. Available at: https://undocs.org/A/RES/69/313.

US Department of Commerce (2021) *Understanding Power Transmission Financing.* United States Department of Commerce. Available at: https://cldp.doc.gov/sites/default/files/2021-10/Understanding_Transmission_Financing.pdf.

USAID (2018) *Review Study of the Zambia Scaling Solar Program.* USAID. Available at: https://pdf.usaid.gov/pdf_docs/PA00ZX2Z.pdf.

USAID (2022) *Off-Grid Energy Access (OGEA): A Learning Guide from the USAID Southern Africa Energy Program.*

Van De Walle, D. *et al.* (2013) *Long-Term Impacts of Household Electrification in Rural India.* The World Bank (Policy Research Working Papers). Available at: https://doi.org/10.1596/1813-9450-6527.

WHO (2023) *Household air pollution.* Available at: https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health (Accessed: 1 July 2024).

Wolde-Rufael, Y. (2009) 'Energy consumption and economic growth: The experience of African countries revisited', *Energy Economics*, 31(2), pp. 217–224. Available at: https://doi.org/10.1016/j.eneco.2008.11.005.

World Bank (2016) *World Bank Group Guarantee Products.* Available at: https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/documents/PPPCCSA_WBGGuarantees_Final%20_%20English%20_Printed%20Oct%202016.pdf.

World Bank (2017) *Linking Up: Public-Private Partnerships in Power Transmission in Africa.* World Bank. Available at: https://openknowledge.worldbank.org/server/api/core/bitstreams/2aa0efdd-f47f-5f9c-b8a6-042e891b2c2c/content.

World Bank (2020) *Public Utility Reform: What Lessons Can We Learn from IEG Evaluations in the Energy and Water Sectors?* World Bank. Available at: https://doi.org/10.1596/35076.

World Health Organization (2014) *WHO guidelines for indoor air quality: household fuel combustion.* World Health Organization. Available at: https://iris.who.int/handle/10665/141496 (Accessed: 1 July 2024).

Wörlen, C. *et al.* (2023) *External Performance Evaluation of the Power Africa Off-Grid Project (PAOP).* ICF.

Zapf, M., Refaeil, N. and de Leon, B.A. (2019) 'Comprehensive Capacity Development: Moving Beyond Training as the Default', *Journal of Peacebuilding & Development*, 14(3), pp. 340–344. Available at: https://doi.org/10.1177/1542316619871231.

Zebra, E.I.C. *et al.* (2023) 'Scaling up the electricity access and addressing best strategies for a sustainable operation of an existing solar PV mini-grid: A case study of Mavumira village in Mozambique', *Energy for Sustainable Development*, 72, pp. 58–82. Available at: https://doi.org/10.1016/j.esd.2022.11.012.