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Derisking Renewable Energy Investment: Off-Grid Electrification

A Framework to Support Policymakers in Selecting Public Instruments to Promote Private Investment in Solar PV-Battery Mini-Grids in Developing Countries

EXECUTIVE SUMMARY & DERISKING TABLE

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ETH Zurich, Energy Politics Group
Haldeneggsteig 4
CH-8092 Zurich, Switzerland
www.epg.ethz.ch

Authors (UNDP): Oliver Waissbein, Hande Bayraktar and Christoph Henrich.

Authors (ETH Zurich): Tobias S. Schmidt and Abhishek Malhotra.

Contributors: Marcel Alers (UNDP), Léonore Haelg (ETH), Claire Jin (UNDP, intern) and Usha Rao (UNDP).

External reviewers: Subhes Bhattacharyya, Courtney Blodgett, Sagar Gubbi and Hisham Zerriffi.

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This publication builds on the original *Derisking Renewable Energy Investment* (UNDP, 2013) report, which established the methodology which has now been tailored to solar PV-battery mini-grids in this publication. For further information, please visit undp.org/DREI

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Design: Camilo J. Salomon (camilo.salomon@optonline.net, www.cjsalomon.com)

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This document is an abbreviated version of the full report, and is composed of the following:

- Acronyms
- Executive Summary
- Derisking Table for Solar Mini-Grids

The full report is available at www.undp.org/DREI

Acronyms

ARPU	Average revenue per user
BAU	Business-as-usual
BDA	Business development advisor
BNEF	Bloomberg New Energy Finance
BOO	Build-own-operate
CAPEX	Capital expenditure
CO_2	Carbon dioxide
DC	Direct current
DFI	Development finance institution
DREI	Derisking Renewable Energy Investment
ECN	Energy Research Centre of the Netherlands
EPC	Engineering, procurement and construction
ESMAP	Energy Sector Management Assistance Program
F/X	Foreign exchange
FDI	Foreign direct investment
FY	Financial year
GDP	Gross domestic product
GCF	Green Climate Fund
GEF	Global Environment Facility
GIS	Geographic Information System
GHG	Greenhouse gas
GTF	Global Tracking Framework
GW	Gigawatt
HDI	Human Development Index
ICT	Information and communication technology
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPP	Independent power producer
IRENA	International Renewable Energy Agency
kW	Kilowatt
kWh	Kilowatt-hour
LCOE	Levelised cost of electricity

LCD	Liquid crystal display
LED	Light-emitting diode
LIC	Low-income country
MECE	Mutually Exclusive, Collectively Exhaustive
MG	Mini-grid
MTF	Multi Tier Framework (on electricity access)
MW	Megawatt
NAMA	Nationally Appropriate Mitigation Action
NREL	National Renewable Energy Laboratory
O&M	Operations and maintenance
ONSSET	Open Source Spatial Electrification Toolkit
OM	Operating margin
OPEX	Operational expenditure
PAYG	Pay-as-you-go
PPA	Power purchase agreement
PPP	Purchasing power parity
PRI	Political risk insurance
PV	Photovoltaic
RE	Renewable energy
SDG	Sustainable Development Goal
SEforAll	Sustainable Energy for All
SHS	Solar home system
TPO	Third party ownership
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UP	Uttar Pradesh
USD	United States Dollar
VAT	Value-Added Tax

Executive Summary

Executive Summary

The objective of this report is to support policymakers in identifying cost-effective public instruments to promote private investment in solar PV-battery mini-grids in developing countries.

This report expands UNDP's existing *Derisking Renewable Energy Investment* (DREI) framework (UNDP, 2013) to solar mini-grids. The report introduces methodological concepts and tools, including an open source Excel-based LCOE tool, and then sets out the results of two illustrative case studies in Uttar Pradesh, India and in Kenya. This report has been prepared by UNDP in collaboration with ETH Zurich.

Opportunity for off-grid renewable energy

Worldwide, around 1 billion people currently lack access to electricity as of 2016 (WB, 2018; IEA, 2017), of which 87% live in rural areas (WB, 2018). Electrifying this population can pay huge dividends in terms of human development.

A real opportunity exists in the coming years to meet this challenge with private sector solutions for off-grid renewable energy, either via solar photovoltaic (PV)-battery mini-grids (solar mini-grids) or solar home systems (SHS). Three key trends are converging behind this opportunity: first, continued reductions in hardware costs – in solar modules, batteries and energy efficient appliances; second, a digital revolution, with mobile communication technology facilitating payments and monitoring, as well as new fintech solutions (for example, end-user credit assessment); and third, innovation in business models, such as pay-as-you go (PAYG) and third-party ownership for solar home systems, which offer energy as a service, and can remove previously prohibitive up-front costs for households.

A remaining challenge is to increase investment from current levels. If universal electrification is to be achieved by 2030, it is estimated that USD 52 billion in annual investment will be needed (IEA, 2017). In solar mini-grids, nearly all current investment is financed through grants and non-commercial, patient equity. In PAYG solar home systems, financing is further advanced, and tier 1 companies are now beginning to access debt, albeit often at favourable, not fully commercial terms. If off-grid electrification is to truly scale, there is a need to access commercial debt financing at large volumes. In the longer term, developing domestic, local-currency sources of financing – to avoid foreign exchange risk – will also be key.

> "If universal electrification is to be achieved by 2030, it is estimated that USD 52 billion in annual investment will be needed."

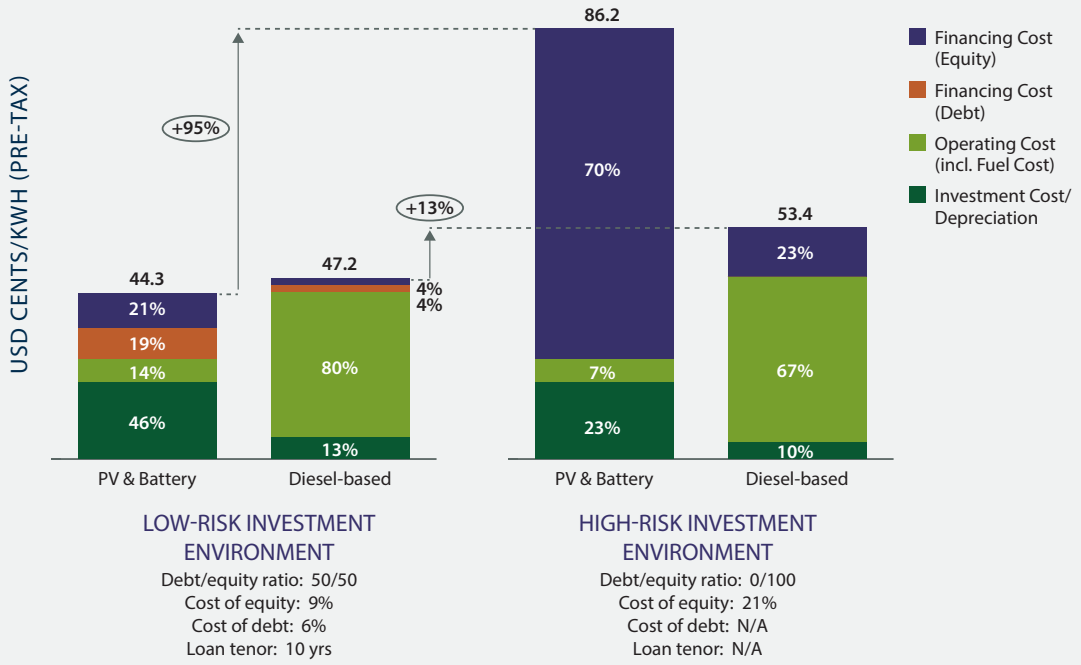
In a private-sector led, fast-moving context, government efforts to support such off-grid renewable energy solutions have often, to date, been lagging. Private sector actors often express indifference with current regulations, and point to burdensome or poorly-formulated public measures. This report seeks to specifically address this policy gap for solar mini-grids, providing policymakers with guidance on implementing systematic, well-designed public instruments – seeking to intelligently support and grow the sector as it evolves into a mature market.

DREI framework for solar mini-grids

A central focus of the *Derisking Renewable Energy Investment* (DREI) framework described in this report is on private sector financing costs – an investment's capital structure, and investors' required return on equity and debt. As illustrated in Figure E.1, due to their capital intensity, solar mini-grids are penalized in high financing cost environments. Developing countries often exhibit high financing costs for renewable energy due to investment risks that can exist in early-stage markets. An opportunity is for policymakers to systematically address these investment risks, lowering financing costs and leading to competitive investment.

"Due to their capital intensity, solar mini-grids are penalized in high financing cost environments."

Figure E.1: Impact of financing costs on solar PV-battery and diesel-powered mini-grids' generation cost in low and high-risk investment environments[1]



Source: Authors' modelling.

There are both public and private strategies to address investment risks. The DREI framework is concerned with public strategies, and identifies three central ways – often used in combination – that the public sector can improve the risk-return profile of private sector investment opportunities:

"Public instruments to promote off-grid electrification can either *reduce, transfer or compensate* for investment risks."

- **Reducing risk**, targeting underlying barriers that create investment risk. These instruments are typically policies, such a legislation, or technical programmes ("policy derisking")
- **Transferring risk**, shifting risk from the private to public sector. These include instruments such as guarantees, or credit lines to commercial banks for on-lending ("financial derisking")
- **Compensating for risk**, increasing the return of investments. These are typically targeted subsidies for renewable energy ("direct financial incentives")

Private sector derisking strategies can be an important complement, and sometimes in early-stage markets, a substitute, to public efforts to address risks. As solar mini-grid markets mature, an opportunity also exists for **diversifying risk** through aggregation of multiple mini-grid assets ("portfolio derisking").

[1] All assumptions – except for financing terms - are kept constant between the low-risk and high-risk investment environment; Generation costs only; Assumes equal annual electricity output; Solar PV Size @ 15 kWp, Li-ion battery size @ 41 kWh, Diesel System Size @ 6 kW, Investment Life= 20 years, Replacement: Battery (10 years), Inverters (10 years), Generator (10 years), Diesel Fuel Price: $0.70/L, Inflation: 2%; Note that operating costs are lower in the high-risk investment environment due to higher discounting effect.

This report introduces a derisking table for solar mini-grids (see Chapter 4), with the aim of providing some structure for policymakers in understanding investment risks and selecting public instruments to promote solar mini-grid investment. The derisking table introduces a taxonomy of nine independent investment risks, 21 underlying barriers, and associated stakeholder groups. It then sets out matching policy and financial derisking instruments.

A key theme in the report is that public measures for solar mini-grids can be phased, targeting different stages as solar mini-grid markets mature. In this regard, one of the report's recommendations is that policymakers consider implementing a dual-regulatory regime for solar mini-grids (see Box 4.1), establishing two parallel regimes at the same time.

"A key theme in the report is that public measures for solar mini-grids can be phased, targeting different stages as solar mini-grid markets mature."

- A **light-touch regime** with minimal regulatory burden for private sector actors – with no concessions, and simple self-registration by mini-grid operators – can allow operators to move fast and can promote experimentation in business models, but will likely be limited to equity financing.
- A **comprehensive regime** – offering exclusive concessions, the possibility of subsidies to operators, with related regulated tariffs, and compensation in case of grid expansion - can provide a favourable regulatory environment, in turn attracting debt financing.

Importantly, mini-grid operators active under the light-touch regime can graduate to the comprehensive regime via a right-of-first-refusal. Overall, by implementing both tracks simultaneously, governments can provide flexibility to build their own administrative capacity, and can best facilitate innovation and evolution as the mini-grid sector grows, in particular as it moves to scale with eventual commercial debt financing.

Case studies – overview and business model

In order to demonstrate the new DREI framework for solar mini-grids, the report applies the methodology to two case studies, in the state of Uttar Pradesh, India and in Kenya.

"The report applies the DREI methodology to two case studies, in the state of Uttar Pradesh, India and in Kenya."

Each of the case studies assumes a government deployment target for solar mini-grids, to be achieved in the period from 2018 to 2023. This is a private sector investment target, which is assumed will be met with commercial financing. The report's 2023 target for Uttar Pradesh, India amounts to 25,000 mini-grids (323 MW total), serving 15 million people; in Kenya the target is 8,000 mini-grids (77 MW total), serving 3.52 million people. In both cases, this equates to 10% of the unelectrified population by 2023.

Uttar Pradesh, India and Kenya have been selected for the case studies as they are both currently promising centres for solar mini-grids, with initial government policies in place, and active private sector developers. They can also act as an interesting comparison: Uttar Pradesh, India has lower irradiation, subsidised grid-connected tariffs, and the modelling assumes local currency financing; Kenya has higher irradiation, a digital finance culture, and assumed hard currency financing. Both cases studies have no diesel subsidies.

The private sector today is experimenting with a wide variety of solar mini-grid models. For modelling purposes, the case studies assume generic 13 kW (Uttar Pradesh) and 10 kW (Kenya) system sizes, with a

40 kWh battery (lithium-ion)[2]. This assumes systems sized to serve 100 households, at 95% reliability, for a MTF Tier 2-3 service level (lighting and mobile phone charging and small, energy efficient appliances), together with limited productive and community use.

Both case studies assume a private sector build-own-operate (BOO) model, and that the private sector takes an aggregative approach to solar mini-grids, improving financial viability by creating economies of scale and lowering the transaction costs related to individual solar mini-grids. A modular design approach is also taken, bringing down design costs, and facilitating future adjustments to system sizing, as demand evolves to incorporate further productive use.

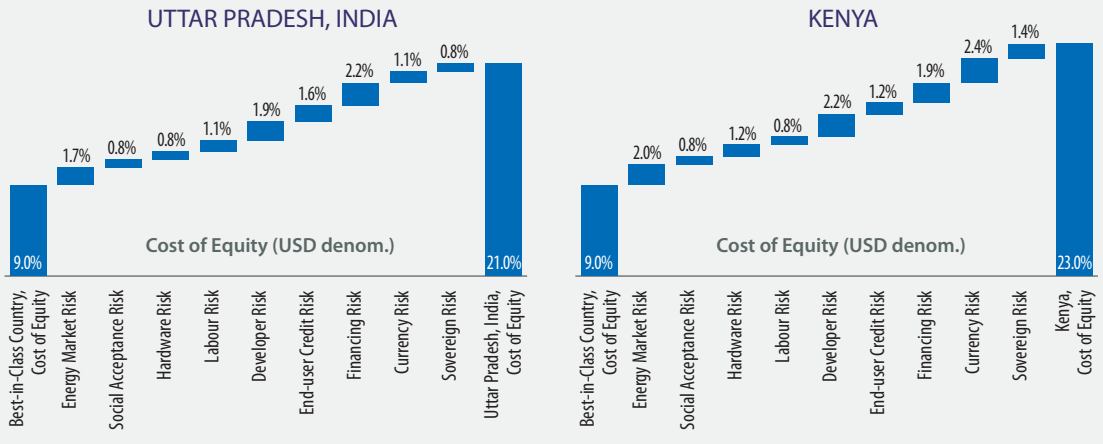
Case studies – current risk environment and financing costs

Currently, financing costs are high in both the analysed cases. Financing for solar mini-grids is limited to equity financing, with no commercial debt available. The analysis estimates that the current commercial cost of equity (USD) for solar mini-grids in Uttar Pradesh, India is 21%, and in Kenya is 23%. This compares to 9% in the Azores, Portugal – which acts as a best-in-class reference.

"Three risk categories were found to contribute most to higher financing in both Uttar Pradesh and Kenya: energy market risk, developer risk, and financing risk."

These higher financing costs reflect a range of investment risks that exist for solar mini-grids. Three risk categories were found to contribute most to higher financing in both Uttar Pradesh, India and Kenya: 1) 'energy market risk', concerning market outlook, access, price and competition (including from grid extension); 2) 'developer risk', concerning the management, track record and credit-worthiness of solar mini-grid operators; and, 3) 'financing risk', which concerns domestic capital scarcity and/or lack of familiarity of domestic investors with solar mini-grids.

Figure E.2: Pre-derisking financing cost waterfalls for solar mini-grids in Uttar Pradesh, India and in Kenya



Source: Interviews with solar mini-grid investors and operators; modelling exercise; see Table 4.1 for definition of risk categories; see Annex A for details on assumptions

[2] The difference in system sizes reflects the higher solar irradiation in Kenya compared to Uttar Pradesh, India.

Case studies – public derisking measures, lowering financing costs

Each case study then examines the selection and cost effectiveness of public interventions to meet the 6 year, 2023 investment target. These public interventions take the form of policy derisking and financial derisking instruments.

"In Kenya, 18 policy derisking and 4 financial derisking measures are identified, estimated to cost USD 37 million to 2023."

The modelling assumes that a full package of instruments, systematically targeting the identified investment risks, is implemented. A summary list of the selected public derisking instruments for Kenya is itemized in Table E.1 below.[3] These total 18 policy derisking and 4 financial derisking measures, and are estimated to cost USD 37 million until 2023.

Table E.1: Summary table of public instruments to promote investment in solar mini-grids in Kenya

RISK CATEGORY	POLICY DERISKING INSTRUMENTS	FINANCIAL DERISKING INSTRUMENTS

Energy Market Risk	• National off-grid targets, tiered approach to statistics
	• Build capacity of rural energy agencies
	• Dual-regulatory regime
	• *Light-touch regime*
	  ◦ Minimal self-registration
	• *Comprehensive regime*
	  ◦ Well-designed concessions
	  ◦ Regulated tariffs
	  ◦ Technical standards for electricity quality
	  ◦ Technical standards for grid expansion
		• *Comprehensive regime*
		  ◦ Grid expansion compensation scheme

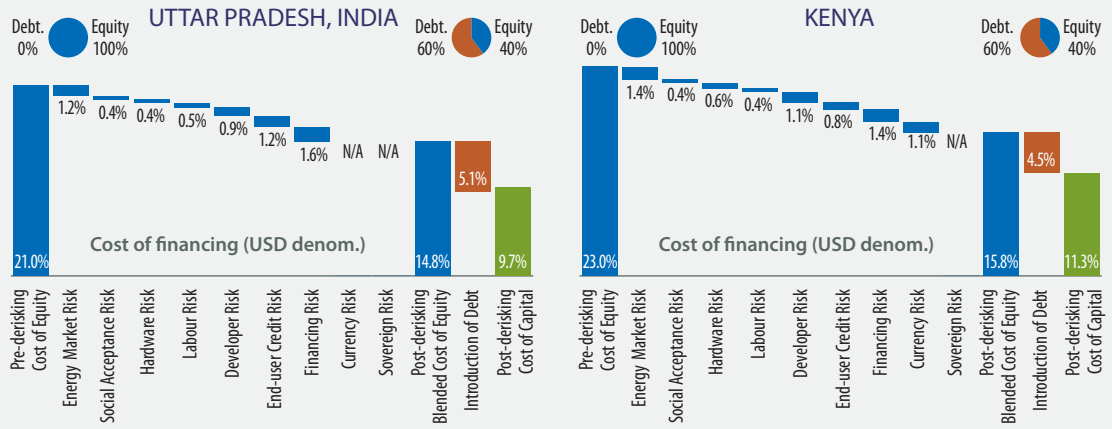
Social Acceptance Risk	• Public awareness campaigns	N/A
Hardware Risk	• Certification and standards for hardware • Streamlined customs procedures	N/A
Labour Risk	• Programmes to develop skilled labour	N/A
Developer Risk	• Government support to improve data sharing and network effects	• Public loans to operators/ credit lines to domestic commercial banks (concessional, hard-currency) • Public guarantees to domestic commercial banks (hard-currency)
End-user Credit Risk	• Facilitate growth of consumer credit data industry • Promote productive use of electricity • Well-designed cellular, mobile money regulations	
Financing Risk	• Reform domestic financial sector to favour green investment • Strengthen investor capacity with solar mini-grids	
Currency Risk	N/A	• Public subsidized F/X hedging
Sovereign Risk	N/A	N/A

Source: Modelling exercise; See Table 4.1 (Chapter 4) for a full description of these instruments. "NA" indicates "Not Applicable".

[3] The final selection of public instruments depends on the country context. Please refer to Table 5.2 for the summary table of public instruments for Uttar Pradesh in India.

"When derisking measures are implemented, financing costs fall, to 9.7% in Uttar Pradesh, India, and to 11.3% in Kenya."

Figure E.3: Post-derisking financing cost waterfalls for Uttar Pradesh, India and Kenya



Additional explanation: pre-derisking capital structure is assumed 100% equity; post-derisking capital structure is assumed at 60/40% debt/equity (end-point). The first 11 columns from the left represent the reduction in cost of equity attributed to individual risk categories. The last two columns represent the reduction in financing costs attributed to the introduction of debt into the capital structure.

Source: Interviews with solar mini-grid investors and operators; modelling exercise; see Annex A for full details on assumptions. Data shown here is for the end of the government investment target period (2023). Data used in modelling is for the mid-point of the investment target, approximating roll-out of investment. Data is blended assuming 90% comprehensive, 10% light-touch regulatory regimes.

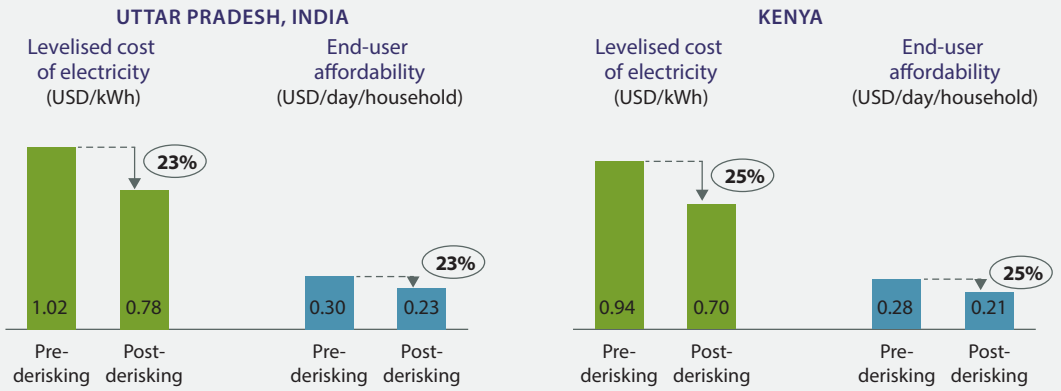
These public instrument packages lower financing costs. Figure E.3 below shows the modelling exercise's *post-derisking* financing costs waterfalls, assuming all derisking instruments are effectively implemented. These show the individual impact of instruments on targeted investment risk categories on the cost of equity, as well as a significant additional benefit when mini-grid operators are able to access debt financing. Overall, the analysis estimates that post-derisking, financing costs in Uttar Pradesh, India, fall from 21.0% (cost of equity) to 9.7% (WACC), and in Kenya from 23.0% (cost of equity) to 11.3% (WACC).

Case studies – levelised costs, performance metrics and impact

The final stage of the DREI framework involves life cycle cost modelling and assessing the selected instrument package against a number of performance metrics – investment leverage, affordability and carbon abatement costs. Sensitivity analyses are also performed, exploring the robustness of the results.

Life-cycle cost modelling for solar mini-grids is performed for two scenarios: first, a *business-as-usual* scenario, representing the current (pre-derisking) investment environment, with today's financing costs; and second, a *post-derisking* scenario, after implementing the selected instrument package, and with lower financing costs.

Figure E.4: LCOE and household daily energy spend in Uttar Pradesh, India and Kenya

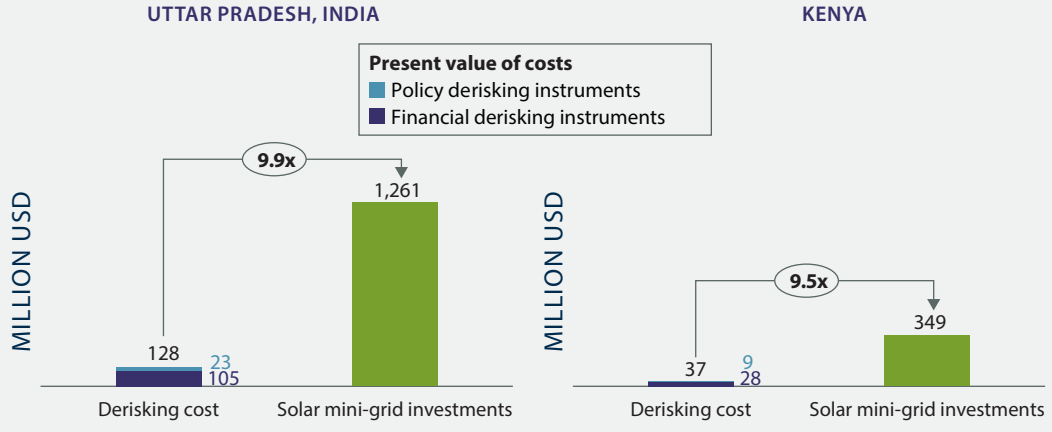


Source: Modelling exercise; See Tables 5.10 and 5.20, and Annex A for details on assumptions

The modelling results for levelised cost of electricity (LCOE), together with end-user affordability (household daily energy spend), are shown in Figure E.4. In both Uttar Pradesh, India and in Kenya, solar mini-grid generation costs are reduced significantly in the *post-derisking* scenario, by 23% and 25% respectively.

Figure E.5 shows the results for investment leverage ratios, which demonstrate that in both Uttar Pradesh, India and in Kenya, implementing the selected derisking instruments leverages approximately 10 times the USD amount in private sector investment.

Figure E.5: Investment leverage performance metrics for the selected instrument packages in promoting solar mini-grid investment in Uttar Pradesh, India (2023 target: 323 MW) and in Kenya (2023 target: 77 MW)



Source: Modelling exercise; See Tables 5.10 and 5.20, and Annex A for details on assumptions

"Implementing the selected instruments leverages approximately 10 times the USD amount in private sector investment."

Overall, the case studies demonstrate the following impact:

- For Uttar Pradesh, India the modelling identifies a package of derisking measures with an estimated cost of USD 128 million until 2023. These derisking measures result in the following benefits:
  - Providing electricity access to 15,000,000 people
  - Catalysing USD 1,261 million of private sector investment in solar mini-grids
  - Increasing affordability and lowering household daily spend on electricity by 23%, resulting in economic savings over 20 years of USD 878 million
  - Reducing carbon emissions by 10.8 million tonnes of CO_2, relative to a diesel mini-grid alternative
- For Kenya, the modelling identifies a package of derisking measures with an estimated cost of USD 37 million until 2023. These derisking measures result in the following benefits:
  - Providing electricity access to 3,520,000 people
  - Catalysing USD 349 million of private sector investment in solar mini-grids
  - Increasing affordability and lowering household daily spend on electricity by 25%, resulting in economic savings over 20 years of USD 226 million.
  - Reducing carbon emissions by 3.5 million tonnes of CO_2, relative to a diesel mini-grid alternative.

Sensitivity analyses are also performed, exploring the robustness of the results and alternative scenarios. Of note, these identify the possibility of including additional targeted subsidies to mini-grid operators, in order to increase affordability of solar mini-grid power. Over time these financial incentives can likely be phased out, taking a 'sunset clause' approach, as economics further improve in the next generation of solar-mini grids (better software, lower battery costs, higher demand and ARPUs, and aggregation of assets).

Case studies – conclusions

"The modelling clearly shows that investing in public derisking measures is cost-effective, generating economic savings in the form of more affordable electricity."

Today's investment environment for solar mini-grids in Uttar Pradesh, India and Kenya is made up of a number of investment risks that result in higher financing costs. The DREI framework seeks to facilitate the task of systematically identifying and then targeting these investment risks.

Through implementing the public derisking measures identified in these case studies, taking a phased approach, the opportunity is to unlock far greater investment, particularly commercial debt financing. The modelling also clearly shows that investing in public derisking measures should be cost effective, generating economic savings in the form of more affordable electricity. In addition to public derisking measures, targeted direct subsidies to mini-grid operators can also be considered, which can further increase affordability.

Derisking Table for Solar Mini-Grids

Table: Derisking table for solar PV-battery mini-grids (private sector, BOO) – Part I

BARRIERS			
RISK CATEGORY	**DESCRIPTION**	**UNDERLYING BARRIERS**	**KEY STAKEHOLDER GROUP**
1. Energy Market Risk	Risk arising from limitations and uncertainty in the energy market (off- and on-grid) regarding market outlook, access, price and competition	*Market outlook:* Lack of political will and/or uncertainty regarding national/state targets for electrification and renewable energy mini-grid investment	Energy sector policymakers; legislators; administrators; utilities; grid operators; regulators
		Market access, competition and grid expansion: Limitations and inability, including due to government regulations, of mini-grid developers to access the electrification market; uncertainty regarding potential future competition in electrification; unclear, or lack of, grid planning and expansion policies	
		Tariffs: Uncertainty or inflexibility in electricity tariff regulations for mini-grids	
		Technical standards: Lack of clarity, uncertainty and/or inconsistent government technical requirements for mini-grids regarding (i) quality of service and (ii) grid integration, should it occur	
		Competing subsidies: Competition from subsidised diesel and kerosene (mostly used for lighting); negative perceptions of mini-grid tariffs due to subsidised grid-distributed electricity	
2. Social Acceptance Risk	Risks arising from lack of awareness and resistance to renewable energy and minigrids in communities	Resistance by general public and local communities due to unfamiliarity with electricity and renewable energy sources; mis-information/ perceptions and lack of awareness for mini-grid offerings; resistance from incumbent businesses (e.g., diesel based generation) and users (e.g., SHS), disrupted by mini-grids	General public; NGOs; incumbent businesses

Source: Authors

MENU OF SELECTED PUBLIC INSTRUMENTS				WAYS MINI-GRID DEVELOPER CAN MITIGATE RISK
POLICY DERISKING INSTRUMENTS		FINANCIAL DERISKING INSTRUMENTS		
ACTIVITY	DESCRIPTION	ACTIVITY	DESCRIPTION	
Build political will and develop realistic and transparent targets, using multi-tier electrification indicators	Establish programmes to raise awareness and build political will with legislators (e.g., conferences, site visits, cross-ministerial committees); establish/strengthen energy statistics office; pursue a tiered approach to statistics for electrification; perform initial resource inventory and mapping, including through spatial planning; formulate realistic and transparent targets by tier, technology and demographics; ongoing monitoring of statistics			
Establish regulatory approach with two, co-existing regimes: (i) light-touch (no license) and (ii) comprehensive (licensed). Mini-grid developers may choose to operate under either regime. Light-touch regime does not provide exclusivity, nor access to government financing or grants (see later risk categories)	***Light-touch regime (no license):*** Establish simple mechanism for mini-grid developers to self-register and provide basic annual reporting; self-registered mini-grid developers have right-of-first-refusal for concessions under the comprehensive regime ***Comprehensive regime (licensed):*** Establish/ develop capacity of institutions (e.g., rural electrification agency, regulator); determine national/state off-grid electricity service areas; define well-designed concessions (e.g, size, years, targets, bundling) for mini-grid developers; implement well-designed mechanism to grant exclusive concessions to mini-grid developers		***Comprehensive regime (licensed):*** Establish compensation scheme (e.g., per kWh subsidy, or exit option) in case of grid expansion	Minimize grid expansion risk via differentiating mini-grid offer in terms of quality of service
Establish co-existing (i) light-touch (no license) and (ii) comprehensive (licensed) approaches	***Light-touch regime (no license):*** No tariff controls ***Comprehensive regime (licensed):*** Establish balanced and well-designed regulated tariffs to address monopoly risk, either through (i) tariff tables or (ii) price discovery, via auctions			
Establish co-existing (i) light-touch (no license) and (ii) comprehensive (licensed) approaches	***Light-touch regime (no license):*** Voluntary compliance with comprehensive regime standards. ***Comprehensive regime (licensed):*** Develop balanced technical standards/ requirements for quality of electricity and grid integration, with active enforcement			Adherence to international good practice on techncial standards
Reform fossil fuel and grid-distributed electricity subsidies	Assessment of fuel and grid-distributed electricity subsidies; phase-out/down of subsidies*; awareness campaigns accompanying reform; design of transfer programs to vulnerable social groups			
Develop and coordinate ongoing community impact and public awareness campaigns	Public awareness campaigns; stakeholder dialogues and workshops between policy makers, NGOs, communities, community leaders and end users			In-house programmes to raise awareness on benefits of minigrids
Pilot models for community involvement	Piloting of community models such as revenue sharing or small equity stakes for households, plus employment prospects for individuals			In-house efforts to incorporate community based models and employment of locals

* Note: This instrument is a direct financial incentive.

Table: Derisking table for solar PV-battery mini-grids (private sector, BOO) – Part II

BARRIERS			
RISK CATEGORY	**DESCRIPTION**	**UNDERLYING BARRIERS**	**KEY STAKEHOLDER GROUP**
3. Hardware Risk	Risk arising from limitations in the quality and availability of mini-grid hardware, as well as the customs treatment of hardware	*Quality of hardware:* Lack of access to information on quality, reliability (performance) and cost of hardware; lack of clarity or uncertainty regarding government technical standards to ensure safety of mini-grid hardware; lack of availability of warranties for components	Technology supply chain; technical regulator; customs (excise)
		Availability of hardware: Lack of a competitive market for buying hardware (from both interenational and domestic suppliers); where appropriate, lack of locally tailored hardware	
		Customs: Cumbersome customs/clearing process for importing hardware, leading to delays in delivery; punitively high customs tariffs on mini-grid hardware, particularly in comparison to other sectors.	
4. Digital Risk	Risks arising from use of cellular networks for remote monitoring and payments; the use of software; and abuse of consumer data	*Cellular networks and mobile money:* lack of cellular coverage in rural areas, where electrification needed; over-dependence on a single operator for reliable cell service and payment processing; lack of mobile money, or limitations relating to fees on mobile money transactions	Telecom sector policymakers; regulators; cellular network operators; software providers
		Software: Limited standardization of software and interfaces on mini-grid developers' back-end data and operations, and mobile money payment platforms	
		Abuse of consumer data: possible abuse of consumer data privacy on payments and usage; lack of understanding/clarity on uses of consumer information	
5. Labour Risk	Risks arising from the lack of skilled and qualified potential employees	Lack of a competitive labor market of educated, skilled and qualified potential employees, leading to higher costs, hiring non-local staff and suboptimal performance	Labour force; training/ education institutions
6. Developer Risk	Risks arising from limitations in the mini-grid operator's management capability, and its creditworthiness and cash flow	*Management capability:* lack of C-suite talent and experience to ensure effective execution (business planning, financial structuring, plant design (resource and demand assessment), installation, operations and maintenance), and to manage challenges (limited information, unforeseen events)	Mini-grid operator (BOO)
		Developer credit worthiness and cash flow strength: Inability of developer to secure low cost financing from investors due to lack of credit worthiness, or insufficient cash flows to meet investors' return requirements	

Source: Authors

MENU OF SELECTED PUBLIC INSTRUMENTS				WAYS MINI-GRID DEVELOPER CAN MITIGATE RISK
POLICY DERISKING INSTRUMENTS		FINANCIAL DERISKING INSTRUMENTS		
ACTIVITY	DESCRIPTION	ACTIVITY	DESCRIPTION	
Develop certification and standards for hardware	Transparently develop, update (as necessary), disseminate and enforce standards for technical performance and safety; mandate minimum warranties for components; adopt internationally recognized standards and share best practices, where applicable			In-house rigorous sourcing and testing of hardware.
Ensure an open, competitive marketplace for buying hardware	Policy measures to ensure a competitive market for hardware availability; balanced industrial policy objectives, where applicable, for domestic manufacturers, with open markets for international manufacturers; government support for R&D into technical modifications to hardware to accommodate local conditions			
Streamlined and consistent customs procedures; reform of punitive custom tariff system	Reduction of customs administrative steps; public response timelines; effective and expedited recourse mechanisms. Full cost-benefit economic assessment and benchmarking of tariffs; phase-out/down of punitive customs tariffs; introduction of import tariff holidays and VAT exemptions*			
Well-designed telecom regulations enabling universal, competitive coverage and mobile money	Regulation on coverage areas and competition for cellular operators; regulations ensuring a competitive mobile money market, including reasonable fees for mobile money transactions			
Government support to form industry associations for standard-setting and sharing of best practices	Encourage engagement of MNOs, mobile money companies, mini-grid developers through industry associations, technology working groups to establish standards around he digitalization of energy services provision			
Institute balanced consumer data protection regulations	Facilitate the development of clear and transparent guidelines on data use by companies in the mini-grid ecosystem; raise awareness among consumers; government enforcement of data privacy laws			
Programmes to develop competitive, skilled labour market in renewable energy (all roles)	Apprenticeships, certificates and university programmes to build skills in renewable energy (e.g., engineering, marketing, business management)			In-house training of local employees
Government support to improve information flows and network effects	Government support for establishing industry association; government support for initial industry conferences; dissemination of top-level, national resource assessment findings; government sponsored academic studies (e.g., on demand evolution)			
		Public loans, credit lines, guarantees and/or equity to mini-grid operators	Direct public loans to minigrid operator; credit lines, public guarantees to commercial banks that are lending to the minigrid operator; public equity investments in minigrid operator	Engage in robust business planning; consider posting personal collateral to strengthen credit worthiness

* Note: This instrument is a direct financial incentive.

Table: Derisking table for solar PV-battery mini-grids (private sector, BOO) – Part III

BARRIERS			
RISK CATEGORY	**DESCRIPTION**	**UNDERLYING BARRIERS**	**KEY STAKEHOLDER GROUP**
7. End-user Credit Risk	Risk arising from customers' willingness, ability, and methods of payment for electricity	*Lack of information on end-user credit worthiness:* Lack of end-user credit data with which to assess the ability of end-users to pay for the initial connection fees, ongoing electricity bills and ancillary equipment (e.g., lights and appliances)	End-users (households, business, public entities); consumer finance actors (consumer banks, credit data actors, and consumer finance regulator)
		Poor credit worthiness and non-payment: Risk of delayed, reduced or non-payment by customers due to poor credit worthiness, lack of funds available, electricity theft and social dynamics	
		Poor consumer finance channels and regulation: Risk arising from lack of or unreliable consumer finance channels (e.g., mobile money and/or local micro-finance) or related regulation that hampers access to consumer finance	
8. Financing Risk	Risks arising from scarcity of domestic investor capital (debt and equity) for minigrids, and domestic investors' lack of familiarity with minigrids and appropriate financing structures	*Capital scarcity – liquidity constraints in domestic banking:* Limited availability of long term domestic loans due to high banking reserve requirements	Domestic investors (equity and debt); investor financial sector regulator
		Capital scarcity – under-developed domestic financial sector: Low number of well-capitalised actors (debt, equity, insurance, pensions); lack of regulatory clarity on new types of financial products	
		Capital scarcity – competing incentives/ mandates: existing policies incentivise or mandate domestic financial sector (banks, pension funds) to invest in alternative, competing sectors to minigrids	
		Limited domestic investor experience with minigrids: Lack of information, assessment skills and track-record for minigrid projects amongst domestic investor community; lack of network effects (investors, investment opportunities) found in established markets; lack of familiarity and skills with appropriate finance structures	

Source: Authors

MENU OF SELECTED PUBLIC INSTRUMENTS				WAYS MINI-GRID DEVELOPER CAN MITIGATE RISK
POLICY DERISKING INSTRUMENTS		FINANCIAL DERISKING INSTRUMENTS		
ACTIVITY	DESCRIPTION	ACTIVITY	DESCRIPTION	
Facilitate growth of consumer credit data industry	Where applicable, government sponsored digital identity scheme; promotion of balanced privacy and financial regulations allowing for collection of credit data by the private sector; piloting of fintech solutions/platforms for credit data analysis			In-house assessment of credit worthiness and risk modelling, using alternative indicators (e.g., employment, mobile money); use of initial connection fees as a mechanism to test for credit worthiness
Facilitate end-user's ability to improve creditworthiness over time	Two complementary approaches: (i) Facilitate access to consumer finance (e.g., government-sponsored digital ID scheme; general consumer finance reform; mobile money); (ii) Promote productive use of electricity (e.g, establish network of business development incubators and advisors providing training and guidance covering mini-grid areas)	Two possible approaches to address credit risk: (i) Public loans, credit lines, guarantees and/or equity to mini-grid operators (ii) Government offtaker via PPA	(i) Direct public loans to mini-grid developer; public guarantees to commercial banks that are lending to the mini-grid developer; public equity investments in mini-grid developer (ii) Government enters into PPA acting as an intermediary offtaker with mini-grid developer. Electricity is then onsold to end-users. This risk transfer/financial derisking approach can be combined with a per kWh subsidy* (direct financial incentive), addressing affordability concerns	Smart payment and metering approaches to incentivize payment, including pre-payment; in-house offering for productive use, with training and hardware for businesses/ entrepreneurs
Government mandates to ensure creditworthy anchor tenants for mini-grids	Government targets and mandates require creditworthy actors, both private (e.g., cell phone towers) and public (e.g., health centres), to obtain their electricity from renewable energy mini-grids			
Well-designed finance and telecom regulations to improve rural access to consumer finance	Enact financial and telecom regulations to enable micro-finance, mobile money etc. at acceptable transaction cost (e.g., fees by mobile telecom network operator for mobile money)			
Reform reserve requirements for domestic lending to businesses	Balanced approach to liquidity requirements, assessing trade-offs between financial stability and renewable energy/electrification objectives	Public loans, credit lines, guarantees and/or equity to mini-grid operators to address capital scarcity	Direct public loans to mini-grid operators; credit lines, public guarantees to commercial banks that are lending to the mini-grid operators; public equity investments in mini-grid operators	Mini-grid developer pursues dual international and domestic financing approaches
Liberalise domestic financial sector	Liberalisation and introduction of competition into domestic financial sector; reforms to introduce and facilitate new types of finance (e.g., crowdfunding, peer-to-peer lending)			
Reform financial sector incentives for investing in specific sectors	Balanced approach to incentives across all sectors; introduce incentives, targets and mandatory lending requirements for renewable energy/minigrids/electrification			
Strengthen domestic investors' (debt and equity) familiarity with and capacity regarding renewable energy minigrids	Mini-grid/electrification finance dialogues and conferences; workshops/training for investors on project assessment and financial structuring			

* Note: This instrument is a direct financial incentive.

Table: Derisking table for solar PV-battery mini-grids (private sector, BOO) – Part IV

BARRIERS			
RISK CATEGORY	**DESCRIPTION**	**UNDERLYING BARRIERS**	**KEY STAKEHOLDER GROUP**
9. Currency Risk*	Risks arising from currency mismatch between domestic currency revenues and hard currency financing	Uncertainty due to volatile local currency; unfavourable currency exchange rate movements resulting in domestic currency revenues not being sufficient to cover hard currency debt/ equity servicing; inability to economically hedge FX exposure due to illiquid FX derivative markets	Macro risk
10. Sovereign Risk	Risk arising from a mix of cross-cutting political, economic, institutional and social characteristics in the particular country which are not specific to mini-grids	Limitations and uncertainty related to conflict, political instability, economic performance, weather events/natural disaster, legal governance, ease of doing business, crime and law enforcement, land tenure and infrastructure in the particular country	Macro risk

Source: Authors

* Note this risk category only applies if financing is in hard currency.

MENU OF SELECTED PUBLIC INSTRUMENTS				WAYS MINI-GRID DEVELOPER CAN MITIGATE RISK
POLICY DERISKING INSTRUMENTS		FINANCIAL DERISKING INSTRUMENTS		
ACTIVITY	DESCRIPTION	ACTIVITY	DESCRIPTION	
Government support for long term development of liquid domestic FX derivative markets	Regulatory reforms enabling derivative trading for local securities exchanges; steering of large government FX hedging contracts to domestic FX markets	Financial products to transfer some or all currency risk to public sector	Various design options exist. One option is the government entering into an intermediary PPA with minigrid operator, denominated in hard currency, and then onselling electricity to end-users at a fixed, or more stable, domestic currency tariff. Another option are public subsidised or facilitated F/X hedging programmes (particularly for illiquid F/X trades)	Mini-grid developer engages with private sector hedging instruments
		Where applicable, risk sharing products by development banks to address political risk	Where applicable, provision of political risk insurance (PRI) covering (i) expropriation, (ii) political violence, (iii) currency restrictions, (iv) breach of contract	

United Nations Development Programme
Bureau for Programming and Policy Support
304 East 45th Street,
New York, NY 10017 USA

www.undp.org

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ETH Zurich, Energy Politics Group
Haldeneggsteig 4
CH-8092 Zurich, Switzerland

www.epg.ethz.ch