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*Research article*

# Removing barriers to women entrepreneurs' engagement in decentralized sustainable energy solutions for the poor

**Yannick Glemarec [1,*], Fiona Bayat-Renoux [1], and Oliver Waissbein [2]**

[1] UN Women, New York, NY, USA
[2] UNDP, New York, NY, USA

* **Correspondence:** Email: yannick.glemarec@unwomen.org.

**Abstract:** Rapidly falling renewable technology costs and new business models mean that decentralized energy solutions hold great promise to accelerate universal sustainable energy access. Across developing countries, women are typically the primary household energy managers. Close to their customers, women entrepreneurs have the potential to lower customer acquisition and servicing costs and drive these new decentralized solutions. However, they remain under-represented in the industry.

This paper attempts to understand the root causes of this gender gap. It formulates the research hypothesis that market transformation policies intended to reduce investment risks to accelerate energy access may not benefit men and women entrepreneurs equally because of the existing structural barriers that women face. To test this hypothesis, the paper conducts a gender sensitive investment barrier and risk analysis, overlaid onto an existing gender neutral taxonomy of investment barriers and risks for decentralized sustainable energy solutions.

A key finding is that for women entrepreneurs, existing structural impediments to gender equality translate into additional investment barriers as well as increased likelihood of occurrence and severity of the financial impact of generic investment risks. The paper offers an illustrative theory of change to facilitate a dialogue on the specific interventions needed to address these gender differentiated risks locally. It concludes that market transformation efforts for universal sustainable energy access must include targeted policy measures to ensure equal benefits to men and women entrepreneurs, and optimize the use of public resources to catalyze private investment and reduce poverty.

**Keywords:** decentralized renewable energy access; women entrepreneurs; investment barriers

## 1. Introduction

Decentralized sustainable energy technologies—both at the individual systems level, such as solar home systems, and at the mini-grid level servicing 50 to100 households—are the cheapest solutions for energy access in an increasing number of locations [1,2,3]. The decline in the costs of renewable and energy efficient technologies combined with the rapid uptake of mobile phones has enabled the development of new business models to adapt off-grid energy service payments to the cash flows of end-users in developing countries. One of the success factors for these new business models is building large, robust distribution and servicing networks to create and maintain customer relationships in a cost-effective manner [4]. Although women entrepreneurs should have enormous potential to create distribution and servicing networks in rural areas and drive these new business models, they are under-represented in the industry.

This paper formulates and discusses a research hypothesis to explain this under-representation of women entrepreneurs in the industry. First, its presents a gender neutral market transformation framework to remove investment barriers and accelerate universal sustainable energy access for the poor. Second, it tests the hypothesis that gender neutral market transformation policies to accelerate energy access may not benefit men and women entrepreneurs equally because of the existing structural barriers that women face. Third, it proposes a generic theory of change to ensure that market transformation efforts equally benefit women and men entrepreneurs, increasing their cost-effectiveness and development impact. The conclusion proposes some additional research avenues to deepen our understanding of the gender investment gap in the industry.

## 2. Market Transformation for Decentralized Energy Access

### *2.1. The Role of Distributed Energy Solutions for Universal Energy Access for the poor*

Until the 1980s, investments in large scale power generation were given a central role in national development plans in developing countries. They were expected to drive economic growth and deliver high investment returns [5]. Investments in electrification programmes slowed down in the following two decades as their results often proved disappointing. Due to poor people's inability to afford electricity, connection rates and consumption remained low despite improved availability. Electricity was mostly used for lighting rather than for productive uses and the income-generating effect of electricity remained low. Electrification programmes contributed to the unsustainable debt burden of many developing countries without delivering the expected economic growth. Furthermore, these programmes mostly benefitted the wealthiest households who could afford the high connection costs to the grid in politically prioritized grid-extension areas [5]. For example, data sources in Kenya found a 1:10 order of magnitude between the lowest and highest income quartile in use of electricity [6].

As a consequence of these disappointing results and subsequent reduction in investment, about 1.1 billion people worldwide still lack access to electricity [7] and nearly 2.9 billion use solid biomass to cook their meals and heat their homes [8]. Energy poverty is most pronounced in sub-Saharan Africa, where 622 million people—two-thirds of the population—lack access to electricity. Around 65% of primary schools and over 30% of health facilities in sub-Saharan Africa also lack electricity [9].

Based on current trends, it will take until 2080 to achieve universal access to electricity, and the mid-22nd century for access to non-polluting energy for cooking [10]. The failure of governments to achieve significant electrification in many countries has seen the growth of decentralized energy solutions based mostly on fossil fuels such as diesel-fueled micro-grids and liquefied petroleum gas.

Over the past few years there has been a renewed interest in achieving universal energy access to reduce poverty, notably with the launch of the Sustainable Energy for All initiative in 2012[1] and the inclusion of sustainable energy as the 7th goal of the Sustainable Development Goals.[2]

The recent Intergovernmental Panel on Climate Change report has shown that the entire global economy by the end of the century could be decarbonized at low costs [11]. To a large extent, it reflects the significant recent decline in the cost of renewable and energy efficient energy, which have become the cheapest sources of distributed energy and are competitive in most locations with fossil-fuel power plants. In 2011, when annual global investment in renewables peaked at $279 billion, 78 gigawatts were installed. In 2014, almost 30% more (95 gigawatts) was installed at a slightly lower investment cost of $270 billion [12].

Cost reductions have been particularly pronounced for solar energy, driven by a dramatic fall in the cost of PV modules and a steady decrease of balance-of-payment costs[3]. These costs are expected to continue to fall in the foreseeable future [13]. In fact, even the most optimistic cost reduction estimates for renewable have not been optimistic enough in the past. For example, today's price projections to 2020 are about half of predictions a decade ago [14].

Tackling energy poverty might have less to do with the capacity to generate electricity, and more to do with the capacity to get energy to those who need it the most. It is true that all of sub-Saharan Africa's power generating capacity amounts to less than South Korea's, and a quarter is unproductive at any given moment because of the continent's aging infrastructure [15]. However, most investment in power generation in Africa is not geared towards serving the basic energy needs of the poor but aims at addressing the existing suppressed industrial and residential demand [3].

There are three broad technological options to provide electricity to homes: (i) grid extension; (ii) mini-grids; and (iii) off-grid systems. The cost of providing electricity access through grid connections depends on how far the lines must be extended. Levelized costs of electricity (LCOE) for on-grid usually exceed those of mini-grid and off-grid technologies in sub-Saharan Africa when the grid must be extended by more than 1 km [1]. Decentralized energy technologies are often the most cost-effective solutions for delivering electricity services that matter the most to poor households, schools, primary health clinics and small-scale enterprises [5]. Even if they deliver relatively small amounts of electricity, they can substantially increase the income of the poor by reducing existing household expenditures and, in combination with mobile technologies, providing

[1] The Initiative brings all sectors of society to the table: business, governments, investors, community groups and academia. The United Nations is the ideal institution to convene this broad swathe of actors and forge common cause in support of three inter-linked objectives: (i) Ensure universal access to modern energy services; (ii) Double the rate of improvement in energy efficiency; and (iii) Double the share of renewable energy in the global energy mix by 2030.

2 The Sustainable Development Goals (SDGs) are an inter-governmentally agreed set of 17 goals and 169 targets relating to international development. SDG 7 aims to ensure access to affordable, reliable, sustainable and modern energy for all by 2030 (see http://www.un.org/sustainabledevelopment/sustainable-development-goals).

[3] Solar PV module prices in 2014 were around 75% lower than their levels at the end of 2009. Between 2010 and 2014 the total installed costs of utility-scale PV systems have fallen by 29% to 65%, depending on the region [2].

access to financial services; and to agricultural, technology, market and meteorological information. For example, Qorax Energy is a solar asset financing and distribution company that targets the poor in fragile and conflict-affected countries. In Somalia, which has the third lowest GDP and highest grid-connected energy cost in the world[4], some of their customers spend one quarter of their small annual income ($375) on kerosene. According to Qorax, a solar lantern can reduce lighting costs from 25% to 3% of their income [16].

Furthermore, providing universal energy access through decentralized solutions is likely to require substantially less time than through grid extension. Bardouille and Muench [4] believe that a significant proportion of the estimated 1.1 billion people around the world presently living without access to basic levels of modern energy services can be reached by distributed energy service companies ('DESCO' model) by 2030. According to Bardouile and Muench, this would require much less capital than previously assumed to achieve this goal, with a very significant share of financing potentially coming from private investors. Decentralized energy technologies would also create between 8 to 10 times more jobs per gigawatt hour they generate than electricity generated by on-grid fossil fuel power stations [9].

**Box 2: The distributed energy service companies ('DESCO' model)**

Typically, a DESCO installs assets at dwellings and small business, collecting an on-going payment for energy (or recurring fees from customers) [4]. The DESCO model has also shown how innovative financing models can be used to make energy services more accessible. Such models include:

- Pay-for use: energy users are billed for services consumed (e.g. per full battery charge, hour of supply of a certain service, per kWh).
- Rental: end users pay a periodic fee linked to a specified amount of time and/or energy.
- Rent to own/lease finance: users pay a regular fee for access to time and/or energy. Renewable energy assets are sold to customers over time.

Payments for DESCO energy services are pre-paid and can be collected manually, for example through scratch cards, or electronically through mobile phones. The rapid expansion of mobile phones in developing countries also shows the important role of innovative business models, including pre-paid platforms. According to Bardouille and Muench [4], with the right conditions, the DESCO model has the potential to cost-effectively reach close to 500 million people over the coming decade.

Rather than meeting the upfront cost of renewable energy technologies (RET), the DESCO model spreads the cost over time through a fee for energy services. Payments can thus be adjusted to the cash profile of the poor. One of the success factors is building large, robust distribution and servicing networks to create and maintain customer relationships. The rapid development of mobile banking provides a cost effective technology platform to process these recurring fund transfers. Minimizing transaction costs associated with acquiring and servicing decentralized end-users become the main challenge to provide attractive returns to investors and agents. The industry is piloting a diverse range of approaches to address this challenge. For example, one of the largest solar product distributors, SunnyMoney leverages teachers as sales agents in Tanzania [4].

[4] Ten percent of the population with access to electricity pays 10 times the US average ($1.00/kWh) [16].

With the exception of China which has become the largest clean energy investor in the world, 9 of the top 10 countries investing in small scale decentralized energy were developed economies [17]. Japan accounted for the largest investment share in 2013, with the US second and Germany third. The bulk of investment in Japan ($23 billion) took the form of small, on-grid commercial and residential PV projects, taking advantage of a generous feed-in tariff introduced in 2012 as the country moved away from nuclear after the Fukushima emergency of March 2011. This small scale decentralized investment dwarfed the $ 5.6 billion in large scale asset investment in Japan in 2013.

These numbers underline a key paradox of small scale decentralized energy. Despite the fact that small scale systems are particularly competitive for off-grid energy access, they scale up faster in grid connected countries than in developing countries facing substantial energy access challenges. What should be a particularly attractive proposition for greater energy access and security in developing countries mostly remains a developed country phenomenon. The following section analyses the key drivers of this apparent paradox.

### *2.2.Market Barriers to Decentralized Energy Access in Developing Countries*

Investment in seemingly profitable sustainable energy opportunities faces a range of informational, technical, institutional and financial barriers [18,19,20,23,61]. The following is a non-exhaustive list of generic barriers to sustainable energy investment clustered into five key categories:

- *Information and awareness barriers*: the business and financial communities in developing countries has a limited awareness of the risks and opportunities associated with global environmental changes and the transition to low carbon and climate resilient development pathways. Information on renewable energy resources and potential markets are limited.
- *Technical and capacity barriers*: technical and managerial skills to adopt and adapt clean technologies and business models are in short supply, and technical standards and quality assurance mechanisms are missing for clean technologies.
- *Institutional and regulatory barriers*: complex, inconsistent or opaque licensing procedures for clean investment lead to transaction delays and costs; lack of integration of climate and environment risks into legislation and codes, including fiscal codes; and insufficient enforcement of existing regulations.
- *Market barriers*: sustainable markets often suffer from uncertainty on market size, entrenched monopolies and policy barriers to new market entrants, difficulty to convert social benefits into private profits, and a mismatch between time horizons of costs and benefits.
- *Financial barriers*: lack of budgets to implement public policies and strategies and provide critical public services (rule of law, security, etc.); limited access to international capital markets; under-developed local capital markets to finance investment projects; and the lack of investment track records to better assess investment risks.

All these barriers translate into perceived higher risks and thus higher hurdle rates for investments. Entrepreneurs will require higher expected return before investing their time and personal equity in a renewable energy project. Similarly, providers of financing will demand a higher margin and will offer less attractive financing terms to compensate themselves for these higher risks. In practice this translates into higher interest rates (debt) and required returns (equity), shorter loan tenors and a higher share of more costly equity in capital structures. High financing cost

environments particularly penalize green technologies, as they typically have higher upfront capital requirements in exchange for lower operations and maintenance costs.

As an illustration, figure 1 compares the LCOE of a generic mini-grid solar PV/battery system with a mini-grid diesel generator system in a higher and lower financing cost environment. The upfront capital requirements of the mini-grid solar PV/battery system are higher than those of the mini-grid diesel generator system. Conversely, annual operating costs are relatively low for wind energy but predominate in the case of gas or diesel systems [19].

In a higher-financing cost environment, the generation costs from a solar mini-grid system are significantly higher than a diesel system. In this specific scenario, a full two thirds of the generation cost for a solar mini-grid system can be attributed to financing costs. In the lower-financing cost environment, the generation cost of the solar mini-grid system improves significantly, falling by 23% and bringing the solar mini-grid system's generation cost into financial parity with the diesel system [20]. While a solar mini-grid system is an attractive solution in low-financing cost investment (it is not exposed to the price volatility and the logistical risk of a diesel system), it is not competitive in a high-financing cost environment.

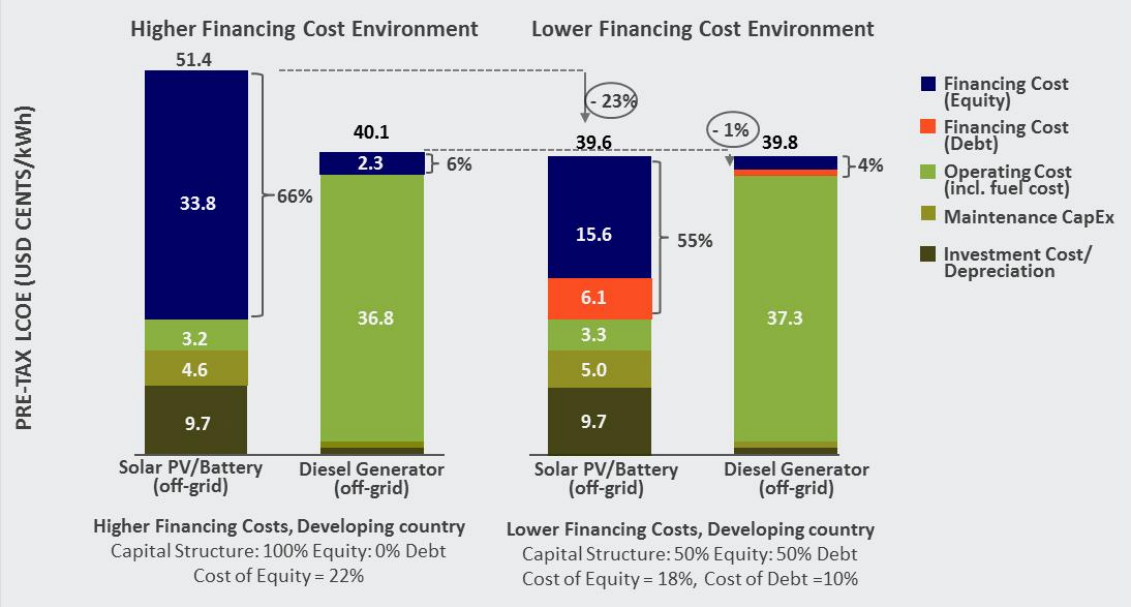


**Figure 1. Pre-tax LCOE Breakdown for solar PV/battery vs diesel [20][5].**

Irrespective of the actual return on investment, upfront costs can be an even greater barrier for residential energy solutions than for mini-grids. A household biogas digester ($300–700) can account for more than a full-year of income for the poor. Even a more modest solar home system for lighting ($100–300) can exceed their financing capacity. Access to affordable financing adapted to the cash flow profiles of poor households is thus a pre-requisite for decentralized sustainable energy access.

[5] UNDP/ETH Zurich calculations and assumptions [20]. Assumes equal annual electricity output; solar PV/battery system size of 25 kW, diesel system size of 14 kW, investment life(20 years), replacement: battery (5 years), inverters (10 years), generator (10 years), diesel fuel price ($0.81/l), inflation (2%); loan tenor (10 years), where applicable.

Five principal market driven models exist to meet upfront costs: (i) dealer/supplier credit-based sales; (ii) consumer credit through commercial banks; (iii) consumer credit through micro-finance institutions; (iv) fee-for-service models where the equipment remains the property of the service provider; and (v) public sector-operated revolving fund credit schemes [61]. A key factor in the suitability of the model to provide upfront finance is the maturity of the domestic financial sector. Developing countries tend to have weak financial systems, with local capital markets lacking long-term financial products in domestic currencies and under-developed financial intermediation, sometimes in combination with excess liquidity in the banking system [63]. In such locations, dealer/supplier credit-based sales and fee-for-service models hold the highest potential. However, the profitability of these models will rest on the capacity of dealer/suppliers and service providers to themselves access long-term affordable finance to maintain the affordability of their energy solutions for the poor. Further, the affordability of finance will depend on perceived or actual investment risks. This explains the apparent paradox in the growth of small scale decentralized energy in developed countries rather than in developing countries. Higher actual or perceived higher risks affect the financial sustainability of these business models for renewable energy in developing countries.

### *2.3.A Market Transformation Framework for Sustainable Energy Access*

This sensitivity of climate investments to financing costs is central to the challenge of reallocating private sector flows from business-as-usual to climate-friendly activities. If private finance (businesses and households) for sustainable energy access is to be mobilized at the scale required to reduce poverty and meet the world's pressing environmental challenges in a timely manner, a key objective must be to provide access to large quantities of low-cost and long-term (with respect to loan tenors) financing.

Given the magnitude of financial flows required, the public purse cannot substitute for private finance [21,22]. However, the public purse has a key role to play in establishing a policy environment that reduces barriers and investment risks in order to incentivize a reallocation of investment from resource-intensive, climate vulnerable to resource-efficient, climate resilient technologies and practices.

The recognition of barriers to potentially viable investment is at the origin of the new paradigm to finance sustainable development. This paradigm shifts the focus of public action away from supporting technology demonstration projects and skills development towards transforming markets. Market transformation aims to improve the risk-reward profiles of resource-efficient climate compatible investment by lowering or removing investment barriers. By removing technology-specific investment barriers, providers of debt and equity can offer lower financing costs and more attractive financing terms, reflecting the lower risks in the investment environment [19,23,24].

Figure 2 illustrates this concept, using the example of renewable energy. The figure visualizes a shift from a commercially unattractive investment opportunity to a commercially attractive one. This can be achieved by reducing the risk of the activity (for example through guaranteeing access to the grid to independent power producers for on-grid energy or streamlining licensing processes for off-grid energy solutions) and/or by increasing the return on investment (for example through a tax break or a price premium).

Since 2004, the number of countries promoting renewable energy with direct policy support has nearly tripled, from 48 to 140, and an ever increasing number of developing and emerging countries

are setting renewable energy targets and enacting support policies [63]. Decision-makers face a broad spectrum of policies, incentives and support mechanisms to create conditions that improve the risk-reward profile of investments in adaptation, and an even more puzzling number of options to combine them. The IEA/IRENA Global Energy and Climate Database listed 554 renewable energy policies and measures in October 2015.[6] There is no single, best instrument to promote low carbon and climate-resilient investment. Most investment faces a number of barriers and a portfolio of mechanisms will be necessary to lower them in a cost effective manner [19,23,24,25]. These public instruments come at a cost - to industry, to consumers and to the tax-payer. Furthermore, they usually involve trade-offs among stakeholders, and can affect the comparative advantages of industries and locations. Ultimately, they embed a set of political choices and societal values.

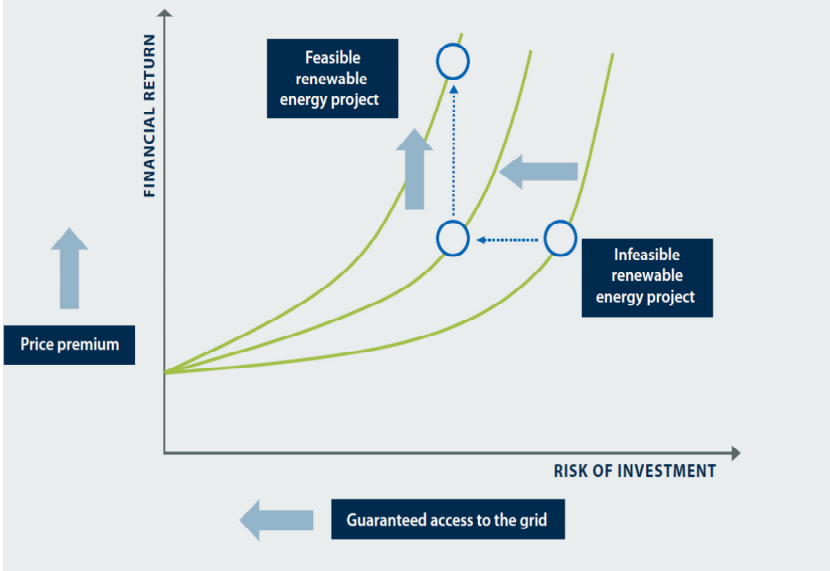


**Figure 2. Shifting the risk-reward profile of renewable energy investments [24].**

Given this multi-dimensional nature, a number of market transformation frameworks have been developed to assist policy makers in identifying and implementing a transparent, accountable, cost efficient and effective instrument mix, aligned to national development goals. Figure 3 summarizes a four-step market transformation process commonly used by sustainable energy practitioners in developing countries [23].

Step 1: Identify priority clean technology and management options. The most important factor in determining market transformation success is the alignment of proposed activities with national resources, priorities and needs as well as private interest of individual economic actors. During this step, the comparative advantages of different technology and management choices are assessed and ranked from these complementary perspectives.

Step 2: Assess underlying barriers to technology or management practice diffusion. When assessing underlying barriers and risks, it is important to take multiple stakeholder perspectives into

[6] The IEA/IRENA Global Renewable Energy Policies and Measures Database provides information on policies and measures taken or planned to encourage the uptake of renewable energy in all IEA and IRENA Member countries and signatories. It can be accessed at http://www.iea.org/policiesandmeasures/

account. Sustainable market development typically involves several main groups of stakeholders: investors, financiers, end-consumers, producers and policymakers. Each group is driven by a different set of motivations and face different investment and behavioral barriers.

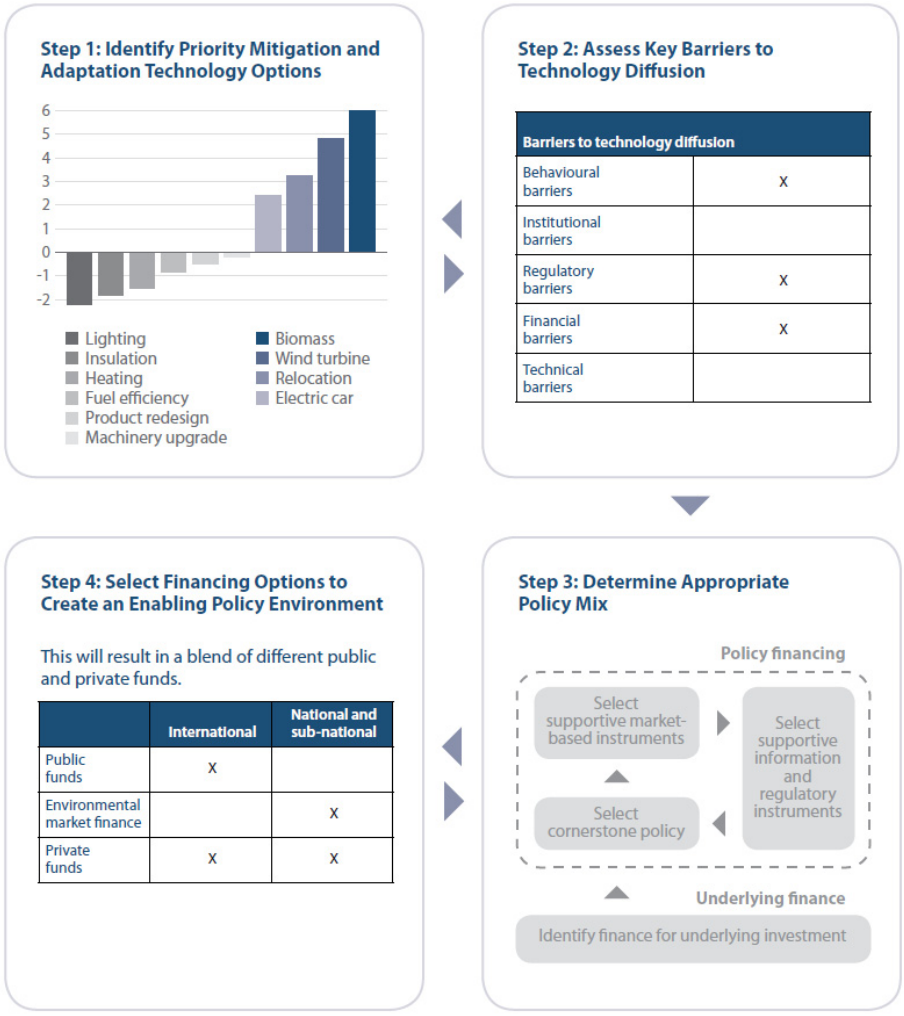


**Figure 3. A four-step market transformation process [23].**

Step 3: Determine an appropriate public instrument mix to address the barriers identified in Step 2. As barriers are typically country specific, the optimal mix of public instruments will also depend on the unique requirements of the country. Public instruments to remove barriers and increase the risk-reward profile of clean investment can be sorted into three main functions (the three "Ts"): treat risk (e.g.: streamlining licensing processes to mitigate or remove the risk of protracted licensing process to seat and operate an asset); transfer risk (e.g.: loan guarantees to fully or partially transfer the risk of default to a third-party); and tax risk (negative tax such as tax breaks or subsidies or positive tax such as carbon tax to increase the comparative reward of clean investment).

Step 4: Identify, access or develop financing instruments. The fourth and final step is to access or appropriate international and domestic funding sources to finance both policy instruments and underlying climate assets. In developing countries, this might require deepening national financial systems [23,63].

## 3. Gender Differentiated Barriers and Risks for Decentralized Sustainable Energy Access

This part of this paper contrasts the pivotal role that women entrepreneurs can play to accelerate universal sustainable energy access through decentralized solutions and their current under-representation in the industry. It formulates and tests the research hypothesis that this under-representation results from gender specific risks faced by women entrepreneurs that offset their potential comparative advantages in terms of creating distribution and servicing networks in rural areas that lower customer acquisition costs and credit repayment risk.

### *3.1. The gender gap in the renewable energy sector*

Across developing country contexts, women are the primary energy managers in households and communities. They are responsible for producing energy mainly through collecting traditional biomass based fuels in rural area, and for consuming energy in their household activities, micro-enterprises, and agriculture [26]. The disproportionate effects of energy poverty on women have been well documented, particularly for female-headed households [6,26,27,28]. The time spent on biomass collection for fuel limits their capacity to seize paid employment and other income-generating opportunities. The IEA [1] estimates that households without modern cooking technologies can spend between one and five hours every day collecting fuel wood. In remote and conflict-affected environments, this exposes women to personal security risks.

Moreover, women and children face significant health and safety risks from household air pollution caused by burning dirty fuels and unimproved cook stoves. Women are more exposed than men to indoor air pollution because of the greater time they spend cooking and on other domestic tasks. The World Health Organization [29] estimates that household air pollution causes around 600,000 premature deaths each year in Africa. Worldwide, 85% of the estimated 2 million annual deaths attributed to indoor air pollution are women and children dying of cancer, acute respiratory infections and lung disease [30]. According to a WHO survey in 11 sub-Saharan African countries, about a quarter of health clinics had no electricity and less than one third had reliable electricity, which limits their ability to respond, particularly to maternal and childbirth emergencies [30].

In addition, women living in off-grid households can spend a disproportionate share of their income on energy services at the expense of health and other essential services. It is estimated that poor households in Africa face recurring expenditures on fuels ranging from 10% to 25% of their monthly household budgets [10]. Relative to her overall income, a woman living in a developing country commonly spends 10 to 20 times more for her energy than a resident of an industrial country.[7]

The recognition of the unbalanced burden of energy poverty on women led initially to the incorporation of gender into clean energy investments as an environmental and social safeguard, where women were seen as a vulnerable group and passive consumers of energy services. However, there is growing recognition of the critical role that women play as agents of change in transition to sustainable energy from the supply side of the energy value chain [31]. Even though women may not

[7] Former UN Secretary General Kofi Annan reports the extreme case of women living in villages in Northern Nigeria who can spend around 60 to 80 times more for her energy than a resident of New York [10].

always be the main decision makers over energy sources at the household level, they are an important constituency to accelerated clean energy access.

Women tend to oversee the smaller, daily transactions linked to the household, and are usually the main decision makers in female-headed households [6]. Women are also an important entry point for credit-based services to households. They account for almost 100% of micro-finance institutions (MFIs) in Asia and 70% in Africa. MFIs focus on women for a variety of reasons. From a development impact viewpoint, there is empirical evidence that cash surpluses controlled by women are more likely to be invested in the well-being of children and the household than are surpluses controlled by men. From a financial performance perspective, they are considered as less of a credit risks as they generally tend to value scarce access to credit and avoid willfully defaulting [32].

Because they are close to their customers and know local circumstances, women entrepreneurs have enormous potential to manage supply chain and acquire new creditworthy customers in rural areas, thus driving down the cost of customer acquisition and repayment risks. They can assess the demand for, and sell energy services more effectively to other women. Notably, their access to potential female clients is not constrained by social and cultural norms [33]. The track record of women-led renewable energy businesses conclusively demonstrates the added-value of women entrepreneurs to accelerate off-grid energy access. For example, the Solar Sister Initiative, which invests in women solar entrepreneurs has grown from two to 1,250 entrepreneurs in five years [34]. According to some estimates, women entrepreneurs can demonstrate more than twice the level of business capacity and success compared to men [35].

This potential to reduce customer acquisition costs and repayment risk is a critical success factor for DESCOs. As seen in Part I, DESCOs depend on affordable finance mechanisms to advance inventory to their clients and allow payments over time, in amounts appropriately sized to local incomes. If firms cannot provide this, consumers cannot pay for their products and services. Traditional on-grid energy service providers mitigate the customer acquisition and customer repayment risks by capturing large, regular cash flows through Power Purchase Agreements (PPAs) with power utilities. Customer acquisition and customer repayment risks are comparatively key risks for DESCOs working with a large base of small customers. One of the main business challenges of DESCOs is to acquire and manage a large clientele that provides steady cash flows. This is key to reassure debt providers on the repayment capacity of the company and access long-term affordable finance. As stressed by Danny Kennedy, Co-Founder of Sungevity and Powerhouse, and Managing Director of CalCEF, "*the technology question has already been figured out for the sector. Now the game is in the cost of customer acquisition. During my time leading Sungevity, we were more successful at lowering this cost when involving women in the design and development of the marketing strategy.*[8]"

Decentralized renewable energy solutions could become a major source of engagement and employment opportunities for women at the local level. In 2014, IRENA [37] estimates that renewable energy employed 7.7 million people, directly or indirectly,[9] around the world, which represents an 18% increase from the 2013 figures. IRENA [36] estimates that 4.5 million direct jobs can be created by 2030 in the off-grid sector, particularly in solar PV, where employment has

[8] Personal communication

[9] Note, this excludes large hydropower

increased significantly. Additional employment will be generated through indirect jobs opportunities for self-employment, entrepreneurship and SMEs [36].

Despite the significant benefits that improvements in decentralized energy access, services and technologies will bring to women and the potentially powerful role they can play as agents of change in making the transition to sustainable energy, women remain under-represented in the climate change and renewable energy sector at both the policy decision-making level and in the workforce. IRENA [36] estimates that only 20% of the workforce in the modern renewable energy sector is women. This is consistent with country studies. According to Solar Census [38], in the United States, women made up 21.6% of the total solar workforce. Similarly, it was estimated at 26% in Spain (in 2010) and 24% in Germany (20007) [31]. Employment in the renewable energy sector also shows significant gender imbalances, particularly at senior levels. In industrialized countries, the share of women among technical staff in the energy industry is about 6%, of which 4% are in decision-making positions and less than 1% in top management [36].

At the policy level, of the 13 constituted bodies and bureaux established under the UN Framework Convention on Climate Change and its Kyoto Protocol, only 4 have a women chair, co-chair or vice chair [39]. Similarly, in a study covering 881 environmental sector ministries from 193 countries, only 12% of the ministers were women [40]. The limited number of women public policy makers in energy is mirrored in the private sector. About 61% of US energy companies did not have women on their Board of Directors in 2012 [41].

### *3.2. Gender Neutral Barriers and Risks Analysis for Decentralized Sustainable Energy Investment*

As highlighted by Anatole France in his famous quip "*In its majestic equality, the law forbids rich and poor alike to sleep under bridges, beg in the streets and steal loaves of bread"*,[10] laws are not income neutral. They are most often not gender neutral either. The World Bank 2016 [42] report on Women, Business and the Law identifies 155 countries out of 173 that have at least one law impeding women's economic opportunities and 18 economies where husbands can prevent their wives from working. The effect of these discriminatory laws is often compounded by harmful social norms and gender differentiated tasks. Women spend on average 250% more time than men on unpaid domestic and care work. In addition to being a human right violation, violence against women can also constitute a major economic barrier, restricting movement and occupational choices. An average of 35% of women are living with violence, rising to 70% in some societies. These structural barriers translate into unequal access to productive resources such as land, finance, technology, labor, markets, justice and information. Even the best intended public policies and measures may not benefit women and men equality and inadvertently discriminate against women because of this unequal access [43].

Closing the gender gap in access to productive assets has shown to lead to greater productivity and societal benefits. For example, in agriculture, the UN Food and Agriculture Organization [44] found that if women had the same access to productive resources as men, they could increase yields on their farms by 20–30 %. A recent report from UN Women, the World Bank, UNEP and UNDP (2015) [45] found that even with conservative assumptions, annual crop output could increase by 7.3% in Malawi, which could bring potential gross gains to GDP of $100 million (or 1.85% of GDP).

[10] *Le Lys Rouge* [The Red Lily] (1894), ch. 7

The McKinsey Global Institute estimates that the world economy could add $12 trillion in growth during the next ten years if countries met best-in-region scores for improving women's access to the labor market [46].

In an effort to better understand the root causes behind the under-representation of women in the decentralized energy industry, this paper hypothesizes that generic policies intended to remove investment barriers and risks for both men and women entrepreneurs to accelerate energy access may not benefit women equally in this sector as in others because of the structural barriers that women face. This research hypothesis builds on experiences in the European Union (notable Germany) and the USA showing that energy policies, legislation and regulatory frameworks are not gender neural and that there are challenges in ensuring gender sensitivity [27]. According to this research hypothesis, gender sensitive market transformation efforts would require that additional policy instruments be deployed to benefit equally men and women DESCO entrepreneurs and optimize the use of public resources to catalyze private investment for universal energy access for the poor.

A two-step approach was adopted to test this hypothesis. First, we have reviewed ongoing work by UNDP and ETH Zurich, who have developed a gender neutral barrier and risk analysis for private sector investment in sustainable energy mini-grids in developing countries [20]. The gender neutral barrier and risk analysis used focuses on solar PV/battery mini-grids. However the analysis is applicable to the broader decentralized sustainable energy sector, including other mini-grid technologies, as well as DESCO-based off-grid systems. In line with the market transformation approach described above [19,23,24], this generic analysis assesses underlying barriers to technology or management practice diffusion, taking into account the perspectives of key stakeholder groups. By using stakeholder groups as the organizing basis, the barriers are aggregated into independent risk categories, which are associated with the stakeholder group that can address or mitigate the particular risk category.

We have used this overall framework with minor modifications, for example, moving the barrier related to developer credit worthiness and cash flow strengths from the developer risk category to the financial risk category since the financial sector is best placed to address these risks. Nine risk categories were identified, which translate into 22 underlying barriers. A summary of the risk categories and underlying barriers are shown in Table 1. Details can be found in Annex 1.

### *3.3. Gender Sensitive Barriers and Risks Analysis for Decentralized Sustainable Energy Investment*

Second, we overlaid a gender analysis to this generic barrier and risk analysis, based on a review of the literature and semi-structured interviews with RE investors and development practitioners in developing countries. For each generic risk discussed in table 1, we assessed its gender differentiated probability of occurrence and potential severity; as well as identified the presence of additional gender specific barriers. Table 2 summarizes the key results of this gender analysis. Further information on the gender differentiated risks is given in Annex 1.

The bulk of the additional gender-specific risks are borne by women as potential entrepreneurs, employees and end users in the following categories:

**Table 1. Summary of the risk categories and gender neutral underlying barriers [20].**

| Risk category | Description | Underlying barriers | Key stakeholder groups |
|---|---|---|---|
| 1. Power Market Risk | Risks arising from limitations and uncertainty in the energy market (off- and on-grid) regarding market outlook, access, price and competition | • Market outlook<br>• Market access, competition and grid expansion<br>• Tariffs<br>• Technical standards<br>• Competing subsidies | Policymakers, legislators, regulators, utility, grid operator |
| 2. Social Acceptance Risk | Risks arising from lack of awareness and resistance to renewable energy and minigrids in communities | • Resistance by end users | General public, NGOs, businesses |
| 3. Technology Sourcing Risk | Risk arising from limitations in the quality and availability of minigrid hardware, as well as its treatment by customs | • Hardware quality<br>• Availability of hardware<br>• Customs | Hardware manufacturers, technical regulator, customs (excise) |
| 4. Labour Inputs Risk | Risks arising from the lack of skilled and qualified potential employees | • Lack of a competitive, educated labour market | Labour force, academic institutions |
| 5. Developer Risk | Risks arising from limitations in the developer's capability to efficiently and effectively design, install, operate, maintain and monitor its minigrid | • Effective-execution – planning and design<br>• Effective execution – installation and operations | Project developer / energy services company |
| 6. Financing Risk | Risks arising from scarcity of domestic investor capital (debt and equity) for mini-grids, and domestic investors' lack of familiarity with mini-grids and appropriate financing structures | • Developer credit worthiness and cash flow<br>• Capital scarcity – liquidity constraints in domestic banking<br>• Capital scarcity – underdeveloped domestic financial sector<br>• Capital scarcity – competing incentives<br>• Limited domestic investor experience with small scale renewable energy | Domestic investors (equity and debt), financial sector regulator |
| 7. Payment and Credit Risk | Risk arising from customers' willingness, ability, and methods of payment for electricity | • Lack of information on customer creditworthiness<br>• Poor creditworthiness and non-payment<br>• Poor consumer finance channels and regulation | End-users, consumer credit data sector and regulator |
| 8. Currency Risk | Risks arising from currency mismatch between hard currency debt/equity and domestic currency revenues. | • Uncertainty due to volatile local currency | Macro risk |
| 9. 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 | • Conflict, political instability, economic performance, weather events/natural disaster, legal governance, ease of doing business, crime and law enforcement, land tenure and infrastructure | Macro risk |

**Table 2. Comparison between the gender blind and an engendered analysis.**

| Risk category | Gender neutral underlying barriers | Increased probability of occurrence and severity of impact of risks for women | Additional gender-specific barriers |
|---|---|---|---|
| 1. Power Market Risk | • Market outlook<br>• Market access, competition and grid expansion | • Gender insensitive market outlook<br>• Women as soft targets for competition from other operators<br>• Women are softer targets for corruption and the lack of transparency when seeking to obtain operating licences | |
| 3. Technology Sourcing Risk | • Hardware quality | • Gender gap in access to information and technical skills | |
| 4. Labour Inputs Risk | • Lack of a competitive, educated labour market | • Discriminatory social norms and stereotypes | • Discriminatory business practices<br>• Women's disproportionate responsibility for domestic work and unpaid care |
| 5. Developer Risk | • Effective execution – planning and design<br>• Effective execution – installation and operations | • Gender skills/capability gap of the developer<br>• Resource and demand - Proximity to clients lowers risk of acquiring and serving other female customers (positive risk)<br>• Gender skills/capability gap of the developer | • Lower access to recourse<br>• Security – risks of violence against women<br>• Gender gap in land tenure |
| 6. Financing Risk | • Developer credit worthiness and cash flow<br>• Capital scarcity – under-developed domestic financial sector | • Lower levels of collateral reduce the credit worthiness of women developers<br>• Lack of rural banks more likely to affect women developers due to lack of mobility | • Capital scarcity - harmful social norms |
| 7. Payment and Credit Risk | • Poor creditworthiness and non-payment | • Women entrepreneurs are more likely to have better knowledge about the credit worthiness of their customers and will particularly benefit from policy instruments that increase the repayment capacity of women customers (positive risk) | |

### *Women as renewable energy entrepreneurs*

- *Power market risk:* refers to risks arising from limitations and uncertainty in the energy market (off- and on-grid), and ability to compete with traditional sources of power. This is likely to be more probable for women entrepreneurs, who are less likely to have certainty around government's commitment and capacity to address the gender-bias in national/state level strategies for renewable energy and electrification. Section 2.1 highlights the gender gap in the renewable energy sector at the policy level. This low-level of women's representation in

decision-making positions in the environment and climate sectors translates into gender insensitive national strategies and policies to promote sustainable energy development. Despite the growing attention given to gender issues in international climate change decisions and agreements, only 39% of the Intended Nationally Determined Contributions submitted by parties to the United Nations Framework Convention on Climate Change as of 11/18/15 explicitly mention "gender" and/or "women" in the context of their national priorities and ambitions for reducing emission [47].

- *Developer risk:* refers to the risks faced by project developers related to the effective design, installation, operations and maintenance of decentralized renewable energy technologies as well as those related to the acquisition of the envisaged amount of creditworthy customers. As discussed earlier, women entrepreneurs have a lower risk in this area due to their comparative advantage in acquiring and serving other female customers. However, this comparative advantage is partially offset by a higher risk of poor execution, including the risk of unforeseen costs or delays during project development. This is due to the occupational gender gap, and the fact that women face disproportionately higher barriers relative to their male counterparts operating their businesses particularly in terms of entrepreneurial skills, financial literacy and management, and technical skills [48, 49]. Women entrepreneurs also face an additional risk related to non-compliance on contracts by their customers because of the gender gap in access to justice to enforce remedial measures [50]. They also face risks of violence, which restrict their personal movement and occupational choices. In some countries, only men are employed as sales agent of decentralized renewable energy solutions, particularly for this reason. For example, none of the community mobilisers from Eco Energy Finance in Pakistan are women.[11] Finally, one of the primary barriers to women empowerment is widespread inequality in ownership and control of land, which often a pre-condition for access to finance and other productive assets. Lack of land ownership will bar women entrepreneurs' investment in renewable energy systems that require land such as wind turbines and biofuel plantations or exposed them to a number of pressures, including the risk of expropriation. It is different in nature from the risk of not being able to secure the required tack of land faced by men entrepreneurs [51,52,31].
- *Financing Risk:* refers to the inability for the developer to secure financing from investors due to lack of credit worthiness. It also includes capital scarcity in the domestic financial sector, which are major investment barriers to entrepreneurs' access to finance. For women developers, these barriers are particularly significant. Across regions, women entrepreneurs have lower access to finance than male entrepreneurs [48]. Women owned formal SMEs have $260 to $320 billion in unmet financing needs worldwide. Women are 15% less likely than men to have a bank account, and significantly lag behind men in saving and borrowing through formal financial institutions, even after controlling for individual characteristics, such as income, education and age [49]. These gender specific barriers exclude women from investing and limit women entrepreneurs from scaling up their enterprises. IFC [48] found that women entrepreneurship makes up between 32 to 39% of the very small segment of firms, compared with 17 to 21% of medium-sized companies. It is largely due to women's lower levels of collateral associated with discriminatory

[11] Based on an interview with the Executive Director of Eco Energy Finance in November 2015. Eco Energy Finance provides solar energy to rural Pakistan. Current gender breakdown in terms of 10 staff (9:1); retailers (390:10) and zero community mobilisers.

laws in terms of land and property rights, which reduces their credit worthiness and their ability to secure financing from investors. While some regions ensure gender equality in property ownership and inheritance law, discriminatory laws remain in place in a number of countries notably in the Middle East, Asia, and sub-Saharan Africa. This is reinforced by the gender gap in terms of income and employment, which further reduces women's ability to save and build assets, resulting in large gender disparities in access to physical capital and assets [43]. It can also be further reinforced by discriminatory social norms and gender stereotypes reducing investor interest in women entrepreneurs and create a gender bias in the investment decisions of potential investors. Under-developed domestic financial sectors, particularly the lack of rural bank branches are also more likely to affect women, due to their lower levels of mobility.

***Women as employees in the renewable energy labour market***

- *Labour inputs risk:* refers to the risks arising from the lack of a skilled and qualified workforce. According to ILO [53] skills shortages are hindering the transition to sustainable energy in many countries and contributing to higher costs, delays and faulty installations. This in turn can lead to negative perceptions about the reliability of RET, reducing public acceptance and hindering renewable energy deployment. As mentioned in section 2.1, women currently represent only about 20% of the renewable energy workforce. One of the key underlying barriers that exclude women from the renewable energy labour market is discriminatory social norms and stereotypes about gender roles and differences in aptitude. This plays an important role in shaping preferences and perceptions that women are 'unsuitable' for sectors that traditionally employ men [43]. Gender stereotypes contribute to the education and skills gender gap, particularly in the science, technology, engineering and mathematic (STEM) fields. For example, in Germany, it is estimated that only 13% of the 2011 graduates in engineering were women [36].
- Furthermore, women's disproportionate responsibility for unpaid domestic work and care further limits the time they have available to participate in the renewable energy labour force. Globally, women do nearly 2.5 times as much of this work as men, with large gender disparities in time spent cooking, cleaning and caring for household members. In the EU in 2013, 25% of women, compared to 3% of men cited care and other family responsibilities as the reason for not being in the formal labour force [43].

Discriminatory business practices create gender bias in the hiring, promoting and payment decisions by renewable energy employers. The existence of a "glass ceiling" in the renewable energy sector, where invisible barriers limit women from advancing their careers to influential positions, may further deter women from entering the sector [36]. Women may also be discouraged by the risk of harassment in the workplace and the inability to maintain a work/life balance. While these have not been documented specifically for the renewable energy sector, they have been documented in the labour market and prevail in many industries [36,43].

***Women as credit risks***

- *Payment and credit risk:* refers to risks arising from customers' willingness, ability and methods of payments. The risk of non-payment is likely to be lower for women entrepreneurs who are more likely to have a better knowledge of their women clients and their ability to make regular

lease payments [32]. This increases the attractiveness and profitability of the third party ownership business models for women entrepreneurs. Women entrepreneurs are also more likely to benefit from policy instruments and interventions that increase the repayment capacity of women customer through promoting productive uses of sustainable energy solutions.

A key finding of the gender analysis is that for women entrepreneurs, existing structural barriers to gender equality translate into additional risks, greater likelihood that risks will translate into negative impacts for renewable energy activities, and greater severity of these impacts. In addition to the barriers and associated risks identified in step 2 of the market transformation process, women entrepreneurs face six new barriers, and nine of the original risks have a higher probability of occurrence for women. In accordance with the research hypothesis, the lower level of developer risk in terms of customer acquisition as well as credit repayment risk is offset by a substantial higher risk level for women overall. This gender inequality of risk means that a decentralized renewable energy investment with an attractive risk-reward profile for men entrepreneur might be too risky for women entrepreneur in the absence of targeted policy efforts to address gender-specific barriers. Market transformation efforts must be engendered to benefit equally women and men entrepreneurs and to optimally achieve their objectives.

## 4. Gender Sensitive Market Transformation Efforts for Decentralized Sustainable Energy

This part of the paper argues that interventions to engender market transformation efforts will need to remove all key barriers and associated risks in an integrated manner as discreet efforts to address a given barrier in isolation might be frustrated by lack of progress on other barriers. It then proposes a generic theory of change to facilitate the development of such integrated gender sensitive market transformation efforts for universal electricity through decentralized solutions.

### *4.1. The need for integrated gender sensitive market transformation efforts*

Risks are technology and context specific. However, the variety and severity of gender specific risks mean that any gender responsive market transformation effort is likely to be hampered by a combination of investment barriers linked by complex power dynamics. Two concrete examples of gender sensitive interventions to promote women empowerment through renewable energy technologies in Georgia and Bangladesh will facilitate the discussion of this point.

#### 4.1.1. Gender-responsive low-cost solar water heating solutions and solar dryers in Georgia

The first intervention is led by women in Europe for a Common Future (WECF) [54] to provide affordable low-cost solar water heating solutions and solar dryers in Georgia. The average rural household in Georgia spends one third of their total household budget on energy. The use of a solar water heater saves each household on average more than 150 EUR per year. A solar water heater costs up to 375 EUR, therefore the payback time is 2-3 years. The gender approach of this Programme was to aim for equal involvement of women and men. Women were actively involved in the adaptation of the technology to the unique requirements of rural Georgia, ensuring both that the technology would be gender responsive and that a strong local demand would exist.

Furthermore, the Programme developed a gender-responsive training to create opportunities for both local work men and women to start a small business with sales and maintenance of solar collector. The training divided the work into two functions: construction and maintenance/monitoring. However, the project did not aim to change gender stereotypes of gender behaviours per se. Participants could select which training to attend. This resulted in almost only men choosing construction, and women choosing the maintenance, as construction is traditional perceived as a man's job, and the women lacked the welding skills.

While a number of men trained in construction were hired to help other households build their solar water heaters, this did not happen for women trained in maintenance. The initial idea was that trained women would help other households with the maintenance of their collectors. But existing insecurity for women travelling alone, the lack of time due to their heavy burden of household responsibilities (caring, cooking, cleaning and looking after livestock), and traditional gender stereotypes that women should stay at home, curtailed their actual employment opportunities.

While interest in solar collectors has risen rapidly as a result of the initial demonstration activities, efforts to scale up the Programme are hampered by in the lack of financial resources amongst rural population. Without access to credit, the poorest segment of the population, which often includes single female headed households, simply do not have the required funds to invest in a solar collector. While people are ready to take a loan to pay for a solar water heater because they save costs on energy, very high interest rates of up to 30% per year of existing energy credits make them prohibitive. It is also difficult for rural people to get a loan from a bank because property in rural areas is not accepted as collateral. This is especially a barrier for women, as assets are usually registered on the name of their husbands.

To overcome this financial barrier and make solar water heaters available for the lowest-income families, the Programme developed a complementary lease-purchase instrument affordable for the great majority of the rural population. Women make up 80% of the clients for the lease-purchase financing instrument. The main challenge with the lease-purchase instrument is that it does not yet have a legal base. For larger scale implementation of this instrument, a formal partnership will need to be forged with commercial banks, overcoming their risk aversion due to their limited experience in servicing the rural poor, and in decentralized sustainable energy solutions.

#### 4.1.2. Integrating women into the renewable energy value chain in Bangladesh

The purpose of the second intervention was to integrate women into the renewable energy value chain of Grameen Shaki and other DESCOs in Bangladesh. It was implemented by Grameen Shaki and supported by a $2.3 million grant from USAID. Grameen Shakti is the leading renewable energy company in the country. It is a full-service DESCO that, in addition to manufacturing and sales, provides installation, maintenance and repair of the systems they sell, as well as customer financing (dealer credit model) and training.

The project linked women's empowerment to decentralized RETs by establishing 35 Grameen Shakti Technology Centers to train rural women to assemble components and construct SHSs. Following installation they would service, maintain and repair SHSs. The Grameen Shakti Technology Centers provided 15 days of technical renewable energy training to 2,797 rural women from 2005 to 2010. Although the training programme focused on SHS assembly, it also included some training in SHS repair, promotion and installation. Trainees were expected to be incorporated

into the supply chain of Grameen Shakti, mostly as contractors to assemble locally SHSs at the Grameen Technology Centers.

Another objective of project was the creation of women entrepreneurs. It was envisaged that some of the trainees would develop as entrepreneurs, assembling, servicing, repairing and maintaining SHS. Accordingly, additional entrepreneurial training were provided to around 500 of the trainees, and some of the best performing trainees were given SHS assembly and construction tools (soldering iron, etc.) as an incentive to engage in entrepreneurial activities. They would be granted space by Grameen Shakti and supported to undertake this activity. Such entrepreneurship would logically follow the increase in SHS, giving rise to independent servicing activities in rural areas.

However, despite the large number of women trained, a survey conducted by a project assessment [55] found that only 86 of the women (3%) work for Grameen Shakti and that none were entrepreneurs in the renewable energy sector. A large proportion (42%) of the trainees who were not employed by Grameen Shakti reported promoting SHSs in their community on a voluntary basis after the training; but this did not lead to any income generation [55].

In terms of employment or outsourcing opportunities, the low level of integration of women trainees in the RET sector can be partly explained by a shift in market conditions. At the time of the initial project planning and design stage, Grameen Shakti anticipated a major growth in local assembly of SHS components. However, the opposite trend materialized during the project with an increased reliance on imported ready-made systems. As a result, employment opportunities for women at this weak point of the value chain contracted.

In terms of entrepreneurial development, most women who attended training came from poor families and few had graduated from high school. Even if given space by Grameen Shakti, their likelihood to develop as independent entrepreneurs was extremely low in the absence of in-depth entrepreneurial skills, integration into established RET supply chains, access to long-term affordable credit, and changes in social norms that perceived SHS installation as a man's work.

#### 4.1.3. The need for an integrated approach

The first intervention takes place in a high middle income country while the second is implemented in a least developed country. Despite their different socio-economic context, the WECF experience in Georgia and the USAID/Grameen Shaki experience in Bangladesh shared a number of similarities.

Both intervention demonstrated the need for complementary strategies to address inter-linked behavioral, technical, financial and institutional barriers disproportionally faced by women in the RET sector and sustainably transform a market. The USAID project assessment study [55] concluded that "*training alone does not guarantee entrance and integration into renewable energy value chains, or in any other sector, and that complementary or even alternative strategies such as apprenticeship or enforceable targets for women's employment should be considered"* to address all existing barriers. Building on its initial training efforts, the growing focus of WECF on access to finance and social norms in Georgia reflects a similar recognition.

A second finding of these pioneering gender responsive market transformation experiences is the importance of defining the path to gender empowerment outcomes from the onset. The USAID study specifically noted that the absence of a pre-defined path to the key outcome of integration,

either as “employees” or “entrepreneurs”, prevented the timely identification of complementary strategies in Bangladesh. The next section discusses the potential of theories of change to help project developers define such paths to gender empowerment outcomes.

### *4.2.Towards a theory of change to foster women’s leadership in decentralized energy*

Theories of change (TOC) are an increasingly popular tool among development agencies. They aim to capture what overall activities must be undertaken in order to deliver transformative results in a given area, why they must be implemented, and how they must be operationalized. Notably, they are focused on bridging the “missing middle” between what a programme does and how it leads to desired change. TOCs can begin at any stage of an initiative. They can be developed at the outset to inform the formulation of an initiative or during evaluations to reflect on what has worked. Despite their growing popularity, there is no uniform format. Some TOCs take the form of comprehensive logical frameworks, while others place more emphasis on a transparent articulation of assumptions and change narratives.

A theory of change can provide a useful analytical platform for development partners to engage in a dialogue on actions required to achieve a given transformative change, identify ongoing activities that are already contributing to the achievement of this transformative change as well as gaps in present efforts, and effective ways to address these gaps. As such, it can help project developers in defining the path to key gender empowerment outcomes within a broader market transformation exercise.

Based on the gender analysis of barriers and risks conducted in part II, we have developed an illustrative TOC for gender sensitive market transformation for decentralized sustainable energy. The ambition of such an illustrative theory of change is to facilitate an initial discussion among partners on required action to promote gender sensitive, cost effective and efficient market transformation efforts to accelerate universal sustainable energy access. By definition, it will need to be adapted to capture the specific risks, ongoing activities and gaps unique to each development situation. Through this localization/amendment process, it will enable partners to reach a shared understanding of underlying barriers and required actions to address them.

To this end, we have first adopted a format for the TOC that can enable project developers to directly translate the localized TOC into a project logical framework, with indicators to ensure effective monitoring of implementation. It directly links narrative TOC statements (the set of beliefs underlying a proposed intervention) to specific goals, outcomes, outputs and activities. It also discloses in a transparent manner the assumptions and risks associated with the proposed intervention. This format was initially developed to guide the investment strategy of United Nations trust funds aiming at achieving transformative change for sustainable development [56]. For our specific purpose, it enables us to capture in a single visual the key finding of the four-step market transformation framework and link it directly to the formulation of specific actions.

In line with step 3 of the market transformation framework, we have then identified a number of possible public interventions and instruments to address each of the gender specific risks and barriers analyzed in part II. Detailed information is given in Annex 1. This exercise was educated by a review of existing literature and a series of exchanges between UN Women and UNEP, policy makers and the private investors in developing countries. These interventions were then systematically translated into desired outputs, with illustrative activities. For example, the increased power market risk for

women associated with the uncertainty and lack of clarity regarding government commitment to addressing gender-bias in national/state level strategies for renewable energy and electrification can be partly addressed through increasing the engagement and decision-making capacity of women in energy planning and policy development. This became the first output of the TOC.

The different outputs were then clustered into four axes of intervention or outcomes: (i) energy access policies and measures are engendered; (ii) skill, information and social norm barriers for women sustainable energy entrepreneurs are removed; (iii) financial intermediation services for access to upfront capital and receivable management are strengthened; and (iv) women's unpaid domestic and care work is reduced and productive uses of energy promoted. Each of the four TOC outcomes and their constituting outputs are briefly described below. The full theory of change is given in annex II. It was presented during the joint IRENA, European Commission and UN Women 'Women in Renewable Energy Conference' (Brussels, June 2015) and further refined at the UN Women/UNEP technical workshop on "De-risking Decentralized Renewable Energy Investment for Women entrepreneurs" (New York, November 2015).

#### 4.2.1. TOC Outcome 1: Energy planning and policies are gender-inclusive, participatory and responsive

Actors involved in planning and policy making tend to benefit from policies and investments because they can ensure reflection of their interests [57, 58]. As highlighted by the gender analysis of a decentralized renewable investment in Part II, additional barriers under the power market risk category affecting women are linked to gender blind policies. Women's involvement in energy planning and policy formulation, including in decision making, is a pre-condition for addressing these gender differentiated risks and improving their role as energy entrepreneurs [55]. Effectively engaging women's organizations in energy planning and policy development, including in decision-making may require targeted capacity development initiatives. This is to ensure they understand the benefits and costs of different energy technological options in terms of time savings and productive uses of energy; as well as of different policy instruments in terms of targeted support to women entrepreneurs. It is also important to link women's organizations to policy makers and the energy policy-making process (output 1.1).

In order to facilitate evidence-based participation of women at the policy making table, gender-responsive baselines, assessments and audits of gender specific risks and underlying barriers will be required to determine the needs and potential impacts of energy plans and policies on women, and to identify the opportunities that policy change can create for women's sustainable energy entrepreneurship and access (output 1.2). For example, gender audits of energy sector policy have been used in several developing countries, including Botswana, India, Kenya, Mali and Senegal, to support the adoption of more gender sensitive and responsive energy policies [27].

Participation by women and assessments do not by themselves ensure the adoption of gender-sensitive and responsive policies. Successfully engendered energy policies must recognize and translate women's specific needs [33] into targeted policies to support women's economic empowerment in the decentralized renewable energy sector (output 1.3). Such policies could include: targeted fiscal incentives; streamlined licensing processes and quotas for women renewable energy entrepreneurs; mandatory targets or incentives for the private sector and public utilities to improve the gender balance in the work force; family-friendly and anti-discriminatory work place policies;

dedicated avenues to facilitate women renewable energy entrepreneurs' access to justice; and complementary investment in essential social infrastructures to reduce the unpaid domestic and care work of women. Energy policy making must be coordinated with policies for education, social protection, trade, industry, labour, land tenure reforms, civil registration and access to justice to address gender specific risks, since the removal of the underlying gender-specific structural barriers fall under the purview of other ministries.

Implementation of energy plans and policies will require the appropriate budget allocations and should be monitored and evaluated to assess the different policy impacts for men and women and educate future market transformation efforts (output 1.4). In line with step 4 of the market transformation process, this will require ensuring that gender sensitive provisions of energy plans are successfully integrated into national budgets. Experiences from Mozambique have shown that a national gender and climate strategy with limited budget allocations has remained largely unimplemented. Rwanda on the other hand, made explicit efforts to link climate change and gender policies to the budgeting process. It included an annex on environment and climate change budgeting in the annual budget call circular. It also adopted a national gender-responsive budgeting programme. These efforts have contributed to an increase in its average expenditure on environment and climate change from 0.4% of GDP (2005-2008) to 2.5% of GDP (2008-2012). The country also established a national climate fund in 2012, with output indicators measuring the percentage of projects with transparent community participation, gender equality and equality in the design and implementation [59].

#### 4.2.2. TOC Outcome 2: Skill, information and social norm barriers for women sustainable energy entrepreneurs are removed

In addition to targeted energy policies, efforts will also be required to improve women's access to technical education, training and information [36] and remove harmful social norms and practices affecting their occupational choices. This includes: encouraging greater participation by women in the STEM educational and RET fields through scholarships, internships, academic and industry research; increasing the technical capacity of women entrepreneurs in terms of planning, designing, constructing, operating and maintaining renewable energy solutions; and improving women's access to information through targeted information shari(output 2.1). UN Women, in partnership with the Barefoot College, a non-governmental organization that provides solar electrification to rural populations, has trained women in assembling and maintaining solar systems in India and South Sudan. In Zanzibar, UN Women is supporting the opening of a new training centre that will be operated by the Barefoot College [60]. UN Women experience confirms USAID/Grammen Shaki finding that technical training alone does not guarantee entrance and integration into renewable energy value chains but is a fundamental element of any market transformation strategy.

In addition to technical skills, enhancing women's entrepreneurial skills through training on business plan development, procurement, marketing, financial management, legal frameworks, existing remedial recourse mechanisms in case of contractual breaches, and alternative supply chains, business models and land titling arrangements might be required. These capacity development efforts could be supplemented by the provision of apprenticeship, mentoring and dedicated business incubation services (output 2.2). Shifting women's perception of suitable gender roles and increasing awareness of their rights might be necessary to promote their engagement in the strongest links of the

RET supply chain such as marketing, installation and receivable management. Public campaigns might also be need to challenge harmful social norms.

In terms of renewable energy companies, it is critical for business policies and practices to promote a safe and bias-free working environments that attract, retain and promote women. This will include promoting the adoption of the Women's Empowerment Principles (WPEs). Developed through a partnership between UN Women and the United Nations Global Compact, the WPEs offer practical guidance to businesses and the business sector on how to empower women in the workplace, marketplace and community. The Principles are designed to support companies in reviewing existing policies and practices or establishing new ones to realize women's empowerment.[12] This will include promoting family friendly policies and child care; and addressing workplace harassment and perceptions of women as 'unfit or not suitable' for employment in engineering, technical or business fields. It will also require ensuring a safe and secure working environment for women professionals by preventing violence against women. This will entail assessing the risks associated with each segment of the supply chain, segmenting the supply chain and adjusting the team composition. Engagement with the private sector through advocacy, skill development and voluntary compacts could be explored to complement mandatory instruments such as anti-discriminatory regulations and quotas or financial incentives such as tax breaks (output 2.3).

#### 4.2.3. TOC Outcome 3: Financial intermediation services strengthened

Appropriate traditional and innovative financial intermediation services are essential to facilitate access to upfront capital and to manage receivables. Access to affordable finance and new financing models adapted to the cash flow profile of poor households can help the energy poor to offset high upfront costs and become key enablers for scaling up deployment of clean energy [61]. New financing solutions are also needed to channel finance to energy access solutions that have not yet attracted commercial investment, and which can benefit communities where women are most in need of energy services [7,62].

A wide range of options exists to strengthen financial intermediation services and can be explored to strengthen financial intermediation services to women entrepreneurs in general and sustainable energy entrepreneurs in particular (output 3.1). Some countries have relied on directed credit to achieve public policy goals (lending quotas to SMEs) while others have relied on policy-driven institutions such as national development banks, national green funds and public-sector revolving fund credit schemes to lend directly to project proponents [61,63]. Others are experimenting with credit enhancement mechanisms, such as partial loan guarantees, to increase the level of consumer credits through commercial banks or RET suppliers [63]. Furthermore, micro-finance institutions (MFIs) are diversifying their financial products and increasingly provide consumption loans to enable the poor to meet the upfront costs of renewable energy technologies [61,64]. More recently, web-based platforms such as the *Defi Diaspora Benin* or ASHIII have been developed to link diaspora investors to decentralized entrepreneurs [65]. Using chain block technologies, these web-based platforms provide both access to low cost upfront capital and a financial identity to users, enabling them to build robust credit scores.

[12] More information on the WEPs can be found at: http://www.unwomen.org/en/partnerships/businesses-and-foundations/womens-empowerment-principles

Based on the assessment of existing financial intermediation options (output 3.1), capacity development can be provided to local commercial banks and MFIs to design and manage new credit products with longer maturities, and to appraise clean energy loans for women sustainable energy entrepreneurs (output 3.2). Partnerships can also be developed with multilateral, regional and national development finance institutions to provide credit lines and credit enhancement instruments to local financial institutions to support these efforts.

Innovative financial solutions might also be required to meet the unique requirements of women entrepreneurs. Challenge Funds have proven effective instruments to incentivize the private sector to try new ways of extending financial services to the poor [66,67,68]. For example, a grant from the DFID's Financial Deepening Challenge Fund helped Vodafone and Safaricom develop M-PESA, the mobile telephony-based commercial platform that piloted mobile banking technologies in developing markets. As discussed earlier, these mobile banking technologies are driving new business models for decentralized sustainable energy through lowering transaction costs for receivable management. Partnership with challenge funds could be developed to pilot/scale up web-based platforms to access affordable upfront capital or mobile banking technologies to reduce the transaction costs associated with managing a large amount of small receivables (output 3.3).

#### 4.2.4. TOC Outcome 4: Women's productive use of RET is promoted, and time dedicated to unpaid care and domestic work is reduced

Sustainable energy availability does not automatically result into sustainable energy access and does not reduce poverty by itself. It must first be translated into specific services that enhance the productivity of existing livelihoods and promote new income generating activities. There is some empirical evidence that benefits from energy availability tend to accrue in a regressive manner, with wealthier households receiving a higher boost of income than poorer households [69, 6]. As discussed in part I, the inability or reluctance by low-income consumers to pay for decentralized RE technologies was one of the key barriers that stalled earlier grid-based electrification efforts in the 1980s in developing countries [5]. Thus, it is critical to couple renewable energy access with other development interventions that promote income and employment generation for women [62,63]. A UNDP/AEPC evaluation [70] of the impacts of mini-hydropower systems installed by Nepal's Rural Energy Development Programme found that the direct benefits attributable to electricity access amount to about USD 150 per year per household. The study estimates that initiating a productive activity using newly available electricity can produce an additional USD 912 for a household. Similar impacts of promotion of productive uses of energy have been reported in other locations [71].

As a first step, access to energy must be coupled with the electrification of health centres, schools and water supply systems (output 4.1). These services are key economic and women's advancement enablers [46]. For example, people often cannot start economic activities or cease activities they have started due to the health problems of family members leading to the family's resources being used to cover treatment costs [72]. In addition, these services are also critical to reduce the disproportionate burden of domestic and care work on women and girls, freeing time for new productive activities. This is a pre-condition to address the energy poverty of women and enable them to seize new income opportunities created by sustainable energy access. A number of studies have shown that electrification of rural communities have resulted in a 9 percentage point increase in female employment, with no comparable increase in male employment [73]. The studies attribute

this largely to the fact that electricity frees up women's time by increasing the efficiency of domestic chores. As mentioned in our discussion of gender responsive energy policies, separate ministries typically look after energy matters, health, women's empowerment, and skills and entrepreneurship. Promoting interaction among these different stakeholders can help formulate solutions that look at the entire ecosystem [74]. In Uganda, UN Women and the UN Foundation and in collaboration with other partners, is supporting the government to bring together representatives from the health, energy and planning sectors in order to develop an action plan to improve energy service provision in health facilities [75].

Promoting the productive use of energy access could be particularly effective in the agricultural sector, where women are disproportionally represented (output 4.2). Land preparation, planting and replanting, weed control, harvesting and processing are mostly powered by human labor in Africa. The United Nations found that labor shortage is a major determinant of the gender agricultural productivity gap in several Africa countries [45]. Energy access could alleviate this labor shortage and substantially close the gender productivity gap that can exceed 20% in sub-Saharan countries. In Morocco, UN Women and partners are supporting women to generate an income by using renewable energy to cultivate medicinal and aromatic plants, increasing their income, consumption and investment capacity. The economic returns from these activities greatly exceed the initial investment and generate substantial co-benefits in terms of women empowerment, climate management, biodiversity conservation and desertification control [76].

Improved agricultural productivity can free some labour and also enable women to migrate towards employment in the service sectors. Micro and small enterprises (SMEs) account for around 60% of employment in developing countries [77]. Although larger, the energy needs of micro and small enterprises in the service sectors are relatively similar to those of households. Energy access can enable service enterprises to remain open longer hours, increase hourly productivity through automation (sewing machines, etc.) and reduce losses (refrigeration, etc.). Promoting the productive use of energy in the micro service sector (output 4.3) can leverage progress made in terms of strengthening financial intermediation services for sustainable energy entrepreneurs. Based on in-depth studies of economic trends at the national and local levels, targeted vocational and business development training could be extended to prospective micro-entrepreneurs. It would reduce the risk for MFIs and local branches of commercial banks to provide SME loans to new entrepreneurs and alleviate the fear of prospective clients to take a start-up loan. Enabling legislation such as exempting micro-enterprises from taxes could also be promoted as part of women's engagement in the formulation of energy policies. Leveraging energy access to promote increase the income of women can create positive externalities and virtuous cycles for societies. For example, an increase to a women's income of $10 achieves the same improvements children's nutrition and health as an increase of $110 to a man's income [78].

## 5. Conclusion

Despite this critical role that women can play in the transition to universal sustainable energy access through decentralized solutions, they remain under-represented in the DESCO sector. A key finding of this paper is that women entrepreneurs face a number of gender differentiated barriers that offset their potential comparative advantages in terms of lower customer acquisition costs and managing credit repayment risk. Market transformation policies intended to remove investment

barriers and risks for universal sustainable energy access need to include targeted policy measures to ensure that they benefit men and women equally. In addition to upholding women rights, such an approach will most cost-effectively use public resources to catalyze private investment and reduce poverty.

However, gender mainstreaming[13]is rare in energy investments, activities and institutions [62]. There is still limited recognition of the role of women and limited knowledge of mainstreaming options to incorporate gender dimensions into universal sustainable energy access efforts. The transition to sustainable energy requires a change in the current paradigm from one where women are seen as passive providers and users of energy to one where they play a leadership role in promoting decentralized renewable energy technologies, and where they benefit from renewable energy services. Shifting the role of women to drivers of change in the transition to sustainable energy can simultaneously address key barriers to decentralized energy deployment, and create multiplier development co-benefits effects.

Past efforts to promote women's engagement in decentralized sustainable energy have primarily focused on skill development. However, training alone is unlikely to address all existing barriers faced by women entrepreneurs. Future initiatives to engender market transformation efforts should aim at removing all key barriers and associated risks in an integrated manner as discreet efforts to address a given barrier in isolation might be frustrated by lack of progress on other barriers.

The paper shows that the generic 4-step market transformation framework and the risks/barriers analysis already in use in some development agencies to de-risk renewable energy investment can be easily expanded to incorporate a gender perspective and support such integrated approaches. It then proposes a generic theory of change to facilitate the development of such integrated gender sensitive market transformation efforts for universal electricity through decentralized solutions. This generic theory of change can serve as a starting point to develop context specific theories of change that transparently define the path to expected gender empowerment outcomes and can be easily translated into project logical frameworks.

Follow-up research is required to quantify the impact of gender specific risks in the cost of financing and to break down its various determinants in different contexts. This will enable policy makers to better assess the cost effectiveness of different public instrument portfolios to address the gender gap and to tailor them to the unique requirements of each market transformation effort.

## Conflict of Interest

All authors declare no conflict of interest in this paper.

[13] ECOSOC 1997/2 has defined gender mainstreaming as "the process of assessing the implications for women and men of any planned action, including legislation, policies and programmes, in all areas and at all levels, and as a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and social spheres so that women and men benefit equally and inequality is not perpetuated."

## Annex 1: Gender-specific risk analysis[14]

| BARRIERS | | | | | MENU OF SELECTED PUBLIC INSTRUMENTS | | Link to the Theory of Change |
|---|---|---|---|---|---|---|---|
| | | | | | Policy instruments to address gender specific barriers | | |
| Risk Category | Description | Underlying Barriers | Increased probability of occurrence and severity of impact for women | Key Stakeholder Group | Output | Description | TOC Output |
| 1. Power 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:* Uncertainty regarding national/state-level targets for renewable energy and electrification | *Gender insensitive market outlook*: Uncertainty and lack of clarity regarding government commitment and capacity to address gender-bias in national/state level strategies for renewable energy and electrification. | Power market policymakers, legislators, administrators, utilities, grid operators, regulators | Ensure strategies and policies are gender-responsive to address the specific risks affecting women investors | Increase the engagement and decision-making capacity of women in energy planning and policy development | 1.1 |
| | | | | | | Recognize and assess the gender specific needs, risks and underlying barriers; conduct gender analysis/audits of SE policies and make specific gender-responsive policy recommendations | 1.2 |
| | | | | | | Build gender specific policy instruments into energy policies to ensure that they benefit equally women and men. Such policies could include targeted fiscal incentives, streamlined licensing processes and quotas for women SE entrepreneurs, mandatory targets or incentives for the private sector and public utilities to improve the gender balance in the work force; family-friendly and anti-discriminatory work place policies; dedicated avenues to facilitate women SE entrepreneurs' access to justice; and complementary investment in essential social infrastructures to reduce the unpaid domestic and care work of women. Energy policy making must be coordinated with policies for education, social protection, trade, industry, labour, land tenure reforms, civil registration and access to justice to address gender specific risks, since the removal of the underlying gender-specific structural barriers fall under the purview of other ministries. | 1.3 |
| | | | | | | Allocate adequate budgetary resources to finance implementation of gender specific policy instruments and monitor and evaluate their impacts for men and women to educate future market transformation efforts. | 1.4 |
| | | *Market access, competition and grid expansion:* Limitations, including due to government regulations, inability of mini-grid developers to access the electrification market; uncertainty regarding potential future competition in electrification; unclear, or lack | *Women as soft competitive targets:* Gender bias results in women developers being expressly targeted for competition | | Ensure regulations concerning market access are gender sensitive. | Targets and quotas for allocating licenses to non-incumbent women mini-grid developers | 1.3 |

[14] The gender neutral components of this table (white boxes) are based on ongoing work by UNDP and ETH Zurich on generic barriers and risks for private sector investment in solar PV/battery mini-grids in developing countries [20]. Red and green boxes reflect gender sensitive components of the analysis. Red boxes denote negative risks and green boxes denote positive risks for women entrepreneurs.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | of, grid planning and expansion policies | | | | | |
| | | | Women are often perceived as softer targets for corruption when seeking to obtain a license. They can be particularly exposed to this risk in the presence of discriminatory business laws. | | Simplify and streamline license processes | Simplify and streamline license processes to increase transparency and reduce unnecessary burden of business registration on women | 1.3 |
| | | *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 subsidized diesel and kerosene power sources; negative perceptions of minigrid tariffs due to subsidized grid-distributed electricity | | | | | |
| 2. Social Acceptance Risk | Risks arising from lack of awareness and resistance to renewable energy and minigrids in communities | Resistance by end users and local communities due to unfamiliarity with electricity and renewable energy sources ; mis-information /perception and lack of awareness for minigrid offerings; resistance from incumbent businesses (e.g., diesel based generation) and users (e.g., SHS), disrupted by minigrids | | General public, NGOs, businesses | | | |
| 3. Technology Sourcing Risk | Risk arising from limitations in the quality and availability of minigrid hardware, as well as its treatment by customs | *Hardware quality:* Lack of clarity or uncertainty regarding government technical standards to ensure safety of mini-grid hardware | Gender gap in access to information and technical skills which makes women less able to assess different levels of quality. They may also be seen as softer targets for poor quality. | Hardware manufacturers, technical regulator, customs (excise) | Increased access to technical education, training and information | Increase women's access to technical skills through trainings and capacity development as well to information. | 2.1 |
| | | *Availability of hardware:* Lack of a competitive market for buying hardware (from both international 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 minigrid hardware, particularly in comparison to other sectors. | | | | | |

| BARRIERS | | | | | MENU OF SELECTED PUBLIC INSTRUMENTS | | Link to the Theory of Change |
|---|---|---|---|---|---|---|---|
| | | | | | Policy instruments to address gender specific barriers | | |
| Risk Category | Description | Underlying Barriers | Increased probability of occurrence for women | Key Stakeholder Group Governance Levels | Activity | Description | TOC output |
| 4. Labour Inputs 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 | *Discriminatory social norms and stereotypes:* about gender roles and differences in aptitude shape preferences and perceptions that women are 'unsuitable' for sectors that traditionally employ men. Gender stereotypes contribute to the education and skills gender gap, particularly in the science, technology, engineering and mathematic (STEM) fields, which further reduces the availability of qualified potential employees and developers | Labour force, academic institutions | Improve women's access to education and training to increase deployment of RETs and achieve gender equity in the field | Promote initiatives that encourage women to seek careers in the renewable energy fields through scholarships, internships, academic and industry research. Enhance women's technical and business skills. Ensure that energy policy making is coordinated with policies for education | 2.1, 1.3 |
| | | | | | Address discriminatory social norms, attitudes and behaviours to encourage women to enter the RE sector as entrepreneurs and employees | Assess and address the root causes of discriminatory norms and attitudes by developers as employers towards women as energy employees; raise awareness of employers of women's comparative advantages in the areas of customer acquisition and credit repayment | 2.3 |
| | | *Discriminatory business practices* in hiring, promoting and paying women; workplace harassment | | | Promote adoption of the Women Empowerment Principles on safe and bias-free working environments that attract, retain & promote women | Promote women in decision-making positions; ensure equal pay for equal work. | 2.3 |
| | | | | | | Access to remedial measures for workplace harassment, discrimination and abuse of power | 2.3 |
| | | *Women's disproportionate responsibility for domestic work and unpaid care:* limits their participation in the renewable energy labour market as entrepreneurs and employees | | | Recognize, reduce and distribute women's proportion of domestic work and care | Promote family friendly policies & child care; promote gender certification of companies. | 2.3, 4.1,1.3 |
| 5.-Developer Risk | Risks arising from limitations in the developer's capability to efficiently and effectively design, install, operate, maintain and monitor its minigrid | *Effective execution – planning and design:* developer's challenges (lack of information, capacity, experience, unforeseen events) in executing its role regarding business planning, financial structuring and plant design (resource and demand assessment) | *Gender skills/capability gap of the developer:* Women mini-grid operators are more likely to be affected due to the occupational gender gap in entrepreneurial and business skills | Project developer / energy services company | Capacity development of women mini-grid operators | Capacity development of women mini-grid operators technical skills in terms of entrepreneurial, business and finance skills | 2.2 |
| | | | | | Targeted information-sharing with women developers | Ensure women developers are a specific target group when sharing demand and resource data | 2.1 |
| | | | *Resource and demand – proximity to customers:* Across developing countries, women are typically the primary household energy managers. Close to their customers, women entrepreneurs have the potential to lower customer acquisition and servicing costs and drive these new decentralized solutions | | | | |
| | | *Effective execution – installation and operations:* developer's challenges (lack of information, capacity, experience, unforeseen events) in executing its roles regarding installation, operations, maintenance and monitoring. | *Gender skills/capability gap of the developer:* Women mini-grid operators are more likely to be affected by the risk of unforeseen costs or delays during project development due to the occupational gender gap in technical skills | | Capacity development of women mini-grid operators | Capacity development of women mini-grid operators technical skills in terms of planning, design, construction, operations and maintenance | 2.1 |
| | | *Lower access to recourse:* Women entrepreneurs may be seen as easier for targets for non-compliance on contracts due to their lower access to remedial measures | | | Access to remedial recourse mechanism for breach of contract | Increase awareness of rights and access to remedial measures and justice for contract compliance (e.g. through a one stop shop for women entrepreneurs) | 2.2, 1.3 |

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| | | *Security:* Risks of violence against women restrict the movement of women and their occupational choices | | | | Adjust the supply chain and team composition to prevent violence against women professionals | Assess the risk associated with each segment of the supply chain, segment the supply chain to prevent exposure to security risk , adjust the team composition | 2.3 |
| | | *Gender gap in land ownership:* due to inadequate or discriminatory legal, and social structures and norms (e.g. male preference in inheritance, privileges of men in marriage). Customary and traditional practices also undermine gender equality with regard to land tenure which limit female mini-grid operators from acquiring land for their projects | | | | Alternative supply chains and titling arrangements; Legal and policy reform; customary and traditional practices reform | Raise the awareness of women entrepreneurs on existing statutory and customary land titling, impact on different business models and alternative titling arrangements; ensure that energy policies are linked to land reform in order to ensure equal rights between men and women to own, use and control land. | 2.2, 1.3 |
| 6. Financial Sector Risk | Risks arising from scarcity of domestic investor capital (debt and equity) for renewable energy, and domestic investors' lack of familiarity with renewable energy and appropriate financing structures | *Developer credit worthiness and cash flow strength:* Inability for developer to secure financing from investors due to lack of credit worthiness, or insufficient cash flows to meet investors' return requirements | Lower levels of collaterals associated with discriminatory laws in terms of land and property rights reduce the credit worthiness of women developers and their ability to secure financing from investors | Domestic investors (equity and debt), financial sector regulator | | Design new financial products | Design and manage new financial products adapted to the collateral and cash flow profile of women entrepreneurs | 3.2 |
| | | | | | | Reduce risk and incentivize local financial institutions to lend to women entrepreneurs | Development of dedicated credit lines, quotas and credit enhancement instruments; partnerships with development banks | 3.2 |
| | | | | | | Capacity development of loan officers | Train loan officers on appraising clean energy loans for women SE entrepreneurs and on new financial products; raise awareness of employers of women's comparative advantages in the areas of customer acquisition and credit repayment | 3.2 |
| | | *Capital scarcity - harmful social norms:* Harmful social norms creates an investor bias against financing women entrepreneurs and thus a greater scarcity of capital for renewable energy operated by female mini-grid operators | | | | Address discriminatory social norms and practices | Outreach, engagement and capacity development with investors and commercial banks to address the gender bias | 3.2 |
| | | *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 | Lack of rural bank branches are more likely to affect women developers because of their lower levels of mobility (due to domestic responsibilities, social norms, security) | | | Design innovative financial solutions | For example, leverage challenge funds to incentivize the private sector to find new ways of extending financial services to women, or diaspora web-based platforms that provide women entrepreneurs with access to affordable upfront capital | 3.3 |
| | | *Capital scarcity - liquidity constraints in domestic banking:* Limited availability of domestic loans, at long maturities, due to high banking reserve requirements | | | | | | |
| | | *Capital scarcity - competing incentives/ mandates* :existing policies incentivize or mandate domestic financial sector (banks, pension funds) to invest in alternative, competing sectors to minigrids | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | | *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 | | | | | | |
| 7. Payment and Credit Risk | Risk arising from customers' willingness, ability, and methods of payment for electricity | *Lack of information on customer credit worthiness:* Lack of customer credit data with which to assess the ability of customers to pay for the initial connection fees, ongoing electricity bills and ancillary equipment (e.g. lights and appliances) | | End-users, consumer credit data sector and regulator | | | | |
| | | *Poor creditworthiness 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 | Women entrepreneurs' greater knowledge of the creditworthiness of their women customers enables them to better mitigate this risk. Furthermore, women entrepreneurs are likely to particularly benefits from policy instruments and interventions that increase the repayment capacity of women customers in terms of increase energy demand | | | SE deployed to health centers, schools and water supply systems as key economic enablers and time saving infrastructure and services | Bring stakeholders from energy, health, water and education sectors together to identify energy gaps, priorities and formulate holistic SE deployment plans and service platforms to increase access to health, education and water centres. | 4.1, 1.3 |
| | | | | | | Promote the productive use of energy access in the agricultural sector | Access to electric irrigation pumps; electrical farming equipment etc. | 4.2 |
| | | | | | | Promote the productive use of energy in the micro service sector | Efficient lighting/electricity for SMEs. Development of other income generating activities, including through establishment of market associations, access to market information and skills enhancement. | 4.3 |
| | | *Poor customer finance channels and regulations:* risk arising from lack of, or unreliable consumer finance channels (e.g. mobile money and /or local micro-finance) or regulations that hampers availability of and access to local customer finance channels. | | | | | | |
| 8. Currency Risk*<br><br>**Note this risk category only applies if financing is in hard currency.* | Risks arising from currency mismatch between hard currency debt/equity and domestic currency revenues. | Uncertainty due to volatile local currency; unfavourable currency exchange rate movements resulting in domestic currency revenues not being sufficient to cover debt/equity servicing. | | Macro risk | | | | |
| 9. Sovereign Risk | Risks arising from conflict, political instability, economic performance, weather events, legal governance, ease of doing business and infrastructure in the particular country | Limitations and uncertainty related to conflict, political instability, economic performance, weather event/natural disasters, legal governance, ease of doing business, crime and law enforcement, land tenure and infrastructure in a particular country | | | | | | |

## Annex 2: Theory of Change to foster women's leadership in decentralized renewable energy.

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|---|---|---|---|---|
| Goal | Women entrepreneurs accelerate sustainable energy access through decentralized solutions<br>**Key indicators:** % of population with electricity access; Renewable energy share in the final energy consumption (%); % change in income of electrified communities.<br>**Guiding normative frameworks** include the SDGs, CEDAW, Beijing Platform for Action, Rio+20, SE4ALL. | | | |
| Goal Statement | If (1) energy planning and policy development is gender inclusive and responsive; if (2) skill, information and social norm barriers for women SE entrepreneurs are removed; if (3) gender responsive financial intermediation services are strengthened; and if (4) women's productive use of SE is promoted; then (5) women will play a leadership role in promoting, managing and benefiting from SE; because (6) women are primary users of essential energy services in households and communities in developing countries and can be powerful actors for change in the transition to sustainable energy, climate resilience and sustainable development. | | | |
| Outcomes | **1. Energy planning and policy development is gender inclusive, participatory and responsive.** Key indicators: % of women involved in designing energy plans/policies; existence of targets in energy plans/policies on women's production and use of energy; budget allocations for implementation of targeted policies for women's production and use of energy. | **2. Skill, information and social norm barriers for women SE entrepreneurs are removed.** Key indicators: % distribution of tertiary graduates by sex and field of study; % of firms with female participation in ownership or top management. | **3. Financial intermediation services for women entrepreneurs are strengthened.** Key indicators: % of firms identifying assess to finance as a major constraint; # or new financial products designed to meet the unique requirements of women entrepreneurs. | **4. Women's productive use of SE is promoted, and time dedicated to unpaid care and domestic work is reduced.** Key indicators: % of schools and health centers with access to electricity; average weekly hours spent on unpaid domestic and care work by sex, age, and location. |
| Outcome TOC | If (1) women can engage in energy planning and policy making; then (2) energy planning and policies are responsive to the needs of women and benefit them because (3) evidences have shown that those actors with control over energy planning tend to benefit the most from energy policies and investments. | If (1) women have access to required skills and information, and their engagement in SE is supported by enabling social norms and safe working places; then (2) equal opportunities are created for women's decent employment in in the SE sector; because (3) key barriers underlying the gender gap in the SE labour market have been addressed. | If (1) women have access to access to affordable, long-term finance; then (2) women entrepreneurs will be able to invest in the SE sector; because (3) key financing barriers have been addressed. | If (1) women have access to reliable and affordable energy services for domestic and productive uses as well as for public services; then (2) women can have higher disposable income; because (3) unpaid care work is reduced, they are better educated and healthier, and can engage in new income generating activities. |
| Outputs | **1.1. Increased effective engagement and decision-making capacity by women in energy planning and policy development** (capacity development of women's organizations, women in government, & women at local level on key energy challenges, different policy instruments and technologies, costs and benefits etc; linking women's association with energy policy makers).<br>**1.2. Gender specific needs, investor risks and underlying barriers are recognized and assessed** (gender sensitive baseline and needs assessments conducted; interviews with women entrepreneurs to identify gender specific investor risks and barriers carried out; gender analysis and audits of SE policies conducted and specific gender responsive policy measures identified).<br>**1.3. Targeted energy plans and policies drafted to support women's access and economic empowerment in the SE sector** (e.g. technology choices take into account gender specific opportunities and challenges; quotas and targets for percentage that power companies need to deliver from women owned decentralized SE sources; women's employment, licensing and access; licensing processes streamlined; fiscal incentives and public financing assessed and/or developed to ensure implementation of gender specific policies; cross referencing on policies related to education, health, water, justice, civil registration and land).<br>**1.4. Implementation of gender-sensitive provisions of energy plans are financed, monitored and evaluated** (appropriate budget allocations for implementation of energy plans and policies made, implementation of the different policy impacts for men and women are monitored and assessed to educate future market transformation efforts). | **2.1. Improved access to technical education, training and information for women in sustainable energy** (Promote initiatives that increase the proportion of women in technology and engineering fields; address discriminatory social norms and gender stereotypes; enhance women's technical skills through trainings on design, installment, maintenance and consumption of SE technologies; skills development to participate in the engineering design of SE solutions and development of technical standards).<br>**2.2. Women's entrepreneurial skills and knowledge is enhanced** (training on business plan development, procurement, marketing, financial management, legal frameworks, land tenure, existing remedial recourse mechanisms in case of contractual breaches; provision of apprenticeship, mentoring and dedicated business incubation services; shifting women's perception of suitable gender roles and increasing awareness of their rights; public campaigns to challenge harmful social norms).<br>**2.3 Increased access to decent employment in SE that attracts, retains & promotes women** (Promote family friendly policies & child care; address workplace harassment & perceptions of women as 'unfit' for employment in engineering, technical or business fields; prevent violence against women professionals through work on social norms, segregation of the supply chain, and team composition). | **3.1. Explore traditional and innovative options to strengthen financial intermediation services for women entrepreneurs in general and SE entrepreneurs in particular** (some options may include: directed credit, direct lending, credit enhancement mechanisms; innovative sources of finance such as web based diaspora platforms).<br>**3.2. Capacity of development of local commercial banks and MFIs** (trainings on the specific needs of women entrepreneurs, appraising clean energy loans for women SE entrepreneurs, and designing and managing new credit products with longer maturities; partnerships developed with multilateral, regional and national development finance institutions to provide credit lines and credit enhancement instruments to local financial institutions in liquidity constrained environments).<br>**3.3. Innovative financial solutions to meet the unique requirements of women SE entrepreneurs designed** (e.g. partnerships with challenge funds, web based diaspora platforms). | **4.1. SE deployed to health centers, schools, water supply systems** (Bring stakeholders from energy, health, education, water supply sectors together to identify energy gaps, priorities and formulate holistic SE deployment plans and service platforms).<br>**4.2. Productive use of reliable and affordable SE in the agricultural sector promoted** (Powered water supply schemes, access to electric irrigation pumps and other farming equipment).<br>**4.3. Productive use of reliable and affordable SE in the micro service sector for women promoted** (efficient lighting and electricity for SMEs; skills training and capacity-building for SE businesses; leverage financial intermediation services for SE entrepreneurs; increase access to market information). |
| Key Assumptions | - Women place a strong premium on clean energy access. However, they do not have the same influence over investment decisions. | - Decentralized SE technologies are the most cost effective solutions in a growing number of developing country contexts; - Growth of SE will create employment opportunities in existing and new sectors; - There is a skilled labour shortage for SE. | - Women have lower levels of collateral due to discriminatory laws (land, property rights), which reduces their credit worthiness and ability to secure long-term, affordable finance; - Women are more likely to be affected by under-developed financial sectors, particularly the lack of rural bank branches due to their limited mobility. | - Productive use of energy will be promoted to increase income-generating opportunities and end-users' capacity to pay for increased energy consumption services over time; - Access to energy reduces unpaid care and domestic work and opens new economic opportunities for women. |
| Risks & Barriers | - Women's participation is not translated into gender-responsive policies; - Gender-responsive policies are not translated into practice (political, technical, behavioural and financial barriers); - Strong interest groups favouring fossil fuel assets win over those favouring SE solutions. | - Investment in education does not necessarily translate into employment; - High skill barriers in the energy service sector; - Social protection and non-discriminatory policies are not translated into practice; - Weak education and justice systems. | - High financing barriers in the SE sector; - Required financing (type & scale) is not available; - Discriminatory social norm regarding investor bias towards women entrepreneurs cannot be shifted in the short-term. | - Women are not included in the design of end products, which reduces adoption rates by women; - Savings in time and money are not translated into higher disposable income for women because of the lack of investment in other productive sectors and income generating activities. |

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