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Understanding the Transformative Potential of Grassroots Energy Solutions

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Section 1: Introduction

1.1 Report Overview

Access to energy remains a concerning challenge for many across the world and grassroots innovation presents a valid solution to this challenge. This document aims to present a comprehensive normative framework for analyzing bottom-up innovations, the *Grassroots Thinking Approach*. Through this approach, we aim to provide criteria for assessing the contextual factors in which grassroots solutions emerge and exist, the characteristics of the innovation and its goodness of fit or appropriateness within the system that it exists in, and elements for 'success.' Recognizing the interactions described in this publication is critical to understanding the transformative potential of grassroots solutions to improve energy access and other development indicators. Each systemic element informs the other. Therefore, optimal performance of grassroots solutions requires an extensive analysis on both the community itself, and the system in which the grassroots solution emerges and exists.

First, we present an overview of the current state of energy poverty and its implications for development outcomes of those affected by it, thus building an imperative for grassroots innovation as a valid solution to improve energy access. Section 1 concludes with a description of the UNDP Accelerator Labs and its role in recognizing and sharing knowledge on the importance of grassroots solutions. Section 2 presents an overview of the *Grassroots Thinking Approach* which is based on the systems analysis process. This approach specifically aims to support a deepened understanding of grassroots innovations. Sections 3, 4 and 5, respectively, highlight the three pillars of the recommended *Grassroots Thinking Approach*:

1. the relevant **contextual factors** that influence the emergence and deployment of the solution;
2. the **characteristics of the innovation** itself including required resources, and how it fits in the community context; and
3. the **elements of 'success'** that increase the transformative potential of the solution based on the needs of the community and innovator.

Pillar 1 recognizes the relevant factors related to the context of the systems in which grassroots innovations emerge: culture and norms; financial and non-financial resources; technological capacity; legislative and regulatory ecosystems; and stakeholders and partnerships. These factors do not operate in silos. As such, it is critical to observe interactions between them. Once a grassroots innovation emerges in a specific context, it is necessary to understand the characteristics of the innovation, the required resources, and how well the solution fits in the location of deployment. These criteria are under Pillar

2 which is the primary component of Section 4 of this report. Pillar 3 in Section 5 focuses on elements of ‘success’. ‘Success’ is dependent on the innovator’s aims and the needs of the innovator and the community. Elements of ‘success’ include novelty/ingenuity, frugality, simplicity, marketability, scalability, transferability, reliability/stability, sustainability and overall capacity for achieving societal and other benefits. It is not possible to present a general framework for measuring success due to its dependence on contextual factors in each situation. Each innovator should prepare success indicators that are relevant to their innovation and the problem it is trying to solve.

Section 6 demonstrates how this approach can be put into practice using case studies of innovations in Ethiopia and Malaysia. Specifically, the document includes an assessment of the Mirt stove in Ethiopia and the solar-powered buggy in Malaysia. Finally, in Section 7, the publication offers recommendations to the UNDP Accelerator Labs Network and other UN agencies on how the insights that have been provided can be used to inform scalable programming. Valuable insights were derived from a literature review and interviews with key stakeholders and are included throughout the publication. The primary recommendations include:

- The Accelerator Labs Network, as well as other relevant international and community organizations, should optimize its solutions mapping process to support the *Grassroots Thinking* process as presented in the report.
- Local Labs should create a directory of resources that are available for innovators in order to increase the access to information.
- Mainstreaming *Grassroots Thinking* should be prioritized across UN Agencies.

We will first present an overview of the current state of energy poverty and its implications for development outcomes of those affected by it, thus building an imperative for grassroots innovation as a valid solution. We will then identify characteristics of conducive environments for relevant innovation by exploring the existing systems that innovators must navigate.

Finally, we will present selected cases of energy solutions developed by innovators in Ethiopia and Malaysia. Through information gathered from literature research and interviews with innovators, Accelerator Lab members and experts, we will assess the elements of these innovations, their effectiveness, lessons learned and the roles of the various types of agents. Doing so will serve two purposes; i) illustrate the transformative potential of grassroots innovation, and ii) demonstrate how studying solutions can provide valuable knowledge for the entire ecosystem of actors and support efforts to achieve sustainable development inside and outside of UNDP.

1.2 What is energy poverty?

Access to energy is a basic need for global populations, as it is used in every aspect of everyday life: from lighting, cooking, heating and electrifying appliances/machinery to transportation. Energy allows communities to realize local assets effectively and supports income generation, technology adaptation, education, health and development (Sovacool and Drupady, 2012). However, despite energy's importance to development, energy poverty remains a significant problem that exists widely, particularly in low-income and post-colonial countries in today's world.

'Energy poverty' refers to an individual or household's lack of access to sufficient electricity or modern cooking fuels to meet their basic needs (Aklin et al., 2018). 'Access' here means both the sufficiency of available energy, and access at time of need. Energy poverty is included among the indicators of household-level poverty (IEA, 2010).

In most developing countries, the problem of energy poverty exists more in rural areas than in urban areas (Aklin et al., 2018). In cities, high population density facilitates economies of scale. Therefore, building a power station and distribution network to connect the most people to energy is more economically feasible. In contrast, the cost of providing electricity to rural communities, which are often far from each other and from existing electricity infrastructure, is high since a more extensive distribution network is needed to transfer energy between households.

People living in energy poverty must rely on alternatives for lighting, such as candles or kerosene lamps, which can be costly and can pose a risk to human health (Aklin et al., 2018). Without adequate sources of artificial lighting, people experience difficulties with functioning and being productive once the sun goes down. With respect to cooking, those who are energy deprived do not have access to traditional fuels (natural gas, liquid petroleum gas and biogas) or technologies that utilize renewable energy sources. Instead, they must rely on wood, crop residues, dung, charcoal and other unclean fuels. Although these fuels are often cheaper, they present constant environmental and health hazards to households as well as to surrounding communities, and even to larger regions (e.g., deforestation).

1.3 What are the most energy deprived countries?

Around 770 million people lack access to electricity and more than 2.5 billion people do not have the capacity to cook using clean, pollution-free energy sources (IEA, 2021). Low-income countries in Africa and Asia have the lowest rates. In fact, the United Nations Development Programme (UNDP) Energy Hub has identified 19 countries in Sub-Saharan Africa and Asia that have the most significant gaps in access to electricity and clean cooking (Figure 1).

Appendix 1 includes a contextual overview of specific indicators related to energy access, consumption and the electricity generation mix in these countries.

Figure 1: *Map of the 19 most energy deprived countries*

It is important to note that while access rates are essential data points, they can often be misleading. For instance, while Bangladesh and India have 92% and 98% access rates respectively, the reliability of electricity services remains a considerable challenge for citizens (Tongia and Mehta, 2015; Ula et al., 2019).

There is a link between the development level of a country and the average demand for energy it faces. States with higher Gross Domestic Product (GDP) per capita tend to have higher energy consumption needs as well as access rates. Two noteworthy exceptions are Mozambique and Sudan; both have GDPs per capita that are lower than $600, while being among the highest consumers of energy among the most energy deprived countries. Data on electricity consumption can also suggest what solutions are most appropriate. In Chad, Niger, South Sudan, Burkina Faso, Malawi and Madagascar, the average citizen consumes less than 100 kWh. As a result, it is conceivable that lower capacity solutions, such as solar home systems, could be suitable options. On the other hand, countries with a larger demand such as India, Bangladesh and Pakistan would require higher capacity systems to cover their needs. Further analysis of consumption patterns is required to identify fitting solutions, particularly in terms of differences between rural and urban settings as well as comparisons of demand between various economic sectors.

Another important consideration is the barriers to access. To that end, there are general challenges that are shared by most countries facing difficulties in providing reliable, clean and affordable energy. The most common roadblocks on the supply side include the geographic disparity of rural populations and the associated distribution costs, inefficient infrastructure, access to financing and poor governance structures. On the demand side, the cost of grid connections, insufficient information regarding modern technologies and affordability constraints are cited as the primary barriers (IEA, 2019a; Bonan et al., 2016; Hafner et al., 2018; Sovacool et al., 2016; Njiru and Letema, 2018; Jessel et al., 2019; Seetharaman et al., 2019).

Of note is that countries that focus solely on grid expansion to increase access face considerable difficulties. The governments of Malawi and Mozambique, for example, have not pursued off-grid solutions to reach rural populations and as such, have fallen short in connecting these hard-to-reach citizens. Reasons for the countries' lack of investment in off-grid solutions must be determined to support deeper understanding of existing barriers to improving energy access. Conversely, 2.17 million people gained access to energy through solar home systems and mini grids in Myanmar from 2016 to 2020, because of government interventions (ITA, 2021). While it is clear that there are many other factors at play, it would be interesting to see if communal actors such as innovators and entrepreneurs can step in to fill the gap in terms of off-grid solutions in energy deprived countries.

Subsequent chapters of this report aim to support improved understanding, albeit preliminary, of the contextual environment that innovators must operate in as well as identification of conducive policies that enable improved access.

1.4 The SDGs cannot be achieved without improving energy access

One of the most important aspects of the United Nations Sustainable Development Goals (SDGs) is their mutual interdependence for collective achievement. As such, achieving SDG 7 - to ensure that by the year 2030, all people can access affordable, reliable, and modern energy sources (UN, 2015) - can accelerate progress towards fulfillment of the other 16 SDGs which each have significant linkages to increasing energy access (Figure 2). Also, the other goals such as education and partnerships can do their part in promoting more informed energy choices and consumption patterns.

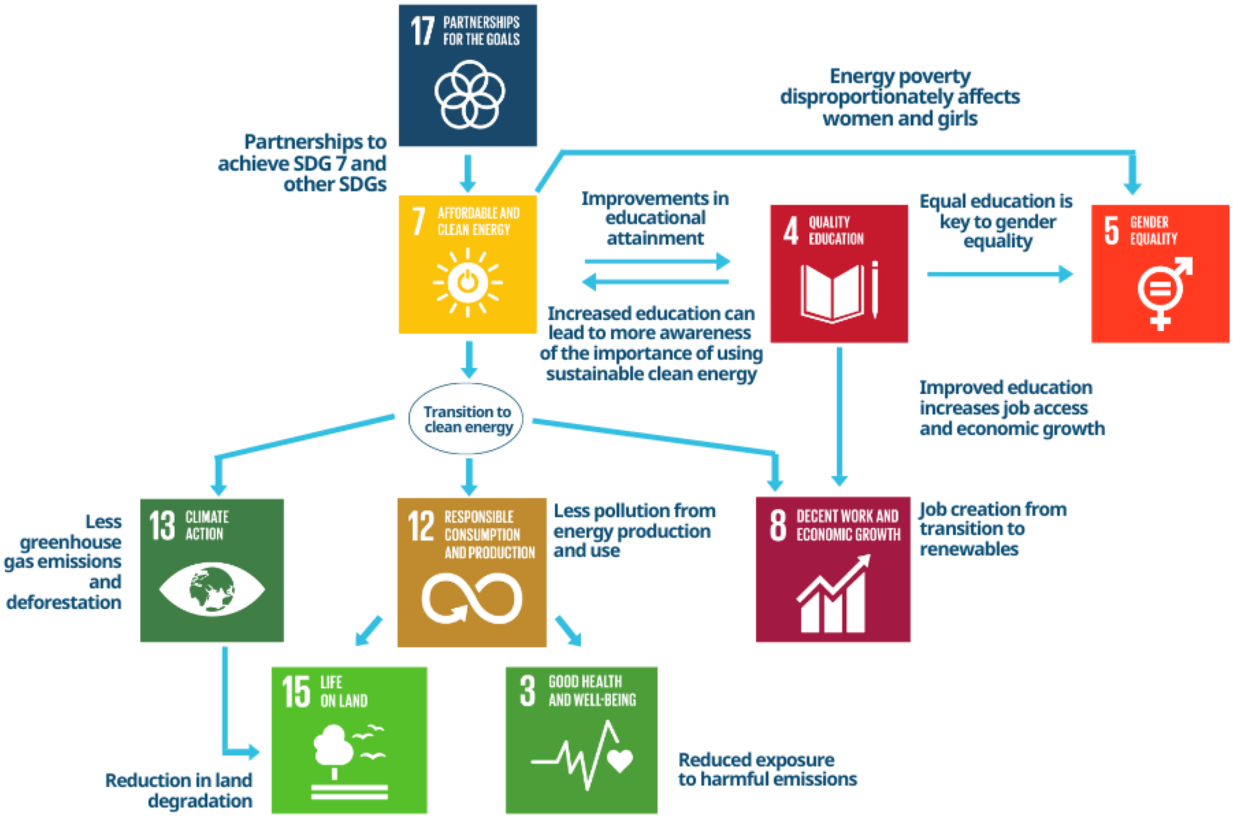

***Figure 2**: Linkages between SDG 7 and other SDGs*[1]

It can be inferred from the definition of energy poverty that access to sustainable energy is closely linked to access to economic opportunities (SDG 1 and 8). Sustainable energy access facilitates educational activities that can be translated into economic empowerment, as education opens new doors for people living in poverty, women and other vulnerable populations. Achieving SDG 7 can thus facilitate the achievement of SDG 4 - quality education - and SDG 5 - gender equality. In addition, the transition to renewable energy when expanding energy access can support job creation and contribute to inclusive economic growth (SDG 8). It is estimated that by 2030, there would be 30 million medium-term renewable energy jobs, with 40 million new jobs created as a result of prioritizing energy efficiency and system flexibility (UN DESA, 2021). In contrast, without the achievement of SDG 7, persons living in poor communities will continue to be at risk of being trapped by limited opportunities and resources.

Energy deprived populations generally rely on solid fuels (wood, crop residues, dung and charcoal) for cooking, which pose an environmental and health risk for households and

[1] Figure 2 was developed based on research and analysis of the linkages between SDG 7 and the other SDGs (Cahill, 2021; Čukić et al., 2021; UN DESA, 2021; OECD, 2021; Energia, 2019).

society. Slow progress in achieving SDG 7 will hinder the achievement of other public health, environmental and climate related goals (SDGs 12, 13 and 15). Meanwhile, the achievement of other SDGs can facilitate the progress towards expanding energy access. For example, quality energy educational activities play a central role in raising communities' awareness about the health and environmental benefits of using clean energy.

Given the internal linkages between SDG 7 and the other SDGs, greater investment is needed for development agencies and governments to foster partnerships between SDG 7 and the other SDGs (SDG 17). The broader partnership blueprint requires governments and development agencies to set partnerships for energy-related goals as a high-level priority and incorporate collaboration criteria in their impact evaluation framework.

1.5 Grassroots innovations can support efforts to improve energy access

Often, individuals affected by social and developmental challenges create ingenious small-scale solutions. These are people who are aware and invested in the communities' needs and who are innately driven to address problems using local, contextual and traditional knowledge (Gupta, 2019). Such solutions are often cheap, and easy for the community to adopt and trust. On-the-ground innovations can bridge the gap between demand and supply in community markets and can have a larger impact on a country's economy by creating employment opportunities, ensuring self-dependence and increasing productivity (Gupta, 2019).

Bottom-up, community-led, frugal solutions are an essential means, if not often the only viable means, to deliver affordable, accessible and appropriate energy services to underserved people living in energy poverty.[2] Grassroots innovation can support the eradication of disparities existing between mainstream energy products and the needs of people in communities with insufficient energy access. These solutions can also promote individual and community-driven opportunities to the energy crisis at the community level and can fill observed gaps in clean energy access. Furthermore, they can also enable communities to engage in productive activities that further drive progress on various development outcomes.[3]

[2] Interview with Philip LaRocco, Energy Expert and Adjunct Professor of International and Public Affairs. April 14th, 2022.

[3] Interview with Angelica Shamerina, Global Environment Facility (GEF) Small Grants Programme Advisor on Climate Change Mitigation and Regional Focal Point. April 14, 2022.

1.6 The UNDP Accelerator Labs represents emerging recognition of the importance of grassroots solutions in improving energy access

The United Nations Development Programme (UNDP) Accelerator Labs Network was launched in 2019 to be “the world’s largest and fastest learning network on wicked sustainable development challenges” (Berditchevskaia et al., 2021). The Network started with 60 teams covering 78 countries and is now expanded to 270 team members supporting 91 Labs covering 115 countries to increase capability for scanning, sensemaking and experimentation for sustainable development solutions (UNDP Accelerator Labs, 2021). A global team oversees the network, monitors its progress, consolidates results and aggregates learnings, helping to generate an enabling and conducive environment to facilitate cross-pollination of ideas while supporting the dissemination of knowledge to the broader development ecosystem.

The Accelerator Labs are included in UNDP’s global policy teams and country offices, and work with them, national partners and other entities at the global level to map, test and experiment on development solutions across its global network. They build on the trust developed with national and local government agencies over many decades. They capitalize on the power of grassroots and youth, empowering them to search and experiment with solutions developed by those dealing with the problems firsthand (Berditchevskaia et al., 2021, 23).

One of the key activities of the Accelerator Labs is to document existing grassroots innovations and gather learnings on developed community solutions to support UNDP and the wider ecosystem of actors in reaching global development goals. In this regard, the Accelerator Labs have developed an online Solutions Mapping Platform to document and share knowledge on home-grown innovations acquired through its global network of national experts, grassroots innovators and social entrepreneurs. Accelerator Lab team members have contributed 2,328 mapped solutions related to all 17 SDGs and developed in 1,361 locations to the Platform.[4]

Recognizing the importance of leveraging small innovations for creating big impacts related to energy access, the Labs launched a Discover and Deploy campaign in 2022. This campaign was designed to seek out grassroots innovations, ethnographic knowledge and signals of change to support the UNDP moonshot goal. This goal is outlined in the new UNDP Strategic Plan (2022-2025) and includes the aim to apply integrated approaches to help “500 million people to gain access to clean energy” (UNDP, 2021). The Accelerator Labs Solutions Mapping Platform has the potential to present all valuable grassroots energy solutions

[4] Data obtained from the UNDP Accelerator Labs Solution Mapping Platform on April 24th, 2022.

sourced through this campaign along with information on the innovators and their operating environment, and an assessment of the solution's scalability and accessibility. The platform can become a knowledge management tool that presents the dynamics between different actors that help incubate a solution from infant stage to scale-up.

Section 2: The Grassroots Thinking Approach: Using Systems Analysis to Understand Grassroots Energy Innovations

The energy ecosystem is highly complex; it involves various actors that interact with each other, as well as with a set of contextual factors that are specific to providing energy access to the targeted community. The actors are bound by their ability to access, provide and regulate resources that are needed to innovate energy solutions, and the solutions themselves are judged on how well they fit within the local context in which they operate. Furthermore, these sets of abilities and local characteristics are fluid; that is, they are constantly adapting to evolving demographic, socio-economic, and political conditions.[5] Therefore, a useful tool to break down these complexities is a systems approach.

A system is a group of parts that interact with each other to form a complex and cohesive entity with a specific purpose (Kim, 1999). Components of a system must be interrelated and interdependent (Acaroglu, 2017). As such, presenting the global contribution of grassroots innovation as part of a system, rather than an assortment of individual solutions, would facilitate the generation of generalized inferences that can inform involved actors on how to leverage these innovations as a cohesive entity with the purpose of improving community-level access to energy. Specifically, when considering the emergence, deployment and transformative potential of grassroots energy innovations, it is important to recognize the systemic structures that shaped the solution's ideation and implementation. Analyzing a grassroots solution at any point in time can provide a valuable **snapshot of the current system set-up at a localized level**.

This document proposes a novel framework based on systems thinking in order to identify these generalized inferences, or *insights*. We have dubbed this framework *Grassroots Thinking* (Figure 3).

The *Grassroots Thinking Approach* is based on the following three pillars:

1. the relevant **contextual factors** that influence the emergence and deployment of the solution;
2. the **characteristics of the innovation** itself, including required resources, and how it fits in the community context; and
3. the **elements of 'success'** that measurably increase the transformative potential of the solution based on the needs of the community and innovator.

[5] Interview with Philip LaRocco, Energy Expert and Adjunct Professor of International and Public Affairs. April 14th, 2022.

The logic here is that the conditions of a community create the need and ability for a solution to emerge. The characteristics of the developed innovation depend on the intended purpose based on the community and/or innovator's need, the availability of resources required to establish it, and the appropriateness of the solution based on the overall context. By considering these systematic components, one can establish the transformative potential for grassroots innovations by looking at various elements of 'success'. These three levels of analysis are essential in order to move from the specific to the general, from the individual solution to scalable programming.

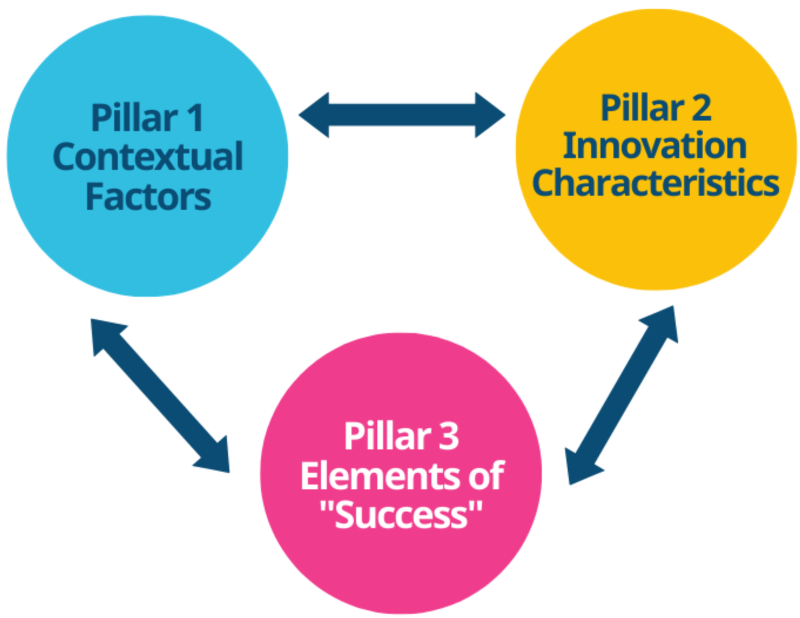

Figure 3: *Three Pillars of the Grassroots Thinking Approach*

Grassroots Thinking has the potential to reinforce the decentralized and human-centered approach to development employed by the UNDP Accelerator Labs Network which emphasizes local communities as the primary driving force for change. This method recognizes grassroots innovators as a key stakeholder in expanding energy access since they are often best positioned to provide guidance on how to reach those most deprived of energy access. To innovate is to maneuver the system, constantly and simultaneously, in order to solve a problem (Taylor, 2017). Thus, innovating creates opportunities for the innovator to learn and adapt. Additionally, there are many behavioral, social and cultural factors that dictate the appropriateness of solutions in a given context (Mentis et al., 2016). Grassroots innovators are the only stakeholder in the ecosystem of actors that have a concrete grasp of these factors since they are members of the community that is facing the problem.

The *Grassroots Thinking Approach* used in this document is informed by research, a contextual overview of the most energy deprived countries, expert interviews and solutions mapped by the Accelerator Labs Network. The Approach is used to **provide generalized insights on context and requirements that promote the emergence and deployment of grassroots energy innovations.** These insights could also help UNDP to **leverage the ecosystem of grassroots innovations to inform scalable programming** to improve energy access.

This approach varies from other frameworks developed to analyze grassroots innovations. For example, Gupta's conceptual framework (2019) which highlights the precursors, categorized as innovator, environment and market factors; outcomes, namely commercial and non-commercial value; and necessary conditions for grassroots innovation, including financial factors, marketing support, user characteristics, organizational support and market accessibility. We place less emphasis on the market as a general influencing factor in the development of grassroots solutions, include the characteristics of the innovator as part of the analysis of the innovation itself, and expand on the outcomes through assessment of elements of success of particular innovations.

Section 3: Pillar 1 - Contextual Factors of Community Influence on the Emergence and Deployment of Grassroots Energy Innovations

This section identifies and describes broad contextual factors and their linkages which are relevant to a community's needs and capabilities, which influence an innovator to create an energy solution at the grassroots level, and which may support the innovation's sustainability or failure. The section includes the results of a systematic assessment of relevant technical, socioeconomic, environmental and political linkages related to a community's energy ecosystem and presents insights on conditions that are conducive to these types of bottom-up innovations.

Figure 4 shows the relevant factors related to community context which were assessed. These are described below:

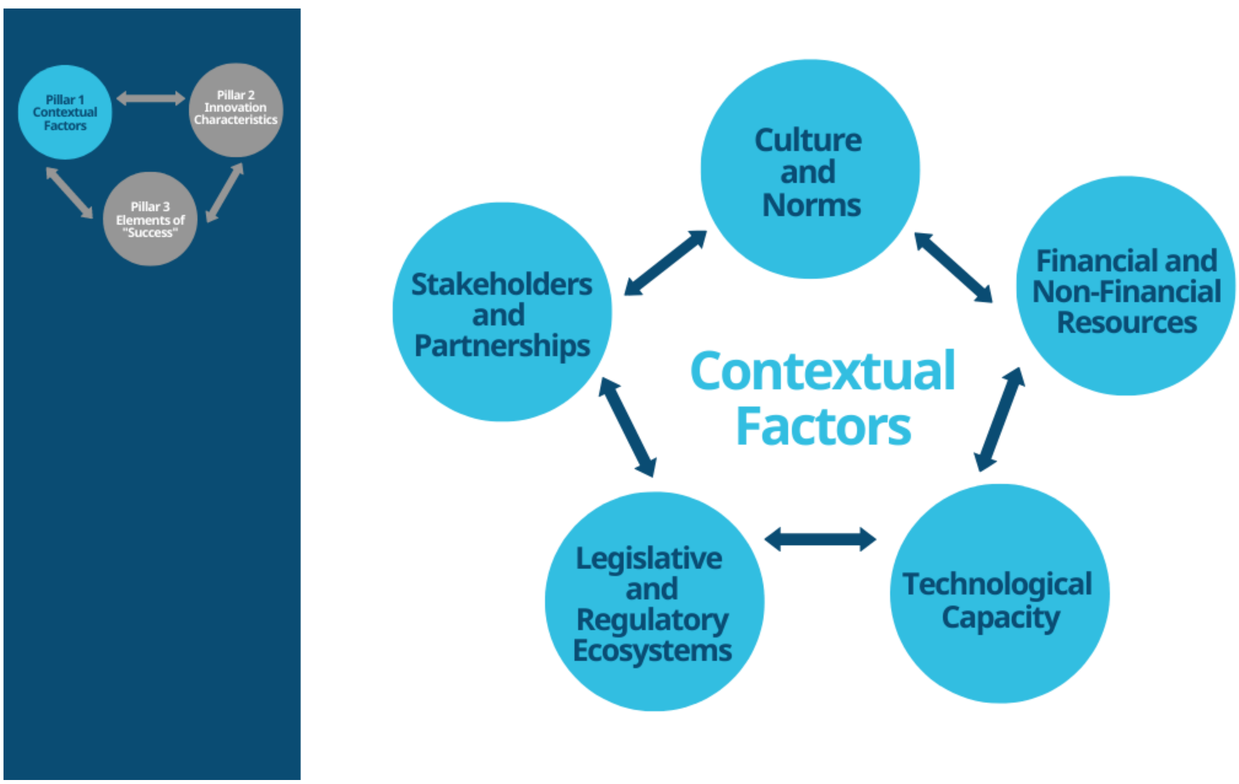

Figure 4*: Contextual factors which influence grassroots energy innovations derived from a review of existing literature and outcomes of stakeholder interviews*

- **Social norms, culture and values** may play a key role in transitioning to clean and renewable sources of energy, but they may also act as a significant barrier to low-carbon transitions (Sovacool and Griffiths, 2020).

- **Financial and non-financial resources** must be available to cover the associated energy production and distribution costs and to effectively provide relevant energy services. Financing mechanisms may include traditional or non-traditional sources such as private equity or public capital investments, loan guarantees, credit enhancements, government issued bonds, stocks, mutual funds, direct aid, grants or seed funding (Kuntz, 2017). Non-financial resources include raw materials for manufacturing and production, space, renewable and non-renewable energy sources and human resources. The availability of some non-renewable resources is dependent on environmental and geographical factors (Mentis et al., 2016).
- **Technological capacity** is important for the development and use of new innovations (Creech et al., 2013). Technological capacity refers to a community's ability to access and utilize technologies and technological support to improve energy efficiency and access. It includes considerations related to energy systems and infrastructure; availability of modern, efficient and clean appliances and electronics; and availability of skilled persons to develop and utilize technical resources.
- **Legislative and regulatory ecosystem** refers to existing public and private institutions, policy tools and laws related to energy generation and distribution, innovation and business development. These support an enabling environment to support local innovators (Creech et al., 2013).
- **Stakeholders and partnerships** speak to the ecosystem of actors involved in the provision of energy services and innovation development, collaborations between these actors and other types of interactions that influence the availability of energy at the community-level. Collaboration of diverse stakeholders and coordination between local and international partners can drive the creation and sustainability of an innovation (Hossain, 2018).

These contextual factors do not operate as isolated silos. In fact, **systems are most productive when their components work together, and actors coordinate to align their directions** (OECD, 2019)**.** As such, presenting them separately would not be instructive. The following section provides insights drawn from the interactions between these contextual factors and how they influence the emergence and deployment of grassroots energy solutions.

3.1 Insights from the analysis of contextual factors related to community energy access

This section attempts to shed light on the interactions between contextual factors that are conducive to the emergence and deployment of grassroots innovations. By assessing the factors that frame the ecosystem that innovators must navigate, and their interrelationships, entities will be able to identify key aspects related to the optimal set-ups of these ecosystems, as well as some actions that stakeholders can take to develop a vibrant environment for the incubation of innovative solutions.

3.1.1 Collaboration and information access are key factors to support the emergence of grassroots energy solutions

Insight #1: *Intra-communal* ***collaboration*** *can facilitate access to* ***non-financial resources*** *and inform* ***technological choices.***

Consider the following solution: an innovator in Timor-Leste developed an efficient do-it-yourself (DIY) cooking stove that replaces kerosene with used motorcycle oil obtained from a nearby garage.[6] By recognizing that the discarded material of a private business could be **transformed into a productive resource,** the innovator built a **partnership** that allowed for a solution with an appropriate **technical** design. This solution prevents the used motorcycle oil from being discarded in the environment and provides low-cost energy.

While this is a specific example, it is easy to conceive other situations where collaboration could be leveraged in a similar manner; for example, in a community where a local farmer discards large amounts of organic matter on a regular basis, or a woodworking shop produces sawdust.

Such interactions can reduce the cost of a solution and enhance its contextual suitability by taking advantage of materials sourced from the local community. Furthermore, this type of **circular economic behavior** is sustainable as it allows for the use of previously discarded material while **strengthening social capital** by promoting the creation of intra-communal linkages and networks (Heshmati, 2017; Areekul et al., 2015). Agents that have deep technical knowledge and that are somewhat close to the ground can **play an important role by identifying opportunities and informing** innovators on potential collaborations

[6] UNDP Accelerator Labs Solution Mapping Platform. “DIY Motorcycle Used-Oil Stove.” Contributed by UNDP Timor Leste Accelerator Lab.

that they can develop. The stakeholders that are best positioned to play this role are local non-governmental organizations (NGOs), development agencies, and academic institutions. This highlights a system requirement that is critical for all stakeholders and across all systems.

<u>Insight #2</u>*: Information** *is a* ***non-financial resource *that could boost* ***technological capacity*** *and support* ***policy development*** *and* ***positive behavioral change****.*

Information is a valuable and sometimes costly non-financial resource. Access to information can support evidence-based policy development, enhance technological capacity and promote positive behavioral change. The fact that access to information is a precursor of well-functioning markets and systems has long been well established (Löfgren, 2002). However, it is still important to consider how that applies to the systems being analyzed from the lens of different stakeholders.

Organizational and government stakeholders should aim to adopt a local, learning and sharing approach to their operations, be it on a single project level or in the design of general policy.[7] **Local** refers to the level of analysis. **Learning** relates to the recognition that communities have a better understanding of the problems they face and as such should inform organizational behavior. **Sharing** means the dispersion of the information obtained, both internally and to other actors.

Innovators must be fully aware of the resources that they have access to in order to best leverage them. For community members, education and information access are critical to changing behaviors and practices related to adopting new energy technologies (Farah et al., 2019). Lack of information can create doubt within a community, reducing trust and thus reducing the uptake of an innovation. At the same time, the communities themselves, including the innovators, should be considered as the primary source of information.

<u>Insight #3</u>*:** *Governments should engage in* ***effective communication *to make stakeholders aware of available resources, opportunities and sectoral direction.*

[7] Interview with Philip LaRocco, Energy Expert and Adjunct Professor of International and Public Affairs. April 14th, 2022.

Governments should play a role in ensuring that all stakeholders have access to the knowledge and learning needed to support enhancements within the overall energy services system.

When this does not occur, informational asymmetries can disrupt markets. For instance, the Government of Bangladesh distributed free solar home systems (SHSs) as a form of social security (Cabraal et al., 2021). As a result, private distributors of SHSs saw their market size decrease after having already invested in inventory. If the government had preemptively declared their intention to pursue this policy, private operators could have allocated their resources accordingly. One way to ensure the alignment of private actors with the legislative framework is to **engage in a consultative process** in the drafting of policies with industry leaders and civil society organizations (Oliver, 2019).

3.1.2 Governments play a key role in creating an enabling environment for grassroots energy innovations

Much information is available on the different policy tools that can generally improve energy access (Bazilian et al., 2012). The following insights attempt to present ways in which **governments can create an enabling environment for grassroots innovation,** specifically.

Insight #4: *Governments should include* ***provisions that promote grassroots innovation in the context of a national energy strategy****.*

First and foremost, governments must develop a national strategy to improve energy access. Unfortunately, some countries have not yet done so and that has hindered their ability to alleviate energy poverty. Assuming that a sectoral vision document exists, the government is well positioned to flag promising areas of intervention, thus establishing regulatory provisions to support innovators with ideation, production and dissemination of their grassroots-level solutions.

In Bangladesh, by adopting a bottom-up lens, the government identified solar micro-chilling and solar ice manufacturing plants as an attractive opportunity for small-scale entrepreneurs (SREDA, 2021). Governments can go a step further by enacting strategically targeted programming.

Insight #5: *Governments should* ***establish public entities and national programs*** *that focus on capacity building for grassroots innovation.*

The presence of a specialized resource that stakeholders can turn to provides a space for **collaborative action for problem solving.** Such an approach can serve a variety of purposes and can stem from a country specific need or opportunity. Governments often build on **partnerships with international development agencies as well as foreign governments** to enact these programs. The following are some examples of initiatives adopted in energy deprived countries:

- Climate Innovation Center, Ethiopia
- Rural Electrification Fund, Ethiopia
- National Biodigester Program, Burkina Faso
- West Bengal Renewable Energy Development Agency, India
- Off-Grid Solar Access Project, Kenya

Such initiatives, as well as other policy tools, aim to build capacity for problem solving by **complementing the efforts of local and international NGOs, private businesses, and grassroots innovators.** For instance, the Government of Madagascar, in partnership with the World Bank, has launched the Off-Grid Market Development Fund (OMDF) to provide credit lines to providers of off-grid energy solutions as well as micro-financing institutions (MFIs) that operate in the sector. This type of financial mechanism aims to build the financial capacity of the general off-grid solution providers. However, governments can engage in activities that directly support grassroots initiatives.

Insight #6: *Governments should **incentivize grassroots innovation** by directing public funds towards targeted programing that enhances access to financing as well as the financial literacy of innovators.*

Governments have the ability to support the incubation of grassroots innovation by providing financing (Gupta et al., 2020). For instance, the Government of India funds the development of prototypes for novel energy solutions by providing grants to innovators through the Value Addition Research and Development (VARD) Fund. However, access to financing is not the only component of financial capacity building (Sakanga et al., 2020).

Many grassroots innovators have underdeveloped financial literacy (Gupta et al., 2020). What this implies is that they may not have a proper grasp of budgeting and account management skills, or a clear understanding of the different financing options available to them. Some governments have developed mechanisms to address this challenge. For instance, some innovators might not be aware that securing intellectual property rights over an innovation can significantly increase its financial value and as a result, how investable it is (Hall, 2007). As such, the Government of India, through the National Innovation Foundation, provides information and financing for the patent application process.

3.1.3 The availability of funding is a critical driver of bottom-up solution development

Public funds are a vital resource to improve the financial capacities of innovators because it is difficult for them to access financial markets (OECD, 2015). However, public resources alone are insufficient to fully leverage community-level potential and therefore, international development agencies and financial institutions have an important role to play. Traditional financing models are not always well suited for funding grassroots innovations due to the high levels of associated risks arising from unproven technology development, low technical capacity of the innovator, low economies of scale and limited resources. Furthermore, fundamental gaps exist between the needs and incentives of innovators on one hand, and private financial institutions and donors of development agencies on the other (UN, 2021). As such, new approaches are required to accelerate grassroots innovation.

Insight #7: *International development agencies should employ a* ***country driven approach*** *to their decision-making process for small-scale project funding.*

One way to bridge the needs and incentives gap described above is by allowing the local context and community norms to inform the decisions of grant allocations within international development agencies. This would ensure that the bottom-up, decentralized approach to development is preserved in the financing phase.

Historically, the approach to financing international development has been based on imposing specific, pre-designed programs on communities. Since 1972, The GEF Small Grants Program (SGP), which promotes “thinking globally, acting locally,” breaks from that tradition as it accepts applications from community members for project-based funding. A steering committee, **composed primarily of local civil society members**, then selects grant recipients. Furthermore, after the disbursement of the grant, UNDP country staff engage in capacity building and mobilization efforts in the recipient communities to facilitate the effective deployment of the solution.[8]

The difference between the historical approach and the mechanism developed by the SGP represents a fundamental shift in the way that the beneficiaries of such programs are perceived. As Dr. Anil Gupta (2013) writes: "Instead of treating economically poor people as a ***sink*** of public aid, assistance, advice, and corporate goods and services, we should treat them as a ***source*** of ideas, innovations, and institutional arrangements with which formal public and private institutions can engage."

While this approach promotes the strengthening of community agency by providing grants directly to community-based organizations, the financial capacities of local communities are still bound by the rigid practices that development donors employ.

<u>Insight #8:</u> *Financial institutions and international donors should embrace agile spending by engaging in **long-term, small-scale investments**.*

Usually, international donors are attracted to large scale projects that reach a maximum number of beneficiaries, and that have short assessment periods.[9] Similarly, private financial institutions generally look for short duration, low-risk projects (Das, 2011). Conversely, grassroots innovators require access to low-cost working capital to finance their solutions over long repayment periods as user uptake can be slow. Moreover, the target customers of such solutions are often low-income individuals, or households, thus further increasing the risk profile of the project. This does not mean, however, that financing grassroots innovation is not feasible, only that the current mechanisms employed by donors and financial institutions are inadequate. As such, it is critical that these stakeholders develop new methods to deliver project financing to those most in need of it.

Shifting organizational behavior can be a long and arduous process (Staw, 1981). It can be made easier by finding ways to bridge the needs and incentives gaps that govern the financing of grassroots solutions. One potential way to do that is by leveraging developments in Information and Communication Technology (ICT).

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[8] Interview with Angelica Shamerina, GEF Small Grants Programme Advisor on Climate Change Mitigation and Regional Focal Point. April 14, 2022.

[9] Interview with Angelica Shamerina, GEF Small Grants Programme Advisor on Climate Change Mitigation and Regional Focal Point. April 14, 2022.

Insight #9: *Innovation and penetration of **information and communication technologies** (ICTs) can facilitate **access to financing** for grassroots innovators.*

ICTs are an important tool to promote financial inclusion (Andrianaivo, 2011). Much of the application of ICTs in the context of small-scale energy solutions has focused on increasing the financial viability of projects by facilitating payment for the consumer. For instance, the spread of mobile banking in sub-Saharan Africa has paved the way for innovative business models for off-grid energy providers (GSMA, 2019). However, there is also room for innovation that aims to bolster supply-side financial capacities. One such example is kiva.org, an online microlending platform that allows individual investors to lend as little as US$25 to local entrepreneurs in developing countries. As trends in ICTs appear to be centered around decentralization and individual agency, emerging technologies, such as blockchain, could pave the way for transformative innovation in the years to come.

Section 4: Pillar 2 - Understanding the Characteristics of Grassroots Energy Innovations Provides Key Information on Community Needs and Capacity

As stated above, grassroots energy innovations emerge from the needs and capacity of community members. Understanding the characteristics of developed energy innovations can provide key information on the community, and can inform the government, development organizations and other stakeholders of the needs of citizens and the potential for the solution to effectively contribute to improving energy access. For example, strengthening knowledge on the purpose and goal of the innovation can inform stakeholders of the gaps in energy access and services that need to be filled at the individual, household or community level. Similarly, understanding the operational status of the innovation can influence the programmatic and funding goals of government and donor organizations.

Furthermore, leveraging community-level solutions to create scalable programming is dependent on establishing the success of the innovation itself.[10] This can only be done by thoroughly assessing the innovation, its requirements and its appropriateness in the location of deployment. Compiling information and data on these factors is critical to the effective assessment, planning, implementation and monitoring of energy services delivery.

Figure 5 provides an overview of the type of information that should be collected as part of this pillar. Appendix 2 lists questions that can contribute to expanding learning on these attributes of a specific innovation.

[10] Interview with Philip LaRocco, Energy Expert and Adjunct Professor of International and Public Affairs. April 14th, 2022.

Figure 5: *Overview of information needed to understand grassroots energy innovations derived from a review of existing literature and outcomes of stakeholder interviews*

Insight #10: *The goal, purpose and function of an innovation depends on the* ***needs of the community****,* ***the problem*** *that the specific innovator is trying to solve, and the* ***community context****.*

Pillar 1 supports developing an understanding of the factors that influence the specific goal and purpose of an innovation. The intended function of the innovation to generate, use, conserve, augment, store or distribute energy depends on the stated goal. The source of energy used to power the solution, as well as other materials needed to create it are all dependent on the available resources in the community. Additionally, the viability of using different energy sources and technologies to generate and distribute energy in a specific community varies based on geophysical, social and economic contexts (Mentis et al., 2016). For example, factors used to determine the most relevant energy technologies for a community include the availability of local resources and infrastructure, settlement patterns and population distribution, financial and technological capacity, and community needs.

Mentis et al. demonstrate that for Ethiopia, high population density settlements, high energy consumption levels, high energy access targets and increased rural electricity demand create a preference for grid-based energy options instead of off-grid, standalone connections (Mentis et al., 2016).

***Insight #11**: The **cultural relevance** of the innovation is also a key factor in its ability to be effective and to be taken up by community members.*

For example, cultural barriers to the adoption of improved cookstoves include incompatibility of stoves with the preparation of traditional meals, perception that food cooked in conventional ways taste better, skepticism of the effectiveness and safety of new technologies, and the spiritual and cultural significance of open fires and smoke generated from traditional stoves (Sovacool and Griffiths, 2020). In Botswana, an open fire is a central location for families and visitors to gather around and socialize. Therefore, a solution that replaces the open fire with a closed stove may not be feasible. In Nepal, some people hesitated to adopt solar cookers out of fear of offending the “god of the household hearth” (Coyle, 2006). Similarly, in some rural Indian households, smoke from traditional stoves is believed to connect the earth and heaven (Shankar et al., 2014). Therefore, there might be challenges with mainstreaming a smoke-free solution. Attitudes towards energy consumption and comprehension of technologies may also affect usage patterns and adoption of technologies (Sovacool, 2009).

***Insight #12:** Documenting the characteristics of the developed solution is necessary to determine the **requirements of the solution and its deployment**.*

Specifically, understanding the innovation could provide key knowledge on the costs needed to manufacture, deploy, use and maintain the solution, and the skills needed to build and implement it. Knowledge of costs can in turn inform appropriate financial mechanisms and funding sources needed. Similarly, awareness of required skills can support identification of levels of expertise and partnerships needed to deploy the solution. The outcomes of Pillar 1 can be used to determine existing financial and non-financial resources that can be tapped into to fill the requirements of the specific innovation.

***Insight #13:** Recognizing **how well the innovation fits** in the location of deployment could support efforts to **scale, adapt and transfer** the solution.*

Pillar 1 describes the general community context, while this component of Pillar 2 refers to how a specific innovation interacts with the community. Once ideated, it is important to recognize how grassroots solutions fit into the wider solution landscape and the community's energy ecosystem.

Potential interactions may occur based on the type of community, the population density, the income status of community members, the scale of reach, the rate of deployment and the level of community participation. Additionally, it is important to recognize how existing formal and informal networks, and the community's regulatory and legislative framework work to support or limit development and deployment of a solution.

<u>Insight #14:</u> *The* ***characteristics of the innovator*** *can also provide key information that could support the solution's* ***potential for 'success.'***

The characteristics of the innovators influence the innovation itself, since their motivation to create a solution often stems from their perceived need and challenge. Relevant attributes include the innovators' education, technical skills, past experience in producing innovation, attitudes and empathy, extent and level of positivity in approaching problem solving, sensitivity to social issues, a sense of belonging to the community and a self-belief to create and improvise in a resource-constrained environment, as well as ambition and motivation to commit to the process of innovation (Gupta, 2019). However, research suggests that grassroots innovators lack knowledge regarding patents or trade secrets, are dependent on intrinsic motivations such as joy and social relations, and when extrinsic motivators are imposed on them, their creativity is repressed (Sheikh and Bhaduri, 2021).

Section 5: Pillar 3 - Elements of 'Success' Can Support the Transformative Potential of Grassroots Innovations

This section outlines Pillar 3 of the *Grassroots Thinking Approach*: key elements that demonstrate the effectiveness and potential of community-based energy solutions. The elements were developed using available literature on grassroots solutions and key informant interviews. They consider the contextual factors identified under Pillar 1 and characteristics described under Pillar 2. Measuring the elements of success through a set of developed indicators specific to innovators' aims and objectives can support monitoring and evaluation efforts and a better understanding of the ecosystem of energy innovations and how they benefit from and contribute to feedback for the local energy system. The elements of success could be used to guide data collection methods for more detailed assessments of trends and outcomes of developed grassroots innovations. Furthermore, they can increase the capacity of primary actors to identify relationships between the purpose and functions of developed innovations, types of energy sources utilized by innovators, and community characteristics and needs. Through enhanced analysis and capacity, the elements of success of particular innovations could support better understanding of costs and required resources for different types of projects, their reach and reliability, and opportunities to scale and transfer solutions to other contexts.

Below are a few of the questions that the indicators aim to address:

- What are the technologies that are yielding results?
- What are the business models that have led to financial viability?
- What are some of the favorable local context characteristics?
- What regulatory framework is most supportive of innovation as well as scalability of solutions?
- What are the conducive interventions that actors in the development space can take?
- What are the effective financing mechanisms and what are some aspects of the solution that can facilitate access to financing?
- What are some causal and corollary linkages between different characteristics? For example, regulatory framework and availability of financing, community participation and transferability of the solution, financial viability and uptake cost on community, etc.

The three categories of information under Pillar 2 can support understanding of existing grassroots innovations and their potential for 'success' within and outside of their original community context: the characteristics of the innovation itself, required financial and human resources and partnerships, and the goodness of fit/appropriateness of the innovation in the location of deployment. Specifically, 'success' is considered to be measurable, and related to novelty/ingenuity, frugality, simplicity, marketability, scalability, transferability, reliability/stability, sustainability and the overall capacity for achieving societal and other benefits (Figure 6). The sections below explain each of these elements.

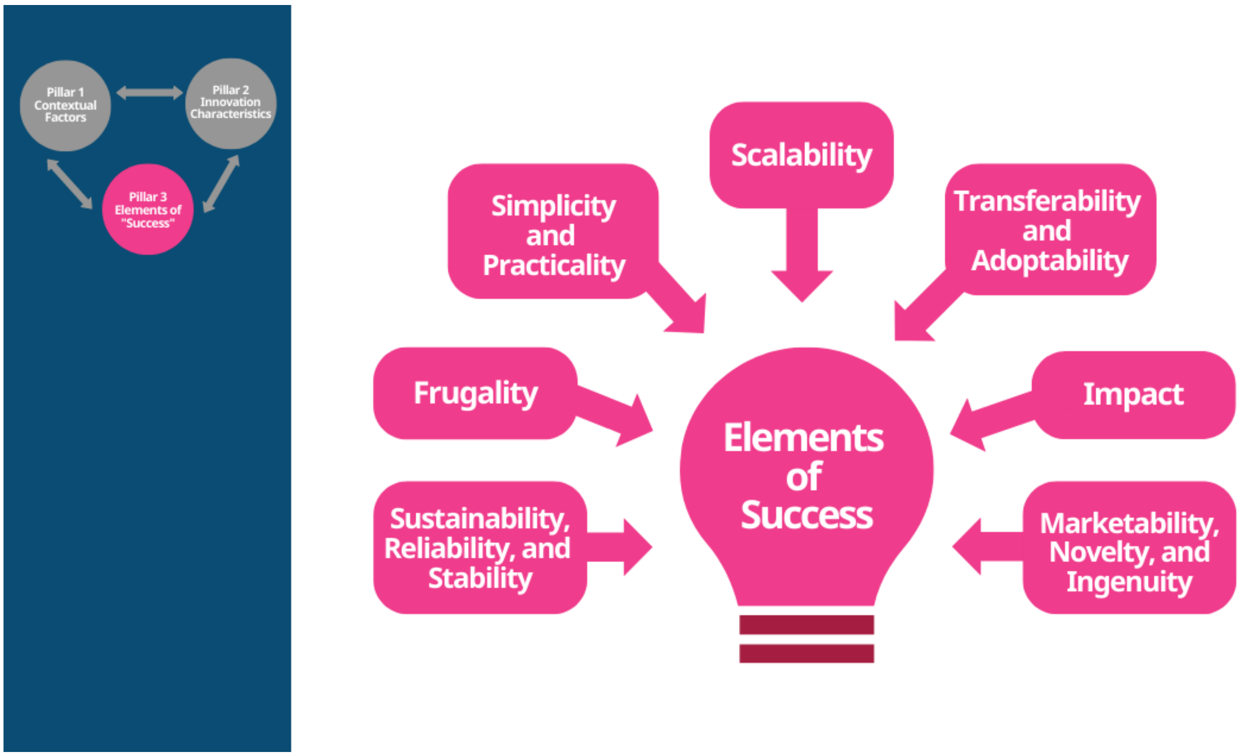

Figure 6: *Elements of 'success' for grassroots energy innovations derived from a review of existing literature and outcomes of stakeholder interviews*

5.1 Elements of 'success' depend on the needs and goals of stakeholder groups and the wider community context

Grassroots innovations emerge from people closest to the problem and who are often marginalized by state, politics and markets. These community members may appropriate existing solutions to suit their needs, or they may contrive their own unique solutions. As such, grassroots innovations, at best, are contextual and place-based, meeting users at their point of need.

The definition of 'success' with respect to grassroots solutions varies based on the needs and goals of the stakeholder groups involved in the particular solution, the wider community context and the characteristics of the innovation. For example, 'success' may refer to the novelty and ingenuity of a particular design for a scientist or engineer who is hoping to acquire a patent for a product. A for-profit company or business owner may define ‘success’ as the development of a marketable, scalable and transferable product. A non-profit social organization or a development agency may view a ‘successful’ solution as one that is frugal, simple and affordable, thus increasing the likelihood of uptake and social impact. Definitions and examples of ‘success’ are examined below.

Impact: *Does the innovation positively affect people in the community of deployment and the environment?*

The Organisation for Economic Co-operation and Development (OECD, 2022) defines impact as “positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended.” This definition generally implies that impact is specific to both the intended and unintended results of a program. Solutions developed by individuals in a community are often intended to fill a social gap. They are also often people-centered, i.e., revolving around the needs of community members, and considering aspects of their behavior, culture and social norms. As such, social impact is often a key indicator of success for grassroots solutions, i.e., the effects of the solution on social well-being. Similarly, environmental and economic impacts are also drivers of the development of on-the-ground solutions.

Specifically, energy solutions often aim to improve access to energy services and energy efficiency and reduce the risk to ecological systems (UNDP, 2016). These objectives can have significant social, economic and environmental impact. For example, a young man, Destin Bibila, from the city of Pointe Noire in the Republic of Congo aimed to convert organic household waste into ecological charcoal to reduce deforestation caused by traditional use of firewood and charcoal for energy (Saya, date unknown). This initiative would serve to reduce piling up of garbage which could be detrimental to human and environmental health in the city. Furthermore, the bio-coal displayed other elements of impact by being more efficient, thus reducing required energy consumption, and cleaner, i.e., producing less carbon dioxide gas.

Insight #15: *Low-cost innovations can be considered a valid form of* ***humanitarian relief*** *in times of crisis.*

In crisis situations, resource scarcity, affordability and access are major concerns. Solutions that are able to eliminate the need for limited resources and replace them with readily available alternatives can offer considerable relief. For example, in the midst of the Syrian humanitarian crisis, an innovator modified a diesel-powered heater into one that runs on pistachio shells.[11] The impact of such a simple and low-cost solution is often overlooked despite its substantial value.

<u>Insight #16:</u> *Innovations that allow for **productive uses of energy** can have a greater impact.*

The impact of some solutions can go beyond improving access to energy, as they can also allow users to engage in revenue generating activities and provide goods and services to their communities. For instance, an innovator in Niger developed a solar dryer that allows vegetables to be preserved and used throughout the year.[12] As such, farmers gain the ability to sell their goods during seasons where they previously could not. This not only benefits the farmers, as they now have an improved revenue outlook, but the community as a whole since access to food is facilitated. The productivity gains of improved access to energy have, in fact, been recognized by the GEF Small Grants Programme (SGP), as it is a primary aspect of their grant making strategy.[13]

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[11] UNDP Accelerator Labs Solution Mapping Platform. "Biomass: Pistachio Shells Hearth (fireplace heater)". Contributed by UNDP Syria Accelerator Lab.

[12] UNDP Accelerator Labs Solution Mapping Platform. "Séchoir Solaire." Contributed by UNDP Niger Accelerator Lab.

[13] Interview with Angelica Shamerina, GEF Small Grants Programme Advisor on Climate Change Mitigation and Regional Focal Point. April 14, 2022.

Frugality: *Is the solution cheap to produce/maintain and affordable for the consumer?*

Consumers of solutions developed at the grassroots appreciate affordable options, especially those in low-income communities and in emerging markets. Similarly, producers value low-cost technologies which minimize costs while maintaining the quality of the product. As such, frugality is another criterion used to determine the success of innovations. Frugal innovations are simple but competitive innovations that are also robust and durable. Frugality is centered around producing lower product manufacturing costs on a technical level (Bhatti and Ventresca, 2013) and using simple technologies with little to no maintenance costs (Rao, 2013).

The development of inexpensive innovations in clean energy solutions arises from the need to access new technologies that are cheaper than alternatives in developing countries (Numminen and Lund, 2016). Frugal energy solutions often utilize sources of energy that are available locally and are therefore cheaper. Additionally, they are a critical way forward for emerging economies for various reasons including their potential to reduce the use of traditional, expensive non-renewable sources of energy and their environmental effects (Kuo, 2017). The bio-coal example from Pointe Noire in the Republic of Congo demonstrates the potential frugality of grassroots energy solutions. The developed innovation was noted to be two times cheaper than traditional charcoal (Saya, date unknown). Furthermore, the use of available waste products to create this innovation would significantly lower production costs.

Insight #17: *Innovators can utilize sources of energy that are* ***available locally*** *to minimize costs and* ***accomplish frugality***

This insight builds on ***Insight #1*** which claims that inter-communal partnerships can facilitate access to resources and inform technological choices. Here we are further developing this idea by stating that such collaboration can reduce the cost of a solution, for both innovators and users, and thus promoting its frugality.

Simplicity and Practicality: *Does the solution require extensive and complicated resources to be implemented? How practical is its offering and performance?*

Grassroots solutions are likely to be more successful if they do not require extensive and complicated resources to be implemented. Simple and practical solutions are viewed as beneficial because they require less technical know-how, minimize the use of raw materials and other resources, thus increasing affordability of the product (Numminen and Lund, 2016). Furthermore, simple innovations can have greater uptake since less skill is required to manufacture and use them, thus increasing accessibility to various communities. These approaches include do-it-yourself models which could support the transfer of products.

Simple solutions can have significant reach. In Mafeteng, Lesotho, community members came up with an easy mechanism to encourage hand washing and prevent the spread of COVID-19 during the pandemic (UNDP Accelerator Labs, Lesotho, 2020). The innovation utilized a 5-liter container with a small hole in the cap that released water if the user stepped on a string attached to the vessel (Figure 7).

Figure 7: *Tippy-tap hand washing solution in Lesotho (Source: UNDP Accelerator Labs, Lesotho, 2020)*

Scalability: *Can the solution's deployment or uptake be increased?*

Scaling can take several forms, including impacting institutions through efforts to change laws and policy (scale up), increasing the number of persons or entities impacted (scale out) or promoting cultural change (scale deep) (Baru et al., 2020). Scaling out is the most common form as it may entail replication of a particular solution and/or increased dissemination to expand the impact. Scaling deep is the most difficult as it aims to change norms and beliefs of community members. Bottom-up solutions can support behavioral change through awareness raising and provision of opportunities to adopt new practices (Moscovich, 2022). Scaling can also refer to knowledge sharing and process development in addition to a specific innovation or solution. Persons on the ground have the most knowledge regarding problems faced by communities. Sharing their experiences and lessons learned can support scaling of ideas and concepts, thus creating opportunities for greater social impact.

Scaling often requires additional resources which community members most likely do not have access to on their own. Partnerships with government entities, development organizations, the private sector or other community members can support these initiatives. The Guatemalan initiative, Mosan, created a closed loop system to contain and transform household sanitary waste into organic fertilizers in rural communities (Constantino, 2022). Considerations for expanding the reach of this solution included partnerships with the Global Environment Facility Small Grants Programme, obtaining technical and business support to enhance the solution, and reaching out to other local governments.

<u>Insight #18:</u> *Sharing the experiences of innovators in order to inform scalable programing should not be limited to solutions that are perceived as 'successful' as* ***lessons can be learned from any attempt to innovate.***

The knowledge acquired by studying any solution, including those that were unable to achieve the other elements of success described in this section, can promote scaling through sharing of best practices as well as initiatives that did not work. By internalizing this insight, multinational organizations can derive value from any grassroots innovation, whether or not it was considered effective.

<u>Insight #19:</u> ***International development organizations*** *are ideally positioned to assist the scaling efforts of innovators and to disseminate the knowledge they acquire to the entire ecosystem of actors involved in efforts to improve energy access globally.*

International development organizations, such as UNDP, have the resources and organizational structures in place to access various local communities across the world simultaneously. This is a unique ability that positions them as a primary resource in the acquisition of knowledge relating to global trends in grassroots innovation. Furthermore, such entities can leverage the existing partnerships they have with governmental stakeholders in order to disseminate this knowledge to inform policy and institutional behavior.

<u>Transferability and adaptability:</u> *<u>Can the solution be deployed in another context?</u>*

Adaptability implies that a solution can easily be adjusted to fit different contexts or purposes. Grassroots solutions are steeped in contextual challenges and the characteristics of the local environment such as norms, beliefs, and political structures. These characteristics contribute to the acceptance or rejection of these innovations. Attending to local realities while seeking wider transferability may not always be feasible for grassroots innovations because of the wide-varying nature of contextual differences. As such, the drawback remains the constant appropriation of innovations to fit into the values, characteristics, resources and capabilities of diverse communities. However, it is still possible to have a solution that can be altered to fit the characteristics of different communities, while maintaining the intended purpose.

For example, the hand washing mechanism designed in Lesotho and shown in Figure 3 above was remodeled and adapted for densely populated and high traffic areas (UNDP Accelerator Labs, Lesotho, 2020). Adaptations entailed the use of more durable flat iron instead of a string. Figure 8 shows an image of the adapted solution.

Figure 8: *Hand washing solution adapted for high traffic areas in Lesotho (Source: UNDP Accelerator Labs, Lesotho, 2020)*

Insight #20: *Donors should have an agile approach to transferring and adapting the most frugal solutions that have demonstrated impact as their **low costs can allow for a low-risk** iterative process.*

While ***Insight #8*** presents some of the gaps that exist between the needs and incentives of donors on the one hand and grassroots innovators on the other, this insight presents one form of agile spending that can reduce some of these gaps.

When solutions have demonstrated their impact, frugality, and potential for adaptability and/or transferability, donors should be willing to spend small amounts of money to attempt to recreate them in different locations. To do so, donors should forgo their prioritization of reaching many beneficiaries at once, and instead recognize the compounded impact that their spending can have.

Marketability, novelty and ingenuity: *Could the innovation be sold for profit? Are there similar products that can be found on the market?*

Urpelainen and Yoon (2016) highlighted that a novel business model allowing affordable energy services for the community's most vulnerable members is also a key driver. Furthermore, the marketability of an innovation remains an important consideration, especially for innovators who aim to profit off of their creation. Grassroots solutions can lead to market stimulation through the development of missing connections across the value chain.

Insight #21: *Innovators can increase the marketability of a solution by* ***diversifying revenue streams*** *through the offering of auxiliary products.*

The diversification of revenue can improve the financial health of any organization (Mayer et al., 2012). This also applies to providers of grassroots solutions. Consider the example of MittiCool, a clay refrigerator that can store and preserve water, milk, fruits and vegetables. The business that grew out of this innovation now offers a wide range of products, such as clay pots, which allow it to generate supplemental income and ensure the longevity of the business.

Sustainability, reliability and stability: *Does the solution consistently fulfill its intended purpose? Is the solution relevant in the long-term? Does it utilize a clean source of energy and clean technologies?*

Grassroots innovations are home-grown and usually go through multiple stages of iteration to fulfill the needs or requirements of the innovator. This enhances their sustainability value and eliminates the need to own multiple products if the innovation can effectively fulfill its intended role. Innovators are also often more connected to their local environment, using natural tools that are readily available, and frugal means, making them high on environmental sustainability (Gupta, 2019). However, the consistency of grassroots innovation provisions can be hampered by a lack of sustained availability of resources and institutional support. Furthermore, in the face of climate change, energy innovations should utilize clean energy sources and technologies to support efforts to mitigate harmful environmental impacts.

Section 6: Demonstrating the Grassroots Thinking Approach Using Case Studies from Ethiopia and Malaysia

This section presents two case studies of innovations from Ethiopia and Malaysia. The case studies include an overview of the contextual analysis of each country and demonstrates the potential of specific grassroots innovations mapped by the Accelerator Labs Network in each nation. The studies connect the identified linkages to the system requirements discussed in Section 3, highlighting, where possible, the conditions in which the solutions emerged and exist. Through the analysis of the innovation's characteristics as explained in Section 4, elements of success are identified to support hypotheses of best practices related to the various measures outlined in Section 5.

Ethiopia is one of the most energy deprived countries. In 2019, the World Bank reported that only 48% of Ethiopians had access to electricity (IEA, 2022). On the other hand, in Malaysia, 100% of the population has access to energy (World Bank, 2019). These two countries' situations therefore vary widely. However, it is important to note that despite having 100% access to energy, there are still some populations in Malaysia that could be considered energy poor due to factors including geographical constraints (Energy Watch, 2018). People in these two countries face different but similar challenges in accessing energy. The challenges are discussed below as well as examples of solutions that have emerged at the community level to solve them.

6.1: Improving access to clean cooking in rural Ethiopia through locally sourced, scalable and deployable cooking stoves

6.1.1 Analysis of contextual factors related to energy access in Ethiopia

According to the Africa Energy Outlook Report (IEA, 2019a), by 2025, the continent will face an increase in its population, leading to a rise in the need for energy. Such growth is expected to overwhelm the amount of energy produced in Africa. Therefore, countries, including Ethiopia, need to refocus efforts to expand the current energy supply within their borders. Renewable energy resources such as hydro-power, wind, solar and geothermal power exist in Ethiopia. Nevertheless, Ethiopia will remain heavily reliant on imports of fossil fuels.

About 48% of Ethiopians have access to electricity, with 85% living in urban areas and 10% in rural communities. According to the International Renewable Energy Agency, Ethiopia's electricity capacity and generation in 2020 was about 4,817 megawatts (IRENA, 2020). Most electricity was produced from hydropower, which accounts for 85% of the energy mix. However, more than half of the population does not have access to electricity, especially in rural and deep rural areas. Since a high percentage of rural and urban households do not have access to electricity, and the power supply is often unreliable and erratic, electricity-based clean cooking solutions will not be as effective as an improved locally sourced and affordable solution. Therefore, biomass is expected to continue as Ethiopia's primary energy source for quite some time.

Ethiopia's low rural electrification rates and its significant, untapped potential for generating electricity from renewable sources (hydro, solar, wind), make it well placed to develop innovative energy products (IEA, 2019b). Increasing electrification rates is of great importance to the government of Ethiopia, which aims to achieve total electrification by 2025 by integrating grids and off-grid networks (Ministry of Water, Irrigation and Electricity of Ethiopia, 2019). Through regulatory support, Ethiopia is enabling grassroots innovations to flourish. In addition, several energy campaigns target Ethiopia, for example, USAID, Power Africa and the international community, support technical transfer and capacity building. For these reasons, multiple community energy solutions have emerged, and the UNDP Accelerator Labs Network has already mapped some.[14]

UNDP Ethiopia stakeholders have highlighted that the country has essential strategies and policies at the national level, including the Growth and Transformational Plan, the 10-Year Perspective Development Plan, and the Climate Resilience Green Economy Strategy. The action plans and strategy articulate the commitment to achieving universal access to clean, reliable and affordable energy. These programs complement ambitious plans for universal access to electricity by 2025. They set the targets to ensure 35% of new connections involve off-grid technologies, while the rest will be on-grid.

Ethiopia's Ministry of Water, Irrigation and Energy and UNDP established the Rural Energy Technologies in 2015 with the help of the Global Environment Facility (GEF). For rural households and small businesses, the initiative emphasizes small-scale energy-efficient technologies, such as improved cook stoves and solar home systems (UNDP Ethiopia, 2015). Furthermore, to promote a vibrant and sustainable market for improved cookstoves, and build institutional capacity, Ethiopia's national improved cookstove program aimed to contribute to the government's improved cookstove distribution plan (Asfaw, 2019).

The innovation ecosystem in Ethiopia receives minimal recognition and support. Things are worse for grassroots energy innovators, thus preventing the growth of new solutions. Furthermore, solution mappers have identified a tendency for innovations to lean towards specific areas such as clean cooking and cooking stoves, leaving out other opportunities to expand electrification services. However, the Accelerator Labs have not fully explored and

[14] Interview with UNDP Ethiopia Team Members. April 15th, 2022.

documented the reason for such heavy concentration of innovations focused on clean cooking.[15]

Additionally, different community innovators invent various biomass inventions for clean cooking due to different standards that might not fit or complement other fuel solutions in the field. These cooking products have experienced high market penetration rates, increasing uptake. One drawback has been that these cookstoves are easily mimicked, but with incomplete features. Such examples of lower-quality copied inventions discourage innovators and represent one of the causes of failure in getting these solutions to scale. Therefore, it underscores the importance of regulatory frameworks that protect innovators' intellectual property and ingenuity.[16]

6.1.2 Solving and reducing the population's dependence on biomass-based fuel by promoting the use of cleaner cooking technologies in Ethiopia

What is the problem?

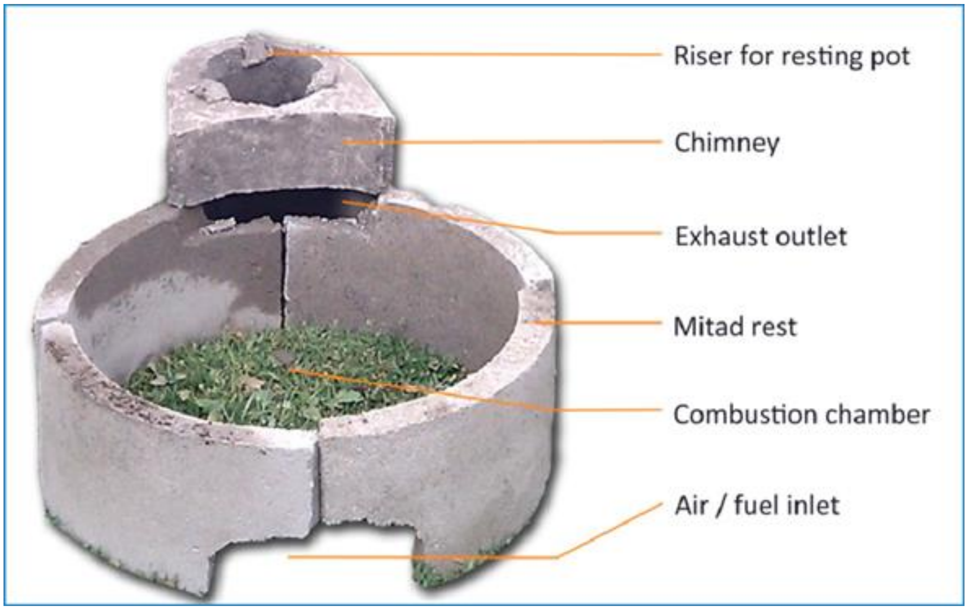
An estimated 4 million annual deaths in Ethiopia are linked to indoor air pollution because of traditional and inefficient biomass usage. Particulate matter from burning biomass in the kitchen can cause premature death for children under 5. Ethiopians frequently use traditional and inefficient "three-stone fire stoves," where stones are arranged as a tripod around a fire for stabilizing a pot or other cooking device. The three-stone fire stove can pose serious health risks, increase fuel consumption and cause deforestation in the long term. There are several options for improved biomass-efficient stoves. Additionally, alternatives like electric clean cooking technologies are available. However, Ethiopia's low electrification rate and the high price of the electric cooking appliances will not be accessible for rural communities in Ethiopia (Nega et al., 2021). Ethiopians need to identify affordable clean cooking and efficient technology that can drastically reduce fuel consumption emissions and pollution and improve indoor air quality.

What did the innovator do?

Injera is a staple food for the majority of Ethiopia. The prevalence of this dish leads to around 50% of the nation's primary energy consumption, and it is therefore one of Ethiopia's most hazardous and tiring traditional cooking practices (Adem et al., 2019). The Mirt stove is an injera baking stove that is more fuel-efficient, affordable and cost-effective. It was developed by Ethiopia's Ministry of Water and Energy in the mid-1990s in collaboration with community members who supported the design and its use of local tools.

[15] *Ibid*.
[16] *Ibid.*

The stove's features include uniform heat distribution throughout the baking pan, and reduced heat loss through improved insulation. The innovation has an expansion chamber and pot rest, four cylindrical enclosure sections that are 6 cm thick, and no chimney (Figure 9). It is now famous in both urban and rural areas of Ethiopia and can also be found in some neighboring countries like Eritrea, primarily in households, commercial bakeries and sometimes restaurants.



<u>Figure 9</u>*: Mirt stove (Source: Dresen et al., 2014)*

<u>What are the benefits of the solution?</u>

Compared with traditional fire stoves, the Mirt stove offers 50% wood fuel savings, substantial reduction of smoke and minimal exposure to heat and fire. According to Beyene et al. (2015), the Mirt stove reduces indoor air pollution, helps mitigate climate change and improves livelihoods if they are used to replace traditional cooking methods. Additionally, the improved efficiency of the stove reduces the time spent to collect firewood. There has been a high acceptance rate in the communities in which the Ethiopian government has distributed the stove. As such, it is considered one of the most marketable products, and it is easy to assemble by users and lasts over four years.

<u>What is next?</u>

Due to the benefits stated above and the affordability of the innovation, the Mirt stove is ready for deployment and sustainable scaling up in Ethiopia and in neighboring countries which also consume injera dishes. The government of Ethiopia could increase the number of distributions of the stoves or open the market for private public partnerships to allow mass production and to ensure that community level markets are involved in mass distribution activities. Scaling up such a stove will result in a lower national fuel consumption rate for cooking the traditional injera dish.

6.1.3 Elements of 'success' of the Mirt stove in Ethiopia

- **Impact:** At all levels, the solution's impact will revolve around improving energy efficiency (including the efficient use of biomass resources at the household level), as well as the development of renewable energy and the rational use of natural resources. This will in turn have a positive social impact as health would improve with reduced air pollution. Furthermore, in Ethiopia, the distribution of improved fuel stoves will have a long-term impact on reducing poverty and enhancing the capacity of the different development partners to implement energy development measures.
- **Frugality:** Mirt stoves can be manufactured with only locally available raw materials, such as scoria (or river sand) and cement, which are widely available throughout the country. The innovation is affordable, and it provides a cleaner energy method of cooking. Through the distribution of Mirt stoves, the cost of cooking will be reduced as the stoves use firewood more efficiently. In terms of design, the Mirt stove can be used for both baking and cooking (GIZ-ECO, 2011).
- **Simplicity and practicality:** The Mirt stove is designed to be assembled by the user, using clay or cement to ensure a stable cooking stove. Such materials are accessible and affordable in the rural community of Ethiopia, and easy to put together. As indicated above, the solution had a high acceptance rate in the community as a practical way to bake and cook compared to traditional cooking stoves with less cooking time (Asfaw, 2019).
- **Scalability:** The Mirt stove is ready for scale and distribution. With the assistance of the GIZ Program, entrepreneurs have been encouraged to take advantage of such solutions by establishing a quality assurance process (GIZ-ECO, 2011). In addition, UNDP and GEF have already established the project Sustainable Rural Energy Technologies which can also be a means for scaling up Mirt stoves in Ethiopia.
- **Transferability and Adaptability:** Injera as a dish and cultural food is a staple in most of the neighboring countries, accounting for more than 50% of energy consumption as highlighted above. Therefore, such similarities in context regarding traditional cooking in Ethiopia and other countries can support the benefits of transferring this solution. Furthermore, the materials used are also available in the surrounding countries.

- **Marketability, novelty and ingenuity:** The Mirt stove is not a unique solution in Ethiopia. After the Ministry of Water and Energy in Ethiopia started the distribution and production of the Mirt stove, there were similar models developed. However, the Mirt stove is ready to be introduced in the market in a sustainable manner, for example, by ensuring raw materials are available for start-up production, setting pilot production phases to assure quality standards are followed, and through public stove administration in the community. The Ethiopian Rural Energy Development and Promotion Center and German Technical Corporation (GTZ) have been pioneering such marketing efforts with the Mirt stove in addition to distributing leaflets and brochures on how to assemble and use it (EPA, 2004).
- **Sustainability, reliability and stability:** After several control cooking tests, comparisons with open fires showed that about 50% of the fuel used was saved, and the carbon monoxide levels in the kitchen were reduced by about 90% (GIZ-ECO, 2011). These benefits will have a direct impact on SDG 13 as they will reduce carbon emissions that are typically released from traditional cooking methods. In addition, this type of innovation will improve community stability and promote better health and gender equality, since it will decrease household air pollution which disproportionately affects women and children, and it will allow women to spend less time collecting firewood. Furthermore, the Mirt stoves have a lifespan of more than 5 years (GIZ-ECO, 2011).

6.2 Using grassroots solutions to solve COVID-19 movement restrictions in Malaysia

6.2.1 Analysis of contextual factors related to energy access in Malaysia

Fossil fuels, such as natural gas and coal, have historically been the main source for power generation in Malaysia (US EIA, 2021). The country maintains a large proportion of Southeast Asia's fossil fuel reserves. However, it is progressively reducing its reliance on fossil fuels and developing its renewable energy market to decarbonize its energy-centric economy and to add value across value chains, unlocking wide-ranging benefits for the country (The Edge Malaysia, 2021). In 2018, Malaysia announced that it would include 20% renewable energy in its generation mix by 2025, and in 2021, the government further revised its renewable energy target to 31% by 2025 and 40% by 2035 (IHS Markit, 2021). According to our UNDP Malaysia stakeholder interview (2022), the government is robustly developing large-scale solar power stations to achieve these targets. There is minimal focus on grassroots solutions within these plans, as they are not considered pivotal to energy access in the context of Malaysia. Grassroots solutions serve as complements to existing government energy policies. These off-grid grassroots energy solutions do not require licenses for generation and distribution, making them more widespread at a community level.

Statistics from the World Bank (2019) indicate that Malaysia has achieved close to 100% electrification since 2015. In Peninsula Malaysia, this rating is due to well-established central grid infrastructure and a relatively accessible population base.[17] There are, however, still pockets, particularly in highly inaccessible rural areas, that lack access to modern energy infrastructure (Energy Watch, 2018). These areas include the states of Sabah and Sarawak, where geography imposes significant barriers for widespread electricity distribution infrastructure, while at the same time, offering tremendous electricity generation possibilities. In remote regions where local utility service providers are not able to reach, local innovators have come up with off-grid energy solutions to fit the communities' needs.[18] These solutions have proven the capacity for such initiatives to overcome geographical barriers to energy access. Abundant solutions have already been mapped by the UNDP Accelerator Labs Network, and several have received funding from the Global Environment Facility Small Grants Program. The section below provides an analysis of one of these innovative solutions.

6.2.2 Solving transportation restrictions with a solar-powered buggy innovation in Malaysia

What is the problem?

Malaysia, in response to the COVID-19 outbreak in the country, began the implementation of the movement control order (MCO) on 18 March 2020 (Yusof, 2021). The MCO measures included restrictions on movement, assembly and international travel, as well as the closure of businesses, industries, government agencies and educational institutions to prevent the spread of COVID-19. It was initially scheduled for two weeks but was extended until 3 May.

Transport of goods from urban areas to villages was also disrupted during MCO, since petrol was in short supply in rural areas. Families in need of supplies were not able to obtain them in time.[19]

What did the innovator do?

In the past, Mr. Lasimbang had always envisioned a solar buggy that could transport materials from village to village (Tan, 2020). The 43-year-old is the founder and director of

[17] Interview with the UNDP Malaysia AccLab Team. April 19th, 2022.
[18] *Ibid*.
[19] *Ibid*.

CREATE Borneo, a social enterprise specializing in rural electrification. He is also a Senator from Sabah in the Dewan Negara, the upper house of the Malaysian Parliament.

However, he and his team were usually busy with micro-hydroelectric projects in Sabah and across the country and did not have time to implement the concept (Tan, 2020). As a result of quarantine and the MCO, he and his team were unable to accomplish any projects, so they decided to build a buggy entirely from scratch, utilizing leftover materials in the workshop, from solar panels to steel tubing for the vehicle frame. Four solar batteries were installed on the buggy. Each battery weighs nearly 80 kilograms and is connected to the others. These batteries provide the buggy with 1,000 Ah of energy, enabling it to operate without recharging for nearly three days.

<u>What are the benefits of the solution?</u>

The solar-powered buggy provides an affordable and usable transport system and power source for rural villages that were previously heavily dependent on generators powered by fuel. The buggy eliminates the need for villagers to travel to town to access fuel for their generators and motorbikes, leading to savings in time and money.

The vehicle can also accommodate six passengers, including the driver (Tan, 2020). Furthermore, in a rural agrarian setting, the buggy supports transportation of rice in larger quantities. This is more practical for farmers, who will otherwise use motorbikes to transport rice sacks during harvest season, incurring several trips that consume considerable fuel.

<u>What is next?</u>

Moving forward, the innovator has seen the potential of a solar-powered buggy to reduce the cost of transportation, as well as enable communities to travel short distances.[20] Likewise, it can also be used for the transportation of goods or materials, as well as to launch an e-commerce project with the same community. A solution such as this arose out of necessity during a time of pandemic but can also be utilized for business continuity purposes.

6.2.3 Elements of 'success' of the solar-powered buggy in Malaysia

This example illustrates how local communities possess the ideas and capacities to resolve local existential energy challenges. When government policies did not reach the community, grassroots innovations emerged and were implemented successfully among

[20] *Ibid*.

the local people, despite having constraints and lack of resources.[21] Elements of success in this initiative are outlined below.

- **Impact**: The solar-powered buggy solution developed by individuals in the community is people-centered, resolving the needs of community members and taking into account aspects of their behavior, culture and social norms. Intended or not, the solution has created positive long-term effects and can help to fill a social gap.
- **Frugality**: Grassroots innovations such as the solar-powered buggy required little raw material and other resources. For the solar-powered buggy, the frame was built using leftover materials and the steering system was salvaged from an old car, which was modified later to fit the much shorter buggy frame (Tan, 2020). This element is viewed as beneficial as the solutions can be produced at minimal cost using material which would have otherwise been discarded.
- **Simplicity and practicality**: Upon performing a series of test runs around the compound and village, the buggy reached a top speed of just 25 kilometers per hour (Tan, 2020). Besides, no speed records are likely to be set by the buggy in the near future. However, it can still accommodate up to six passengers, including the driver. In a rural agrarian setting such as paddy fields, it is still useful to transport harvested rice in larger loads. Being pragmatic emphasizes the broader practical and performative dimension of the solution. The down-to-earth nature of the solution acts as a key component towards success.
- **Scalability and transferability**: Using the framework provided by Baru et al. (2020), discussed in section 3, the solution has the potential to "scale-out" and "scale-deep." That is, there is potential to increase the number of persons or entities impacted by this solution and opportunities for replication and dissemination to other communities, for example, to communities in the states of Sabah and Sarawak with similar geographical constraints. There is also a potential for a more long-term effect to change norms and social behaviors of community members. Instead of relying on fuel-powered motorbikes or vehicles, the bottom-up solution can help the community to adopt new practices to transport goods and materials in a cleaner and cost-effective manner, thus promoting behavioral change.
- **Reliability and stability**: The buggy has batteries capable of holding a 1000 Ah charge, which is much larger than a typical buggy (Tan, 2020). In case of rain or in case of no sun, because the inverter is bi-directional, the user can also plug it into a

[21] *Ibid*.

power source and the inverter will convert house AC to DC to store in the batteries, so it is still possible to drive the buggy in various weather conditions.

- **Sustainability**: The innovator is well-connected to the local environment, and he used material and resources that are readily available and frugal, thus contributing to the sustainability of the solution.

Section 7: Conclusions and Recommendations for Channeling the Grassroots Innovation Ecosystem Toward Achieving UNDP's Moonshot Energy Goal

The *Grassroots Thinking Approach*, a novel framework conceptualized by the SIPA Workshop team, was used to understand the transformative potential of grassroots innovation. This approach was derived by using information gathered from the literature review, complemented by country energy analyses, expert interviews and assessment of the Accelerator Labs' solutions mapping platform.

This approach emphasizes the importance of **understanding the contextual and systemic factors** (Pillar 1) that innovators must navigate to ideate and implement their solutions. These solutions emerge due to **community needs and have certain characteristics and requirements that make them appropriate (Pillar 2)** within the contexts where they emerge and locations of deployment. By combining the contextual and innovation characteristics (Pillar 1 and 2), we **assessed the potential of grassroots solutions in improving access in energy deprived settings (Pillar 3).** We characterized this "potential" as elements of "success" that can transform innovations into full-fledged solutions.

7.1 The *Grassroots Thinking Approach* is a normative instrument that can be used across various organizations to support achievement of the SDGs

This approach is a normative framework that could support the UN and other public, private and international development entities. Grassroots solutions could foster learning and thus contribute to achieving the SDGs and the UNDP moonshot goal. Specifically, this approach supports data collection and analysis, thus resulting in knowledge building and learning that could facilitate the direction of funds by investors and donors, and scaling or transferability of solutions to contexts based on their appropriateness. Our analysis yielded insights that are interlaced across the entire publication. Some noteworthy inferences based on these insights include:

Pillar 1 - Government action, agile funding support, collaboration and information sharing are key to developing an enabling environment that is conducive for grassroots energy innovation.

Critical inferences derived from this pillar include:

- the importance of cross-community collaboration and information access in informing technology choices;

- the role of local learning and sharing operational structures in facilitating behavior change, technological use and policy development;
- the critical role of government in establishing bottom-up development paradigms in national energy strategies that are based on extensive consultation, effective communication and backed with extensive funding and support;
- the role of development partners in developing long-term, agile and innovative funding mechanisms in line with grassroots innovators' incentives and risk profile; and
- the power of technology to facilitate new entrants that can provide low-cost funding in the grassroots innovation funding ecosystem.

Pillar 2 - Characteristics of an innovation and its location of deployment determine its appropriateness.

Critical inferences derived from this pillar include:

- The goal, purpose and function of an innovation depends on the needs of the community, the problem that the specific innovator is trying to solve, and the community context.
- Recognizing how well the innovation fits in the location of deployment could support efforts to scale, adapt and transfer the solution.
- Cultural norms and attitudes can affect the effectiveness of a solution and usage.
- Understanding and documenting the characteristics of the developed solution can provide knowledge on the financial and human requirements needed for deployment.

Pillar 3 - The potential for success depends on alignment between enabling contexts, needs of stakeholders and innovation characteristics.

Specifically, 'success' is considered to be related to novelty/ingenuity, frugality, simplicity, marketability, scalability, transferability, reliability/stability, sustainability and overall capacity for achieving societal and other benefits. Identified elements of success should be measurable to support monitoring and evaluation. Critical inferences derived from this pillar include:

- Low-cost solutions that allow for productive uses of energy, especially in times of crisis, score high on impact which matters for success.

- The use of locally available resources is essential for minimizing costs, accomplishing frugality, simplicity and improving user experience and reach.
- By attending to unmet energy needs, grassroots innovators can increase the marketability of their innovations, while also diversifying income with auxiliary products.
- Development actors should leverage their extensive reach in disseminating learnings from both successful and unsuccessful grassroots innovation attempts to influence policy and scaling.
- Donors should embrace more agile smaller-scale spending on frugal solutions that have proved impactful and adaptable.

7.2 Adopting the *Grassroots Thinking Approach* can facilitate expansion of knowledge and increased access to information

Finally, we present three main recommendations that are hinged on knowledge management of grassroots innovation through solutions mapping, information and resource sharing for innovators and an overall mainstreaming of grassroots innovations thinking within the development ecosystem.

1. The Accelerator Labs Network, as well as other relevant international and community organizations, should optimize its solutions mapping process to support the **Grassroots Thinking Approach** ***as presented in the report.***

The Accelerator Labs Network’s solutions mapping platform can serve as a knowledge management tool for localized, contextual knowledge about the lived experiences of grassroots innovators, including their behavioral norms and motivations and the type of innovations that are appropriate to their needs and location. With the right mix of data collected and analysis, this tool can be ethically extracted to answer questions on what solutions work, why and how to support their scaling.

Hence, an overall recommendation is to enhance the data collection process, utilizing the outlined contextual factors and innovation characteristics that lead to ‘success’. Improving solutions mapping requires enhanced on-the-ground operations and would facilitate more robust learning and sharing.

The current information collected on the platform provides sparse data points offering limited opportunities for data mining and prediction. Currently, solutions mappers are expected to venture into the field, looking for interesting, intriguing and inspiring solutions and asking questions about the solutions, unmet needs and the target audience. Their findings are recorded and later uploaded onto a platform when time permits. It is not clear which indicators solutions mappers are basing their questioning on. As such, the information on the platform is limited to descriptive statistics on what the solution is, and it is not consistent. There is limited information on what materials were used in solutions, why the innovations exist, and the scale of reach. Indications of impact such as energy efficiency are sparse, and information on the stability of provisions and marketability are absent. In rare instances, we were able to glean some of this information from the description of the solution. However, there needs to be clear and uniformed headings and markers to identify and delineate them, to allow for comparison and analysis. The only clearly identifiable markers within most solutions are the SDG tags.

Efforts can be made to make the process more methodical or scientific. Therefore, the process for future mapping should account for the location characteristics and elements of success discussed in this report. Drawing on the characteristics and elements for success, the Labs can devise metrics to assess these criteria so that data collection points are standardized and informed by questions to be answered for policy makers.

The process can work by having solution mapping questions that serve as proxies to the data points on impact, frugality, simplicity, scalability and sustainability. For example, a proxy for *impact* can be how the solution improves energy access or what difference it makes to access rates in a particular community. *Frugality* can be assessed based on the costs of the solution including its production costs, in comparison to other mainstream provisions, the type of materials (new products vs. waste products) and how readily accessible and available these products are. *Simplicity* can be assessed based on who can use the solution and the extent of know-how or literacy required for deployment. *Transferability* could be how strongly embedded the solution is in the local context which will affect aspects that can be easily appropriated to other situations.

Once these proxies are established for the different contexts, it will feed into questioning and facilitate more robust data-gathering on what materials are being used in existing solutions, product mix, affordability, scaling mechanism and financial requirements.

It is worth noting that these proxies might differ in different contexts and not all success criteria will apply to all solutions. This new process might also require repeated visits and/or consistent engagement with the innovators to validate such solutions and how they are performing with respect to the identified indicators. However, with the availability of this information, mappers can begin to observe trends and patterns of unmet needs, novelty of solutions, occurrence of certain types of solutions and characteristics of the deployment locations, which can facilitate data mining and predictions on where and how stakeholders and partners can intervene.

This new scientific approach could be supported through the development of a Toolkit or Guidance Document for solutions mappers in the Accelerator Labs or other institutions to refer to when gathering data.

A further project for the Accelerator Labs might be to better define and establish these success indicators for different contexts to be able to standardize data collection to answer tough policy questions on the role of grassroots innovation. This process will lend more quantitative validity to the current analysis the team has proposed.

Another potential improvement is on how data is collected. The current process collects data manually to be uploaded at a later period, which could create attrition between what is mapped and uploaded due to collector fatigue. One improvement is to include a real-time data collection feature on the current platform that could be run through a low-cost mobile application. Ethiopia's Accelerator Lab is already in the process of designing such a tool to support data gathering.[22] The adoption of mobile technology will reduce the time-burden of recording information as solution mappers would be able to directly input innovation characteristics in a consistent format while in the field. GIS features can also be included in this real time data collection process to automatically collect information on the location of deployment such as geography, proximity to grids, population density, etc., which can be validated following field trips. Peer vetting and validation of solutions is also encouraged to ascertain the extent of clarity of information conveyed through documentation.

If the Accelerator Labs adopt this evidence-based approach, it would be recognized as a knowledge hub for information on grassroots innovation. Over time, as the data is harnessed and analyzed, UNDP can become a "thought leader" in the space of grassroots innovations. Enhanced data collection and documentation would lead to the creation of a valuable resource for governments, development agencies, private and non-profit organizational actors, and grassroots innovators in their own pursuit of the UN SDGs.

2. Local Labs should create a directory of resources that are available for innovators in order to increase the access to information.

UNDP has a strong presence in many countries, so this extensive in-country presence complemented by the ethnographic capacity within the Accelerator Labs can be leveraged to scan for local information and resources that would be useful to grassroots innovators. This information can be aggregated into a directory that can serve as a go-to information resource for grassroots innovators in countries where the Labs are active.

[22] Interview with UNDP Ethiopia Team Members. April 15th, 2022.

This directory of resources can be hosted either offline and/or online and include the following information as a starting point:

- A global list of innovators that they can reach out to for co-creation, information, expertise, experience sharing and talent,
- A list of grants, national competitions and other sources of funding they could access. (The availability of these competitions in Ethiopia and recognition created the impetus for the innovator of the solar powered bicycle to persist),
- A list of local NGOs, and other organizations that provide capacity building support such as training programs, business management classes or financial literacy resources,
- A list of materials that can be used as alternative fuels in clean cooking or heating, and
- A list of local private sector providers of low-cost energy technology that can assist innovators in appropriating and/or navigating technology choice.

Other categories of resources can be added incrementally as they become available. This broad array of resources readily accessible to innovators through the Accelerator Labs can provide innovators with the needed tools and resources to positively navigate existing systemic barriers and de-risk failure, increasing their chances of survival, scale and sustainability.

3. Mainstreaming 'Grassroots Thinking' should be prioritized across UN Agencies.

The United Nations' strong convening power in bringing stakeholders together to dialogue and influence development paradigms can play a critical role in raising the legitimacy of grassroots innovations within the global development mix. It can start through mainstreaming the *Grassroots Thinking Approach* across UN agencies and other development stakeholders. This thinking emphasizes more bottom-up programming that takes into account the ingenuity that people close to a problem possess and the systems they have to navigate to sustain ideation. The approach also supports the inclusion and mainstreaming of these actors and their solutions within programming.

This can be done through:

- **Education outreach programs across UN agencies** to provide information on this frontier approach to addressing development challenges. Colleagues from the GEF Small Grants Programme can share information with other funding units on how they are including local community members in selecting grant recipients and what is working in this process in improving community project-based funding. The Accelerator Labs can also organize knowledge sharing sessions on grassroots innovations with other agencies. The recent spike in familiarity and skills around virtual meeting technology can greatly enhance this capacity.

- **Development of grassroots innovation education programs** to augment the existing support provided to grassroots innovators and facilitate cross-pollination of ideas within the grassroots ecosystem. UNICEF or UNESCO can host workshops of do it yourself (DIY) solutions within communities to learn more on uptake and transferability of solutions.

  Imagine facilitating a workshop that takes the cheapest possible solution, for example, a type of cookstove, and teaches many people from a community how to build it with the innovator being part of the instruction. In parallel, they are also taught about different resources that can be used in other types of DIY solutions. At the end of the workshop, members have improved access to energy directly. The value of such a program goes beyond the access to the solution but also improves community agency, equips them with the skills of ideating to solve local problems and creates the foundation for more grassroots innovation.

- **Procurement and programming processes could emphasize inclusion of grassroots and home-grown solutions.** For example, UNHCR could fund grassroots innovations as a form of humanitarian assistance and purchase them in the establishment of camps.

  WFP could purchase clean cooking solutions from grassroots innovators to distribute as a form of in-kind assistance and include a category for grassroots innovations within the WFP Accelerator.

These are some of the ways to support existing solutions to scale. By finding opportunities for grassroots innovations to be included within existing programming and creating new programs for grassroots innovations, this bottom-up approach, as differentiated from earlier models ‘imposing’ potential solutions, can be cemented as a fundamental tool to aid the development efforts of communities as well as the wider ecosystem of actors in the space. The learning and experiences from these auxiliary opportunities must be fed into the solutions mapping platform and the opportunity should also be included in the resource directory. This concerted mainstreaming effort will further raise the legitimacy of these solutions leading to national and sub-national governments recognizing and appreciating grassroots innovations where they have hitherto been unrecognized. As such, while this document is centered around improving energy access, it is easy to see how this *Grassroots*

Thinking Approach can also be applied to any field of development that can benefit from the empowerment of local communities.

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Appendix 1: Overview of UNDP Priority Energy Deprived Countries

The United Nations Development Programme (UNDP) Energy Hub has identified 19 countries in Sub-Saharan Africa and Asia that have the most significant gaps in access to electricity and clean cooking. The country overview table below attempts to present a contextual overview of these 19 countries. A list of key metrics and descriptive indicators are used to support this analysis. Specifically, the indicators related to the following thematic areas have been included: access, consumption and electricity generation mix. Indicators relating to access are based on the SDG 7 (Affordable and Clean Energy) tracking efforts. The inclusion of the rural access rate is important as it is expected that most grassroots innovation will stem from such environments. In terms of consumption, the demands for electricity and other energy sources serve as critical expositions of country specific habits. The energy generation mix allows for a better understanding of the available resources within each state.

An assessment of national energy policies was also completed to better understand the environment in which innovators must operate. To that end, a focus was placed on rural and clean cooking policies, and an initial list of potential resources that grassroots innovators could take advantage of was compiled.

(Sources: World Bank, Our World in Data, IRENA, BP Statistical Review of World Energy & Ember, IEA, RISE. Population estimates based on UN data.)

	Access					**Consumption**				**Electricity Generation Mix (% of total generation)**						
	Access (% of population)	Population without access (millions of people)	Rural access rate (% of population)	Access to clean cooking (% of population)	GDP per capita (2020)	Energy consumption per capita (in kWh)	Electricity consumption per capita	Residential sector share of electricity consumption	Renewable energy share of total final energy consumption (2018)	Hydro and marine	Solar	Wind	Bioenergy	Geothermal	Total Renewable	Non-renewable
Angola	46%	17.3	7% (2018)	50%	$1,896	3,606	392	66%	57%	71%	0%	0%	1%	0%	72%	28%
Bangladesh	92%	12.7	89%	23%	$1,969	2,995	489	42%	31%	1%	0%	0%	0%	0%	1%	99%
Burkina Faso	18%	16.6	5% (2014)	10%	$831	763	61		67%	13%	13%	0%	0%	0%	26%	74%
Chad	8%	14.6	4% (2018)	4%	$614	98 (2016)	14		85%	0%	0%	3%	0%	0%	3%	97%

DRC	19%	70.2	1%	4%	$557	489 (2016)	127	32%	96%	99%	0%	0%	0%	0%	99%	1%
Ethiopia	48%	58	36%	7%	$936	777 (2016)	130	57%	90%	94%	0%	6%	0%	0%	100%	0%
India	98%	29.9	97%	64%	$1,901	6,924	1,009	24%	32%	9%	3%	4%	1%	0%	17%	83%
Kenya	70%	15.9	62%	17%	$1,838	1,906 (2016)	217	33%	72%	31%	1%	0%	1%	46%	80%	20%
Madagascar	27%	19.1		1%	$496	693 (2016)	87		82%	48%	1%	0%	1%	0%	49%	51%
Malawi	11%	16.5	4%	2%	$625	475 (2016)	77		73%	72%	2%	0%	3%	0%	77%	23%
Mozambique	30%	21.4	5%	5%	$449	3,498 (2016)	505	14%	66%	95%	0%	0%	0%	0%	95%	5%
Myanmar	68%	17.1	58%	30%	$1,400		367	42%	60%	50%	0%	0%	1%	0%	52%	48%
Niger	19%	19.9	13%	2%	$565	473 (2016)	25	55%	78%	0%	6%	0%	0%	0%	6%	94%
Nigeria	55%	89.7	34%	13%	$2,097	2,726 (2016)	177	56%	80%	25%	0%	0%	0%	0%	25%	75%
Pakistan	74%	56.5	59%	49%	$1,194	4,567	671	49%	42%	25%	2%	3%	1%	0%	31%	69%
South Sudan	7%	10.3	5%	0%	-	457 (2016)	50	40%	33%	0%	0%	0%	0%	0%	0%	100%
Sudan	54%	19.8	39%	53%	$595	2,234 (2016)	395	60%	61%	61%	0%	0%	0%	0%	0%	39%
Tanzania	38%	36.1	19%	4%	$1,076	1,299 (2016)	121	27%	84%	29%	1%	0%	4%	0%	34%	66%
Uganda	41%	26	32%	0%	$817	716 (2016)	110		90%	89%	3%	0%	6%	0%	98%	2%

Appendix 2: Recommended Questions to Support Learning on Specific Grassroots Innovations

Characteristics of the Innovation

To develop knowledge of a specific innovation in energy, the following information should be sought, and can form a basis for survey construction:

1. What is the overarching goal of innovation? What problem is innovation trying to solve? What are the evaluation targets that the innovator is attempting to reach? How close (or far) are they from the goal?
2. How should the innovation's purpose be categorized: lighting/heating, clean cooking, power for electronics/appliances, clean water access, health/medical, industry, services, education and awareness raising, or other purpose?
3. What is the function of energy innovation: generate/use, conserve, augment, store, distribute, convert waste to energy, or other functions?
4. What is the source of energy used to power the solution: solar, fossil fuels, wind, hydro, mechanical, biomass, other thermal, other chemical, or other energy source?
5. What type of connection to grid does the innovation utilize: on-grid: connected to a large-scale centralized energy system; mini-grid: connected to a small-scale decentralized energy system; or stand-alone energy system.
6. What is the operational status of the solution: ideation, initial design, prototype development and piloting, validation of design, small-scale deployment, or full-scale deployment? How long has the solution been operational?
7. Is the innovation culturally specific or can it be generalized widely through different social groupings?

Financial and Human Resources and Partnerships Needed to Support the Innovation

Documenting the characteristics of the developed solution is necessary to determine the requirements of the solution and its deployment. The questions below could support information gathering to determine the resources needed to ensure the success of the innovation:

1. How much does it cost to manufacture, deploy, use and maintain the solution?

2. Where does funding for the solution come from? Is there a specific financing mechanism associated with the innovation? Does the innovation have its own stream of revenue?
3. How is the solution able to viably deliver outcomes? Are there any innovations in the operating or financing of the business model?
4. What skills are needed to build and implement the solution? Is it a do-it-yourself solution or does it require technical expertise? This would affect the individual transferability, deployment and frugality of the innovation.
5. Is there an uptake cost, i.e., a cost for community members to purchase or subscribe to the innovation such as a subscription tariff, installation cost, land requirement, or other cost?
6. What is the role of partnerships in deploying the solution? Does the solution benefit from (or require) partnerships with the government or other local or private actors? What are the forms of collaboration that could support success, for example, subsidies, land concessions, grants, technical assistance, etc.

Characteristics of the Location of Deployment

Questions that should be asked to understand how the specific grassroots innovation fits into the context of the location of deployment are included below:

1. What is the site of deployment of the particular solution? The site of deployment is usually the context where the innovation emerges and must be in alignment with local needs, resources and socio-environmental contexts to prevent any form of market resistance.
2. What type of community is the site of deployment: rural, sub-urban, urban, or other?
3. What is the population density of the site of deployment? Geographical dispersion influences the diffusion of grassroots innovation as they usually spread through word of mouth and social interactions. With high population density, the likelihood of social interactions is greater which can lead to higher diffusion and adoption of solutions.
4. What is the average income level of the target population? Users of grassroots innovations often live in environments with limited cash availability. Hence the innovation must be in line with their purchasing power, which makes affordability

one of its main appeals. Low-cost solutions in low-income settings could influence acceptance positively.

5. What is the scale of reach of the solution: community, household or individual? The scale of the reach depends on the magnitude of the problem or need being met. Some of the solutions are a result of personal needs and will solve individual problems, while others serve to address wider community specific problems.
6. What is the deployment rate or reach of the solution, i.e., how many people are benefiting from the innovation? Uptake is a function of how the innovation aligns with social frames such as customs, stereotypes and behaviors. Innovators can experience difficulty in product acceptance by going against social norms.
7. What is the level of community participation in the solution? The level of community participation is influenced by how well the innovation is understood, the ease of use and access to the solution. Consequently, community literacy can either hinder or facilitate the diffusion and scale up through community use and input.
8. What existing networks, formal and informal, exist that can support the innovation? Networks refer to the existence of support structures that the innovator can rely on. These are often provided informally such as the innovators' social connections within their community or through more formal relationships with non-governmental agencies and community groups.
9. Does the country's specific legal and regulatory framework facilitate or hinder the deployment of the innovation? Are there additional legal considerations to be taken into account at scale? - This depends on the extent to which grassroots innovations are recognized. Some countries have agencies that map out and support grassroots innovations while other grassroots innovations are largely unrecognized. Standardization of grassroots innovation is required in countries where they are recognized and in critical sectors like energy. Their regulation and standardization can also garner affiliations and facilitate uptake.