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A Comprehensive Approach to the Governance of Universal Access to Sustainable Energy

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Abstract: Achieving universal access to energy by 2030 (Sustainable Development Goal 7.1) hinges on significantly scaling up and accelerating electrification efforts in developing countries. Governing the ecosystem of government agencies, energy utilities, practitioners, development and finance institutions, banks, NGOs, academia, and, most importantly, beneficiary communities to accelerate the pace of electrification requires the interweaving of technological innovation, disruptive business models, improved institutional frameworks, and inclusive multi-stakeholder decision-making, to ensure that no one is left behind. The foundation of this article is based on extensive insider research, including 14 national electrification plans, numerous visits, field studies, and semi-structured interviews with these actors conducted over ten years in 25 countries. This article presents a novel comprehensive conceptual approach that integrates both macro (national and global) and micro (local and individual) level mechanisms and the role of cultural factors and shared values within the ecosystem in driving and accelerating action within a harmonized regulatory, policy, and planning framework. It outlines the essential mechanisms for effectively engaging and empowering governments, utilities, donors, and local actors to accelerate the path to universal electrification through the most cost-effective articulation of diverse technologies and business models.

Keywords: universal access; energy poverty; energy transition; governance; multi-stakeholder; decision-making; human factor; least-cost planning; regulation; energy policy; shared values; SDG7; SDG17

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Citation: González-García, A.; Díaz-Pastor, S.J.; Moreno-Romero, A. A Comprehensive Approach to the Governance of Universal Access to Sustainable Energy. *Sustainability* **2023**, *15*, 15813. https://doi.org/10.3390/su152215813

Academic Editor: Antonio Caggiano

Received: 24 August 2023
Revised: 12 October 2023
Accepted: 18 October 2023
Published: 10 November 2023

1. Introduction

Universal access to electricity, modern heat, and cooking by 2030 [1–3], meeting essential service levels to fight energy poverty, particularly in developing countries, and to enable the achievement of the Sustainable Development Goals [4] by 2030 could be potentially within reach for several countries [5]. However, it will not be feasible for many, even by 2030 or later, unless urgent and appropriate action is taken commensurate to meet the challenge, especially for the less developed countries in Africa [6].

The search for solutions to the lack of access to electricity, with some 774 million people still relying on kerosene lamps, candles, or disposable battery lanterns for lighting (and 75 million more who have lost their ability to pay for electricity after the recent COVID pandemic) and 2.4 billion still relying on wood and three-stone fires for domestic cooking and heating [7], along with those who have unreliable and inadequate quality of service [8], demands an in-depth analysis of what drives decision-making and the different frameworks and approaches to how different governments, institutions, private companies, donors, banks, NGOs, and, most importantly, beneficiaries face this challenge.

While in the Americas, the challenge is focused on electrifying "the last mile" [9] of isolated rural areas, in vast regions of sub-Saharan Africa [10] and Asia [7], the challenge is how to supply energy to a significant portion of the population. At the same time, an additional challenge is how to ensure the affordability and the economic and environmental sustainability of a power industry burdened with high outage rates, tariffs that are typically not cost-reflective, and a high dependency on public subsidies or international funding and grants to extend the national grid or electrify with mini-grids or even solar-kits.

An effort of this magnitude [11,12] requires the careful consideration of several interrelated factors (institutional, financial, technological, social, environmental, etc.) from multiple perspectives (individual, local, regional, national, and international) [13–16]. The necessary participation of private capital and the financial, human, and technological resources, which could potentially be scaled up for the involvement of large companies, would still require highly efficient innovative "glocal" approaches (integrating the global and local understanding of the problem, in terms of critical issues such as management, financial needs, social and economic change, gender, corporate diversity, cultures, etc.). These will also entail the digitalization of the operation and maintenance of grid and off-grid systems (e.g., remote payments, fault detection, demand management), which will drastically reduce the management and service costs of supply when, more than ever, it will be necessary to meet the needs and payment capacity of the energy-poor. At the same time, innovative bottom-up approaches can play an essential role in fostering the dynamism of the beneficiary communities and help bridge the gap between working effectively at the base of the pyramid and the need to replicate and scale up electrification efforts involving large-scale actors, programs, and policies.

In line with Porter and Kramer's shared value paradigm [17] for solving large-scale social problems, the authors agree that success will only be possible if a set of common drivers can help establish sustainable, attractive, and scalable business models, with the active involvement of the beneficiaries and the participation of a necessary large ecosystem of actors, including large private companies, social organizations, educational, research and capacity-building institutions, and financial and international institutions.

Approaches to universal access to electricity, in theory or practice, usually tend to be limited. They derive from not considering utterly unacceptable the present inequity in access to modern energy services, with the corresponding legal, budgetary, and policy implications, among other considerations. Therefore, they lack ambition in the electrification objectives and in the evaluation of the consequences from a more realistic approach, as well as the short-termism of governments, donors, and regulatory authorities in establishing the conditions for sustainable business models of a dimension commensurable to the magnitude of the challenge:

1. The equity gap: The present inequity in access to modern energy services, electricity, and heat must be considered utterly unacceptable [7] and will require decisive leadership from governments, support from Development Finance Institutions (DFIs), and the engagement of utilities, practitioners, and all the electrification stakeholders around a common set of shared values to bridge the equity gap [17].
2. The ambition gap: Acknowledging the first gap immediately leads to the need to mobilize efforts of a dimension commensurable to the magnitude of the challenge. Achieving universal access to the first acceptable level of modern electricity will require that 110 million people gain access every year from 2022 to 2030 [7], and over 30 countries in Africa to connect would require 30 billion USD per year (60% of which should be capitalized in Africa and 38% in Asia). This adds up to no more than a 2% increase in the estimated investment of the New Policies Scenario 2030 and could be funded with 1.25% of the annual electricity bill of the OECD countries. Nevertheless, this first step, out of the complete energy exclusion, cannot be seriously approached without daring to lock in more ambitious electrification targets and accept their implications. "The world's poor need more than a token supply of electricity. The goal should be to provide the power necessary to boost productivity and raise living standards." [12].

3. The business opportunity gap: Every year, people without access to electricity spend 47 billion USD on low-quality alternative solutions (candles, disposable batteries, phone charging, and kerosene for lighting) to satisfy their basic needs for lighting and communication [18–22]. Out of 274 million non-electrified households (roughly 1.3 billion people) in 2010, a fully private potential market can be estimated at no less than 20 billion USD annually [18]. New approaches are needed to address these challenges, such as the integrated framework proposed by the Global Commission to End Energy Poverty [5].
4. The sustainable development challenge: Energy is a prerequisite for economic development [11,23]. On the other side, the prosperity enabled by economic growth fosters the demand for better and higher energy services [24]. This virtuous circle can be observed in different countries, but development is a complex phenomenon characterized in many cases by its non-linearity. Achieving a minimum level of lighting and modern cooking drastically improves the health quality of the household environment [23], but to unchain this virtuous circle, a much higher level of energy services will be required, to raise added-value services in agriculture, commerce, industry, or public services. Though an increase (or reduction) in energy access cannot always be interpreted as progress (or decrease) in terms of development [11], as energy by itself is not sufficient to eradicate extreme poverty, no country has been able to improve its situation in recent times without achieving a substantial increase in the use of modern energy forms [23]. Access to energy improves productivity, the generation of local revenues, and access to education.
5. The opportunity for a favorable international climate: Universal access has received an extraordinary impulse in the political and scientific international and national agendas in the past few years. The Sustainable Energy for All (SE4all) [2] initiative has been assumed in its integrity by the Sustainable Development Goal number 7 [4], establishing a universal access global target for 2030. The International Energy Agency has also developed a Global Tracking Framework to measure and monitor the progress of SE4all/ODS7 targets [25], promoting the harmonization of surveys, energy data, and statistics around the globe. In addition to these global efforts, many large-scale regional initiatives have been launched, mainly in Africa and Asia, but also in Latin America [26]. However, despite this effervescence of government and public-private initiative, the volume of resources effectively agreed upon is still far below the amount required, even for the most basic level of universal access.

The article presents a vision of how understanding the decision-making contexts and drivers at different levels in this entangled ecosystem could benefit from the proposed conceptual approach, which frames the complexity and scale of the challenge of achieving sustainable universal access to energy. This framework is based on the authors' findings and the experience of the members of the Universal Access Laboratory, a joint research initiative of the Massachusetts Institute of Technology (MIT) and the Institute for Research in Technology of the Pontifical University of Comillas (IIT-Comillas), in integrated multimodal planning for access to electricity, modern heat and cooking, sustainable business models for universal access, and appropriate financial, regulatory, and energy policy frameworks. The authors have gained this experience through their projects in Colombia, Ecuador, Perú, El Salvador, Panama, Rwanda, Uganda, Nigeria, India, Pakistan, and Indonesia (among many others), working not only with governments or multilateral organizations but also directly with utilities and off-grid companies, non-profit organizations, universities, or international cooperation agencies, but above all by working in the field in these countries and understanding the needs of the beneficiaries.

2. Methodology

The large-scale implementation of the infrastructure required for universal access, not only for residential electricity, cooking, and heating, but also for economic development, productive activities [27,28], and social services for all [29], demands innovative business models. This infrastructure must be sustainable. It will involve not only long-term operation and maintenance [18,30], but also the replacement and upgrading of existing assets to provide low-cost, efficient, adequate, and modern quality of service for both grid expansion [31–33] and off-grid electrification with mini-grids, solar kits, and other stand-alone systems [34–36]. It must also enable productive and community services and be compatible with reaching upper levels of clean electric or gas heating and cooking [37,38], allowing the transition from one technology of supply to the next [39] as demand grows or changes, requiring an ambitious "think big" approach that is comprehensive and integrated from multiple perspectives [26,40,41].

The main objective of this article is to analyze how a conceptual approach based on understanding the decision-making contexts and drivers at different levels in the energy-access ecosystem can contribute to achieving sustainable universal access to energy faster and at a large scale. We aim to identify the key challenges and opportunities associated with large-scale infrastructure implementation for universal energy access and how innovative business models can address these challenges while ensuring sustainability and adaptability to evolving energy needs.

The results of this article stem from a longitudinal methodology spanning more than a decade, examining cases and projects developed in 25 different countries, each developed with a specific methodology tailored to each case, but based on the substantial experience of the Universal Energy Access Laboratory of MIT and IIT-Comillas in research on energy systems, modeling, regulation, markets, and business models. The foundation of this article is based on extensive insider research, including numerous visits and field studies conducted over the years. These field studies have focused primarily on India, Indonesia, Rwanda, Uganda, Peru, and Colombia. We conducted more than 120 in-depth, semi-structured interviews during this extensive research period. Our interviewees represented a wide range of stakeholders, including government agencies (such as ministries and electrification agencies), regulators, development finance institutions, practitioners, nongovernmental organizations (NGOs), and local communities.

The overarching conceptual framework proposed here is the result of the confluence of this longitudinal analysis and a comprehensive review of relevant theoretical trends in the mainstream academic and practitioner literature. This approach not only provides a more holistic understanding of the energy access process at the local, utility, government, and international levels but also brings to the fore the complex interplay of organizational and human elements alongside technological, financial, regulatory, and institutional aspects. By bringing these dimensions together, our research adds value by shedding light on the multifaceted dynamics inherent in the acceleration and upscaling required to achieve universal access to modern energy.

3. Multi-Stakeholder Governance Framework and Decision-Making Circular Roadmap for Universal Access to Modern Energy Services

This approach is illustrated in a circular roadmap, shown in Figure 1, with four quadrants.

Figure 1 shows the key elements of this comprehensive approach to sustainable universal access to energy services in four quadrants. Two vertical and horizontal axes divide these quadrants. The vertical axis separates elements at the (micro) local, customer-facing level from those that have an impact at the (macro) national and international levels. The horizontal axis considers, on the upper side, the main drivers for decisions on universal access (needs, technological breakthroughs, innovation, economics, and development) and, on the lower side, the characteristics of the enabling environment for achieving the goal of universal access [42].

In the first quadrant (Q1, reading clockwise, upper right quarter), the focus zooms in on each end user (energy needs, uses, and priorities) [14] and the innovation that has created the opportunities, drivers, and choices (generation technologies, clean and modern cookstoves, digitized management and business models, local capacity building) needed for an efficient, affordable and sustainable energy supply. In the second quadrant (Q2), we focus on the circumstances and characteristics of local customers, in particular, the considerations and choices required to address the development needs of the "last mile": isolated rural communities [43] and the population at the bottom of the pyramid, not only deprived of energy but bound by multiple dimensions of social and economic exclusion. In the third quadrant (Q3), we outline the Integrated Distribution Framework (IDF), as defined by national and regional government electrification and energy planning, financing, regulation, and policy [5,6,16,44,45]. Finally, in the governance quadrant (Q4), we need to explore the forces and levers that can mobilize all the actors that need to play a role in scaling up and accelerating the rate of electrification and access to modern heat and cooking to achieve the goal of universal supply by 2030. These forces can be analyzed from the perspectives of governments [46], international organizations, donors and cooperation agencies [47–49], private banks and capital investors, developers, social organizations, and other enablers, taking into account the governance of this complex ecosystem of actors in the fight against energy poverty and, specifically, for universal access [50–53].

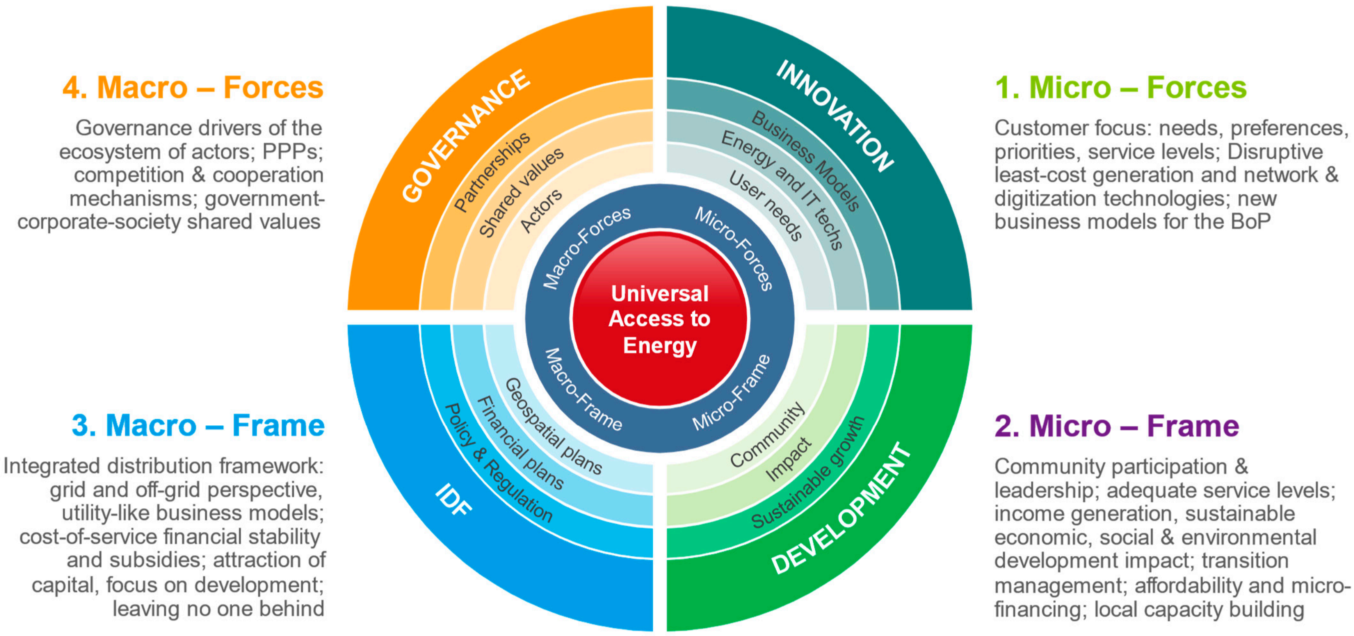

Figure 1. Multi-stakeholder circular roadmap for universal access decision-making. This circular layered diagram is adapted from a free SLIDEMODEL PowerPoint template available at slidemodel.com [54].

4. Key Decision Points in the Four Quadrants of the Universal Access Roadmap

4.1. Q1 Micro-Forces: Involving Beneficiaries and Local Actors in the Decision-Making Process

This first quadrant (Micro-Forces) focuses in detail on the key elements that drive the electrification process at the local level, considering the individual customers and user types in a community, and the technologies and business models available for that micro context.

We begin in this quadrant precisely because we understand that conceptually, the value creation process must be focused on satisfying user needs [14,28,29,55], and according to this user-centric focus, we will analyze how all of the key elements of the electrification strategy align.

The Sustainable Energy for All (SE4all) framework [25], also adopted in the integrated Sustainable Development Goals (SDG) [4,56] target 7.1 for universal access to affordable, reliable, sustainable, and modern energy, establishes the main reference framework for universal access to meet these end-user energy needs by 2030. The five tiers defined by this framework are scaled according to the different access needs of residential customers. They are immediately decoded into five tiers of quantity and quality of electricity supply, plus another five for access to modern heat and cooking. This framework can also be extended to productive [28] and community activities [29].

The existence of a potential market that is currently unsatisfied (or under-satisfied) for the population without access to electricity (or with a weak and unreliable power supply) is the first driving force of the universal electrification process. This market is estimated at over 37 billion USD a year [18] worldwide, which is the lower limit set by the annual consumption of these families in candles, disposable batteries, lanterns, or kerosene for lamps, with much lower quality and usability than other affordable modern electric alternatives (e.g., low-cost grid extension, mini-grid supply, solar lanterns or kits). This amount is similar in scale to the 36 billion USD of investment needed to achieve universal access to energy by 2030 in the WEO NZE Scenario [7].

The accelerated pace of technological innovation, especially in the last two decades, has provided the following drivers for achieving universal access to electricity worldwide in the medium term. First, the establishment of low-cost grid extension standards allowed countries like Brazil to jump from an 82% electrification rate in 2003 to 98% in 2014 through the "Luz para todos" ("Light for all") program [33,57]. Second, innovations in battery and photovoltaic technologies, among others, have dramatically reduced the cost of investment in distributed generation (especially for solar battery mini-grids and off-grid systems) and have led to an explosion in the market for solar kits (cheap, light and portable, and highly efficient) that can provide basic energy services such as lighting and phone charging (along with other services such as powering small radios, televisions, and other high-efficiency devices such as small fans) at a fraction of the cost of grid connection.

When looking at supply technologies, it is also important to consider the "micro" issues related to the local environment, needs, and preferences. We visited low-income rural communities in Uttar Pradesh, India, where the grid was unreliable and suffered from long and frequent power outages, mostly in the evening and at night during peak hours, where companies can prioritize service to urban areas (with lower service costs and higher revenues) and selectively reduce the power of feeders serving certain rural areas (whether because of a history of insufficient generation capacity or because of the financial losses associated with serving those areas at that time of day, given the difference between the non-cost-reflective tariffs paid by those customers and the cost of energy at peak electricity market hours). Illegal connections, which are very common in these poor communities in rural and peri-urban areas, pose a danger to the population and are unreliable. They also burden the distribution companies and jeopardize their financial sustainability, so they often resort to selective blackouts to punish these customers (along with the legal ones who also receive electricity from the same line). Under these conditions, some grid-connected customers must rely on more expensive backup systems (diesel generators, batteries) for these frequent blackouts. At the same time, some other households will turn on their solar kits and lanterns or even receive a basic but affordable backup supply from a small DC microgrid that, redundantly, provides only a few hours of electricity per day but is fine-tuned to the evening hours when these customers need the light and phone-charging services. Other members of the same community will continue to rely on traditional kerosene lamps (even though they are aware of the lower quality of their light and the potential health effects of the smoke and soot) because, as one of these users said, "*it is the only light you can trust*".

This example illustrates that local characteristics and priorities, affordability and willingness to pay, and service quantity and quality expectations are key to choosing a supply technology. Therefore, the traditional least-cost principle [52,58,59] must also integrate not only the economic dimension but also the social and environmental perspectives for each supply choice, incorporating multi-criteria methodologies that can support the evaluation of these local preferences [60] as will be explained later in this paper.

Current cooking practices have significant barriers to the transition to modern cooking technologies [6]. These barriers include economic disparities, underdeveloped and ineffective policies, inadequate promotion of modern stoves and alternative fuels, lack of a comprehensive multi-technology approach at the household level, lack of robust national planning [38], and challenges for women to influence public discourse. In particular, economic hardship is the primary barrier to access to modern cooking, as those with greater purchasing power tend to choose modern technologies. At the same time, those with fewer resources rely on readily available, but often more polluting, fuels such as wood and charcoal. Despite its critical health, environmental, and energy implications, the clean cooking sector remains marginalized and overlooked due to its orphan status in several areas. Technologically, efforts have predominantly focused on improving the affordability and cleanliness of traditional fuels or subsidizing cleaner options such as Liquefied Petroleum Gas (LPG), which raises fiscal and trade concerns. A lack of strategic coordination, a tendency to promote a single, one-size-fits-all solution, and the historically limited influence of women further complicate progress in this area.

For access to electricity and modern heat and cooking, at this micro level, another important driver is the development of innovative business models, many of which are decentralized, rooted in these beneficiary communities, and tailor their services to their specific needs [9,61].

This innovation in business models, especially at the bottom of the pyramid, whether centralized or decentralized, public or private, is facilitated by the development, universalization, and cost reduction of information, communication, and intelligent technologies. These enable the adoption of digital business models for the low-cost engagement and management of a large customer base, supporting the collection and management of tariffs using only the customer's mobile phone or the remote disconnection of individual service for unpaid bills [62,63].

Combining these three key elements of power supply has a broad impact on local communities, as electricity changes the socio-economic dynamics and allows new local trades, businesses, and jobs to emerge (Box 1).

Box 1. New business models at the base of the pyramid: the case of Acciona Microenergía in Perú (The business model of Acciona MicroEnergía – Acciona Energy and Water Foundation is presented in this paper from different perspectives, as it exemplifies some of the elements of the governance approach proposed in the paper, from innovation in business models and supply technologies (Q1), to engagement, capacity building, or gender approach in communities (Q2), participation in the articulation of national regulations (Q3), or as a player in Public-Private Partnerships (PPPs) (Q4), also showing how a particular actor can play different roles in the different quadrants.) and its role in covering customers' last mile in America (Quadrant 1). The case studies are included to illustrate specific aspects of each quadrant as examples of good practice, with no intention to cover all issues exhaustively [64].

Acciona Microenergía Perú [64] is a social enterprise focused on providing renewable energy solutions to rural communities in Peru.
The organization is part of the Acciona Energy and Water Foundation, a nonprofit entity created by the Acciona Group, a Spanish multinational company.
AccionaME's mission is to improve the lives of people living in remote areas without access to electricity. They do this by implementing sustainable energy projects based on solar photovoltaic systems. These systems provide clean and affordable electricity, enabling communities to meet their basic energy needs and improve their quality of life.
The organization also focuses on community development, capacity building, and entrepreneurship. They work closely with local communities to promote social and economic development, encourage the creation of micro-enterprises, and provide training and support.
Acciona Microenergía Peru has implemented projects in different regions of Peru, including the regions of Cajamarca and Loreto. Through their initiatives, they have positively impacted many people's lives by providing access to electricity, promoting sustainable development, and empowering local communities.

Box 1. Cont.

The organization was established to be self-sustaining in the long term by implementing business models that generate income and cover operating costs. By providing affordable services and promoting appropriate financial frameworks to cover the viability gap between what the population can pay and the actual cost of the electricity service, they ensure sustainable growth of their activities and stable supply to their beneficiary communities.

One example is their contribution to establishing a sustainable financing framework in Peru, which includes FISE and FOSE, two subsidy programs in Peru that have been instrumental in supporting the deployment of solar home systems (SHSs) and improving access to electricity in rural and underserved areas. Here is an overview of these programs:

- FISE (Fondo de Inclusión Social Energético—Energy Social Inclusion Fund): FISE is a government subsidy program in Peru that aims to provide access to electricity for low-income households. It focuses on financing electricity solutions in remote and marginalized areas. FISE subsidizes the installation costs of solar home systems, enabling off-grid households to obtain electricity from renewable sources. Under FISE, eligible households receive a subsidy to cover a portion of the costs associated with installing solar home systems. The subsidy helps reduce the financial burden on families and encourages the adoption of clean and sustainable energy solutions.
- FOSE (Fondo de Electrificación Rural Sostenible—Sustainable Rural Electrification Fund): FOSE is another grant program in Peru that promotes rural electrification. It supports deploying renewable energy systems, including solar home systems, in remote communities that are not connected to the national grid. FOSE provides financial resources to cover the cost of installing solar home systems and other off-grid renewable energy solutions. The program also supports the training of local technicians, maintenance activities, and community engagement to ensure the sustainable operation of the energy systems.

Both FISE and FOSE grants have been instrumental in expanding access to electricity in rural and underserved areas of Peru. By reducing the financial barriers associated with providing solar home systems (both DC and AC), these programs have facilitated the deployment of clean energy technologies and improved the quality of life for households that previously relied on traditional, often polluting, and expensive energy sources.

4.2. Q2 Micro-Frame: Energy as a Vector for Local Sustainable Development

The second quadrant also focuses on the local level, but considers the structural elements that will frame the electrification process.

In this sense, the first issue to be considered is the impact of the electrification process on the beneficiary communities (desirable, but with the requirement to assess and prevent negative effects). This technological, economic, social, and environmental change must be managed with the community's involvement from an early stage and perhaps with its leadership on issues such as the definition of quality and service level targets, affordability and willingness to pay, business model, or even technological choices [63,65].

It is important to note that connecting every household does not guarantee universal and sustainable access to electricity. We must ensure that customers are able (and willing) to pay for the service. They must also be able to afford to purchase and use the equipment they need to meet their needs (from light bulbs, phones, or radios in their homes to sewing machines, refrigerators in grocery stores, or laptops for students, to water pumps, agricultural equipment, and many others).

In this sense, it is imperative to assess whether the cost of electricity supply, including any applicable grants or subsidies, needs to be affordable either at the individual level (for each customer) or at the collective level (taking into account implicit cross-subsidies between wealthier and less wealthy clients across the customer base). In this respect, open market approaches (such as those commonly applied to retail sales of solar kits or unregulated mini-grids) will address this issue at the micro level. In contrast, the regulated retail sector's socialization of distribution costs is an implicit mechanism.

Finally, we must emphasize the need and opportunity to bootstrap the electrification process in the existence of resources at the local level. This applies not only to energy sources (e.g., hourly solar radiation throughout the year, wind and hydro profiles, biomass, etc.) or to existing infrastructure (close distribution network, existing productive loads such as telecom towers, agricultural industries or irrigation pumps, and other larger consumers, perhaps even already electrified with stand-alone systems that could anchor the supply for a small area), but also to the impact of the electrification process on local social, economic, and environmental development [66–69].

From a multidimensional integral development perspective, the electrification process could and should promote the development, sustainability, economic growth, and income generation of the beneficiary communities, thereby bootstrapping the viability of the supply business model itself in a virtuous development cycle at the local level, with the future sustainability of the electricity service based on the benefits induced by the electrification process in these beneficiaries. Electrification alone will not create this virtuous cycle of community development; it will require local capacity building, awareness raising, education, incentive mechanisms, and accompanying public and private policies to stimulate sustainable human, social, and economic development. These efforts should focus on the most relevant productive and social uses of electricity, such as improvements in agriculture and access to food, adequate health and education services, economic growth, gender equality, security, communications, and healthy environment, among others [69–71], establishing a dialogue between the electrification process and local achievement of the Sustainable Development Goals [72] (Box 2).

Box 2. Women-led customer service centers in Acciona Microenergía México [73]. The role of the electrification process in promoting sustainable development gender goals (Quadrant 2).

Acciona Microenergía has established customer centers called "Centros Luz en Casa" in Oaxaca, Mexico. They agreed with the municipalities and state government that they would be owned by local entrepreneurs and led by women.

The initiative aims to empower women by providing them with leadership roles and opportunities in the operation and management of these customer centers. The centers serve as hubs where community members can access clean and affordable energy solutions, specifically solar home systems, providing basic DC electricity to more than 30,000 impoverished people.

> "A basis for ensuring this service with 3G SHS is to offer users, in strategic locations, technical services of advice, information and repair of systems, as well as the purchase of lamps and other compatible devices . . . ACCIONA Microenergia Mexico has identified and trained local entrepreneurs who, since the beginning of 2017, have been providing service from their small family businesses. These are located in reference locations in six regions of Oaxaca, where the users of "Luz en Casa Oaxaca" usually go to receive services, as well as to buy and sell products in the markets: San Sebastian Tecomaxtlahuaca (Mixteca), Santa Maria Colotepec (Costa), Juchitan de Zaragoza (Istmo), San Pedro y San Pablo Ayutla (Sierra Norte), Villa Sola de Vega (Sierra Sur) and San Juan Bautista Tuxtepec (Papaloapan)" [73].

By involving women in leadership positions, Acciona Microenergía is promoting gender equality and providing economic and professional opportunities for women in the renewable energy sector. This approach recognizes women's important role in community development and emphasizes their participation and contribution to sustainable energy initiatives.

4.3. Q3 Macro-Frame: Large-Scale Planning, Institutional, Political, Regulatory, Economic, and Financial Key Factors

In this third quadrant, we address key national and global (macro) issues to achieve the universal electrification goal, starting with those related to the comprehensive framework and electrification scenario.

The first two fundamental elements of this scenario are the need for a geospatial techno-economic electrification plan that integrates all modes of supply (including grid extension and off-grid technologies, either with mini-grids or solar kits or other larger stand-alone systems) and a sound financial plan. These two elements are necessary to rapidly identify, assess, scale up, and mobilize all of the necessary resources (technical and economic) to have a measurable impact on the lives of millions of people [16]. An adequate geospatial electrification plan that minimizes the total cost of service in line with the electricity access targets set by the government will help policymakers, donors, electrification agencies, companies, entrepreneurs, and other stakeholders to determine and plan the better use of their (usually scarce) resources. The financial plan will enable the attraction of private capital and the bankability of electrification projects, thus providing a comprehensive and stable framework for investments and sustainable business models associated with each electrification service mode.

Regarding geospatial electrification planning, determining the best electrification mode for each customer (i.e., grid extension, mini-grid, or solar kit/stand-alone system) requires a techno-economic analysis of each of these alternatives to determine which has the lowest socio-economic cost. One such model is the Reference Electrification Model (REM) [74], developed by the Universal Energy Access Lab MIT & IIT-Comillas for universal electricity access planning, which, for a given analysis scenario intended by the decision maker, calculates for each customer in the planning area what is the best electrification mode from a techno-economic point of view, considering (a) grid extension, (b) mini-grid, or (c) solar kit/stand-alone system, taking into account the following information:

- Grid extension: characteristics and design of the existing grid, reliability and cost of energy supplied by the grid at the distribution level, technical and cost characterization of the distribution grid, catalog of components (Medium Voltage, MV, and Low Voltage, LV, lines and MV/LV transformers), technical grid codes, cost of unsupplied energy, other social costs, (smart) connection of end-users, financial and administrative costs.
- Off-grid systems: Technical and cost characterization of mini-grid grid (LV lines for micro-grids, and MV lines and transformers for large mini-grids that may require an MV grid) and distributed generation component catalogs (for solar, battery, diesel, and hybrid mini-grids and off-grid systems), characterization of solar kits to be distributed to small isolated customers, hourly dispatch for a year of generation and customer demand, local energy resources, mini-grid technical codes, cost of unsupplied energy, other social costs, (smart) end-user connection, financial and administrative costs.

Figure 2 illustrates this comprehensive on-grid/off-grid planning approach by showing the results of the Rwandan National Electrification Plan 2024 using the Reference Network Model. The existing central network is shown in black, grid extension MV/LV transformers are blue, MV lines are red, LV lines are light blue, mini-grid generation and LV lines are green, and stand-alone systems are orange dots.

This comprehensive planning approach will also allow the prioritization of investment projects (for each grid extension trench, off-grid mini-grid, or bidding lot) according to different phases of implementation, taking into account the availability of investment and operational funds and the priority areas or energy uses in line with energy and sustainable development policies. It will allow the optimization of the electrification project pipeline, considering the most efficient projects (those with a lower cost per customer) and weighting other factors such as education and health or productive uses.

In terms of regulation, a critical first issue for rural electrification worldwide, whether in developing or developed countries, is the evidence that rural electrification, especially in isolated and dispersed areas, is significantly more expensive than electrifying high-density, well-communicated urban areas. This iron law of rural electrification applies likewise to grid extension, mini-grid electrification, and the implementation of off-grid systems. Grid extension customers are usually unaware of this significant difference in service costs because the tariffs do not reflect this cost differential. When deciding whether a particular group of customers (a village or an optimized cluster of customers) should be better served off-grid or connected to the central grid, it is important to determine the precise impact of this law and compare the actual cost of service of the grid extension system that would serve that particular group (and not the average cost of grid connection or the average cost per km of distribution grid) with the best combination of off-grid options (mini-grids and kits), including the social costs of unreliable and low-quality access. Regarding tariffs or retribution of centralized distribution utilities, most regulatory designs worldwide consider the specifics of this iron law for grid extension (creating de facto implicit cross-subsidies between low-cost urban and high-cost rural customers). To achieve universal access, it is also important to consider this iron law when governments and electrification agencies allocate funding, resources, and subsidies to off-grid systems, with appropriate cost-of-service calculations for mini-grids and off-grid least-cost alternatives.

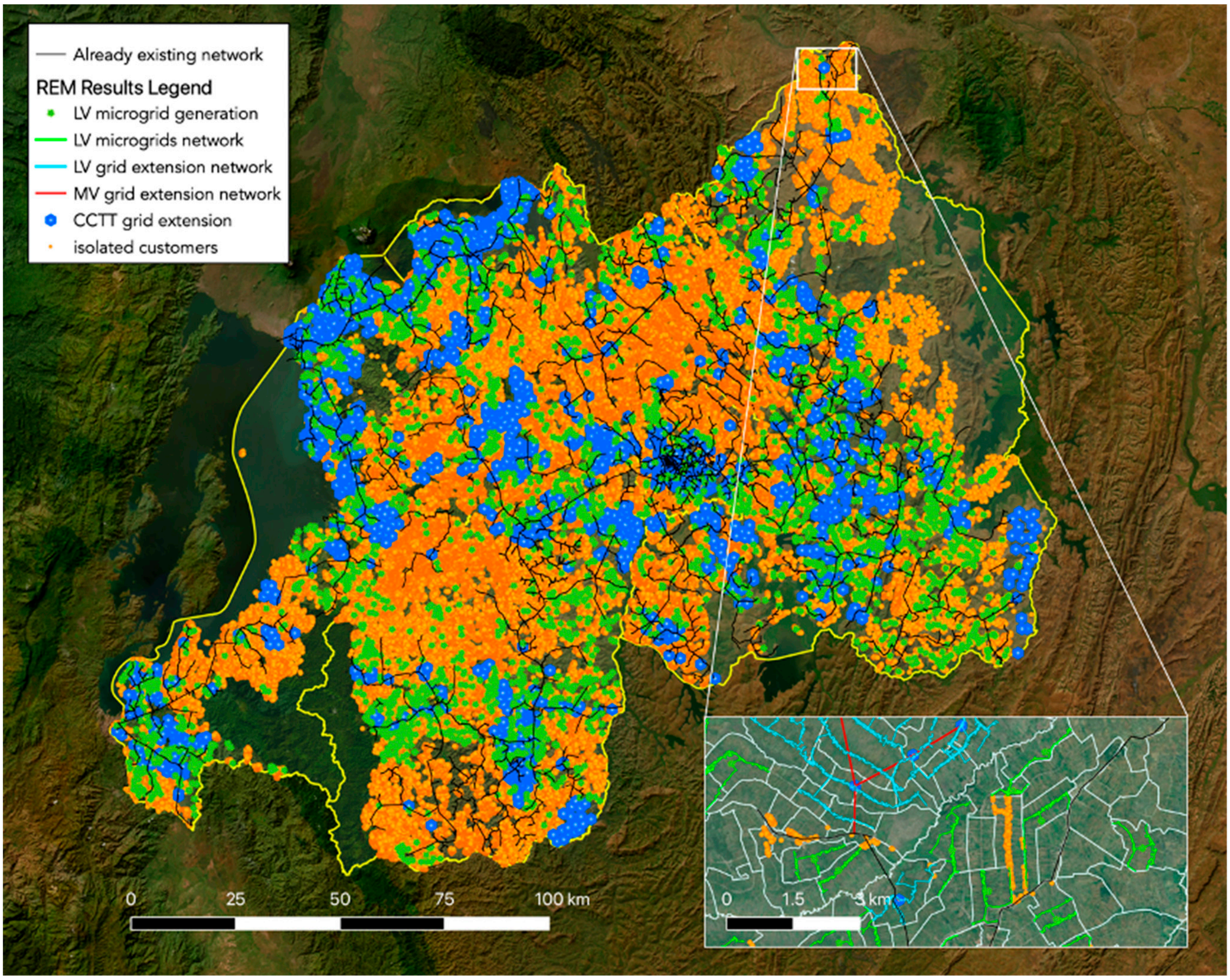

Figure 2. Map of electrification modes for the Rwandan National Electrification Plan 2024, including a zoom in an area to show the detailed netwoks layout [75].

A second characteristic shared by most people in poverty (not only in developing countries) is the lack of means to afford the cost of the electricity service itself. The difference between this affordability and the cost of service contributes to the overall viability gap between what business models can collect from customers and the total cost of providing electricity service.

The impact of these two facts, the iron law and the viability gap, illustrates the depth of the power divide between the cost of service and affordability in the urban grid and the rural off-grid areas and the need to find solutions to close this gap [76] so that universal service at a fair price can be offered to the poorest populations in isolated rural off-grid areas (at least in a similar way as it is implicitly cross-subsidized for grid customers, wherever they are located).

The quantification of this gap and its implications for tariff design can take advantage of advanced planning models that determine the cost of service of each grid and off-grid system so that it can be factored into the calculation of electricity tariffs (either public or set by private agreements between companies or small entrepreneurs and their customers).

These tariffs can therefore integrate this variability in the cost-of-supply so that the average tariff will reflect a fair return on investment capital, financing mechanisms, and the business model. Tariffs may also consider additional financing, such as other direct subsidies from the national budget, electrification funds (general or for specific technologies and energy sources), or grants or concessional loans from international development banks and agencies [76].

In every country in the world (to our knowledge), electricity tariffs are the same in rural and urban areas (although there may be differences in quality-of-service requirements). This implies the naturally accepted existence of cross-subsidies favoring rural and poorer customers. The establishment of appropriately regulated tariffs, not necessarily limited to grid-connected customers but also, for example, to those served temporarily or permanently by mini-grids and even home solar systems, as in Peru, would allow for adequate remuneration of distribution companies and an equitable sharing of the burden of different types of customers in different urban and rural areas on the country's electricity system. A more natural and implicit method would be establishing comprehensive cross-subsidies integrating all of the distribution technologies.

Suppose mini-grids are a transitional solution before the arrival of the national grid. In that case, the regulation should also identify the characteristics of grid-compatible mini-grids and define appropriate support for them, which could also apply to (expected) permanent mini-grids in very isolated villages. This support is justified because grid-compatible mini-grids are typically more expensive than other types of mini-grids (e.g., DC grids serving small loads for only a few hours a day) and, on the other hand, provide standard levels and qualities of service similar to those of the grid itself at a lower cost than the equivalent grid extension for that cluster (provided that a techno-economic model has determined where and how it is less costly to develop a grid-compatible mini-grid than to extend the grid or provide off-grid systems [77]). The regulation should also determine when and how these mini-grids could be connected to the grid, what compensation should apply to the entrepreneurs who developed the mini-grid network for the activities to be integrated into the central grid, and what retribution regime should apply to the existing distributed generation once it is connected to the grid. This scheme will reduce the risk for these types of grid-connected mini-grids. It will attract private investment to areas where the grid will take time to reach (or may never reach), reducing the pressure on the incumbent utility to extend the grid everywhere and accelerating the electrification rate to achieve universal access.

The electrification process is also part of the national energy policy, coexisting with other objectives such as quality and security of supply, energy efficiency, cost-effective generation mix, promotion of renewable energy sources, reduction of energy dependency, or resilience of the power system in natural disasters. All of these concerns have an impact on new electrification planning. Grid-connected customers will receive energy from the same central grid generation mix, while mini-grids in remote areas will certainly contribute to the penetration of renewables. Using off-grid diesel gen-sets could impact the energy dependency of countries that need to import fuel and the country's carbon emissions. However, in some cases, a small amount of diesel in a mostly solar generation mix could help reduce the cost of batteries needed to provide a good quality of service. In any case, the contribution of diesel to the off-grid generation mix is expected to diminish due to declining trends in renewable generation costs, the difficulties of transporting fuel to remote locations, and price volatility. Therefore, off-grid access technologies will also contribute to the fight against climate change.

As mentioned above at the micro-framework level, electrification also has an impact on and is required for the development of many other national policies [78], so national electrification targets must also be set taking into account the different needs and priorities of other policies (e.g., development of productive activities, education, communications, and others).

Energy resilience must also be factored into universal access planning and strategies and will influence the choice of technologies and business models. Some developing regions are particularly vulnerable for various reasons: natural disasters, climate or weather conditions (e.g., floods, hurricanes and typhoons, earthquakes, and others), humanitarian or security risks (e.g., refugee camps and conflict zones), or simply because of the uncertainty associated with energy sector governance (e.g., unexpected changes in the decision-making logic of policymakers). In these scenarios, technology choices and related business models will be much more flexible (e.g., distribution of solar kits), aiming for shorter payback periods to minimize exposure to these risks and facilitate disinvestment and relocation of assets if necessary. The need for resilience to various threats will increase service costs. It may make it difficult to achieve levels of electrification beyond those required to meet basic lighting and communication needs.

Definitively, attracting sufficient private capital to achieve the goal of universal electrification will require the creation of an appropriate investment climate that supports the creation of fair financial services commensurate with the types of risks associated with providing electricity to the bottom of the pyramid (Box 3).

Box 3. The Case of Brazilian Programs "Luz para Todos" (Light for All) and "Mais Luz para a Amazônia" (More Light for the Amazon) [33,57,79,80]. Large-scale political initiatives and regulatory frameworks impact in electrification (Quadrant 3).

These programs were implemented in Brazil to expand access to electricity in rural and remote areas, focusing on the Amazon region. Here is an overview of their history:

Luz para Todos (Light for All):

1. Luz para Todos was launched in 2003 as a joint effort by the Brazilian government, through the Ministry of Mines and Energy and various electricity distribution companies. The program aimed to bring electricity to households and communities that were not connected to the national grid.
2. The main goal of Luz para Todos is to overcome energy poverty and promote social inclusion by providing electricity as a fundamental service. The program focuses on rural and isolated areas, where extending the traditional power grid is challenging and costly. To achieve this, the program created its own low-cost grid extension standard.
3. Luz para Todos has made significant progress in electrifying rural areas, reaching millions of households and communities across Brazil. It has improved living conditions, enabling access to education, healthcare, communication, and economic opportunities. It has been extended beyond its original time frame to help reach the last-mile unelectrified customers where grid extension is still cost-effective.

Mais Luz para a Amazônia (More Light for the Amazon):

1. Building upon the success of Luz para Todos, the Brazilian government launched the Mais Luz para a Amazônia program in 2009. This initiative specifically targeted the use of off-grid mini-grids (MIGDI) and stand-alone systems (SIGFI) in the Amazon region, where electricity access was particularly limited due to geographical challenges and the presence of remote and dispersed communities.
2. The program aims to bring electricity to these isolated areas in the Amazon, providing clean and sustainable energy solutions. It involves the implementation of renewable energy isolated solutions. The objective is not only to improve access to electricity but also to reduce environmental impacts and promote clean energy sources.
3. Mais Luz para a Amazônia seeks to benefit both indigenous and non-indigenous communities, prioritizing their needs, and respecting their cultural and social diversity. By expanding access to electricity in the Amazon, the program aims to foster development, support local economies, and contribute to the well-being of communities while preserving the region's natural resources.

These programs, Luz para Todos and Mais Luz para a Amazônia, have been significant in Brazil's efforts to achieve universal access to electricity, particularly in rural and remote areas. They have helped bridge the energy gap and improve the quality of life for millions of people, promoting social inclusion and sustainable development.

Box 3. Cont.

Much of this success can be attributed to the well-established regulatory and financial framework for the distribution sector in Brazil. The government's explicit goal of achieving universal access to electricity by 2030, the allocation of this responsibility to the incumbent utilities, initially under the supervision of Eletrobras and the Ministry of Mines and Energy, and the regulatory framework established by ANEEL, which defines the minimum quality and quantity of service to be provided to each family in Brazil, has greatly expanded the coverage of electricity services to date. However, this regulatory framework is also struggling to reach the most isolated communities in the Amazon. Not only the investment, but also the operation and maintenance of the isolated mini-grids and off-grid systems in these remote locations increases exponentially as new connections are located further from the main villages, away from roads and rivers, straining the public funds that provide the viability gap necessary to serve these populations under the current affordable tariff design. Therefore, lighter regulatory frameworks and new business models (that help incumbent utilities reach these remote communities more effectively) could help reduce the viability gap by digitizing operations and maintenance, enabling smaller and stackable solar kits that are lightweight and easier to transport, or integrating both energy supply and development activities to increase affordability for these remote populations.

4.4. Q4 Macro-Forces: Decision-Making Drivers for Governments, Funding Agencies and International Organizations, Energy Companies, Private Investors, Social Enterprises, and the Third Sector

This last quadrant returns from a macro perspective (at the national and international levels) to the actors and mechanisms that, given the policy and regulatory framework, can mobilize the actions needed to achieve universal access in each country.

As we have already mentioned, the ecosystem of actors involved in the electrification process is very complex and diverse, starting with the beneficiaries and their communities, followed by the incumbent distribution companies, the incumbent transmission operator (which will also be responsible for the necessary reinforcements at High Voltage (HV), where the volume of energy associated with the new grid extension is significant compared to existing consumption), the power generation companies, the off-grid electrification actors, the regulator, national, regional and local governments, international organizations and development banks, donors and the financial sector, the third sector, suppliers of electrification equipment and appliances, and other ancillary service providers.

Many countries already have energy sector dialogue mechanisms that bring together different actors to address the electrification challenge, such as the Sector Wide Approach in Rwanda, which brings together the private sector, international development agencies, the regulator, and the government [47].

The governance of this ecosystem of actors in the access to energy process cannot take place without their active contribution and steadfast long-term commitment around a core of shared values [17,81] but also from the perspective of the energy poor [82–85], according to their diverse realities, needs, goals and objectives.

The value of electrification to individual customers (not only those who lack electricity, but also those already electrified) is not directly related to the quantity and quality of the power supply, but to the specific uses that these customers access through power appliances (home lighting, communications, productive tools or equipment, community facilities). To create value for customers, it is necessary to consider both the level of energy supply and the energy efficiency of these appliances to maximize the use of limited resources and create value for the customer.

At the same time, value creation for the different stakeholders or actors can be studied from different perspectives. First, there is the creation and expansion of the on-grid and off-grid electricity market, not only for 774 million people without access but also for millions of non-electrified communities and potential productive users, as well as the provision of adequate service to several hundred million more existing underserved customers who receive unreliable, inadequate service. This new market represents an opportunity for incumbent utilities and entrepreneurs, new energy companies, suppliers of power equipment and appliances, and financial and microcredit services for the bottom of the pyramid.

With this economic value, there is a process of creating social value in electrification as an essential infrastructure with a broad impact on multiple dimensions of sustainable human development (education, health, income generation, security, gender equality, productivity, and others). The ecosystem of actors will gain momentum through the alignment of interests around these values, from the communities to be electrified to national governments or international agencies and donors, as well as businesses and other private or third-sector organizations.

These pillars would be needed to engage large companies and attract capital to accelerate electrification in developing countries through an integrated approach that combines the least-cost supply technology (mini-grids, solar kits, or grid extension) with disruptive innovations in business models, smart management, communication technologies, and customer engagement that have proven successful in different experiences [86]. The primary goal is to create the conditions necessary to attract the economic, technological, and human capital required to achieve universal access to electricity rapidly [15,16] in the always challenging and complex context of developing countries. In this sense, implementing partnerships for the goals (SDG17), as shown in the case study below, can play a fundamental role (Box 4).

Box 4. The Shire Alliance in Ethiopia [87–89]. Public–Private Partnerships and shared values as drivers of Universal Access (Quadrant 4).

Launched in December 2013, Alianza Shire is a multi-stakeholder partnership experience in the humanitarian sector focused on improving services and quality of life, based on the provision of sustainable energy access solutions (electricity and modern cooking) for vulnerable populations in refugee camps, particularly in the Dollo Ado refugee camps in Ethiopia, in the southeast of the country, near the borders with Somalia and Kenya.

The alliance includes two leading utilities (Acciona.org, Iberdrola) and a technology provider (Signify, formerly Philips). It is supported by the Spanish Agency for International Development Cooperation (AECID), with the Center for Innovation and Technology for Development at the Universidad Politécnica de Madrid (itdUPM) acting as the knowledge hub in collaboration with the United Nations High Commissioner for Refugees (UNHCR).

Alianza Shire seeks the long-term self-sustainability of its activities, embodying an innovative, evolutionary, and transformative character. Since its inception in 2013, Alianza Shire has grown from a prototype in a single camp to a project in four refugee camps. The level of participation, alignment, and trust among the partners in the partnership has increased, fostering collaboration, co-creation, and co-design.

Each member of the partnership brings specific expertise and resources to the project. For example, AECID provides institutional support and partial project funding; acciona.org (Acciona Foundation) provides innovative energy access solutions and a business model tailored to the development cooperation environment; Iberdrola contributes organizational, technical, logistical, and purchasing capacity; and itdUPM serves as the research center that leads the project, facilitates partnerships, and provides technical expertise.

It is also a source of transformative corporate culture for the institutions involved, as several volunteers from both Iberdrola and Acciona (Spain), and researchers from itdUPM, have participated in the project.

The United Nations High Commissioner for Refugees (UNHCR) plays a key role in the partnership, diagnosing the problem and evaluating the pilot project. UNHCR also assists the partnership in seeking additional funding to expand and replicate the project. Alianza Shire uses various international frameworks, including the World Refugee Pact of December 2018, the New York Declaration of September 2016, and the Comprehensive Refugee Response Framework (CRRF), as theoretical frameworks for its work.

Box 4. Cont.

Over the past decade, Alianza Shire's engagement has demonstrated that its sustainable contribution to improving energy access, livelihoods, and quality of life for refugee camp residents aligns with broader global efforts to support and protect refugees. The multi-stakeholder approach and collaboration with international organizations demonstrates the partnership's commitment to energy access and human development solutions in challenging contexts, providing sustainable grid services to 31% of the camp population and clean cooking to 23% [89]. In the Hillaweyn camp in the Dollo Ado region alone, more than 15,000 people (2000 households) have access to adequate, affordable, and sustainable electricity. The key to this success lies in the combination of the customized business model, local engagement through community participation in the electrification committee, and their involvement in the operation and management of the supply, all supported by a stable and enabling public–private partnership macro-force and a local multi-stakeholder micro-frame involving the beneficiary community, the Murukmale Energy Cooperative of Hilaweyn, the NGO Save the Environment Ethiopia (SEE), a Photovoltaic Electrification Committee (CEF), and an Advisory Council [88]. Its activities include not only the supply of electricity and the sale of electrical appliances, but also the capacity building of local actors, especially women [90], the support of existing primary schools in the different camps, and the promotion of productive activities. Users benefit from the electricity provided by the systems and commit to contribute to their sustainability. The microfinance institution supports the collection of service fees and the affordable installation of any equipment purchased by the beneficiaries. At the core of the business model is an energy cooperative that supplies the systems and provides technical assistance. The NGO SEE remains the owner and responsible for the systems (playing the role of an incumbent utility). It contracts the energy cooperative to manage the technical services with its support and supervision, while supporting the Photovoltaic Electrification Committee. As the representative body of the beneficiary population (elected by and from the users), this committee is the link between the customers, the energy cooperative, and SEE. The PPP supports the business model through an Advisory Council (including acciona.org, AECID, UNHCR, SSE, RRS—Ethiopian government agency for refugees, and two local authorities), which is responsible for overseeing the proper implementation of the delivery model and approving key strategic or operational aspects that affect it. The macro forces in this case are an example of the ability of SDG17 to foster coordination down to the field and beneficiary population, up to the regional and national government, as well as international actors such as the European Commission or UNCHR, with the involvement of companies, NGOs, and academia, acting on a common goal and shared values.

5. Discussion

Universal Access to electricity, modern heat, and cooking at a level that can meet the essential needs of the people and create virtuous cycles of development to enable the achievement of the Sustainable Development Goals will not be feasible for many countries, even by 2030 or later, unless urgent and appropriate action is taken, commensurate to meet the challenge, especially for the least developed countries in Africa.

An undertaking of this magnitude requires a thorough consideration of multiple interrelated factors, including institutional, financial, technological, social, and environmental dimensions, approached from a variety of perspectives, including individual, local, regional, national, and international. It is imperative to engage private capital and to leverage financial, human, and technological resources that are potentially scalable for collaboration with large corporations. However, such efforts require innovative "glocal" strategies that seamlessly integrate global and local insights into critical facets such as governance, financial requirements, social and economic transformations, gender dynamics, business diversity, and cultural factors.

The article shows that success depends on the establishment of shared values that can drive different stakeholders, governments, institutions, private companies and banks, international development and financial institutions, NGOs, academia and, most importantly, the beneficiaries, into coordinated action to create sustainable, attractive, and scalable energy supply models that integrate different supply technologies (grid extension, mini-grids, and stand-alone systems).

This conceptual framework outlines a vision of how comprehending the decision-making dynamics and driving forces at various levels within this intricate ecosystem can be enriched through the proposed conceptual framework. This framework provides a lens through which to understand the complexity and magnitude of the endeavor to achieve sustainable universal energy access.

The complexities of this mission require innovative business models, sustainability, and a focus on the implementation of energy access infrastructure and its long-term operation and maintenance. These strategies also encompass the digitization of grid and off-grid system operations, which is essential to meet the energy needs and payment capabilities of those without access. At the same time, grassroots innovation plays a critical role in fostering the dynamism of recipient communities and bridging the gap between effective frontline work and the need to replicate and scale up electrification efforts by engaging larger actors, programs, and policies.

6. Conclusions

Evidence shows that success in universal access is not happening in 2030 worldwide; it will take much longer in many countries. Success in meeting Sustainable Development Goal 7.1 hinges on significantly scaling up and accelerating electrification efforts in developing countries. Tackling energy poverty on this scale requires strong government commitment, active private investment, and the collaborative participation of a complex ecosystem of actors, including local entrepreneurs, specialized energy companies, development finance institutions, private banks, telecommunications, development and social organizations, and, crucially, the explicit involvement of beneficiary communities. Governing this ecosystem to accelerate the pace of electrification requires the interweaving of technological innovation, disruptive business models, improved institutional frameworks, and inclusive multi-stakeholder decision-making, all to ensure that no one is left behind.

This endeavor requires both macro (national and global) and micro (local and individual) level mechanisms that strengthen electrification drivers (technological advances, business innovations, resources, and capacity building) within a harmonized regulatory, policy, and planning framework. Our proposed approach, illustrated as a circular framework, delves into four quadrants, emphasizing various pivotal elements.

Quadrant 1 (Micro-Forces) focuses on how beneficiaries, innovative technologies, and business models drive the energy access process. Understanding user-centered needs and aligning universal access strategies accordingly is critical. Technological innovation, cost effectiveness, and business models tailored to the bottom of the pyramid in local contexts shape the choice of supply modes.

The Quadrant 2 (Micro-Frame) is centered on the impact of energy access on beneficiary communities and the local environment. Ensuring affordability and managing the impact of energy in communities requires a focus on development, capacity building, and beneficiary leadership of their own energy transition process.

The Quadrant 3 (Macro-Frame) concentrates on the Integration Distribution Framework (IDF) as defined by national and regional government electrification and energy planning, financing, regulation, and policy. Robust geospatial energy access planning and financing plans are critical to the success of SDG7. Improving the state of the distribution sector, promoting equitable cross-subsidies, prioritizing energy access, addressing resilience to risks and natural disasters, and aligning with development goals are essential to achieving universal energy access.

Quadrant 4 Macro forces, the governance quadrant, addresses how to set in motion the forces and levers that can mobilize all of the actors that need to play a role in scaling up and accelerating the rate of electrification and access to modern heat and cooking to achieve the goal of universal coverage by 2030. These forces need to be analyzed from the perspective of governments, international organizations, donors and cooperation agencies, private banks and capital investors, developers, social organizations, and other enablers, taking into account the governance of this complex ecosystem of actors in the fight against energy poverty and, in particular, for universal access.

The convergence on a common set of goals and values of the different actors in this ecosystem is a process that needs both a wide participation of the incumbent actors and decisive leadership not only of the governments but of technological, financial, and business actors that need to implement those strategies, with a clear allocation of responsibilities to leave no one behind, together with the implication and participation of the beneficiary communities, empowering and driving progress towards a more energy-inclusive future.

Author Contributions: Conceptualization and methodology, A.G.-G. and A.M.-R.; validation, formal analysis, and investigation, A.G.-G., S.J.D.-P. and A.M.-R.; writing—original draft preparation, A.G.-G.; writing—review and editing, S.J.D.-P. and A.M.-R.; supervision, A.M.-R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially funded by the Spanish National Plan for Research, Development, and Innovation: Research Challenges through the project Challenges of Universal Access to Energy and impact on Climate Change: Decision support models.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors want to thank Ignacio Pérez-Arriaga, Clara Pérez-Andújar, Kristin Dietrich, María García-Almenta, Pedro Ciller, Julio Eisman, Rafael Palacios, José Gabriel Martín Fernández, and Carlos Sallé for their inputs, and all the researchers and students of the Universal Energy Access Laboratory MIT and IIT-Comillas whose experiences in actual planning, regulatory, and business models projects have contributed to this paper.

Conflicts of Interest: The authors declare no conflict of interest. The funding from the Spanish National Plan for Research, Development, and Innovation did not influence the interpretation and analyses of data or in the writing of the manuscript.

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