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A Framework for Sustainable Energy Development Beyond the Grid

Meeting the Needs of Rural and Remote Populations

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Advances in energy access in developing countries over the past 25 years have been remarkable with more than 1 billion unserved people gaining access to electricity and modern fuels. However, as impressive as this may sound, large gaps remain: 1.6 billion people still lack access to electricity and another 2.5 billion continue to rely on traditional biomass fuel for cooking and heating. The problems of access are greater in rural areas than in urban areas. If today's energy policies and inv estment trends were to continue, the situation will not look any better, especially in least developed countries, in the coming decades. Drawing on recent theoretical advances regarding the meaning of development and the role of energy with empirical evidence from case studies, the article suggests an alternative energy and development paradigm to guide efforts toward meeting current and future needs for modern energy services.

Keywords: *access; energy; environment; development; sustainable*

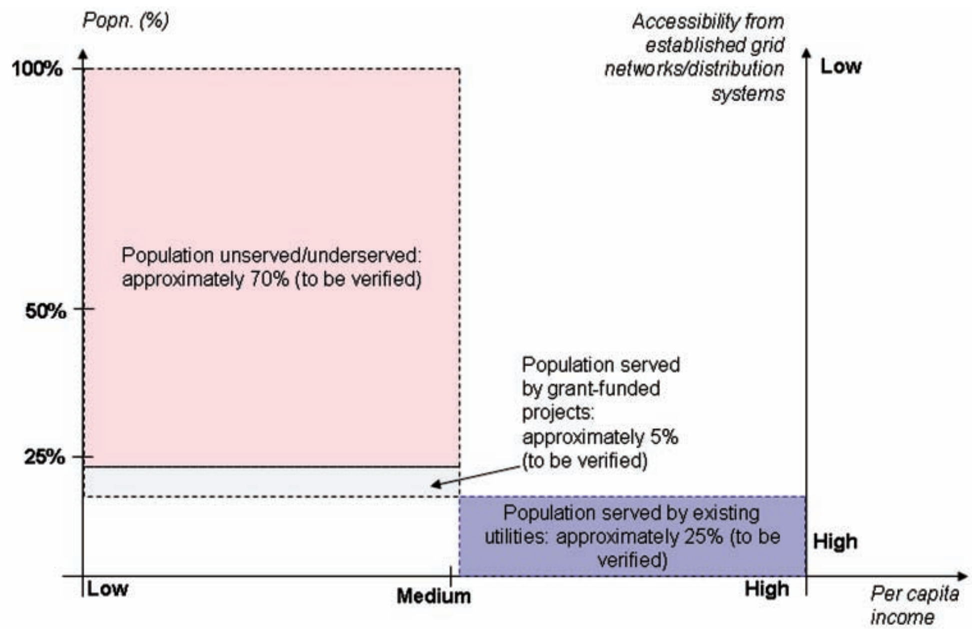
1. Introduction

Access to modern, clean, and environmentally sound energy is a key condition for overall improvements in quality of life and sustainable development throughout the world. It fulfills the basic human needs of nutrition, warmth, and light and is an engine for economic growth. Indeed, energy and human development are inextricably linked. Advances in energy access in developing countries over the past 25 years have been remarkable with more than 1 billion unserved people gaining access to electricity and modern fuels.

However, as impressive as this may sound, large gaps remain: an astounding 1.6 billion people still lack access to electricity, and another 2.5 billion people continue to rely on traditional biomass fuel for cooking and heating. The problems of access are far greater in rural than in urban areas. Indeed, four out of five people without access to electricity live in rural areas of the developing world, mainly in South Asia and Sub-Saharan Africa (Gardonneix, Sambo, Guobao, & al, 2008). The conventional means of providing modern fuels and electricity through centralized production and grid extension has often proven too expensive for remote and dispersed rural settlements, so that the majority of inhabitants in many regions are excluded from basic energy services. Figure 1 offers a stylized representation of this problem. These conditions suggest that conventional energy utilities, and even grant-funded programs that seek to fill preexisting service gaps, are not up to the task of meeting current and future needs for modern energy services "beyond the grid."

Besides the technical limits of the existing system, however, a greater issue exists, that of environmental limits to energy production and consumption. Given the present-day reality of global climate change and the central role of the conventional energy sector as a contributing factor, it is clear that future energy needs, especially in the global South, cannot be met by reproducing the "dirty" power solutions (Byrne & Mun, 2003) originally followed by the rich countries. Analyses by industry and independent researchers have shown that a wide array of efficiency alternatives, for instance, can yield energy savings at or below the cost of supplying electricity (Wamukonya, 2003). In virtually every energy application, traditional supply approaches are more economically and environmentally costly than energy-efficiency options. Recent studies have also demonstrated new possibilities for delivering energy services cost-effectively to people in remote areas based on renewably powered generation. However, existing energy markets remain biased in favor of urban consumers and so are unlikely by themselves to bring the benefits of these technologies to dispersed populations in rural areas of developing countries where the majority of people actually live. A complementary and sustainable energy regime

Figure 1
Limited Coverage of Conventional Energy Utilities and Grant Programs



capable of reaching communities beyond the grid with sustainable and least-cost energy products and services is therefore needed.

In response to this need, many national and international agencies have embarked on a variety of projects and programs designed to bring the benefits of sustainable energy to the "have-nots." Although they have only managed to reach a small proportion of the excluded majority to date, the potential exists to synthesize and apply lessons learned from these experiences toward a more rapid replication and scale-up of the most successful approaches.

As a contribution to this effort, this article reviews recent thinking about the nature of the development process and how energy systems may be structured and aligned to support development goals. From this review, an alternative energy and development paradigm is put forward. The expectation is to stimulate discussion leading toward a refinement of this alternative paradigm: sustainable energy for sustainable development.

2. Emergent Paradigm Shifts in Development Thinking: From Linear to Complex Adaptive Systems Development Models[1]

In recent years, the idea that development strategies should be derived on the basis of complex adaptive systems (CAS), rather than linear systems (LS) interpretations of reality, has gained ground among influential stakeholders (Rihani, 2003). A growing number of energy and development initiatives have been informed either explicitly or implicitly by CAS thinking.

2.1. Conventional Thinking: The Linear Systems View of Energy and Development

The linear view envisions development as a whole—alongside the evolution of energy and other modern infrastructure systems—as a finite process in which countries are either still "developing" or are already "developed." As perceived by linear systems thinking, the overarching ambition of those in the former category is to become like those in the latter, by closely following their movement up the energy ladder of progress. Processes here are orderly and predictable: obeying laws of universal applicability and moving toward universally recognized ideal states. Hierarchical structures and top-down management are assumed to be the most effective means to realize this state. People overall are seen as passive recipients of the benefits conferred by development. Emphasis goes to worldwide models, and faith is placed on large infrastructure projects and in dramatic policy initiatives, such as rapid industrialization, structural adjustment programs, and power sector reforms. By their nature, these initiatives tend to rely on external expertise and resources and can be extremely inflexible and insensitive to actual local conditions.

2.2. An Alternative Paradigm: The Complex Adaptive Systems View

By contrast, the CAS perspective maintains that development is basically a continuously evolving, open-ended activity with no fixed end state. Its worldview emphasizes survival, adaptation, and "learning" over time. A system such as an energy regime must survive long enough to adapt and must remember lessons from the past and gather knowledge about the present in order to adapt effectively. Advocates of this paradigm place great value on human capacity and freedom to interact with and learn a framework of simple rules that encourage their general and willing compliance.

Importance is also attached to the value of diversity and the need to exercise pragmatism in all matters as the basis for survival, adaptation, or learning. Furthermore, the context in which people and societies interact is of critical importance and is perceived to always be in a state of flux caused by many factors, including the activities of other people and codeveloping nations. The CAS worldview embraces an assumption that the outcomes of local interactions are neither orderly nor predictable. Minor local disturbances or initial conditions could be magnified by positive feedback, helping to produce large global changes. Crucially, the same cause is deemed capable of potentially producing different effects.

3. Sustainable Energy and Development From a CAS Perspective

While acknowledging the possibility that an inherently open-ended energy-development process may actually produce unsustainable outcomes, the CAS view of reality does not render society powerless to actively affect such outcomes. In fact, under CAS, governments, civil society, and even individuals could, and should, do much to optimize the process (Rihani, 2003) and "coax" the system, as it were, to evolve in the direction of sustainability. Indeed, the nonlinear CAS worldview calls for fundamental changes in development management styles that are in line with sustainability principles:

1. The CAS asserts that local actions and initiatives determine whether a nation is engaged in a process of development, or not; it repositions local people, their interactions, and associated energy needs to centre-stage and makes them ultimately responsible for the outcome—as in "sustainability"—of the process.
2. The CAS insists that no *economic* development is possible in the absence of *human* development; it places a high premium on capacity building and the elimination of conditions—illiteracy, disease, and oppression—that threaten the freedom and ability of human beings to interact.
3. The CAS argues that interactions between people require careful handling if self-organized, stable, yet evolving patterns are to be achieved; it therefore perceives the creation of a regime of rules and institutions that invite willing compliance from the majority of people as a basic prerequisite in order for beneficial interactions to occur, as "[h]uman rights and good governance are not optional extras to be introduced at a later stage" (Rihani, 2003) in energy and development planning.
4. It observes that successful exploration of energy and development opportunities depends on copious diversity, readiness to experiment—and sometimes make mistakes—and a pragmatic outlook that rejects rigidity in all matters. By implication, it rejects all "inhibitors to diversity," including global institutional and political systems that insist on local compliance and perceive any departure as major challenges that should be eliminated.
5. Shuns detailed plans and calls for a shift in emphasis away from steep global hierarchies toward local decision making and actions.

Nothing in the preceding summary of the process management implications of the CAS perspective conflicts with the accepted principles of sustainable development, as stated originally by the World Commission on Environment and Development (1987):

> "[Sustainable development] is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technology development, and institutional change are made consistent with future as well as present needs."

A central challenge of sustainability from a CAS standpoint, therefore, centers on how to build people's awareness of, and commitment to, such principles, so that interactions among people and between society and the environment consistently produce sustainable development outcomes. The weight of global experience and expert opinion regarding this important challenge points

Table 1
An Emergent Model of Sustainable Development

Orientation of political-economy (sustainability):
Long-term growth and viability in line with environmental/climate stability
Equitable access to basic services
Regionally dispersed centers of production
Reduction of vulnerability to shocks
Balancing of consumption and conservation
Economic costs balanced by social and environmental considerations
Orientation of technology development/choices:
Preference for decentralized and locally responsive systems
User-driven technology choices
Sensitivity in design to social and environmental costs
Multiplicity of technical options—those that create flexibility are preferred
Orientation of environment–society relations:
Universal recognition of environment as exhaustible but sustainable resource
Popular support for, and commitment to, rules of environmental conservation to ensure long-term viability in economic and noneconomic dimensions
Centralization and internalization of environmental impacts in economic decision making

Source: Adapted from Byrne et al. (1992:26).

to an emergent model of sustainable development, the main elements of which are listed in Table 1. Although the list is by no means exhaustive, one may be hard-pressed to define a model of sustainability that does not include the orientations presented in the table.

From a CAS standpoint, energy system development should be grounded in a better understanding of how energy systems might enhance the ability and freedom of people to interact in ways that improve the conditions of their daily lives. CAS thinking abandons the traditional belief that once energy is infused into a rural economy, it is only a matter of time before social concerns—such as reaching the poorest of the poor—fall into place. By contrast, an energy-planning process informed by a CAS paradigm would first identify the basic energy services by which the poor may be enabled to develop and pursue sustainable livelihood strategies. Put differently, the sustainability agenda of *development* expressed through the orientations of Table 1 calls for an *energy* paradigm shift from a technology-driven approach to a people-focused agenda for energy production and use. Moreover, the energy needs of people would be assessed within the overall context of continuous interactions involving political-economic, technological, and environmental systems as well as individual actors. And rather than promote particular technologies for rural energy service delivery through detailed planning, decision makers would operate on the premise that the needs of different rural communities vary widely and therefore the effort to find appropriate technologies and effective implementation strategies should be context-specific. Furthermore, energy strategies would be developed in a holistic way with specific projects designed, implemented, and evaluated in parallel with other development interventions relating to human and ecosystem health, education, agriculture, and job creation. The overall picture of energy system development that emerges from this perspective may thus be discerned as a collection of vectors or goals for sustainable energy development, to which we now turn.

4. General Goals for Sustainable Energy System Development

The following goals would characterize energy systems that are evolving in the "right" direction:

4.1. Satisfaction of Basic Energy Needs and Equality of Energy Access for All

Equal opportunities for people to access energy resources and energy services to meet their basic needs are being created and guaranteed, with initial emphasis on eliminating rural energy inadequacy and promoting rural development, including achievement of the millennium development goals (Arvidson, 2006). In many developing country contexts, this requirement entails progressive improvements in access to the following services and technologies (although the particulars will vary):

a. Lifting and/or pumping of drinking water to convenient points near or inside homes.
b. Cooking with clean and efficient stoves and/or fuels. In practice, this might require, in specific situations, an initial focus on transitional solutions based on liquid fuels (alcohol and kerosene), solid fuels (biomass), and gaseous fuels (liquefied petroleum gas and biogas).
c. Electrical illumination in all homes to improve the quality of life and to save kerosene, bearing in mind that many village electrification initiatives in the past have not necessarily resulted in the electrification of all homes.
d. Energy (electricity/fuels) for employment-generating agricultural operations, such as water-lifting/pumping, mechanized ploughing, and the like.
e. Energy (electricity/fuels) for employment-generating industries, particularly in rural areas.

4.2. Availability and Security of Energy Sources

Steady, scaled-to-need energy supplies are being secured by relying increasingly on local energy resources and pursuing a strategy of energy diversification (fuels and technologies), thereby strengthening the capacity of the system to react to crises. Generally, this implies that the following short- and long-term measures are in place and working:

a. Reduction of oil consumption through the use of more fuel-efficient vehicles and furnaces (this is especially the case for oil-importing countries);
b. Avoidance of dependence on oil as the economic base (in the case of oil-producing countries): the idea here is that the long-term interests of such countries are best served by diversifying their economies to minimize their vulnerability to economic disruption and technological path dependence over the long term;
c. Emphasis on micro-hydro, biomass (via new technologies), producer gas, biogas, wind and solar energy, and in the long term a reliance on photovoltaics;
d. Promotion of renewably fuelled distributed generation; in most cases, this would call for a massive program of rural energy centers based on biomass sources (animal waste and energy forests) and solar energy.

4.3. Demand and Supply-Side Energy Efficiency

During the conversion of primary energy (such as biofuels) to energy services, energy carriers normally run through several processes, all of which are associated with efficiency losses. In a sustainable energy regime, such losses are minimized through progressive and comprehensive improvements in the efficiency of conversion technologies and energy management techniques. On the demand side, similar measures result in more rational use of energy in all end-use appliances and avoidance of energy waste, through the substitution of high-grade energy by less “valuable” energy (e.g., using electricity in electric heaters becomes unnecessary when heat from combined heat and power plants is utilized instead).

4.4. Resource Conservation

Various energy resources on which the system relies are maintained for coming generations, or comparable options are being developed to provide sufficient energy services for future generations. Consistent with the CAS emphasis on context, these measures would vary according to the situation. For instance, given the importance of fuel-wood as a basic energy resource in developing countries, the requirement for resource conservation would translate, for the most part, into a focus on efficient biofuel stoves, efficient management of existing forest resources, fuel-wood plantation projects, and promotion of alternate and clean fuels.

4.5. Compatibility With Environment, Climate, and Health

The adaptability and the regeneration capability of natural systems (the environment) would not be exceeded by the energy-related emissions and waste generated by sustainable energy regimes. Risks for human health, as resulting from the accumulation of problematic pollutants and harmful substances, are either avoided completely or minimized.

4.6. Social Compatibility and Engagement

In a sustainable energy regime, the design of energy service delivery systems is open to the participation of all individuals likely to be affected by its operation. The system does not restrict the ability of economic players and communities to act and influence conditions; on the contrary, opportunities to broaden these abilities are explored and developed whenever possible. Rural populations form the core of rural energy planning and implementation. (Burrell, Rijssenbeek & Wijgers, 2007).

Despite significant advances in knowledge about the requirements for sustainable rural energy development, progress in practice has been hampered by the relative deficit of viable institutions capable of mobilizing the resources and orchestrating the actions needed, especially in the developing countries of South Asia and Africa. The next section draws on experiences from an ongoing rural energy enterprise development program to illustrate how small and medium enterprises (SMEs) can be powerful tools for achieving the goals for sustainable energy system development outlined above.

5. Case Studies: Rural Energy Enterprises Development (AREED)

The United Nations Environment Program began the Rural Energy Enterprise Development (REED) initiative in 2000, in cooperation with the public purpose investment company E+Co, which pioneered the enterprise-centered model, the foundation of the REED initiative. REED currently operates programs in five African countries (AREED) and China (CREED). The REED approach is based on the recognition that one of the most potent engines to produce and distribute modern energy services is an enterprise, powered by an entrepreneur. Each of these REED programs has therefore sought to encourage the growth of sustainable energy enterprises and utilities that use clean, efficient, and renewable energy technologies to meet the energy needs of under-served populations, thereby reducing the environmental and health consequences of energy use.

The REED approach offers sustainable energy entrepreneurs a combination of enterprise development services and start-up financing. This framework of integrated financial and business development support, buttressed by appropriate policy interventions, allows entrepreneurs to improve how they manage their business and to demonstrate their potential to mainstream financiers, which may provide follow-on growth investment. The resulting business growth and improvements to service delivery affect REED's end beneficiaries: the enterprises' customers, employees, and local community.

A detailed analysis of a sample of eight REED enterprises (described below) provides strong—albeit isolated—evidence of movement toward attainment of sustainable energy system development goals identified earlier. The sample of enterprises (Table 2) utilized in this study is drawn from AREED and a selection of REED-type enterprises from E+Co's portfolio in Central America, where different technologies have been supported compared with Africa.

Table 2
Sample of REED Enterprises

Enterprise Name	Business Area	REED/E+Co Investment (US$)	Country
BETL	Alternative fuel retail	50,000	Tanzania
CISA	Grid-connected small-hydro	450,000	Honduras
SHLN	Grid-connected mini-hydro	250,000	Honduras
Sodigaz	Liquefied petroleum gas retail	183,088	Mali
Tecnosol	Solar-home-system retail	100,000	Nicaragua
USISS	Solar food-drying	19,665	Mali

Source: Napier-Moore (2004).

6. Conclusion

The above example suggests how a variety of approaches, ranging in size and focus, may be utilized to spread energy service to a number of users in nonindustrialized or more rural regions. A flexible, adaptive approach is one reflecting the ideals and practices of a sustainable energy utility (SEU), in that—ultimately—a recognition of basic energy needs and the need for equality of energy access are primary drivers of action. These types of approaches, if added to and supported by further constituencies in Africa and elsewhere, may help ensure the availability and security of energy sources, benefiting a much greater number of people. At the same time, energy service, with emphasis on efficiency and renewable resources, can act as a facilitator of locally sensitive and desired economic opportunity, whereas avoiding the negative environmental and health impacts that have, in many cases, accompanied conventional energy development. The challenge here, to arrive at this point, will be an energetic social engagement among project developers, energy users, relevant government sectors, communities, and other actors, in deliberating on goals and strategies with an eye toward the well-being of those often excluded from decision making and evaluation.

An important role of the SEU, in this context, would lie in stimulating, building capacity for, and cofinancing small- and medium-sized energy businesses to develop and bring innovative energy products and services to emerging energy markets within their jurisdictions. Just as conventional utilities are points of contact for energy supply, the SEU becomes the point-of-contact for energy efficient end-use appliances, decentralized, low-carbon generation, and other modern energy services for individual buildings, communities, or groups of communities. The SEU would not replace conventional energy utilities (public or private) or other private sector-led energy ventures. Rather, the SEU would complement them by providing a focal point for design and implementation of energy efficient and low-carbon energy services. It would support such initiatives with information, seed funding, capacity building, and incentives for contractors to deliver services to segments of the population currently beyond the reach of urban-biased services and programs (see Figure 2).

Drawing on lessons learned from previous and ongoing programs, and in line with the institutional strategies outlined earlier, it is thus envisaged that the organizational structure of a typical SEU would contain the elements, linkages, and funding sources illustrated in Figure 3.

Figure 2
Potential Coverage of an SEU-Type Model, Versus Existing Utilities

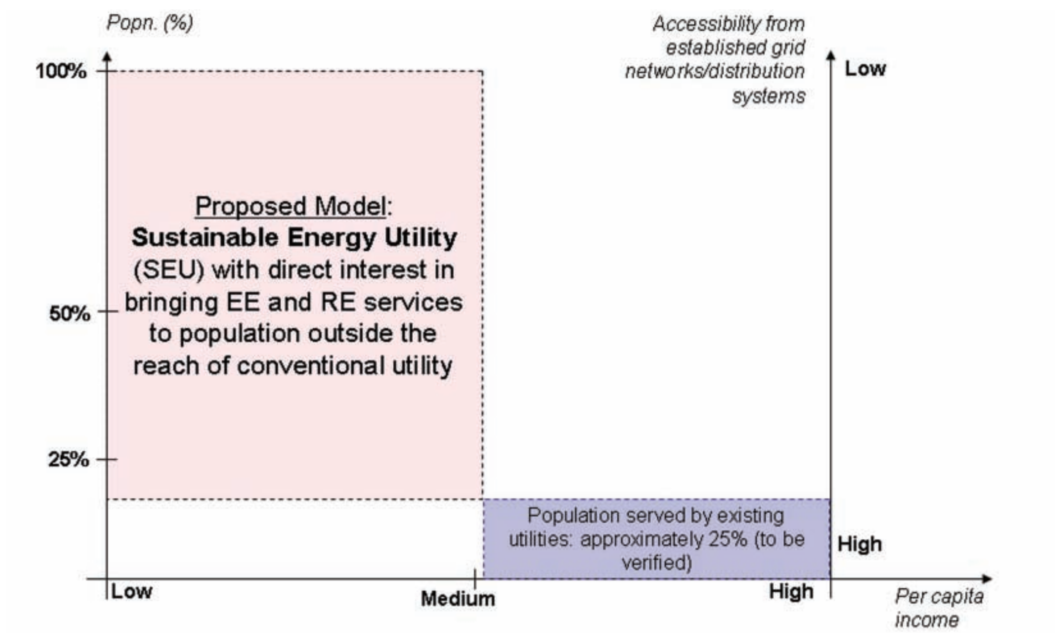
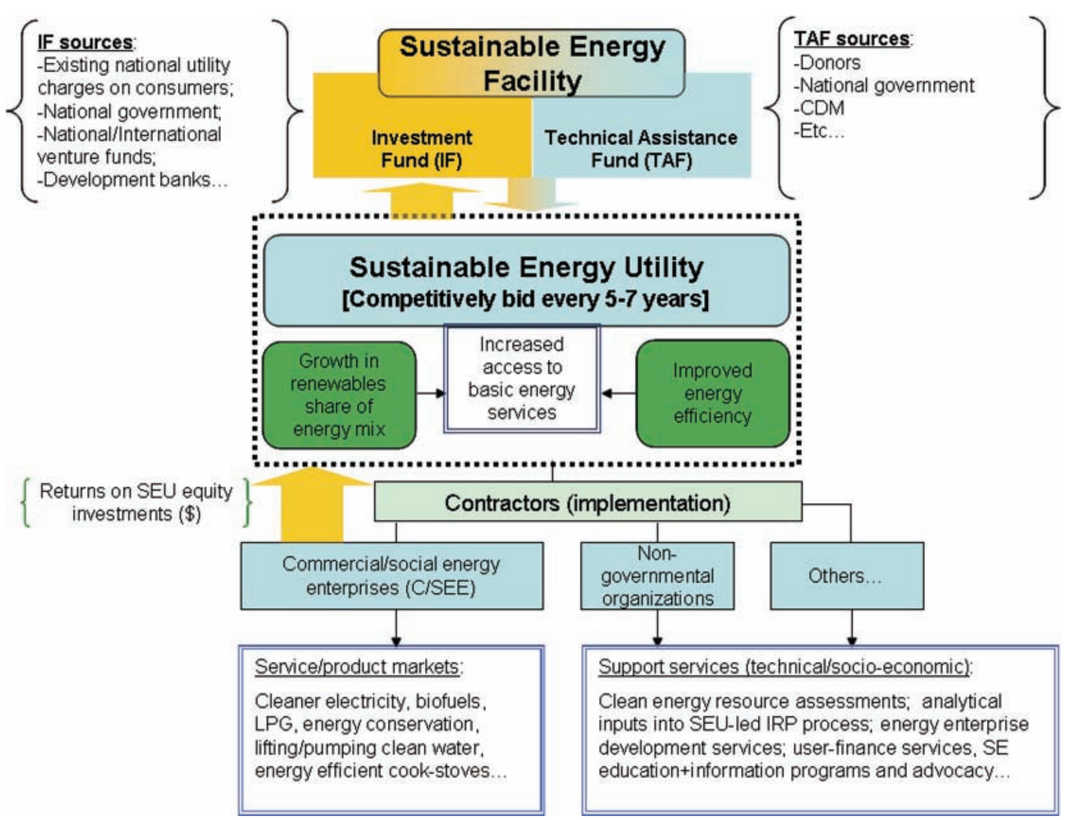


Figure 3
Organizational Structure and Funding of a Sustainable Energy Utility



An SEU, with its direct interest in bringing sustainable energy services and products—based on innovative technologies—to households, businesses, and communities, holds significant promise for meeting the needs of those who are currently beyond the reach of grid networks. Its strategies and offerings, as refined in the years to come, stand to markedly alter the character of energy service in many locales and regions throughout the world.

Note

1. The bulk of the material in this section draws on Rihani (2003).

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