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Summary

Energy-based economic development (EBED) can provide economic, social and environmental benefits related to national economic development and sustainable growth activities. As both policy and research interests in responsible mechanisms for economic development grow, EBED benefits are becoming increasingly attractive to planners in both developed and developing countries. The incentives, trade-offs, and payoffs for developing countries, however, are not well documented. To help address that gap, this paper identifies the general scope and role of EBED in a developing economy context, and outlines opportunities and challenges for decision-makers.

Keywords: Economic Development; Energy, Developing Countries, Sustainable Development

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ENERGY-BASED ECONOMIC DEVELOPMENT:
MAPPING THE DEVELOPING COUNTRY CONTEXT

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Abstract: Energy-based economic development (EBED) can provide economic, social and environmental benefits related to national economic development and sustainable growth activities. As both policy and research interests in responsible mechanisms for economic development grow, EBED benefits are becoming increasingly attractive to planners in both developed and developing countries. The incentives, trade-offs, and payoffs for developing countries, however, are not well documented. To help address that gap, this paper identifies the general scope and role of EBED in a developing economy context, and outlines opportunities and challenges for decision-makers.

Keywords: Economic development; Energy; Developing countries; Sustainable development

1. Introduction

The challenges facing developing countries are enormous and diverse. A key challenge is how resources – including natural, human, and capital resources – are organized, managed and allocated, which affects the quality and quantity of economic activities. The demand for jobs, incomes, and improvements in welfare in developing countries, coupled with young and growing populations and constrained by resource availability, place a great deal of pressure on developing countries (see Arrow et al.[1]).

The international economic development community – both in practice and in research – has generally converged in the "post-Washington consensus" era[1] toward several broad trends: local participatory programming, contextually-tailored programming, accountability and transparency, reconciling practice with measurement and evaluation efforts, and sustainability. Sustainability is particularly important, and focuses on meeting current needs without sacrificing the inputs and capacity required to meet future needs, built around economic development, environment protection and social equity[3]. Sustainability has wide-ranging implications for demographic policy, to banking infrastructure, to emissions regulations.

While matters related to environment and sustainability are not new, environmental sustainability is sometimes presented as an impediment to growth and development, rather than contributing to it (e.g, the debate on the environment and the Kuznets curve; see Stern[4]; Cole[5]; Bulte and van Soest[6]; Hettige et al. [7]; Ekins[8]; Beckerman et al. [9]). The opportunity cost of protecting the environment can be particularly difficult for developing countries to manage (for a review, see Martinez-Alier [10]). Recent work on green growth and a green economy, however, attempts to address some of the difficult choices presenting

[1] See, for example, Easterly [2] for a discussion of the evolution of international development policy.

opportunities for environmentally-sustainable economic progress (OECD[11]; UNEP[12]; Strietska-Ilina et al[13]; UNEP[14]). Emerging insights from this literature is part of a broader global interest in developing a coherent framework for an integrated sustainability platform.

The energy sector is critical in developing countries since it fuels development and drives the productive capacity of other economic activities. The connections between energy and other development needs, and energy and growth, respectively, have been well documented in the literature (see e.g., UNDP[15]; UN-Energy [16]; Modi et al.[17]; Bazilian et al.[18]; AGECC[19]). Economic advancement has been a primary goal of most developing country governments and many have seen improvements in the quality of life, incomes, and other such indicators over time in conjunction with an expansion in the use and sophistication of energy production and consumption [20]. Growth has been fuelled by energy use, but ensuring sustainability as part of this fast-moving energy agenda has not necessarily been prioritised. In addition, energy security considerations, important for geopolitical and economic reasons, have recently created enhanced pressure for domestic governments to pursue, inter alia, diversification of energy sources and improved energy system reliability.

Energy-based economic development (EBED) has the potential to provide important economic, social, and environmental gains in the move towards sustainability, as well as improved access to modern energy services and energy security. Energy-based economic development includes efforts that stand at the intersection between energy policy and planning, and economic development. In developed economies, such programs have become increasingly attractive as knowledge of their scope, payoffs and implications grow, although not without challenges [21]. The application of such programs in developing countries, however, has not been adequately conceptualized, nor has a working framework been formulated.

This paper advances the state of current knowledge of EBED in a developing country context. We identify the role and scope of EBED in developing economies, and present a framework for conceptualizing, categorizing, and evaluating EBED approaches. We begin by defining energy-based economic development, as well as the need for development efforts that incorporate energy policy and planning.

2. Energy-Based Economic Development

2.1 Definition

In work focused on the United States, Carley et al. [21] defined EBED as a process by which, "economic developers; energy policymakers and planners; government officials; industry, utility, and business leaders; and other stakeholders in a given region strive to increase energy efficiency or diversify energy resources in ways that contribute to job creation, job retention, and regional wealth creation." Several components of this definition are distinctive, as compared to traditional energy policy or economic development activities, respectively. First, the list of actors is diverse, and indicates the need for coordination among participants in a variety of disciplines, interests, and approaches to policy and development. Second, the energy resources that can be employed in EBED include energy efficiency and combinations of different technologies that are defined as advanced, efficient, and clean[2]. Third, EBED is characterized as being motivated by both energy and economic development goals, with a need for integration and coordination between the two.

[2] Advanced means innovative technological improvements upon conventional or alternative energy; efficient technologies use less input energy to produce the same amount of output energy; and clean technologies produce energy via low- or no-carbon processes.

Applying the basic principles of EBED in a developing country context requires augmentation and some repositioning. Access to modern energy services, for example, is a key question in many developing countries, affecting productive capacity and social equity. Economic growth and energy security are also two critical problems facing developing country governments. While aspects of these issues are important in the United States, the risk associated with poor outcomes in developing countries is immediate and critical[3]. We therefore adapt our EBED construct and propose the following definition of energy-based economic development, when considered in a developing country context:

> Energy-based economic development is a process by which multiple stakeholders in a country or region strive to increase access to modern energy services, energy efficiency, improved energy governance, and diversify energy resources in ways that contribute to wealth-creation, economic growth, and security.

This modified definition includes several important elements. First, consistent with Carley et al. [21], multiple stakeholders are involved in the process of setting goals and developing and implementing policies, including members of the national public and private sectors, civil society, as well as international actors and donor representatives. This list of actors also includes a wide range of technical and managerial talent, ranging from irrigation experts to administrative staff.

[3] This includes implications for internal political stability (e.g. such as instability related to poverty and lack of access to inputs for production) and greater regional geopolitical stability (e.g., from conflict spillover in a neighborhood of countries such as the Horn of Africa, marked by inequitable access to energy, lack of energy security, and poor economic growth).

Second, the elements of wealth-creation, economic growth and security reflect fundamental and acute inter-related challenges for developing countries. For example, unemployment can be associated with regional political instability (see Goldstone et al. [22], and Oxfam [23] for related work), and security threats can be partially mitigated through employment and income-generation opportunities that accompany economic growth. Therefore, implicit in our definition is that economic development is a process that can support these, among other, goals. To give an example that is not related to energy, girls' education projects are instituted not based purely on gender equity considerations, but on findings that gender inequity is bad for growth (see e.g., Klasen [24]). Education projects can increase female literacy, which is associated with benefits from lower fertility, as well as boost the skill base of the labor force and increase women's productivity. The point that we seek to convey is subtle but important: in developing countries, economic development includes processes that ultimately facilitate the achievement of greater levels of employment, wealth, growth and security.

Third, our definition incorporates the realities of significant demand for energy services in developing countries, where conventional, carbon-intensive energy supply remains dominant, technical and non-technical losses in the systems are high, and large populations and sectors of the economy do not have access to energy services. A dramatic shift occurs in energy systems with economic growth and EBED programs are integral to this process. In many cases, an EBED approach in the developing context includes the move towards low-carbon and efficient energy systems.

2.2 EBED Goals

Motivation for EBED projects can be either based on economic development goals or energy goals, but most commonly include goals that relate to both disciplines. Development-related goals include but are not limited to job creation[4], wealth creation, and economic diversification (see Carley et al. [21]), all of which ultimately are necessary to support growth. Energy-related goals in the international development context include but are not limited to energy access, greater energy security, increased energy efficiency, or a reduction in greenhouse gas (GHG) emissions.

Some argue that an EBED effort is more sustainable if it includes both energy and development goals. For example, Bazilian et al.[18] argue that "pursuing energy access solely as an 'end' in itself may create misdirected and ineffective policy; it must be aligned with the growth of sustainable demand for those services." Others similarly argue that EBED efforts are more effective and sustainable if the approach is holistic, and includes secondary goals of community involvement, capacity building, resource management, and gender equality (see e.g., McIntyre and Pradhan [26]; Alazraque-Cherni [27]).

3. The Need for EBED

Two important conditions demonstrate the need for EBED in developing countries: (1) lack of access to energy services and (2) the generally low-quality and degrading energy systems in many countries.

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[4]For a comparison of the employment effects of different energy technologies, refer to Kammen et al. [25].

More than 25 percent of the world's population – between 1.4 and 1.6 billion people – live without electricity, mostly in developing countries; and approximately three billion people rely on traditional biomass for cooking and heating (IEA [28]). In sub-Saharan Africa, approximately 30 percent of the population has electricity access (Brew-Hammond and Kemausuor [29]). A lack of energy access – defined as, "access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses" (AGECC [19]) – is most prevalent in the least developed countries, but also affects the lowest income individuals within all countries. For example, roughly three-quarters of African households that have access to electricity are considered "upper income", and fall within the top two quintiles of the income distribution [30]. Despite the increased focus on energy access on the international development agenda and the global awareness of the issue of energy poverty[5] over the past two decades, the need for basic energy access in some regions like sub-Saharan Africa has not changed much over this time, nor is it projected, under business as usual conditions, to change significantly over the next two decades given population growth (IEA [28]; Brew-Hammond and Kemausuor [29]). However, the recent political momentum, coupled with the goals and plans of these countries and regions makes for an opportune time to develop and implement EBED.

Energy consumption in developing countries cannot be separated from economic growth trajectories. While it is exceedingly difficult to assert causality in the relationship between electricity or other energy access and economic growth, although a large body of literature attempts to do just this (see e.g., Apergis and Payne [32]), the literature leaves no doubt that there is a strong association between energy consumption and growth. One recent study [32]

[5]See Pachauri and Spreng [31] for a review of energy poverty measures and indicators across sources and actors.

detects unidirectional causality from electricity consumption to economic growth in the short-run for both lower-income countries and lower-middle income countries, as categorized based on the World Bank classifications. Thus increased access to electricity helps countries achieve economic growth. The authors find this is maintained over the long-run for lower-income countries, but lower-middle income countries eventually become bidirectional in causality, so that economic growth begets electricity consumption and vice versa. In other words, industries cannot grow without reliable and reasonably priced access to energy sources, particularly electricity[6]. Entire regional markets have weakened, for example, due in part to lack of access to electricity, such as a once vibrant brick industry in southern Iraq (see Gunter [34]).

An acute lack of access to energy services is also tied to energy security. Domestic concerns about energy security in developing countries are certainly not new (Sovacool and Brown [35]; Cherp and Jewell [36]) – indeed, one can look at the evolution of India's post-independence energy concerns (see Noronha and Sudarshan [37] for a general discussion) as an early example. The concept of energy security, however, has evolved, and most recently conceptualized from the perspective of access to energy. Energy security has thus recently been defined to include the ability to access reliable, affordable, and diverse energy (see e.g., UNDP [15]; Bazilian et al.[18]). Similarly, Sovacool and Brown [35] argue that energy security includes accessibility, affordability, efficiency, and environmental stewardship. Fundamental to the concept of energy security is a growing understanding that energy challenges are overlapping

[6] Energy access is also an enabling condition for other basic needs, including several targeted in the Millennium Development Goals (Brew-Hammond and Kemausuor [29]). Without access to energy and, in particular, electricity, it is difficult to ensure adequate health or educational facilities, sanitation, food, or water (UNDP [15]). Health is also affected by exposure to by-products of carbon-intensive energy use. Access to modern energy also affects gender equality, since women are often responsible for gathering traditional biomass and cooking in poorly ventilated homes (IEA [33]).

and may require a broader, comprehensive approach that simultaneously addresses a variety of complex energy problems [36].

Quality of energy supply and delivery is also a crucial consideration. When power plants or transmission and distribution lines shut down due to system malfunctions, overloading, or other shocks, including natural disasters and conflict, those individuals or facilities that rely on that electricity are left vulnerable. Unreliable and inefficient energy can inhibit industrial production. It is becoming increasingly common for those individuals or organizations that experience frequent power outages to purchase back-up generators, so that power for important services can be maintained during periods of black-outs; but these back-up generators add to the cost, sometimes significantly, of electricity [30]. Generators are most commonly fuelled by oil or diesel, which makes owners particularly vulnerable to crude oil or diesel price shocks.[7]

One source estimates that unreliable and decaying energy infrastructure costs sub-Saharan Africa approximately one-quarter of a percentage point off of its annual GDP growth rate per year; and the combination of utility under-collection and efficiency losses amounts to approximately $2.7 billion per year, or 0.8 percent of GDP on average [30]. The annual cost of running back-up generators during power shortages in sub-Saharan Africa ranges from one to four percent of GDP [30], and these are only direct costs. Indirect costs, such as shipping payments and cost of corruption, are imposed on top of these. Losses attributable to energy inefficiencies, outages, and over-investment in back-up generators is approximately one to two percent of annual African growth potential [39]. Some countries have much higher economic costs of outages, including Malawi (approximately 6.5 percent of GDP), South Africa (approximately 5.5 percent), and Uganda (approximately 5 percent) [30]. In short, lacking and

[7] Transmission and distribution losses can also be quite high. Many countries in sub-Saharan Africa have efficiency losses up to 41 percent of total electricity generation, compared to the global average of nine percent ([38]; [19]).

unreliable power affects GDP, and therefore needs to be the focus of any economic development policy.

Beyond short-term trends associated with GDP loss and attenuated growth, global energy conditions also present medium to long-term fiscal challenges related to energy infrastructure repairs and replacement. The trend is similar across economies in transition, including those in the Balkans, southern Europe, and many countries in the Middle East and North Africa region.

Economic production depends on inputs, including energy inputs. The microeconomic implications of dependence on carbon-intensive fuels can increase vulnerability of firms in global markets. The macroeconomic implications affect overall economic performance, growth rates, political and foreign policy, as well as social and environmental problems, such as health effects from pollution[8] and poverty related to depleted resources from over-exploitation.

4. The Practice of EBED in Developing Economies

Energy policy in the developing world has transitioned through several phases. Many developing countries, such as India and Egypt, embraced self-sufficiency as an economic growth agenda after independence. The energy sector in such countries changed over decades and

[8] Energy consumption is the major global source of air pollution and water pollution [40], the latter occurring mostly in developing countries. As of 2008, 86 percent of global primary energy production came from non-renewable, carbon-emitting fossil fuels, with 35 percent from oil, 28 percent from coal, and 23 percent from natural gas [41]. Electricity generation in developing countries is sourced primarily from coal, oil and hydroelectricity, with minimal contributions from other sources [42]. Heavy reliance on fossil fuel resources contributes significantly to the release of greenhouse gas emissions. Rapidly emerging economies in particular are experiencing high rates of energy consumption growth, and have become some of the world's leading GHG emitters. In 2007, energy use in non-OECD countries exceeded OECD energy use for the first time; the projected difference between non-OECD and OECD energy use by 2035 is 63 percent [42]. Also in 2007, China and India combined, both countries that rely heavily on coal for energy needs, accounted for 26 percent of total global carbon dioxide emissions, up from 13 percent in 1990 [42]. The projected annual increase between 2007 and 2035 in energy-related carbon dioxide emissions in OECD countries is 0.1 percent, while the projected increase in non-OECD countries is 2.0 percent. China's energy-related carbon dioxide emissions are projected to grow at an annual rate of 2.7 percent, which would render China responsible for 31 percent of global carbon dioxide emissions by 2035 [42].

moved – very – slowly toward privatization and more open markets. This was partly driven by the inability of many governments to provide reliable energy and partly driven by the role of international organizations in domestic economic planning and structural adjustment programs. These efforts produced mixed results (see Wamukonya [43] ; Pineau [44] ; Nhete [45] ; Karekezi and Kimani [46]; Dubash [47])[9]. Two subsequent phases followed. First, from roughly the 1990s onward, energy service provision emerged as a key goal of development activities undertaken by domestic governments and international organizations, and became increasingly integrated into poverty alleviation efforts; although these efforts were not always prioritized at the national scale and often faced budgetary constraints [48]. Finally, the most recent phase in energy policy in developing countries is marked by a focus on energy as a comprehensive goal itself, but not in isolation from other development goals. Such efforts focus on energy access, service provision, security, and innovation. For example, China and Brazil have prioritized country-wide energy access and energy innovation by drafting comprehensive energy plans, clean energy or energy efficiency targets, and significant investment in domestic energy development and deployment[10]. This trend is complemented by a push for "energy for sustainable development" to become an international, institutional priority[11]. Yet, interest among countries can differ, as can EBED goals and approaches. In our discussion below, we review some goals and approaches related to EBED projects.

[9] In the period between 1990 and 1997, when structural adjustment programs led by international development organizations were most common, 76 developing countries pursued some form of energy market privatization activity [43].

[10] For a review of these policies, refer to Carbon Disclosure Project [49].

[11] The United Nation's Secretary General's Advisory Group on Energy and Climate Change, for example, recently released their summary report, in which they advocate for the UN to integrate and mainstream both energy access and energy efficiency into "all relevant programmes and projects" (2011). The UN General Assembly also declared 2012 to be the "International Year for Sustainable Energy for All" [50].

4.1 EBED Approaches

The practice of EBED in developing economies is categorized broadly around two classes of activities. First, countries can refocus existing activities within on-going development efforts; and second, countries can invest in energy sector innovations for future EBED applications. The former approach comprises three types of activities – supply-side approaches, demand-side approaches, and energy market reform and competition – while the latter focuses on the role of technological advancement and the expansion of markets.

Supply-side approaches tend to focus on provision of energy technologies, services, and infrastructure, as well as repairs and replacement of degraded infrastructure. Actual physical resources that may be provided or repaired under this approach include transmission and distribution infrastructure, centralized power plans, distributed generation energy systems, smart- or mini-grids[12,] appliances, or other household or personal energy applications such as flashlights or solar cook-stoves. Supply-side projects also include efforts to connect electric grids or power pools, so as to increase the opportunities for power trade and transactions across locations. Energy system and service provision efforts can target individuals and households to address the problems associated with energy poverty discussed above, but can also target productive uses and entrepreneurial or income-generating activities, as advocated Brew-Hammond and Kemausuor [29].

[12] Bazilian and his colleagues [51] define a "smart and just grid" as that which "embraces all measures in support of immediate and future integration of advanced two-way communication, automation and control technologies into local, national or regional electricity infrastructure" and to "optimise grid systems and their operation, integrate high levels of renewable energy penetration, and improve the reliability and efficiency of electricity supply." There are a variety of benefits associated with advanced information energy technologies and, in particular, smart grids, including the following: 1) smart grids address power quality and efficiency loss problems through reactive power compensation, voltage control, and line-drop compensation; 2) smart grids can help mitigate power theft through smart metering infrastructure; 3) smart grids reduce energy demand during peak times through demand response programs; 4) they have the potential to reduce GHG emissions through enhanced energy efficiency, better coordination between supply and demand, and the use and integration of renewable energy into the larger grid; and 5) smart grid construction and operations often offer new job opportunities [51].

Demand-side approaches to EBED include energy efficiency, conservation, or load management[13]. Energy efficiency can occur at power plants or at the transmission and distribution level with more technologically advanced equipment, or at the level of the end-user through the use of more efficient appliances and lights.

Energy market reform and increased competition is the third component in the class of refocusing existing activities. One of the challenges to electricity service provision in developing countries is the tendency toward operational inefficiency of utilities and electricity markets, due to inefficient management, hidden costs associated with utility operations and generation, or under-collection of costs from end-users. Studies have found that some form of private participation in the electricity market, either exclusive or in combination with typical state-owned utility participation, reduces the hidden costs of electricity [30]. Although complete privatization – while once considered a panacea for inefficiencies associated with electricity state-owned enterprises in developing countries – is not always the most effective or efficient solution for many countries [43, 52]. In addition, many countries are reluctant to engage in privatization to maintain energy security, particularly if they have politically unstable neighbours or themselves face problems of government effectiveness. Energy market reform may entail converting the market to a fully competitive model, in which only private utilities provide electricity or targeted policies to restructure the market, and other steps to restructure the market. Market reform could alternatively mean involving private participants in the electricity market, or implementing other policies that target management efficiency, such as personnel recruitment

[13] Load management refers to efforts that aim to shift or reduce electricity demand, so that less electricity is consumed during peak hours. For example, a utility can negotiate terms with large commercial or industrial end-users so that these end-users curtail or entirely cut their electricity consumption during specific times of peak demand.

policies, incentives for public sector contracts and decision-making scope of the board of directors [30][14].

Finally, the fourth category of possible EBED activities relates to the energy innovation side of EBED. A key challenge in EBED applications in developing economies is support for technological innovation, particularly in low-carbon and efficient energy production. With the exception of a relatively small group of rapidly developing countries, few countries can afford to invest in research and development in the energy sector; studies confirm that technological innovation is statistically associated with higher income levels [53, 54] and are less common at lower income levels.[15] The global demand, however, for energy technologies that are advanced, efficient, and clean is robust and growing, and offers significant opportunity for profitable investment in technological innovation. This market opportunity is particularly attractive for those rapidly developing countries capable of undertaking research and development, such as India, Brazil, and China. For these countries, the incentives to invest in energy sector innovations come from their own needs to fuel growth as well as the possibility of moving first in what promises to be internationally competitive industries based on alternative energy technologies. Alternative energy industries have the potential or already exist in developing country markets around the world. Solar panel investments by China, for example, have been costly but offer a dominant strategic position in global solar manufacturing markets [56][16].

[14] For example, investment, ownership and construction of small power plants by a strong industry cluster or industry partnership could help bridge the gap between the needs of private firms (e.g., reliable and consistent energy) by increasing supply, without compromising the concerns of the state (e.g., energy security). This type of industry model could result in financial and efficiency gains, including relieving the government of financing new power plants.

[15] Factors that the literature has presented as affecting investment in innovation include levels of educational attainment, governance, business climate, and flows of information [53], [55]. For a more detailed discussion of innovation opportunities in developing countries, see Aubert [55].

[16] China has also been one of the leaders in electric vehicle innovation, through the provision of subsidies, research and development support, and national manufacturing goals [57], [58].

In addition, innovations that occur along value chains require investment in production of parts that range from basic hard inputs, to expensive technologies, to highly-skilled human capital. While some of these investments may only be realistic in rapidly developing economies, there is significant opportunity for other countries to feed into the value chain in other places [59].

These four EBED approaches are not mutually exclusive and can be designed to complement each other. For example, the South African Renewables Initiative (SARi) combines supply-side EBED approaches with an energy technology innovation approach. As formally established in November 2011 during the United Nations Framework Convention on Climate Change, SARi is a government-led initiative, managed by the Department of Trade & Industry and the Department of Energy, which aims to stimulate industrial activities through the increase of renewable energy. The initiative plans for an increase of one to three GW per year of renewable energy, to achieve a 15 percent renewable energy goal by 2020-2025. Through government and international partner sponsored financing for renewable energy, the effort is predicted to result in 50,000 new jobs and $55 billion in green investment in South Africa over the next 15 years [60]. The South African government considers SARi to have the potential to establish South Africa as a wind and solar manufacturing and servicing hub, and also help achieve national GHG reduction targets [60]. As is indicative of EBED efforts, where goals tend to include both energy and economic development benefits, the driving goals associated with the SARi project include industrial development, export competitiveness, renewable energy development, energy security, and green growth [60].

5. Evaluation and performance metrics

There is a significant need for rigorous and systematic monitoring and evaluation of EBED programs, so as to provide information that can be shared globally on which factors best enable EBED achievements, and the strengths and limitations of EBED approaches in different circumstances. The primary challenge in measuring EBED programs is that the joint goals of energy and development provide multiple platforms for assessment. While it is easier to assess costs related to EBED programming, it is far more difficult to quantify and measure outcomes. For example, EBED programs that lead to a general shift from coal to wind for electricity, or from gasoline or diesel powered vehicles to lower-emissions vehicles, can reduce air pollution, a phenomenon that is not simple to quantify. In both cases, the reduction in air pollution contributes to cleaner air, and a reduction in the occurrence of asthma and other respiratory and cardiovascular complications.[17] While it is difficult to quantify and measure every outcome of EBED programming, it is possible to identify some key guiding metrics.

In the framework presented by Carley et al. [21], there are at least four classes of outcomes that one can measure in EBED projects: economic, energy, environmental, social. The same framework is useful in developing countries, but we expand it to include security, among other important details. In particular, we identify the following outcomes[18] from EBED projects and programs:

- Economic outcomes:
    - Growth outcomes: expansion in GDP, growth of export base.

[17] Another relevant example is the creation of jobs in some of the "incubator" industries in the energy sector. If wind farms in China become successful and scalable, the employment and income outcomes will be significant, as well as the resulting chain of effects created by higher incomes, including but not limited to higher levels of consumption, improvements in education, and investment in lateral sectors.

[18] This list is not intended to be comprehensive, but merely suggestive of evaluation metrics that one could employ when measuring EBED outcomes. The items listed here are also not intended to be mutually exclusive. For example, security outcomes such as ability to provide services also matter for economic development outcomes.

    - Development outcomes: income growth, financial savings associated with avoided costs, employment, income disparity in the general population, as well as by ethnic group, gender, and age.
    - Market outcomes: increased business activity, new industry activity, innovation creation and diffusion, competitiveness of industry, job creation, development and evolution of regulatory and market tools.
- Energy outcomes: total new generation, total electricity savings, number of new distributed generation systems, measure of the use as intended of energy systems, amount of new energy infrastructure, avoided efficiency losses, energy demand, energy access at the individual, household, regional, or national level.
- Environmental outcomes: decreased GHG emissions from the energy sector, GHG emissions from end-use sectors, indoor air pollution, deforestation, and other sources of environmental pollution.
- Social outcomes: perceived benefits and challenges, personal use of energy services, health outcomes, education outcomes, equity in access across ethnic groups, gender and age.
- Security outcomes: reliance on domestic or imported energy sources, ability to provide services, energy mix, electricity reliability, and extent of government involvement.

The role of the donor community in measurement and evaluation should not be overlooked. The relevance of EBED comes conveniently at a time when measurement and evaluation are a key focus among donors in international development activities. This presents the opportunity to integrate measurement considerations as the emerging field of practice continues to grow, and for on-going research and practice to better identify and isolate the effects of financing at the project level. This also presents an opportunity for collective sharing of reports, results and lessons. While the literature has fairly extensively covered institutional and technical barriers to energy technology development and deployment in developing countries, more systematic study and rigor are needed[19], including studies that feature ex post analysis, which is currently neglected in the literature [27].

6. Conclusion and Next Steps

The guiding objective of this analysis was to present key considerations, applications, and trends related to the practice of EBED in the developing country context, and provide an initial framework of EBED practices, on which future work can build. We approached this objective by first defining energy-based economic development, and then identifying the need for EBED given significant incidence of energy poverty, as well as poor and degrading infrastructure. We then reviewed current practices of EBED in developing countries, including a discussion of the goals, approaches, and evaluation of EBED. Although this paper is only a first foray into this area, it does highlight that EBED presents a significant opportunity for practice as well as practice- and policy-oriented research.

The related components of the framework outlined in the present analysis raise several important questions and topics worthy of further investigation about EBED practices that deserve attention as activities in this field evolve. We present these issues to encourage the assessment of

[19] Zerriffi [61] notes that most rural electrification distributed generation (i.e., small-scale, localized energy systems) evaluation efforts are specific case studies, or are location or technology specific, with a glaring omission from the literature of any meta-analyses or more systematic efforts to synthesize these findings. Aubert [55] reports that studies on innovation policies and instruments in developing countries tend to rely on piecemeal information, and lack both rigor and objectivity.

these EBED dimensions in future work, with the ultimate objective to build on this framework in ways that refine and expand our collective understanding of EBED.

A first topic concerns ethics, equity and environmental justice. While ethical questions surrounding economic development and energy are certainly not new, EBED brings with it a quest for balance that may reshape the existing ethical debates. Second, how can the integration of projects be achieved most effectively? Rather than adding energy as an after-thought to development activities, integration at the design stage requires focus and information. Forecasting, risk management, cost-benefit analysis and other quantitative tools can play a key role in designing effective and comprehensive systems for EBED.

A third and related question is how can implementation best be streamlined among multiple actors? This is not simply the classic question of interagency coordination; rather, it addresses major questions of process, such as mechanisms for goal-setting, the relationship between donor and beneficiary, questions of liability and credit, insurance and risk, information-sharing and reporting, and the overlapping roles of participating actors in each of these dimensions. Donor intent is an important consideration in these second and third questions on integration and implementation. For example, donors may prioritize and finance projects for reasons other than likely effectiveness or need; in some cases, donor intent may even be directly or indirectly in conflict with domestic government goal-setting and prioritization.

A fourth question concerns measurement and implementation, including not only the challenges of measuring and evaluating these projects but also a fundamental examination of how success is defined: how should project success be defined and evaluated? Time considerations are critical – for example, some studies may show immediate effects in terms of energy use patterns, but changes in economic production and social development may happen after a time lag. Impact evaluations may be particularly useful for EBED projects, in order to understand how a region would look had the project not been implemented.

Finally, a fifth area of inquiry concerns the role of markets and innovation in furthering the scope of EBED. Policy-oriented work on this question could include identification of promising markets, policies to support supply- and demand-side restructuring, innovation support and financing strategies, and on reconciling domestic government priorities.

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