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Leap-Frogging Challenges & Possibilities for Renewable Energy Transition in Developing Countries

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ABSTRACT
Shifting to new energy as well as other low carbon solutions was conceived and viewed as serious challenge even to the most developed countries in the world. Hence, with the disadvantaged position of the least developing countries, whom, in most locations around the world are at the highest risk of climate change effect, the challenges will be even more higher. These are from the perspective of technology, finance and policies of ensuring smooth renewable energy transition in these countries. However, within this challenge, there is opportunity to start enjoying new energy particularly in areas where not much investment is done in the fossil technologies. The study highlights these challenges as they are posed by climate change and the opportunities by way of estimating the investment requirements and environmental vis economic benefits of leapfrogging in West African sub-region. Reasons for slow to non-adoption of RE in developing countries as well as arguments for the possibilities of leap-frogging to renewables are also reviewed, so also the challenges/barriers associated with the process of leap-frogging are highlighted. At the end, a simple Emission/Energy Demand Based Strategy depending on energy intensity and necessity is proposed and a very good case-study of leap-frogging to renewables in developing countries is discussed. It is established that, slowly developing countries can and should choose not to be only victims of, but take the opportunity presented by climate change.

I. Introduction

As industrialization became more deeply rooted as the development path for which the current civilization will be known for in history, the associated costs as well as its growing need for the growing global population is posing serious global challenges. From the discovery of steam engine to electricity the global economy and its continuous survival depended for the most part on energy (J. Urry, 2014). Energy and its transitions from one form to another, have always been, and will continue to be, at the centre stage of most human activities (P. Lombadirdi, 2014), that the "history of industrial civilization is viewed by many as history of energy transitions" (Timmons D., J. M. Harris, and B. Roach, 2014). The life of industrialized countries with the sophisticated technologies became energy dependent, and longing for even more energy to increase productivity for the increasing population.

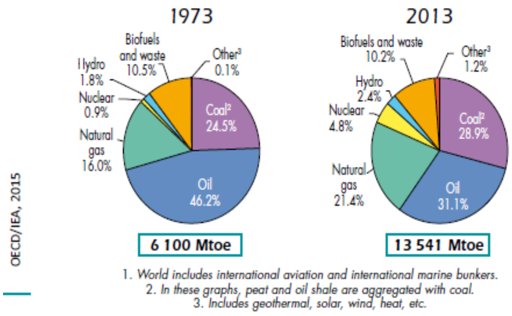

Figure 1. World Energy Landscape.

In the quest to meet the respective energy need of economies, various forms of fuels were utilized by humanity at different times. Currently the most widely used form of energy are fossil fuels consisting of coal, oil and natural gas in combination with nuclear from the last couples of decades and few renewables(of which only bio-fuels and hydroelectricity are significant) here and there. To have clear picture of the world energy supply situation in the last four decades, the International Energy Agency(IEA, 2015) depiction below may come handy.

To meet energy requirements of energy dependent world economy, fossil energy resources were hunted and exploited to maximum possible level until the dangers of such practices became apparent, particularly with global warming and climate change threatening the long-term human survival on planet earth among other concerns (depletable nature, price volatility and unsteady supply of fossil fuels).It took scientists decades, from Kyoto Protocol in 1992 to recent Paris Agreement on climate, to prove the case (though still with some oppositions) and bring world leaders together on greenhouse gases emissions(Elliott L., 2015).

As can be seen above, the dominant role of fossil fuels in the world energy scene specifically in relation to the issues raised here poses risk to not only world energy security, but life on earth itself. Other major concerns include safety issues of nuclear energy particularly with the costs of handling the toxic waste it creates and few cases of catastrophes it resulted in when things go wrong in nuclear plants, the actual economic costs of which is yet to be determined with certainty(B. BF Wittneben, 2012).

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The world attention in terms of energy has now shifted away from fossil energy and slightly from nuclear energy even though, the world will be stuck with these energy fuels for some time before the transition is complete, as fossil energy is currently providing more than 80% of global energy requirement (IEA, 2015). This paradigm shift in global energy scenario, as motivated by the factors stated above will have profound consequences on the global economy in general and individual economies in particular in several ways that researchers are currently working on. It will have effect on energy generation, storage, distribution and trade. It will directly and indirectly, as the case may be, affect national and international institutions at varying degrees that can only be determined through careful studies.

With the 2015 Paris Agreement, it was established beyond questioning that, global warming is true and change in world energy pattern is the first strategy for reversing it. The United Nations (UN), prior to the Paris Declaration, has this in mind when drafting the new Sustainable Development Goals adopted in September 2015 as the 21st century Global Development Agenda for the next 15 years .Energy and climate are explicitly stated as two (2) of the seventeen (17) goals that constitute the new direction of global sustainability the world advances towards (United Nations Gen. Assembly, 2015).

This new world energy transition is in favour of Renewable Energy (RE), the resources of which have proved their safety in consumption to man and the environment, and the technologies of which are now ripe, in some places even cheaper than the fossils and are evolving fast to handle the energy challenges of the 21st century. Renewable energy is not a new form of energy, it has been there since the beginning of life on planet earth. Its utilization remained small to the subsistence level in the underdeveloped and some part of developing world if not of the hydroelectricity generation in the developed nations. Hydroelectricity is however considered environment friendly in consumption, even though it is alleged to be not so friendly to environment from the perspective of large scale production. The share of renewable in the world can be better appreciated in the World Final Energy Consumption illustration below by Green Rhino Energy (2013).

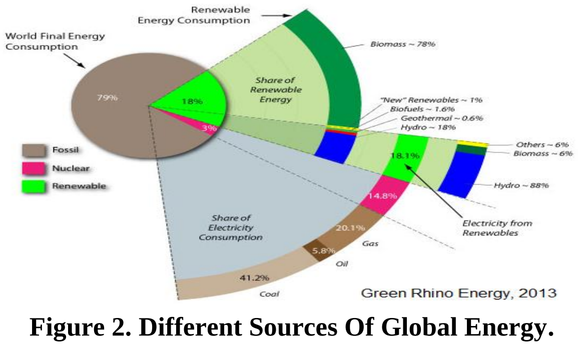

Figure 2. Different Sources Of Global Energy.

The role of RE in addressing the global energy challenges of the growing mismatch between energy demand and supply cannot be over emphasized. Equally, RE has the potential to meet the upcoming energy demand from the developed, the emerging and the least developed nations of the world, thereby helping in addressing the energy challenges of industrialization as well as playing a key role in reversing global warming and climate change. However, while this is easily acceptable when it comes to developed countries, the same is not true for emerging and least developed nations of the world, mainly due to problems of finance, technology and policy as reasons advanced for their inability to engage in intensive carbon emission reduction. On this background, the objectives of this paper are to;

i. Briefly discuss leapfrogging, its nature and patterns

ii. Discuss the energy challenges of developing countries & reasons for slow to non-adoption of RE in developing countries

iii. Estimate the investment requirement as well as economic and environmental benefits of Leap-Frogging for West Africa

iv. Highlight arguments for the possibilities of leap-frogging to renewables

v. Discuss the challenges/barriers to leap-frogging in developing countries

vi. Propose some strategies for leap-frogging in developing countries

vii. Briefly review some case studies of leap-frogging to renewables in developing countries

II. Leapfrogging, Nature & Patterns

It is quite an interesting idea that developing countries can avoid the fossil dependent as well as energy-intensive pattern of economic and energy development by skipping or jumping to the adoption of the most advanced energy technologies available commercially and otherwise, rather than repeating the same pattern of conventional energy based development that was used by the highly industrialized nations in their development journey. K.S. Gallagher (2006) identified two patterns of leapfrogging that are most prevalent are:

1.Leapfrogging by skipping over generations of technologies; and

2.Not only skipping over generations, but also leaping further ahead to become the technological leader.

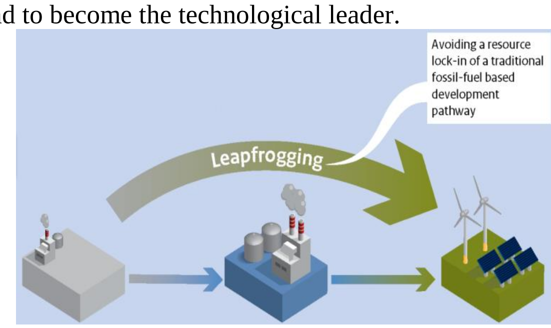

Figure 3. Leapfrogging In Power Sector.

Source: Curbed from PBL (2017)

However, other patterns of technical change that are not necessarily ‘‘leapfrogging’’ but could result in the deployment of substantially cleaner energy technologies in developing countries includes:

1.Encouraging the use of the cleanest technologies available, even if they do not actually require skipping generations of technologies; and/or

2.Deliberately choosing not to adopt more polluting technologies (K.S. Gallagher, 2006).

It is also worthy of consideration to include the recent improvements in energy efficiency within the conceptual spectrum of leapfrogging, particularly in developed countries that have the highest kWh per capita in the world. The costs and benefits of leap-frogging are areas that require careful attention and consideration particularly for developing countries, an attempt at these estimates for West Africa is made in the following section.

III. Investment Requirement/Economic And Environ mental Benefits Of Leap-Frogging

Energy is used in many forms, for various purposes in wide range of economic activities, the covering of which is beyond the scope of this study. However, for clarity's sake, the study conducted a small analysis of costs and benefits of leap-frogging in the area of electricity for West Africa, with a view to determine direct economic and environmental gains in terms of improving standard of living through creation of jobs and avoiding potential CO2 emissions.

Table 1. Africa's Energy Landscape (2016).

Region	Population (Mil. People)	GDP (Billions of CI$/Yr)	Access to Electricity (% of Population)	Power Consumption (kWh per capita)
West Africa	327	1,310.00	47%	188
Sub-Saharan Africa	1033.15	1,512.60	37.4%	480.52
Africa	1223.32	2,186.53	45.9%	779.61
World	7442.14	75,845.12	85.3%	2674

Source: World Bank Data

There are over 600 million people in Africa without access to electricity, and over 750 million rely on traditional biomass (IRENA, 2015). The less than 50% population of West Africa that have access to electricity in the continental sub-region as whole, enjoys a little above 188KWh annually as shown in table 1. One interesting question is, what will be the costs and benefits of giving all West African population access to clean electricity in the following measured standards as shown in table 1;

i. West Africa per capita kWh
ii. Sub-Saharan Africa per capita kWh,
iii. African kWh per capita, and
iv. The Global per capita kWh

Using more recent data and holding other variables as population, time, technology etc. constant, figure 4 depicted the following estimates based on the sub-regional, Sub-Saharan and global kWh per capita listed above;

- the amount of power needed (power shortage/excess demand),
- the average investment in renewables needed,
- the average number of jobs to be created and
- the potential emission avoided.

The aim of this little analysis here is to vividly see what it will take to give all population of West Africa access to at least the current sub-regional, Sub-Saharan and global KWh per capita.

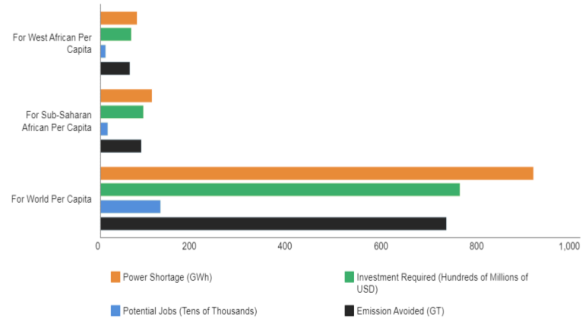

Figure 4. Estimates Of Costs & Benefits Of Leap-Frogging.

Source:Plotted from own calculations using World Bank data

It should be noted that, the per capita for West Africa and Sub-Saharan Africa were recomputed based on real share of population having access to electricity in those regions. However, it can be seen that, for all West Africans to enjoy the present 396KWh per capita of the sub-continent using renewables, they need to produce 76.08GWh of electricity by investing about USD 63.15 hundreds of millions into the renewables.

While this seemed a huge stride to go for, the benefits are worthy of the costs, as they generated at least more than 105 thousand jobs while avoiding over 60 giga-tons(GT) of CO2 emission.On the extreme, for West Africa's populace to reach the current World's 2674KWh per capita using renewables, the needed power to be produced in the sub-region is in the tune of 901GWh, which require the renewable investment of more than USD748 hundreds of millions.The associated benefits are over 1.2 million jobs and carbon savings of over 721GT. The numbers for the Sub-Saharan African KWh per capita are in between the two extremes.Despite these estimated benefits over the costs, the speed at which developing countries, we are considering here, are adopting renewables and efficient technologies is not very impressive. Next section attempts to discuss some of the energy challenges faced by these countries.

IV. Energy Challenges Of Developing Countries

According to United Nations Gen. Assembly (2015), the speed at which the world population is increasing, energy dependent cities/urban springing up through massive urbanization going on in developing countries, the globalization of production, distribution and consumption of high tech commodities and the speed of energy dependent innovation are among the drivers of energy demand. The demand for more energy has been and will continue to increase particularly with the ever increasing aspirations of developing economies to experience their respective ages of mass production and consumption.

In virtually all the projections of future energy production and consumption in the run up to the adoption of SDGs and the historic Paris Climate Agreement in 2015, developing countries are projected to, and in some cases even negotiated to, continue using great share of fossil fuels and their contribution to greenhouse gases, though now small, is expected to continue to increase in the next half a century or more Destouni and H. Frank (2010), International Energy Agency (2014), United Nations General Assembly (2015) and United Nations Framework Convention on Climate Change (UNFCCC) (2015). This need not to necessarily be the case, because, usually these economies are not having the fossil infrastructures now in place, and where there are infrastructures installed, the output generated in terms electricity or transport fuel does not provide a significant share of what is required as K. Kaygusuz (2012) observed that, of the 15% (1.4 billion people) of the world population still lacking access to electricity, majority (85%) are living in rural areas of Sub-Sahara African Countries.

But unfortunately, developing countries were given or perhaps negotiated for little role in the global carbon mitigation war adopted as the 2015 Paris Agreement in the Conference of the Parties (COP21). All the States were invited to submit their Intended Nationally Determined Contributions (INDCs) towards reducing greenhouse gas emissions ahead of COP21. The UNFCCC secretariat published the synthesis report of the 186 national action plans received by December 12, 2015, which ultimately showed that, at the current rate global warming would still be between 2.7°C and 3°C, i.e. above the threshold set by scientists. With these contributions, the target of 2°C by 2100 may be reached, provided we speed up the process. These contributions are the basis of the Paris Agreement and countries are all asked to review these contributions every five years from 2020, for targets to be raise instead of lowered.

Emissions are expected to peak as soon as possible, with the target of carbon neutrality in second half of the century.

Even though the agreement adopted the *common but differentiated responsibilities* (CBDR) for different countries when it comes to climate change as one of the main principles of climate negotiations, depending on their wealth in particular, developing countries can still do more than the agreement required from them. Under the agreement, it is an obligation for industrialized countries to fund climate adaptation and mitigation projects for poor countries, while developing countries are invited to contribute on a voluntary basis. When one quantifies the amount of energy needed to replenish the reduction needed in existing fossil energy and the unavailable supply with both renewable sources and energy efficient technology in developing countries, the role of these countries as well as the prospect of renewable energy within them becomes more glaring in the future green planet with lower carbon emission. The previous section gives a clear picture to this argument, looking at West Africa as a sub-continental region with low income countries. In addressing this huge challenge the usual questions asked are;

1. Do we have the technology? Instead of;

How can we have the technology given the available resources?

2. Can we afford the needed investment? Instead of;

How can we generate the needed investment?

3. Do we have the right energy policies needed in place? Instead of;

How can we design and implement the right energy policies?

The first class of questions block all chances of thinking out of the box, whereas, the second class, the 'HOWs", open a new frontier of trying not to only understand the challenges but also coming up with ways to handle them at the least cost possible. It will also enable the developing countries to begin the process of trying to achieve some carbon mitigation results that will ultimately set them in motion to initiate, now, the process that would have waited for half a century to begin if thing were to continue the way they are. That is to say, instead of sticking to the traditional fossil fuel, as evidences begin to show, developing countries can muster the courage to leap-frog into intensive renewable energy use, as argued in the following segment.

V. Arguments For The Possibilities Of Leap-Frogging In Developing Countries

Is it possible for developing countries to leap-frog to intensive renewable energy use given the challenges that seem to hinder them from doing that? In this section, an attempt is made to highlight the reasons or arguments that can facilitate the possibility of developing countries'leap-frogging into intensive renewable energy use.One may argue that,because of the financial challenges,technology bottlenecks and policy inconsistencies mentioned in the previous section, plus other host of reasons not mentioned, like skills and manpower for the technology,developing countries cannot participate in the on-going renewable energy transition. One of the problems with this thinking pattern as stated earlier is that it blocks all avenues of thinking out of the box, and suggests that developing countries should be stuck where they are,with the fossil fuels.This leads to the realization of yet another problem mentioned in the introduction,that is,most of the developing countries in the world are not having the fossil infrastructures installed on ground presently.The installation of these infrastructures, though easier now that their technology is relatively available, is going to cost the developing countries and may be even more than the renewable technology in the longer term,because of the recent global energy market developments we will be discussing later.However, for few developing countries or more precisely the emerging global powers as they are called, the likes of China and India that have demonstrated a huge advancement in not only the fossil technologies but also the renewables,the above argument made sense, based on the fact that, they have acquired and installed these technologies recently, in fact some attribute their successes to these fossil technologies, hence their increasing carbon emission.Therefore,these reasons or arguments for the possibilities of leap-frogging to renewables is advanced in favour of those developing economies not in the category of the emerging global powers and are currently experiencing power/energy deficits.

With this distinction set clearly,we now turn to the arguments for the possibilities of leap-frogging in developing countries that do not have the required energy infrastructures installed or experiencing energy deficits. The arguments for leap-frogging can be categorized as follows;

1. Availability of Renewable Energy Sources and Resources: these though not evenly distributed around the globe or between rich and poor nations, are relatively available at almost all parts of the world depending on the environmental condition of a given geographic location and based on the type of renewable energy resource in question. A breakdown of the different technologies, resources and possible locations are provided in table 2.

Table 2. Classification Of Renewable Energy Sources, Resources & Technologies.

Technologies	Solar Photovoltaic	Solar Thermal	Biofuels	Wind Energy	Wave Energy	Tidal Range	Tidal Stream	Hydro	Geothermal
Sources	Sun			Wind		Gravitational Forces		Rivers	Inner Heat
Conversion Process	Photovoltaic	Collector	Photo Synthesis	Turbine	Wave device	Turbine / Dam	Turbine	Turbine	
Where?	Anywhere	Anywhere	Anywhere	Best off-shore or near coast	Oceans	Few locations worldwide	Near shore, few locations	most rivers	Few locations. E.g. Iceland

Source: Rhino G. E. (2013)

2. Global Energy Market Trends: the blanket assumption and perception that renewable energy is expensive and uncompetitive is now beyond all reasonable down outdated (IRENA, 2018). The declining costs of renewable energy technology, coupled with other factors as the depletable nature, supply and prices volatility of fossil fuels are adding to both parity and economic feasibility of large (utility) scale renewable projects for various purposes. It was first reported in the mainstream media by Dubai Electricity and Water Authority - DEWA on June 2016, that it will be producing electricity in the project that will come online in 2018, at a cost cheaper than the fossil fuel that it locally produces. This triggered an abrupt rethinking of so many power plants on development stage across the world with declarations from various countries as to their next cheaper than fossil power projects. The years 2016 and 2017 have seen auction results with record low prices for solar PV not only in Abu Dhabi, but also Saudi Arabia, Mexico, Chile, Peru and Dubai with an LCOE of around USD 0.03/kWh. So if RE is now cheaper than fossils at least in electricity production, then, it would be in the best interest of developing countries to go for RE

instead of fossils that would later appear more expensive. Some onshore solar PV and wind project coming online in 2018 and later are observed tobe less than only the variable costs of many existing fossil fuel-fired generators (IRENA, 2018).

3.International Interventions:The United Nations Framework Convention for Climate Change has as far back as 2005, on the foundations of Kyoto Protocol, devised the methods to assist developing countries in their Mitigation and Adaptation strategies. Clean Development Mechanism (CDM), Carbon Trading & Joint Implementation are three of the different strategies that enabled developing countries to access both technology and finance from the developed country for the purpose of easing their transition to cleaner energy sources. On the other hand these same projects enable the developed nations meet the emission reduction targets.

4. Increased Innovations & Advances in RE Technology: New and recent advances in different lines of RE as well as the various kinds of innovative applications of the existing technologies have made the use of RE attractive and cheaper in most instances. For example, the ideas of Flying Wind Farms or Space Based Solar Plants are noteworthy innovations.The Los Alamos National Laboratory in New Mexico made serious advancement recently in Quantum-Solar-Cells that allow highly effective solar cells to double as transparent glass, which has the potential of turning every tall building into a power generating plant Zhao Y. et al, (2014). Equally, advances in other areas as turbine mechanics, reactor technology etc. have made the use of RE more efficient and easy that developing countries can start using now, though mostly at high initial cost that will surely come down later. Additional support to this argument is the global patenting trend in the RET that is at the center of the World Intellectual Property Organization (WIPO)'s 2011 report on alternative energy patent-based technology analysis. It was shown that, from the 1990s, renewable energy technology's annual patent filings increased by 10%, while from 2001 to 2005 it rose by 25% (WIPO, 2011)(IRENA, 2013).

5. Growing Environmental Awareness and Support for Climate Action: quite a number of people are thinking in this line, whom just like in this study, share the understanding that, in most developing countries, the needed energy infrastructure is not in place as indicated by small share of their population with access to modern energy (electricity) and that using appropriate technology, suitable policy options and investment strategy, these countries can significantly enhance the mitigation action by leapfrogging to Intensive Renewable Energy Use instead of repeating what the developed nations have done in their development paths. The Following are worth nothing in line with this thinking;

"The developing countries on their part can legitimately expect the developed countries to take the lead in accelerating mitigation action, and also do more by way of providing financial assistance. However, they must also recognize that they will also have to do more to reduce their GHG trajectory and provide policy stability to foster investment and guide the transition." M. Ahluwalia , H. Gupta & N. Stern (2016)

"Although developing countries are characterized by their dependence on inefficient technologies, they canbenefit from technological advances and leapfrog the technological ladder by adopting cleaner technologies and avoiding the mistakes made by the developed countries in their development process." S. C. Bhattacharyya & G. R. Timilsina (2010).

"Fortunately for Nigeria, the energy infrastructure is still evolving and it is essential that the infrastructure bedeveloped in ways that avoid retracting the wasteful and destructive stages that characterizedindustrialization in the past." NECAL2050 (2015)

"They are going to be skipping the stage where industrialized countries were stopped for a long time, for many decades, ……We were dependent on fossil fuel, which means we now have to concentrate on the transition in the medium to long term of abandoning fossil fuels. But they (some developing countries) have the chance to move immediately to the new technologies." President Francois Hollande of France at annual meeting of the Organization for Economic Cooperation and Development, Paris.The Guardian (2015).

"Africa has significant clean energy resources available that make it technically and economically feasible for 80% of the continent's energy to be switched to renewables from fossil fuels no later than 2030" Mark J. (2016).

Nevertheless, another argument for leapfrogging in Developing Countries is the potential spill-over benefits associated with it, as it will promote technology transfer, energy security, employment generation, skills and capacity development, foreign direct investment as well as cheaper and more energy access for the economy in question. More surprisingly,Marcotullio,P. J., & Schulz,N. B.(2007) observed three important differences in energy trends while comparing the energy transitions of the United States with several developing countries including the slowly ones we are considering here as follows:

- The developing world experiences energy-related transitions at lower levels of income, with faster rates of change in conditions over time, and in a more simultaneous fashion than that of the United States
- Over similar income ranges (i.e., segments of economic growth), current developing economies are using less energy per capita than the United States did historically.
- More efficient economic growth translates into lower systemic environmental impact per capita than that of the United States.

With all these, one might question as to why developing countries are not adopting renewables. Perhaps, a look at the key barriers that hinder the transition at the expected speed is a worthy attempt.

VI. Barriers To Leap-Frogging For Developing Countries

From the start, technology, finance and policy were mentioned as the three (3) main barriers, not only to leapfrogging, but to adoption of cleaner technologies, and as the discussion progresses, we come to the realization that, while there are readily available solutions to these challenges, understanding how to apply these solutions requires a sound understanding of the various dimensions of the trio as well as the fact that, they are not the only challenges to deal with to effectively leapfrog to renewable energy in developing countries.In this section, the paper discusses the barriers to leapfrogging as identified by other studies, with a view to making clear both the obvious and the hidden barriers of leapfrogging.However, we need not to dwell more on the obvious barriers and on the more hidden ones as they are more likely to be ignored, and can make the task of overcoming the obvious barriers much more difficult.

To explain some of these barriers, a topology of the possible barriers to energy efficiency improvement developed by Reddy, A. K. (1991) can be considered for adoption here for its holistic and elaborate approach, at least on the energy value chain, to discussing barriers to energy efficiency improvement vis-a-vis leapfrogging in the case here. Reddy's topology is represented here with some modifications to suit the purpose of this paper as follows;

1. Energy Consumers; Just as relevant the consumers are to the story of energy efficiency improvement, so are they to that of leapfrogging for the simple fact that efficiency improvements is somewhat an integral part of leapfrogging. One cannot expect a smooth transition without having a careful look at the energy consumers situation, who are in some cases the producers (combined generation of heat & power) of energy as well. Difficulty or barriers arises when the consumers are ignorant about new energy technologies, sources and resources, equally so when they are poor or sensitive to the initial cost required for leapfrogging. Difficulty is also faced when consumers are indifferent to sources of energy despite knowledge, or they are helpless, or uncertain. All these cases will lead to situations in which, the decision to leapfrog might either not be made or actualized if at all made.

2. End-User Equipment Manufacturers/Providers; These of individuals can, in their bid to maintain market share and current profits, turn a blind eye to the sustainability and efficiency of cleaner energy technologies. Or as in the case of equipment providers, who turn a blind eye to the operating cost in terms of both financial and environmental costs to the consumer. Though they may be forced to adopt the cleaner technologies either by government policy or fear of competition, they did so at the cost of the consumers who are forced to buy equipment at high price if not subsidized by the government.

3. Energy-Carrier, Producer & Distributer; Here the supply obsessed, the centralization biased, the supply monopolists and the cogeneration blind as explained in Reddy, A. K. (1991) provide a clear picture of the cases in which, cleaner technologies are neglected for the stated reasons, which in turn posed a serious barrier to leapfrogging in Developing Countries with their weak institutions.

4. Local/National Financial Institutions; The supply biased, the unfair and anti-innovation attitude from the local and national financial institutions can be one of most influential barrier to leapfrogging in developing countries and can also lead to same attitude by foreign financial institutions/investors as the local financial institutions provide the first measure of financial risks of their market. The crucial nature of their support cannot be overemphasized in the process of economic growth and development, hence energy transition.

5. Governments/Countries; In this process, the limitless role of governments in ensuring the success or otherwise of leapfrogging can be compared to none, because no transition will take place if the government or country is uninterested, skill-short, without adequate training facilities, without access to hardware & software, capital short, infrastructure poor, sales promoted regulator, having powerless energy efficiency agency, cost blind price fixer, fragmented decision maker, operating with large-is-impressive syndrome and or being a large-is-lucrative sponsor.

6. International, Multinational & Industrialized Country, Funding/AID Agencies;Turning to the international perspective of the leapfrogging process, foreign partners in their different roles and capacities can bring about barriers that will sometimes be difficult to overcome.

Such barriers may result if the foreign partner is inefficient-technology exporter, supply biased, has anti-innovation attitude, large-is-convenient funder, project-mode sponsor, self-reliance under-miner (alias, the dependent perpetuator). From technology, finance and policy angles, foreign partners can facilitate or hinder leapfrogging in developing countries by displaying any of these attitudes towards their leapfrogging technology partners.

However, similar issues were looked from different perspectives by other researchers, most notable include the concern for un-strategic and inconsistent policies, weak domestic technological capabilities, and an apparent unwillingness of more advanced multinational firms to transfer cleaner or more efficient technologies beyond those simply required by standards by Gallagher, K. S. (2006) and the issues of skills & competences, R&D, patents & publications, participation in global technology markets by Walz, R. (2010) among others that attempted to identify barriers to leapfrogging in developing countries in particular as well as in energy transition in general.

VII. A Simple–Emission/Energy Demand Based(Edb) Leap-Frogging Strategy For Re Transition In Developing Countries

Several strategies and methodologies were and are still being proposed and developed over the recent years for the developing countries to utilize this unique opportunity of skipping some steps in their development journey.Most popular of these strategies or methods include the UN's Clean Development Mechanism, Joint Implementation and Carbon Trading and host of other multilateral, bilateral as well as country specific strategies and assistances similar to these.

However, the success of these strategies and methods in promoting renewable energy to significantly contribute in meeting the energy requirements of developing world has not come to its full fruition,as most of them require the involvements and guarantees of governments, (whom in some developing nations are the source of the problem), sophis ticated and long procedures that local businesses are not able to handle, hence, the need for more simpler strategies that involve the key energy players whose actions or inactions have the potential of hindering the success of leapfrogging at the level of developing countries we are talking about. The EDB Leap-frogging Strategy is proposed here for purposes of supporting as well as enhancing the workings of the existing effective methods and strategies already in operation.

The strategy adopts the recommendations of Reddy,A. K. (1991) of relying on combinations of measures at strategic level,in this case, for ensuring energy transition by employing both policy-assisted and market-oriented mechanisms to promote renewable energy technology adoption based on the nature, purpose and area of the energy demand in question. For example, household energy demand can be categorized into different uses, hence different types or sources of energy that should be used satisfy those different uses in the most efficient manner with no or as little emissions as possible.In this process, there is the need to look at the classifications of energy demand, energy technologies and investment options in the process of developing, and deciding from, a set of policy options that combines all these into an actionable renewable energy leapfrogging strategy.

In classifying energy demand, the necessity and intensity of the energy demand on the basis of sectoral projects are two important factors that can help in determining the categories of energy demand and the corresponding energy technologies, investments as well as the appropriate set of policy options.

Necessity is viewed here from the perspective of how essential is the nature, purpose or area to which a particular energy project is intended. Intensity on the other hand gives insight into the measure of the energy efficiency of the purpose or area for which the project is intended. Putting the two together gives the following types of energy demand for this analysis;

Necessity	Highly Essential and Intensive	e.g. manufacturing, construction
	Highly Essential but Non-Intensive	e.g. lighting
Intensity	Intensive but Fairly Essential	e.g.
	Fairly Essential and Non-Intensive	e.g. decorative & festive uses

On the part of energy technologies classifications, apart from the sustainability of supply and other advantages of RE, environmental concerns in terms of emissions of different kind of environmentally degrading substances is another major benefit, hence, technologies that has zero or emit less will naturally be more preferred than those with more emissions.Therefore all categories of sustainable technologies,covering the fossils and renewables,will be considered in the spectrum of technology options categorized here based on their emissions level and the technology choice will be made with environmental and financial concerns in mind as well as the type of energy demand at hand. Here we also consider the technologies being put forward for the reductions of emissions in fossil technologies.

From the investment point of view, it is known that the cost of energy differs from one technology or source to another, i.e. the amount of finances needed for one source of energy is different from the amount needed for another technology.On this note, investment can be strategized in such a way that important and high density demand for energy will be provided by expensive technologies, hence high investment. Equally,when there is a low level demand for less intensive energy, cheaper and less intensive technologies will be utilize using fewer finances. In this way, cheap technologies will be used for less intensive energy demand while expensive technologies will be used for high intensive energy demand. While, the financial concern of these economies will be guiding these decisions in the sense that a carefully laid investment options that addresses both concerns is key to the success of any strategy less that of RE transition, environmental as well as the type energy demand will give some inputs into the decisions. Under this scheme, the costs of different energy technologies will be taken into account to make sure appropriate technologies are assigned to each class/category of energy demand. There are various kind of technologies at different prices for different kinds of applications at different settings. For example, given the fact that the costs of technologies are coming down generally, the cost of solar is the most declining among other technologies. Therefore, it will naturally cost less to invest in solar as it gives every dollar of investment maximum energy output as well as return on investment.

Using unique combinations of the above classifications on case by case basis, the best policy options for every situation can be found within the set of policy options such an arrangement provides in such a way that policies of energy will reflect the different concerns of the economy, majorly the desire to adopt the most suitable energy technologies to produce clean energy in an environment friendly manner that simultaneously takes into account the financial situation and development concerns of these slower emerging economies. These demand based energy policies bring to the table, for governments, combination of energy technologies and investment options based on the nature of energy demand as classified in the energy technologies classifications and energy investments classifications. Under the demand based energy policy system, cost of technologies will be matched with the nature of energy demand in arriving at the decision on how best to supply energy to a given location or sector of the economy. For example, an industrial location will require different renewable energy technologies from what a business areas or residential area might require. Equally, within each of the three locations, different level of income or available investments will lead to utilization of different technologies. At the end, there will be a smooth facilitation of energy transition through leap-frogging into intensive renewable energy utilization using these energy demand based policy options that enable different types of energy demand to be met using different combinations of energy technology and investment options.

VIII. Case Study On Leap-Frogging To Renewables In Developing Countries

Here we will concentrate on a single renewable source, solar, being the most widely available and relatively cheaper and easy to use. We will also focus on the success stories and impact of a unique approach developed in India, where the most unlikely segment of the most remote communities of the least developing world are being empowered to make a difference and push the whole community forward on the track of growth, modernization and development. Barefoot College is a concept conceived, developed and founded by Sanjit "*Bunker*" *Roy* an Indian social activist and educator since the year 1972, where they"…..designed new ways to nurture and support a journey to empowerment, one village at a time, one woman at a time" and their uniquely unbelievable method and strategic focus on Least Developing Countries to "….demystify and decentralize technology and put new tools in the hands of the rural poor with a singular objective of spreading self-sufficiency and sustainability", has left an indelible developmental mark in the communities involved, the result of which will definitely spur more local innovations to tackle local challenges. Barefoot College have recorded some important success stories over the years in areas ranging from education, health, water sanitation, crafts, energy etc. in some of the remote communities of Asia, Africa, Americas & Small Island Nations.Narrowing down to the scope of this paper, the energy case study will be highlighted to show case practical Leap-Frogging possibilities at the most remote parts of the developing world.Till date, Barefoot College Solar Engineers have electrified about 18,047 households in about 83 countries, saving about 4,020 grams of emissions from domestic lighting, heating and cooking. Among the solar application solutions developed at Barefoot include those for lighting, water heating, water desalination and parabolic solar cookers.This is a clear case of Leap-Frogging where traditional fuels were completely removed from the household energy-mix using solar technologies that are readily available at the hands of the poor and illiterate villagers, taking charge of their lives and solving their own problems in the best way possible by skipping fossil (kerosene etc.)and switching to renewable technology (solar).

IX. Conclusion

From the discussion and analysis in the study so far, it can be seen that, renewable energy have come a long way in altering the global energy mix, if the current trend is to continue. And from all indications, the odds are that, we will be seeing tremendous increase in these trends, despite some of the challenges the world is currently facing.

Developing countries do not have any excuse not to use renewable energy now, particularly those that do not have fossil deposits within their borders. The major challenges and barriers to leapfrogging from technical, finance to policy are all addressed in one way or the other, while the benefits are ever increasing, so the strategies to adopting them. There are more examples to copy from now than ever and as such the expectation for developing countries to heavily launch into the use of renewable energy is adequately justified.

However, one other major area of challenge for developing countries that even though there are solutions to, will take some time to cover is the area of human capital and the capacity to receive the new energy technologies that will come with it. Therefore, government and businesses in these countries should incorporate these issues in the new energy, climate and environmental policies.

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