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Modern Microeconomics Renewable Energy

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Abstract: *Renewable energy is widely regarded as future substitute to fossil fuels mostly because it is self-replenishing and environmental-friendly. However, its use in the electricity industry is presently limited because it is about four to eight times more expensive than fossil fuels. This paper examines the global macroeconomics of renewable energy in electricity utilization from the perspective of a developing country such as Nigeria and the rest of Africa. The energy macroeconomic variables examined are access to energy, cost-competitiveness, electricity demand supply curve, net energy ratio, entropy, capital intensity, environmental externalities, energy efficiency and dispatchability. The implications of each of these macroeconomic variables projected future outlook of the energy industry with particular reference to electricity utilization and recommended strategies for developing countries are also examined.*

Key words: *Electricity, Energy, Fossil fuels, Macroeconomics, Renewable Energy.*

1. INTRODUCTION

The world is an energy economy. All forms of existence on earth and in the universe, both living and non-living things, contain energy in different forms and quantities. The total amount of energy in the universe is fixed because according to Isaac Newton's Law of Motion, energy can neither be created nor destroyed. The survival of mankind through the ages has revolved around the transformation of energy from one form to another. The greatest challenges to man's energy transformation activities are cost and energy losses associated with the transformation processes and technologies, Renewable energy in the form of wood was the first major global source of energy before it was displaced by coal during the Industrial Revolution of the 18th century. The discovery and exploitation of petroleum oil and gas led to its dominance as a global source of energy during the Second World War and it has remained the dominant source of energy till today. The Middle East Oil Embargo of the1970's which led to global shortage in the supply of crude oil and huge upsurge in the international price of crude oil and spiraling inflation in Europe and the United States served as a catalyst for the western countries' drive for improved energy security through the reduction of dependence on

imported fossil fuels for electricity generation, heating and mass transportation (Faninger 2012). This is the reason for tremendous increase by western countries in research budget to develop alternative energy sources to fossil fuels that will be commercially competitive and readily available. This is contrary to the perception today that the main driver for the developed countries' interest in renewable energy development is carbon footprint reduction and concerns about externalities associated with environmental pollution (Stokes 2015).

An understanding of the most important and distinguishing characteristics of electricity is crucial to understanding its economics. These characteristics are unstorability (due to the high cost of doing so), society and government perception of electricity (as a merit good or a social good) and the inelastic nature of demand-supply curve of electricity. These features are examined in detail below.

2. Macroeconomics of Renewable Energy Development

The macroeconomics of renewable energy will be examined from the following perspectives:

a) Self-replenishing and uncontrolled access of renewable energy resources
b) Cost-competitiveness of renewable energy resources
c) Inelastic demand-supply curve of electricity
d) Net Energy Ratio, Net Energy Gain (NEG) and Entropy
e) Capital Intensity
f) Environmental externalities
g) Energy efficiency and energy subsidies
h) Dispatchability

a. Self-replenishing and uncontrolled access of renewable energy resources. Renewable energy resources can be regarded as public goods or quasi-public goods because they are inexhaustible and access to them is almost uncontrollable. While renewable energy resources have value in use, they do not have value in exchange since they are available to all and their consumption does not diminish the amount that is available for others to consume (characteristic of public goods). These characteristics exposes renewable energy resources to the Tragedy of the Commons whereby their uncontrolled consumption can as a result of destructive self-interest, lead to damaging exploitation behavior. This is because the utilization of renewable energy resource provides no incentive for individuals or the users to preserve the resource. This can have a future military application through the transformation of uncontrolled access to renewable energy resources especially as solar energy, to deliberately limited access to energy sources.

b. Cost-competitiveness of renewable energy resources. There are two major sources of energy for electricity generation namely fossil fuels and renewable energy sources. Fossil fuel power technology has a well-established global supply chain network and has become acceptable, available and affordable to people all over the world. In contrast, renewable energy technology is more recent, less well researched and developed, relatively more expensive and does not yet have established global supply chain infrastructure. Some countries in recognition of the commercial shortcomings of renewable energy technology when compared to fossil fuel power generation technology, have introduced various schemes that makes the former more cost-

competitive, e.g., UK's Renewable Obligation (RO) certificates. On the other hand some other countries such as Nigeria are yet to develop policies that will make renewable energy competitive with the dominant fossil fuels. With the pace of progress being made in renewable energy development, it is projected that in the next few decades, the unit cost of renewable power generation may be as cheap as that of fossil fuel power generation.

c. **Inelastic demand-supply curve of electricity.** Electricity is inelastic in many countries because it plays a central role in the everyday lives of people and there is yet no viable and competitive alternative to the roles that it plays in the society. Irrespective of the price of electricity or the quantity in supply, its demand will barely be affected. Consequently, in many developing countries where there is a strong societal perception of electricity as a social good, governments impose a price ceiling on electricity tariff in order to make it affordable for the citizens. Even in the developed countries where electricity is perceived as a merit good with emphasis on its efficient supply, social welfare schemes are put in place in order to make the lower segments of the society are able to pay for electricity - a further recognition that there is yet no commercially competitive alternative to electricity and hence the reason why electricity has inelastic demand-supply curve. Debates still persist concerning whether electricity markets should be free-floating or government controlled via price ceiling and other control mechanisms.

d. **Net Energy Ratio. Net Energy Gain (NEG) and Entropy.** Net energy ratio or Energy Return on Energy Invested (EROI) is the energy available for final consumption divided by the expended in producing it. A related expression is Net Energy Gain (NEG) which is the difference between energy that can be usefully consumed and the energy that is spent to make it available for consumption. Fossil fuels contain energy in concentrated form and have low entropy and more energy available for useful work/consumption compared to renewable energy resources which are characterized by energy in dispersed form and higher entropies. This is illustrated in Table 1 which shows that renewable energy resources have lower net energy ratios than fossil fuels. From an energy management perspective, this makes renewable energy resources more expensive to process for final consumption.

Energy source	Energy category	Net energy ratio
Shale oil	Fossil fuel	5
Natural gas		10
Oil (global)		35
Coal		80
Ethanol (sugarcane)	Renewable energy	0.8-1.0
Ethanol (corn-based)		0.8-1.0
Biodiesel		1.3
Photovoltaic cells		6.8
Wind		18

Hydropower		>100

Table 1: Net Energy Ratios for Fossil Fuels and Renewable Energy Sources (Source: Timmons, Harris and Roach 2014a)

e. **Capital intensity.** Accordingly to IRENA (2016), in terms of capital intensity, renewable energies have considerably higher capital costs per kW compared to fossil fuels and thus are more capital intensive - refer to Table 2. However, renewable energy resources have much lower operation and maintenance cost compared to fossil fuels. Total Cost of Electricity Produced (TCOE), also called Levelized Cost of Electricity (LCOE) or Levelized Energy Cost (LEG) is used to calculate the net

Energy source	Energy category	Capital cost($)/kW
Natural gas (combined cycle)	Fossil fuel	1,019
Coal (advanced pulverized fuel)		3,607
Hydropower	Renewable energy	3,915
Wind (onshore)		8,852
Biomass		9,089
Wind (offshore)		17,800
Solar (photovoltaic)		19,365
Solar (thermal electric)		25,335

Table 2: Capital Intensity of Renewable Energy and Fossil Fuel Sources (Source: Timmons, Harris and Roach 2014b)

Present value of the unit cost of electricity throughout the life time of the plants that produce the electricity (Dyesol 2017). An ideal energy source should have low capita! intensity. It is expected that sustained research and development will continue to reduce the capital intensity of fossil fuels and renewable energy resources for power generation.

f. **Environmental externalities.** Externalities are the costs of benefits that affect a person or party without their consent or input and which usually does not reflect in the cost of the activity that produces that cost or benefit. Environmental externalities are the costs or benefits that affect the environment as a result of the execution of an economic activity. Generally speaking, renewable energy utilization generally produces lesser negative environmental externalities such as pollution compared to fossil fuels that generate a lot of it. Externalities whether positive or negative should ideally be completely internalized in order to fully capture the total cost of electricity generation, moderate producer and consumer behaviour and promote efficiency (Borenstein 2012). The full integration of the cost the of the of all environment externalities into levelized energy cost (LEC) for power generation will significantly increase the unit cost of power generation from fossil fuels and thus enhance the cost-competitiveness of renewable energy power generation. Most developing countries such as Nigeria have very low recognition of the economic cost of environmental externalities associated with power generation activities.

g. **Energy efficiency and energy subsidies.** Renewable energy suffers from resource intermittencies (mainly solar and wind) and have lower dispatchability compared to fossil fuels especially natural gas.

3. Implications of Macroeconomics of Renewable Energy Development

Fossil fuels, as finite and exhaustible energy sources, have a limited period within which they can be relied upon to supply global energy needs, unless a form of technology leads to changes that will make this inapplicable. Unless another form of available energy source is presented, renewable energy resources will remain the most potentially viable alternative energy source to fossil fuels. This makes it imperative that people, the society and governments to have a more active interest in the activities of scientists involved renewable energy research and development. Economic cost, defined by affordability in energy security 4 A's, is the most important criterion that determines the viability of any alternative to fossil fuels.

Different countries attach different weights to the economic indices enumerated above that affect renewable energy development. In developing economies with low per capita income, inadequate power generation capacity, low level of infrastructural development and numerous competing socio-economic challenges such as Nigeria, capital intensity (capital cost of development) is probably, the most important economic index to consider in making an investment in renewable energy development. The internalization of environmental externalities is the least important factor. On the other hand, in developed countries of United States and Europe with already well developed physical and socio-economic infrastructure, sufficient power generation capacity, high per capita income and high standard of living, relative cost-competitiveness and environmental externalities will likely be the most important criteria for renewable energy investment decisions. These factors apply to both public and private sector investment decisions in renewable energy projects. While taking cognition of these factors that influence today's investment decisions, it is also important to develop adaptive strategies for the economic variables that will affect renewable energy investment decisions in future.

One major index that can significantly affect renewable energy decisions in the future is the International Seabed currently managed by the International Seabed Authority (ISA). It is estimated that there abounds in the international seabed, a vast amount of fossil fuels (coal, oil and gas) deposits and renewable energy (wind and wave energies) resources. The fossil fuels deposits in the international seabed are reputed to be more than the presently known proven fossil fuels reserves added together. Similarly, the whole energy of the vast oceans and open seas in the international seabed is also known to be enormous. However, the geographically fluid and non-restrictive nature of renewable energy resources brings into perspective ownership and rights over them. For example, in the absence of international delineation over the International Sea Bed (ISB) which is reputed to contain the largest amounts of fossil fuels as well as tidal and wave resources, and since the economic value of any commodity is derived as a function of its limited supply viz-a-viz demand and the existence of ownership rights over it to a finite number of persons, it becomes challenging and important to determine the true economic value of the resources abundant in the ISB by the time technology development makes commercial exploitation of the ISB resources possible and competitive. The determination of the economic value of a commodity is fundamental to the assignment of a basis of exchange in a market between suppliers (supply side) and consumers (demand side).