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Looking into the energy future of developing nations (a case for nuclear technology)

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ABSTRACT

The energy poverty being witnessed in many developing countries and the fear of a deteriorating environment are some of the factors driving the nuclear renaissance. Over the years, global energy demand has continued to increase without matching supply, giving signs of impending energy crises. The argument for nuclear technology seems to sound more convincing in the face of these problems. After more than two decades following the accidents of Chernobyl and Three Mile Island, the fear of global warming allegedly coming from fossil fuel seems to be trumping the fear and apprehension associated with radiation. With the rise in trade and industry in many emerging economies, the proponents of nuclear technology have been advocating for its usage in some of these developing nations. This paper examines different alternative energy sources. It also explores the potentials of nuclear technology vis-a-vis the environmental, health and safety issues. **In** conclusion, the paper contends that even though nuclear energy has great potential, and is capable of providing emission free energy, the financial cost, security, environmental health, and safety implications of its usage currently makes it an unrealistic means for most developing nations.

Introduction

Many people in developing nations live in infrastructural deficiency. The most pronounced of this lack of electricity. Even though some of these countries (especially in Africa) have huge reserves of natural oil and gas - the world's main sources of energy, such abundance has not been reflected in power generation. As the world's population increases and many citizens of the developing nations become more enterprising in an attempt to break the shackles of economic hardship, energy demand has been on the rise. In an attempt to generate more energy to support their strategic economic programs, policy makers in developing nations are diversifying their search for a viable means of electricity generation. The bid to join the league of developed economies in the so called global village is intensifying. In addition to the global warming concerns, the increase in population has made the search for viable means of energy, devoid of any emission, so frantic. In this attempt, energy experts are pushing for different alternative sources in order to save our planet from degradation by curbing the environmental hazards allegedly caused in part by fossil fuel..

Energy demand over the years has continued to surge without a matching supply, giving signs of impending energy crises. According to Wolfe, "third world population growth and economic development are setting the stage for an energy crisis in the next century." Energy poverty is about to become the number one issue, not only to the developing nations, but to the rest of the world. With the concerns of global warming as the driving force, energy issues have assumed a global socio-economic and political dimension. Among the energy alternatives, nuclear technology has elicited the most controversy. The security, environmental health and safety implication of the technology has been of paramount discourse even after more than two decades following the nuclear accidents of Chernobyl and Three Miles Island. However, recently enthusiasts of nuclear technology have launched a renaissance, using the energy-deprived developing nations as a lunch-pad.

Background of the Problem

Economic activities in most African and Asian countries have been increasing. Medium and small scale industries have sprung up in countries like China, India, Nigeria, and Ghana, and experts have predicted that the trend will continue. This has necessitated the need for improved power generation. More homes are being built.. The citizens are becoming more enterprising in an attempt to improve their economic standing. However, there is lack of sufficient power that could match the rate of development. A typical case is Nigeria. With an estimated population of about 130 million people, the question of power generation has remained unanswered for most of the citizens. With huge natural gas and petroleum reserves, most of the citizens do not have access to basic electricity. In many oil rich economies, life is characterized by lack, deprivation and crises, occasioned by civil disturbances for the basic means of livelihood. For the policy makers, figuring out the best supply source has proved elusive and difficult over the years, and the desperation of the citizens is of untold proportion. NEPA (National Electric Power Authority), a long time agency ofthe federal government was supposed to generate and distribute electricity (by hydroelectric means). However, the agency was characterized by inefficiency in the discharge of its function. The excuse for inability to generate enough power is too obvious; low water level in the rivers and dams occasioned by dry season. In a bid to mock the fate of the power agency and the citizens, a Nigerian musician once revealed the proper meaning ofNEP A in a satire, nicknaming it as 'never-expect-power-always.' It is this caricature that revealed the operation of the agency; intermittent power supply. Even changing the name to 'Power Holdings of Nigeria' (which was perceived by many as an attempt to diffuse the mockery of its previous name) has not reflected in the efficiency of their operation. The change, according to policy makers, was in conformity with Vision *20120* - an economic strategy that will purportedly transform the nation's economy and position it among the world's 20 best economies by

the year 2020. And it is in the same gesture that the energy policy makers have embraced the nuclear renaissance. A report by *USA Today* indicates that many countries such as Yemen, Algeria,, Egypt, Jordan, Nigeria, are proposing building reactors for energy generation.

The greatest challenge facing humanity today is to alleviate the energy poverty of an increasing populace and doing so in a more environmental friendly fashion. The environmental and security connotation of energy has made it a global concern. Energy policies in the developed world are often geared towards green issues, energy independence and environmental sustainability. However, in the developing nations, policies are aimed at providing energy irrespective of means or effects. Put differently, greenhouse gas emissions are less important issues to developing nations, hence China was exempted from Kyoto based on the argument that it needs energy assistance to sustain its emerging economy. So it could burn its coal. Burnings also take place in the other remote villages of Africa and Asia, but in contrast, it is the woods, wild life, and unclean fuels that are being burnt. The motive and objectives are the same; in search ofthe much needed energy. According to the Food and Agricultural organization (FAO) "most people assume that global warming is caused by burning oil and gas. But in fact between 25 and 30 percent ofthe greenhouse gases released into the atmosphere each year - 1.6 billion tones - is caused by deforestation." Mundane and archaic means such as felling trees for fuel causes deforestation and adds to the global warming conundrum.

The Great Disparity

The international atomic energy agency reports that "per capita electricity consumption is as low as 50 kilowatt-hours per year" in some of the developing countries. According to that estimate, this quantity "translates to an average of 6 watts- much less than a nonnallight bulb - for a person." The inequity in world's energy consumption is also shown in a 2001 study. The world's energy consumption stood at 10.20Gtoe (Giga tons of oil equivalent). Africa with a population of about

0.812 billion had a share ofO.52Gtoe. This represents a meager 5.1% for a group that makes up 13% ofthe world's population (see table below). Even with huge amount of oil and gas reserve, most African and Middle East economies still lack the capacity to translate this abundance into reasonable electricity generation. This fact makes the energy conundrum more ironic. In many villages of Africa and Asia, people trek for thousands of mile to fetch ordinary drinking water, they cut trees and set wild life on fire in order to get wood to cook their food. Heating of homes is a luxury that is highly unaffordable. Compared to their counterparts in the developed nations, electricity consumption is 150 times less.

Energy consumption in various region: 2001 (adapted from Cugnon p. 236)

	Energy consumption (Gtoe)	Population (billion)	Consumption Indice (toe/capita)
EU	1,50	0,380	3.95
Africa	0.52	0.812	0.06
Latin America	0,45	0,422	1,06
Asia (excluding China	1,15	1,935	0.59
China	1,15	1.278	0.90
FomerUSSR	0.92	0.289	3.18
Middle East	0,38	0.169	2,31
USA + Canada	2.50	0.317	7.88
Rest	1,15	0.500	
World total	**10.20**	**6.102**	**1,67**

(1 toe = one ton oil equivalent)

A look at the energy sources of African and Asian developing nations reveals that oil and gas forms the principal supply. This is complimented by other sources such as woodfuel.. Nigeria, the 5th oil exporting nation to the United States has more than 6000000 (billion cubic feet) proved natural gas reserve, according to the U.S. Energy information administration. However, it generates about 3000MW of electricity (from many sources ranging from hydropower to woodfuel) for its teeming population of about 130 million. Such meager quantity of electricity makes it hard for economic

development and industrial sustainability - which are sure means of stemming the tide of poverty. Many people here still rely on woodfuels lighted in open flames for domestic purpose. Farmers resort to old ways of drying crops in the open air while many home and industrialists depend on nuisance and smoke-gusting power generating sets. How long can the world cope with the devastation of deforestation and its environmental consequences as a result of nature and wild life destruction. Should the world continue its dependency on the depleting petroleum? What about the emission laden coal and natural gas? Do we keep recycling the ever-ephemeral hydropower? What of the nature-dependent wind and sun. Can we live with the high risk and dreaded nuclear technology. Where is the remedy?

Energy issues

Nuclear technology elicits much controversy of all alternative energy sources. Because of it's supposedly non-emission capabilities and the contrasting radiation issues, authorities are in discord about the real criterion. The debate is hinged around emission, radiation, waste disposal and economic factors. For more than two decades experts and non experts have all been mired in a war of words, facts, figures and statistics about the safety, and economic feasibility of nuclear reactors especially in developing nations. Transcending different disciplines, nuclear safety has been in the forefront of public discourse, with environmentalist, lawyers, scientists, and public affair analysts proffering different opinions. Some of the topic (such as radiation) - fluid, engaging, and ever-evolving seems to be wrapped in some elements of myths, very inscrutable to the minds of an average person especially in developing countries where there are about "39 nuclear plants" out of the world's 440 (Baird par. 3). All forms of power generation give rise to safety, environmental and economic issues. Among other issues, radiation and carbon dioxide emission are matters that need to be addressed. Unraveling these mysteries to an average person who sees nuclear technology as a call to

nuclear arms race, dirty bomb and radiation exposure will require more than the political maneuvering being embarked upon by politicians.

As a result of the events of Three Mile Island, Pennsylvania, USA in 1979 and that of Chernobyl, Ukraine in 1986 the public's apprehension of the high risk of nuclear technology will persist for a long time. The two accidents have stood out to stunt the development of nuclear technology by spurring the public against it. The effects of those accidents were instrumental to the decline in the deployment and use of new reactors in the United States. Even after more than two decades of improved safety regulations and successful use in places such as France, there are still lots of concerns on the safety and security of reactors, especially in the event of an accident (natural or manmade) which could release radioactive materials into the atmosphere. However, contemporary issues such as global warming and impending energy crises seem to be trumping the fears and effects of the two accidents. As the world's population is projected to be around 9 billion within the next ten years amidst dwindling energy sources and degrading environment, energy policy makers are looking beyond the fears and sentiment (some of which are based on mere exaggerated opinions rather than facts) about nuclear energy. Global population and economic activities has continued to increase, and the international energy agency predicts that there will be about "53% increase in global energy consumption in 2030 - and 70% of the [new] demand will come from developing countries," where, in the words of Cugnon, "1.6 billion people are in energy poverty" (236). Here comes the nuclear solution: really?

History of Nuclear energy

Nuclear energy is an offshoot of the Manhattan (nuclear) project during the Second World War. The deployment of nuclear bomb in Hiroshima ushered in the nuclear age. Subsequently, the technology

has been used as a means of energy, surpassing the initial destructive and myopic intent.. The establishment, by the United States Government in 1946, of the Atomic Energy Commission (AEC) opened up the nuclear industry and allowed civilians to have access to information and facilities regarding its uses. Since then, civilians have been involved in nuclear energy, as it has continued to be part of contemporary and highly energy-hungry society. The United Nations International Atomic Energy Agency (IAEA), established on July 29 1957 oversees the peaceful application of nuclear technology. It monitors the industry, using several means to inhibit military use. It gives guidelines and regulations on the minimum level of radiation (including those coming from reactors) which is permitted and considered safe in our environment.

Socio-economic needs of society coupled with issues related to radiation and emission have led to innovative reactor technology. These advancements and needs have given rise to reactors such as light-water reactors (LWRs), Liquid metal reactors (LMRs), gas cooled reactors (GCRs). Generation IV reactors are touted to have the capability of automatically shutting down - to prevent spill of radioactive materials - in the event of an accident. These reactors generate abundant energy, devoid of environmental emission that is characteristics of a typical fossil fuel plants.

Changing Technology

Reactor innovation today has assumed a compact and portable dimension. Progress is being made towards smaller commercial reactors termed Generation IV. Because in the past century, petroleum, coal and natural gas have dominated the energy equation, there has not been a significant improvement in reactor research. With Chernobyl and TMI, many developed nations slowed down on building new reactors. Hence there was no great stride in reactor innovation. But the tide is changing. According to Fanchi "increasing trends in population and consumption, price volatility, supply

instability and environmental concerns are motivating changes to the energy mix and energy strategies in the twenty first century" (24). The increase in global economic activities in developing nations as a result of poverty improvement drives by many nations has given rise to more enterprising citizens. Utility companies are reshaping and streamlining their activities and pushing for smaller and commercial reactors. In an attempt to meet the challenges of the emerging markets, energy companies are diversifying their source of generation. Part of the move is by championing the course towards producing portable 'grid appropriate' reactors that will serve the needs of developing nations. According to a report, the US department of energy's Oak Ridge National Laboratory (ORNL) is building nuclear reactors that are "cost effective and a better-fit for developing nations," and many developing nations are embracing the gesture aggressively.

Globally, nuclear power seems to have made little impact.. Fossil fuels still dominate the electricity market.. Its indispensability is obvious as it contributes about 65% of the world's electricity need compared to nuclear power's 16%, wind's and hydropower's 19% (see adapted diagram next page.) But one thing is obvious; the fear of global warming (whether real or imagined), the quest for energy independent western nation such as U.S. and the desperation of energy-deprived developing nations such as Nigeria seem to be overriding the fear of nuclear accidents like Chernobyl..

Greenhouse Effects

The effects of greenhouse gases (from fossil fuel) results to heated arguments on the real causes of global warming. These gases, mainly carbon dioxide from petroleum, natural gas and coal have been a major concern to energy experts. Reports indicate that about "25 billions of carbon dioxide is released" into the atmosphere by fossil fuel yearly (Baird 9). Even though controversial, there has been proof that the increase in the use of carbon emitting fossil fuels has a lot to do with global

warming. In recognition of this fact, the office of fossil fuel in the United States Department of Energy developed two major plans to reduce carbon emission. The strategies involve "making fossil energy systems more efficient" and "capturing and sequestering greenhouse gases." These will help to reduce "carbon emission that contribute to global climate concerns" According to the Department;

> "the first approach focuses on innovative technologies that boost the fuel-to-energy efficiencies of both coal- and natural gas-fired power plants. The second approach might one day virtually eliminate concerns over emissions of greenhouse gases from fossil energy systems. Carbon capture and sequestration systems could store, convert, or recycle greenhouses gases, preventing them from building up the atmosphere."

Finding ways of taking advantage of the base-load power generating capabilities of fossil fuel is a good way of providing constant and reliable electricity. Coal generation is cheap when compared to sources such as wind and nuclear. And there is abundant of it. In the United States for example, it forms the major source electricity generation. Hence the ultimate coal challenge is figuring out how to reap the benefit of its base-load power and doing that in a more environmentally friendly fashion. Achieving both objectives seems to be economically unrealistic because carbon capture and sequestration technologies will definitely erase the cost effectiveness advantage that coal has over other sources.

With such a scenario, the nuclear mantra of 'base-load power' and 'emission free' generation sounds appealing. The world-wide yearn for reliable and affordable electricity that is devoid of greenhouse gases has gained the interest of energy policy makers in developing nations. And they are responding in nuclear terms. According to a report, "twenty two out of the 31 nuclear power plants connected to the world's electricity grid have been in Asia, driven by the pressures of economic

growth, natural resources scarcity, and increasing population." The improvement in electricity supply in India and China today, for example, has been attributed to their aggressive pursuit of nuclear technology program. Such feat is always used as reference point for which nuclear proponents tends to return to in pushing their agenda in the African continent..

In the past, the bulk of electricity generation in most developing nations has been borne by hydropower. Hydroelectricity does not contribute to any kind of emission. But such source has not been efficient because of its unreliability attributable to environmental limitations: low water level during dry season. Today different forms of alternative energy such as clean coal technology, nuclear energy, wind energy, geothermal energy and hydrogen energy are being touted to be the best option. Bearing in mind that most electricity problem in Africa stems from lack of generation, one can argue that it is only coal and nuclear that can generate the needed 'base-load' with low outage or maintenance time. From greenhouse point of view, nuclear energy and hydropower seems to rank high. According to Balat,

> "Large hydroelectric power plants and nuclear power plants (NPPs) are the only proven both economically and technologically, techniques able to replace [preferably, compete] fossil fuels in the production of electricity. The development of hydroelectricity is limited by severe environmental constraints. Thus, nuclear power is the only realistic possibility to reduce C02 emissions while providing more reliable energy to developing countries. In a probable distant future, new forms of renewable energies could concur with nuclear power to curb C02 emission. Meanwhile it is wise to push the nuclear contribution to its limit.."(382)

And pushing it to its limit the proponents are doing, touting it as the 'all in all' of the electricity problems of the developing world without setting in place necessary safety and environmental regulations. Many countries in Africa today are embroiled in one form of civil or religious war. The political instability coupled with technological incompetence experienced in many developing nations poses a lot of risk of a devastating nuclear accident.. Such scenarios remind one of the nuclear accidents of Chemobyl (even though the Chemobyl reactor was operated by technically competent fellows).

Economic Issue

There are varied opinions on the actual cost of building a reactor. Varied estimates shows that it costs as much between $1200 $3000 for lkW of electricity. Some estimates have even suggested $4000 for a kilowatt. The fact remains that the capital cost of nuclear reactors today are high and in most countries, they are heavily subsidized by government.. So the economic decay that ravage most developing nations in African and Asia today can not allow their governments the willingness to sink billions of dollars into projects that will take years to realize its return on investment.. From cost point of views, the argument does not favor nuclear energy in developing nations. Ian lowe sums up the arguments against nuclear energy in developing country when he posits that

> "... nuclear power is not a rational response to the legitimate material aspiration of a typical developing country. It is too expensive, too risky, too inflexible, too slow and would require huge investment in the skills needed to safely operate and responsibly regulate the industry."(19)

At present, the economic, technological and safety arguments of nuclear energy disfavor developing nations. Because the technology is still in the infancy and renaissance after more than two decades of

staying in the energy limbo, pursuing it aggressively in developing nations at this stage may deal it a devastating blow that will make Chemobyllook like a child's play. Such situation will set the technology back and it might never recover..

Radiation

Apparently, safety and health issues associated with radiation have been one of the major a drawback to the development of nuclear power because of its deadly connotation. It is true that nuclear reactors produce a great deal of radioactive materials. Ordinarily, these materials - subatomic particles traveling in the air at a great speed of up to 100,000 miles in a second - can penetrate deep into our bodies, causing diseases like cancer or genetic defect in later generations. However, the chances of occurrence are very rare and the amount of radiation that occurs to our environment from nuclear reactors is allegedly very negligible when compared to radiation from other natural sources.

Radiation is measured in millirem. World agencies such as IAEA and WHO oversee and establish minimum amounts of radiation that are supposedly safe for health and safety, even though no level of radiation exposure (no matter how small) is perfectly safe. A single particle, out of the thousands of exposures to the body, could be deadly. However, the chances that it will do so is rare; it is "only one chance in 30 quadrillion (30 million billionj)" (Kaku and Trainer 70).

It is important to note here that there are several uses and advantages of radiation. For example, radiation is used in industrial application to check for faults and deformities in industrial appliances like turbine blades and steam boilers. The body is exposed to radiation during an X-ray at the hospital.. The impression that all radiation is bad is a misconception, an apparent misrepresentation of fact. If it were true, virtually everybody would have been cancer patient by now because "each ofus ... is struck by about 15,000 ofthese particles of radiation from natural sources

every second ... " (Kaku and Trainer 70). Through X-rays, air plane travel and other sources, the human body is exposed to radiation. The chances of contracting a disease, cancer for instance, from a single exposure to these radiations are very uncommon.

Radiation, scientists say, is not something unusual; a form of energy floating freely in our environment that has been part of our human existence. Some of them like potassium -40 (K-40) is a "constituent" element of our body tissue (Kaku and Trainer 48). According to Kaku and Trainer,

> Since 1 millirem is a typical radiation exposure in highly publicized incidents - for example, the average exposure received by nearby citizens in the area of the Three Miles Island accident in Harrisburg, Pennsylvania was 1.2 millirem - let us pause to give some perspective on the dangers of 1 millirem exposure .... Such exposure has one chance in eight million of causing a fatal cancer, which corresponds to reducing life expectancy by 1.1 minutes. This is the amount of life expectancy we could loose from taking three puffs on a cigarette, eating ten extra calories (e.g., one lick on an ice cream cone) if we are overweight, or being exposed to typical city air pollution for one week.. (72)

This implies that it is more dangerous (radiation wise) to live in cities like Beijing, Lagos and other metropolitan cities that is characterized by a high rate of industrial pollution, than to live near a normal working nuclear reactor. There has not been any proof that the natural occurring radiations have mutated the genes. However, in a nuclear accident, excessive exposure of about 3000 - 50000 millirems could occur. With most developed nations, there is an apparent disregard for occupational safety. Lack of industrial regulations and labor standards, non compliance for basic safety principle, blatant abuse of operational procedures and incompetency (and the list goes on) are among the factors that could contribute to human error, that could cause accident of great magnitude.

Accidents and Human error

All forms of energy generation are man made. They are all operated by individuals prone to human error and managed by agencies that are sometimes bedeviled by incompetency and other limitations. These deficiencies were witnessed in the TMI and Chernobyl and may not necessarily be a true nature of how things are right now in the nuclear energy industry. Maybe these accidents have been overemphasized and the public has been coerced to believe that reactors are deadly. The accidents have been analyzed from a myopic point of view, leaving out the institutional inefficiencies that characterized regulatory agencies during those periods. According to the report of the Presidential Committee on the Three Miles Island accident, the disaster was caused by, among other human errors, a dysfunctional institution. In its recommendation to forestall future occurrences, it said that "fundamental changes" are needed in the nuclear regulating and monitoring agency, the Nuclear Regulatory Commission (Commission's Report 7). Institutional deficiencies and operator error usually complicate accidents in complex automated processes. It is the high risk nature of any eventual accident that is of concern. Atomic reaction is not dangerous. It is not more dangerous than refining petroleum. It is incompetence and negligence on the part of authorities and operators, as it was exhibited in Chernobyl, (and is typical of most developing nations where there are no strict safety regulations) that is of great concern to the pushers of the technology.

Chernobyl

Chernobyl accident of 1986 occurred in Ukraine, a former Soviet enclave. The accident could be described as the worst in the history ofthe nuclear industry. The institutional rot that resulted to the accidents has made energy observers think of it as a soviet accident; a bad product of the soviet era. It could be used as perfect picture of inefficiency that marks regulatory agencies and authorities in the lesser democracies. The nuclear installation was built without a "safety technology"; the organized

system of "protective barriers" that acts as normal safety procedures elsewhere in the world (Ritch par. 14). During the construction, a lot of safety procedures were compromised by political authorities, who ignored advises from experts of nuclear science. These politicians engaged in 'political patronage'; appointing non experts and incompetent politicians - who shortchanged the masses and jeopardized their safety through inappropriate regulation - in the Energy Ministry. They operated like a secret cult, using laws and edicts to prohibit the disclosure of any information whatsoever as it relates to energy operations. These secrecy and safety compromise reached its climax in the scraping of the Energy Ministry's department that oversees research, design and construction of energy facilities. The resultant effect was that some energy installations were constructed without regard to the technical details from expert; so Chemobyl was constructed as "'a death sentence waiting to explode"' (Medvedev, "Prologue"). To be fair, the industry has witnessed tremendous safety record since the two accidents. There has been a global effort at reevaluating licensing and operational standards in an attempt to make the industry safer. Analyzing causes of failure, embarking on better training among nuclear workers has resulted in years of accident free operation. The industry has become more professional and respectful of rules (Weeks par. 23). According to Weeks "... the industry has become much more responsible about policing itself." This is a significant improvement and coupled with the successes of operations in countries such as France, the success stories could not be much better. Nevertheless, such achievement can not be easily replicated in most developing nations without human capital development, skill acquisition and setting in place proper occupational safety and health guidelines.

Oil today

Experts have no doubt that oil production has peaked. According to J. Cugnon, "oil is running out." Even though experts say that there is an "underestimation" of the life span of world's oil sources, there is still the uncertainty of a long availability because the possibility of "extracting" some of the world's oil reserves is yet to be "demonstrated" (236). In other words, many resources are out there but they will most unlikely be available for human consumption. In the words of Schroeder, these sources are "known or suspected to exist" but the "cost or technology required to recover" them may not be feasible (slide 10). Furthermore, events and crises in most oil-rich countries are always great and constant reminder that there is need for energy plan B. For example, in recent time there has been incessant kidnaps of oil workers in the Nigeria's oil rich Niger Delta. Oil related crises in the Niger Delta of Nigeria are putting authorities in an uncomfortable situation as the issues are threatening the continued stability and unity of the country. There are many problems here as the residence of the Niger Delta - who lack the basic facilities of life like electricity, and clean water- whose air, farmlands, rivers, lakes and ponds has been polluted by gas flaring, acid rains, and toxic waste disposal has continued to agitate for self-actualization and increased control of their resources. How long will the resources last? Experts have warned that oil, the world's energy prima donna will run out within the next 50 years if current trend in consumption continues. This amount is the smallest compared to other energy sources like coal which has 220 years projected span and nuclear energy with an astronomical figure of21000 projected years (Cugnon 237).

Sources	Amount	Number of years
Coal	760Gt	220
Lignite	189Gt	237
Oil	~100Gt	42
Oil shale	151Gm³	
Natural gas	3,28Mt	63
Uranium		100
Nuclear (fast reactors)		21000

Adapted from: Hardronic physics, J. Cugnon et al, American Institute of Physics, 2005, p. 237)

Demographic issue

Nuclear technology does not depend on the ever-changing atmospheric conditions. One can reasonably argue that it is more viable than some renewable energy such as solar and wind which depend on the sun. But such point is narrow-minded considering Africa's demography and climatic condition. Because in most remote towns in developing nations, residents are located in sparsely populated communities that are often separated by uninhabited arable lands, using a reactor could be a waste of resources. Reactors generate huge amount of energy. Attempt to use nuclear in Africa's sparsely populated villages will be overkill because of lack of expansive transmission grid to support the base-load generation of a reactor. Having to put transmission line between sparsely separated villages seems to make less sense. What makes sense is using solar and wind, which in reality does not need elaborate transmission lines. The energy from solar and sun are harnessed and utilized close to the point of collection hence they are less feasible in metropolitan cities. According to Lorenzini;

> "New York, for example, uses 10 times more energy than its land area collects in sunshine. Resources such as sunlight and wind require elaborate system of collection, conversion, transport and distribution to make them available as electricity. Substituting wind power for the Indian Point nuclear Complex that serves New York City would require somewhere between 125 and 385 square miles of wind farm" (Lorenzini 32).

What might be considered as a constraint of solar and wind energy in metropolitan cities such as New York, makes it feasible for small cities with lower electricity usage. For sun and wind energies, it is not beneficial for the points of generation (from source) and transportation (to point of utilization) to be located hundreds of miles apart from each other.

Summary of different energy sources

Source	**Pros**	**Cons**
Coal	Inexpensive and abundant, baseload generation	Contributes to acid rain and global warming. Carbon capture and sequestration are expensive
Gas/Oil	Good distribution, good heating source	Depleting source, contributes to global warming
Hydroelectricity	No greenhouse gas emission, reliable when there is constant water supply	Moderately expensive for new dams, Depend on high level of water in dams, environmental damages from dam/river flooding
Nuclear	Compact waste, No acid rain and greenhouse gas, baseload generation	Long term radioactive waste storage, nuclear proliferation issues, expensive to build reactors
Wind	Free when available, Good source for seasonal pumping of water for irrigation, renewable source	Limited by wind, may affect birds
Solar	Free sunlight, used at source, No elaborate transmission	Not available without sunlight, high initial start up cost

Conclusion

There is no doubt that nuclear energy has a great prospect. It is energy for the future. But for people in developing nation, there seems to be no future. Their future is restricted within the limitations of energy sources provided by human muscle. Lacking usable energy, they cannot "augment their water supply by desalination, or increase food production by farming more extensively ... Not only do people, usually women, walk miles carrying water ... they often risk their health traveling on unsafe motor bikes or cooking in badly ventilated kitchens with dirty fuels that pollute the air." Considering

all the environmental health and safety issues of different energy sources used in developing nations, and the alternative sources being pushed by energy juggernauts, one can conclude that there is need for a plan B; an energy resource that is devoid of environmental degradation and greenhouse gas emission.

Reactors are safe and can generate "emission-free" and viable means of electricity. (Baird par. 4). Compared to other sources of energy, nuclear power is safe, and reactors do not ordinarily pose any greater danger to our lives and environment. However the safety, economic and technological issues surrounding reactors does make it a 'rational response to the legitimate' energy aspiration of developing nations. For now, there is the need to channel more resources towards reactor research so that the future potentials of nuclear energy could be maximized. Also figuring out the necessary ways of handling nuclear waste should be paramount.

Science and politics are two different things. Scientifically, nuclear technology is sound. However, rather than the arguments and politics that trail it, more research and study are necessary. Politicians should realize the importance of professionalism and expertise, and allow nuclear experts to do their job. Sacrificing expertise for '[politics and] patronage'(a scenario that is typical of many lesser democracies should be discouraged in order to prevent incidences like that of Chernobyl. Politicians are likely to be incapable of making better decision on the safety and operations of nuclear energy because their decisions are often too parochial in technicality, "too tendentious and sometimes prejudiced, as it is paralyzed by a network of mutual [and often incompetent] solidarity" (Medvedev viii). As the science of nuclear energy continues to grow and become acceptable, exporting the technology to developing nations will become much easier. It should take a less hurried process. Attempting to solve the energy problem of society hurriedly with nuclear technology is as bad as

attempting to solve it without it. Both of the outcomes will be tantamount to inadvertently mortgaging the future of our generation to one form of environmental degradation or the other..

Recommendation

Nuclear energy is a long-term source of abundant energy with many environmental advantages, but it is still in its developmental phase. The desperation of energy starved developing nation may stunt its growth and drive it to extinction. The design and advancement in reactor technology has made tremendous progress. The generation VI reactors such as the much publicized 'take away' portable reactor (promoted by the department of energy through the global nuclear energy partnership (GNEP)) needs to operate for years in developed and technology advanced countries before it could be tried for use in developing countries. This will help to avoid any problem as a result oflack of safety regulation and incompetence. In the interim, it will be realistic to use "locally-appropriate renewable energy supply technologies with efficient end-use." In addition, the availability of sun and wind makes solar and wind energy more realistic at this time. This way, the electricity needs of people in developing nations will be met and the pressure to provide them with energy will be much less. This will enable more time to focus on research and development of safer and efficient reactors.

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