Information and Communication Technology for Renewable Energy Creation and Management In Nigeria – A Paradigm Shift

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ABSTRACT
The need for stable energy in any developing country cannot be overemphasized as it is a catalyst for speedy economic growth and development. Information and communications Technology (ICT), even though it is a consumer of energy, can also be used to support the generation, management and conservation of energy. ICTs could be used to automate systems for power generation, distribution and management thus saving the government and investors lots of efforts and increasing the reliability, speed and conservation of power or energy. This paper focuses on some of the roles ICTs could play in renewable energy creation and management in Nigeria.

Keywords: Power generation, Energy conservation, renewable energy management.

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1. INTRODUCTION

The issue of energy has become commonplace in so many of the discourses in our nation within the last two decades. So many suggestions, approaches and formulae have been advocated as the magic wand needed to realize stable power generation, distribution and consumption in Nigeria. Unfortunately, the present situation in our nation only confirms the fact that we are yet to realize the desired energy status so long after by citizens of our nation. The need for a stable energy system in our country cannot be over-emphasized judging from the fact that Industrialization, commerce, the health sector and of course the general welfare of the society is highly dependent on this prime mover called energy. Technocrats have insinuated that a viable and consistent supply of energy will address some of the myriads of problems such as insecurity, unemployment, high cost of goods and services production and provision and the need to attract foreign investors into our nation.

With the advent of Information and Communication Technology (ICTS) which has become pervasive and has invaded practically all areas of human Endeavour, it is no gainsaying that the populace are beginning to wonder if ICTs can proffer some solutions and quench their thirst for a more virile and efficient energy situation in Nigeria. Although ICTs *consumes* energy, it remains an important means to support the generation, management and conservation of renewable. The quest for energy and more energy has always been, and will continue to be, prominent in the global sustainable development agenda. Fears have been expressed about possibility of exhaustion of energy resources if the rapidly depleting natural and artificial resources are not replenished, or if the growing world population is not controlled. Energy scarcity and crisis are common causes of social, economic and political woes. Even renewable supplements and alternative energy sources so far discovered have not met the minimal energy demand of the world.

One way energy generation, management and conservation using ICTs can be achieved is by using ICTs to optimize the performance of energy-using systems and processes in industry, society and individual energy usage. ICTs can also play a critical role in supporting the necessary paradigm shifts within the energy sector towards a more sustainable generation of electricity. With the advent of "smart" technology from the ubiquitous computing domain, further possibilities to reduce the growing energy consumption in the residential sector are now emerging. Efficiency gains can be realized when ICTs are used to automate systems.

Information and communication technology (ICT) consumes energy, but it is also an important means to conserve energy. Classically, it did so by optimizing the performance of energy-using systems and processes in industry and commerce. In the near future, ICT will also play a critical role in supporting the necessary paradigm shifts within the energy sector towards a more sustainable generation of electricity. However, with the advent of "smart" technology from the ubiquitous computing domain, further possibilities to reduce the growing energy consumption in the residential sector are now emerging. In that respect, we discuss how taking the consumer "in the loop" can realize energy savings on top of efficiency gains through automated systems, and we describe a prototype application that aims at inducing a desired behavioral change by providing direct feedback on household electricity consumption.

2. ICTS IN PERSPECTIVE

ICT encompasses research and development in Information technology (IT), Telecommunications, Robotics, Software engineering, Networking, Remote Sensing etc. Scientists, engineers and technologists are increasingly deploying ICTs to tackle important challenges in diverse areas including Energy, Health, Water, Food, Governance, etc. ICTs not only constitute an industry in their own right but they also pervade all sectors of the economy – as integrators and enablers. They are essential for both system management and empowering end-users for innovations and creativity. There is increasing evidence that significant opportunities and threats are involved in widespread use of ICTs. Information and communication technology (ICT) is one of the pillars of today's society – it not only has a major impact on our professional and private life, it has also become one of the most important drivers of economic growth. In the past, however, economic development with its steady increase in productivity, consumption, and mobility usually went hand in hand with increasing usage of natural resources. Even though for most countries energy consumption grew slower than the gross domestic product (GDP), the world-wide yearly energy consumption steadily increases and reached 139,700 TWh in 2007, with approximately 12% (16,429 TWh) final electricity use.

While ICT with its favorable effect on the economy is certainly an important indirect cause for the overall use of natural resources and energy, the total energy consumption of ICT itself is difficult to estimate. Studies vary with respect to the definition of ICT, the methodology to generate the estimates, and the share of energy consumption of a device that is attributed to ICT. In a recent study published by the European Commission, total electricity use of the ICT sector (without consumer electronics) in the European Union (EU-27) is estimated to 119 TWh in 2005, which corresponds to 4.3% of the overall electricity consumption, or 0.6% of total energy consumption. For the U.S., Laitner et al. (2009) estimate that ICT's share on electricity consumption was around 8% in 2008. This share by the ICT sector on total electricity consumption is certainly noteworthy. It deserves attention and calls for adequate measures, in particular because it is increasing fast – for the EU-27 by about 50% within 15 years in a "business-as-usual" scenario . Indeed, quite some effort has already been undertaken to ad-dress this issue, striving for low-energy ICT systems. The drivers are manifold and include several incitements beyond environmental considerations ("*green ICT*"), such as the cost of operation for large data centers, challenges related to heat dissipation of processors, and the operating lifetime of battery-supplied devices.

However, high hopes also rest upon ICT to reduce resource and energy consumption in other economic sectors, and thus to mitigate global warming. This could mean, for example, to improve with the help of ICT the energy efficiency in established processes (i.e., increase the ratio of a relevant target variable such as productivity or comfort to energy consumption), or to enable by ICT new concepts to generate, allocate, distribute, share, and use energy in a resource-efficient and environmentally-friendly way. As, alongside rising energy cost, environmental sustainability became more important in recent years, a growing number of large infrastructure systems and processes were optimized for lower power consumption. Here, ICT with its general potential for large-scale simulation, optimization, and real -time control plays an outstanding role. In the business context, ICT also helps to come to better decisions with respect to resource and energy consumption – examples include optimization of production and supply chain processes or environmental information systems.

3. ENERGY, RENEWABLE ENERGY

Energy is closely related to economic development, poverty alleviation, and provision of vital services. Increasing energy demand is also closely related to global climate change. Major natural disasters in recent years – tsunamis, hurricanes, tornados, gully erosion, etc. – are closely linked to climate change. The present pattern of energy production and consumption which has resulted in increasing CO_2 emission resulting from production and use of energy appears to be unsustainable. Incidentally, unsustainable trends undermine future economic growth and impact on the quality of life despite the increasing demand for natural resources, including energy.

Renewable energy refers to sources of energy that are generated by nature and sustainable in supply. These sources include Solar, Wind, Geothermal, Biomass, Hydro, etc. The shift to these forms of energy sources is premised on the need for sustainable development which looks at energy generation from the perspective of being able to meets the needs of the present without compromising the ability of future generations to meet their own needs" . Energy is paramount for a nation to drive her critical infrastructures.

4. NATIONAL CRITICAL INFRASTRUCTURE

A nation's critical infrastructure comprises assets that are essential for the smooth running of society and the economy. These includes

- Electricity generation, transmission & distribution
- Oil and gas facilities
- Telecommunications
- Transportations systems
- Water supply systems
- Agriculture

- Public health facilities
- Security services
- Financial services

A nation's economy runs on these infrastructures which in turn depend on availability of energy which in turn depends on the nation's Critical Energy Infrastructures (CEI). Unfortunately, these critical energy infrastructures are vulnerable to natural hazards such as Hurricanes, Earthquakes, Tsunamis, Floods and system failures due to equipment breakdown, human error and intentional events (vandalism, terrorism, etc)

5. SHIFTING THE ENERGY PARADIGM USING ICTS.

Although ICTs consumes energy, it remains an important means to support the generation, management and conservation of renewable. The quest for energy and more energy has always been, and will continue to be, prominent in the global sustainable development agenda. Thus, ICT is an enabling tool for *energy efficiency* (typically as a side effect of process or infrastructure optimizations) with a tradition of many years already. The recent slogan "*ICT for green*" suggests, however, in addition to this a more direct use of ICT to *energy conservation*. Examples include reducing com-muting by teleworking or the support of energy savings in home environments. Since already about one third of the electricity is consumed by households, the latter represents an important sector.

However, while industrial processes and public infrastructures still offer many opportunities for energy saving through automation and optimization with classical ICT, this is more difficult in a home environment. Classical measures to reduce the energy consumption of households are limited, essentially they consist in the use of more energy-efficient appliances, including the reduction of stand-by losses. Fortunately, however, technologies from the ubiquitous computing domain (such as low-power sensors, cheap wireless communication, embedded Web servers, etc.) now become available which offer new opportunities to save energy, even without direct user involvement. Example scenarios include automatically detecting activity in the home, so that the heating or the air conditioning can be adjusted accordingly, or the fridge that communicates in an "Internet of Things" with a smart household electricity meter in order to use, when available, cheap excess energy in the power grid (for example produced by intermittent renewable energy sources) to cool below its normal temperature (and thus store energy).

Although "ICT for green" alone will not save the planet, we believe that "smart" ICT can, when it is being used consistently, reduce domestic electricity consumption by at least a few percent. In the rest of this paper we shall provide some arguments that support our belief. And in any case, electrical energy that doesn't have to be produced because it isn't needed, is certainly the "greenest" energy. The new role of ICT as a more direct enabler of a sustainable development gives rise to a number of important challenges. These include questions such as how the technology can contribute to the optimal use of renewable energy, how to control a changing network topology with a huge number of energy providers, how to help to establish new energy services and solutions, or how ICT can best contribute to smart energy market places. The interest in new ICT solutions is mainly driven by a number of (partially interwoven) paradigm shifts within the energy sector, which we now briefly discuss.

5.1 From "unlimited" supply to a precious resource.

Building new atomic or coal-based power plants has become unpopular in most industrialized countries. Furthermore, the debate about the effect of carbon dioxide on global warming and the political pressure to decrease carbon dioxide emissions not only favors "green" energy, but also incites to reduce energy consumption in general. Conserving energy is now even becoming "chic" in some circles, and means to reduce energy consumption without decreasing the standard of living are thus welcome.

5.2 From regulation to deregulation.

Politics, in particular in Europe, introduced a number of measures in recent years to open the traditional oligopolistic and regulated market of energy production and distribution. As new players (independent main operators, resellers, billing service providers, etc.) enter the market, the interactions across company borders are intensified. The rise of complex and timely interactions necessitates new ICT solutions, for example to avoid costly media breaks in processes such as billing and to efficiently exchange control information that is necessary to operate the electrical power grid. Deregulation also leads to a stronger competition among the players, which, together with a growing demand for green products and services (accentuated by some political pressure) forces companies to clearly position themselves on the market. This even leads to promoting "smart energy conservation products and services".

5.3 From centralized to distributed generation.

Local renewable energy generation, for example by solar panels on the roofs of buildings, is becoming more and more important. Excess energy that is not needed locally should be fed into the grid. One can also imagine that in the future the batteries of a parked electric car serve as a buffer for energy that send power back to the electrical grid when demand is high. Managing a bidirectional grid and making optimal use of various small (and intermittent) energy sources (while guaranteeing high reliability) is a non-trivial issues that requires an adequate information and communication infrastructure.

5.4 From control to cooperation.
Traditionally, electricity generation by power plants had to meet momentary consumption. In the future, power consuming devices will more and more make the best out of the energy that is currently available. More precisely, one expects that in a "smart grid" energy consuming appliances, energy generation units, power distribution units, and various other intermediaries negotiate and cooperate to optimize their situation. For that, suitable ICT- based market platforms are required, which would then also enable new forms of energy brokers or even virtual power plants formed by distributed small generators such as combined heat and power (CHP) plants.

While automation and energy-optimized systems will be without doubt essential to reach the saving targets, the adoption of these systems and the user behavior in general has a major influence on the energy demand. ICT can play an important role in that respect because it can assist individuals to make better informed decisions or reward socially desirable behavior in their daily life. In fact, taking the user in the loop can not only help to guide individuals when using energy consuming devices, but also induce favorable decisions, e.g. when purchasing electrical devices, heating systems, and family cars with lower energy demand.

There exist many situations where people – despite their general intention to protect the environment – do not take even the simplest measures to reduce their energy demand. As an example, virtually all PCs and imaging equipment feature automated power saving techniques which set screens or CPUs in low-power mode after a period of user inactivity. These features, however, are all too often not active in both private and office environments, even if they are pre-installed on most devices. As another example, consumption in identical homes, even those designed to be low-energy dwellings, can easily differ by a factor of two or more depending on the behavior of the inhabitants.

5.5 Informational support.
It is widely accepted that communicating consumption data by a mere value and physical unit is not adequate for most people. For a more thorough interpretation, analogies are regarded as helpful, which can also increase the time a user reflects and processes the information. The type of analogy must be carefully chosen, however, to guide the user in the desired direction, e.g. specifying the size of a solar panel that is required to produce an energy equivalent, for example, manifests the feeling that the amount of energy is high; mentioning the number of tea cups that can be heated up has the opposite effect.

5.6 Feedback on Electricity Usage
There already exists several energy monitoring solutions that provide feedback about the electricity consumption. They aim at helping users to understand where energy wastage occurs and thus try to establish a basis for conscious energy usage. These electricity feedback solutions can broadly be classified into two categories according to the number (and type) of sensors used to acquire the electricity consumption information.

ICTs can also be used to achieve and support the following

1. Optimization use of natural resources, including energy, throughout the whole life-cycle of products and processes
2. Design of smarter and cleaner products and processes, optimizing energy consumption and reducing waste
3. Reduction in vulnerability of CEI
4. e-materialisation: the shift from products to services
5. Intelligent transport systems' impact on increasing transport performance and promoting
6. shift from the use of the private cars to public transport;
7. Promotion of efficiency in electricity generation and distribution e.g. smart electricity grids;
8. ICT-supported facilities for the management of energy savings e.g. intelligent lighting and environment conditioning system in smart buildings and neighborhoods;
9. Support systems for decentralized energy generation from renewable sources;
10. With ICT we can monitor and detect emerging problems in energy infrastructure leading to possible failure
11. ICT elements for this purpose may include
    a. Sensors
    b. Communication channels
    c. Remote monitoring systems
12. Real-time control and monitoring systems achieved using SCADA (supervisory control and data acquisition)
13. With ICT we can make energy infrastructure more robust
14. We can remotely monitor energy infrastructure and perform preventive actions before failure – condition-based maintenance

6. CHALLENGES OF USING ICTS TO SUPPORT RENEWABLE ENERGY

ICT is itself vulnerable to attack – hence introducing new vulnerability to ICT-based systems. The digital divide which is represented in our nation by inadequate infrastructure and inadequate ICT skills is also a threat to a virile ICT-Based renewable energy paradigm. In addition to the fact that ICT-based products require considerable amounts of energy to realize (thus, generating a huge energy footprint which itself is a problem), there are numerous threats that use of ICTs tends to herald, and these range from stealing classified information and sensitive data to conducting warfare in cyberspace. Other issues include:

1. **Web Vandalism:** This involves attacks that deface web pages or cause denial-of-service.
2. **Propaganda:** Political messages and anti-government campaigns can be spread through to anyone with access to the internet.
3. **Vadalization of Critical Infrastructure:** Power and water supply networks, oil and gas pipelines, communications, commercial and transportation facilities are all vulnerable to cyber attack.
4. **Compromised Counterfeit Hardware:** Hardware used in computers and networks that have malicious computer programmes hidden inside the software, firmware or the microprocessors.
5. **Malicious Data Gathering**: This involves intercepting, and even modifying, secure information, making defined and intelligently directed illegal surveillance possible from any part of the world. For instance, business orders and communications can be intercepted or replaced; payments can also be diverted, thereby putting businesses at risk.
6. Also, during 'Operation Enduring Freedom' in Iraq, a smart weapons system used by US soldiers rebooted and unknown to the soldiers inserted their position as the missile target location into the system. Consequently, the missile vectored into their position instead of the selected target location.

7. CONCLUSION

ICT can make a significant contribution to saving energy, both by autonomous optimization efforts and by inducing changes of user behavior. Yet, achieving the latter is not that easy . The coalescence of the Internet of Things and energy topics will also foster the development of new product-as-a-service concepts, and give new stimuli to the adoption of home automation systems. It will thus also strengthen the interest in business service research. A consolidated approach should be evolved to upgrade existing critical energy infrastructure with ICT-enabled devices and components with a view to optimally managing energy production and consumption, while new infrastructure should be designed ground-up to incorporate ICT facilities.

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