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Future of Humanity: Energy and Knowledge Engineering

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Abstract Energy has become the keyword relevant to the economic and social development and sustainability of all countries as well as the ecological future of the world. Knowledge-based strategic planning and decisions in energy are therefore very crucial for all. Knowledge may be defined as the information needed for good planning and intelligent decisions for any human being, from a lay man to a top man in a public or private organization up to even the country president. In the article, after some introductory remarks about energy and knowledge, knowledge - energy relation is defined. Smart cities and intelligent utilities / smart energy, Energy Engineering and Knowledge Engineering terms are also elaborated. As a conclusion, the synergy and even a symbiosis between energy and knowledge is noted and it is stated that energy engineering and knowledge engineering together with nano science and technology will be very crucial for the future of humanity.

Keywords Decision Making, Energy, ICT (Information and Communications Technologies), Intelligence, Knowledge, Smart City, Smart Energy

1. Introduction

First, the critical place of energy in life, life of anything alive, is briefly noted in the article. As it is elaborated a bit later in the article, knowledge is needed for good decision making in any action by any human being. Thus it would be proper to discuss briefly the triad: data-information-knowledge and ICT (information and communications technologies). Next, energy and ICT relation is elaborated and smart cities – intelligent utilities or smart energy are defined and discussed. The article ends with discussions and conclusions. The relevant references are given at the end.

Two major objectives of the article are first to elaborate the synergy and symbiosis between energy and knowledge and later to claim and prove that energy engineering and knowledge engineering together with nanoscience /technology will have a very special value for the future of humanity.

2. Energy and Life

Energy has a controlling and coordinating role over **economical, ecological and social** life of humanity all over the world. It is, therefore, very vital for all countries with no exception at all. Clearly, sustainable and reliable supply of energy is one of the major preconditions for achieving the primary human development goals.

Zhang and Ding [1] had noted that as the pressing social, economic, energy and environmental challenges unfold simultaneously in China at this new decade, makes it imperative to alter the current development course in dealing with the climate change as well as improving the country's long term economic competitiveness and social welfare. Thus China has decided to change its development model by creating knowledge-intensive and green technology-based inclusive economic growth. Considering the growing potential of China in the world arena one should pay attention to the reasoning behind such a strategic decision for the future of the world.

EU Energy Road Map 2050 [2] is an important step for energy future of EU. As noted in there, people's well-being, industrial competitiveness and the overall functioning of society are all dependent on safe, secure, sustainable, affordable and smart energy. The social dimension of the energy roadmap is important. Engaging the public is crucial for the success of that attempt. The transition will affect employment and jobs, requiring education and training and a more vigorous social dialogue. In order to efficiently manage the change, involvement of social partners at all levels will be necessary in line with just transition and decent work principles. Mechanisms that help workers confronted with job transitions to develop their employability are needed.

Recently Sano and Richards [3] noted "A groundbreaking study published in November 2013 revealed that the activities of a mere 90 producers of coal, oil/ gas, and cement – dubbed the "carbon majors" – have led to 63% of all CO_2 emissions since the Industrial Revolution. The report was released just weeks after Typhoon Haiyan (or Yolanda) tore through a region in the Philippines. With unprecedented wind speeds of 315 kilometers per hour, the storm killed 6,300 people, left four million homeless, and caused more than $2 billion of damage."

3. 'Data-Information-Knowledge' Triad and ICT

Before going further to elaborate the relationship between energy and knowledge, it would be proper to discuss briefly here the three terms that are used as if synonymously, although untrue.

According to its meaning content, one may define a message being transmitted in any media as data, information and knowledge, successively. [4-6]

Data comprises facts, observations, or perceptions; and represents raw numbers, characters or assertions.

Information is processed data; is a subset of data, only including those data that possess context, relevance and purpose; and involves manipulation of raw data.

Knowledge is a justified true belief; it is the richest, deepest & most valuable of the three; and it is information with direction.

Thus, knowledge is different from data & information; it is at the highest level in a hierarchy of meaning content of a message with information at the middle level, and data to be at the lowest level as shown in Figure 1.

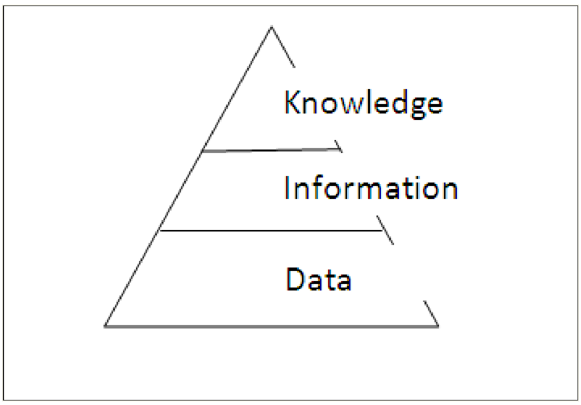

Figure 1. 'Data-Information-Knowledge' Triad

In general knowledge is further classified into two as tacit knowledge and explicit knowledge. In the early years of computer engineering / science and data processing area, only 'data' and 'information' terms were being used. Information Technologies (IT) was the relevant term that we had used. We had used the term 'Information Age' to define post-industrial era. Starting in early and mid-eighties the term 'knowledge' also appeared and we had to use these terms more carefully and properly since then. After internet explosion in late nineties –early years of 2000 and realizing the value of data communication and networking, we started to use the term ICT (Information and Communications Technologies). Starting first in OECD circles "Knowledge-Based Economy" term initiated the term 'knowledge' in its proper place. In the early years of this century it became acceptable to name the new era and society as "Knowledge Age and Knowledge Society" to replace the former "Information Age and Information Society". As noted by Grant et al. [7] a respect for both explicit and tacit knowledge opens a wealth of previous research that can be drawn upon to strategically identify opportunities for successful development. The growing research in knowledge management provides tactical methods for leveraging the "information or knowledge revolution" to facilitate both tacit and explicit knowledge flow. Further development should be considered to provide ICT support that follows synergy development through barrier removal, commercialization, review, and documentation. Lastly, creating a successful knowledge network requires establishing a critical mass as networks' value in the user participation. A knowledge network requires a great deal of upfront investment to create the participant-driven value required to self-perpetuate the system. Understanding how knowledge is communicated requires a distinction between two types of knowledge as explicit knowledge or information and tacit knowledge or know-how. Explicit knowledge or information is easily communicated, codified, or centralized using tools such as statistics. However, tacit knowledge is complex and is not easily codified as noted earlier. It is revealed through application and context and is therefore costly to communicate between people [7].

4. Energy Efficiency, Security, Sustainability and ICT

As recent researches clearly show, there has been a very close relationship between ICT and efficiency, security, sustainability of energy and smart cities. It would be proper first to give general and common definitions of these energy relevant terms. Referring mainly to NSTI (National Science and Technology Institute) of the USA and IEA (International Energy Agency) one would then define them as follows:

Energy efficiency is the goal to reduce the amount of energy required to provide products and services.

Energy security is the uninterrupted availability of energy sources at an affordable price.

Sustainable energy is a term used to describe the provision of energy in a way that will not affect the ability of future generations to harness the same energy for their needs. This type of energy is renewable and does not cause permanent change to the means by which it was received.

Smart Cities have intelligent transportation and smart grid standards for electrical and lighting management systems [8-10].

Espiner [11] was stating that EU Information Society and Media commissioner V. Reding has urged member states to use information and communication technologies to consume less power and improve energy efficiency and so combat climate change and aid economic recovery. "Targeting energy-efficient and low-carbon growth will help Europe face its biggest challenges: climate change, energy security and the economic crisis," Reding said in the Commission's statement. "ICT have an enormous untapped potential for saving energy right across the economy."

Another interesting note was delivered as ACM Tech News reporting the results of a study at the University of Melbourne saying that "High Speed Broadband Will Create Energy Bottleneck and Slow Internet". Study also claimed that the growing use of VOD (Video on Demand), Web-based real-time gaming, social networking, peer-to-peer networking, and other advanced Web applications will drive the increase in power consumption. "To support these new high-bandwidth services, the capacity of the Internet will need to be significantly increased. If Internet capacity is increased, the energy consumption, and consequently the carbon footprint of the Internet, will also increase". [12]

Wing [13] was claiming that ICTs account for 2% of global carbon emissions, according to estimates by Gartner five years ago. She was adding that reducing our footprint with more energy-efficient devices, computers, and data centers would have a direct effect on ICTs' carbon footprint. Moreover, we needed to look at the entire lifecycle: creation, use, re-use / re-purpose/recycle, and disposal of energy. She was asking the question: And what about ICTs' role in the other 98%? Answer was that ICTs will enable smart cars, smart buildings, smart infrastructure, smart grids, and smart logistics; they would enable telecommuting, telepresence, and telemedicine. So, ICTs have had an indirect effect too, by helping other sectors save energy.

In IEEE Software, Penzenstadler et al. [14] were considering the five dimensions of sustainability—human, social, environmental, economic, and technical—all but one can be supported to some extent by current software engineering methods because the concerns are not new, per se. They were claiming that missing from consideration is environmental sustainability.

5. Knowledge and Energy

As stated by Masanet and Matthews [15], when the first commercialized transistor entered into the solid-state area nearly 60 years ago, few could have imagined the many ways that information technology (IT) first and later information and communication technology (ICT) would permeate and transform our lives ever growing even in the 21st century. Today, ICT is a critical component of nearly every sector of the global economy, and has led to considerable transformations in the way that humans interact with each other and with the world around them. Information and communication technology (ICT) can be broadly defined as systems whose fundamental functions are anchored in the generation, processing, storage, communication, and/or presentation of digital information. Many ICT systems employ most or all of these elements, and the vast majority of these systems are based entirely on solid-state technologies. Arguably the most prominent example of a transformative ICT system is the Internet, which serves as the global backbone of the information or knowledge age and whose reach extends into most modern ICT applications in every sector. Increasingly, ICT systems are being recognized and promoted for their benefits to productivity, cost effectiveness, energy and resource efficiency, and environmental burden reduction in many applications. Chowdhury [16] discusses building green information services. Climate change has become a major area of concern over the past few years, consequently many governments, international bodies, businesses, and institutions are taking measures to reduce their carbon footprint. However, to date very little research has taken place on information and sustainable development in general, and on the environmental impact of information services in particular. Based on the data collected from various research articles and reports, such a review article showed that information systems and services for the higher education and research sector currently generate massive greenhouse gas (GHG) emissions, and it was argued that there was an urgent need for developing a green information service that should be based on minimum GHG emissions throughout its lifecycle. Based on an analysis of the current research on green information technology, it is proposed that a green information services should be based on the model of cloud computing.

6. Energy Plus Knowledge Equals Smart Utilities and Smart Cities (E+K = SU + SC)

The evolution of SG (Smart Grids) relies on not only the advancement of power equipment technology, but also the improvement of sophisticated computer monitoring, analysis, optimization, and control from exclusively central utility locations to the distribution and transmission grids. Many of the concerns of distributed automation should be addressed from an information technology perspective, such as interoperability of data exchanges and integration with existing and future devices, systems, and applications. A smart information subsystem is used to support information generation, modeling, integration, analysis, and optimization in the context of the SG.

Smart Cities is a vendor / city term commonly used to refer to the creation of knowledge infrastructure. Smart City, in everyday use, is inclusive of terms such as 'digital city' or 'connected cities'. Smart Cities as an applied technology term often refers to smart grids, smart meters, and other infrastructure for distribution and metering of power and water supply as well as the waste management system. [8-10]

Conti [17] stated that in a smart city, the widespread use of ICT technologies provides a virtual infrastructure for the control and coordination of physical-city services: transport, energy and lighting, waste management, entertainment, etc. The ICT infrastructure is able to learn the behaviors and needs of the citizens in order to adapt the services of the city to their actual needs and, at the same time, to reduce the wastage of resources and make the city sustainable; for example, adapting the public lighting to the safety requirements. Smart cities generate several new research questions for computer-communication researchers. Balancing the efficiency of the smart city (which depends on the accuracy of the monitoring activities) with the privacy of the citizens is one of the hottest research questions. Another relevant example of cyber-physical system is the emerging concept of smart grid. The term smart grid (SG) is commonly used to refer to an advanced electrical system in which new and more sustainable models of energy production, distribution and usage will be made possible by incorporating, in the power system, pervasive communication and monitoring capabilities, as well as distributed and autonomous control and management functionalities.

An example of Microgrid with power flow and information flow is given by Fang et al. [18] in Figure 2. In that figure the Microgrid at the lowest layer shows a physical structure of the Microgrid which has buildings, wind generators, solar panel generators, and one wireless access point (AP). These buildings and generators exchange power using power lines. They exchange information via an AP-based wireless network. The top layer shows the information flow within the Microgrid and the middle layer shows the power flow.

As noted by Gattuso and Pellicano [19], the term ITS, "Intelligent Transportation System", refers to integrated telematics, communication, control and automation technologies that contribute significantly to improve the quality of transport services. At the end of last century, studies about ITS applications were mainly focused on urban public transport. Another comment made by van Arem et al. [20] states that "The Keys to Success in Transportation Systems are Networks and Information".

Aghemo, C. et al. [21] note that one of the major challenges in today's society concerns the reduction in energy use and CO2 footprint in existing public buildings without significant construction works. In this context, key challenges are concerned with the design and the development of a monitoring and control infrastructure to manage appliances so as to effortlessly optimize energy efficiency usage without compromising comfort for occupants in lighting and HVAC (Heating, ventilating and air conditioning) services and to offer to decision makers dedicated tools to plan and manage energy saving strategies. As a conclusion of a research conducted in this field, actions of retrofitting on building envelopes or services to reduce energy consumptions are not always possible or economically convenient in existing buildings and in particular in historical buildings where conservation is a matter of priority. Nevertheless savings can be achieved by designing intelligent ICT-based service to monitor and control environmental conditions, energy loads and plants operation. [21]

It would be proper here to recall IBM effort in 'smart planet' and European plans for Green Europe. In the year 2010, IBM started a move that they called then "Let's build a smarter planet" and declared "The decade for a smarter planet". [22] Energy is one of the seven key industries, for any developed country, together with Banking, Education, Government, Healthcare, Telecom, and Transportation. "***Smarter power for a smarter planet***" is claimed as a motto for energy. In that move IBM claimed that "Our political leaders are not the only ones who have been handed a mandate for change. Leaders of businesses and institutions everywhere have a unique opportunity to transform the way the world works. We find ourselves at this moment because the crisis in our financial markets has jolted us awake. We are seriously focused now on the nature and dangers of highly complex global systems. And this isn't our first such jolt. Indeed, the first decade of the twenty first century, that is the new century, has been a series of wake-up calls with a single theme: the reality of global integration. The problems of *global climate change and energy*, global supply chains for food and medicine, new security concerns ranging from identity theft to terrorism — all issues of a hyper connected world — have surfaced since the start of this decade. The world continues to get "***smaller***" and "***flatter***." But we see now that being connected isn't enough. Fortunately, something else is happening that holds new potential: the planet is becoming "***smarter"***. That is, intelligence is being infused into the way the world literally works — into the systems, processes and infrastructure that enable physical goods to be developed, manufactured, bought and sold. That allows services to be delivered. That facilitates the movement of everything from money and oil to water and electrons. And those helps billions of people work and live. . . . "

Jennings [23] stated that in recent years a host of national and state governments have planned for large scale metering upgrades. Some governments have recently mandated the replacement of domestic gas and electricity meters with smart meters. Their deployment strategies differ based on the extent to which deregulation of the gas and electricity market has been successful. There were two major premises for rolling out automated meter readers to the housing sectors: demand management, and accurate billing.

On 3rd of March 2010, the European Commission has launched the EUROPE 2020 Strategy [24] to go out of economic crisis and prepare EU economy for the next decade. The Commission identified three key drivers for growth, to be implemented through concrete actions at EU and national levels: *smart growth* (fostering knowledge, innovation, education and digital society), *sustainable growth* (making our production more resource efficient while boosting our competitiveness) and *inclusive growth* (revising participation in the labor market, the acquisition of skills and the fight against poverty). Sustainable growth also includes promoting a low-carbon, resource-efficient and competitive economy. Program towards these objectives will be measured against five representative headline EU level targets, one of which is stated as "The "20/20/20" climate/energy targets should be met."

The "**20/20/20**" climate / energy targets of the EU were defined as follows:

a. A reduction in EU greenhouse gas emissions of at least **20%** below 1990 levels;
b. **20%** of EU energy consumption to come from renewable resources;
c. A **20 %** reduction in primary energy use compared with projected levels, to be achieved.
d. In order to meet these targets, the commission had promised the EUROPE 2020 agenda consisting of a series of flagship initiatives. Three of these flagship initiatives were stated as:

- A digital agenda for Europe-All Europeans should have access to high speed internet by 2013.
- Resource-efficient Europe: supporting the shift towards a resource efficient and low-carbon economy. Europe should stick to its 2020 targets in terms of energy production, efficiency and consumption. This would result in €60 billion less in oil and gas imports by 2020.
- An industrial policy for green growth-helping the EU's industrial base to be competitive in the post-crisis world, promoting entrepreneurship and developing new skills. This would create millions of new jobs.

Right after declaration of EUROPE 2020 strategy on March 3rd, the European Commission declared the European Digital Agenda on 19 April 2010. [25]. Two of the most recent publications of EU on the energy issue may be cited as [26, 27].

One may refer to Lazaroiu and Roscia [28] for a definition methodology for the smart cities model. They stated in their article that the cities consume a large amount of energy, demanding more than 75% of world energy production and generating 80% of greenhouse gas emissions. Nowadays, the large and small districts are proposing a new city model, called "the smart city" which represents a community of average technology size, interconnected and sustainable, comfortable, attractive and secure. In their article, they proposed a model for computing "the smart city" indices. The chosen indicators were not homogeneous, and contain high amount of information. They claimed that smart city objective can be reached through the support of various information and communications technologies. These can be integrated in a solution considering the electricity, the water and the gas consumptions, as well as heating and cooling systems, public safety, wastes management and mobility. A smart city model is proposed by the Department of Spatial Development Infrastructure and Environmental Planning of Vienna University of Technology SRF - Centre of Regional Science. [29, 30] In that model a smart city is supposed to have six characteristics as shown in Fig.3. Marciniak and Owoc [31] have added four basic factors such as Technological, Economic, Social, and Environmental, to that model.

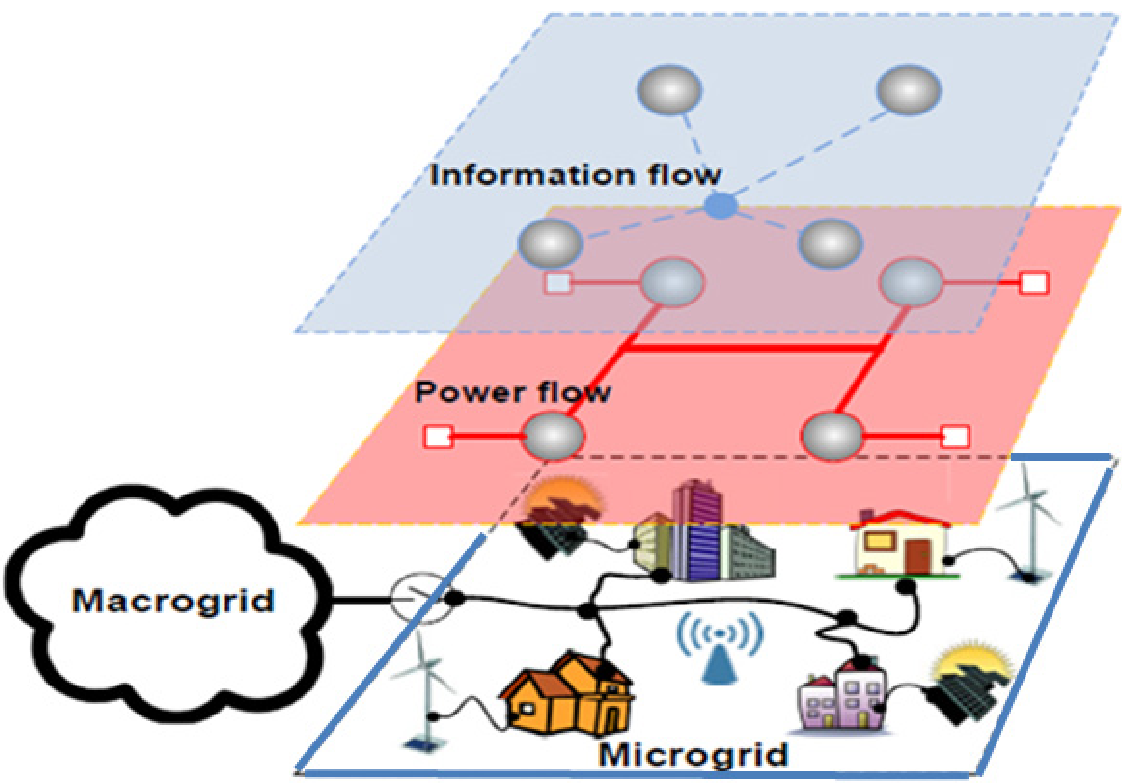

Figure 2. An example of Microgrid with power flow and information flow

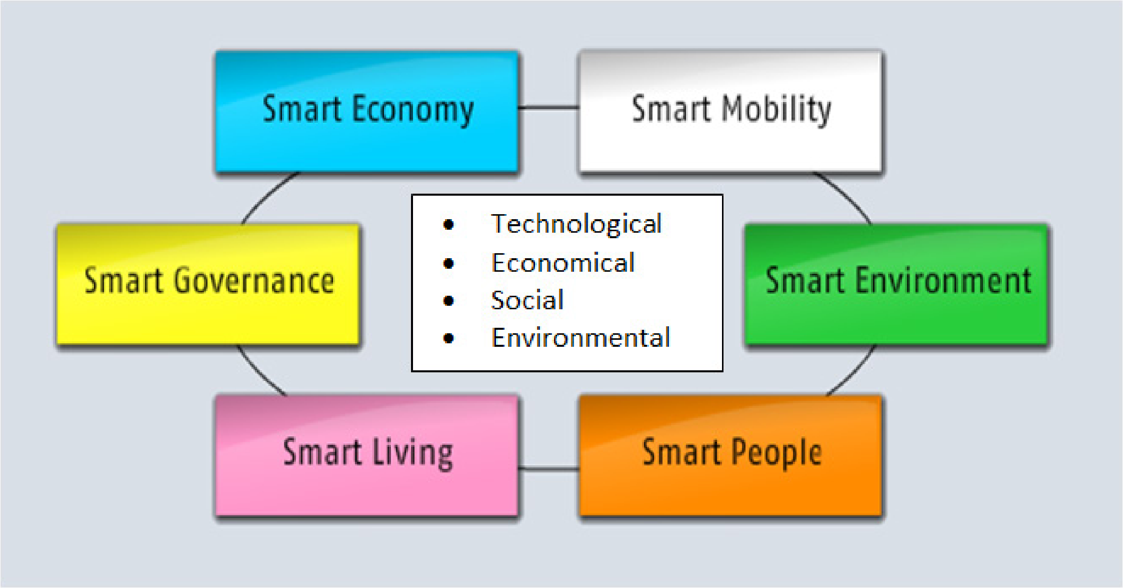

Figure 3. A Smart City network and four basic factors

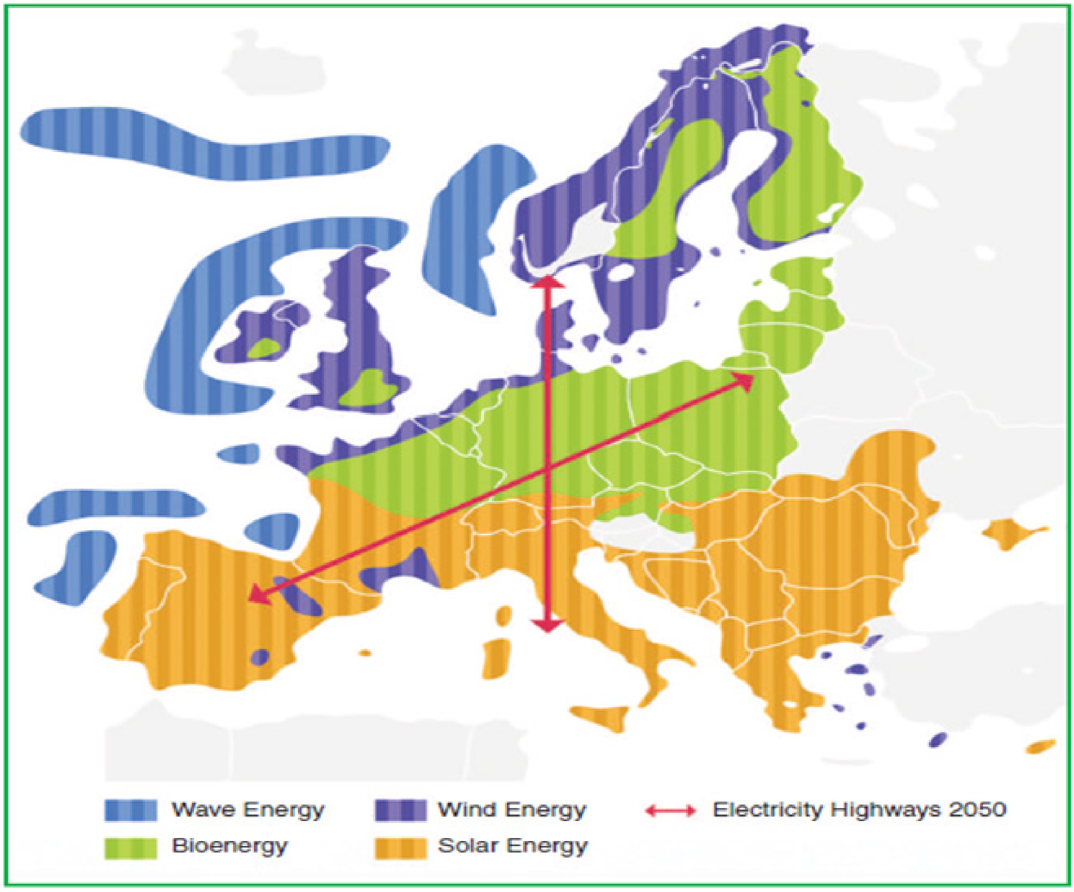

Figure 4. Renewable energy sources in Europe

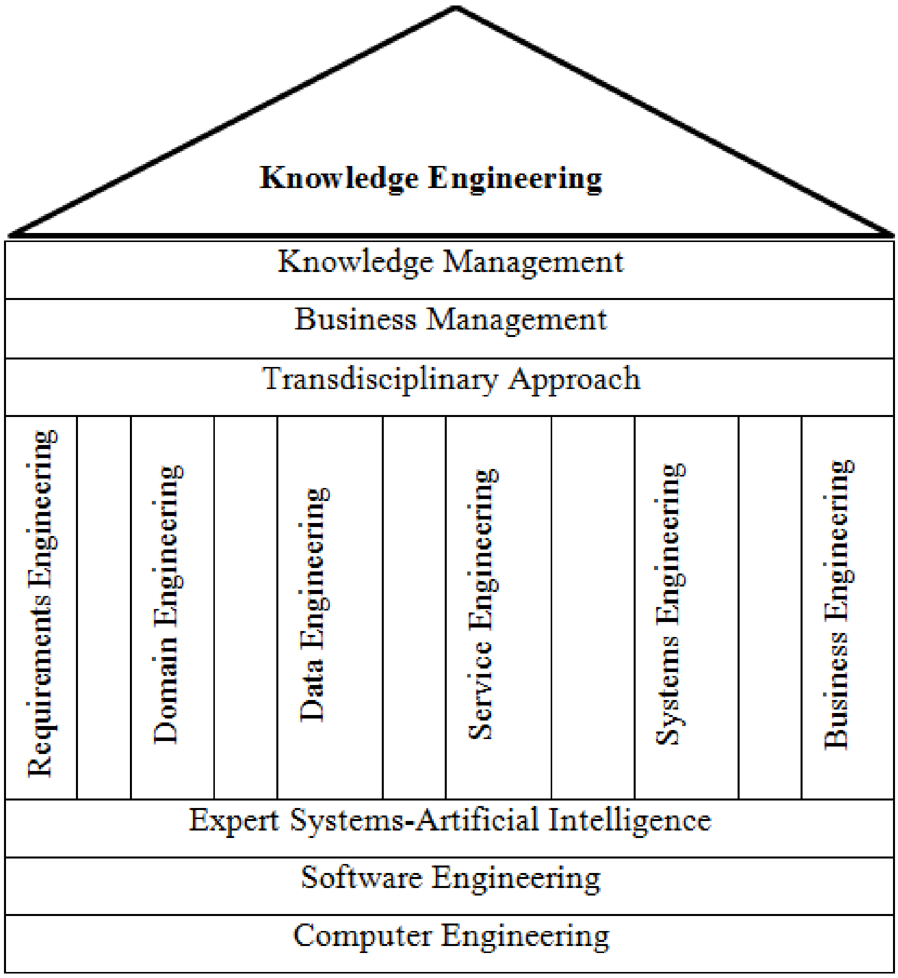

Figure 5. The foundations and six pillars of knowledge engineering

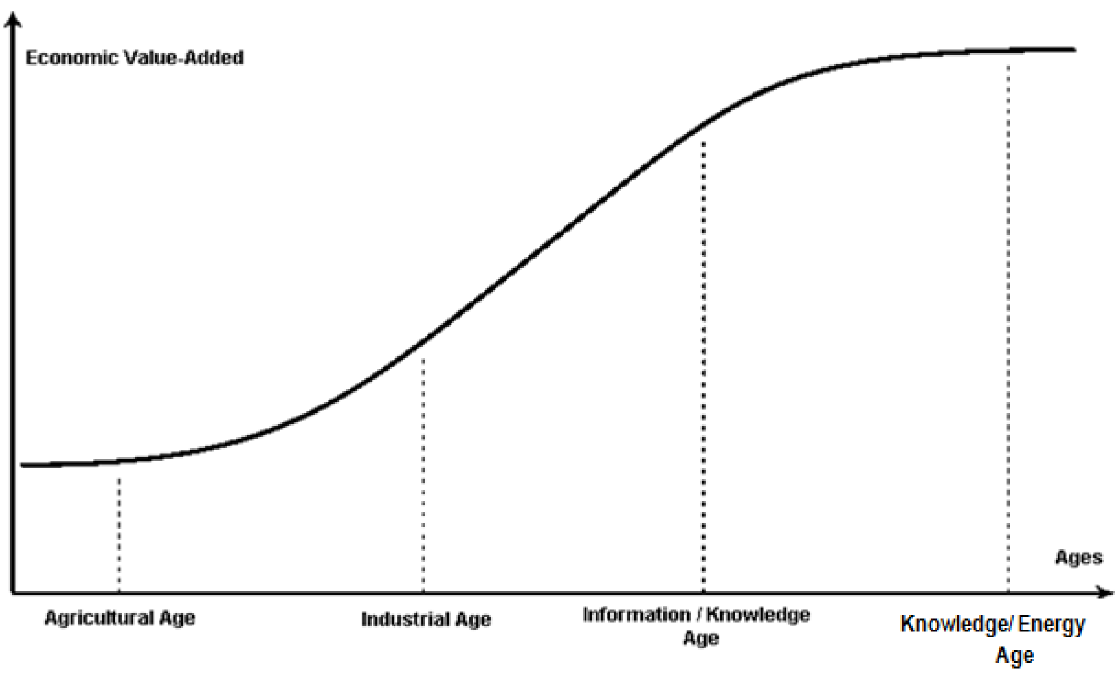

Figure 6. Energy-Knowledge Relationships

Henry et al. [32] claimed “Transmission Grids as Enablers of the Transition to a Low-Carbon European Economy”. They also noted that the transition to a low-carbon economy will create major challenges for the European energy sector in the 21st century. In this sector, electricity is a very important vector for allowing a lower consumption of fossil fuels while maintaining a competitive European economy. The European transmission grid and European transmission system operators (TSO s) are at the core of the complex European electrical system. Aging infrastructure, low public acceptance of new overhead power lines, and long permitting processes only increase these challenges. In the low carbon Europe renewable energy has the most promising and crucial position. Henry et al. had given the location of renewable energy sources across Europe in Figure 4 where European Electricity Highways of 2050 is also shown. [32]

Çolak et al. [33] had defined a smart grid as a system that uses ICT to integrate, in an intelligent way, all users connected to the electrical power system considering their behavior and actions. For this purpose, information about the electrical network, such as the current, the voltage or the power, is gathered together overtime so that the behavior of suppliers and consumers can be observed and automatically coordinated. Smart grids are becoming a significant part in the configuration of future electrical power systems. In that article difficulties transforming conventional electrical networks into smart grids were elaborated. These difficulties were named as the integration of renewable energy and different grid systems at national and international levels due to changes in frequency, voltage and in the synchronization mechanism. In the article an outline of the European smart grid projects was provided and an overview of the current infrastructure and smart grid applications of the Turkish Electricity System was given.

A significant part of smart cities may be cited as Smart Energy Management noting intelligent control and management of street lighting as a special topic.

As noted by Wojnicki, Ernst and Kotulski [34], methods of obtaining energy from renewable resources are well-studied and under constant improvement. Yet reduction of power consumption is the other main factor contributing to improvement of sustainability. Consumption reduction techniques are therefore most important in global electricity usage.

Outdoor lighting accounts 19% globally and is around 14% in the European Union. The difference is due to EU’s commitment to replacing legacy technologies, with eco-friendly ones like Solid State Lighting (SSL). They claim that the change of technology itself usually yields savings of 40%, though this value may increase depending on the initial technology used and the quality of the existing infrastructure. An additional 30% reduction can be achieved by improving the design quality (thus reducing over lighting) and introducing adaptive or dynamic control of light intensity based on sensor data. They note that SSL can also decrease the maintenance costs, improving the total cost of ownership (TCO). The domain of energy management and distribution is an example of problems that appeared after the rapid development of technologies and their practical applications. Sedziwy and Kotulski [35] focused on the following two problems in their article: how does one design (retrofit) energy-efficient street lighting in the scale of an entire urban area, and what is the control strategy leading to the maximum power savings?

7. Twin Engineering: Energy Engineering and Knowledge Engineering

Engineering is the analysis, design and/or construction of works for practical purposes of humans. One who practices engineering is called an engineer. Engineers use imagination, judgment, appropriate experience and know how (tacit knowledge), and reasoning to apply science, technology, mathematics, and practical experience. The result is the design, production, and operation of useful objects or processes. The crucial and unique task of the engineer is to identify, understand, and interpret the constraints on a design in order to produce a successful result. It is usually not enough to build a technically successful product; it must also meet further requirements.

Engineering is a key driver of human development. As with all modern scientific and technological endeavors, computers and software play an increasingly important role in engineering.

In addition to classical engineering disciplines, there are some new engineering fields relevant to knowledge such as: Business Engineering, e-Business Engineering, Enterprise Engineering, Biomedical Engineering, and Knowledge Engineering. Nearly twenty years ago the term “Knowledge Engineering” started to be used as a part of AI concerned with the principles, methods and tools for acquiring knowledge and developing knowledge-based systems. More recently we have been talking about ‘knowledge workers’ and a new context for “Knowledge Engineering” to include AI but also business engineering, e-business engineering, computer science/engineering, software engineering, Data Mining, Big Data, ICT and knowledge management.

“In the 1990s, knowledge engineering emerged as a mature field, distinct from but closely related to software engineering. Among its distinct aspects are a range of techniques for knowledge elicitation and modeling, a collection of formalisms for representing knowledge, and a toolkit of mechanisms for implementing automated reasoning.” [36]

The knowledge society has been developed and shaped by amazing improvements during the last two decades. On that development and improvement, social sciences such as psychology or anthropology have also had significant impact as much as real sciences like medicine or engineering, especially Information Technology (IT) or Information and Communications Technology (ICT). The new trends and explosion of knowledge due to Internet and Web technologies have radically changed the way we structure business and its main building block, i.e. "knowledge". Though information system and knowledge system development efforts have been regarded formerly as mere information technology activities, now we have been experiencing alternative ways that business departments model, design and execute the actual businesses where information technology professionals assist them with tools and techniques. Hence, all these advancements force us to revisit the classical definition of "knowledge engineering" or "expert system development". In that article, it was pointed out the needs for this redefinition by reviewing the steps forward in software engineering and how these steps have supported the knowledge engineering so far. Also, in Figure 5 the authors put forward an improved definition of knowledge engineering, which raises on the pillars of emerging engineering disciplines such as domain, service and business engineering, as well.

8. Discussions and Conclusions

Modrea [37] discusses a strategy for the future in terms of research and development in the field of nanoscience and nanotechnology. In a different article, Markovic et al. [38] discussed the impact of nanotechnology advances in ICT on sustainability and energy efficiency. Gammaitoni [39] had already discussed Sustainable ICT: Micro and nano scale energy management.

In addition to nanoscience and technology and energy and ICT relation, Cloud Computing is the relatively new field for energy and ICT symbiosis and synergy. Addis et al. [40] reported their research in an article titled as Energy-aware joint management of networks and Cloud infrastructures.

The futurists Meyer and Davis [41] were predicting that energy will shape the future of humanity. Recall that information and lately knowledge has become the name of the age that followed Agricultural and Industrial Ages of humanity as shown in Figure 6. One may then speculate the name of the next age as *Knowledge – Energy Age* as depicted in Figure 6.

The key point in this article is that energy issue is very crucial for any country, developing or developed in the whole world. In handling such an issue, many dimensions must be taken into consideration. ICT and more explicitly knowledge and energy synergy becomes almost number one issue to be taken care of.

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