

White Paper



Utilizing technology to provide cost-effective energy for a sustainable future

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Abstract

Reserves replacement for leading energy companies is barely keeping pace with production. These problems are the result of both supply and demand challenges. To meet the future energy requirements of an increasing global economy, new techniques for finding energy and new sources of energy will be required. Doing this in an efficient manner will require the use of technology across multiple disciplines such as nanotechnology and chemistry. Facilitating these developments and innovations will be information technology (IT). IT will provide critical capabilities required to expedite the R&D phase and to increase the efficiency of the manufacturing and construction phases. This paper identifies some of the technologies that will be used to meet future energy demands and how IT can play a facilitating role.

1.0 Introduction

Providing adequate energy supplies at an affordable price is a key goal of any developed society. Over the past 30 years, the global energy balance has been in balance or in favor of the consumer. For the past three years, the balance has tilted in favor of the producers. Booming demand caused by economic growth in China and India are leading causes of the rising energy prices. At the same time, the challenges to extract energy from the Earth are increasingly demanding. New fields are smaller than those of the past and often in environments that are either physically and/or politically demanding.

According to Hoovers' "Energy focus" article, global demand for energy in 2030 will be 50 percent higher than it is today; more than 60 percent of that demand will be for oil and natural gas. According to IEA, Meeting increased demand will come at a huge price. The entire energy sector needs to invest about \$17 trillion, or about \$680 billion a year for 25 years, to keep pace. This calls for bringing in measures two fold – one towards energy conservation and another towards alternate energy sources.

Some of the measures towards this direction is the 38-point program agreed in the G8 summit. Innovative programs (by IEA) like the 1 WATT standby power program that claims that today roughly 5-10% of the usage is caused by standby power. If the standby power consumption of the electronic equipment is reduced below 1 Watt then the power wasted will be reduced by 90%.

Given this background innovation will lead to effective and efficient ways of finding and using energy. This paper deals with the some of the technology innovations that will help reduce dependence on traditional energy sources and enhance the energy density of next generation technologies. IT has been a close follower of the innovation. IT-led innovations will lead to much quicker in development and delivery of these new energy opportunities.

2.0 Background

Energy is a key building block for sustaining any nation's socio-economic development. As the global economy continues to grow, global energy needs as well as global emissions will increase by approx 60% between 2004 and 2030 as per the World Energy Outlook 2004 published by the International Energy Agency. Policy makers in developed as well as developing countries have realized that economic security of a nation has direct linkage with its energy security; hence for the sustainable growth of an economy it is essential to ensure the availability of dependable and affordable energy sources. [Table 1](#) highlights the linkages between issues relating to energy security, their adverse impact and the mitigation measures.

Issues	Impact	Mitigation Measures
Rising crude oil and natural gas prices	Slows economic growth. More and more people will be deprived of using modern energy services.	Promote energy conservation measures by encouraging energy efficiency through effective policy measures and technology.
Increasing demand for fossil fuels is leading to reduction in fossil fuel reserves and increasing emission of Green House Gases (GHGs)	Redundancy of traditional fossil fuel based energy value chain in the long run. Harmful effects of Global Climate Change.	Promote research on clean, efficient, energy technologies and increase the use of renewable energy. Continuing to improve and encourage deployment of lower-emission technologies.

Table 1: Energy Security - Issues, Impact and Mitigation Measures

An article titled “What’s next for Big Oil?” published in the McKinsey Quarterly in 2005 mentions that the major oil companies are struggling to replenish their reserves amid increased competition for new sources of petroleum. Figure 1 gives a graphical view of the Ratio of reserves added (excluding acquisitions) to reserves produced in given year; for major oil companies.

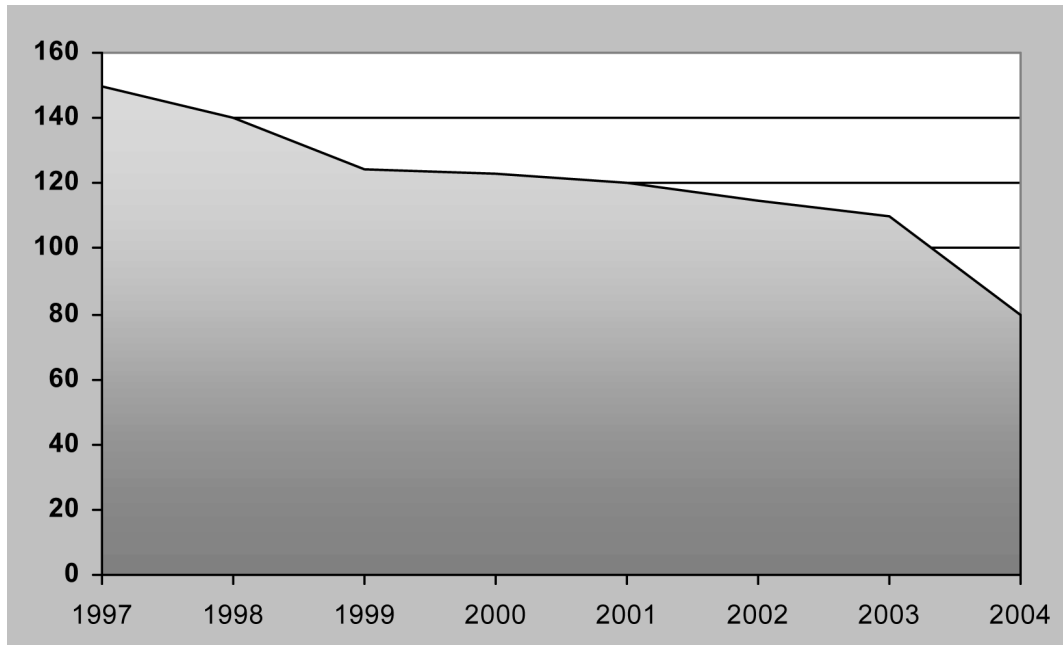


Fig 1: Average replacement rate of oil reserves %

Nations are now encouraging pragmatic energy policies and implementing state-of-the-art technology to mitigate the harsh economic impact of volatile energy prices, global climate change and to manage their energy security requirements. We believe that technology innovations can significantly contribute towards the development of clean, efficient, affordable energy sources over the longer term, while continuing to contribute towards improving the efficiency across various segments of the energy value chain.

Increasingly Information Technology (IT) is playing a role of a facilitator in realizing complete benefits from such innovations. Such technological breakthroughs will help countries manage the energy needs of its population, grow their economies and reduce poverty.

3.0 Energy Conservation and demand

There has been reinforcement of energy conservation including the 38-point program by G8 summit in 2005 focus on conservation measures on surface transport, domestic appliances etc, State of Union address by President Bush who urged passing legislation to modernize US electricity system, promote conservation.

The US Energy Policy Act of 2005 (EP Act) lays down the guidelines to incorporate alternative fuels and conserve energy. The goal of the EP Act is to enhance USA’s energy security. Several parts of the EP Act are designed to encourage the use of alternative fuels to help reduce U.S. dependence on imported oil.

In the World Energy Council report on “Long-term Energy Scenarios”, one of the ecologically driven scenarios described, appears to be the ideal solution for achieving energy independence. This is a scenario based on new renewable energy resources allowing a gradual phasing out of most fossil fuel use and also creation of a new generation of inherently safe small scale nuclear reactors which achieve public and political support. The indicated possibilities over the next century are huge; For instance, global fossil fuel dependency may decline from its present 76% to scarcely 20%. There will also be huge shifts lying behind these global figures. The present developing countries that accounted for 34% of world primary energy consumption in 1990 are expected to account for about 50% by 2020, at least 60% by 2050, and over 70% by 2100.

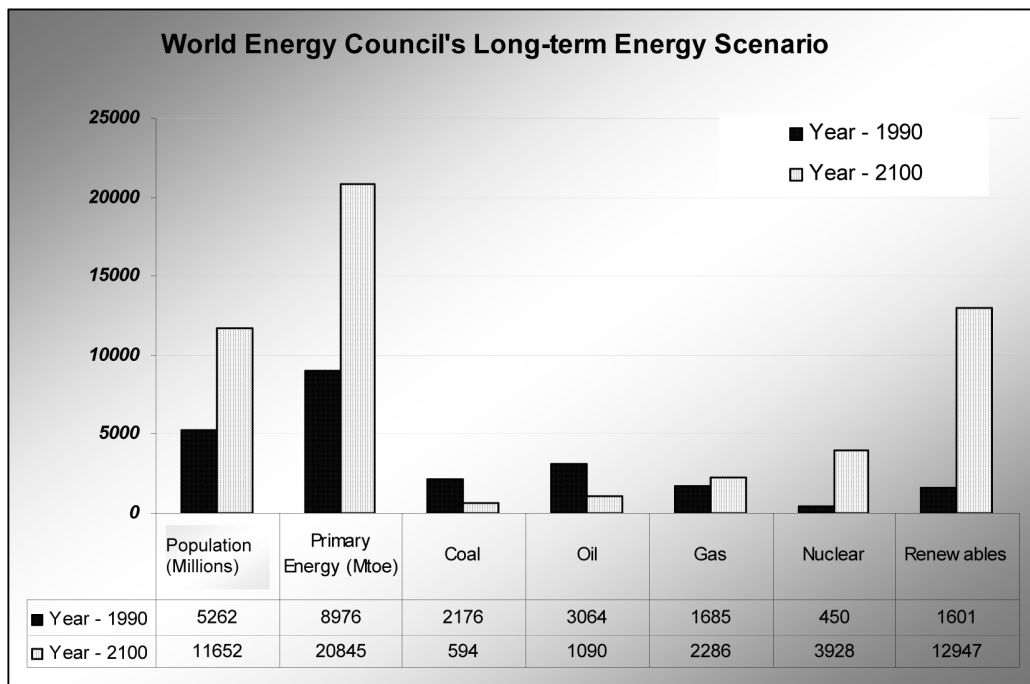


Figure 2

Source: Long-term energy scenarios: the approach of the World Energy Council

4.0 Technology-led energy initiatives

An environmentally sustainable energy system necessitates technological breakthroughs which can bring about a paradigm shift in the way we extract, produce, deliver and use energy. Harnessing energy successfully from various sources will require advanced materials, new designs, and storage solutions.

We look at two alternate energy technologies and two advance computing innovations that support the technology innovations to reduce time to market. While these technologies have been in the around the economy of scale has not permitted commercial utilization of these technologies. For example, manufacturing carbon nano tubes with controlled conduction property and in various shapes like ropes etc and transmission losses at the tube junction still remain a technology challenge. Producing the required quantities of Hydrogen for use in the Fuel cells is not economical at this time.

4.1 Alternate Energy Technology

4.1.1 Nanotechnology

Recent scientific advances in the field of **Nanotechnology** will contribute significantly in developing advanced materials and devices which will enhance cost effectiveness and increase operational effectiveness. Nanotechnology will induce efficiencies in the entire energy value chain leading to substantial reduction in energy demand and ecologically sound production of energy which in turn will lead to energy independence for energy consuming Nations.

In Power Transmission, a major challenge is to develop new transmission line materials which are light in weight and have lower transmission losses. Individual carbon nanotube fibers have an electrical conductivity similar to or better than copper at only one-sixth the weight and with negligible eddy current loss. Several researchers have demonstrated that a carbon nanotube fiber bundle could carry currents of 100 million amperes per square centimeter – 100 times the current carrying capacity of the best low temperature superconductors. With current technology, losses in power transmission lines are about 7% in the United States. Research has shown that reducing these losses by 1% would result in an annual energy savings of 4×10^{10} kilowatt-hours – an annual energy savings roughly equivalent to 24 million barrels of oil. Source: www.nano.gov (The National Nanotechnology Initiative (NNI))

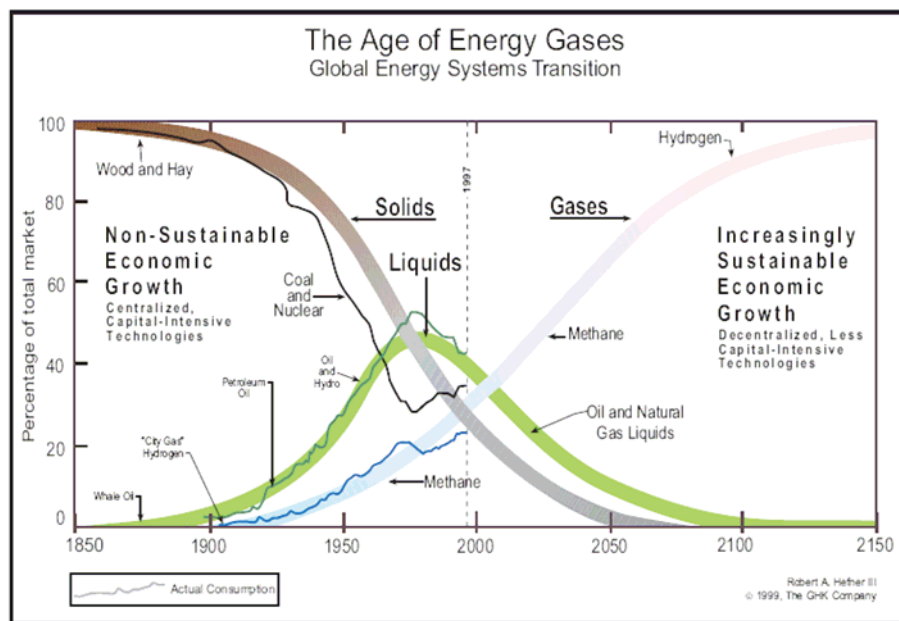
4.1.2 Fuel Cells

Fuel cells are a key enabling technology for many renewable energy systems and represent a critical bridge between traditional fossil-fuel energy systems and a clean, distributed and diverse energy infrastructure. Fuel cells and the associated hydrogen-based energy storage systems also provide a revolutionary opportunity to transform our energy system from, one based on the instantaneous use of power generation to one where energy can be efficiently stored and dispatched.

In a fuel cell, hydrogen and ambient oxygen react electrochemically to produce water and electricity, without emitting air pollutants or greenhouse gases. In an electrochemical reaction there is no combustion, so the efficiency can be far higher than existing technologies. The only immediate products of the reaction are electricity, water, and heat.

The most economical way to produce hydrogen at the present time is from natural gas, through a process known as reforming that does lead to small air pollutant and greenhouse gas emissions. However, hydrogen can also be produced from water and electricity, as well as from biomass and green algae. If the electricity used to produce the hydrogen is generated from renewable technologies, then the entire energy cycle of producing the hydrogen and using it in a fuel cell to produce electricity is air pollution and greenhouse gas emission free.

Figure 3 below shows the history of fuels in global use and envisioned Hydrogen-Energy future. The figure highlights the reducing dependence on hydrocarbons as the primary energy source by 2100 which will be substituted with increased usage of hydrogen.



Source: *The Role of Fuel Cells in The Renewable Roadmap to Energy Independence* - Daniel M. Kammen, Director, Renewable and Appropriate Energy Laboratory (RAEL) University of California, Berkeley

4.2 Advance computing

4.2.1 Quantum computing

Quantum computing can also significantly contribute towards improving design and control aspects of energy management systems. These kinds of computers run with very low energy consumption and are many times faster than current silicon based computers. Quantum computing relies on quantum physics by taking advantage of certain quantum physics properties of atoms or nuclei that allow them to work together as quantum bits, or qubits, to be the computer's processor and memory. By interacting with each other while being isolated from the external environment, qubits can perform certain calculations exponentially faster than conventional computers with negligible energy consumption.

4.2.2 Artificial Intelligence

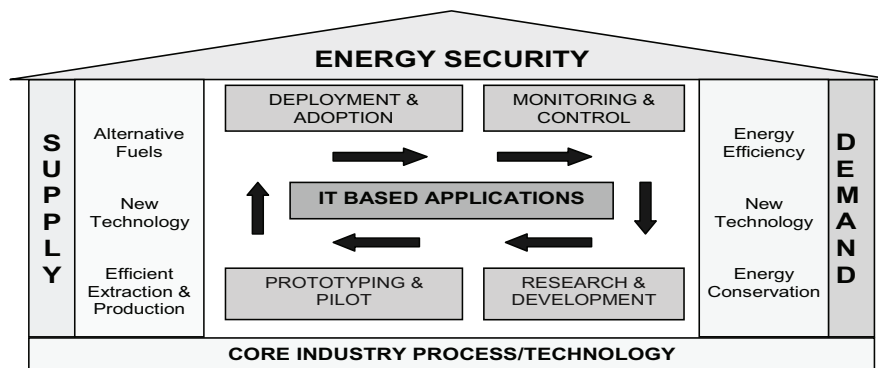
Artificial Intelligence in electrical power systems can contribute significantly in demand side management (DSM). Unlike conventional DSM programs where customers are encouraged to modify their level and pattern of electricity usage, the intelligent systems would have electronic intelligence such as a smart chip for every device hooked to the grid, from power plants to substations to home appliances. The continual communication and interplay of smart devices will optimize the grid for economical rates, reliable service and environmentally clean operations.

5.0 IT as a facilitator for realizing these technologies

Leveraging IT will increasingly be critical for optimizing existing fuel sources, developing new sources, operating and maintaining assets, manufacturing equipment, delivery, and monitoring energy use. IT could immensely contribute in the area of introducing new devices that can operate in real-time, facilitate dynamic pricing, risk management, demand side management, energy efficiency and monitoring energy flows.

Figure 4 provides a snapshot of the energy supply & demand - IT imperative relationship in the energy security space. We are observing an explosion of initiatives in the drive to ensure energy security and IT has taken a center stage like never before as a facilitator to realize the benefits from the state-of-the-art technologies.

Figure 4: Framework to achieve Energy Security



5.1 Contribution of IT to the energy value chain

In the following section we have provided some of the areas where IT has been making significant contribution to the various segments of the energy value towards enhancing energy security.

In the **exploration & production** segment, IT will facilitate improved finding and recovery rates and drive efficiencies, for example in:

- Estimating reservoir boundaries using of remote inference techniques.
- Development of a reservoir simulation model able to accurately predict the production capacity of a given reservoir.
- Assist the line managers and corporate office function in tracking of production operations.
- Delivering new technologies and techniques to increase recovery and reduce “dry holes”.

Some of the recent trends in utilizing technology to improve efficiency, quick and accurate decision making, reduce the risk of aging work force are:

- The gaining popularity of RFID technology in managing assets. RFID has not only enabled tracking of asset, intelligent technologies are making the operations and maintenance more predictive as opposed to reactive.
- The advent of the wireless communications and intelligent sensory and control networks has enabled the setting up of shore base stations that support of completely control the drilling or production rigs that operate in extreme conditions and remote locations in land or in the deep sea.

In the **refining** segment, IT will improve plant operations, reduce manpower requirements and drive efficiencies, for example:

- Flexible software solution that supports refining operations will help in managing plant assets more effectively.
- IT enabled control systems will help in managing a plant's operational and environmental performance characteristics and assist in complying with government regulations.

- Software solutions will help manage both sales and purchasing operations. The system must facilitate the purchase of feedstocks; help track feedstock and product inventories, demand forecast and supports tracking of sales of a wide range of fuel outputs. Such systems will have the ability to easily handle multiple product origins, multiple units of measurement and multiple currencies.
- The advanced LP / NLP models or refineries, integrating with the other supply chain application has provided real time single – window - view of the world hence enabling quick decision making and effective supply chain.

In the [network or delivery](#) segment, IT will improve knowledge of energy flows to optimize delivery, for example:

- IT systems will help track energy flow, usage and losses and also assist in handling contingencies which may occur for a variety of operational and accounting-related reasons.
- The technology integration of GPS, RFID & GIS has enabled online tracking of inventory across the globe. Integrating this with the ERP / Supply chain system had brought about efficiency in the distribution area.

In the [consumption or end-use](#) segment, IT will be a key factor in delivering advanced devices to enable demand side management and reduce overall demand, for example devices such as:

- Automatic Demand Controllers
- Tools for monitoring equipment performance in energy-intensive industries

6.0 Conclusion

By 2030, there is likely to be even further changes to the energy mix and the way energy delivery systems operate. We are of the opinion that advanced, efficient, cleaner, affordable energy technologies will play a key role in managing the energy demand to improve energy security and IT will be a key enabler in the implementation of all such technology led solutions. IT and the state-of-the-art technologies discussed in this article have a symbiotic relationship as behind the successful development and deployment of these advanced technologies is IT based systems without which it would be impossible to derive the benefits from such technological breakthroughs. While encouraging the developments IT also support in optimizing and controlling the current usage of the energy to provide the necessary energy security.

About the Authors

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