



Energy Informatics: A Gentle Introduction

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Abstract Energy is the underlying heartbeat of the global economy. Both developed and developing countries are facing great challenges in improvements in energy efficiency. Energy problems include supply availability, energy distribution, preventing energy waste and theft, cost efficiency, and pollution reduction. Energy informatics is a research field that uses information and communication technology to address energy problems. Energy informatics plays a significant role in managing the world's growing energy demand. This paper provides a brief introduction to energy informatics.

Keywords energy informatics, energy information systems, environmental sustainability

Introduction

World energy consumption is steadily increasing, while energy companies today are at a crossroads. Energy is fundamentally needed at our homes, offices, industries, etc. It is a crucial factor in the production of all goods and services in the modern world. The three critical stakeholders in the energy supply/demand system are suppliers, consumers, and governments. Suppliers provide energy services that consume energy. Consumers bear the ultimate cost of energy consumption. Governments enact regulations that change the basis of supplier competition and consumer behavior. Future energy supply needs to be stable, secure, affordable, and sustainable.

Informatics is the interdisciplinary study of systems that represent, process, and communicate information. It is the study of the application of information technology to solve problems within a specific discipline [1]. Energy Informatics (EI) is an application of informatics to the realm of energy. It is an emerging discipline that utilizes powerful ICT tools to solve energy supply problems [2]. Energy informatics is data driven, multidisciplinary study, which focuses on efficient energy distribution and consumption. Recent technological developments have boosted its relevance and exposed its opportunities.

Background on Energy Informatics

EI refers to using information systems to reduce energy consumption. It deals with electricity and other types of energy. It leverages information and communication technology (ICT) to tackle the problems of global warming and climate change. It applies information technologies to improve the efficiency and effectiveness of energy utilization from source, through distribution, to consumption. This includes maximizing energy utilization of existing and new renewable generation sources, energy conservation, and end-use efficiency. Figure 1 shows the multiple contexts of energy informatics [3].

Our society has an energy consumption problem in both supplying and consumption. Every organization wants to reduce its energy consumption and cost. Energy informatics is concerned with analyzing, designing, and implementing systems to increase the efficiency of energy demand and supply systems. This can be concisely expressed as [4]:

$$\text{Energy} + \text{Information} < \text{Energy}$$



EI solutions broadly fall into two categories: solutions for improving energy efficiency and handling of renewable energy sources [5].



Figure 1: Multiple contexts of energy informatics [3]

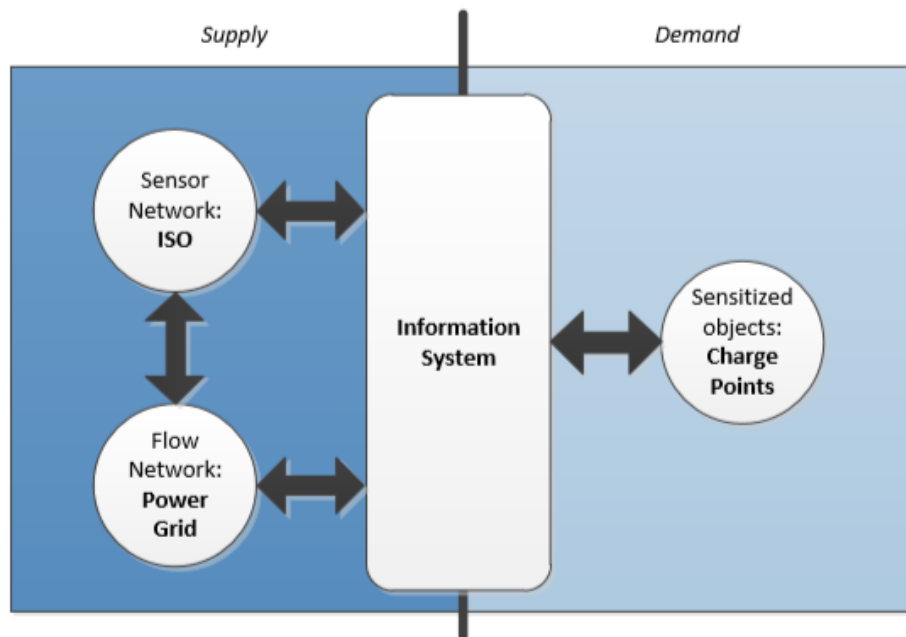


Figure 2: The energy informatics framework [6]

To show the linkage between the concept and information systems, the energy informatics framework is shown in Figure 2 [6]. The framework incorporates the following three energy system technologies [7]:

- *Sensor network*: A set of spatially distributed devices that report the status of a flow network. A sensor network provides information (data) that can be analyzed to determine the optimum use of a flow network.
- *Flow network*: A movement of continuous matter (e.g., electricity, oil, air, and water) or discrete objects (e.g., cars, packages, containers, people) through a set of connected components (e.g., an



electricity grid or a road system). Since flow networks are critical to economic activity, increasing their efficiency is a necessary for creating a sustainable society.

- *Sensitized object*: A physical good that can sense and report data about its usage and whose status may be controlled remotely. For example, vehicles are equipped with a GPS that can record travel information.

Energy informatics focuses on how information systems can be used to reduce energy consumption. An information system has several important functions [4]:

- Collect data from the sensor network and feed them into flow optimization algorithms
- Transmit data to automated controllers in the flow network
- Supply information to flow network managers so they can manage and monitor their networks
- Supply information to consumers about the consumption of resources within their control
- Enable consumers to automate or control object usage to reduce energy consumption
- Supply information to governments on flow network performance

Applications

Energy informatics (EI) covers research, development and application of ICT, energy engineering, and computer science to address energy challenges. Energy informatics can be applied to the following areas [8]:

Smart Buildings by developing ICT-centered solutions for improving the energy-efficiency of buildings. Since buildings account for approximately 40% of the total energy consumption, the energy-performance of buildings must be improved to reduce energy consumption (e.g. heating, cooling, electricity, and water)

- *Smart Cities* by investigating the synergies between demand patterns and supply availability of energy flows in cities and communities to improve energy efficiency and increase integration of renewable sources.
- *Smart Industries* including the development of ICT-centered solutions for improving the energy efficiency and predictability of energy intensive industrial processes. By incorporating the energy informatics framework, a company can realize environmental and financial benefits
- *Smart Energy Networks* by developing ICT-centered solutions for coordinating the supply and demand in environmentally sustainable energy networks. Energy Informatics deals with the software engineering aspects of smart grid.

Benefits and Challenges

Energy informatics applies information systems thinking and skills to increase energy efficiency. It can be used to improve the effectiveness of electricity demand management and reduce energy consumption. EI is an approach to reducing global warming, addressing sustainability issues, and reducing energy consumption. EI systems are useful for several entities such as hospitals, military, financial institutions, education, and smart cities. In fact, EI systems are particularly useful when customers demand high reliability, security, and quality supply [9].

Challenges for EI research include developing and evaluating systems and tools that (i) collect and store energy-related data, (ii), attribute energy usage to single devices, people, processes, and organizational units, and, (iii), present and contextualize this data in a way that enables energy savings. The challenge of transitioning to sustainable energy supply is linked to the large-scale integration of renewable sources of energy [10]. Energy sustainability is a critical, global mission that has both economic and social implications. Achieving energy sustainability in the energy economy poses challenges. Another problem is that the majority of EI solutions are currently not assessable. This makes it difficult to argue for their benefits compared to passive building improvements.

Conclusion

Energy informatics is an emerging discipline that applies information technology to integrate and optimize energy assets including energy sources, generation and distribution infrastructure, billing and monitoring



systems, and consumers. The field has gained significant attention in the information systems community in the past few years.

Some academic institutions have started to offer courses on energy informatics as well as to train the workforce for the emerging energy economy. Such courses will provide a comprehensive coverage on almost all the relevant aspects in the smart energy domain. For more information on energy informatics, consult the books in [11-13] and the journals that is exclusively devoted to it: *Energy Informatics*.

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