Policy Issue Paper 14-19

Development of ICT Convergence and its Influences on Energy Sectors

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I. Research Background

1. Research Background

□ In the 21st century, beyond the development of advanced technologies, ICT Information and Communications Technology (ICT) has created new values throughout convergence.

○ ICT accelerates the creation of new products and services.

○ As the boundary between ICT and non-ICT has disappeared, the capabilities of ICT convergence is considered as one of core factors to secure competitiveness in the future.

□ As the competitiveness of energy industries has been shifted from natural resources to technical capacities, it is expected that ICT convergence will be increasingly common phenomenon in the energy industries.

○ The efficiency, safety, and environment-friendly features of energy systems can be improved throughout ICT convergence by energy sources (power, gas, oil, renewable energy, etc.) and life cycle (from production to delivery, and to consumption).

○ Recently, the intellectualization of energy has been remarkable in the fields using power and renewable energy for energy sources, and the stages of delivery and consumption for life cycle.
ICT convergence in the energy sector has led huge changes in policies related to energy industries.

Beyond the issues related to technology, the changes toward smart energy has included social and economic aspects, comprehensively connected with the changes of value chain in energy industries, the expansion of customers’ participation in energy markets, and the appearance of various stakeholders.

- The introduction of new technologies and market participants create new markets and change the industrial structures.

- The role customers has also changed. In the past, they were a party simply consuming energy, but now they are considered to be more active agents providing information of energy consumption and selling energy they save or produce.

- In addition to the sector of electric power, various stakeholders have emerged in response to the issues related to the improvement of energy efficiency and the countermeasures of climate changes throughout the field of all energy sources including oil, gas, renewable energy, and nuclear energy.

2. Research Needs and Purposes

Research needs

- To actively respond to changes in new environments, it is necessary to
systematically understand the structure and influences of ICT convergence in the energy sector.

- This paper analyzes the development and influences of ICT convergence in the energy sector, and suggests the basic theoretical foundation to promote the creative economy in this field.
- This paper suggests the challenges of policies in response to current energy industries going through changes toward ICT convergence.

□ Research purposes

○ This paper aims to systematically suggest the structure and influences of energy-ICT convergence, and more specifically identify relationships among the spreading effects.

- Prior studies related to this issue have mostly examined the areas where ICT is utilized in the energy sector in terms of technology, or focused on economic benefits that ICT convergence could bring to specific fields.
- This study will comprehensively review the concept of energy-ICT convergence, development process, spreading influences, and prospects, and extensively discuss policy issues on the promotion of ICT convergence.
II. Research Results

ICT convergence by energy source and life cycle

- Among energy sources, ICT convergence is the most actively performed in the power sector, followed by oil and gas sectors.
  - Smart grid projects have been developed worldwide to improve the efficiency of power industries by applying IT technologies to all the links of value chain, and to promote the dissemination of renewable energy and electric vehicles.
  - Smart grid projects in the power sector has been expanded to smart gas grid projects in the city gas sector.
  - As the depletion of 'easy oil' has led to the rapid increase of oil and gas exploration costs, oil majors have actively developed projects to increase productivity with various techniques including simulation, sensor and remote measurement, and data analysis of seismic waves.

- As for life cycles, ICT convergence is progressed to increase productivity in energy production, delivery, and consumption, and to improve stability and efficiency.
  - In the energy resource development sector, major resource development and ICT companies have propelled projects to increase productivity based on ICTs including sensors, networks, data processing, visualization, and pattern recognition.
- In the process of power production, the utilization of big data, advanced control solution, GIS technologies has been increasing to monitor the performance of power systems in real time for a wide range, and to improve the productivity of distributed generation using renewable energy sources.

- As for energy delivery, the utilization of ICT has been increasing to reduce the loss of energy networks, to discover abnormal signs from networks, to improve the resilience of network when problems occur, and to enhance the quality of energy.

- The sector of energy consumption focuses on the development of tools to manage and examine the energy consumption at houses and buildings, and the improvement of technologies in control algorithms.

□ Changes of value chain in the era of convergence

○ The trends of huge convergence focusing on ICT at present has been creating new businesses, services and values. This phenomenon can be summarized into a few types including back flow of value chain, multidimensionalization, insertion, and removal.

※ A value chain, suggested by Porter (1985), is the whole series of activities, functions, and processes that create and deliver values to customers based on direct or indirect connections.

※ It was initially coined to distinguish production activities of companies, but it has been widely used in the business management fields, expanding the concept for industrial structures in general.

- The backflow of value chain implies that the starting point of the chain
is not products, but customers.

· Existing value chains start from products, go through distribution, and end with delivering the products to customers. However, value chains in the era of convergence forms a link starting from customer demands and ending with customer satisfaction.

- The multidimensionalization of value chains represents more intricate aspects beyond a simple route throughout the breakup or integration of existing chains to create new values, of new values, and complex delivery routes of products and information.

· These interactions, more multidimensional and intricate than existing value chains, have an effect to increase demands on the standardized platforms again, and to promote the creation of new values on the platforms.

- The insertion of value chain means a process where new businesses or services enter with new values, resulting in the reorganization of the value chain.

· Existing companies need to consider the expansion of strategic partnership and M&A in response to the rapid changes in the environments of convergence.

- The removal of value chain explains a phenomenon where existing value chains failing to deliver values to customers disappear.

· The acceleration of convergence speeds up these changes. The places of disappeared value chains are replaced with new links, creating the insertion of value chains.
Changes in energy industries according to ICT convergence

- Increasing energy prosumers
  - As mentioned in the back flow of value chain, the delivery route of values has been diversified from one direction to multiple directions. In addition, customers’ demands have been increasingly influential to start the process of value creation.
  - Under the circumstances, energy consumers have begun to participated in the process of energy production beyond energy consumption, changing their role to prosumers.
  - The creation of prosumer energy markets has been strongly promoted
by intellectualized communication devices, which can be connected to other devices or networks via various protocols including Bluetooth, Wi-Fi, 4G, 3G, and so on.

· In addition to smart devices, social media have been also actively utilized, beyond expectation, to assist the outage management of power companies. Consumers are asking various services based on this platform.

· The smart grid infrastructure as well as intellectualized devices is encouraging prosumers to participate in energy markets.

○ Increasing influence of platforms

- Smart grids, which deliver energy and information to various directions, are expected to support the interaction among all participants in the markets. This change will accelerate the development of multi-directional platforms in power industries.

※ A platform refers to a general architecture (the design of products, services, and infrastructure, promoting the interaction among users) and rules (protocols, rights, pricing conditions, etc.), which provide the standardized foundation in the transaction among two or more users.

- As the delivery of products in the energy industries has been practiced completely based on a physical process, the energy industries did not need to consider multiple-directional platforms. However, the creation of

<Table 2-1> Potential Platforms in the Energy Sector

<table>
<thead>
<tr>
<th>Features of Ecosystem</th>
<th>Participants</th>
<th>Platform Provider</th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th>Carbon dioxide capture &amp; storage (CCS)</th>
<th>Power generation companies, and carbon product users</th>
<th>CCS power station operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon discloser</td>
<td>Governments, NGOs, customers, and power companies</td>
<td>A third party reporting agencies</td>
</tr>
<tr>
<td>Demand response (DR)</td>
<td>Customers, businesses, and power distributors</td>
<td>DR companies</td>
</tr>
<tr>
<td>Electric car charging</td>
<td>Customers, power retailers, and vehicle manufacturers</td>
<td>Public space providers (shops, parking lots, etc.)</td>
</tr>
<tr>
<td>Power purchase by comparison</td>
<td>Customers, power retailers, and advertising agents</td>
<td>Web portal providers</td>
</tr>
<tr>
<td>Power delivery</td>
<td>Power retailers, energy users, and distributed generation providers</td>
<td>Power transmission &amp; distribution companies</td>
</tr>
<tr>
<td>Energy transaction</td>
<td>Power retailers, energy users, distributed generation providers, and power generation companies</td>
<td>Energy brokers and transactors</td>
</tr>
<tr>
<td>Energy management</td>
<td>Customers, businesses, energy management service providers, and application and content providers</td>
<td>Equipment and system manufacturers, or web portal providers</td>
</tr>
<tr>
<td>Energy storage</td>
<td>Distributed generation providers, and energy users</td>
<td>ESS operators</td>
</tr>
<tr>
<td>Information integration (equipment-based)</td>
<td>Customers, businesses, energy product and service providers, and application and content providers</td>
<td>Equipment and system manufacturers</td>
</tr>
<tr>
<td>Information integration (web portal-based)</td>
<td>Customers, businesses, energy product and service providers, and application and content providers</td>
<td>Web portal providers</td>
</tr>
<tr>
<td>New and renewable energy or carbon emission trading</td>
<td>Power generation facility owners using renewable energy, coals, gas, or oil, power retailers, and governments</td>
<td>A third party market makers</td>
</tr>
</tbody>
</table>

Various industrial demands is expected to diversify the types of platforms.

Source: IBM (2010)
○ The rapid increase of data and the expansion of analytical values

- The establishment of a smart grid can lead to the creation of mass data in the infrastructure with energy-ICE convergence.

- Supposing that about 400 MB data can be created by a smart meter acquiring data every 15 minutes, a power company with 10 million customers will see 4,000 TB increase of data in a year when they supply the smart meter to their customers.

- To improve the performance of outage management and asset utilization, thousands of monitors, switches, and remote terminal devices related to GIS were installed during distribution automation projects.

- Smart grid applications such as a synchro-phasor unit can also create mass data.

- For instance, Figure 2-2 shows how much data within the infrastructure of a company can increase yearly after establishing a smart grid based on the case of a middle-standing power company in the US, which is integrated vertically, and has 1 million customers.
ICT convergence will cause a rapid expansion of energy data. Therefore, it is critical to consider how to manage and utilize this mass data.

Throughout the analysis on mass data, companies will be able to intensify their customer relationship, and more efficiently operate their power networks and assets.

New businesses entering energy sectors
- In addition to existing energy companies, various businesses including communication, software, terminal device, security, construction, and automobile companies will participate in energy-related projects. The range of participants will be gradually wider.

- As a smart grid has different classes including power, communication, and applications, companies in different fields can jointly form a smart grid system.

- A company can participate in one or more classes of smart grid. For instance, a power company may provide their own communication network using an independent application, or a communication company may propel a smart grid project integrating power sales and the provision of demand reaction program.

○ Changes in the roles of existing power companies

- The power industries have faced new demands created by growing distributed energy sources, emerging clean technologies, expanded energy-efficient programs, customers’ increasing desire on energy management with their familiarity with ICT, and competitions with other energy providers.

- The extensive dissemination of renewable energy with a large amount of carbon emissions and intermittent outputs has increased the burden on power network operation, and shrunk profitable foundations as many customers has begun to have their own distributed power producing system.

- As abnormal climates have more frequently occurred, and as the
acceptability for the installation of substations and transmission towers has lowered, the usefulness of centralized remote power systems has been increasingly questionable.

- Companies who could not adapt themselves to these new environments and fail to meet customer demands have been losing their competitiveness in the market.

○ Increase of new risks

- ICT convergence in the energy sector has highlighted some problems, especially risk issues related to this sector, which were not considered importantly in the past.

- The new environments using smart energy connect distributed energy including wind power and photovoltaic energy to power networks. This situation allows more various stakeholders to join the networks and create more connected points, increasing not only the bidirectional information sharing but also cyber security problems.

  · The use of bidirectional communication technologies increases security threats, which may cause monetary damages by forged or falsified data, power system operation interruptions, and manipulated account data.

  · The increasing use of commercial hardware and software, which are likely to expose their system information or week points, adds to security threats compared to existing power networks.

  · When tens of million smart meters and electric vehicles are connected to power networks, the points where customers can access to the
systems will rapidly increase.

· The increase of interactive connectivity, detached from existing vertical communication structure, using smart grid devices and communication for intellectualized services leads to more difficulties in risk management.

· The widely spread smart grid devices including smart meters and distribution sensors may cause problems in risk management and security control.

· The modernization of energy network increases the possibility of the exposure as well as collection or utilization of private information.

· Existing power systems measure power use once a month, while smart meters obtain such information almost in real time.

· New technologies make it possible to collect or estimate individual data including the number of residents, current residency, bed time, and wake-up time by monitoring power consumption.

· As for households privacy including individual hobbies, behavior patterns, and lifestyle can be exposed to public, and it can be used for other purposes than power services, leading to the invasion of privacy.

□ Future of ICT convergence in energy sectors

○ Changes in the direction of ICT-based business

- Expansion of IoT connecting all things to networks

· The spread of information devices and the development of networks will connect not only people but also all different things based on
Internet. It is called Internet of Things (IoT).

- Upgrade of big data analysis substituting jobs requiring professional knowledge
- The development of big data and analysis technologies will considerably substitute what workers with professional knowledge.
- Expansion of free models such as free web services
- Utilization of Social Network Service (SNS) as business tools beyond social relationships
- Expansion of as-a-service business models, allowing customers to make a payment according to the amount of service use
Interaction between smart energy and ICT business trends

- ICT business trends described above are combined with smart energy to consistently spread the influences of ICT in the energy sectors.
- Various services have been developed in the energy sectors, while some specific services of them have begun to be provided for free.
- The expansion of free service models is expected to join the increase of combined services in the energy sectors.

Source: NIA (2013); modified.
- SNS can be used as business tools to promote communication between energy providers and customers, to encourage customers to use new smart energy services, and to improve the efficiency of energy use. It can also play a role and to play a role as one of major sources to create big data.
III. Policy Implications

○ ICT convergence has progressed in the all sectors related to various energy sources, and different stages of life cycle. Under the circumstances, the value flow of energy industries has changed from unilinear to interactional direction, and customers have become to be important agents in value chain.

- When companies joint the value chain with new products and services, new types of cooperation and competitive relations will occur. In this process, companies who fail to achieve customer satisfaction and create appropriate values may lose their competitiveness in the market.

- In addition, the advancement of big data analysis technologies and IoT has increased the utilization and market values of energy data, and also expands ICT-based business models including free services and as-a-service models in the energy sectors.

○ To promote the creation of new values in the energy sectors throughout ICT convergence, it is necessary to share energy data and to further open smart energy markets with the increasing opportunities of participation.

- New ICT-based services in the energy sectors are usually relying on the utilization of energy data.

- Energy data sharing systems need to be established to pay the price for the obtainments of energy data, to protect energy customers’ privacy, and to promote new energy services.
- New energy services should be extensively provided to create new jobs and to enhance the competitiveness of energy industries.

○ Countermeasures should be prepared risks which may be caused by smart energy.

- ICT-based risks can occur due to ICT convergence. In particular, it is critical to properly respond to the problems related to cyber security threats and private information exposure.

- The increasing number of connected points at energy networks under the environments using smart energy not only widens the opportunity of information exchange, but also diversifies the routes of cyber security threats. Hence, the utilization of smart energy data has also more serious problems in private information exposure.

- Alternatives to prevent or minimize new risks in the energy sectors should be consistently discussed and developed.

○ The continuous development of smart energy should be pursued based on the final customers’ acceptance of smart energy.

- To improve the acceptability of smart energy, it is important to raise a public recognition on the usefulness of smart energy technologies based on a flexible rate system. In addition, the efforts to mitigate customers’ recognition on risks related to smart energy should be made at the same time.

  - Customers recognize smart energy-related risks as well as benefits. This negative impression which can discourage customers to use smart
energy.
- In addition, the efforts to minimize the gap between customer expectation and satisfaction should be made. In other words, it is not helpful to make customers have too many expectations on smart energy.
  - Training or promotional programs should not deliver exaggerated information on smart energy.
  - Smart energy technologies should be developed with balanced efforts to reduce smart energy-related risks as well as to expand benefits.
  - To make the use of smart energy use easier, it is important to improve the compatibility with existing technologies and to design a intuitive user interface.

○ In terms of national informatization, national visions on smart energy should be established, and ICT convergence projects, which are actively propelled at preset, should be developed to connect them with other energy intellectualization projects.

- Smart energy is not a short-term transient trend. It should be considered as mega trend, which will bring consistent changes with the development of ICT in the energy sectors.

- Currently, in Korea, most projects utilizing ICT are actively progressed in the power industries. However, global trends show that ICT convergence is utilized in various energy fields, and is responsible to provide solutions necessary for each field.

- It is an important time to make plans for the future in response to the
changes of energy demand and supply, competitive structure among market participants, and relevant policies, laws and regulations caused by energy intellectualization beyond technological convergence.
IV. Expected Achievements

□ This paper will provide a theoretical foundation to establish policies for the intellectualization of energy services, essential to be one of leading countries in the energy industries.

○ It is helpful to define the intellectualization of energy services, and to specify the development direction of energy-ICT convergence.

○ While only a very few studies have conducted on intellectualized energy services, this paper introducing a simulation method will be inspiring to relevant fields.

○ It can lead to the upgrade of existing strategies related to the establishment of clean, efficient, and stable energy systems.

□ This paper can be used as a basic literature in promoting intellectualized services related to all energy sources including gas, oil, new and renewable energy, and nuclear energy as well as smart grid.
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