

Foreign Green ICT Development Practice and Its Implications in the Context of Information and Communication Technology

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Abstract. The 13th Five-Year Plan of China has made it clear that we should initiate the green development concept. In the context of information and communication technology, the development of green ICT in China faces an unprecedented opportunity. This study summarizes the practical experience of green ICT development from foreign countries and analyzes the environment for green ICT development in China. On the basis of this, we propose that we should implement green ICT policies as soon as possible, increase R & D funding and human capital investment and make the green ICT development concept known to more and more people.

Introduction

As an important driving force for the development of the national economy, information and communication technology (hereinafter referred to as ICT) has developed rapidly in recent years. It has played an important role in creating new employment opportunities, promoting economic growth, stimulating consumption and enhancing national competitiveness. However, technology is a double-edged sword. While promoting economic development and the extensive use of ICT, we have witnessed many environmental problems. IEA (2009) noted that, over the past 20 years, the electricity consumption from ICT equipment, such as communications systems, personal computers and databases, maintained an annual growth rate of nearly 7%. [1] Greenpeace International (2014) estimated that the ICT industry had caused at least 2% of global CO₂ emissions. [2] Because we are faced with the increasingly serious global environmental problems, coordinating the relationship between technological progress and human development has become an important strategic issue in the world, which needs to be solved urgently.

Under the circumstances, the international community supports the spread of "green ICT" concept strongly. Green ICT aims to emphasize that while maintaining the economic benefits of ICT, we should reduce its negative impacts on the environment and extend its comprehensive use of effectiveness. The development of Green ICT is an important part of national social responsibilities. Therefore, Green ICT has caught worldwide attention at the beginning of its implementation. Now, China has entered an important stage of information technology. Systematically analyzing the characteristics of Green ICT development in foreign countries will provide beneficial implications for the implementation of China's information technology development strategy.

Overview of Green ICT

The Origin of Green ICT

Since the late 1990s, the global economy has undergone a stage from "Industrialization" to "Informatization" gradually. Information and communication technologies were integrated constantly and developed rapidly. The original concept of ICT was proposed by the federal government of the

United States, which appeared in its work report in 1997. Subsequently, countries all over the world began to regard ICT industry as an important part of the development strategy. According to the statistics, the ICT industry has become major impetus for social progress and economic growth in many countries. Despite the development, resource shortages, climate changes and other environmental issues have become so serious that they can't be ignored. The practice of developed countries fully shows that when the degree of economic development reaches a certain level, the problem of environmental pollution will become the main obstacle to social development. So, the ICT "green nature" has gradually been emphasized by more and more countries. This nature is not only reflected in the ability to reduce carbon emissions, but also in the natural advantage to cooperate with other industries in order to complete energy conservation targets. Because of ICT, all aspects of social life become more intelligent and energy-efficient. Smart grids, intelligent buildings, intelligent logistics, intelligent medicines, and other "immersive" applications of ICT in various fields have an important impact on urging the whole community to achieve energy-saving and emission-reducing targets. Moreover, as to the adjustment and optimization of industrial structure, ICT has been very useful. It is the primary driving force for green economy. As a result, more and more countries have adopted ICT in order to achieve long-term environmental protection and social development. In the context of this, the information and communication technology industry and the concept of sustainable development are integrated, creating the concept of "Green ICT".

The Connotation of Green ICT

As a new concept, "Green ICT" frequently appeared in news and reports, but the domestic or foreign research on it is not sufficient. The current literature depicts Green ICT from different aspects. Yong Ho Shim (2009) defined Green ICT as the acts to reduce energy consumption and pollution of the environment through ICT.[3] Gartner (2008) describes Green ICT as encircling the use of environmental sustainability to contribute to environmental preservation.[4] Sergio Benedetto and Byeong Gi Lee(2015) hold that Green ICT is generally referred to as the design and application of information and communications technology(ICT) which aims to attain environmental benefits. The environmental benefits associated with Green ICT can be measured by the reduction of carbon emissions, higher energy efficiency and so on.[5] Suryawanshi Kavita and Narkhede S. (2014) think that Green ICT is a pioneering way of using ICT that consists of policies and practices which ensure environmental sustainability by minimizing carbon emission, decreasing ICT waste, optimizing energy consumption structure and protecting natural resources from the cost-effectiveness standpoint.[6] Generally, we have narrow and broad views of understanding green ICT. The narrow sense focuses only on the environmental effects of the ICT industry itself(Green of ICT), while the broad sense focuses on the effects of ICT technology on the environment in other areas of society(Green by ICT).[7] Considering the fact that ICT technology has been widely used in the most aspects of human life, we use the broad definition in this study.

The Analysis of Green ICT Development Characteristics in Foreign Countries

Improve the Mechanism of Policy Guidance

The development of Green ICT can't be achieved without policies and regulations. Any country that attaches importance to ICT strategy will put the policies and regulations concerning ICT in the first place, and raise the implementation of green ICT to a strategic level. Back in 2005, EU proposed a "i2010: European Information Society 2010" five-year development plan, aimed at promoting ICT industry development. In September, 2009, at the end of the "i2010" program, the European Union completed "A Green Knowledge Society" development report in time, revealing the concept of the development of Green ICT and coming up with ten green subjects as the main reference for EU policies from 2011 to 2015. [7] As the leader in ICT industry, Germany established a competitive tax system in 2008 to encourage ICT's long-term development by reducing tax amount of IT industry. [7] In "i-Japan Strategy 2015", Japan elaborated on its ICT policy trends in detail. Based on the global

ICT market, it delved into Japanese own technologies which can extend worldwide and solve social problems.[7] In April, 2010, Japanese government launched the "Smart Community" program, as an important step to fulfill the promise to achieve 25% reduction in 2020. [7] Similarly, developing the intelligent energy is also a strategic consensus from America government and industry association in America. In "The American Energy Independence and Security Act In 2007", "A Policy Framework For The 21st Century Grid: Enabling Our Secure Energy Future" [7] and other policy documents, the green ICT-related plans are expounded. In addition, Germany and Australia have all published "The White Paper of Green ICT", offering comprehensive analysis of developing green ICT and providing the ways to achieve it. It is the promulgation of these policies and regulations that lead these countries to promote the practice of Green ICT.

Increase Capital Investment Efforts

The development of science and technology cannot be separated from capital investment. In order to develop Green ICT, many countries not only provide policy support, but also invest a lot of money. In "i2010", The European Union proposed the steps to improve R & D investment and output in ICT industry, making it clear that all members should increase the R & D investment in ICT by 80% from 2007 and provide financial support for high-performance ICT projects. Particularly, they should treat ICT applications like Smart Grid, Logistics traffic, construction, Solid-state lighting as top priorities, and increase the proportion of investment in these fields. [7] As a typical country short of energy, Japan released the "ICT New Deal" in 2009, hoping to get rid of the economic dilemma by increasing ICT-related investments. [7] In "A Policy Framework For The 21st Century Grid: Enabling Our Secure Energy Future", America explains the four pillars of the latest Smart Grid policies, one of which is supporting the sharing of information on smart grid. This is designed to facilitate the formation of cost-effective investments or the R & D and demonstration of smart grid projects. [7]

Focus on Innovation

Xi Jinping proposes that innovation is the driving force for the development of technology. Nowadays, innovation-driven development has become a worldwide consensus. The ICT industry is a technology-intensive industry. Countries and industry organizations all over the world have put innovation into the Green ICT development plan. In "i2010" Communication Conference at 2009, the European Commission proposed a policy framework that Europe should transfer to a low-carbon economy by ICT application service innovation. It is believed that companies of ICT in Germany are mostly small or medium ones, most of which are engaged in high-tech products R & D, showing a strong atmosphere of innovation. In 2009, the Obama administration put forward the "Strategy of Technology Innovation ", and published ARRA 2009, planning to invest 100 billion dollars in the innovative area. Then, American government released Blueprint For A Secure Energy in 2011, calling for a clean energy future through innovation, and stressing that becoming a world leader in the field of clean energy is the key to strengthening the US economy and winning the future. [7] In addition, Digital Energy Solutions (DESC), co-founded by Intel and some information and communication technology companies, treat the public policymaking which promotes innovation as one of the missions, so that obstacles to fully deploying energy-efficient ICT solutions are eliminated. This is dedicated to making people comprehensively aware of the important role of ICT in the living environment and the long-term development of the economy.[7]

Set up Implementation Safeguards

In the "Criticism of the Gotha Program", Marx stressed that step-by-step actions are more important than programs. Without efficient implementation, all policies will be empty talk. Foreign policymakers are aware of this and have taken steps to go forward. The European Commission formulated policies to implement the application of ICT energy-saving measures in 2009. Websites should be set up, letting public and private enterprises and departments share successful experiences, implementing regional and local guidelines by cooperating with regional councils, and improving the

efficiency of energy use by the application of innovative ICT. [7] In *A Policy Framework For The 21st Century Grid* released in 2011, The United States reported that the successful application of smart grid technology depended on the effective participation of residents and small companies, and on appropriate measures to ensure that consumers proactively supported smart grid technology. The measures may include educating consumers by a variety of ways and designing simple and practical intelligent equipment to ensure the consumers' convenient operation.[7]

Attach Importance to ICT Personnel Training

Innovative and technological competition, in the final analysis, is the talent competition. While profoundly describing the development prospects of the ICT industry, vigorously creating a favorable policy environment and constantly promoting the rapid development of ICT industry, countries around the world without exception have encountered serious problems of professional and technical personnel gaps. Taking measures to enhance the efficiency of senior professional training is undoubtedly the premise of promoting the healthy development of the ICT industry. Finland is one of the leaders in information technology. Its mature educational system promotes the rapid development of the ICT industry. In Finland, all citizens enjoy compulsory education from primary schools to universities. As for the cultivation of high-tech talents, the Finnish government attaches great importance to the actual needs of enterprises, and has established a cooperative model of private companies, universities and research institutions, thus providing a sustainable power for the development of ICT industry. [7]The P21 (The Partnership for 21st Century Skills) in American organizes a set of 21st century public education systems - the 21st century capacity training standards, one of which is specifically designed for ICT personnel training. It also works with a number of disciplines to develop ICT capacity maps, explore the integration of ICT capabilities and knowledge of various disciplines, design ICT capacity portals, and provide adequate information and resources related to ICT capabilities. [7] Facts have proved that the efforts of these countries in personnel training have contributed to the effective development of the ICT industry.

Analysis of the Environment of Green ICT Development in China

Since the foundation of the first Institute of Computing Technology in 1956, the development of ICT industry in China has undergone several significant stages. From the "ICT bottleneck period" before the reform and opening up to the "ICT policy adjustment period" after the reform and opening up, and from the "ICT take-off phase" in the early 1990s to the "ICT application phase" since the 21st century, China has always been endeavoring to keep pace with the world and intensify its efforts to develop information and communication technologies, promoting social progress and economic development. Since 2004, "China International Information and Communication Exhibition" and "ICT China High-level Forum" have both been held 11 times, launching high-level dialogues to discuss industry development plans which focused on how to achieve the simultaneous development between the industrial economy and the national economy, and the win-win situation between corporate interests and social benefits, and providing decision-making basis for the development of ICT in China. In recent years, as the world focuses on the development of Green ICT and the transfer of extensive economic growth pattern, China has been following the pace of the world and integrating the development of green ICT into national strategies.

Although China has not promulgated policies specifically designed for ICT development, the 13th Five-Year Plan has regarded green development as one of the ideas and made it clear that we should speed up the improvement of safe, efficient, intelligent-green and interconnected modern infrastructure networks, accelerate the development of energy in all areas and intelligent aspects, promote the integration of new technologies in energy, information and other areas deeply, and employ the supportive and leading role in the economic and social development. At the same time, Chinese social organizations at all levels have also played their pioneering roles, promoting the domestic green ICT development through forums and meetings. In March, 2011, China released *IEEE*

Standard for Ubiquitous Green Community Control Network Protocol(IEEE1888), which is significant for promoting the integration of energy saving, environmental protection and new generation of information technology, and can greatly promote the internationalization of China's Green ICT Industry. [7]In 2011, the Green ICT Forum, organized by the Ministry of Industry and Information Technology, was held, aiming to promote the application of ICT technology in the field of energy saving, and the cooperative exchange in the field of global wisdom and energy. In 2012, the China Green ICT Industry Technology Development Forum was held, the theme of which is "Green ICT Industry Sustainable Development, Low-carbon Energy-saving Technology Application Innovation". The participants discussed the development strategy of technology and application in various industries with the background of green industry, reaching a consensus on the establishment of green industry development concept, the increase of investment in green technology research and development, and the promotion of the environmental protection of the whole industry chain. The forum also released "The White Paper of Green ICT Industry Development in China at 2012". The above shows that China has a certain policy guidance in the development of Green ICT.

However, in 2012, Tsinghua University Media Investigation Laboratory received a commission by Alcatel-Lucent to conduct a national survey of Chinese ICT industry practitioners' awareness of Green ICT. The investigation revealed that the ICT industry practitioners greatly accepted the green concept, but there was still some controversy over how to achieve the goal of reducing carbon emissions through technology. [18] This shows that China hasn't done enough to safeguard the implementation of Green ICT, rendering residents unable to find an effective way to apply Green ICT.

The Chinese government always treats the personnel training as a priority. In the 13th Five-Year Plan, China puts forward the talent priority development strategy, takes building a large-scale talent team, promoting the optimal allocation of talents and creating a good development environment for talents as a policy direction in this new stage, and launches the "Innovative Talent Promotion Plan", "National High-skilled Talent Revitalization Plan" and other major projects. However, compared with foreign countries, China's talent strategy on the development of Green ICT industry isn't not that advantageous. On the one hand, the basic education in China is weak, affecting the improvement of talents. On the other hand, the cultivation of the comprehensive quality of talents doesn't develop in line with the ICT industry.

In addition, the lack of innovation is also a serious impediment to the development of China's green ICT industry. As a productive power in the world, China has reached a world-class level in system integration design and manufacturing technology, but the patent layouts on ICT technology are generally on the external level. When facing the global market competition, China is vulnerable to a variety of technical and patent barriers due to the lack of independent brands and core technologies. [7]Increasing R & D investment and finding ways to improve the quality of innovation in the country are fundamentals of the development of Green ICT. China policymakers have realized the important role of innovation in social development. The 13th Five-Year Plan puts forward the innovation-driven development strategy clearly, advising that we should regard scientific and technological innovation as the core, strive to enhance the ability of independent innovation, and stress the acceleration of breakthroughs of the core technology in information and communication, intelligent manufacturing and other areas. However, how to promote the Green ICT innovative ability? There has been no clear-cut policies so far.

The Revelation of China

In the context of the green development concept, the development of Green ICT in China faces an unprecedented opportunity. China should seize this opportunity, learning from foreign countries, and take all possible measures to enhance the strength of Green ICT and to foster the green construction in China. Specifically, efforts can be made from the following:

Introduce a Systematic Policy That Contributes to the Development of Green ICT ASAP

The industrial development needs the lead of national policies. Only when the development of green ICT rises to the national strategic level can its development efficiency be effectively guaranteed. The Chinese government should adhere to the five development concepts and plan the overall development of green ICT, based on the current and long-term goals. First, we should clearly understand the overall objectives and requirements of Green ICT development, and clarify the specific responsibilities of units and departments at all levels in promoting green ICT development. Second, we should improve the Green ICT-related operational standards, monitoring and assessment systems, and improve the laws and regulations of green development. For example, as to the supervision and inspection, we should build a green GDP performance evaluation system for government officials, and state the clear ecological responsibilities of the government.[20] Finally, we should establish a coordination mechanism in the technological research, promotion, demonstration and use, and develop long-term development strategies to meet the basic conditions of our national environment and resources, providing a favorable policy environment for the development of Green ICT.

Increase R & D Funds and Human Capital Investment; Improve the Innovation Capacity in ICT Industry

The 13th Five-Year Plan takes innovation as one of the five development concepts, stressing the need to put innovation in the core. With much potential, ICT industry is a technology-intensive industry. In the information era, ICT industry is charged with an important mission of leading the national scientific and technological innovation, and it is urgent to make major breakthroughs in this field. Many studies have shown that R & D capital investment has a positive effect on technological innovation, and human capital has a moderating effect on the relationship between ICT and economic growth.[21] Therefore, investment in green ICT technology research and development should be increased. We should set up special funds for Green ICT development in the central budget and give enough support to Green ICT-related research projects in national, local and departmental research projects. Besides, we should encourage all types of financial institutions to develop credit products suitable for the Green ICT projects, and all kinds of innovative funds and social donation funds to be put into the investment in Green ICT. Tax support should be given to enterprises that adopt Green ICT technology. We should allocate educational resources reasonably, not only paying attention to the cultivation of high-end scientific research talents in ICT industry, but also focusing on the cultivation of the basic ICT quality in citizens. Furthermore, we should explore the joint mechanism of enterprises, scientific institutions and universities, promoting the combination of production, learning and research, and striving to integrate the personnel training in universities and the actual needs of the country. Moreover, we should accelerate the construction of the research bases and innovation teams for Green ICT. In short, these comprehensive measures are devoted to speeding up the research of core technology in green ICT and improving the Green ICT-related innovation.

Increase the Popularity of Green ICT Ideas to Ensure the Effective Implementation of Green ICT Policy

As mentioned earlier, Green ICT is a new concept. Citizens are not fully aware of this. In order to ensure the effective implementation of green ICT policy, the state needs to increase the popularity of Green ICT concept. First, the government should be the pioneer to lead Green ICT, increase the procurement of Green ICT products through the construction of e-government, and build a system conducive to the promotion of Green ICT technologies, such as giving subsidies to individuals or organizations that adopt Green ICT technology, and promoting the applications of Green ICT products. Second, the enterprise is the main force of the development of Green ICT. We should strengthen the understanding of business leaders on green development through training and education, and encourage enterprises to enhance green awareness and fulfill their green responsibilities. These measures include making full use of the news media to publicize the

enterprises which have significant achievements in the field of Green ICT, setting the industry benchmarks and so on. Third, we should strengthen the training guidance on the use of Green ICT technologies for the public. Traditional media and new media such as newspapers, television, microblogs, WeChat and traffic publicity board must be used to propagate Green ICT-related knowledge and application methods, creating an atmosphere of green development. In sum, we should attain the full applications of Green ICT products as soon as possible, encouraging the transfer and upgrading from the ICT industry to the Green ICT field.

Conclusion

With the awareness of environmental protection in the world, as for the major indicators of a country's comprehensive power, comprehensive indices with the evaluation dimensions of green competitiveness have been added to simple economic indices. In the context of information, the development of Green ICT is an important way to respond to the national green development ideas, and has a far-reaching effect on the green development of China's economy. In order to promote the efficient development of Green ICT, China should adhere to the concept of open development. In the meantime, we should understand that different stages and environments allow distinct ways and focuses to achieve the green economy. Therefore, while conducting in-depth international communication and leaning from foreign experience, we need to explore roads peculiar to China's development of ICT. In particular, we should focus on the overall planning and establish coordination mechanisms of Green ICT development in order to promote the balanced development of ICT industry in various regions.

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