Analyzing the Configuration of Knowledge Transfer of the Green Island Projects in S. Korea

Taewook Huh*

Abstract: This paper explores the cases of the Gapa and Gasa green (energy-independent) island projects, based on a micro-grid system, in S. Korea in the context of knowledge transfer. It analyzes the rationale of knowledge transfer (including the international environment such as the INDC (Intended Nationally Determined Contribution) commitments), the process and objects of knowledge transfer (the actors involved and the objects (hardware/software/orgware)), as well as the degree and results of knowledge transfer (technological, economic, and environmental impacts) in the green island projects. Looking at the findings of both cases, this study reveals that although some meaningful results have been produced, the projects are so far based on a government-led top-down approach and overemphasize a 'hardware-intensive' way. In conclusion, this paper argues that the degree and results of knowledge transfer in the green island projects show an aspect of "incomplete transfer." Also, it suggests that the green island projects in S. Korea are required to take 'community-customized' and 'residents-friendly' approaches in the comprehensive context of knowledge transfer.

Keywords: green island, knowledge transfer, micro-grid, INDC, hardware, software, orgware

INTRODUCTION

To date, there is growing attention paid to side effects caused by climate change around the world. These are not area-defined issues and therefore require responses and cooperation both at domestic as well as global levels. Since the 1990's such multi-lateral cooperative efforts have increased, especially because of the fear that many islands might disappear in the near future due to the rising sea level. In fact, islands are very vulnerable to the impact of climate change, which may bring about catastrophic consequences to the world as we know it. Currently, various development

---

* Research Assistant Professor, Moon Soul Graduate School of Future Strategy, KAIST.

Manuscript received September 19, 2016; out for review October 1, 2016; review completed February 28, 2017; accepted March 8, 2017.

The Korean Journal of Policy Studies, Vol. 32, No. 1 (2017), pp. 1-26.

projects of such islands are being carried out in cooperation with international organizations and regional entities. In terms of tackling the problem of lack of electricity on the islands, such 'green island' (energy-independent) project cases around the world show a model of knowledge transfer between regions for low-carbon green development in the islands (GTC, 2014; KEPCO, 2014a; U.S. Department of Commerce, 2016).

In fact, the green island projects based on micro-grid technology is in line with the trend of increasing renewable energy projects worldwide. Europe sets the example for developments in renewable energy technology; for example, in Denmark 42% of total domestic electricity generation is from renewable energy, and in Portugal 48% from renewable energy (KEPCO, 2014a). In Korea, the paradigm of energy supply and demand is also dramatically transforming. One of the typical examples is the green (energy-independent) islands, where power consumption is based 100% on renewable energy. Currently, the seven green island test-bed projects in South Korea, including the Gapa Island and the Gasa Island are still in their development stage, in which the conventional fossil fuel energy such as diesel is replaced by a renewable energy with the ESS (energy storage system).

The key technology for the green (energy-independent) islands is micro-grid, which refers to a small electric grid, and "an integrated energy system which consists of distributed energy resources and multiple energy loads operating as a single controllable entity in parallel to or islanded from the existing utility power grid" according to the US department of Energy (Dan and Merrill, 2011: 91). Compared to the conventional massive electrical grid, the micro-grid system has many advantages in terms of multiplying the renewable energy sources and managing the risk of blackouts especially in relation to high energy efficiency (60-80%) and low electricity loss (10-20%) (GTC, 2015c; LG Electronics, 2015). The green island projects based on micro-grid systems are spreading around the world, not only in developed countries but also in developing countries.

This paper highlights such knowledge transfer as an umbrella concept (framework) including technology transfer. Knowledge transfer generally refers to the multiple channels through which knowledge can be transferred so as to generate economic value (Argote and Ingram, 2000). Knowledge and technology hold common characters and often these terms are used without distinction. However, as Farley and Sharer (2005) and Landry et al (2007) argue, there is a difference between knowledge and technology in terms of purpose, degree of codification and type of storage, and in fact, technology can be regarded as a sub-type of knowledge.

This study tries to describe such global efforts in tackling the issues of green (energy-independent) islands in the context of knowledge transfer. It notes both cases of the Gapa Island (the 'first-generation' green island in S. Korea, completed in Jeju province in 2013) and the Gasa Island (the first fully micro-grid based green island, completed in Jeonnam province in 2015), and tries to analyze the related processes and interactions involved in the context of knowledge transfer. They can be characterized by three major components: the rationale of knowledge transfer, the process and objects of knowledge transfer, and the degree and results of knowledge transfer in the green island projects.

As a case study, this paper adopts a qualitative methodology including multiple methods, which involves semi-structured interviews with related experts (14 respondents) from the governmental, academic, and private sectors. They were involved in the process of the Gapa and/or Gasa Green Island projects in S. Korea. For the anonymity of the respondents, this paper utilized a numbering system in relation to respondents' quotation. Snowball sampling was used, and with regard to the analysis, this study adopts narrative and content analysis.

THEORETICAL ISSUES AND ANALYTICAL FRAMEWORK

The Comprehensive Context of Knowledge Transfer for Global Climate Change

Knowledge transfer has become a hot topic of theoretical research as one of the most important means to increase the competitiveness of organizations in the private and public sectors (Bang et al, 2015). As many researchers point out, including Farley and Sharer (2005) and Landry et al (2005), technology can be understood as a subtype of knowledge where technology is concrete, of specific use impact, and able to change a technical environment, but knowledge is intangible (implicitly saved in people's brains), of not specific use impact, and able to utilize theories and principles. Knowledge includes a product of human reflection, experience, and resources.

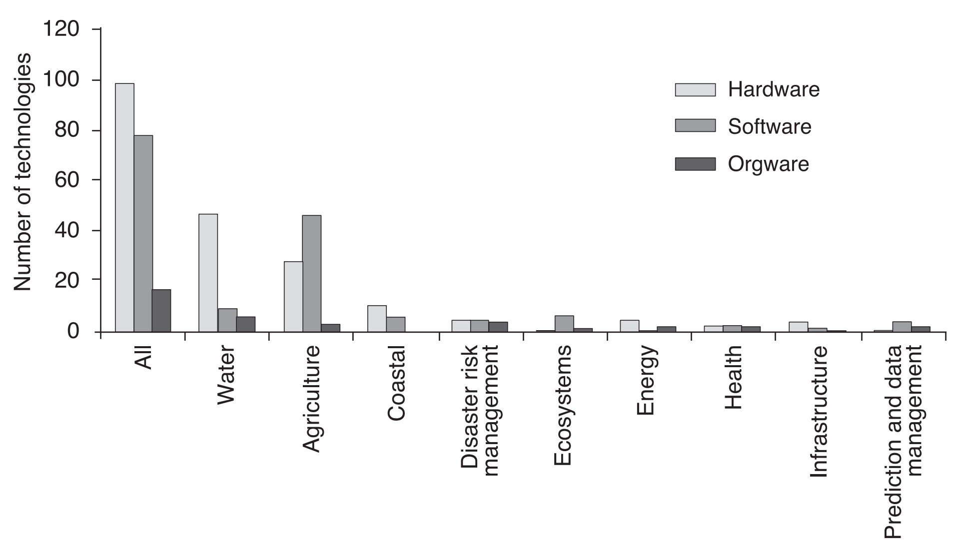
Knowledge transfer (KT) has been used to encompass a very broad range of activities to support mutually beneficial collaborations between the public, private, and voluntary sectors. In fact, it is all about the transfer of tangible and intellectual property, expertise, learning and skills, which is located in an individual or a collective, or embedded in a routine or process (Bang et al, 2015). Many researchers have various ideas on KT; Kogut and Zander (1992) regard it as an important reason for the existence of enterprises; Szulanski (1996) sees it within and between organizations across the boundaries of knowledge sharing; and Szulanski (2000) and Argote & Ingram (2000) underline it as a process in which an organization learns, applies, and recreates sets of routines in a new setting. Knowledge transfer includes a much broader range of activities, which is not limited to the science and technology disciplines. In terms of activities, KT can be carried out through people, publication and events, collaborative research, consultancy, licensing, and new businesses. Also, Arvantis et al. (2008) classify the activities of KT into six categories: informal activities, technology infrastructure, education, research, and consulting. The activities of KT (which are shared and leveraged) operate in the various levels such as individual, intra-organizational, inter-organizational, and transnational levels.

Technology transfer—regarded as a sub-type of knowledge transfer in this research—has been defined in various ways in many research disciplines including Sadelin (1994), Megantz (2002), Kingsley and Klein (1998), Landry et al. (2007), Link et al. (2006), and so on. Friedmann and Silberman (2003) and Roessner (2000) define it as the movement of know-how, skills, technical knowledge or technology from one organizational setting to another. Also, the technology transfer is understood as that of transfer spinoffs, spillover, fusion and so on in the economy (among economists), focusing on a link between technology transfer and production (and commercialization) (Arvanitis, et al, 2008; UNEP Riso Centre, 2011). In sum, the meaning of technology transfer varies according to the discipline of the research and according to the purpose of the research as well. Also, in general, the types of technology transfer can be categorized into six subtypes: assignment, cooperative research, licensing, spin-off, joint venture, and M&A (Eom, 2015).

This study highlights that there are three technology category types: 'hardware,' 'software,' and 'orgware.' As various reports from UNEP (2014), UNFCCC (2015b; 2015c) have explained, hardware includes capital goods, particularly technologies requiring "the installation of physical material from sources outside the targeted locality" (Inderberg, et al. 2015: 12); software refers to the processes involved in the use of the technology, including knowledge and skills; and orgware relates to institutional arrangements of the community and organization where the technology will be put to use (Schoen, et al., 2014). Orgware can also refer to the aspects of capacity development, education and training.

However, in reality, the relative weights of hardware, software and orgware vary significantly in the individual sectors projects, and as a result, technology projects tend to be 'hardware-focused' and 'hardware-intensive.' As shown in Figure 1 below, comparing the individual sectors in the 25 countries, although there is a difference between the individual characteristics of each technology sector for climate change, the total number of 'hardware' technologies is the largest one among the three categories - 21% larger than 'software' technologies and 82% larger than 'orgware' technologies. (Inderberg, et al. 2015: 118)

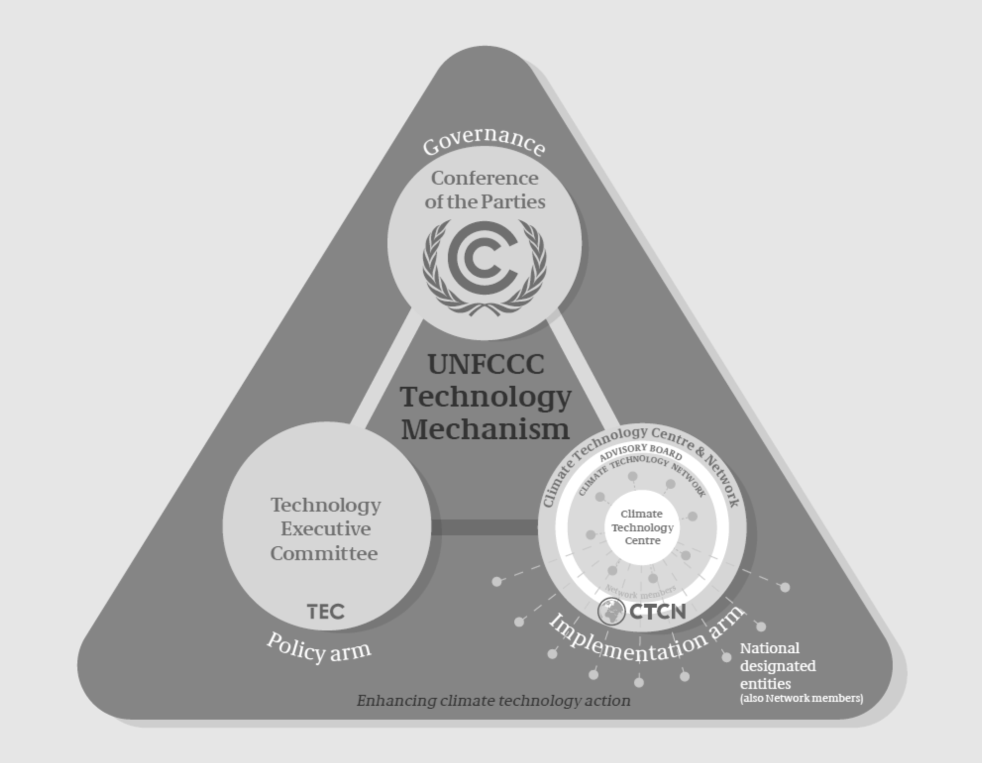
Figure 1. Distribution of hardware, software, and orgware by individual sectors for the 25 countries



Sources: Inderberg, et al. 2015. Climate Change Adaptation and Development: Transforming Paradigms and Practices. p. 121.

This study tries not to review technology transfer in a narrow way, focusing on individual sectors, types, and activities, but to analyze technology contents in the comprehensive context of KT; for example, focusing on including rationales, processes, and objects of KT. In fact, such KT activities have been facilitated at the global level. Within the United Nations Framework Convention on Climate Change (UNFCCC) process, countries have confirmed the importance of enhancing the development and transfer of climate technologies to developing countries (UNFCCC, 2015b; 2015d). To facilitate action in this regard, in 2010 the Conference of the Parties to the Convention established the Technology Mechanism. As shown in Figure 2, the Mechanism consists of two complementary bodies that work together to achieve its objective: The Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN).

Figure 2. UNFCCC Technology Mechanism



Sources: http://unfccc.int/ttclear/templates/render_cms_page?TEM_home

The Technology Mechanism supports countries' efforts to accelerate and enhance action on climate change (UNFCCC, 2015a; 2015b). It helps countries develop and transfer climate technologies so that they can effectively reduce greenhouse gas emissions and adapt to the adverse effects of the changing climate. Technologies play a central role in acting on climate change, which help us to reduce greenhouse gas emissions, include renewable energies such as wind energy, solar power and hydropower, and utilize drought-resistant crops, early warning systems and sea walls. There are also 'soft' climate technologies, such as energy-efficient practices and know-how to operate machinery.

The two bodies of Technology Mechanism, the TEC and the CTCN, work together to enhance a climate technology action. Their complementary functions support developing countries' efforts to address both policy and implementation aspects of climate technology development and transfer. They work to enrich coherence and synergy in the delivery of climate technology support and to respond effectively to the needs of countries (UNFCCC, 2015b; 2015c).

Green Islands based on Micro-grids in the Knowledge Transfer

UNFCCC has paid attention to the island areas. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) points out that the foundation of existence in the island regions has collapsed, and in particular, the dependence on foreign energy sources such as fossil fuels has threatened the sustainability of islands. In fact, island regions suffer from structural limitations including climate change vulner- ability, accessibility limitation, resource limitation, and scale diseconomies. Climate change vulnerability involves limitation of land use, water shortage, sea level rise, the threat of typhoon, the decrease of marine resources, and so on. The accessibility limitation refers to the issue that most islands are located far from other islands, and isolated islands lack the energy (electricity) supply such as power transmission and distribution from the inland and/or main lands. The resource limitation refers to the fact that island regions mostly lack the capacity of technology, information, human capital and finance for the maintenance and operation of renewable energy. The scale diseconomies indicates that the production cost of energy (electricity) keeps increasing since the scale diseconomies and externality work in the island region with a low demand for energy (electricity).

Given the above limitations to the development of islands affected by climate change, attention has been paid to the green (energy-independent) island projects in which electricity problems are tackled through micro-grid technology. (GTC, 2014; KEPCO, 2014a; 2014b) To reiterate, knowledge transfer (KT) plays a critical role in an effective global response to the climate change challenge, since technology infrastructure (one of the sources of KT) is the source of greenhouse gas (GHGs) emissions (UNFCCC, 2015a; 2015b). Achieving the global reduction of GHGs requires innovation to transform current technologies into cleaner and more climate-resilient technologies (Phillips, et al. 2013).

Micro-grids, while definitions of the term vary, mean a small grid electrical system equipped to self-produce and self-consume electricity. In particular, micro-grids utilize distributed energy resources including solar power (PV), wind power, and cogeneration. Micro-grids are seen as a smaller version of the larger electric grid and are designed to serve localized electric loads (GTC, 2015c). As a future energy system, micro-grids can be operated in parallel with the broader utility grid or with a small, independent system, which increases reliability with distributed generation, efficiency with reduced transmission length, and easier integration of renewable energy sources.

In the context of making micro-grids smart, a smart-grid—a modernized electricity transmission and distribution network including two-way communication systems which enable the integration of grid efficiency, reliability and security—is an important technology. As a key factor, the micro-grid system plays a critical role in the network flexibility and in the effective production of electricity. In addition, a micro-grid offers an alternative path for smart-grid development, and helps make it less difficult and costly for a smart-grid to deploy smart technologies (Eom, 2015; GTC, 2015c).

In particular, smart grid (and micro-grid) technologies can play a catalytic role in the effective implementation of policies to reduce greenhouse gas emission. In terms of transferring and deploying smart grid technologies, as the US ITA (2016) assessed, the global smart grid outlook will be critical in meeting countries' INDC (Intended Nationally Determined Contributions) targets which would need to be submitted at regular, five-year intervals under the Paris Agreement of UNFCCC (nearly 200 developed and developing countries agreed in 2015). This paper notes that the agreement with the requirements of INDC will likely become the main driver in transferring and deploying smart-grids and micro-grids. Under the 'new climate regime,' countries (developed and developing) try to live up to their commitments, setting newer and stronger climate change and adaptation goals which are symbolized by the national INDC reports submitted to UNFCCC.

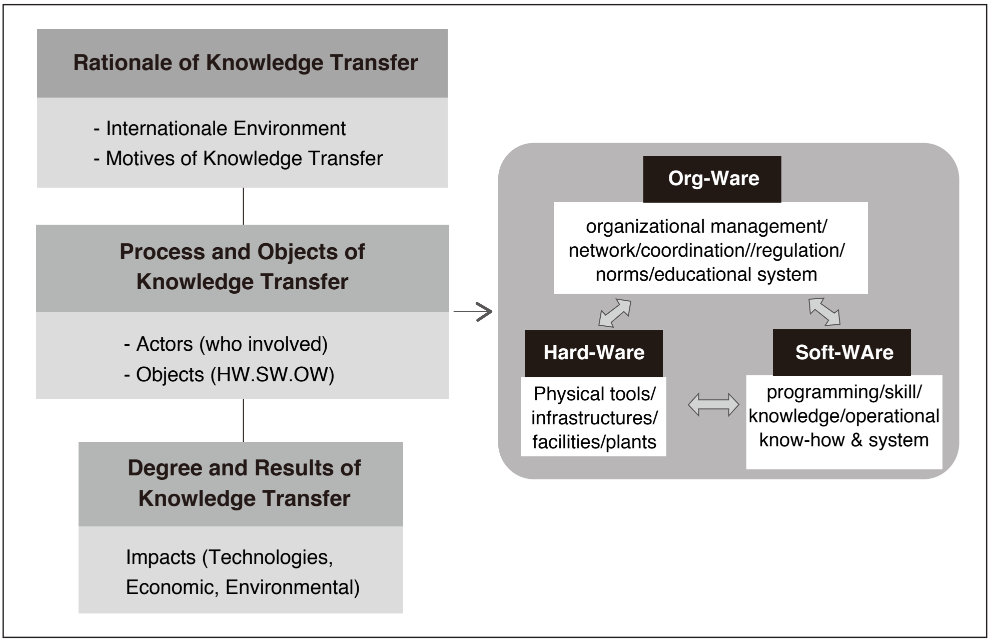
Analytical Framework for the Knowledge Transfer of Green Island Project

This study finds that the research on knowledge transfer (KT) takes both perspectives in general: Works focusing on the characteristics of the knowledge transferred including Kogut and Zander (1993) and Nonaka and Takeuchi (1995), and focusing on the processes and interactions involved in knowledge transfer including Simonin (1999), Szulanski (1996; 2000), and Argote and Ingram (2000). Given both perspectives, this paper tries to set up a comprehensive analysis framework in order to encompass multiple features of KT in relation to the rationale, processes, objects, and results of KT.

In particular, this paper notes the relevant theoretical lessons from the research results of Dolowitz (1996, 1997, 2000) and Dolowitz and Marsh (2000). They have developed the policy transfer (regarded as a type of KT, particularly focusing on the public areas) framework, which focuses on those factors of the transfer process, including "why transfer," "who is involved in transfer." "what is transferred," "degree s of transfer," "how transfer leads to policy failure" and so on. Also, Tews et al. (2003) pay attention to external variations (environments) around a policy transfer. Yi (2010) highlights that the analytical framework of policy transfer consists of 'independent variations' including reasons, processes, features, and 'dependent variations' including results. Ha (2010: 252) suggests the key factors in the three stages of policy transfer: the first stage of "idea adoption" including a context, motive, object, degree of transfer, the second stage of "idea sharing" including an operation of transfer network and actors' organization and activities, and the third stage of "idea institutionalization" including legislation and the settlement of norms.

Utilizing the above results, this paper tries to create an analytical framework for the knowledge transfer of green island projects, which may enable one not only to analyze a process embedded in KT but also to explain the rationale, objects, and results of KT. As Figure 3 shows, the analytical framework sets the criteria of the rationale of knowledge transfer, the process and objects of knowledge transfer, and the degree and results of knowledge transfer. Through the criteria of rationale of knowledge transfer, this study explains the international environment and the motives of knowledge transfer in the knowledge transfer of green island projects. Through the criteria of process and objects of knowledge transfer, it shows which actors are involved in the transfer process, and what is transferred, focusing on the three technology types: hardware, software, and orgware.

Figure 3. The Analysis Framework for Knowledge Transfer



In fact, this paper notes the argument that although the technology category consists of three types—‘hardware,’ ‘software,’ and ‘orgware,’ the biggest emphasis is on hardware elements, accompanied by poorly-defined ‘knowledge-raising’ for software, and very little recognition of the orgware (Arvantis, et al. 2008; Hansen, 1999; UNEP Riso Centre, 2011). Particularly in this study, in relation to ‘Hardware,’ electricity plant facilities and plant spaces are included. ‘Software’ means the ‘soft skills’ (and operational system) required to make behavioral and socio-cultural changes, and also a use of hardware including skills, programming, knowledge, operation know-how, and so on. ‘Orgware’ (organization+ware) focuses on the organizational and institutional processes including an organizational management, composition and related networking and systems, and also refers to the institutional set-up and coordination mechanisms required as support for implementing hardware and software. (Nasiri, 2012; Retnannestri and Outhred, 2013; UNEP, 2014). It also includes such institutions, planning, regulations, norms, education system, and so forth; for example, training around different planting techniques. (UNEP Rio Riso Centre, 2011)

Finally, in the criteria of degree and results of knowledge transfer, this study tries to reveal the three features of impacts (technological, economic, and environmental) on the communities of the Gapa and Gasa islands.

FINDINGS (1): THE RATIONALE OF KNOWLEDGE TRANSFER

International Environment: Paris Agreement and UNFCCC Technology Mechanism

In order to tackle the global issue of climate change, the UN Framework Convention on Climate Change (UNFCCC) was established in 1992 for global collective action. The UNFCCC paved the way for a regulatory ascendance by the adoption of the 1997 Kyoto Protocol which fleshed out a greenhouse gas reduction (GHG) target of 5% on average for the commitment period (2013-2020). This Kyoto regime, entering into force in 2005 and staying in force until 2020, has been stumbling because of strong opposition from developed countries regarding its legally-binding regulatory measures and the allocation of obligations only to developed countries. To developed countries’ dissatisfaction, there have been discussions of a new climate regime under which both developed and developing countries would participate and voluntary efforts to reduce GHG emissions would be permitted.

As a result, at the 21st session of the Conference of the Parties to the UNFCCC (COP21), the Paris Agreement, which draws a new architecture on global governance on climate change from the year 2020 and promises a new climate change regime, was agreed on 12th December, 2015. The Paris Agreement has architectural features that are differentiated from the Kyoto Protocol (UNFCCC, 2011; 2013; 2015). Firstly, it consists of six elements: mitigation, adaptation, finance, technology transfer, capacity building and transparency. Mitigation and adaptation are set as objectives; finance, technology development and transfer, and capacity building are the means of implementation to achieve the objectives; and transparency is to be applied to all the other elements. Secondly, global collective efforts to respond to climate change are to be made not only by developed countries but also by developing countries. Thirdly, private sectors as well as government actors are encouraged to participate in international efforts in the Paris Agreement. Finally, unlike the Kyoto regime where burden-sharing and implementation are designed in a top-down manner at the center of a multilateral international system, the Paris Agreement is designed with a bottom-up approach in which parties voluntarily set up and submit intended nationally determined contributions (INDC). In the face of the new climate change regime, this study focuses on the framework of knowledge and technology transfer, which will be one of the most important means of implementation.

In relation to the global context of transfer and deployment of micro-grids (and smart-grids) for climate change, many research and test-bed projects are growing in both developed and developing countries. The global market of micro-grids will increase steadily and is expected to reach 18 billion USD by 2020 (in 2014, 2.8 billion USD) (ITA, 2016). Particularly, the US government (Dep. of Environment) declared the ‘Grid 2030’ project in 2003, and three stages have been in progress (currently in the second stage until 2020, 30 major test-bed projects carried out in 13 states and 153 cities) (Hanaif, 2010). In Europe alone, countries like Germany, Finland, France and UK have invested 38 billion Euro in a smart-grids test-bed project encompassing 23 countries in order to promote the supply of renewable energy and the exchange of knowledge among EU member countries (Hanaif, 2010). Also, the Chinese government (the second largest country in investment in smart-grids),[1] through the five-year plan (2011-2015), already invested 81.5 billion USD and until 2020 a total of 652.2 billion USD. As a result, the global competition regarding micro-grids and smart-grids and related knowledge transfer (including technology transfer) will [can be expected to] accelerate more and more.

---

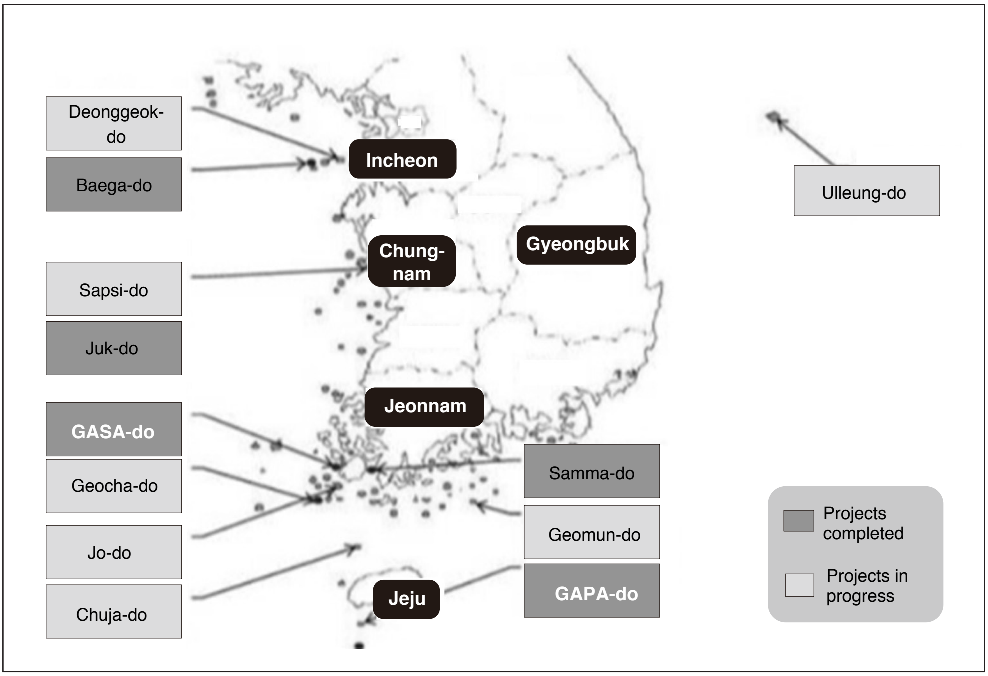
[1] The first one is US.

Motives of Knowledge Transfer: 'Energy New-Industry' Promotion and INDC

Taking part in the global trend, the Korean government has recently given attention to the green island (energy-independents islands) projects. Various attempts were made particularly by the Ministry of Trade, Industry and Energy (MOTIE) and the Ministry of Science, ICT and Future Planning (MSIF). Examples of such attempts include the establishing of new-industry promotion schemes, the formulating of supporting policies and the creating of the platform for the development of energy new-industry and related technology infrastructures (such as micro-grids and smart-grids). Also, MOTIE has tried to set up a robust public-private partnership for various green islands projects, in conjunction with the Energy and the Korea Electric Power Corporation (KEPCO), and a global partnership with the international microgrid network such as ISGAN (International Smart Grid Action Network) and GSGF (Global Smart Grid Federation) (GTC, 2015b; KEPCO, 2014b).

In 2015, seven islands out of the 62 main islands of Korea were transformed to green (energy-independent) islands. As shown in Figure 4 below, the five green island projects were completed in three provinces, including the Gasa-do (island) in

Figure 4. The Green Island Projects Completed or in Progress in 2016



Jeonnam province (regarded as the 'first-generation' green island)[2] and Gapa-do in Jeju province (the first fully micro-grid-based green island). There are also seven other projects in progress in four provinces, including Incheon metropolitan city (KEPCO, 2014a; 2014b). The projects in Gapa island and Gasa island were deployed during the commercialization stage, to then be exported to overseas markets such as Africa, Asia, and North America, in cooperation with the Green Climate Fund (GCF)[3] and the UNFCCC Technology Mechanism organizations such as the Climate Technology Centre and Network (CTCN) (GTC, 2015b; KEPCO, 2014b).

Meanwhile, in relation to the INDC (intended nationally determined contributions) under the Paris Agreement, the Korean government expects that the green island (eco-friendly energy-independents island) projects will contribute to the national plan of INDC to reduce greenhouse gas (GHG) emission by 37% from the business-as-usual (BAU) level by 2030. Particularly, the expected GHG emission reduction through the green islands projects will be an important contribution to not only the domestic reduction objective (25.7% out of 37%) but also the international performance (11.3% out of 37%) through the global carbon market. Actually, in terms of the increasing amount of CO2 emissions, Korea has become the third biggest emitter in the world (GTC, 2015b).

Looking at the motives of KT around the green island projects, characterized by the promotion of energy new-industry and the contributions to INDC, it shows an aspect of "voluntary transfer driven by perceived necessity" (Dolowitz and Marsh, 1996; 2000). Based on the transfer continuum of Dolowitz and Marsh (1996; 2000), the motives of KT can be classified into "lesson drawing" (most voluntary, the left end of the continuum), "voluntary transfer driven by perceived necessity," "obligated transfer" (negotiated transfer) and "coercive transfer" (the right end of the continuum). In short, the green island projects including the two cases of GAPA and GASA are more likely to be in line with the context of voluntary transfer driven by perceived necessity between the key actors (including the Korean government, public organizations and companies) and the international mechanism (organizations)—agreed by many interviewees including 1, 2, 5, 10, 14.

---

[2] The system of Gapa Island is not fully based on the micro-grids, so that it is regarded as that of 'first-generation' green islands.

[3] GCF was founded in 2010, within the framework of the UNFCCC, as a mechanism to assist developing countries in adaptation and mitigation practices to counter climate change. It is based in the new Songdo district of Incheon, S. Korea.

FINDINGS (2): THE PROCESS AND OBJECTS OF KNOWLEDGE TRANSFER

Actors: Who is Involved in the Process of Green Island Projects

As described in Table 1, the Green island projects of Gapa Island and Gasa Island have been carried out in cooperation with several main stakeholders from the public and private sectors.

Table 1. Main Stakeholders and Roles in the Projects of Gapa Island & Gasa Island

	Gapa Island	Gasa Island
Term of Construction	2011. 11 – 2013. 10 (24 months)	2012. 10 – 2015. 9 (36 months)
Supervising	① **Jeju Provincial Gov.:** project planning, approval, adm. support	① **KEPCO:** 'independent type' microgrid technology supervising
	② **KEPCO:** 'independent type' microgrid system building	② **Jindo Council:** support for microgrid ted-bed & tech. development
		③ **Jeonnam Provincial Gov.:** project planning & policy development
Constructing	① **KEPCO:** microgrid system building (smart-meter)	① **KEPCO:** ESS & EMS-based diesel & renewable energy mix building
	② **KOSPO:** aerogenerator installation	
Managing	① **KEPCO:** microgrid system integrated operation	① **KEPCO:** 'control tower' of supplying & stabilizing electricity in the field
	② **Jeju Provincial Gov. &** ③ **JECO:** residents' cooperation	② **Jindo Council:** cooperation & communication with the residents

Gapa Island is one of the islands in Jeju Island, 5km away from the Moseulpo port in South-western part of Jeju Island. Gapa Island is 0.85km^2, with a population of 281 and 134 households (in 2015).[4] The Gapa green island project is actually in line with the first stage of the grand project of the national and (Jeju) provincial governments,

---

[4] http://www.etnews.com/20160712000291.

'Jeju Carbon free island 2030.' The Jeju provincial government has divided the project into three steps; the first stage is "Gapa carbon-free island" with a microgrid to supply its own energy , the second stage is to expand the Gapa microgrid system to Jeju, the main island, and supply 50% of the total electricity use on Jeju Island from renewable energy with a bigger smart grid (Hanaif, 2010). The last stage is to establish 'Carbon free island' and gain a reputation as a global green island. Therefore, the project of Gapa Island is important thing that serves as strategic base for low carbon green growth for the entire Jeju Island (GTC 2015c; Kang, 2012).

In the Gapa project (completed in 2013, construction for 24 months), the Jeju provincial government and also KEPCO (Korea Electricity Power Corporation) have taken a role of supervising the project; particularly the project planning and approval, and the administrative support from the Jeju government, and 'independent type' micro-grid system,[5] constructed by KEPCO. Also, KEPCO has built the micro-grid system, including the smart-meters,[6] and KOSPO (Korea Southern Power Co.) has installed aerogenerators (KEPCO, 2014b; 2015). In terms of management, KEPCO has taken in charge of the integrated operation of micro-grid system, and the Jeju provincial government and the JECO (Jeju Energy Co.)[7] has carried out the roles of bringing the cooperation with residents in Gapa Island (GTC, 2015c; KEPCO, 2014b).

On the other hand, Gasa Island is located in between Jodo and Jindo (islands), Jeonnam province and the area is 6.4km^2, with a population of 286 people and 163 households residing in it.[8] It is the only island excluded from the national marine park area near Jindo and not influenced by the marine traffic system near the biggest port, Mokpo. The Gasa green island project was initiated by the Korean electricity power corporation (KEPCO), named 'Energy Independence Island Business.' (KEPRI. 2015a; 2015b) Under the 2010 national strategy of renewable energy development, the Korean government has planned the renewable energy research and development (R&D) for 'low carbon green growth' (GTC, 2015c; KEPRI, 2015a).

In the case of Gasa project, KEPCO has been in charge of supervising 'independent type' micro-grid technology; the Jindo council for support for the micro-grid

---

[5] Generally, there are both types of microgrid system: 'Independent Type' (particularly for the isolated regions including islands, deserts, and polar areas) and 'Grid Connected Type' (particularly for the downtown area such as buildings, university campuses, and factories).

[6] It plays an important role to monitor the performance and the energy usage of the grid loadings and power quality.

[7] The Jeju provincial government has founded the Jeju Energy Corporation, making it in charge of administrating wind power system and research renewable energy in the future.

[8] http://www.newsis.com/ar_detail/view.html?ar_id=NISX20150623_0013746872&cID=10401&pID=10400

test-bed and related technology development; and the Jeonnam provincial government for the project planning and related policy development—for example, 'energy-independence' policies for 74 islands in Jeonnam province by 2020 (KEPRI. 2015a; 2015b). With regard to the construction, KEPCO has built the diesel and renewable energy mix based on ESS (energy storage system)[9] & EMS (energy management system);[10] and in terms of the management, KEPCO has operated the control tower for supplying and stabilizing electricity in the field, and the Jindo council has tried to cooperate and communicate with the residents in Gasa Island (GTC, 2015c; KEPRI. 2015a).

In fact, the micro-grid system of Gasa Island is an important and practical business model for renewable energy use, because it is a proven case in which the optimized EMS (Energy Management System) capable of regulation and operation of renewable energy has been applied for predicting the total amount of power and capacity of the island (GTC, 2015c; KEPRI. 2015a; 2015b).

Objects: Technology Types of the Green Island Projects

Hard-ware

The hardware elements of the Gapa green island project is composed of two wind turbines, eight solar panels, and battery energy storage system (ESS). Two 250 kW wind turbines and 141 kW solar panels (3kW*37 and 30kW*1), and ESS (lithium-ion battery and lead storage battery) have a capacity equivalent to three diesel generators (Kang, 2012; GTC, 2015c; KEPCO, 2015).

KEPCO has built the control center that is the main operator of micro-grid system. The system connects each sources of renewable energy with optimized Energy Storage System (ESS), Distribution Automation System (DAS),[11] Smart Meter to each other, which enables to improve power quality, monitoring and operation system (KEPCO, 2015). By replacing diesel oil-driven operation to renewable energy through the microgrid system, the use of diesel oil and carbon emission has been reduced.

---

[9] ESS is to store and capture energy produced at one time for use at a later time.

[10] EMS is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and/or transmission system.

[11] DAS offers utility personnel the ability to reduce line voltage during peak demand times by remotely taking control of the load tap changer.

Table 2. The Elements of Hardware in the Gapa and Gasa Green Island Projects

	Name	Details	Function
Gapa Island	Battery	1MWh Li-ion, 0.85MWh lead storage battery	Electricity storage
	Wind Turbine	250kW×2	Vertical axis wind turbines
	PV	141kW(37 * 3kW, 1 * 30kW)	Power limitation, module monitoring
Gasa Island	Battery	3MWh, Li-ion	Electricity storage, 1C-rate, NMC 3 GFIs[1] connected to 3MWh
	Wind Turbine	100kW×4	PMSG[2]+Full converter, Power limitation, Power, Slew rate control of power and voltage, LVRT, FRT
	PV	314kW(8ea)	Power limitation, module monitoring, water floating PV system(48kW)
	Diesel Generators	100kW×3	Drop control, remote on/off

Notes: [1] GFI (Ground Fault Interrupter).
[2] PMSG (Premanent Magnet Synchronous Generator).

Sources: GTC. (2015). Global Strategies of Global Diffusion of Microgrid; KEPCO. (2015). Internal Report; Kang (2012). Green Island Establishment Project of Gapa Island, Jeju.

On the other hand, in the Gasa Green Island project, the hardware elements of the wind turbines and solar photovoltaic (PV) panels make the island energy independent (GTC, 2015). The Gasa Island is known to have the first automated energy management system (EMS), which features a 314 kW array of solar photovoltaic (PV) panels, four NPS wind turbines, and a 3 MWh Hyosung (company) battery storage facility (KEPRI, 2015a). The installation of EMS in Gasa Island covers the amount of energy from three 100 kW diesel generators, and makes it possible to supply the energy for all 168 households on the island (GTC, 2015; KEPRI. 2015b; LG Electronics, 2015).

Soft-ware

As described in Table 3, the software elements of the Gapa Island projects commonly consist of the advanced driver assistance system (ADAS), which as a multisensor driver support system includes the optimum power system and the smart meter that improves grid reliability and promotes energy efficiency while providing improved services to customers (KEPRI, 2015a; 2015b).

Table 3. The Elements of Hardware & Software in the Gasa Island Project

	Name	Details & Function
Gapa Island	Smart meter	Optimum power system, Smart meter (improving power quality, monitoring and operation system)
	Grid control center	Optimize the grid management (enhancing the electricity stability, minimizing the power cut)
Gasa Island	EMS System (SCADA)	Supervisory Control and Data Acquisitions (SCADA) & Application SW Sustainable energy and battery management Load control, Real time adjustments to the mixture of energy sources

Sources: GTC. (2015). Global Strategies of Global Diffusion of Microgrid. KEPRI. (2015a). Internal Report 1; KEPRI. (2015b). Internal Report 2.

Along with the software factors in Gasa Island, the Energy Management System (EMS), also known as software automatically controlling the power supply, [?] is a core factor . The EMS functions as a supervising, controlling, optimizing and managing generation and transmission system. SCADA (Supervisory Control and Data Acquisition), a sub-control system of EMS, plays a key role of monitoring and controlling the various sub-facilities. It operates in cooperation with a variety of application soft-wares for the sustainable energy and battery management, load control, real time adjustments to the mixture of energy sources, and so on (KEPRI, 2015a; 2015b).

Org-ware

In terms of the inter-organizational cooperation, the Jeju provincial government, the Korea Electric Power Corporation (KEPCO), and the Korea Southern Power Co (KOSPO) agreed to designate Gapa Island as a net zero carbon footprint place. In particular, since 2014, the International Green Island Forum (IGIF) has been taking place in Jeju Island to establish a global network of green islands and share green policies and technologies with [among] developing and developed countries. For this, the service bureau of IGIF was founded as a non-governmental organization in 2011, in order to make islands become sustainable green places by sharing awareness and exchanging knowledge and information.

In the case of the Gasa project, Jindo County, Jeonnam Province, KEPCO and other private companies have joined the project together to produce electricity through alternative energy sources. The provincial government established the 'Energy Independent Islands Plan' and also related energy independent policies on 74 Islands in the county until 2020, and the county council presented its effort to supply sustainable renewable energy sources for pilot projects (test-bed) (KEPCO, 2014b). KEPCO has taken charge of developing a model to supply sustainable energy. Additionally, KEPCO has developed the high penetrated remote microgrid system (see the details in Table 4) (GTC, 2015c; KEPCO, 2014b).

Table 4. Main Participants' Roles in the Gasa Island Project

Participation	Roles
Jeonnam provincial gov.	Establish Energy Independent Islands Plan Energy independent policy on 74 Islands in the county until 2020
Jindo council	Develop energy-system connection technology based on renewable energy Support pilot projects
KEPCO	Overall system management, Cooperation with other companies

However, this study reveals that (through the interviews with respondents 2, 3, 6, 7, 12), although attention was given to the formal partnership of the organizational management between various-level stakeholders (public and private organizations), the Gapa and Gasa projects are too much rooted in the government-led top-down approach. Also, they have a lack of creating 'community-customized' and 'resident-friendly' orgware features in relation to the institutional and organizational set-up, coordination mechanisms, and education systems to support and operate hardware and software. This finding was particularly identified from the interview with many interviewees (1, 2, 3, 5, 6 7, 12, 14).

> We tried to raise awareness in relation to community participation and related education programs during the process of the green island project, but honestly speaking, not substantially implemented for them so far.... First, we focused on building up such facilities according to the governmental budget appropriation

> (interviewee 2, 3, 6, 7).
>
> Such orgware stuff will be able to be created as the project is going further.... however, it will be based on a top-down approach same as the present, rather than bottom-up one focusing on 'community-customized' and 'residents- friendly' ways because the former one is much easier and effective for the government to implement and manage the project in the end (interviewee 1, 5, 12, 14).

In fact, in the case of Gasa project, there was a constructive partnership built among the provincial government (Jeonnam), the county council (Jindo), and the private enterprise (KEPCO and KEPRI (Korea Electricity Power Research Institute)), on which organizational management and networking seems to have worked in part. Nevertheless, as interviewees 3, 4, 6, 8, 10, 11 argued, such individual top-down efforts of orgware factors could not become intertwined with coordination mechanisms and training & education system required to support for implementing hardware and software.

POLICY IMPLICATIONS: THE DEGREE AND RESULTS OF KNOWLEDGE TRANSFER

Through the Gapa and Gasa green (energy-independent) island projects, meaningful results have been produced. For example, in terms of the technological results (performance), on the Gapa island, PV facilities have been equipped in 43 of 134 households (36%), which generates 174kw a day (KEPCO, 2016). On the Gasa Island, with the full [?] saving in the 3MW EMS (energy management system), all residents are able to use electricity for 24 hours without any concerns, which shows the island has been transformed to be 100% energy-independent (except during a rainy period). Regarding the economic performance, on the Gapa Island, the electricity price during the summer that residents should pay is reduced by one-fifth, and the number of tourists increased by a factor of three from 40,000 in 2011 to 110,000 in 2015 (KEPRI. 2015a; 2015b). On the Gasa Island, the cost of generation of electric power decreased to 1060 won (KRW) after the establishment of the micro-grid system (the existing diesel power, 1100 won before), and through the reduction of electric generator fuel cost, 320 million won is saved annually (KEPRI, 2015b; 2016). In terms of the environmental effect, through the Gasa green island project, the reduction effect (amount) of CO2 is expected to reach approximately 1000 tons a year and about 750 CO2 tons annually through the Gapa project (by replacing diesel with wind turbines and PVs. The result is equivalent to the effect of planting about 26,600 pine trees in total

(KEPCO, 2016; KEPRI, 2016).

However, currently the energy-independent rate of the Gapa Island is around just 42% in the normal times (wind power 32% and PV 10%), dropping lower during rainy times (KEPCO, 2016). Therefore, this paper highlights that even as the 'first-generation' green island, the Gapa project has been only a qualified success. In addition, particularly focusing on the findings of the process and objects of knowledge transfer (KT) in the Gapa and Gasa projects, this study reveals that despite relatively sufficient capacity of hardware and software technologies and the administrative partnership—a factor of orgware—among multi-level stakeholders, they are so far based on a government-led top-down approach and overemphasize the 'hardware-intensive' way. This result prevents an intertwining with the coordination mechanisms of orgware, required to support for implementing hardware and software. Also, it lacks such orgware features in relation to 'community-customized' and 'residents-friendly' approaches. In fact, this study emphasizes that among the three technology categories (hardware, software, and orgware), software and orgware are too often only considered in relation to hardware, and not in their importance and functions. This may lead to a risk of impeding effective response of technologies to climate changes.

In conclusion, this paper believes that the degree and results of KT in the green islands projects show an aspect of "incomplete transfer," reflecting the argument of transfer degree and results (Dolowitz and Marsh, 1996; 2000) that indicates that the transfer without a critical factor for success is likely to lead to a failure.

To tackle the problems found in the Gapa and Gasa Island projects, this study suggests the necessity of participatory governance activities in the orgware features (Huh, 2010). For this, it is required to look at global best practices regarding the green (energy-independent) islands projects. For example, this study finds that the Samso Island project (in Denmark), shows various exemplary lessons; including the methodologies of residents' behavior changes (Changing Behaviour, 2009; Wang and Cha, 2011) that emphasizes financial support along with community cooperation and ownership, the campaigns to provide knowledge and practice to neighbors to save energy [is necessary] [?], and the heat metric education, certification, and so on. Another one of the best examples is the Bright Green Island project of Bornholm, Denmark (GTC, 2014; 2015b; Wang and Cha, 2011), which boosts its economy in an environment friendly way. Particularly, regarding to the orgware, a variety of elements have been carried out, such as campaigns (and energy tour), education, energy consulting, energy fora, brand marketing and so on.

This paper notes that both the cases of Samso and Bormholm emphasize the participation of citizens and cooperation between organizations and government in order to build a 100% sustainable and carbon free community. Particularly, both projects were approached by bottom-up methodologies rather than top-down by encouraging citizens' involvement. Therefore, the main goal of the project was to encourage local residents to have ownership of the solutions. The results of the cases of Samso and Bormholm recommend further and detailed orgware plans. Creating local residents' ownership of project and community involvement are the key success factors of the significant renewable energy project including the Green Island ones (Changing Behaviour, 2009; Chung, 2011; GTC, 2015b).

In short, given the lessons from the cases of Samso and Bormholm, the Green island projects in S. Korea need to break away from the existing ways—focusing on the government-led 'hardware-intensive' technology transfer—and to take 'community-customized' and 'resident-friendly' approaches in the comprehensive context of knowledge transfer.

REFERENCES

Argote, L. and Ingram, P. 2000. "Knowledge transfer: A basis for competitive advantage in firms." *Organizational Behavior and Human Decision Processes*. 82(1): 150-169.

Arvanitis, S., Kubli, U. and Woerter, M. 2008. "University-industry knowledge and technology transfer in Switzerland: What university scientists think about co-operation with private enterprises." *Research Policy*. 37(10): 1865-1883.

Bang, H., Wang, F. and Lu J. 2015. "Knowledge Transfer Between MNC"s Headquarter and Overseas Subsidiaries—Through Reducing Two Gap," Korea Academy of International Management, Autumn Conference 2015.

Bazilian, M. 2009. *Technology in the UN Climate Change Negotiations: Moving Beyond Abstraction.* Harvard Project on International Climate Agreements.

Changing Behaviour. 2009. *Samsø—renewable energy island programme.* Con-textualising behavioural change in energy programmes involving intermediaries and policymaking organizations working towards changing behaviour. Changing Behaviour. (http://www.energychange.info/)

Chung, Kum-Ho, 2010. "A study on the Energy Self-sufficient Island Using New and Renewable Energy." *The Journal of Korean Island*. 22(4): 275-293.

Dan T. T. and Merrill A. S. 2011. "he U.S. Department of Energy's Microgrid Initiative." *The Electricity Journal.* 25(8): 84–94.

Dolowitz, D. 1997. "British Employment Policy in the 1980s: Learning from the American Experience." *Governance*, 10(1).

Dolowitz, D. and Marsh, D. 1996. 'Who Learns from Whom: A Review of the Policy Transfer Literature,' *Political Studies*, 44(2): 343-57.

Dolowitz, D. and Marsh, D. 2000. "Learning From Abroad: The Role of Policy Transfer in Contemporary Policy Making." *Governance*, 13 (1): 5-24.

Eom, S. 2015. "Eco Energy Self Sufficient Island Project," The Korean Society for New and Renewable Energy, Spring Conference 2015.

Faley, T.L. and Sharer, M. 2005. "Technology Transfer and Innovation: Reexamining and Broadening the Perspective of the Transfer Discoveries Resulting from Government-Sponsored Research." *Comparative Technology Transfer and Society*, 3(2): 109-128.

Friedman, J. and Silberman, J. 2003. "University technology transfer: Do incentives, management, and location matter?" *Journal of Technology Transfer*, 28:1, 17-30.

GTC. 2014. *Study for Building a Global Green Energy Community*. Green Technology Center.

GTC. 2015a. *Study on the Integrative Planning of Global Climate Change: the Cases of Green Islands.* Green Technology Center.

GTC. 2015b. *Study on the Establishment of Green Technology Cooperative System in Developing Countries in relation to International Organizations' Activities.* Green Technology Center.

GTC. 2015c. Global Strategies of Global Diffusion of Microgrid. Green Technology Center Forum of Energy Independent Microgrid Diffusion Strategy (10 December 2015).

Ha, D. 2010. "Policy Transfer and Spread: the Case of Manifesto Movement in Japan." *Korean Policy Studies Review*, 19(2): 245-273.

Hanaif (Hana institute of finance). 2010. "Review of smart grid trend and market analysis." *Industry Research Series*, 18.

Hansen, M.T. 1999. "The search-transfer problem: The role of weak ties in sharing knowledge across organizational subunits." *Administrative Science Quarterly.* 44: 82-111.

Huh, TW. 2010. "Towards Reflexive Governance for Sustainable Development." *The Korean Journal of Policy Studies*. 25(3): 1-22.

Inderberg, T. H., Eriksen, S., O'Brien, K., & Sygna, L. 2015. *Climate Change Adaptation and Development: Transforming Paradigms and Practices.* New York: Routledge.

IPCC. 2007. *The Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* UNFCCC IPCC.

ITA (International Trade Administration). 2016. 2016 Top Markets Report: Smart

Grid. ITA.

Kang, J. 2012. "Green Island Establishment Project of Gapa Island, Jeju." KEPAS (Korea Environmental Policy & Administration Society) Seminar: the conservation and wise use of natural resources (September 2012).

KEPCO. 2014a. "ICT-Based Energy Demand Management: Plan of Turning Ulleung-do into a Green Island." Green Energy Forum (22 to 24 October 2014).

KEPCO. 2014b. "The Status and Prospect of Smart Grid and Micro Grid in KEPCO." Green Energy Forum (22 to 24 October 2014).

KEPCO. 2015. Internal Report (Management and Operation of the Gapa Island Project). KEPCO.

KEPCO. 2016. Internal Report (Performance and Impact of the Gapa Energy-independet Island Project. KEPCO.

KEPRI. 2015a. Internal Report1 (Management Procedure of the Gasa Island Project). KEPCO KEPRI (Korea Electricity Power Research Institute).

KEPRI. 2015b. Internal Report 2 (Operation Manual of the Gasa Island Project). KEPCO KEPRI (Korea Electricity Power Research Institute).

KEPRI. 2016. Internal Report (Results and Performance of the Gasa Energy-independet Island Project. KEPCO KEPRI (Korea Electricity Power Research Institute).

Kingsley, G., Klein, H., 1998. "Interfirm collaboration as a modernization strategy: a survey of case studies." *Journal of Technology Transactions*, 23(1).

Kogut, B., and Zander, U. 2003. "Knowledge of the firm and the evolutionary theory of the multinational corporation." *Journal of International Business Studies*, 34(6), 516-529.

Landry, Rejean, Nabil Amara and Mathieu Ouimet. 2007. "Determinants of Knowledge Transfer: Evidence from Canadian University Researchers in Natural Sciences and Engineering." *Journal of Technology Transfer*, 32, 561-592.

LG Electronics. 2015. "Global Microgrid Market Strategies of Private Enterprises in S. Korea." Green Technology Center Forum of Energy Independent Microgrid Diffusion Strategy (10 December 2015).

Megantz, R.C. 2002. *Technology Management: Developing and Implementing Effective Licensing Programs*, John Wiley and Sons: New York.

Mun, C., Jang, Y. Park, T. and Jeong, M. 2015. "The Developing Strategies of the Energy Independence Island for Jeollanam-do." The Korean Society of New and Renewable Energy, Spring Conference 2015.

Nasiri, M. F. 2012. "Relationship between educational technology and knowledge creation in Islamic Azad University Mazandaran Branch." *Advances in Environmental Biology*, 6(7), 2120-2125.

Nonaka, I.and Takeuchi, H. 1995. *The knowledge creation company: How Japanese* *companies create the dynamics of innovation*, Oxford University Press.

Phillips, J., Das, K., and Newell, P. 2013. "Governance and technology transfer in the Clean Development Mechanism in India." *Global Environmental Change Global Environmental Change*, 23 (2013) 1594–1604.

Retnanestri, M. and Outhred, H. 2013. "Acculturation of renewable energy technology into remote communities: lessons from Dobrov, Bourdieu, and Rogers and an Indonesian case study. Energy." *Sustainability and Society*, 3(1): 1-13.

Roessner, J.D., 2000. Technology transfer. In: Hill, C. (ed.) *Science and Technology Policy in the US, A Time of Change.* Longman: London.

Sandelin, J. 1994, "Knowledge transfers through patenting and licensing, Stanford University," Office of Technology Licensing, Unpublished paper.

Schoen, A., Potterie, B.P., and Henkel. J. 2014. "Governance typology of universities' technology transfer processes." *Technology Transfer*, 39: 435-453.

Simonin, B. L. 1999. "Ambiguity and the process of knowledge transfer in strategic alliances." *Strategic Management Journal*, 20(7): 595-623.

Szulanski, G. 1996. "Exploring internal stickiness: Impediments to the transfer of best practice within the firm." *Strategic Management Journal*, 17(S2): 27-43.

Szulanski, G. 2000. "The process of knowledge transfer: A diachronic analysis of stickiness." *Organizational Behavior and Human Decision Processes*, 82(1):9-27.

Tews, K., Busch, PO. and Jorgens, H. 2003. "The Diffusion of New Environmental Policy Instruments." *European Journal of Political Research*, 42: 569-600

UNEP. 2014. *UNEP Adaptation Gap Report 2014*. UNEP.

UNEP Riso Centre on Energy, Climate and Sustainable Development. 2011. *Technologies for Adaptation: Perspectives and Practical Experiences*. UNEP.

UNFCCC. 2011. Report of the Conference of the Parties on its seventeenth session (28 November to 11 December 2011). UNFCCC.

UNFCCC. 2013. Report of the Conference of the Parties on its eighteenth session (26 November to 8 December 2012). UNFCCC.

UNFCCC. 2015a. Annex Key messages to be delivered to the Conference of the Parties at its twenty-first session. UNFCCC.

UNFCCC. 2015b. *Technology Mechanism*. UNFCCC.

UNFCCC. 2015c. *Joint annual report of the Technology Executive Committee and the Climate Technology Centre and Network*. UNFCCC.

UNFCCC. 2015d. *Linkages between the Technology Mechanism and the Financial Mechanism of the Convention.* UNFCCC.

U.S. Department of Commerce-International Trade Administration. 2016. *Top Markets Report Smart Grid.* U.S. Department of Commerce.

Wang, GY. and Cha, J. 2011. The Establishment Plan of Korean Green Island Model. *The Land*, 365: 51-59.

Yi, C. 2010. “Policy Transfer in Policy Making Process of Science and Technology: The Korean Case of the Adoption of Research Council System.” *Social Science Research Review*, 26(1): 27-54.