Stakeholder Analysis on Geothermal Development: A Case Study in Japan

Joni Jupesta[1,2], Aki Suwa[1,*] and Govindan Parayil[1]

[1]*United Nations University-Institute of Advanced Studies (UNU-IAS),*

1-1-1 Minato Mirai, Yokohama 2208502, Japan

[2]*National Graduate Institute for Policy Studies (GRIPS),*

7-22-1 Roppongi, Tokyo 1068677, Japan

Corresponding author: email address: Jupesta@ias.unu.edu, suwa@ias.unu.edu

Abstract

The concept of 'earth system governance' has a root in the complexities of global environmental change that require multiple academic disciplines to deliver a new paradigm for global solutions. The greatest challenges are to influence the policy makers and shape the stakeholders' willingness to participate in the transition and implement the relevant policies. This requires strategies for dealing with numerous stakeholders – many with whom the policy makers have had little experience. The case of a significant energy technology – geothermal electricity – provides an illustrative context for demonstrating the process of stakeholder analysis. In recent years, there is a growing interest in geothermal energy, as geothermal energy generation does not have emissions and other byproducts. In Japan, especially after the big earthquake in March 2011, it is expected that geothermal energy could secure sufficient electricity, as Japan is one of the countries where a large number of geothermal resources suitable are available for electricity generation. This paper applies a stakeholder analysis framework in Japan, as it is highly important to analyze these stakeholders' views, and to establish local governance for geothermal energy development. The result of the analysis will have strong implication for future energy development through identification of the key driving forces for effective local energy governance, which will be a crucial element for a transition to a new paradigm for energy solutions.

1. Introduction

The Fukushima Triple Disaster on March 11th 2011 made a significant change in Japan and the world. This so called Higashi Nippon (Great East Japan) Disaster was in the midst of another crisis: this triple disasters occurred during a ongoing economic stagnation and social occlusion which faced Japan for over a decade (Japan's Cabinet Office, 2011). The earthquake and tsunami caused the Fukushima nuclear power station accident, and all nuclear power stations were shut down for security checks, except a few stations which were activated a while later.

To meet the energy demand, there is a need to supply energy from diverse sources. Technologies to develop renewable energies are comparatively well advanced in Japan, and deployment of clean energy from renewable sources is encouraged, as outlined in the Japan`s Ministry of Economic, Trade

and Industry (METI) Energy White Paper Outline 2012 (METI, 2012a). However, their practical application is unsatisfactory (Jupesta and Suwa, 2011) whilst Japan is at a cross roads in terms of long term sustainability, energy security and economic viability. In other words, questions are raised about the role that policy and political science could play in comprehending and reacting to energy supply and demand crisis after the disaster.

Scientific assessment, such as 'earth system analysis' (Schellnhuber, 1999), already measured the impact of climate change, but the impact of this Fukushima disaster is more likely to need an analysis from social and political science in the form of a governance analysis. There is a need to determine institutional, economic and behavioral changes to enable effective steps toward sustainability (Reid et al., 2010). The governance concept, i.e.: 'earth system governance', suggests that changes in behaviors of citizens, new engagement of civil society organizations and reorientation of the private sector toward a green economy, are all crucial to achieve progress toward sustainability (Biermann et al., 2012). The Japanese energy situation provides a highly relevant case for understanding the role of governance for transition to sustainable energy development.

This study evaluates the governance process for a low carbon development. The study will give policy recommendations on how to accelerate the deployment of geothermal energy through addressing the relevant governance frameworks. As explained later, one of the high barriers for geothermal power development in Japan is the conflict with local hot spring business operators. Yet, there are insufficient studies on how local acceptance impacts the lock-effect on geothermal deployment. Research on earth system governance so far considered the capacity of public actors (at local, national and international level) to respond global change and how this capacity may be changing (Dellas et al., 2011). Instead of a top down approach, the present study uses local participatory assessment to identify the agents and the network of agents in a multi-partnership governance as proposed by Lemos and Agrawal (Lemos and Agrawal, 2009). Chapter two will elaborate upon geothermal development in Japan. Chapter three describes, as the research framework, the agency with its multi-partner governance. Chapter four applies the research framework to geothermal development in Japan using the Matsunoyama geothermal power plant at Tokamachi city, Niigata prefecture as the study case. Chapter five summarizes this study and provides some policy recommendations as well as an outlook for further study.

2. Geothermal Development in Japan

Japan is endowed with the third largest potential in the world for geothermal power generation. Table 1 shows the worldwide geothermal potential. Japan only used geothermal energy for 0.2% of its total electricity demand in 2008 and 0.06% of total world demand in 2005 (METI, 2010). Considering the abundant resources and Japan's technology capability, geothermal sources could be an alternative energy source that may pave the way for a transition away from thermal and nuclear energy sources. Geothermal energy generation has a history since 1966 in Japan (IEEJ, 2011), and Japan developed its

own technical knowhow. The geothermal turbine technology of Japanese companies is highly regarded and is used in geothermal power plants in Europe and Southeast Asia (METI, 2010); the worldwide market share of Japan's industries is 70%. The companies involved in this industry are Mitsubishi Heavy Industry, Fuji Electric and Toshiba.

The development of geothermal energy in Japan is, however, rather modest set against its geological potential and technological capacity, because it faces multiple regulatory, institutional and social barriers:

1. High cost of the geothermal based electricity compared with those of coal, nuclear and gas based electricity generation,
2. High development risk, since geothermal sources are underground resources,
3. Geological problems as geothermal spot are usually located in protected Natural Parks.
4. There are conflicts with local hot spring business operators for the geothermal resources, as the business operators are fearful of resource depletion.

Table 1 Geothermal resources worldwide (METI, 2010).

Country	**Geothermal resources (MW)**
Indonesia	27,791
US	23,000
Japan	20,540
Philippines	6,000
Mexico	6,000
Iceland	5,800
New Zealand	3,650
Italy	3,267

Nature conservation laws, for example, conflict with geothermal development since two thirds of the Japanese geothermal potential areas are located in nature conservation zones. The Japanese government started to restructure regulations under the green new deal initiative, hoping that geothermal development can stimulate the market and create jobs (MOEJ, 2012a). By this green new deal initiative and the subsequent regulatory restructuring, the MOEJ started to allow geothermal developments in conservation areas under certain conditions. Also, to promote geothermal development, Japan's Ministry of Economic, Trade and Industry (METI) has provided subsidies to pioneering general research on the possibility of development in promising geothermal areas and construction cost. The

Renewable Portfolio Standard (RPS) Act was enacted since 1992 and partially supported geothermal power production[1].

After the Fukushima disaster, most of the nuclear power plants were shut down not only in Fukushima but also in other places due to the concern over safety. Three issues arose after that incident: what choices to make in the national energy and governance structure that decide this country's energy strategy (domestic domain), how such a choice should made on the issue that would have international implications (international domain), and what the impact will be on the future generation (intergenerational domain) (NPU, 2012a). Accordingly there are three viewpoints on how to reform the energy systems: 1- shifting to clean energy sources and securing green growth, 2- reforming the energy system led by demand side, and 3- multifaceted international contribution from the energy and environmental field. Also, there are four important perspectives in choosing energy options: 1- Securing nuclear safety and reducing risk in future, 2- Strengthening energy security, 3- Contributing to the solution of climate change, and 4- Restraining the cost and preventing hollowing out industry.

3. Multi partner governance research framework

The World Development Report 'Dynamic Development in a Sustainable World: Transformation in the Quality of Life, Growth and Institutions' advances the idea that the spectacular failure to tackle poverty and environmental degradation over the past decade is caused by a failure of governance by "poor implementation and not poor vision" (World Bank, 2003). The challenges for governments are therefore to provide space for the private sector to join hands to achieve inclusive growth. In terms of environmental issues, the new governance concept should involve stakeholders such as civil society and industry as well as the policy makers.

Moreover, the transition should be pursued in a broader perspective from environmentalism to sustainability (Riordan, 2009). The challenge in environmental governance research is the ability to combine and meaningfully connect a meta-theory that is able to capture the broader macrodynamics and historical conditions (Newell et al., 2012). This challenges the research as a part of the Earth System Governance Project, which seeks to develop relevant models and theory.

In 2009, a new concept, the 'Earth System Governance' (ESG), was introduced by the International Human Dimensions Program on Global Environmental Change (IHDP) as 'the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating,

[1] The Renewable Portfolio Standard (RPS) was not sufficient to scale up the renewable energy deployment (Suwa and Jupesta, 2012). The consultation process to find the new scheme to replace RPS scheme has been made among stakeholders (local communities, industries and policy maker) already done since 2010 but the pace is accelerate in 2011 triggered by this Fukushima Triple Disaster (MOEJ, 2012a). In July 2012, the government implemented the feed in tariff, which created a market incentive for renewable energy sources, such as solar, wind and geothermal electricity (METI, 2012b).

and adapting to global and local environmental change and, in particular, earth system transformation, within the normative context of the sustainable development' (Biermann et al., 2009a, Biermann et al., 2009b).

The planetary boundaries concept states that humankind is already affected by the exceeded planetary boundaries such as by climate change, biodiversity loss and disturbed nitrogen cycle (Rockstroem et al., 2009). This concept of planetary boundaries offers an important conceptual framework for a research and assessment program rather than only being a clear guideline for political action. The term 'tipping point' was introduced for highly nonlinear transitions, where a 'small force can make a big difference' in climate change (Lenton et al., 2008). This tipping point is the corresponding critical point at which the future of the system is qualitatively altered. How public policy can contribute to initiating such changes and to help identify 'social tipping points', remains a major research issue (Biermann, 2012).

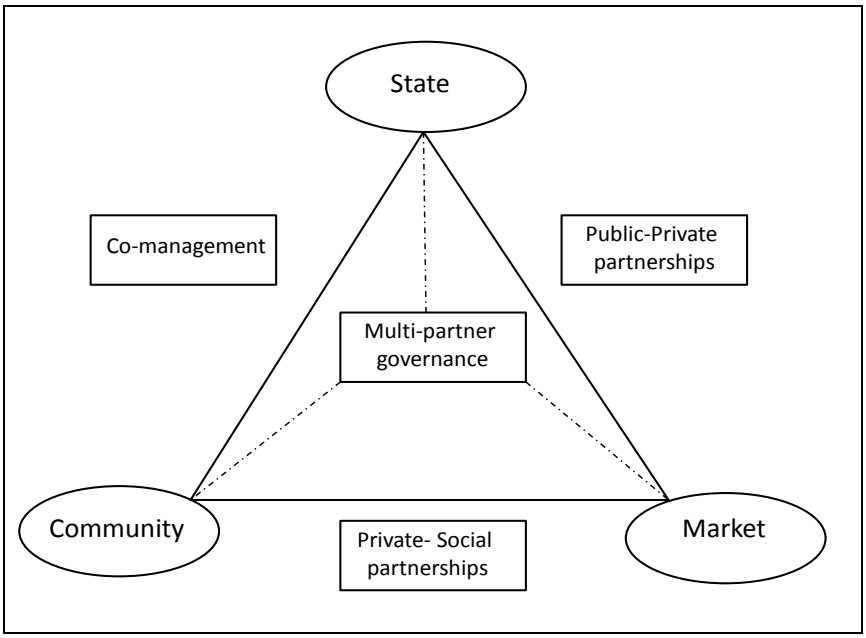

Fig. 1 Multi partnership governance framework (adapted from Lemos and Agrawal, 2009).

This earth system governance concept does not aim to govern the earth or manage the entire process of planetary evolution, but this concept is concerned with the impact of humans on planetary systems (Biermann, 2012). There are five analytical themes in earth system governance concept: architecture, agency, adaptiveness, accountability and legitimacy, and allocation and access. There are four themes that cross these themes: power, knowledge, norms and scale. This paper focuses on the second theme: agency. Research on agency in the earth system governance considers the capacity of public actors (at local, national and international level) to respond to global change and how this capacity may be changing (Dellas et al., 2011a). The analytical problems of agency begin with the assumption that credible, stable, adaptive and inclusive earth system governance is affected by a wide

range of actors including national governments and their bureaucracies as well as the growing population of non-state actors such as environment organization, expert networks and corporations (Dellas et al., 2011b).

This theme often cuts across public and private levels. At international level, actors span the entire spectrum from public institutions such as government bureaucracies or city governments to public-private such as environmentalist alliances or scientific networks, to purely private actors such as business associations and indigenous networks. There is a reconfiguration of authority in the realm of governance, which tries to distinguish between actors and agents. Actors refers to the individuals, organizations, and networks that participate in decision making related to the earth system governance (Biermann et al., 2009a). An agent (authoritative actor) is an actor who possesses the ability to prescribe behavior and to obtain the consent of the governed. Authority refers to legitimacy and capacity to exercise power, while power refers to the capacity to influence an outcome of events, with or without the legitimacy to do so.

Agents contribute here to purposeful steering of the constituents, either indirectly (by influencing the decisions of other actors) or directly (by making steering decisions). Research on the agency is closely linked to four broad areas of social science that addresses questions of who governs and how. In the governance system there are many agents: private, public, civil society and intergovernmental agreement (Young, 2009). The research question is: who governs the system and how? This study will take a look at the local context of the Matsunoyama geothermal power generation at Tokaichi city, and the multi-partnership relations among agents. The agents in this study refer to community, market or industry, and local policy maker refers to the framework of Lemos and Agrawal (Lemos and Agrawal, 2009) shown in **Fig. 1.**

This theme often cuts across public and private level. At international level, actors span the entire spectrum from public-state agencies? such as government bureaucracies or city governments to public-private such as environmentalist alliances or scientific networks, to purely private actors such as business associations and indigenous networks. There is a reconfiguration of authority in the realm of governance, which tries to distinguish between actors and agents. Actors refer to the individuals, organizations, and networks that participate in decision making related to the earth system governance (Biermann et al., 2009a). An agent (authoritative actor) is an actor who possesses the ability to prescribe behavior and to obtain the consent of the governed. Authority refers to legitimacy and capacity to exercise power, while power refers to the capacity to influence an outcome of events, with or without the legitimacy to do so.

4. Case of Matsunoyama geothermal power plant

This part will outline a stakeholder analysis based on a common framework that identifies the context in which the project is initiated, carried out and eventually evolved, based on the framework

of Lemos and Agrawal, (Lemos and Agrawal, 2009). This study is principally concerned with the issues of who are the agents and how the authority creates the agency for environment governance, using the case of the Matsunoyama power generation).

4.1. Who are the agents

The Matsunoyama power generation pilot plant was started in 2010 with the competitive fund of the Ministry of Environment Japan (MOEJ, 2012b). This project was to develop and demonstrate a new kind of geothermal power generation between 2010 and 2013. The project is the brain-child of the National Institute of Advanced Industrial Science and Technology (AIST) and Hirosaki University. The project is to develop a binary power production mechanical system using waste heat of hot spring water without affecting the power system and the hot springs, in the hot spring Matsunoyama in city Tokamachi, Niigata Prefecture. **Fig. 2** shows the geothermal Matsunoyama power plant. In many areas in the Japan, hot spring water has a high-temperature (70 ~ 120 º C). The temperature is "too high" for bathing. Therefore, in many cases, hot spring business operators use artificial means to lower the temperature, relying on electricity to cool to around 40º C.

Fig. 2 The geothermal power plant Matsunoyama.

The hot spring Kalina cycle power production (HSKPP) can generate electricity by a binary cycle that uses the waste heat converted into steam, so that steam can generate power. Binary system here uses two media: water and a liquid with low boiling point. The Kalina cycle uses ammonia as a medium, which has lower boiling point. While the steam produced by the Kalina cycle produces electricity, the hot water (with lower temperature after going through the system) could be used for bathing as in the normal hot spring/ onsen. It is good for hot spring business operators, as they do not have to use

additional energy to cool down the temperature of the hot spring water. The output of the power plant at Matsunoyama is 87 KW.

The Niigata prefecture started a feasibility study in 2011 to identify the potential of HSKPP, where Matsunoyama and other several sites are spotted as candidate locations for further development (Niigata, 2012). Based on the Niigata study, the Ministry of the Environment initiated a project to demonstrate hot spring Kalina cycle power production (HSKPP), and to test geological and mechanical feasibility, in line with the global climate concern and energy security contexts. After the project had been initiated in 2011, official consultation of the facility started. The Matsunoyama hot spring committee (MHSC) was formed and the first meeting was held in 2011 January. The members of the committee are academics, NGOs and officials from local governments. The main issues discussed in the committee are of a technical nature related to geological monitoring and mechanical stability, as these are directly related to sustainability of hot spring businesses. At the same time, members of the committee gradually started to discuss how the HSKPP can contribute to local tourism, agriculture, etc.

The official committee meetings serve as a mechanism to consolidate local technical concerns. The hot spring owners respond by improving their mechanical design and demonstrating practices. The committee meets regularly twice a year, but the hot spring owners can raise concerns anytime, if necessary, through the local authority and to the developers (GERD) directly. The technical platform of engineers, business community and government officials seems to ensure local trust in the project and its implementation.

The novelty of the project is perceived positively by the residents. The MOEJ demonstration project is the first of its kind in Japan, thus several delegates study the project from various municipal authorities and business communities. Though not all of them actually "stay overnight" in the hot spring hotels as the locals may expect, the increased number of visitors is regarded positively from a local business perspective. As the Matsunoyama project is currently ongoing, it is difficult to predict its exact pathways. This case demonstrates the dynamics of the process, in the form of proposals by the local hot spring operators to link energy production and tourism.

The national government plays the leading role as the funder of this project. The roles of the subnational government are equally important, which act as interfaces between the local community, developers and the national government. In Matsunoyama, the developer, Geothermal Energy Research & Development Co., Ltd (GERD) plays a key role. It provides professional geological and mechanical expertise, designed the power plant, tests the devices, compiles and analyzes data. The developer was also assigned to organize the consultation process with the local stakeholders, as illustrated in the **Fig**. **3**. The agents are divided in three parts: the local policy maker, Tokaichi city authority, the national level Ministry of Environment Japan, and the market for this geothermal plant. The excess of production will be sold to electricity utility companies under Fit in Tariff (FIT) scheme. The

community here refers to the user of the energy as hot spring visitors with intermediary the hot spring owner as well as the local people.

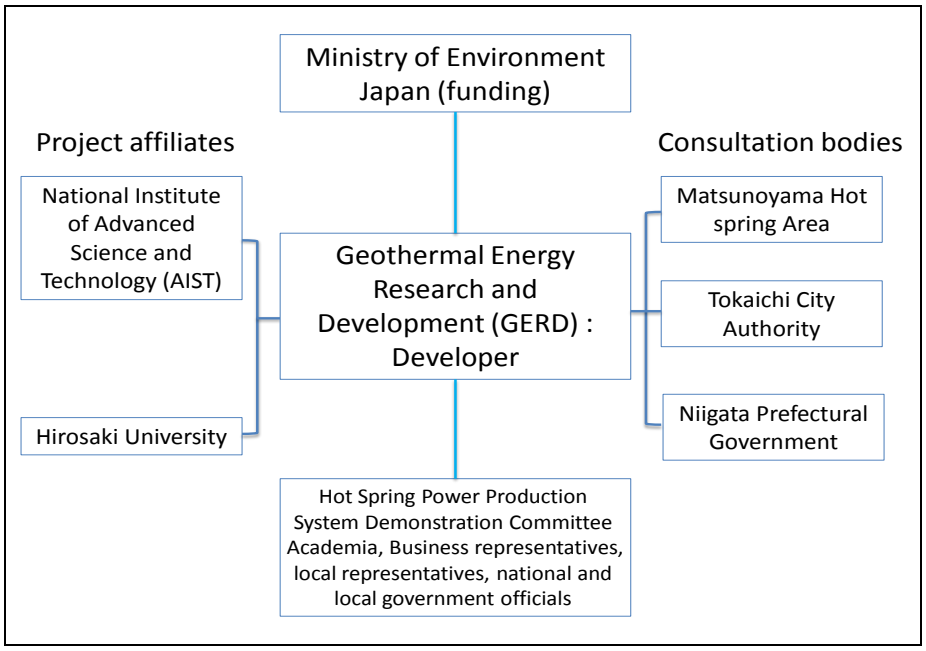

Fig. 3 Project flow of the Matsunoyama geothermal power generation.

4.2. How the agents partnership form the agency

Three relationships exist between the three agents (state, market and community): public-private partnership, co-management partnership and private-social partnership.

4.2.1. Public private partnership

There is a vertical linkage between the national and sub-national governments: the Ministry of the Environment recently took various initiatives to promote geothermal development. In one way, the public private partnership was materialized by concessions given by the Ministry of Environment (MOEJ, 2012a). Also, the Mayor of the Tokamachi shows his strong interest in the demonstrating project. The mayor's leadership spreads to the city authority officials and the organizational consolidation favored MOE's trust in the Tokamachi as a bidder. The objective of the project is to first test its technical feasibility and secondly to evaluate its social acceptance. The result of this analysis is expected to contribute to the application of the HSKPP in other areas. The MOE is the funding agency, with Geothermal Energy Research and Development Co., Ltd. (GERD), as the principle developer. Niigata Prefecture and Tokamachi city are consultation bodies.

After the Niigata feasibility study, the Ministry of Environment opened a bid for demonstrating project on HSKPP. The bidding call is to screen candidate sites for HSKPP, to test geological and mechanical feasibility of HSKPP. Therefore, the fact that the ownership of the hot spring resource belongs to the Tokamachi-city was perceived advantageous. GERD, together with a mechanical spe-

cialist companies, developed a tailored power production system for the project. The market uptake of the HSKPP is a recent development. Japan Geothermal Association addressed the need for creating a win-win relation between the hot spring business and geothermal usage as energy production. HSKPP is recognized as one of the ways to co-benefits local energy production that potentially be benefiting the local community in terms of energy security and safety. Therefore, manufacturing of the binary production system, though modestly initiated through the project, is one of the initial steps to understand the technical feasibility and possibility of the HSKPP, and benchmark its wider applications in other areas.

4.2.2. Co-Management Partnership

Upon the initiation of the project in 2010, GERD organized a consultation meeting with local stakeholders, including hot spring business operators. It is highly important to have this consultation process even before the project officially starts, because the business interests of the hot spring owners often hold the key to successful local acceptance. As a consequence to the process, some technical agreements were made. For example, it was agreed not to increase the volume of drilled hot water for power production, since hot spring owners are generally highly sensitive to the risk of depleting hot spring reservoirs. It is generally observed that most of the local residents recognize the HSKPP project in the Matsunoyama region, though the degree of understanding as to the technical details of the project varies. The local acceptance is also generally high: one reason for high acceptance may be that binary power production is less likely to impact hot spring resources, as it is only to utilize the heat of drilled hot spring water in the a binary system. Most of the interviewees did not express any disagreement with the facility operation.

4.2.3. Private social partnership

Based on interviews carried out in early 2012, it can be concluded that the locals are generally more concerned with the energy safety and security issues after the Fukushima nuclear accident. Some of the residents expressed their increased attention to these issues, and are hopeful that the project in their area would be a successful benchmark to contribute to the energy security and safety issues in Japan. It was found that the local residents do not exhibit any strong opposition towards the binary project. The project, however, is still of a top-down nature, envisaged and implemented by the central government (MOEJ) and the developer (GERD) with some involvement of academia, local authorities at prefecture and municipal levels. Although the hot spring business operators are invited to the public consultation process, the ownership of the project facilities belongs to the central government. Whether and how the project ownership would be transferred to the local authority may decide the degree to which the local community may feel a sense of ownership of the locally available energy resources and the related facilities.

It is common practice in Japan that, once a demonstration project funded by the central government is completed, with successful application proved, a facility will then be transferred to the local authority. The demonstrating project was originally planned to finish by March 2013. There is, however, a debate going on if the project should continue longer than originally planned. Technical issues emerged over the steam control of the facility. It is estimated that it will take another couple of years to obtain more solid data. With this technical concern, the project is now likely to continue until 2015. The longer demonstration period is good for the local authority in terms of finance. The depreciation period usually is 4 to 5 years. GERD is currently paying asset tax to the Tokamachi-city authority. If the project continues till 2015, the facility does not carry bookkeeping value. The Tokamachi city authority, which may be given the right to own and operate the facility, would not be payable for the asset tax by then. Also, in 2012 July, FIT would officially start. The produced electricity is sold to the Tohoku Electricity Company. The selling price is determined between GERD and Tohoku Electric Company, and is estimated at around JPY60/kWh. Therefore, Tokamachi city, as an owner, is likely to receive funds from the Tohoku Electric Company.

It is hoped that financial gain may benefit the local community, by being the source for supporting various local initiatives that stimulate businesses, tourism and agriculture. The Matsunoyama area is endowed with rich natural resources such as natural forest and hot water resources, that utilize the complicated land structure in that region. Some of the local businesses are starting to discuss how they connect the local energy production with these natural resources to make a package to attract more tourists.

With the potential for HSKPP identified, there is a growing interest as to its wider application in Japan. Also, the geothermal and the related technologies received increasingly growing recognition after the feed-in tariff became legislated. There is, however, a fundamental problem to spur the technology: power produced from a geothermal source can receive around JPY40/kWh, that gives an incentive for the hot spring owners to consider producing electricity with their resource, though the cost of power production may not yet be competitive enough. Also, the national framework for hot spring resources is not sufficiently developed and the resource availability in Japan has not been fully documented (MOEJ, 2012b); thus, it is difficult to understand the potential market for the technology. In order for the similar technology to be grasp the scale merit, institutional and regulatory framework to be better coordinated to fully estimate heat potential of hot spring resources.

5. Summary

There is a general perception in Japan that development of geothermal energy genmeration is difficult because it would face opposition from local hot spring owners. This perception is based on the media coverage and opinions expressed by some of the hot spring owners. Contrary to this perception, hot spring related energy production using the Kalina binary cycle in Matsunoyama is generally per-

ceived well by the local hot spring owners and residents. A reason may be that the Kalina binary cycle does not require additional drilling of geothermal resources. Careful public consultation process, involving local authority, academia and business operators seem to help smooth over problems and create a platform for common problem sharing and understanding.

In the Matsunoyama case, it is notable that public acceptance does not come up as a significant barrier. The stakeholders are hopeful that this case contributes to the wider application of HSKPP in Japan and elsewhere. The project design, analysis and other soft issues, e.g. transfer of the facilities, use of feed in tariff, depreciation of asset tax, etc. are all designed such as to deliver not just technical success but also to create a sense of ownership among local community. It would be the key for successful creation of governance models that may be transferable to other cases. The result addressed the significant roles played out by the national government, local authorities, developer, and local business operators and community, linkage and network still vertical, but there is a sign that more horizontal and active bottom-up linkage may emerge.

It is also important to focus on the elements that might contribute to the smooth implementation and mainstreaming of the project. Although it is only one case, and further elaboration is needed, the initial assessment shows that this case is "up-scaled" with strong support from the national government, with the due involvement of local authorities and responsive and professional developer serve as an intermediate agent. The political support for the project also helped the social-technical aspects of the project, e.g. leadership demonstrated by the Tokamachi city mayor. The political will can penetrate institutional coordination, leveraging actions necessary for smoothing up the project implementation.

Although it has been indicated cross-case learning is not "simple", lessons from one case may be shared through the national government, local authorities and developer networks. For the mainstreaming of the HSKPP practices, the elements identified above (national and local government commitment, identification of linkage, etc.) present initial formula for this kind of project to be implemented. According to the analysis, continuous support from the national and local government is crucial to continue the project. In order to duplicate this kind of project, similar pattern of governing formula will be required.

The analysis focuses on a 'first of its kind project' in Japan, thus comparison with other cases in different countries cannot be drawn. More lessons could be learned once several other cases are analyzed. Comparison with cases outside geothermal premises may also provide useful suggestions as to how governance system may contribute to the emergence of new technological applications. HSKPP is an emerging technology, but it is relatively small in its power production capacity. The potential of the system lies in how much the costs of a system and the electricity production costs would be reduced as market volume increases. Apart from differences in local or national conditions, further study also needs to be done on how much reduction and electricity capacity cost generated in larger scale to produce affordable and reliable electricity.

Acknowledgement

This study was part of 'Green New Deal Policy' project conducted by National Graduate Institute for Policy Studies (GRIPS) and was funded by Ministry of Environment Japan (MOEJ). JJ thanks to the funding from the Japan Society for the Promotion of Science (JSPS) for its JSPS–UNU Postdoctoral Fellowship.

References:

Biermann F., 2012. Planetary boundaries and earth system governance: exploring the links, Ecological Economics, Vol.81, 4-9.

Biermannn, F., Betsill, M., M., Gupta, J., Kanie, N., Lebel, L., Liverman, D., Schoreder, H., Siebenhuener, B., with contribution from Ken Conca, Leila da Costa Ferreira, Bharat Desai, Simon Tay and Ruben Zondervan. Earth System Governance: People, Place and the Planet. 2009a. Science and Implementation Plan of the Earth System Governance project. Earth System Governance Report 1, IHDP Report 20. Bonn, IHDP: The Earth System Governance Project, 2009.

Biermannn, F., Betsill, M. M., Gupta, J., Kanie, N., Lebel, L., Liverman, D., Schroeder, H., Siebenhuener, B., Zondervan, R. 2009b. Earths System Governance: a Research Framework, *International Environment Agreements* 2009; 10: 277-298.

Biermann et al., 2012. Navigating the Antrophocene: Improving Earth System Governance, Science, Vol. 335, 1306-1307.

Dellas, E., Pattberg, P., Betsill, M. 2011a. Agency in earth system governance: Refining a research agenda, International Environment Agreements, 11: 85- 98.

Dellas, E., Pattberg, P., Betsill, M. 2011b. Editorial for Special Issue Agency in Earth System Governance, International Environment Agreements, 11: 1-6.

Japan's Cabinet Office, 2011. The Guideline on Policy Promotion for the Revitalization of Japan. Cabinet Office, Tokyo. http://www.kantei.go.jp/foreign/topics/2011/20110517_guideline_1.pdf

Jupesta J., Suwa A., 2011. Sustainable Energy Policy in Japan, post Fukushima, Energy Forum Fall 2011, International Association of Energy Economics (IAEE). http://www.iaee.org/en/publications/fullnewsletter.aspx?id=20

Lemos, M.C., and Agrawal, A., 2009. 'Environmental governance and political science' in: *Delmas M.A. and Young O.R., Governance of the Environment: New Perspectives*, Cambridge University Press, UK

Lenton, T. M., Held, H., Kriegler E., Hall, J.W., Lucht W., Rahmstorf S., and Schellnhuber H.J., 2008 Tipping Elements in the Earth's climate system, Vol. 105, 1786-1793.

MOEJ, 2012a. White Paper 2012. http://www.env.go.jp/en/wpaper/2012/index.html

MOEJ, 2012b. *in Japanese.* http://www.env.go.jp/earth/ondanka/rep/EN/index.html

METI, 2010. The Strategic Energy Plan of Japan- Meeting global challenges and securing energy futures-(Revised in June 2010). http://www.meti.go.jp/english/press/data/pdf/20100618_08a.pdf

METI, 2012a. Feed in Tariff Scheme in Japan http://www.meti.go.jp/english/policy/energy_environment/renewable/pdf/summary201207.pdf

METI, 2012b. Outline of the Annual Report on Energy for Fiscal year 2011 (Energy White Paper 2012). http://www.meti.go.jp/english/report/downloadfiles/2012_outline.pdf

Newell, P., Pattberg, P., Schroeder, H., 2012. Multiactor Governance and the Environment, Annual Review of Environment and Resources, 37:365-387.

Niigata, 2012. (accessed by December 1st 2012). http://www.pref.niigata.lg.jp/sangyoshinko/1328648444662.html

NPU, 2012a. Options for Energy and the Environment: the Energy and Environment Council Decision on June 29th, 2012 http://www.npu.go.jp/policy/policy09/pdf/20120720/20120720_en.pdf

NPU 2012b. Innovative Strategy for Energy and the Environment, Report http://www.npu.go.jp/en/policy/policy06/pdf/20121004/121004_en2.pdf

Reid, W.V. Chen, D., Goldfar, L., Hackmann, H., Lee, Y.T., Mokhele, K., Ostrom,E., Raivio,K., Rockstroem, J., Schnellhuber, H.J.,Whyte,A. 2010. Earth System Science for Global Sustainability: Grand Challenges, Science 330 916-917.

Riordan,T.O., 2009. Reflections on the pathways to sustainability, in Adger W. N., and Jordan A., *Governing Sustainability*, Cambridge University Press, UK.

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin III F.S., Lambin, E.F., Lenton T., M., Scheffer, M., Folke C., Schellnhuber H., J., Nykvist B., de Wit C.A., Hughes T., van der Leeuw, S., Rodhe H., Sörlin S., Snyder P.K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R.W., Fabry V.J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., & Foley J.A. ,2009. A safe operating space for humanity, Nature 461, 472-475.

Schellnhuber, H.J., 1999. Earth system' analysis and the second Copernican revolution, Nature Vol.402, C19-C23.

Suwa, A., Jupesta J., 2012. Policy Innovation for Technology Diffusion: through a case with Japanese Renewable Energy Public Support Programs, Sustainability Science. http://dx.doi:10.1007/s11625-012-0175-3

World Bank, 2003. World Development Report 2003: Sustainable Development in a Dynamic World: Transforming Institutions, Growth, and Quality of Life, World Bank, US.

Young, O.R., 2009. 'Governance for sustainable development in a world of rising interdependencies' in *Delmas M. A., and Young O.R., Governance for the Environment: New Perspectives*, Cambridge University Press, UK.