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Original Articles

Integration of natural and social environment in the implementation of geothermal projects

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ABSTRACT

Recent geoscientific, socio-technical, and sociological studies aimed at achieving social acceptance for geothermal development accommodating the natural and social environment are integrated in this paper. The geoscientific study presents the potential effects of geothermal development on the nearby hydraulic systems. Geochemical analysis of hot springs provides an effective means of investigating possible interference of the hot springs due to geothermal exploitation.

The authors have proposed a socio-technical approach, Overall System Design, which is a concept aimed at maximizing business profitability and social acceptance. In this approach, the optimal solution may vary with the extent of project implementation because increasing data volume facilitates more accurate system design. Visualization of the benefits of geothermal development is an important part of this approach because it promotes mutual understanding among stakeholders.

Stakeholder attitudes and needs are diverse hence from a sociological approach, project developers approach for social acceptance should differ depending on the situation for each geothermal prospect. Results of attitude surveys of local municipal governments as key stakeholders suggest that governments and developers should continue to provide information to improve social acceptance. In order to achieve social acceptance, explanation based on geoscientific facts and the concept of Overall System Design may be effective.

1. Introduction

Japan has geothermal potential of 23 GW_e (Muraoka, 2009). However, the current installed capacity in the nation is merely 520 MW_e (Yasukawa, 2015) while direct use except for bathing and ground-source heat pump is quite limited. This is attributed to legal, economic and social problems. The three major barriers include: 1) regulations on natural parks, 2) development risk and cost and 3) social acceptance. The former two barriers were mitigated by supportive policy of the central government after the nuclear accident in March 2011, which resulted to changes in several regulations and subsidies for geothermal development. Feed-in Tariff system including geothermal power generation under "Act on Purchase of Renewable Energy Sourced Electricity by Electric Utilities" was enacted as well. However, social acceptance still remains a major problem. This is supported by the reports on delays and termination of several geothermal developments due to opposition by groups of hot spring owners fearing degradation of hot springs (Uechi et al., 2013).

There are many reasons why such negative campaigns occur. As shown in Fig. 1, regional communities are based on stable mutual relationships through human activities such as agriculture, industry, construction, transportation, service industries, etc., which is expressed by "regional economic circulation model" (Soma et al., 2015). A balanced circulation of money, persons and goods, etc., exists to some extent in regions (Fig. 1 top). Likewise any sudden development of a geothermal project might disturb the pre-existing local human activities, influencing various elements in the region (Fig. 1 bottom). Such development may make some stakeholders happy and others unhappy thus triggering opposition campaigns. Therefore to gauge acceptability of this impact on local residents and stakeholders, research related to social acceptance of geothermal development has been conducted. The latest research includes Barasa (2015), Batac and Dugan (2015), Khoirunissa et al. (2015), Pellizzone et al. (2015, 2016), Toth et al. (2015), Shoedarto et al. (2016), van Douwe et al. (2016) and Mellera et al. (in press).

Uechi et al. (2013) carried out a preliminary study on the factors that could influence community acceptance by comparing two geothermal development projects in Japan, a successful case in Yanaizu-

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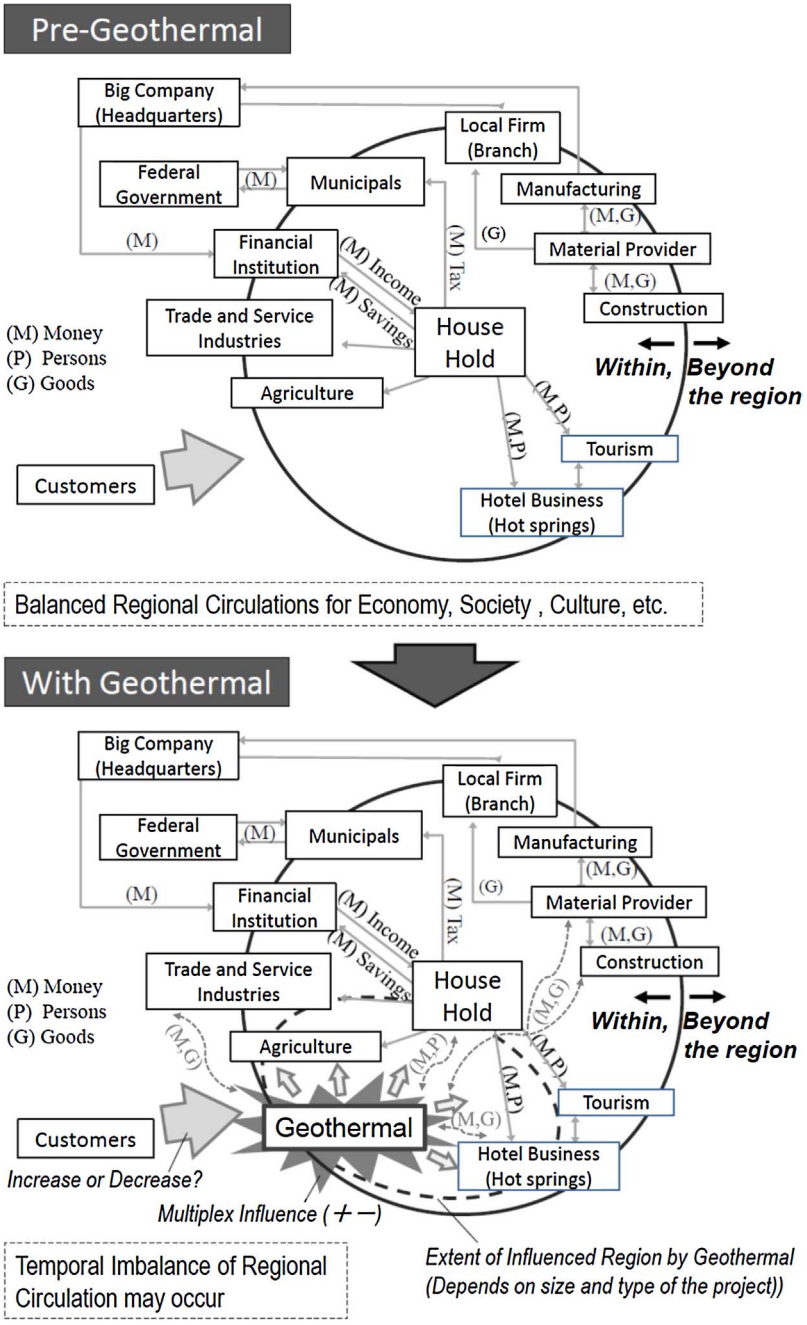

Fig. 1. Conceptual diagram of *regional economic circulation model* before (top) and after (bottom) introduction of geothermal energy system (modified from Soma et al., 2015).

Nishiyama and an unsuccessful case in Oguni. The noticeable difference between the two cases are related to recognition of benefits, recognition of risks, and equity in process, although the expected benefits and risks were equivalent and communication with the local communities had begun at a quite early stage for both projects. In Oguni, a larger diversity of the stakeholder opinions on the benefits of geothermal energy use was observed. For risk recognition and equity in process, the developer at Oguni simply explained that there was no risk of impacts on the hot springs while the developer in Yanaizu-Nishiyama concluded a written agreement on risk management with the local stakeholders at an early stage of construction. These results shows the importance of open information on both benefits and risks as well as equity in process for social acceptance.

In this paper, geoscientific, socio-technical, and sociological research related to social acceptance of geothermal development are discussed. Section 2 of this paper, “Relationship between a geothermal reservoir and nearby hot spring aquifers”, is a geoscientific study on sustainable geothermal utilization with hot spring resources. Section 3, “Overall System Design of Geothermal Energy Systems”, is a conceptual socio-technical study on comprehensive optimization of a geothermal system for all stakeholders. Section 4, “Stakeholders Attitude”, is a sociological study on acceptance of geothermal development based on analysis of questionnaire responses from municipal governments as key stakeholders.

2. Effect of geothermal development on nearby hydraulic systems

2.1. Relation between hot springs and geothermal reservoirs

Stakeholder engagement is essential for the development of new geothermal resources. Environmental and Social Impact Assessments should be carried out to identify and mitigate potential negative