EIMY (ENERGY IN MY YARD)
A CONCEPT FOR PRACTICAL USAGE OF RENEWABLE ENERGY FROM LOCAL SOURCES

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INTRODUCTION

To maintain a sustainable civilization throughout the 21st century, it appears necessary that humankind utilize renewable energy sources to the maximum degree. Although various efforts are underway in various countries to develop renewable energy, they are still far from sufficient. Geothermal energy is a reliable and environmentally benign source and is one of the most competitive of the renewable resources. However, this view is not universally shared by the general public. Moreover, the current low price of fossil fuels, combined with deregulation of the electric power industry since 1990, has made it very difficult for new geothermal power plants to compete (Murphy and Niitsuma, 1999).

Given this situation, a workgroup was assembled recently in Japan to investigate strategies of geothermal development that are consistent with the expected earth environment of the 21st century. The recommendations of the group were presented as a report in May 2002. Central to their proposals was the concept of EIMY - Energy In My Yard which advocates the development of integrated renewable energy systems that are customized to the needs and resources of local communities. Such systems not only increase net renewable energy utilization, but also benefit the local economy and energy security in the area (Murai, 2002 and Niitsuma, et al., 2002).

In this paper, we describe the concept of EIMY and the role of geothermal energy within it. An analysis of cost and environmental benefit of an integrated renewable energy system is presented. We also discuss problems to realize the EIMY in a local area.

STUDY ON A STRATEGY OF GEOTHERMAL DEVELOPMENT IN JAPAN

The study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Group members are listed in Table 1. To date, geothermal energy in Japan has been developed as a substitute for oil energy since the oil crisis. No adequate study has been done to evaluate the potential of geothermal energy as a renewable energy consistent with the earth environment. Internationally, geothermal energy is recognized and categorized as a new and/or renewable energy together with solar, wind, hydro and biomass energy. However, in Japan, only solar and wind are classified as "new energies" that enjoy protection under the law concerning Promotion of the Use of New Energy enacted in 1997. Geothermal is not included. Moreover, in 2001, biomass was added to the list of renewable energies to be promoted by the New and Renewable Energy Subcommittee of the Advisory Committee for Natural Resources and Energy, but not geothermal. According to the Energy Supply and Demand Outlook presented by the Japanese government, future growth in geothermal energy is assumed to be zero. Consistent with this perspective, in 2001, the Ministry of Economy, Trade and Industry (METI) decided to cut the entire budget for research and development on geothermal energy. This decision was merely political.

Table 1. Members of the Study

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Given the radical changes in the Japanese government policy on geothermal energy development, and the crisis it prompted, the group of geothermal experts set about conducting a systematic and scientific analysis of the role geothermal might play in meeting societal energy needs in the medium- and long-term.

The following items were the subject of discussion.

1. Geothermal energy as an environmentally benign energy source
   (a) Environmental benefit and impact
   (b) Reserves, quality, distribution and characteristics
   (c) Current development problems and their solutions
2. Geothermal energy in the Japanese society
   (a) Market and profitability

(b) Contribution to the local economy and its role as a diversified energy

(c) Current system of geothermal energy development, problems and solutions.

3. Key concepts in utilizing "geothermal energy consistent with the earth environment."
4. Strategy for a geothermal energy development in the 21st century.
5. Foreign strategy.

The group compiled a report of 220 pages, which was distributed to government officials, politicians, local government, local authorities, industries, universities, etc.

The report identified the following problems for geothermal development in Japan: (1) Geothermal projects have been strongly biased towards the development of 50 MWe-class power plants that could be connected to the national grid. This bias has effectively suppressed diversity in the methodology of optimally utilizing the resource: for example, the use of cascade or binary systems, and heat pump; (2) The market mechanism has not worked well, largely because the customer for geothermal developers has been limited to the electric power companies; (3) Lack of consideration of environmental aspects and objectives in geothermal projects; and (4) Geothermal power plants were not always seen by local inhabitants as a community resource but rather as being just as great a nuisance as the other type of power plants. Indeed, developments occasionally met with hostility from "onsen" (hot spring) communities, a reaction that erodes the incentive of people in surrounding area to introduce further geothermal facilities.

Based on the above considerations, the report advanced the concept of EIMY: Energy In My Yard as a rational usage of renewable energy resource for 21st century.

CONCEPT OF EIMY

EIMY is a local energy/economic system in which combinations of local renewable energy resources are utilized to the maximum degree that technical and economic considerations permit. Shortfalls and surpluses in local energy production are accommodated through an interface with the national grid (Figure 1). It should be emphasized that EIMY is a system for local people and is conceived to engender the converse reaction to that of NIMBY (Not In My Back Yard).

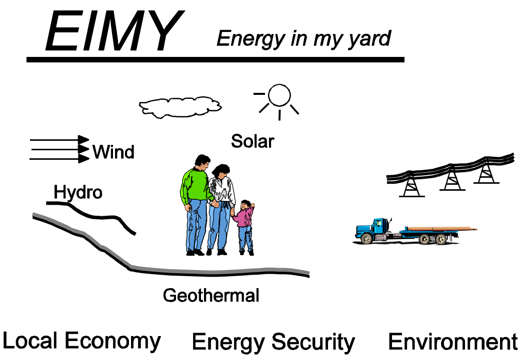

Figure 1. Concept of EIMY.

Figure 2 is a schematic diagram of business models for conventional energy/resources development in both growth and saturated periods. In the growth period, high density and/or high quality energy/resources are explored, developed and brought to market in pursuit of substantial profit. However, in the saturated period, the cost tends to climb because of progressive exhaustion of the resources and the attendant increase in difficulty of exploration and exploitation. Eventually, the resource loses its competitiveness in the energy/resource market. In contrast, natural, renewable energy resources are generally low density, but widely distributed and sustainable. It is, therefore, basically improbable that substantial profit can be derived in the short term from the development of renewable energy resources, except for limited locations that are blessed with high density/quality resources. In some countries including Japan, such favorable geothermal spots have already been fully developed. The same pattern may be followed for the development of wind power in the future.

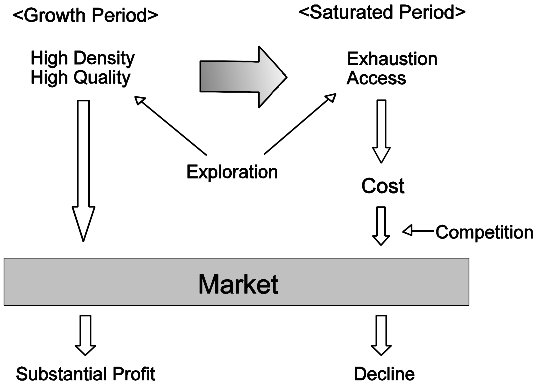

Figure 2. Business model for energy and resources development.

The conventional business model works well for developing favorable resources. However, the vast renewable resource that falls outside this limited category can only rationally be developed within the framework of a different business model that considers additional factors besides short-term profit. EIMY is one such model that also includes consideration of environmental benefit, contribution to the local economy through job creation, and local energy security. Such a revision of the business model would not only greatly extend the exploitable renewable resources, but would also lead to an increase in economic productivity of the host area. This in turn would provide an incentive for local people to utilize local renewable energy, and hence, contribute to the usage of green energy in the country as a whole.

The function of EIMY within the national energy supply system can be figuratively understood through analogy with the circulation system of the human body. EIMY represents the pumping function of the peripheral muscles for the peripheral arteries; while, the power supply to the national grid represents the pumping function of the heart for the main artery. Both functions are required.

INTEGRATED RENEWABLE ENERGY SYSTEM

The EIMY system seeks to utilize the optimum combination of every green energy resource that is locally available to the maximum extent that practical and economic conditions permit. Recognized resources include wind, solar, geothermal, hydro and biomass. We have applied a simulator, which can be used to identify the optimum combination, to the case of the hour-by-hour energy needs and source availability for a local village with a population of 9,000 in Iwate Prefecture in northern part of Honshu Island, Japan (Nakata, et al., 2002). There is no conventional geothermal activity in this area. The yearly average temperature is 8.3°C, with minimum and maximum values of -18.0 and 31.0°C, respectively. The simulated energy system consists of wind, photovoltaic (PV), biomass co-generation and conventional grid power for electricity supply, and of biomass-cogeneration, geothermal heat pump (GHP), petroleum and gas for heating. Shortfalls and surpluses of electricity from the renewable energy sources are accommodated with an interface to the grid.

The analysis uses a nonlinear energy modeling system to find the optimal configuration and operation of the energy system. Using this approach, the system is modeled as a market, with nodes passing information about energy demands and prices until equilibrium is reached. This equilibrium corresponds to a cost minimization. By this means, the most economical energy system will be configured and optimized (Lamont, 1994).

Figure 3 shows changes in the quantity of electricity supply during a windy period. The demand is shown by the central, relatively-regular periodic curve, and the optimized contributions from the various sources that combine to meet this demand are shown by the superposed colored areas below this curve. The area above the curve represents surplus electricity sold to the grid. The wind generator performs well and its electricity accounts for the major part of the total electricity generated. However, its production becomes insufficient during windless period at which time grid electricity is used. PV and biomass constitutes only a small portion of the electricity generated because of their costs.

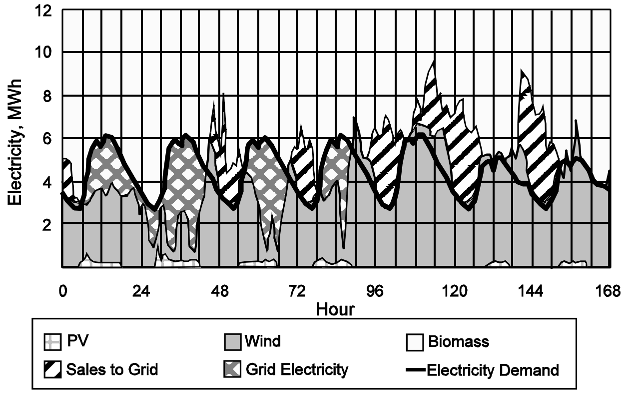

Figure 3. Electricity supply during a windy period.

Figure 4 shows changes in sources of heat supply for the same windy period. The GHP and petroleum serve as the main sources of heat, with the GHP favored during very windy periods. This is because the GHP runs on electricity; hence, the price of its heat is influenced by the price of electricity.

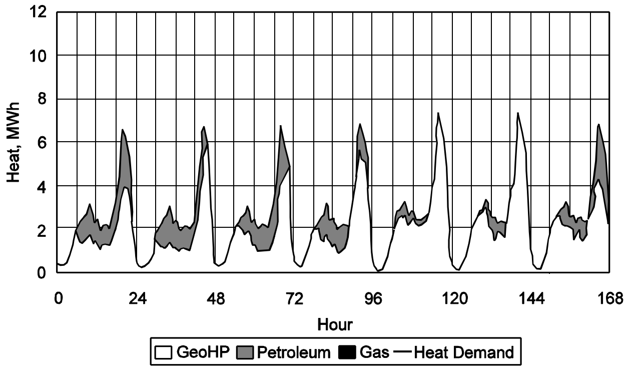

Figure 4. Heat supply during the same period.

The simulation-derived, optimum combination of installed capacity of the various renewable sources required to supply the village's energy needs throughout the year is shown in Figure 5. Evidently, this includes a large amount of wind and GHP, and a small amount of PV, biomass and petroleum.

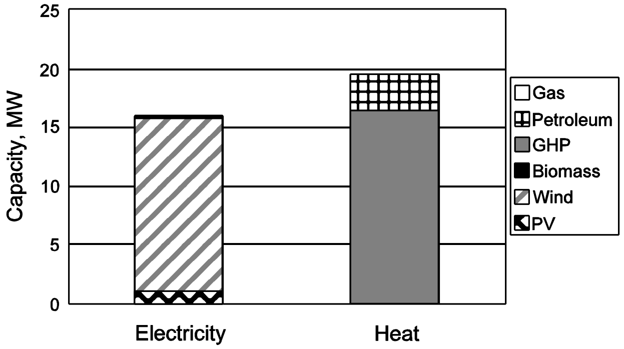

Figure 5. Optimized capacity of renewable energy sources.

CO_2 emission from the integrated renewable energy system in the village is compared to that from the conventional energy system in Figure 6. The optimized renewable energy system proposed here would reduce CO_2 emissions by 79% and hence, contribute significantly to the reduction of fossil fuel combustion.

Figure 7 shows the annual cost of meeting the village's energy needs with an integrated renewable energy system as compared with conventional sources. The costs include fuel, operating and capital investment expenses. The renewable energy system can reduce the annual cost by 15%. If sales of wind electricity to the grid during windy periods are included, the reduction increases to 23%. It should be emphasized that the calculations were performed using current market prices of commodities. The imposition of a carbon tax would improve the cost benefit even more.

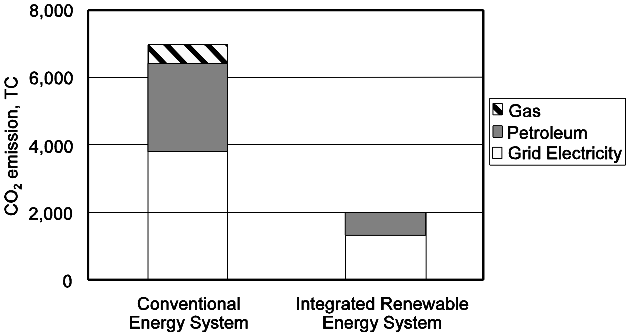

Figure 6. ***Suppression of CO_2 emission with the integrated renewable energy system.***

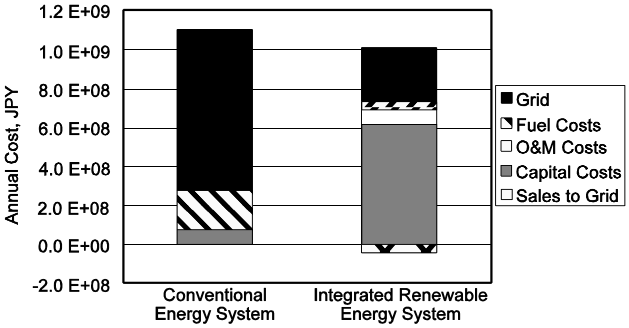

Figure 7. ***Comparison of annual cost between conventional and renewable system.***

The analyses we have conducted make it abundantly clear that wind electricity and GHP are both necessary in order to optimize renewable energy systems economically in the rural areas. On the contrary, significant PV and biomass co-generation capacity are not installed in the proposed system. This is because the capital cost of wind electricity is lower than that of PV, and there is little difference between the ancillary operating costs of the two. The price of wind electricity is quite low, varying between 3 cents/kWh and 5 cents/kWh; whereas, the current price of grid electricity used in households is 23.3 cents/kWh in Japan. Thus, wind electricity can supply rural areas at one-fifth the price of current electricity sources. This allows GHP to supply heat at low prices, as the power source of GHP is electricity.

As shown in this example, the integrated renewable energy system has great advantage over the uncoordinated utilization of renewable resources. The optimum configuration of a renewable energy system for a given site will vary according to availability of energy sources, local climate conditions, demand patterns and costs of component.

GEOTHERMAL TECHNOLOGY WITHIN THE EIMY SYSTEM

Geothermal energy will play a key role in the EIMY system as was demonstrated by the example in the previous section. It is relevant to ask what are the essential features of geothermal that make it so suitable for the EIMY system? One feature is consistency with the environment and the other is ubiquity. Zero emission and sustainable production are essential features for the consistency. With regard to the latter, the technologies of reinjection (Cappetti, et al., 1995) and HDR/HWR (hot dry rock/hot water resources)are important. Technology to facilitate stepwise increases in production rate and monitoring are also important for sustainable production, because an optimum production rate in a geothermal system is usually difficult to estimate in advance, and it is reasonable to start with a lower rate. The technologies of HDR/HWR, binary system and heat pump taken collectively allow subsurface heat to be exploited from a diverse range of depths and conditions, and thereby greatly enhance the ubiquity of the geothermal resource. In this regard, it is necessary to compile a new database that shows the true picture of geothermal energy resources in a given area rather than just high density/quality resources. In the case of HDR/HWR, small systems of less than 1 MWe will be more useful for the EIMY system.

REALIZATION OF EIMY

For EIMY systems to be developed to the point of supplying a significant part of a nation's energy needs requires a considerable supportive infrastructure. Figure 8 shows a possible organizational chart of entities and links that might support a national EIMY system. As a first step, inhabitants must be informed about the benefits of introducing a renewable energy system, and be given financial incentives to install one. This financial and information support might be provided by local government and other advisory organizations. Because the contribution to the local economy is one of the major features of the EIMY, the renewable energy system should be constructed and maintained by local industries. However, it is unreasonable to expect that they will have enough knowledge to design and construct systems optimized to local conditions and resources themselves. It is, therefore, important that there exists a supporting organization such as consulting companies, national institutes, universities, etc., which has expert staff and maintains a database. The machinery and materials needed in the construction of the system should, whenever possible, be provided by central industries at reasonable cost. An association, which includes local and central industries, a national institute and universities, should be established with government support in order to further develop the requisite technologies. An insurance system is desirable to protect the local industries against cost increases arising from unforeseen circumstances. It must be recognized that there is always risk in developing natural resources.

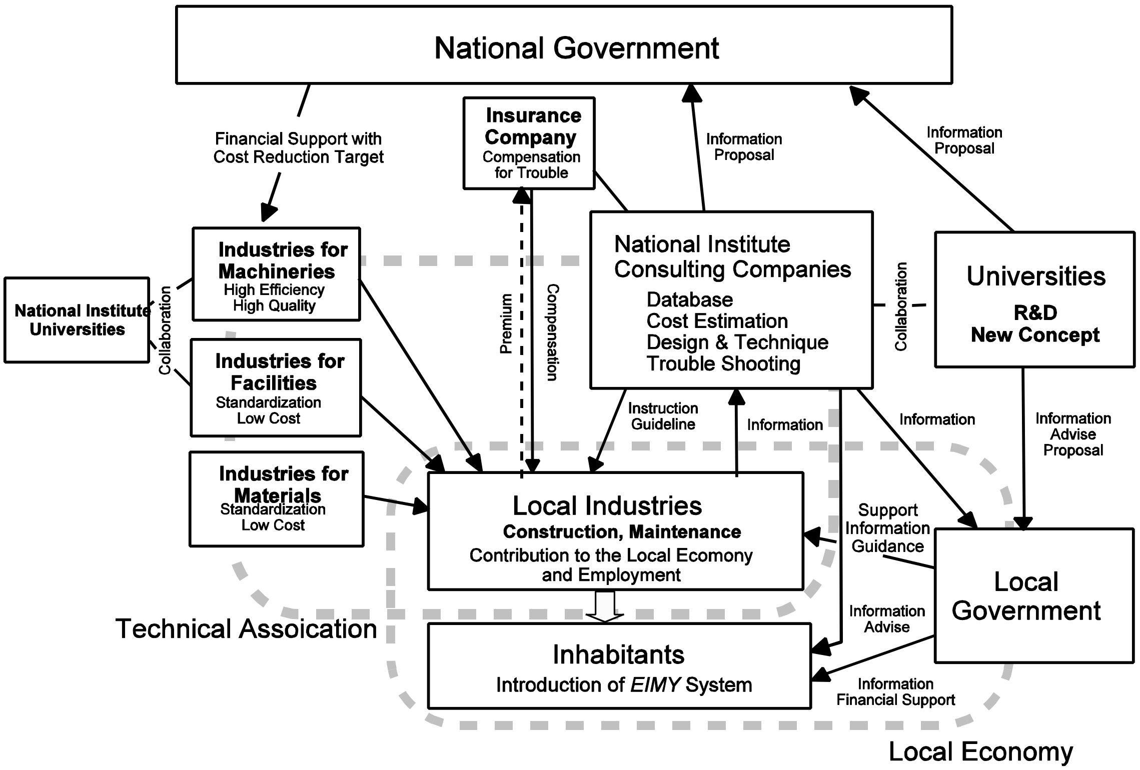

Figure 8. An example of economy system to realize EIMY.

Current regulations governing energy distribution in Japan do not favor the development of an EIMY system. For example, the Electric Utilities Industry Law in Japan gives exclusive rights to the electric companies to supply electricity in an area. This means that privately generated electricity from say a community wind turbine cannot be directly distributed to the inhabitants but must be sent through the electric company's grid. Thus, changes to the law are needed to allow the full benefits of EIMY system to be practically realizable, at least in Japan.

CONCLUSION

In this paper, we describe the concept of EIMY and the role of geothermal energy within it. EIMY allows the utilization of renewable energy resources that current business models deem to be unfavorable for exploitation. It also contributes the local economy, and provides for local energy security.

The integrated renewable energy systems have considerable advantage over independent utilization of renewable resources. The computer simulation for a rural area in Japan shows that an integrated renewable energy system with an optimum combination of resources can decrease not only CO_2 emission but also the cost, even though the installation and operating costs were assigned at current market rates, without weighting for advantages such as low CO_2 emission in the simulation.

Geothermal energy will play a key role in the EIMY systems. Heat pumps are of primary importance together with the geothermal technologies of reinjection, HDR/HWR, binary system. It is also important to compile a database that describes the expanded geothermal resource opened up by these technologies.

For EIMY systems to be developed to the point of supplying a significant part of a nation's energy needs requires a considerable supportive infrastructure. In order to realize EIMY, not only the technologies to utilize resources but also the establishments of economy system and the social system are required.

Renewable energy can supply a considerable part of the total energy requirements of an industrialized country. However, even if the political tide turns in its favor, it will take much time and effort to establish an EIMY system at the national level. Nonetheless, in some mostly-rural areas, it is possible to supply more than 100% of total energy needs by integrated renewable energy systems. These are obvious places to nucleate the development of EIMY. Subsequent extension of such areas to form a national EIMY system is one of the steadiest ways to decrease CO_2 emission in the world.

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