Does the surge in resource prices make wind and PV more cost competitive against nuclear and fossil fuel power?

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1. Introduction

In 2008, crude oil once soared to a record high of more than 140 U.S. dollars per barrel. .At the same time, the surge in resource prices since 2000 covers a wide range of commodities including non-energy materials such as input products for renewable energy, and it is not clear which types of power generation have become more promising. Therefore, this study attempted to verify whether renewable energy have become more economical as a result of the surge in resource prices including fossil fuels since 2000, taking wind power and PV as examples.

2. Data (Input Quantities and Prices of Fuels and Materials)

Table 1 shows the per kW inputs of materials for nuclear power, thermal power (with different types), wind power and PV (taken from Imamura & Nagano (2010)), and Table 2 shows the prices of the individual resources, materials and fuels during the subject period.

kg/kWh

	LNG Combined	Coal	Nuclear	Wind (300kW)	Wind (1000kW)	Wind (2000kW)	Wind (2500kW)	Solar(thin policrystalline silicon)
steel	87.9	166.3	156.1	77.0	202.4	515.2	684.9	56.1
cement	410.0	509.1	1433.2	55.7	120.7	527.4	818.6	−
silicon	−	−	−	−	−	−	−	6.9
alminum	−	−	−	−	−	−	−	15.2
ethylene	−	−	−	−	−	−	−	15.3
copper	−	−	−	−	−	−	−	1.0
flat glass	−	−	−	−	−	−	−	53.9
glass fiber	−	−	−	2.3	11.4	19.5	29.9	−
durable years	40	40	40	30	30	30	30	20
utilization rate	80%	80%	80%	20%	20%	20%	20%	12%

Table 1 Inputs (kg/kW) of Resources/Materials

The figures shown in the tables are for newly built thermal power, nuclear power, wind power and PV plants. For thermal and nuclear power, the materials included in the analysis are cement and steel, which are the main construction materials. For wind power, cement, steel and glass-fiber (the main input material of blade) are included in the analysis.

And for PV, the analysis included silicon (the main input material for the photovoltaic cells), ethylene (the main input material for EVA (ethylene vinyl acetate) used as the filler), tempered glass (used as the covering for the photovoltaic panels), steel (material for the frames), and aluminum and copper (materials for the control equipment, etc.).

	'2003	'2008	price change
steel (Yen/kg)	45	113	149%
cement (Yen/kg)	5.6	5.5	−1%
silicon (Yen/kg)	4012	8284	106%
Alminum (Yen/kg)	166	266	60%
ethylene (Yen/kg)	95	386	306%
copper(Yen/kg)	246	782	218%
armored glass (Yen/kg)	810	834	3%
glass fiber(Yen/kg)	269	299	11%
crude oil (CIF, US$/bbl)	29.1	102.6	252%
steam coal(CIF, US$/bbl)	34.8	124.6	258%
LNG (CIF, US$/bbl)	246.0	647.3	163%

Table 2 Prices of Resources, Materials and Fuels

Figure 1 shows per kWh material inputs for power generation facility types. With regard to per kWh material input, only the weights were compared without considering the characteristics of the resources and materials.

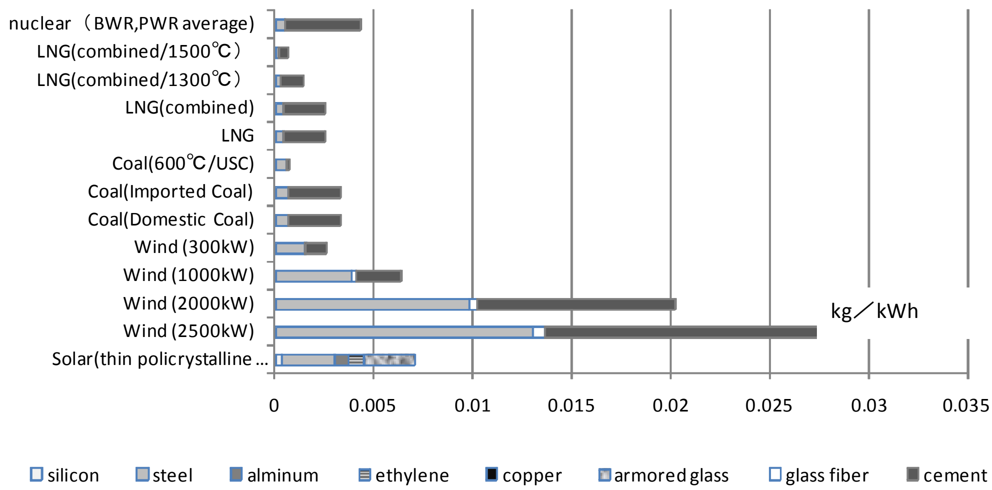

Fig. 1 Per kWh fuel and material Inputs for Power Generation Facility Types
(in terms of weight; other than fuels)

3. Methodology

In this study, a comparison was drawn between the changes in the power generation unit costs of coal-fired thermal power, natural gas-based thermal power, nuclear power, wind power and PV due to fluctuations in the prices of fuels and main materials in Japan from 2003, the year before the start of the crude oil price surges, to 2008, the year in which the crude oil price peaked. This was done by measuring the difference between the power generation costs incurred under certain cost structure and technological conditions if systems of the respective types had been newly constructed in 2003 and 2008, respectively.

The per kW material costs for thermal power and nuclear power were calculated by multiplying the per kW inputs (kg) by the corresponding per kg prices. The Federation of Electric Power Companies of Japan (2004) presents the power generation costs of various power sources at the power end that they calculated (each of these prime costs consists of the facility cost, operation cost and fuel cost). The standard assumptions used to estimate the facility costs are an operation period of 40 years, discount rate of 3%, business return rate of 3.4%, property tax rate of 1.4%, residual value rate of 10% and the use of the diminishing balance depreciation method. Under these assumptions, the annual overhead expense rate (as a percentage of the construction cost) for thermal and nuclear power plants is estimated as 4.7%. The per kWh material costs were calculated by multiplying the abovementioned per kW material input cost by this annual overhead expense rate (4.7%) and dividing the product by the annual power generation hours using an assumed facility utilization factor of 80%.

The changes in the per kWh material costs for thermal and nuclear power due to the surge in resource prices were estimated by applying the abovementioned method to the differences in the actual material prices between 2003 and 2008. The change in the per kWh fuel cost for thermal power due to the fuel price surges was estimated by multiplying the per kWh fuel input by the difference in the actual fuel price between 2003 and 2008.

The change in the fuel cost for nuclear power due to the fuel price surges was estimated from the effect of the natural uranium price to the change in the fuel price (including the back-end costs) and the difference in the actual natural uranium price between 2003 and 2008 referred from Nagano (2008)[15)].

The per kW material cost for wind power and PV were calculated by multiplying the per kW inputs of the individual materials by the respective material prices and summing up all of them. The kWh unit material cost of wind power was estimated by multiplying the per kW material cost by the annual overhead expense rate of 5.0% that had been calculated assuming a service life and discount rate of 30 years and 3%, respectively, and dividing the product by the annual power generation hours using an assumed facility utilization factor of 20%. Using the same methodology, the kWh unit material cost of solar PV was estimated by multiplying the per kW material cost by the annual overhead expense rate of 6.5% that had been calculated assuming a service life and discount rate of 20 years and 3%, respectively, and dividing the product by the annual power generation hours using an assumed facility utilization factor of 12%.

The change in the per kWh material costs for wind power and PV due to the surge in resource prices were estimated by applying the difference in the actual material price between 2003 and 2008 as in the abovementioned method.

4. Results: Effects of the Resource Price Surges on the Power Generation Costs

Fig. 2 shows the contribution of the increase in fuel, parts and material prices to the per kWh power generation cost increase between 2003 and 2008 for the different power sources. It is clear from these results that the surge in resource prices between 2003 and 2008 affected not only thermal power, for which the fuel cost had soared, but also wind and PV, for which the input material cost has sharply risen.

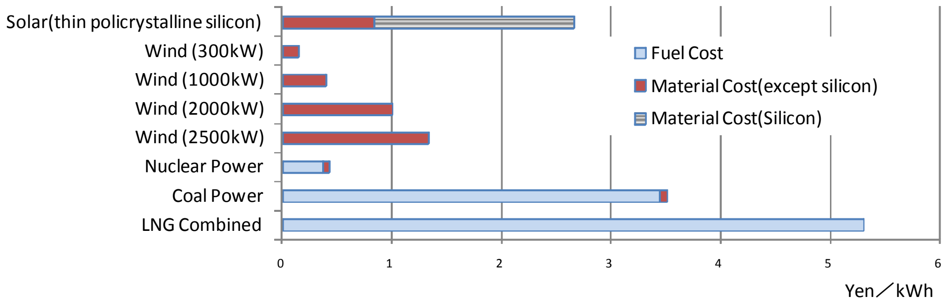

Fig. 2 Increase of the Per kWh Power Generation Cost (Yen) from 2003 to 2008 due to the Effect of Fuel/Parts/Material Price Surge

The per kWh price changes for cement and steel used to construct nuclear and thermal power plants are very small: 0.04 yen for nuclear power plants, 0.05 yen for coal-fired thermal power plants, 0.03 yen for oil-fired thermal power plants and 0.02 yen for LNG-based thermal power plants. Therefore, in practice, only the fuel price changes need to be considered for nuclear and thermal power.

On the other hand, PV was significantly affected not only by the increase in silicon price but also by the increase in the prices of copper, ethylene and aluminum. Although this result is for thin-type polycrystalline silicon photovoltaic cells, which is produced with smaller silicon inputs, the combined contribution of the material cost and silicon price to the increase in the power generation cost for PV is as high as 2.7 yen per kWh. This figure is not necessarily small compared with the increase in the power generation cost by 3.5 yen due to the increase in fuel and material prices for coal-fired thermal power plants. In contrast, impact on the power generation cost for nuclear power plants is as small as 0.43 yen in spite of the increase in uranium price.

With regard to wind power, the larger the scale of the plant, the bigger the unit material cost increase caused by the material price increase. As we have seen in fig.1, building the large scale wind power plant requires much amount of material input.

5. Conclusions

Attempts have been made to increase the use of renewable energy as a means of preventing global warming. In addition, as a result of the fossil fuel price surge since 2000, attention is focused on renewable energy in order to ensure energy security by stabilizing energy prices.

If only fossil fuels and nuclear fuels become scarcer and their prices significantly rise in the future, renewable energy such as wind power and PV may become more competitive than nuclear and thermal power. However, the history of price changes shows that price fluctuations are likely to occur simultaneously for a wide range of resources rather than for only certain resources. Against possible future resource price rises, in order to ensure energy security and the average economy of all power sources, it is necessary to look at not only the effects on fuel-intensive technologies, but also the effects on material-intensive technologies. The results of our analyses for the period from 2003 to 2008 show that the effect of resource price surges on the power generation cost for renewable energy is not small.

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