Study of Specific Work Process (D, E)

A study of specific work process was carried out observing the work of employees with the purpose of improving capability and achievements of an individual or a group.

On the basis of the work process scheme (Fig.1), literature sources [1; 2] and the work processes observed in the course of the pilot projects, a work measurement method has been elaborated, which is expressed by an algorithm (Fig. 2).

Summary

Work process study cannot be accomplished in a day or a week. It is a continued process carried out progressively improving work organization at each work place and in the company in general. The time and work put into the study process pays off with interest when it turns out that it is possible to complete more orders as compared with the period before the work study and making the improvements.

Likewise time measurement shall be introduced gradually in the company, summarising in the course of time the information on all the jobs performed at the company and determining a standard time for each. Introduction of standard times is related to changes in the work performed by the employee and its control.

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Analysis of the effectiveness of the FIT (Feed-in Tariff) mechanism

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Keywords: FIT (Feed-in Tariff) mechanism, renewable energy, power generation, effectiveness, electricity cost, a subsidy, "marginal cost" concept, coal-fired power generation

Abstract. In Japan, a policy mechanism called the "Feed-in Tariff (FIT)," which was designed to accelerate investment in renewable energy technologies, was introduced in July 2012. However, thus far, only solar power has been introduced, whereas other renewable energy options such as wind, geothermal or biomass have only made small progress; although, wind power, especially, has been found to have a very large potential for providing electricity in Japan. In addition, the price of electricity will essentially increase as a result of the FIT scheme. This indicates that the FIT may not always be a good option for accelerating the use of renewable energies. This study intends to analyze the effectiveness of the FIT mechanism in Japan and to propose another way to introduce renewable energies through the use of the concept of "marginal cost of power facility." The basic idea of this concept is that the financial resource of a subsidy for renewable energy is neither a tax nor an increase in the price of electricity, but is actually money saved on imported fossil fuels through the utilization of renewable energy.

Introduction

The feed-in tariff (FIT) is a program that guarantees the purchase of electricity generated from renewable energy sources, such as sunlight, wind, water and biomass, at fixed prices. Its aim is to accelerate the introduction of renewable energy by providing economic incentives for the installation and use of this technology, which is currently expensive. Feed-in tariffs are often referred to as an effective policy approach for promoting the introduction of renewable energy. By early 2014, renewable energy support policies were in place at the national or state/provincial level in 144 countries, 98 of which had adopted the FIT scheme [1]. It was often said that FIT laws had proven to be a very effective framework for developing renewable energies. However, there is firm criticism that the price of electricity will inevitably increase due to this scheme, such as in the case of Germany (as shown later).

In Japan, the price of electricity in the FIT scheme was set according to the kind of energy source [2]shown in Table 1. Since the general price of electricity in Japan is 10 to 14 Yen/kWh, the prices

Table 1 Price of electricity from various renewable energy sources set in the FIT scheme of Japan

[2014, Unit: Yen/kWh]

Source	size			Source	size	
	≧10 kW	< 10 kW			≧ 20 kW	< 20 kW
Solar	*32* (+tax, 20 years)	*37* (10 years)		*Wind*	*22* (+tax, 20 years)	*55* (+tax, 20 years)
Wind (sea)	*36* (+tax, 20 years, all sizes)					
	≧15000 kW	< 15000 kW				
Geothermal	*26* (+tax, 15 years)	*40* (15 years)				
	30000 kW> size ≧1000 kW	1000 kW> size ≧200 kW	< 200 kW			
Hydro	*24* (+tax, 20 years)	*29* (+tax, 20 years)	*34* (+tax, 20 years)			
Biomass *	*13～39* (+tax, 20 year)					

*The value varies depending on the type of biomass.

Note: 1US$≒100 Yen (2014)

in the FIT scheme are about two or three times higher than the usual rate. This case is not an exceptional one because the purpose of the FIT scheme is to encourage a broader use of expensive renewable energies, which are stated above. Thus, the price of electricity will inevitably increase as a result of the widespread application of the FIT mechanism.

Current situation of the introduction of renewable energies in Japan

The current situation of renewable energies in Japan is shown in Table 2, according to data from the Japanese government (the Agency for Natural Resources and Energy)[2].

Table 2 Introduced Power Capacity of Renewable Energies in Japan[2] [Unit : MW]

	Power Capacity			
	Before FIT introduction	After FIT introduction		α*1
Energy source	(~Jun. 2012)	(~Mar. 2013)	(~Feb. 2014)	[%]
Solar (housing)	4700	969	1221	86.6
Solar (non-housing)	900	704	5052	15.8
Wind	2800	63	15	7.8
Hydro	9600	2	4	2.3
Biomass	2300	30	90	9.0
Geothermal	500	1	0	7.7
Total	20800	1769	6382	19.8

Note) *1 : α = (in operation power capacity) / (authorized power capacity), Data at the end of Feb. 2014

It is evident from the Table that solar power alone (97.5%) was introduced by this mechanism, whereas hydro, wind, and biomass, which had occupied a large portion of renewable energies until the FIT was introduced, made only small progress afterward. In particular, the increase of non- housing solar is distinct, meaning that this scheme substantially promoted only the solar power business on a large scale. On the other hand, the introduction of hydro or geothermal was almost zero.

In addition, there is a large difference between the real operating capacity and the authorized one in documentation. Although only solar power in housing showed a normal rate of operation (α=86.6%), the values of α in other renewable energies were very small; the real operating non-housing solar power was 5760 MW whereas the authorized capacity was 36520 MW, i.e. the value of α is only 15.8 %, and the value of α in total is only about 20%. Why wasn't at least 80% of authorized capacity in real operation despite high electricity prices set by the FIT scheme? Several possible causes are; a large part of the power facilities after the introduction of FIT might be "dummy" ones, which could be used for commercial speculation, or investors might have hesitated to move into action due to heightened sense of uncertainty about the future of the FIT scheme, because the set prices were lowered annually in Japan, and the discussion about the need for an overhaul of the FIT mechanism was growing even in EU countries. Anyway, the data shown in Table 2 indicated that there are some structural defects in the design of institutional arrangements.

Real electricity supply capacity

One of the most important points to be considered is not power capacity [W] but real power generation [Wh], which can be estimated as the product of the power capacity and the "annual average rate of operation". The latter value can be calculated as a ratio of real power generation over the " ideal " one (=8760 hour continuous operation per year under rated operating condition).
The authors estimated this value as a national average by using reference data [3], for instance 10.4% for solar power, 25% for wind and 70% for geothermal and so on as a result. With these values, the possible annual power generation was estimated and shown in Table 3. Since the total amount of power generation, 8152 [GWh] in this table, was the value from July 2012 to Feb. 2014 (20 months), the estimated annual power generation should be 4891 [GWh], which was only 0.45 % of total domestic power generation in 2012 (1094 TWh). In addition, nuclear power generation in 2010 (before the Fukushima accident) was 288.2 [TWh], meaning that the value of 4891 [GWh]

Table 3 Estimated power generation from renewable energies by FIT in Japan [Unit : GWh]

Energy source	Power Capacity[MW]	A*1[%]	Power generation[GWh]	Composition rate[%]
Solar(housing)	2190	10	1995	24.5
Solar(non-housing)	5756	10	5244	64.3
Wind	78	25	171	2.1
Hydro	6	65	34	0.4
Biomass	120	67	702	8.6
Geothermal	1	70	6	0.07 *
Total	8151	-	8152	100.0

Note) *1 : A = "annual average rate of operation" estimated by the authors using reference data[3].
Data of the power capacity : at the end of Feb. 2014 (Table 2)

was only 1.7% of the nuclear power and that it will take about 59 years (=288.2/4.89) to replace nuclear power with renewable energies if the same progress situation is maintained (Total power generation data was obtained from the reference [4]). This fact indicates that the FIT scheme in Japan has not functioned effectively so far as either a promoter of renewable energies or as an introducer of alternatives to nuclear power.

Structural contradiction in the FIT mechanism

The most effective method to accelerate the FIT scheme would be to set much higher prices for renewable energies than present ones, but it will be very difficult because the present set prices are already as high as two to three times as expensive as the usual price. Assuming that the average price using FIT is 36 [Yen/kWh] and the normal one is 14 [Yen/kWh], the difference is compensated by raising the electricity price, resulting in a 0.107 (=(36-14) [Yen/kWh] × (4.89 [TWh]/1094[TWh])) [Yen/kWh] increase in the price under current conditions, but if the entire nuclear power sector was replaced by renewable energies through FIT, the rise in the electricity price would be 6.32 [Yen/kWh] (= 24×288.2/1094), or about 45% higher than the normal price. The wider spread of the FIT scheme will bring a higher price of electricity. Table 4 shows several examples of electricity prices from 1978 to 2011. It is clear that the Japanese electricity price, particularly for home use, is constantly high, although nuclear power (which was said to be very cheap) increased, and also the same price in Germany rose sharply after 2005 when the FIT mechanism spread widely (Italy has a different, complicated domestic situation). The Japanese electricity price will also go up if renewable energies increase under the FIT scheme as stated above. In addition, only solar power was introduced whereas other energy sources such as wind, small scale hydro or geothermal showed little, if any, progress as illustrated in Table 2. This indicates that the FIT mechanism has had little effectiveness as a promoter of various renewable energies, at least in Japan.

Table 4 Electricity prices in several countries [Unit : US cent/kWh]

	Industry					*Home*				
Year	Japan	U.S.	Germany	UK	Italy	Japan	U.S.	Germany	UK	Italy
1978	6.2	2.8	4.7	3.8	4.3	9.3	4.3	8.5	5.3	5.0
1980	10.0	4.3	5.7	6.3	6.5	11.7	5.4	10.0	8.9	7.7
1985	9.5	5.2	4.7	4.6	5.9	12.6	7.8	8.2	6.9	7.7
1990	12.2	4.8	9.1	6.8	9.8	17.7	7.9	16.4	11.8	15.7
1995	18.5	4.7	10.0	6.8	9.3	26.9	8.4	20.3	12.7	16.9
2000	14.3	4.6	4.1	5.5	8.9	21.4	8.2	12.1	10.7	13.5
2005	12.3	5.7	8.4	8.7	17.4	18.9	9.5	21.2	15.0	19.8
2010	15.4	6.8	13.6	12.1	25.8	23.2	11.6	*31.9*	18.3	26.3
2011	17.9	7.0	15.7	12.7	27.9	26.1	11.8	*35.2*	21.1	27.9

Data from IEA "Energy Prices and Taxes"

The new concept of "marginal cost of power facility"

The authors make a proposal about a new concept for the introduction of renewable energies without the FIT mechanism. The basic idea is that the financial resource of a subsidy for renewable energy is not a tax nor an increase in the price of electricity but money saved on the importation of fossil fuels by the utilization of renewable energy. This idea is expressed by the following equation:

$$T \text{ [Yen/kW-facility]} \leqq B \text{ [Yen/kW-facility]} + C \text{ [Yen/kW-facility]} \quad (1)$$

where T is the marginal cost of a power facility using renewable energy, B is profit from the electricity generated by the facility, and C is the official amount of money provided corresponding to the amount of money saved by reducing the importation of fossil fuels. The value of B can be calculated by the next equation:

$$B = H \text{ [kWh/year/kW-facility]} \times b \text{ [Yen/kWh]} \times Y \text{ [year]} \quad (2)$$

where H is the possible power generation shown in Table 3 (product of power capacity and the annual average rate of operation), b is a unit selling price of electricity, and Y is the depreciation period of the power facility. The value of b is usually the current power generation cost in electricity firms, but in the case of solar power in a home, this value can be a unit selling price of electricity in the home because the power producer is at the same time the consumer of the electricity. The value of C in Eq. (1) should be estimated as follows:

$$C = H' \text{ [kWh/kW-facility]} \times p \text{ [Yen/kWh]} \quad (3)$$

where H' is the total power generation during the depreciation period of the power facility, and p is the cost incurred for the importation of fossil fuels, which should be that of the CIF price of coal because coal is the most inexpensive. The concrete model case study is as follows: Solar power (home): Suppose that A=0.1, 15 year depreciation, $b = 24$, $H' = (1\text{kW}) \times (8760 \text{ h/yr}) \times (0.1) \times (15 \text{ yr}) = 13140$ [kWh/kW-facility], then B is 315360 [Yen/kW-facility]. It is assumed that the value of C is 91980[Yen/kW-facility] if the CIF price of coal is 7 [Yen/kWh]. Then, $T = B + C =$ 407340[Yen/kW-facility], meaning that if the power facility cost is lower than this value the introduction of solar power at home is feasible. But the real cost of a solar power facility at home is about 700000[Yen/kW-facility] requiring a serious cost reduction. On the other hand, in the case of wind, a similar calculation derives a result where T = 477000[Yen/kW-facility] even if p = 7 [Yen/kWh](coal CIF price) is used. Since the real cost of a wind power facility is 250000~300000 [Yen/kW-facility] (750~1300 kW size), a wind power plant could be feasible without the FIT mechanism.

Summary

This study revealed that the FIT mechanism has little effectiveness in accelerating the introduction of renewable energy technologies, at least in the country of Japan. The authors had sought another way to introduce renewable energies, and were eventually led to the concept of the "marginal cost of power facility". Now not only whether power generation using renewable energy is feasible can be judged, but also how much a power facility should cost can be estimated by this concept.

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Investigation of one macro-level model of distribution logistics

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Abstract. In this paper, we investigate the problem of optimal allocation of indivisible consumers in the presence of multinomenclature resource constraints of fuzzy nature: under the assumption that the restriction on the amount of multinomenclature resources consumed is not defined clearly. A mathematical model for one of the many possible formulations of the given problem is constructed from scratch; efficient approximation algorithm for solving the approximation model in the dual formulation is also elaborated.

Introduction

Distribution logistics, commonly referred to as (for instance, see [1], [2]) a set of interrelated technical, economic, financial, administrative and management operations carried out in the distribution of flow of some divisible and/or indivisible products between various divisible or indivisible consumers. Formulation of both tasks and the models of distribution logistics can be conditionally divided into two categories (for instance, see [1]-[3]): macro-level challenges and models, micro-level tasks and models. Among the macro level problems of distribution logistics there is a class of intractable problems, called distribution tasks with indivisible consumers, in which the variables are Boolean variables. Feature of these problems is that the effectiveness of the optimization combinatorial methods (for instance, see [4]-[6]), which are applied in solving them, decreases rapidly as with the increase in scale of the problem, as with the growing number of significant restrictions (even linear) in the form of inequalities and/or equations. Besides that, in many practical problems of distribution logistics with indivisible consumers, one has to deal with significant limitations, right side coefficients of which may not be specified clearly. Consequently, the use of combinatorial (or rather, partially exhaustive search) algorithms for solving such type of problems of distribution logistics is associated with the problem of impossibility to determine the exact values of some control parameters. The above features of the distribution problems with indivisible consumers lead to the formulation that takes into account the fuzziness of a number of significant limitations that define the set of feasible solutions. In this paper, we investigate the problem of optimal allocation of indivisible consumers in the presence of multinomenclature resource constraints of fuzzy nature: it is assumed that the restrictions on the amount of multinomenclature resources consumed are not defined clearly. In the distribution problem with indivisible consumers under study, variables are Boolean variables, which refer the given problem to the class of integer mathematical programming problems with fuzzy input data.