The 6th Keio-Tsinghua Students' Environmental Symposium

Considering the new energy target ～for cost effective CO2 reduction by new energy

Keio Univ. Faculty of economics
Yamaguchi Seminar

New Energy Group

Akio Tominaga

Eri Fujii

Kentaro Nara

Shino Sasagawa

Takehiro Hakoda

Introduction

Recently, the global warming is progressing. Japan has the obligation to reduce CO2 emissions 6% less than the amount of 1990 by average amount of 2008~2012. In order to prevent the global warming, it is necessary to restrain the use of fossil fuels. Therefore, new energy is being focused on. Switch from fossil fuels to new energy contributes to prevent global warming because of less CO2 emissions. However the share of “new energy” in primary energy supply is at most 1.2% because it is so expensive.

Under such situations, Japanese government set the amount of CO2 reduction target by new energy to 34million t-CO2.[1] In order to achieve this CO2 reduction target, new energy introduction target is to increase up to 19.1billion l (crude oil equivalent) in 2010.

However, we wonder if there is consistency between these two targets. Therefore, we calculate how much CO2 would be reduced if the new energy introduction target would be achieved. From this calculation and consideration, we found that the new energy target is not appropriate. We think that Japan had better set lower introduction target with taking cost into consideration. This is the conclusion of this paper.

In this paper, the definition and the necessities of new energy will described first, and introduction target and current situation second, and our trial calculation thirdly, and finally our proposal for introduction target will be described.

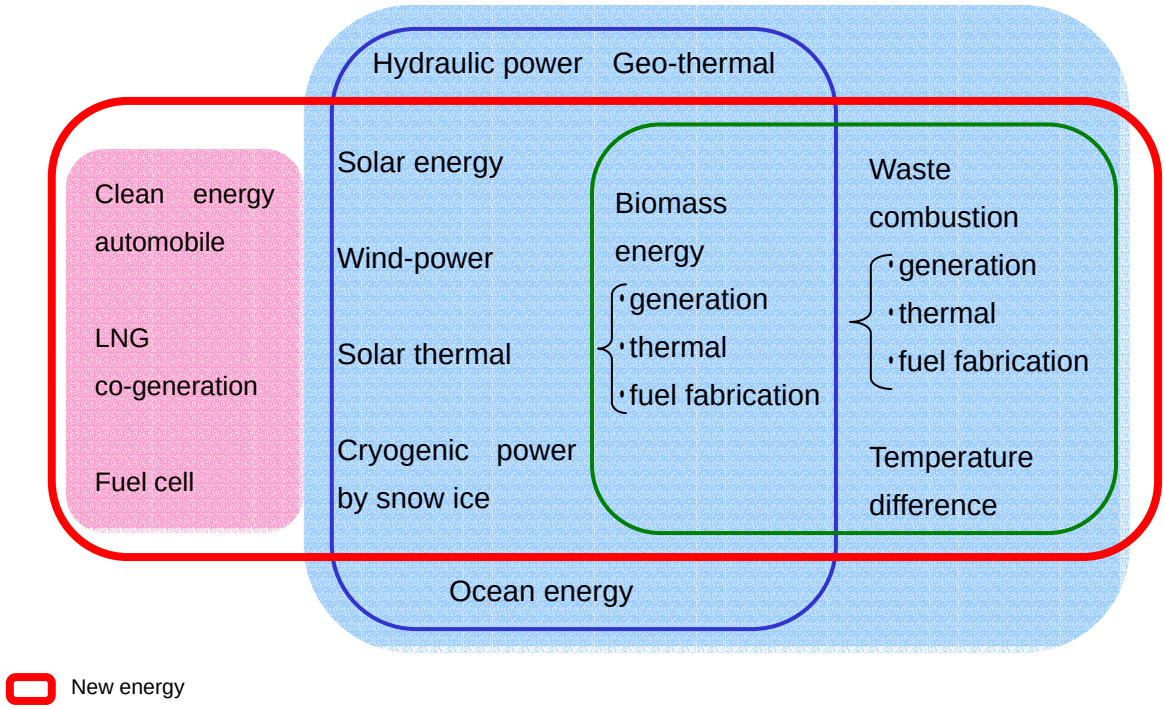
[1] annual amount

Chapter1 the current situation of new energy

1.1 What is new energy?

First of all, we will explain what new energy is[2]. According to the enforcement of "the new energy law" in 1997, new energy was defined that it is technically available, but not marketable, and also the alternative energy resource to oil. It should be noticed that new energy is not equal to renewable energy. As indicated in figure 1-1, renewable energy, such as hydraulic power, geo-thermal energy and ocean energy is not included in new energy, because hydraulic power and geo-thermal energy are marketable, and ocean energy is not technically available.

Figure 1-1 Categories of new energy and renewable energy



Made by author
based on the data by NEDO

[2] "New energy" is different from the target energy of RPS system.

There are 14 kinds of new energy:

① solar energy generation
② wind-power generation
③ solar thermal utilization
④ cryogenic power by snow ice
⑤ waste combustion energy generation
⑥ waste combustion energy thermal utilization
⑦ waste fuel fabrication
⑧ temperature difference energy
⑨ biomass energy generation
⑩ biomass energy thermal utilization
⑪ biomass fuel fabrication
⑫ clean energy automobile
⑬ LNG co-generation
⑭ fuel cell

The merits and demerits of “new energy” will be described. The merits are; it emits small amount of CO2, it is domestically produced, and that it is non-exhaustible energy. The demerits are; the instability of power because of its dependence on conditions of nature, low energy conversion efficiency, and high power cost.

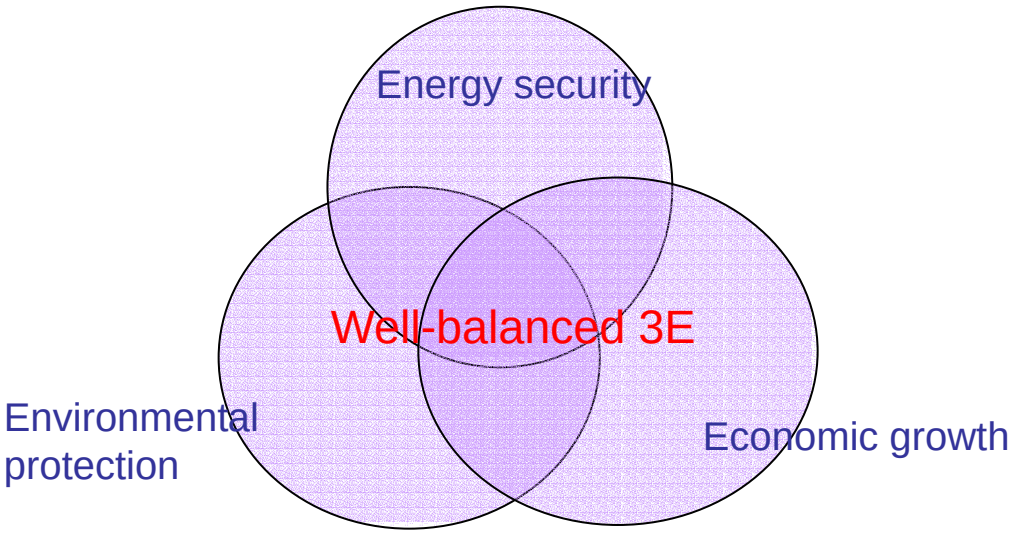
Next, we will explain the necessities of new energy.

1.2 The necessities of new energy

First of all, we will explain the energy policy in Japan. There are three targets of energy policy; energy security, environmental protection and economic growth (3E). Japan aims to well-balance 3E. Under this policy, Japan is going to introduce new energy more because it can contribute to 3E.

We will explain these targets in detail one by one in the following.

Figure1-2 image to accomplish three targets of energy policy



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based on the data by Agency for Natural Resources and Energy

1.2.1 Energy security

Japan has a problem about energy security. Most of the energy resources that are used in Japan are imported from foreign countries. The share of imported energy in domestic consumption is up to 80%[2], and the share of imported oil is up to 100%[3]. And the share of dependences to Middle East oil is 85%[2]. Considering the possibility of inflation in oil prices or stop of import from the Middle East, energy supply structure is very weak in Japan. Therefore, Japan must diversify the energy resources. Introducing new energy can contribute to energy security. This is why we focus on new energy because new energy such as wind power and solar energy is non-exhaustible, moreover it is domestically produced, and the alternative energy resource to oil. Therefore, we consider that new energy resources are indispensable for the energy security.

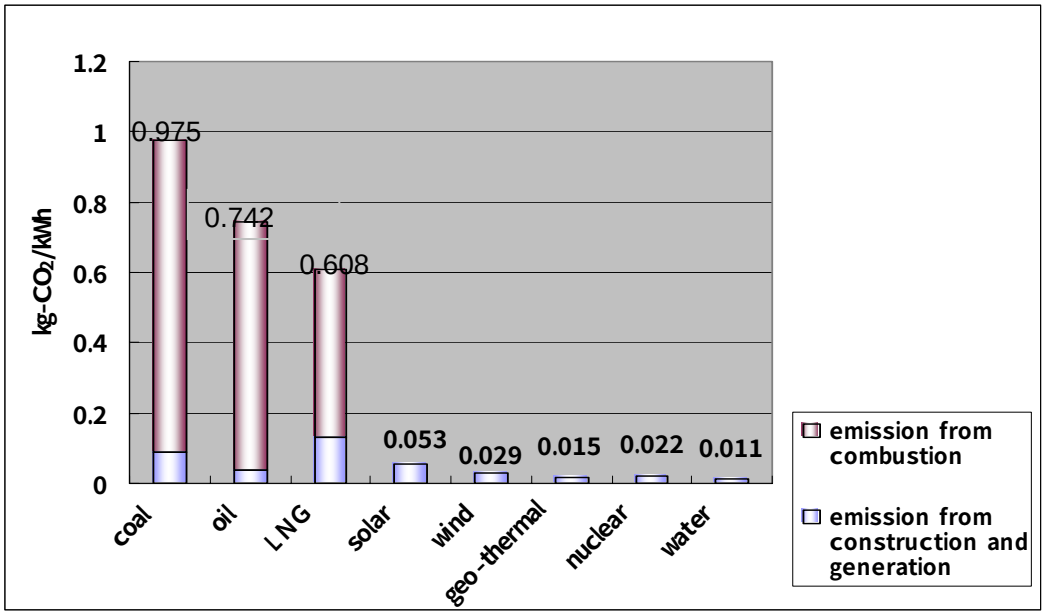
1.2.2 Environmental protection

Secondly, we will explain that new energy can contribute to environmental protection. Recently, the global warming is progressing. Thus Japan has the obligation to reduce 6% of CO2 emission from 1990 level in Kyoto Protocol. In order to prevent the global

[3] From data by IEA(1999).

warming, the restraint of the use of fossil fuels will be necessary. Figure 1-3 shows the amount of CO2 emission of every energy resource. As indicated in this figure, the amount of CO2 emission of new energy such as solar energy and wind-power generation is less than that of fossil fuels such as coal, oil and LNG. Therefore, new energy can contribute to environmental protection.

Figure 1-3 the amount of CO2 emissions of every energy resource



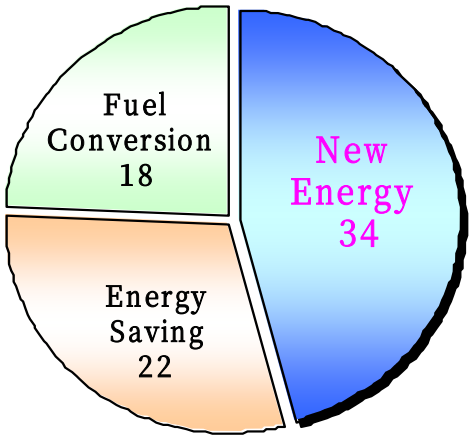
Made by author

based on the data by Central Research Institute of Electric Power Industry

Japanese government aims to reduce 74 million t-CO2 in energy sector to fulfill the obligation in the Global Warming Prevention Action Plan. Figure 1-4 shows the CO2 reduction target of each energy sector in this Action Plan. New energy is assigned 34 million t-CO2, therefore it is very important to accomplish Action Plan's target.

Figure 1-4 the CO2 reduction target of each energy sector

(unit: million t-CO2)



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based on the data by Ministry of the Environment

Next, we will explain the alternative energy of new energy. Figure 1-5 shows long-term energy supply and demand outlook. It should be noticed that the composition ratio of oil will be reduced on a large scale from 1999 to 2010. According to this figure, it is possible to alternate new energy for oil. But there is a theory that it alternates average of all power sources, so it is hard to say which energy new energy alternates for. But we take the possibility of alternative to oil considering the definition of new energy as indicated above.

Figure 1-5 long-term energy supply outlook

Year / Kinds of new energy	1999 (composition ratio)	2010(Target) (composition ratio)
Oil	52%	45%
Coal	17%	19%
Natural Gas	13%	14%
Nuclear	13%	15%
Water	4%	3%
New Energy	1%	3%

Made by author

based on data by long-term energy supply and demand outlook

1.2.3 Economic growth

Finally, new energy has a possibility of having competitiveness in future. If Japan promotes the measures to new energy from now, Japan will be able to lead other countries in this sector.

As we mentioned before, the cost of new energy is high, but with respect to this, new energy can contribute to economic growth in future.

Therefore new energy can contribute to 3E. Next, we will explain the target of introduction and the current situation in Japan.

Chapter 2 Introduction target and present situation

2.1 Amount of actual introduction achievement and target volumes

Chart 2-2 shows you the amount of actual introduction achievement of new energy in the year 1999 and target volumes in the year 2010 in Japan, and tells you that it expanded in a large amount in every fields. This target was set based on the premise that the amount of diffusion and introduction can be maximized4. It is envisioned to reduce 34 million t-CO_2 by attaining the target case of the year 2010 in chart 2-1, which is crude oil equivalent 19.1 million kl. This figure is incorporated into the outline of impulsion of provision against global warming.

Chart 2-1 amount of introductory actual achievement and target volume in new energy

	Actual result of **1999**		Prospect /target of **2010**			
			Case of keeping the current measure		**Target case**	
	Convert into oil	Capacity of plant	Convert into oil	Capacity of plant	Convert into oil	Capacity of plant
	10000kl	10000kW	10000kl	10000kW	10000kl	10000kW
Power generation field						
Solar energy	**5.3**	20.9	62	254	**118**	482
Wind power	**3.5**	8.3	32	78	**134**	300
Waste combustion	**115**	90	208	175	**552**	417
Biomass energy	**5.4**	8.0	13	16	**34**	33

[4] Refer to the distributed material of the second meeting of new energy subcommittee

	Actual result of **1999**		Prospect /target of **2010**			
			Case of keeping the current measure		**Target case**	
	Convert into oil	Capacity of plant	Convert into oil	Capacity of plant	Convert into oil	Capacity of plant
	10000kl	10000kW	10000kl	10000kW	10000kl	10000kW
Thermal utilization field						
Solar thermal	**98**	–	72	–	**439**	–
Unutilized energy	**4.1**	–	9.3	–	**58**	–
Waste combustion utilization	**4.4**	–	4.4	–	**14**	–
Biomass thermal utilization	–	–	–	–	**67**	–
Black liquor/scrap wood etc	**457**	–	479	–	**494**	–

Made by author
based on data by new energy subcommittee (2001)

However, because the cost of power generation is higher than other power sources, it hampers the introduction of new energy. Government has adopted policies such as a menu to buy surplus electricity and green electricity regime to promote new energy, but the cost of power generation[5] is higher[6] than other electric sources. For example, the cost of wind power, which is relatively inexpensive among new energy, is 10~24 yen/kWh[7]. Compared to that, the cost of nuclear energy is 5.9 yen/kWh, hydraulic power is 13.6 yen/kWh, oil-fired is 10.2 yen/kWh, liquid natural gas-fired is 6.4 yen/kWh, coal-fired is 6.5 yen/kWh[8]. As just

[5] The power generating cost is due to the following trial calculations. (installation cost × expenditure rate of year + the fuel expense during year +the drive expenditure during year) ÷ the amount of the power generation electric power during year. (kWh)
[6] It is a cause with a high power generating cost of new energy that the amount of the power generation electric power is low during year.
[7] 10~14 yen/kWh by large scale power generation, 18~24 yen/kWh by smaller scale power generation
[8] Refer to Trial calculation by Ministry of Economy, Trade and Industry(1999) The element summed up is

described, the high cost of power generation is the greatest challenge in the promotion of new energy.

Japanese government adopt RPS[9] legislation to strike a good balance between the achievement of the introduction target of new energy and economical efficiency in the field of power generation. From now on, we will give specific explanation of RPS legislation.

2.2 the current condition of the field of power generation

To attain the introductory target volume of new energy, a law on special measures on the use of new energy and so on by electrical power suppliers, officially RPS legislation, was proclaimed on 7 June 2002, and was totally enforced from 1 April 2003. RPS legislation is a law to enforce electrical power suppliers[10]to use more than a certain percentage of electricity generated by new energy and so on[11], in proportion to annual net sales of (system) energy. (law Article 4,5)

The aim is “to take measures with respect to the use of new energy by electrical power suppliers, and contribute to environmental protection and to the sound development of national economy, in order to help steady supply of energy.”[12] In light of the discussions at the new energy subcommittee（year 2002 October & November）, the utilization target in chart 2-2 was decided as a notice by Ministry of Economy on 27 January 2003.

Chart2-2 the utilization target of electricity of new energy and so on

year	‘03	‘04	‘05	‘06	‘07	‘08	‘09	‘10
Target-volumes（million kwh）	7320	7660	8000	8340	8670	9270	10330	12,200
Target-percentage[13]（%）	0.87	0.91	0.94	0.97	0.99	1.05	1.16	1.35

Made by author

based on data by Agency for Natural Resources and Energy, Electric use promotion room like new energy etc.（2003）

capital expense, drive maintenance expense, and fuel expense, etc.

[9] Renewable Portfolio Standards (future RPS)

[10] General electric utility(10 companies), Specially designated power supplier(5 companies) and Specific scale electric entrepreneur(10 companies), As of June 10, 2003

[11] It is the one that solar energy generation, wind-power generation, biomass, small and medium-sized hydro-power and geothermal power generation is converted and electricity was generated by the equipment recognition in the obtained electricity.

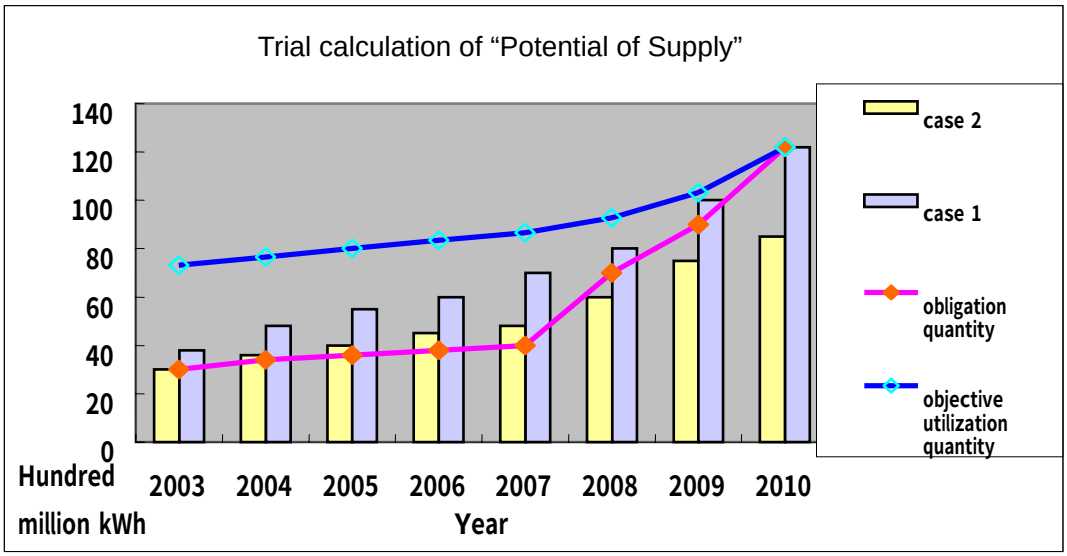
[12] Excerpt from Article 1 of RPS method

[13] Ratio to the previous year's of each fiscal year concerned amount of nationwide electric power expectancy sales of amount of target in each fiscal year. The ratio of targets is a final value in 2003 fiscal year.

At this moment, we refer to the basic idea of goal setting. 12.2 billion kwh, which is the sum of electricity generated by new energy（11.5 billion kwh）and electricity generated by medium to small hydraulic powers （700 million kwh）, is the target volume in the year 2010 among volume of generated output showed by Long-term Prospect of Supply and Demand of Energy and the report of new energy subcommittee. This numeric 11.5 billion kwh is consistent with Introductory target volume of power generation in target volume of new energy[14].

As you can see in chart 2-2, the target is to cover 12.2 billion kwh(1.35%)[15] by electricity of new energies by 2010, starting from 7320 million kwh(0.87%) in 2003. In the chart 2-3, target of annual use (which reaches) until the year 2010 is on a basis that all object actors are laid duties at a equal rate, It decides to set up target of new energy input on all parts of the country, based on an obligatory rate of the leading runner[16] of electrical power supplier, which is the highest rate of adoption of new energy at the present moment.

Chart 2-3　estimation of potential supply of new energy



Source: Yamaguchi seminar (2002) based on the 9th meeting of new energy subcommittee

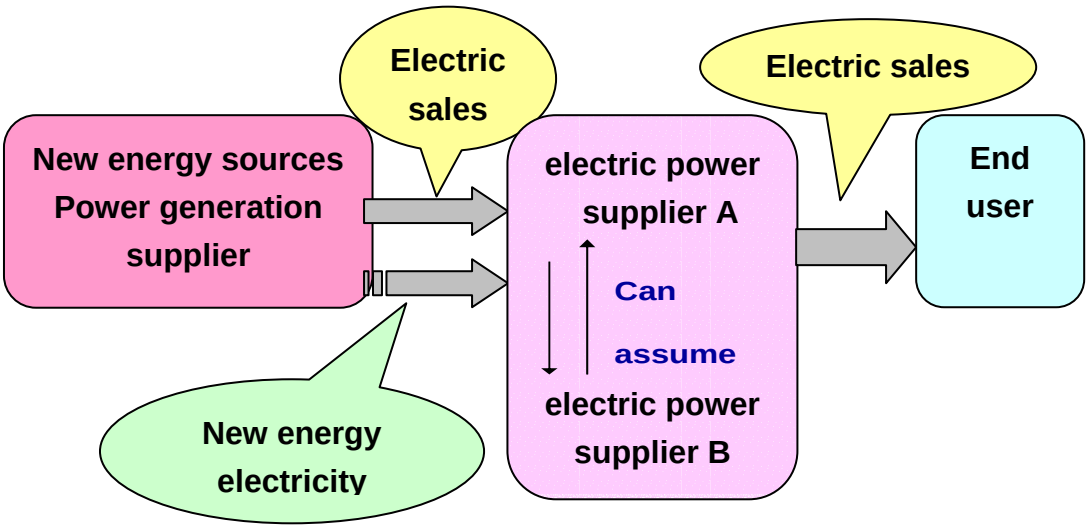
However, the following basic idea was accept with regard to obligatory volume. “At this

[14] Integrated resource energy investigation association, Integrated departmental meeting/ Supply and demand departmental meeting (2001)
[15] It differs from 3% of the target of the entire new energy because the target only of the power generation field.
[16] The leading runner is Hokkaido Electric Power Co., Inc., the ratio is at the time of March, 2003, and existing availability is 0.84%. Refer to Hokkaido Electric Power Co., Inc. homepage.

moment, there is a great deal of difference as to degree of utilization of electricity including new energy among electrical power suppliers who are obligated actors. If all electrical power suppliers throughout the country have to keep up with the obligatory average rate in line with those whose utilization of electricity including new energy already have gone on as planned, it would be very difficult for those who are still going behind in attaining the obligation. Therefore, even as electrical power suppliers are premised on attaining obligatory average rate across the board in 2010, it is appropriate to give a transitional measure on those who show low actual performance of utilization of electricity including new energy at the the beginning this of this regime, and to set practical obligatory average rate and amount of the obligation."[17] Transitional measure was adopted based on the idea like this. It is just downward-line in chart 2-3[18].

Next, we touch on duty. When the power supplier accomplishes their obligation, they are free to select from the following four options; 1.generate themselves, 2.purchase new energy from other power suppliers, 3.purchase "account" from new energy power generators, or 4.trade the amount of obligation with other power suppliers. Electrical power suppliers can select the most profitable ways by considering economical efficiency and other circumstances[19] (reference chart 2-4,2-5).

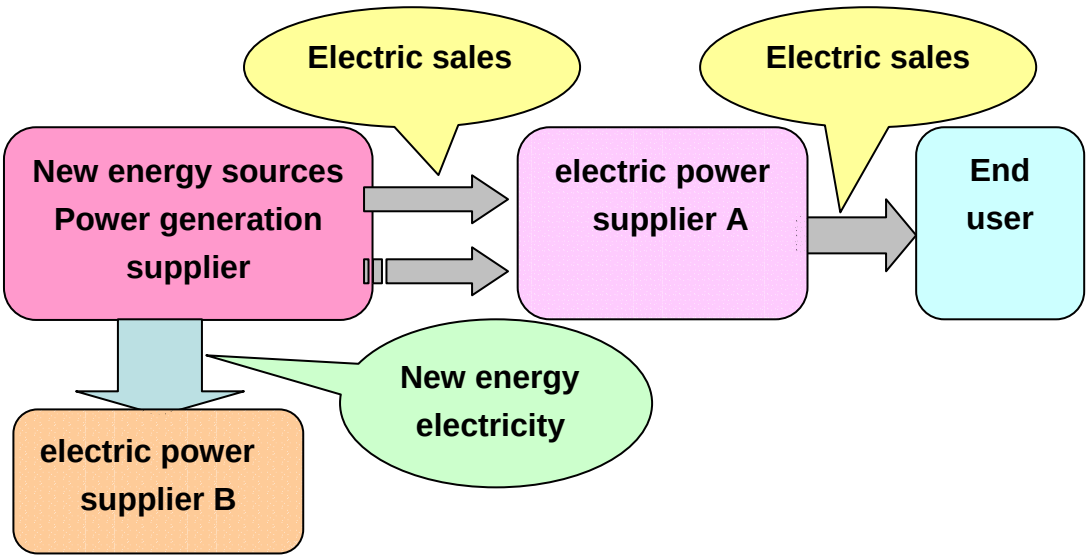
Chart 2-4 the image 1 of attaining obligation in RPS law



author made based on the 9th meeting of new energy subcommittee

[17] Refer to Article 3, 4 and 5 for the RPS method and the 8th report of new energy subcommittee(2001)
[18] Numerical values in each fiscal year are totals of ten general electric utility companies.
[19] Refer to Article 5 and 6 for the RPS method

chart 2-5 the image 2 of attaining obligation in RPS law



author made based on the 9th meeting of new energy subcommittee

Both electric sales and new energy electricity could be sold to the same supplier together as in chart 2-4, or to different supplier separately as in chart 2-5. The important merit here is that electric power suppliers do not only attain the obligated amount of new energy but also meet their obligation in minimum cost because they can select options by considering economical efficiency. In power generation field, it is expected that the target of introduction in 2010 is going to be attained cost-effectively, if the RPS law works properly.

2-3. the actual condition of thermal utilization field

On the other hand, below chart 2-6 shows the actual condition of thermal utilization field and the target of introduction.

Chart 2-6, the actual achievement of introduction in thermal utilization field and the target

Type of thermal utilization	Actual achievement of 1999	Actual achievement of 2001	Introduction target of 2010
Solar thermal utilization	98	82	439
Unutilized energy	4.1	4.4	58
waste combustion utilization	4.4	4.5	14
Biomass thermal utilization	―	―	67
Black liquor/scrap wood etc.	457	446	494
Total	563.5	536.9	1,072

Unit: crude oil equivalent (million kl)

author made based on Integrated resource energy investigation association(2001), Agency for Natural Resources and Energy(2003)

As you see and understand chart 2-6, total amount of thermal utilization field decreased from 1999 through 2001. This result from the fact that the demand of thermal utilization energy has decreased for the limitation of uses unlike electric power, and that their cost is still high, and so on. For this condition, in this point of the time, it will be difficult to attain the target in 2010. There is no such policy as RPS law in the power generation field, and a major policy of introduction is subsidy and PR active because as mentioned above, it is naturally also difficult to boost the demand of thermal utilization. And with regard to cost there is no policy which promotes cost reduction like RPS law. In consideration of these points, it is more difficult to attain the target of introduction in thermal utilization field in 2010 than in the power generation field.

Above, we mentioned the target of introduction of new energy and the actual condition toward achieving the goal. From the next chapter, we will mention CO2-reduction and how much cost it will take to attain the target of introduction.

Chapter 3 Our trial calculation

In this chapter, our trial calculation to know the consistency between new energy introduction target and CO2 reduction target will be described. Explanation for trial calculation by Keichi Yoshida(Tokyo Electric Power Co.) which was used as reference will be described first. And after that, our trial calculation will be described.

3.1 Trial calculation by Tokyo Electric Power Co.

Figure 3-1 shows result of trial calculation by Tokyo Electric Power Co.

Figure 3-1 trial calculation for amount of CO2 reduction
by eligible energy resources of RPS

	introduction target in 2010					carbon reduction from power generation field	carbon reduction from eligible energy sources of RPS
	billion l	billion w	electrical energy output (billion kwh)	volume of sales (billion kwh)	notice	(million t-C)	(million t-C)
solar power	1.18	4.82	5.1	1.6	utilized capacity 12%	0.41	0.13
residential		3.90	4.1	1.6	percentage of selling 40%	0.34	0.13
non-residential		0.92	1.0	0		0.08	0
wind power	1.34	3.00	5.8	5.0	utilized capacity 22%	0.47	0.41

large scale		2.64	5.1	4.6	percentage of selling 90%	0.42	0.37
smaller scale		0.36	0.7	0.5	percentage of selling 65%	0.06	0.04
waste combustion energy	5.52	4.17	23.7	4.6	utilized capacity 65%	1.94	0.38
general		2.07	11.8	4.6	percentage of selling 39%	0.96	0.38
industry		2.10	12.0	0		0.98	0
biomass energy	0.34	0.33	1.4	0.3	utilized capacity 50% percentage of selling 20%	0.12	0.02
total of new energy	8.38	12.32	36.0	11.5		2.95	0.94
hydro power				7			0.06
total				12.2			1

* carbon emissions from average of all energy sources is 0.082kg-C/kwh (target of 2010)

made by author, based on the data by The Institute of Energy Economics, Japan

As you can see in this figure, if the introduction of new energy reach the target, the amount of carbon reduction from power generation field will be 2.95million t-C, and carbon reduction from eligible energy sources of RPS will be 1million t-C. This converted to CO2, the result is 10.82million t-CO2(power generation field)and 3.67million t-CO2(eligible sources of RPS). Then, the calculation method will be described.

Two rows of data from the left side in figure 3-1 shows new energy introduction target (same number as figure 2-1).

And the right side row of new energy introduction target is “electrical energy output”, which was calculated by the equation below.

electrical energy output(kwh)
=capacity of plant(kw)×8,760hour(24×365hour)×utilized capacity

For example, in the case of solar power, capacity of plant is 4.82milion kw ×8,760× utilized capacity0.12=5.06678billion kwh. As well as this case, electrical energy output of other energy source was calculated. Utilized capacity of energy sources are shown in data row of notice.

The data row “volume of sales” was calculated by this formula: electrical energy output ×percentage of selling. The reason he calculated volume of sales was that eligible energy of RPS is the energy which was sold. Consequently, to know carbon reduction from eligible energy sources of RPS, he had to calculate “volume of sales”. Percentages of selling are shown in data row of notice.

The data row “amount of carbon reduction” was calculated by this formula: “electrical energy output” or “volume of sales” ×carbon emissions from average of all energy sources which is written on the bottom of figure 3-1.

The result is that carbon reduction from power generation field will be 2.95million t-C, and carbon reduction from eligible energy sources of RPS will be 1million t-C. Converted into CO2, the result is 10.82million t-CO2(power generation field)and 3.67million t-CO2(eligible sources of RPS).

In the next page, our trial calculation, which changed assumption of this calculation, will be described.

3.2 Our trial calculation

Up until now, we explained the trial calculation of CO2 reduction by New energy which are calculated by Tokyo Electric Power Co[20]. Now we want to improve this trial calculation and consider the New energy introduction target.

3.2.1 Considering the reduction target

As we explained in the 1st chapter, in the Action plan, government set the target to keep the CO2 emission of the energy sector at 2010 as the same level as 1990. To achieve this target, it is absolutely imperative to reduce 34million t-CO2 by new energy. (reference to chart 1-5)

In this case, can the new energy introduction target really come off the 34million t-CO2 reduction? To solve this question, we made a new trial calculation that improved by the T.E.P. model.

3.2.2 Assumptions of the trial calculation

Now we want to explain how we improved the T.E.P. model. (The key points are 4 point) There are four key points. Hereinafter, we will explain this 4 points.

① At T.E.P. model, they calculate the CO2 emission basic unit of Average of all power sources at 0.3kg-CO2/kwh. This is the targets of the electrical power suppliers in 2010. We changed this numeric to 0.419kg-CO2/kwh which is the CO2 emission basic unit in 1990, because, the baseline of the action plan is 1990.（Calculating at 1990's basic unit will be more pertinent.） It will be more pertinent to calculate at…

The CO2 emission of the "Average of all power sources"

0.3kg-CO2/kWh (2010) ⇒ 0.419kg-CO2/kwh (1990)

② (About) As to the energy alternated by the new energy, T.E.P. model is considering only the Average of all power sources, and calculated only that case. However, one of the New energy property is an alternative to Oil energy. Adding that, we can reaffirm this property by the "long-term energy supply-demand outlook[21]". (reference to chart

[20] hereinafter called " T.E.P. model "
[21] made by Ministry of Economy, Trade and Industry (2000)

1-6) From these reasons, we also considered the case of alternating Oil energy. And calculated the CO2 reduction at both cases.

Chart 3－2

The CO2 emission of each power sources

Power source	CO2 emission (kg-CO2/kwh)
Average of all power sources	0.419
Oil thermal power generation	0.742

Made by author, based on the data by Central research institute of electric power industry(2000)

③ At the T.E.P. model, they were not calculating the CO2 emission by New energy generation from its property. CO2 emission of New energy generation is very low but not 0. They discharge CO2 by running their equipment. So we consider this CO2 emission from each type of New energy and add in to the calculation.

Chart 3－3

The CO2 emission of each type of New energy generation

New energy generation	CO2 emission (kg-CO2/kwh)
Solar energy generation	0.053
Wind-power generation	0.029
Waste combustion energy generation	0.092
Biomass energy generation	0.092
Water power(small-scale)	0.011

Made by author, based on the data by Central research institute of electric power industry(2000)

④ At the T.E.P. model, they did not calculate the CO2 reduction by the thermal utilization field of New energy. We calculated this one also. In our trial calculation, we considered the coal oil and city gas (for) as the alternative energy of the thermal field and made a calculation with those CO2 emissions. This is coming from the “Report of New Energy Subcommittee”. In this report, they are considering this two energy (for) as competing energy of New energy thermal utilization field. Each CO2 emission is like chart 3-4.

Chart 3－4

(Each) CO2 emission of each alternative energy

Energy	CO2 emission(g-CO2/MJ)
Coal oil	68.5
City gas	58.6

Made by author, based on the data by Ministry of the Environment (2002) [22]

From next chapter, we will explain the detail about our trial calculation which (added in) include these 4 key points.

3.2.3 Detail of our trial calculation

（1）The amount of CO2 reduction by the power generation field

At first, we calculate the CO2 reduction of the power generation field.

If the New energy is alternative (for) to Oil thermal power generation(=Oil case), the calculation becomes like the following formula.

The amount of CO2 reduction by Oil case＝Generated electricity ×(CO2 emission of Oil thermal power generation－CO2 emission of New energy generation)

For example, when we calculate the Solar energy generation, it (become) comes out like this. The Generated electricity which we explained at 2nd chapter 5.1 billion kwh × （CO2 emission of Oil thermal power generation: 0.742kg-CO2/kwh － CO2 emission of Solar energy generation 0.053kg-CO2/kwh）＝3.52 million t -CO2. The amount of CO2 reduction of Solar energy (when it was the alternative of oil) 3.52 million t-CO2 was calculated by this process.

Next, we want to explain the case when New energy was the alternative (of) to All power sources. In this case we used the numeric of the average of all power sources.

The amount of CO2 reduction by All power sources case＝ Generated electricity × (CO2 emission of the Average of all power sources in '90 － CO2 emission of New energy generation)

[22] Ministry of he Environment (2002)

For example, (like) as in the oil case, Generated electricity 5.1 billion kwh×(CO2 emission of the Average of all power sources in '90 0.419kg-CO_2/kwh － Solar energy generation 0.053kg-CO_2/kwh）＝1.87 million t-CO_2 . From this calculation, the amount of CO2 reduction of Solar energy (when it was alternative of all power sources) 1.87 million t-CO2 is derived.

We calculated at all cases like this. The chart 3-5 is the result of our trial calculation.

Chart ３－５

The amount of CO2 reduction by the New energy power generation field

	Oil case (million t-CO_2)	All power sources case (million t-CO_2)
Solar energy generation	3.52	1.87
Wind-power generation	4.11	2.27
Waste combustion energy generation	15.40	7.74
Biomass energy generation	0.92	0.48
Total of power generation field	**23.95**	**12.36**

Made by author

（２）The amount of CO2 reduction by the thermal utilization field

Next, we explain about the calculation of the amount of CO2 reduction by the thermal utilization field. In thermal utilization field, we convert the New energy introduction target(KL) to calorie(J). The calculation is following.

Introduction target calorie converted (J)＝ Introduction target(KL)×Calorie of crude oil[23] (38.2MJ/l)

Let's convert the introduction target of Solar thermal utilization into calorie, for example. In fact, introduction target 43.9 million KL × calorie of crude oil 38.2MJ/l＝16.8 million J. 16.8 million J is the introduction target that is converted into calorie. Using this numeric, we calculated how much CO2 was discharged by coal oil and city gas in the same case. We consider it as the amount of CO2 reduced by the thermal utilization field.

Now, we will explain the calculation of coal oil case (the case when the thermal utilization

[23] Reference the Ministry of the Environment (2003)

field was the alternative of coal oil). Calculation becomes like the following.

The amount of CO2 reduction by coal oil case＝ the introduction target of thermal utilization field × the CO2 emission of burning coal oil

For example, if we calculate Solar thermal utilization, the introduction target of Solar thermal utilization would be: 16.8 million J × the CO2 emission of burning coal oil 68.5g-CO_2/MJ＝11.49 million t-CO_2, so the amount of CO2 reduction of Solar thermal utilization in coal oil case is 11.49 million t-CO2.

Next, we will explain the calculation of city gas case. (the case which the thermal utilization field is the alternative to city gas)

The amount of CO2 reduction of city gas case＝ the introduction target of thermal utilization field × the CO2 emission of burning city gas

Explaining as the coal oil case, the introduction target of Solar thermal utilization would be: 16.8 million J × the CO2 emission of burning city gas 51.3g-CO_2/MJ＝8.6 million t-CO_2, so the amount of CO2 reduction of Solar thermal utilization in city gas case is 8.6 million t-CO2.

We calculated all cases like this. The chart 3-6 is the result of our trial calculation on thermal utilization field.

Chart 3－6

The amount of CO2 reduction by the New energy thermal utilization field

	Coal oil case (million t-CO_2)	City gas case (million t-CO_2)
solar thermal utilization	11.49	8.60
Unutilized energy	1.52	1.14
waste combustion utilization	0.37	2.74
Biomass thermal utilization	1.76	1.31
Black liquor/scrap wood etc.	12.93	9.68
Total of the thermal utilization field	**28.07**	**23.47**

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（3）the amount of CO2 reduction by New energy as a whole

From these calculations, we can estimate the minimum value (all power sources case + city gas case) and the maximum value (oil case + coal oil case) of the amount of CO2 reduction by New energy as a whole. The result is in chart 3-7.

Chart３－７

the amount of CO2 reduction by New energy as a whole

	Maximal value (million t-CO_2)	Minimum value (million t-CO_2)
The power generation field	23.95	12.36
The thermal utilization field	28.07	23.47
The total of New energy	**52.02**	**35.83**

Made by author

From this trial calculation we can estimate that the amount of CO2 reduction by New energy as a whole would be 35.83 million t-CO2 for 52.02 million CO2. Considering this result, if the introduction target of New energy was achieved, we can come off the 34 million t-CO2 reduction that was set by the Action plan. Additionally, it belongs to the energy they alternate but there is a big possibility of reducing excessively.

From the next chapter we will calculate how much these CO2 reductions are and consider the improvements of the introduction target.

3.2.4 the trial calculation of costs

Next, we will think how much it costs when the carbon is continuously reduced by introducing new energy as our trial calculation.

First, we calculated the cost of new energy when electricity was generated as much as the amount of the introduction target. Its calculation is based on the introduction target in fiscal year 2010 which existed in the report of new energy subcommittee (2001) and the example of trial calculating of economical efficiency of the typical new energy. Next, the cost of the carbon reduction in each type of new energy will provisionally be calculated. The trial calculation method is described as follows.

Chart 3－8

The example of trial calculating of economical efficiency of the typical new energy

Kinds of new energy		Cost
Solar energy generation	Residential	Average：66 yen/kWh
	Non-residential	Average：73 yen/kWh
Wind-power generation	Large scale	10～14 yen/kWh
	Smaller scale	18～24 yen/kWh
Waste combustion energy generation (biomass energy generation is included[24])	industry	9～11 yen/kWh
	General	11～12 yen/kWh
Solar thermal utilization		28 yen/Mcal
Unutilized energy[25]		10 yen/MJ

Made by author

based on data by: report of new energy subcommittee（2001）

The total of power generating costs in the power generation field is derived from the following expressions. The amount of the new energy power generation that Tokyo Electric Power Company calculated (above mentioned) and the cost of power generation-a kWh in the example of trial calculating of economical efficiency of the typical new energy was multiplied.

The total of power generating costs＝the amount of new energy power generation×the cost of power generation-kWh

Taking the residential solar energy generation as an example, 270.6 billion yen is derived from 5.1 billion kWh (the amount of power generation) ×66 yen (the power generating cost-kWh). When other energy is similarly calculated, the result of the following diagrams is obtained.

As to solar power generation, the number was used from the division description for the residential and for non-residential, and the average was indicated at the new energy subcommittee report (2001). There was a wide gap between the outputs of a large scale and a smaller scale in the wind-power generation field, between industry and general in the

[24] The biomass power generation is summed up a part of the waste combustion energy generation in the report of new energy subcommittee (2001). Moreover, for the biomass, it was calculated by the maximum value of general in the waste combustion energy generation for the maximum cost and the minimum value of industrial in the waste combustion energy generation for minimum cost because the amount of power generation was not possible to distinguish industry and general.

[25] Temperature differential energy and waste combustion utilization

waste combustion field. So values which are the minimum output and the maximum output were used and calculated provisionally. It is separately described later for the thermal utilization field as the power generation field.

Chart 3－9

Trial calculation of power generation cost（unit: billion yen）

Kinds of new energy		Cost
Solar energy generation	Residential	270.6
	Non-residential	73
Wind-power generation	Large scale	51～71.4
	Smaller scale	12.6～16.8
Waste combustion energy generation	industry	108～132
	General	129.8～141.6
Biomass energy generation		12.6～16.8

Made by author

The cost of the reduction for each t-CO2 is understood by dividing these costs by the amount of the CO2 emission reduction in the power generation field that we previously did in the following expressions. The result is in the following diagrams.

The cost of the reduction for each t-CO2＝total cost of power generation÷the amount of the CO2 emission reduction

When taking the solar thermal generation at the oil substitution as an example, 97,614 yen (the cost of the reduction for each t-CO2) is derived from (270.6+73=)343.6 billion yen (the total power generating cost) ÷3,520thousand t-CO2 (CO2 exhaust reduction amount at the oil substitution). When other energy is calculated similarly, the result is obtained as in the following diagrams.

Chart 3－10

the cost of the reduction for each t-CO2

Kinds of new energy	Alternative for oil	Alternative for average of all power sources
Solar energy generation	97,614 yen	183,743 yen
Wind-power generation	15,474～21,460 yen	28,018～38,855 yen
Waste combustion energy generation	15,442～17,766 yen	30,724～35,349 yen
Biomass energy generation	13,696～18,261 yen	26,250～35,000 yen

Made by author

Next, we will explain trial calculation of the cost in the thermal utilization field. Firstly, the unit of the calorific value of the introduction target (crude oil conversion) in fiscal year 2010 which is written in new energy subcommittee report (2001) was converted into MJ from the idea that it was possible to use 100% of the heat generated by the thermal utilization equipment in the case of the thermal utilization field. Then these figures and the cost of thermal utilization per 1MJ[26] in the example of trial calculation of economical efficiency of the typical new energy of the value were multiplied. Accordingly, the cost in the case of the introduction target was accomplished was derived from the following expressions.

The total of thermal utilization cost＝the calorific value of the introduction target（MJ）×the cost of thermal utilization-MJ

Taking the solar thermal utilization as an example, 1,122.2 billion yen is derived from 4390 thousand kl (the amount of heat generation) ×28 yen (the thermal utilization cost-Mcal). Calculating unutilized energy is similarly, the result of the following diagrams is obtained. The same value as unutilized energy was used and calculated provisionally for the waste combustion utilization, the biomass thermal utilization, and the black liquor/scrap wood etc. The grounds are as shown in the following three points.

For the waste combustion utilization, the cost was provisionally calculated by using the value of unutilized energy because it calculated a part of unutilized energy in the example of trial calculating of economical efficiency of the typical new energy.

Moreover, for the biomass thermal utilization, it was calculated provisionally using the value of unutilized energy by assuming that as the same kind as the waste thermal

[26] For the solar heat utilization, the unit was converted into MJ because the cost for each Mkal had been described in the example of trial calculating of economical efficiency of the typical new energy.（28 yen/Mcal=6.692 yen/MJ from 1cal=4.184J）

utilization, because the biomass power generation was included in the waste combustion energy generation in the new energy subcommittee report (2001)[27]

In addition, for the black liquor/scrap wood etc., it was assumed that it was equal to the biomass thermal utilization, that is, it was equivalent to unutilized energy, because the new energy subcommittee report says "It is arranged as one of biomasses".

Chart 3－11

The total of thermal utilization cost（unit: billion yen）

Types of new energy	cost
Solar thermal utilization	1,122.2
Unutilized energy	221.6
Waste combustion utilization	53.5
Biomass thermal utilization	255.9
Black liquor/scrap wood etc.	1,887.1

Made by author

The cost of the reduction for each t-CO2 is understood from dividing these costs by the amount of the CO2 emission reduction in the thermal utilization field, which we previously did as well as in the power generation field. The following diagrams is the result.

Chart 3－12

The cost of the reduction for each t-CO2[28]

Kinds of new energy	Alternative to kerosene	Alternative to city gas
Solar thermal utilization	97,693 yen	130,448 yen
Unutilized energy	145,985 yen	194,932 yen
Waste combustion utilization	145,985 yen	194,932 yen
Biomass thermal utilization	145,985 yen	194,932 yen
Black liquor/scrap wood etc.	145,985 yen	194,932 yen

Made by author

In this chapter, the amount of the CO2 reduction of the new energy origin was provisionally calculated, and the cost of the reduction for each t-CO2 was derived. In the

[27] Waste and biomass were similarly treated because there were a lot of cases with the cogeneration.
[28] As shown in ahead, the costs of the reduction for each t-CO2 such as the waste combustion utilization, the biomass thermal utilization and the black liquor/scrap wood etc., these four values including unutilized energy, are same because the cost of each 1MJ thermal utilization costs are equal to the cost of unutilized energy-MJ.

next chapter, this trial calculation result is considered, and we will make our proposal.

Chapter4 consideration and proposal

We put together our trial calculation in the prior chapter as below.

First, we did a trial calculation of CO2-reduction in all of new energy and reaped the result of chart 3-7. when we consider this result, we think that about 3,400million CO２, which is the target amount of CO2-emmision reduction by new energy set up at Action Plan, can be attained if we estimate its reduction. This is in a case of the present target of introduction of new energy. When we consider of the definition of new energy, we think that alternative energy of power generation field can be most likely to be oil-fired, and we expect that it will exceed the target of reduction substantially in Action Plan.

Next, we made a trial calculation of the cost, in which CO2 was reduced according to our trial calculation by the introduction of new energy and reaped the result of chart 4-1.

Chart 4-1 the reduction cost/t-CO2

Kinds of new energy	Alternative to oil and kerosene	Alternative to all power sources and city gas
Solar energy generation	97,614 yen	183,743 yen
Wind-power generation	15,474～21,460 yen	28,018～38,855 yen
Waste combustion energy generation	15,442～17,766 yen	30,724～35,349 yen
Biomass energy generation	21,087 yen	40,417 yen
Solar thermal utilization	97,693 yen	130,448 yen
Thermal utilization except solar thermal[29]	145,985 yen	194,932 yen

Made by author

When you see the chart above, you could understand this: CO2 reduction cost/t-CO2 in new energy is varies much in response to its category. In particular, solar energy generation and all-around thermal utilization field takes much higher reduction cost/t-CO2 than wind-power generation, waste combustion energy generation, and biomass energy generation.

On the other hand, see the introduction target(chart 2-1). The target of waste combustion energy generation and biomass energy generation in 2010, in which its reduction cost is relatively modest, is set up about 5,6 times as large as that in 1990. In contrast, the target promotion of introduction of solar energy generation and unutilized energy, which reduction

[29] Because the cost of the reduction for each t-CO2 was equivalent, unused energy, the waste heat use, the biomass heat use, and the black liquor/scrap wood etc. were put together in one for convenience' sake.

cost is relatively modest, is about 23 times, 14 times respectively. The target of solar thermal utilization, which reduction cost relatively high, is 4 times and its average of (increasing) growth is low. Although there would be a decrease if the present action is maintained, the target to be 4 times is set.

We doubt whether this target is set considerate of the cost which is needed of CO2 reduction really. The reason is that the cost is significant issue posed to the introduction of new energy, as we mentioned above in chapter 1. The key to the diffusion of new energy is how is the introduction of new energy could be promoted while the cost is also kept down. Nevertheless, the data of the second meeting of new energy subcommittee says that “in premise of the introduction of the promotion of new energy, the target of the maximum introduction of new energy attainable by that promotion is drawn up into the scenario.” You can see that they do not consider of the view of the cost. It is hard not to feel that the feasibility is low, in such a target that lacks the view of cost which is the biggest issue that needs to be surmounted.

Now, it is certain that the introduction target of new energy needs to be substantial amount because the target of CO2 reduction of 34 million/t-CO2 by new energy is allocated by Action Plan. However, by our trial, we think that chances of are high if the present introduction target of new energy is attained. Its Chances are that more CO2 than allocate at Action Plan is reduced. Present introduction target of new energy is on the premise of maximum introduction in their fields, and assumes maximum introduction in the fields of solar power generation and thermal utilization which costs are high. As for power generation field, low cost the power source will be selected, and the introduction is done cost-effectively spontaneously when considering the effect of RPS law. By promoting the introduction of the power source which cost is low, we can anticipate that the amount of the introduction of all new energy increases and new energy cost decreases wholly. However in thermal utilization field, they assume to implement everything they could without taking such particular measures as RPS law, so we fear that it will not be implemented cost-effectively. We think we need to reconsider of the introduction target of new energy, which considers the effect of cost toward to attaining the 34million/t-CO2 reduction by new energy at Action Plan more, because we consider of the situation like this. For example, the target should be re-set so that they increase the introduction target of wind power generation, waste combustion energy generation and biomass energy generation which reduction costs are relatively low, meanwhile limiting the growth of that of solar energy generation, solar thermal utilization and unutilized energy, which costs are relatively high.

When we think about the introduction target of new energy, we essentially need to consider

such varied problem as the capacity of technical innovation in new energy and the demand of new energy. However, as an example, we took only the view of cost into consideration and reviewed actual introduction target. When they try to attain 34million/t-CO2 reduction by minimum cost, we did a trial about how much cost was cut down in comparison to the present introduction target.

We will explain the method of this trial below. We calculated how much cost was reduced when energy with a high cost was sequentially subtracted from the amount to exceed the target 34,000,000t-CO2 in the maximum reduction amount case 52,020,000t-CO2[30] and the minimum reduction amount case 35,830,000t-CO2[31] (Refer to diagram 3-7), and it was assumed the reduction 34,000,000t-CO2 times.

For example, when we do a trial of a case of minimum reduction, excess reduction is 35.83 million-34 million, that is to say, 1.83million/t-CO2. They can attain 34 million/t-CO2 at the most cost effective way by reducing as much 1.83 million/t-CO2 as the introduction of thermal utilization except solar thermal utilization which cost is the highest. Chart 4-2 shows our trial above.

Chart 4-2 the amount of cost capable to reduce in the case of minimum reduction

	Amount of correction reduction	Reduction cost /t-CO2	Total reduction cost
Amount of reduction by our trial calculation・・・ 35,830 thousand t-CO2			
Thermal utilization except solar thermal	－1830 thousand t-CO2	194,932 yen	356.7 billion yen
Total	**－1830 thousand t-CO2**		**356.7 billion yen**

Made by author

Excessive cost is 5.202 million-3.4million, that is to say, 1.802 million/t-CO2 in the case of maximum reduction. When we allocate this in turn to high cost, they can attain 3.4 million/t-CO2 at the lowest price by reducing the introduction of both 1.656 million/t-CO2 which is all of the reduction in utilization field except solar thermal utilization and 1.46 million/t-CO2 which is a part of solar thermal utilization. Chart 4-3 below shows this our trial.

[30] Power generation field: Oil substitution, heat use field: Case with kerosene substitution

[31] Power generation field: All power supply substitution, heat use field: Case with city gas substitution

Chart 4-3 the cost is capable of the reduction in the case of maximum reduction

	Amount of correction reduction	Reduction cost /t-CO2	Total reduction cost
Amount of reduction by our trial calculation・・・ 52.02 million t-CO2			
Thermal utilization except solar thermal	－16.56 million t-CO2	145,985 yen	2,417.5 billion yen
Solar thermal utilization	－1.46 million t-CO2	97,693 yen	142.6 billion yen
Total	**－18.02 million t-CO2**		**2,560.1 billion yen**

Made by author

As shown above, when we review the introduction target focusing only on the view of the cost, we find that they can reduce about 356.7 billion yen to 2560 billion yen of CO2 reduction cost. Of course, this is an extreme case that we do not take into any consideration except for the viewpoint of cost. However, from our trial above, we think that they can reduce substantial cost of CO2 reduction by new energy when they recheck the introduction target of new energy which considers the view of cost. As we reflect this, we think that they need to reconsider the introduction target of new energy, considering the viewpoint of the cost more toward attaining 34 million CO2 reduction by new energy, which is the target set in the Action Plan.

Special Thanks

•The Institute of Energy Economics, Japan　Mr. Tsutomu Toichi

•The Institute of Energy Economics, Japan　Mr. Shinichi Nakakuki

•Agency for Natural Resources and Energy, Energy Conservation and Renewable Energy Department　Ms. Keiko Ogata

•Agency for Natural Resources and Energy, Energy Conservation and Renewable Energy Department　Mr. Yasuhiro Nagami

•Agency for Natural Resources and Energy,Energy Conservation and Renewable Energy Department　Ms. Eri Nakajima

Internet Resources

•Ministry of Environment http://www.env.go.jp/index.html

•Ministry of economy, trade and industry http://www.meti.go.jp/

•New Energy Foundation　http://www.nef.or.jp/

•Central Research Institute of Electric Power Industry　http://criepi.denken.or.jp/jpn/

•The Institute of Energy Economics, Japan http://eneken.ieej.or.jp/

•Agency for Natural Resources and Energy http://www.enecho.meti.go.jp/

•Green Energy “law” Network http://www.jca.apc.org/~gen/

•New Energy and Industrial Technology Development Organization （NEDO） http://www.nedo.go.jp/

•The Federation of Electric Power Companies of Japan http://www.fepc.or.jp/index-f.html

•Japan Natural Energy Company Limited http://www.natural-e.co.jp/

•Hokkaido Electric Power Co.,Inc.　http://www.hepco.co.jp/

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