Estimation of SNF Amount from Various Scenarios of Power Consumption Prediction in South Korea – 15394

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ABSTRACT

The Korean government is reviewing the methodology for every condition such as treatment, storage, disposal for the management of spent fuel. In order to establish the control policy of spent fuel, it is necessary to predict how much spent fuel is produced as the time changes.

In this thesis the spent fuel production amount was predicted with the basis of the forecast number of the nuclear power plant. Until 2024 the construction plan was applied and until 2035 the number was predicted considering the ratio of nuclear power production. From 2035 to 2100, long term assessment was done assuming the energy consumption in different cases to calculate the necessary power production and then the amount was applied to the of the current power plant production rate to calculate the power production amount by nuclear power plant and the number of necessary nuclear power plants.

As the estimated number of the operated power plants of each year and period is correlated with the nuclear power production amount, the main factors of the assessment were spent fuel production amount, the number of operated nuclear power plant, power consumption amount, power production amount, and the proportion of the nuclear power plant to assess.

In long-term view the spent fuel production amount differed highly depending on the different conditions so it’s thought to be necessary to establish policies after predicting the spent fuel production amount by every case for the management plan of spent fuel.

(This is just individual study, Never government study)

INTRODUCTION

Korean government has suggested nuclear power plant operation plans and number of nuclear power plants until 2024 at the 6th Power Supply Plan in 2013, and the same was suggested considering the power production ratio of nuclear power plants of the whole power production until 2035 at the 2nd Energy Basic Plans in 2014. Therefore the number of the nuclear plants until 2024 is fixed and the number of the nuclear plants until 2035 can be predicted. The management of spent fuel is important in short-term but it is more important to plan it in long-term. Therefore it is necessary to assess the production amount of spent fuel and nuclear power plant operation until 2024 or 2035 but what is more important is the assess until 2050 or 2100 although considering the uncertainty.

It is hard to determine the long-term power consumption amount because it is affected by different factors. However the short and mid-term power supply prediction and construction plan of the nuclear power plants are done by the government energy policies so it is carried on according to the plan as long as there isn't a big social issue. Korean government is announcing the supreme plan-Energy Basic Plan- and lower plan-Power Supply Plan- for the establishment and suggestion of the power consumption and production and nuclear power plant construction. In this thesis, for the proposal of the short and mid-term power supply plan, the outline of 2nd Energy Basic Plan and 6th Power Supply Plan is introduced. Also, for the assessment of the period after the plan, the energy consumption was predicted and therefore bring out power production amount as in a whole and power production amount produced by the nuclear power plants.

THE OUTLINE OF 6TH ELECTRIC POWER SUPPLY BASIC PLAN (announced in 2013)

The 6th power supply plan was announced in applying the 1st power supply plan announced in 2008. In this plan the power consumption and production from 2013 to 2027 was predicted and suggested the power plant construction plan.
The outline of the power consumption amount is as the following table.

Table 1. Forecast of Electric Power consumption and Maximum Electric Power

	Electric Power Consumption (GWh)	Maximum Electric Power (MW)	
		Summer	Winter
2015	526,356	83,532	84,658
2016	547,794	86,919	86,499
2017	569,141	91,031	89,694
2018	590,257	94,694	92,699
2019	610,823	98,621	96,243
2020	630,964	102,205	100,809
2021	651,845	105,852	104,714
2022	672,544	109,476	108,528
2023	693,056	113,065	111,913
2024	713,310	116,602	114,442
2025	733,060	120,078	116,982
2026	752,364	123,450	119,345
2027	771,007	126,740	121,684

'13~'27 Annual Increasing Rate	3.4 %	3.4 %	3.0 %

It predicted that 3.4% of the power supply will increase daily until 2027 and in order to replenish the deficient power production amount the construction of the new power plant was suggested. Therefore in total of 34 unit of nuclear power plant will be operated by 2024 including the currently operating nuclear power plant.

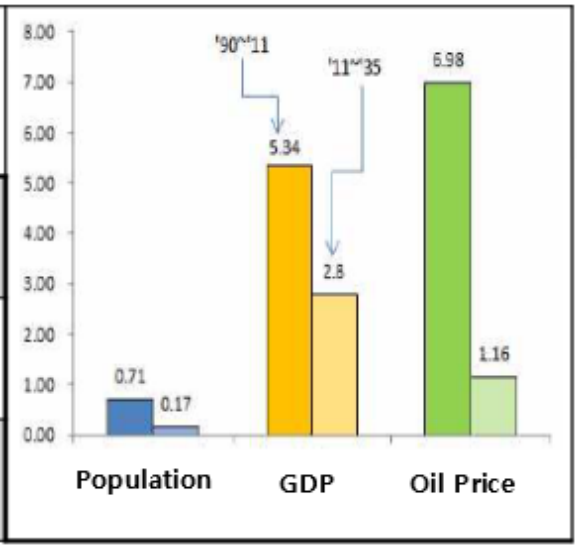
THE OUTLINE OF THE 2ND ENERGY BASIC PLAN (announced in 2014)

The Energy Basic Plan doesn't provide the results of the detailed plan and it only provides the prediction of energy in mid-term view and the plan in a big view. The 2nd Energy Basic Plan predicts the energy consumption until 2035 and provides the basic power plan to satisfy the necessary additional power supply. The prediction until 2035 was suggested by analyzing the economic growth, population, international oil price, and industry constitution.

- Economic growth rate: An average of 2.80% yearly from 2011 to 2035
- Population and household: In case of population an average of 0.17% yearly (decrease after 30 years) and in case of household an average of 0.96% yearly
- International oil price: An average of 1.2% yearly and expects to reach $140 by 2035
- Industry constitution: The growth of high-energy-consuming industry will fall down and fabricated metal (machinery, car, ship, telecommunication, semiconductor) industry will lead the economic growth

Table 2. Assumption

	2011	2035	Avg. Increasing rate per year (%)
GDP (trillion korea won)	1,082	2,101	2.80
Population (million)	49.8	51.9	0.17
Oil Price (Dubai, USD/bbl)	106.0	139.8	1.16



The total energy is estimated to grow about an average of 1.3% yearly according to the

conditions above but the final energy is estimated to grow an average of 0.9% yearly due to the slow down of economic growth and population growth. The final energy was determined considering the consumption control policy such as establishing energy reduction goal by the government and the total energy production rate by the nuclear power plant was determined considering the proportion of nuclear power production.
The total facility amount of the nuclear power plant by 2035 is 43 GW.

Table 3. Resources Forecast (Total Energy)

(Unit: million toe)

	2011	2025	2030	2035	Annual Avg. Energy consumption Increasing rate (%)
Coal	83.6	100.2	107.7	112.4	1.24
Oil	105.1	111.0	107.1	101.5	0.15
Natural Gas	46.3	64.8	69.8	73.3	1.93
Water Power	1.7	1.7	1.9	2.0	0.70
Nuclear Power	32.3	59.6	65.3	70.0	3.28
New & Renewable, Others	6.6	16.8	18.0	18.8	4.44
Total	275.7	354.1	369.9	377.9	1.32

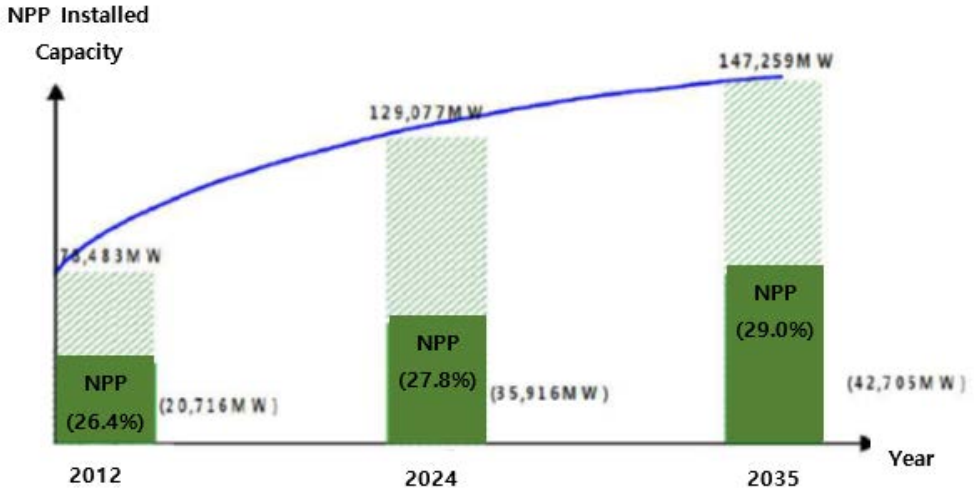


Figure 1. Forecast of Nuclear Power Plant Installed Capacity

THE PREDICTION OF ENERGY CONSUMPTION AND POWER PRODUCYION BY 2100

Even the 10 to 30 year short and mid-term prediction shows a great gap when the actual year comes. Therefore in fact it is actually impossible to accurately predict in a long-term period like 100 years. However although it's impossible to perfectly predict the actual number, it is able to assess in long-term trend separating the conditions into increase, decrease, or stable of energy consumption compared to now. Therefore in this assessment the increase is 1.3% increase yearly, the decrease is 0.8% increase yearly, and the stable is 1.0% increase. The total energy consumption until 2100 considering the facts above are shown in the following.

- Annual electric power increasing rate is 3 cases (0.8, 1.0, 1.3 % per year)
- Scenario of 2013~2035 is the same with published plan
- Portion of nuclear power plants is the same with 2035 until 2100 (around 29%)

By the upper assumption, result of energy consumption and NPP installed capacity are shown below.

Table 4. Total energy (million toe) by annual Avg. energy consumption increasing rate (%)

	Annual Avg. increasing rate (%)		
Year	0.8%	1.0%	1.3%
2040	393.3	397.2	403.1
2050	425.9	438.7	458.7
2060	461.2	484.6	521.9
2070	499.5	535.3	593.9
2080	540.9	591.3	675.8
2090	585.7	653.2	768.9
2100	634.3	721.5	875.0

Table 5. NPP installed capacity (MW) by annual Avg. energy consumption increasing rate (%)

	Annual Avg. increasing rate (%)		
Year	0.8%	1.0%	1.3%
2040	44,441	44,883	45,554
2050	48,127	49,579	51,835
2060	52,119	54,766	58,982
2070	56,441	60,496	67,114
2080	61,123	66,825	76,367
2090	66,193	73,817	86,896
2100	71,683	81,540	98,877

ADDITIONAL NUCLEAR POWER PLANT NEEDED UNTIL 2100 AND PREDITION OF SPENT FUEL PRODUCTION

In the analysis and assessment above the total number of nuclear power plant units was estimated with the basis of the plan and policy until 2035. With this fact the power consumption will be analyzed until 210 to estimate the necessary nuclear power plant need to be constructed and the yearly spent fuel and it is shown in the following.

It needs a few of assumptions about NPP operation condition to be calculate. Assumptions is below.

- New constructed nuclear power plant is APR 1500 type (1500Mwe)
- Designed life time of new nuclear power plant is 50 years
- Designed life time of operated NPP now is 30~40 years
- All of NPP will be operated and re-operated after finishing their designed life time until 2035
- All of NPP will be not operated after finishing their designed life time between 2036~2100
- No consideration of fourth generation type of nuclear power plant
- No consideration of reprocessing and any other treatments of spent fuel

By the conditions of upper assumptions, new nuclear power plant construction plan is below table..

Table 6. Units of operating NPP every decade by increasing rate

	Annual Avg. increasing rate (%)		
Year	0.8%	1.0%	1.3%
2014	23		
2024	34		
2035	39		
2040	40	40	41
2050	42	43	45
2060	45	46	49
2070	48	50	54
2080	51	54	60
2090	54	59	67
2100	58	64	74

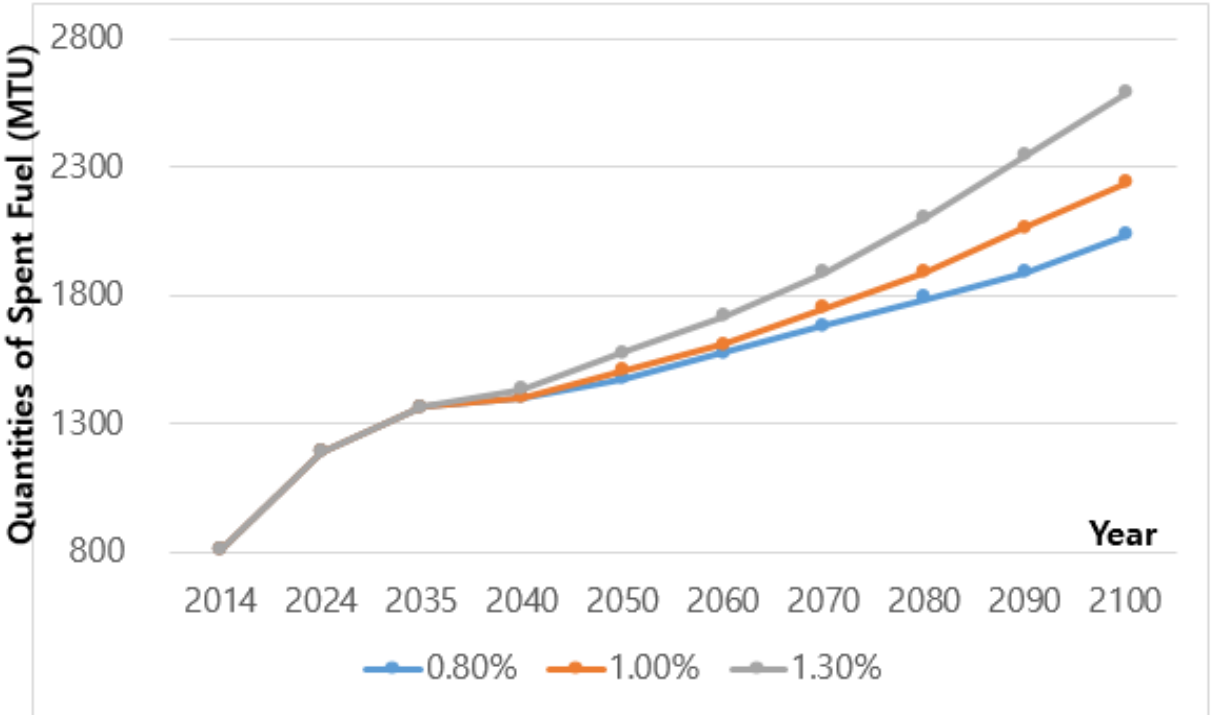


Figure 2. Quantities of Spent Fuel every decade by increasing rate

RESULT

In this thesis the outline of the energy and power plans of Korean government was introduced and predicted the power consumption until 2100. Also predicted necessary nuclear power plants and spent fuel production amount until 2100 considering the estimated power consumption. The results are simple, showing the increase proportional to the energy consumption increase but one fact is impressive, that the maximum is about 1.7 times bigger than the and the minimum in 2100.
The reason of this assessment is because it is important to not only assess considering the current situation but also carry a long-term assess as the storage and disposal facility of spent fuel will be constructed and operated in the far future.

The construction and operation of the spent fuel storage or disposal facility is not just a matter of technology but a complex business which needs a gathering of different opinion of the society. Therefore in order to proceed this type of plans it isn't easy in the early planning process but it is necessary to find a solution in the long-term to minimize the trouble when starting the business. Especially when determining construction and operation plan of the intermediate storage facility or permanent disposal facility the amount of spent fuel is closely related to the size of the construction territory and it is related to the facility size and location so it is necessary to accurately assess in long-term.

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