Modeling for Nuclear Energy for IoT Systems as Green Fuels in Mitigating COVID-19

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COVID-19 완화를 위한 녹색 연료로서 IoT 시스템용 원자력 에너지 모델링

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Abstract It is analyzed that the energy pattern is affected by the social matters of the disease trend where the energy consumption has been reduced following the depression of the national economy. The campaign of social distance for the people has been done by voluntary or legally due to the epidemic of the Coronavirus Disease 2019 (COVID-19). Some economic stimulus policies have been done in some countries including the United States, South Korea, and some others. It is shown the susceptible, infectious, and recovered (SIR) modeling applied by system dynamics (SD) where the logical modeling is constructed with S, I, and R. Especially, the I is connected with Society including Population, Race, and Maturity. In addition, Economy and Politics are connected to Income, GDP, Resources, President, Popularity, Ruling Government, and Leadership. The graph shows the big jump on 2020 April when is the starting month of the S value multiplication. This shows the effect of the COVID-19 and its related post-pandemic trend. The trends of OECD and non-OECD are very similar and the effect of the virus hazards causes significantly to the economic depressions.

Key Words : Energy, Consumptions, Dynamics, System, Pandemic

요 약 에너지 패턴은 국가 경제 침체에 따라 에너지 소비가 감소한 질병 트렌드의 사회 문제에 영향을 받는 것으로 분석됩니다. 사람들을 위한 사회적 거리 캠페인은 2019 년 코로나 바이러스 질병 (COVID-19)의 전염병으로 인해 자발적으로 또는 법적으로 수행되었습니다. 미국, 한국 등 일부 국가에서 일부 경제 부양 정책이 시행되었습니다. S, I, R 로 논리적 모델링이 구성되는 시스템 역학 (SD)에 의해 적용된 SIR (Sceptible, Infectious, Recovery) 모델링을 보여줍니다. 특히 I 는 인구, 인종, 성숙도를 포함한 사회와 연결되어 있습니다. 또한 경제 및 정치는 소득, GDP, 자원, 대통령, 인기, 통치 정부 및 리더십과 관련이 있습니다. 그래프는 S 값 곱셈이 시작되는 2020 년 4 월의 큰 도약을 보여줍니다. 이것은 COVID-19의 영향과 관련 유행병 이후 추세를 보여줍니다. OECD와 비 OECD의 경향은 매우 유사하며 바이러스 위험의 영향은 경제 침체를 크게 유발합니다.

주제어 : 에너지, 소비, 역학, 체계, 감염병

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1. Introduction

It is analyzed that the energy pattern is affected by the social matters of the disease trend where the epidemic behavior is significantly important to present the prospect. The energy consumption has been reduced following the depression of the national economy. The campaign of social distance for the people has been done by voluntary or legally due to the epidemic of the Coronavirus Disease 2019 (COVID-19) [1-3]. Even the self-isolation should be done for the high fever symptom persons. These kinds of the social enforcements have made the energy consumption decrease that results the energy price to be down. Some economic stimulus policies have been done in some countries including the United States, South Korea, and some others. In this work, the energy selections by the social modeling is performed in [Fig. 1] where the energy consumptions are affected by several usages including IOT stuff.

〈Table 1〉 shows the comparison of crude oil price in dollars per barrel [4]. There is an abrupt price-down in the crude oils of West Texas Intermediate (WTI) and Brent which are very representative oil products. In addition, there is the comparison of petroleum and other liquids in barrels per day in 〈Table 2〉 where the organization for economic cooperation and development (OECD) country is distinguished [4]. Since the value of the OECD countries are nearly similar in quantity to that of the non-OECD countries, 〈Table 2〉 is reasonable to be considered as the major energy of petroleum and other liquids. So, the energy distribution from 2018 to 2021 is in [Fig. 2] which shows the short-term energy outlook which was publishes in 2020 May [4].

One of simple algorithm for the diseases is the susceptible, infectious, and recovered model (SIR model) where there are several cases such as measles, mumps and rubella (MMR) that are usually

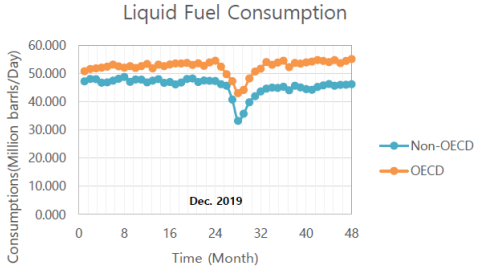
[Fig. 1] Energy selections by the social modeling

〈Table 1〉 Comparison of crude oil price in dollars per barrel [4]

Source	2019	2020	2021
WTI (West Texas Intermediate)	57.02	30.10	43.31
Brent	64.37	34.13	47.81

〈Table 2〉 Comparison of petroleum and other liquids in barrels per day [4]

Source	2019	2020	2021
OECD	47.36	42.27	45.37
Non-OECD	53.38	50.32	54.15



[Fig. 2] Short-term energy outlook [4]

treated by the vaccine. This is one of tractable mathematical equations to find out the solution [5-7]. In addition, the disease pandemic model is incorporated with the system dynamics (SD) modeling which has been used for analyses in the social as well technological matters. This was created by Dr. Jay Forrester in 1960s for the purposes of the industrial dynamics, civil dynamics, and so on. That is, the numeric modeling of SD could give the much more reliable modeling in the energy consumptions for the major energy source, liquid energy such as the oil. The are some previous energy related

study using SD where the nuclear energy is analyzed [8-10].

This kind of global disaster could happen in the local area such as the local war, chemical plant explosion with poisonous gas leak, or the other kind of the hazardous incident to the public. So, the dynamical analysis could be modeled for the prospect of progresses where the future situations can be described by the logical algorithm like the SIR model which is mentioned in above sentence. Although the case could be changed, the modeling is similar to this study.

2. Methods

2.1 *System dynamics (SD)*

For the modeling in this study, the characteristics of the disease population is associated with the random sampled algorithm, SD. Therefore, the comparison with SD applied modeling could give to the much more reliable solution in the outlook in the energy consumptions in the liquid type source.

According to description the SD by Radzicki, which is a powerful method and simulation modeling technique for understanding, discussing and framing the complex matters and problems [11,12]. So, it is possible to imagine for managers to improve their understanding, that is practicable in all kinds of policy and design areas. The basic block diagram could be expressed by the SD for how and why complex real-world systems behave the way they do during the specified time. SD can give numeric understanding in implement for much more effective policies. One of most important things in SD is to show dynamic behavior in system, in which the operator tries to identify the patterns of behavior exhibited by interested system variables, and then builds a model with the characteristics of patterns. For SD moldings, it is typical to use single and double arrow lines which are used for the designed purpose. The meaning of lines is the event and time flows. The dynamic behavior of a system is manipulated by the commercialized software including its key physical and information flows, stocks, and feedback structures for SD. Some particular characteristics of the SD are explained. Nonlinearity is that the large part of the SD modeling process includes the application of common sense to dynamic problems whose behaviors indicate a nonlinearity of the events. Usually, this system is seen as single and double arrow lines in the modeling. So, the arrow line shows the event flow without any restriction. Feedback menas that an event could be backward as well as forward following the event characteristics. The loops of feedback behavior are shown by the stocks and flows in real world systems. Feedback loops are often joined together by nonlinear couplings where any object often causes counterintuitive behavior. Stock-flow shows that the accumulation of event is indicated for raising the dynamic behavior, which means that all kinds of dynamic behaviors could be happened when flows accumulate in stocks. The informational and non-informational object can move through flows and accumulations in stocks. Time Paths is that the dynamic behavior of systems is quantified by the modeling, in which the operator tries to identify the patterns of behavior exhibited by interested system variables, and then builds a model with the characteristics of patterns. The SD has been used widely in the social as well as technological issues using the quantification where the subjective meaning could be clarified by the numeric values.

2.2 *Modeling*

First of all, the modeling is constructed by the simple differential equations where the birth and death of the virus could affect on the energy consumption following the economic behavior

depression by the economically active population. In the modeling, the dynamical consequences are described as follows [13],

$$\frac{dS}{dt} = -\frac{CIS}{N} \tag{1}$$

For the dynamics variations of I,

$$\frac{dI}{dt} = -\frac{CIS}{N} - KI \tag{2}$$

Also, for the dynamics variations of R,

$$\frac{dR}{dt} = TI \tag{3}$$

where S is the cumulated number of susceptible elements, I is the cumulated number of infected elements, R is the cumulated number of removed elements, and N is the summations of above elements. So, [14]

$$\frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} = 0 \tag{4}$$

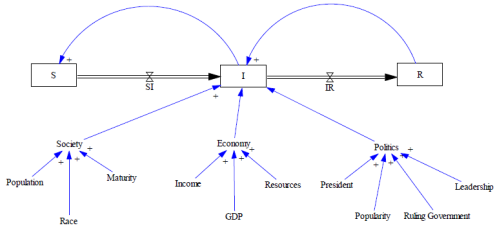
In addition,

$$S(t) + I(t) + R(t) = N = Total\ \ summations \tag{5}$$

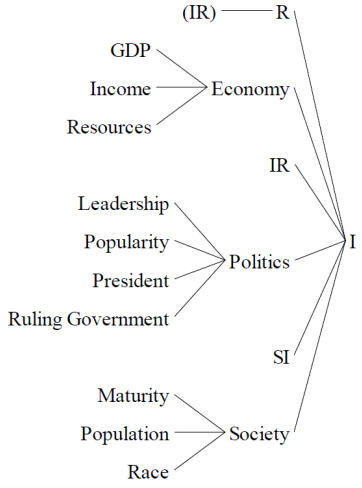
So, this is applied to the SD modeling to reflect the economic depressions where the software of SD is used of constructing the modeling with the event flows with arrow lines and block diagrams. The designed variables are inserted in the diagram and events are connected between the variables.

2.3 *Analysis*

[Fig. 3] shows the SIR modeling by SD where the logical modeling is constructed with S, I, and R. Especially, the I is connected with Society including Population, Race, and Maturity. In addition, Economy and Politics are connected to Income, GDP, Resources, President, Popularity, Ruling Government, and Leadership. For the connectivity, it is shown in [Fig. 4] which is the causal loop for SIR modeling. 〈Table 3〉 is the number of modeling variables. For example, in S, the value is obtained as 1/(-S + I - SI) with accumulated by repetitions. For the SI, the values are produced by random sampling with average of 0.5 and deviation of 0.341 between 0.1 and 1.0. Others are obtained in similar ways.



[Fig. 3] SIR modeling by system dynamics (SD)



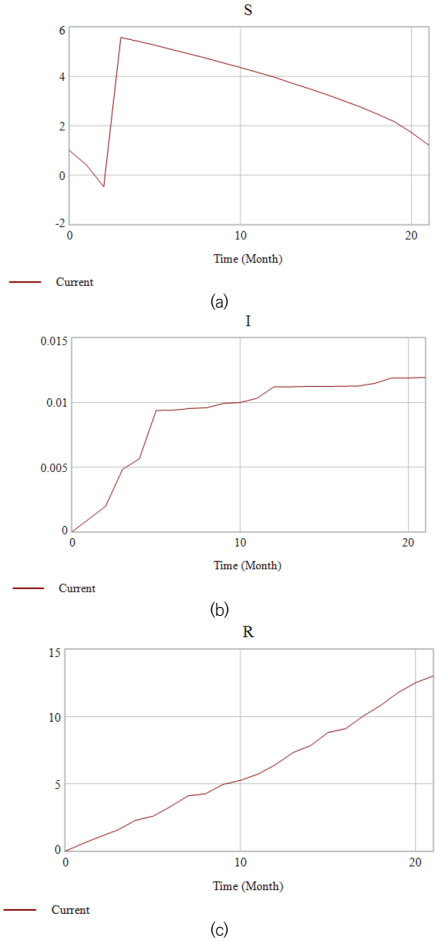
[Fig. 4] Causal loop for SIR modeling

〈Table 3〉 Number of modeling variables

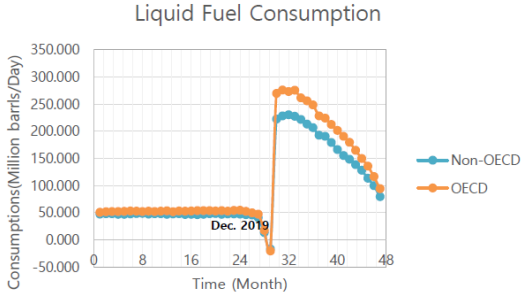
Variable	Number
S	Level: 1/(-S + I - SI)
I	Level: (1/(SI - IR + R - I)) * Economy * Politics * Society
R	Level: IR
SI	RANDOM normal(0.1, 1, 0.5, 0.5+0.341, 1000)
IR	RANDOM normal(0.1, 1, 0.3, 0.5+0.341, 1000)
Society	Maturity*Population*Race
Population	RANDOM normal(0.1, 1, 0.5, 0.5+0.341, 1000)
Race	RANDOM normal(0.1, 1, 0.5, 0.5+0.477, 1000)
Maturity	RANDOM normal(0.1, 1, 0.5, 0.5+0.477, 1000)
Economy	GDP*Income*Resources
Income	RANDOM normal(0.1, 1, 0.5, 0.5+0.498, 1000)
GDP	RANDOM normal(0.1, 1, 0.5, 0.5+0.477, 1000)
Resources	RANDOM normal(0.1, 1, 0.5, 0.5+0.341, 1000)
Politics	Leadership*Popularity*President*Ruling Government
President	RANDOM normal(0.1, 1, 0.5, 0.5+0.498, 1000)
Popularity	RANDOM normal(0.1, 1, 0.5, 0.5+0.477, 1000)
Ruling Government	RANDOM normal(0.1, 1, 0.5, 0.5+0.498, 1000)
Leadership	RANDOM normal(0.1, 1, 0.5, 0.5+0.477, 1000)

3. Results

[Fig. 5] shows the weighting number for removed elements by SIR modeling for S, I, and R where S is used for the newly modified short-term energy outlook in [Fig. 6]. The *Y*-axis shows the relative value obtained by the designed calculations. So, there are values are obtained the values in [Fig. 2] is multiplied by the S value. The graph shows the big jump on 2020 April when is the starting month of the S value multiplication. This shows the effect of the COVID-19 and its related post-pandemic trend. The trends of OECD and non-OECD are very similar and the effect of the virus hazards causes significantly to the economic depressions.



[Fig. 5] Weighting number for removed elements by SIR modeling (a) S, (b) I, and (c) R.



[Fig. 6] Newly modified short-term energy outlook

4. Conclusions

It has been performed for the liquid energy such as oil to make the modeling of the post-depressions by the global pandemic situations where the social and economic depressions are widespread. So, the relationship between the abruptly produced disease and the society has made the energy consumption decrease. The reason of the importance of energy consumption is that it can show the status of the energy outlook in a nation or the global sectors like the OECD and others [15]. It is shown of the importance of this study as follows,

- The SIR modeling is applied to global pandemic.
- Energy consumption trend is described by the applied SD modeling.
- The economic depression affects on the energy price and consumptions.
- Economy recovery of the future could be estimated.

The quantification of this study could give the prospect in the near future and using this modeling, the long-term planning could be produced, which is used for the national energy strategy for the economic development.

Pandemic situation is one of the national or global disasters considering the energy related status. For example, the local war could give the

economic depressions or social stagnations, that could result on the energy consumption decreases. Otherwise, if one investigates on the energy status of demand and supply, the nation's state could be analyzed with future prospect. Therefore, the estimation of the energy state associated with the virus pandemic could give the national state in the economic or social progresses.

Considering the portion of the country's energy demand reflecting the 'energy mix' policy incorporated with non-carbon emitted green fuels, the state of the economy could be analyzed. In the COVID-19 case, the liquid energy such as the crude oils can show the estimations of the social recovery when it can return back to the normal state like the time before epidemic situations.

In the energy case of this study, the 'energy mix' policy should be considered in the further study. There are some energies like coal, nuclear, and renewable energy sources which are quite high portion in energy sectors in a nation or global state. Therefore, the other energies could be considered for much more reliable study. For example, in the case of the nuclear energy, considering the characteristics of the energy, it is very difficult to reduce or extend energy supply due to the neutronic behaviors. Hence the general strategy is needed to manage the energy portions.

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