A Game Changer Modeling for Global Warming Mitigations as Suitability Implications by Nuclear Energy

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1. Introduction

It is proposed that the nuclear energy has been investigated as a role of game changer in global warming era, which is in Fig. 1. In the aspect of the social energy selection, the global warming is analyzed in which the carbon based energy consumptions should be decreased by the nature-oriented side effect like air pollutions. In this study, the evolutionary game theory (EGT) is proposed for the simulations of the climate change incorporated with energy consumptions where the evolution is analyzed for the game theory as the game changer role in energy sectors (Woo, 2020). That is to say, the natural selection of the creatures is analogized to the social matter of the energy consumptions. The energy choice could be considered as the social selection by analogy of the natural selection of creatures. Furthermore, the nuclear energy could be thinkable as one of the energy sector models.

The EGT is able to be one of promising algorithms in tasks of the global warming matter, because the dynamic descriptions reasonably can be done due to the characteristics of evolutions in the designed system like the energy industry life cycle. Fig. 2(a) shows the common model for phylogenetic tree in life evolutions (Baum, 2008) in which the alphabet means the stage of the creature or event. Hence, 'A' is primitive one which is developed to 'B' and so on. The other trees are shown as another kind of species. In addition, the natural selection could be happened in many species to be adapted to the environment on this planet. Regarding this fact, Table 1 shows the characteristics of evolution where Natural section, Long time, Offspring, Genetics, and Mutations are explained for the meaning (Than, 2018). Especially, the genetically mutations are done as the random incidents. On the other hand, Fig. 2(b) shows the game theory incorporated with evolutions. The energy choice of a society is related to the many kinds of the social matters where the non-energy factors such as man power or governance could be included. The connected lines show the nonlinearity with Monte-Carlo quantifications. The competitions could be described the non-straight lines. In modeling, the system dynamics (SD) is applied to the quantification which has the tools as dynamical simulations. Fig. 2(C) has the analogy between evolution and dynamics in which the evolution in social matter as the global warming is expressed as the dynamics of SD algorithm. It is applied to renewable energy support schemes evolution incorporated with SD (Yi et al., 2019). The random methods related to game theory-based optimization approaches are used to speed up for the solution (Sohrabi et al., 2019).

2. Method

In the historical review, the EGT was created by John Maynard Smith and George R. Price for the gaming algorithms (Maynard Smith and Price, 1973). It is necessary to make the mathematical descriptions for the quantifications. The distribution of evolutionarily stable strategy (ESS) by Bishop-Cannings theorem could be used for the global warming problem in the society (Maynard Smith, 1982). Parker and Thompson described as follows (Maynard Smith, 1982),

$$p(x) = \frac{e^{-x/V}}{V} \tag{1}$$

where the specific value is *V*. For the cumulating,

$$p(c) = 1 - e^{-c/V} \tag{2}$$

where *c* is cost. There is the modeling of evolutionary game theory where the Vensim software as window version 7.2 single precision is used (Vantana, 2015). The modeling graphics is in Fig. 3(a) in which there are basic factors connected by arrow lines with the variables in Table 2. In the case of System Control, if the generated random numbers are lower than 0.3, the value is 0.0. Otherwise, it is 1.0. So, the Boolean values are produced by the Monte-Carlo method based random number generations. In addition, the other generated values of Motor, Pipe, Pump, and Value are summed. There is the graph of Nuclear energy productions in Fig. 3(b) where the values are increased slightly after the first month as around 1.9. Using the stock algorithm in SD, there is used in Nuclear Energy Productions as assuming the initial value 0.01 in case of Cumulating EGT where the data are accumulated with time steps. Therefore, it is shown mathematically as,

$$Output = f(t_0) + f(t_1) + f(t_2) + \cdots + f(T) = \int_0^T f(t)dt \tag{3}$$

where, $f(t)$ is the Electricity Generations in each time step. In the case of discrete values, the summations could be used instead of the integrations. So, the energy production is stabilized. Then,

$$\begin{aligned}\text{Nuclear Energy Productions} &= \text{Electricity Generations } (t_0) \\ &+ \text{Electricity Generations } (t_1) \\ &+ \text{Electricity Generations } (t_2) + \cdots \\ &+ \text{Electricity Generations } (T)\end{aligned}$$

$$= \int_0^T \text{Electricity Generations } (t)dt \quad (4)$$

This means the nuclear energy is produced as stabilized trend after the first year of the 60-year time period in this modeling. The values are compared each other without dimensions.

In the other more model, in Fig. 4(a), there are the modeling of cumulating evolutionary game theory as the graph in which the cumulating EGT factor is added with Energy Mix. Therefore, the simulations of the cumulating EGT are shown in Fig. 4(b). Hence, there are several factors to be calculated associated with time as,

$$\begin{aligned} p(x_1) &= 1 - e^{-c(t_1)/V} \\ p(x_2) &= 1 - e^{-c(t_2)/V} \\ &\vdots \\ p(x_i) &= 1 - e^{-c(t_i)/V} \end{aligned} \quad (5)$$

where the *V* is the Energy Mix term. So, this graph could mean the combination of energy sectors described by the dynamical manner which reflects the significance of the social development as characteristics of the evolution, even though the time period is very short comparing to the biological evolution in which the term is extremely long as much as a creature like the human can't feel and find out the tiny change in the organ or function of the body. Furthermore, the stock method in SD is used in Nuclear Energy Productions as assuming the initial value 0.01 in case of Cumulating EGT.

The slope of values is lowed after 20th year which is the typical trend in cumulating EGT model. So, in Fig. 5, there are causes loops for Electricity generations where the factor connectivity is described. It is analyzed by the double lined arrow called as 'Rate' in which the data flows are shown in the graph. Hence, Electricity generations are affected by designed factors. In addition, Nuclear energy productions could affect on the other factors. Even though many factors are same, the logical descriptions reflect the characteristics of the SD of feedback algorithm.

3. Results

There are some designed quantifications in this study. In Fig. 6, there is the modeling of electricity generations as evolutionary game theory and cumulating evolutionary game theory. It is important that the comparison between above two game theories in the trends of interested variables in order to confirm of the dynamical characteristics of nuclear energy. The highest value of the evolutionary game theory is 115.553 in 57th year. This could show just one simulation with the interested case. But, the time transient could be described by the analogy of the biological evolution. So, the dynamical variations could express the mimicking of evolutions in the nature. Hence, the highest value of the cumulating evolutionary game theory is 1523.74in 59th year. These are dimensionless values and compared each other. Comparing two graphs, the trends are similar to be stabilized in later time where the priority of nuclear energy as the aspect of the global warming factor increases to be paralleled.

4 Conclusions

The finest evolution algorithm is used to the global warming matter. The dynamical transition could show the analogy of the biological evolution where the time period is very loner than the social development such as the energy mix in an interested society. Energy policy is dependent on many factors according to the social states. However, it has difficulties to make the sequential descriptions especially for the numeric results, because the preference of the social choice is not shown as the exact numeric value. The analogy between natural selection and social choice is applied to the global warming algorithm incorporated with the nuclear energy preference. Considering the other kind of social cases such as a nation's interest, the evolution theory is important to make a decision for the selection such as the nuclear waste repository site section, because the interested factors to be considered are easy to be changed. In near future, the much more complex systems in the population, traffics, international policy, and so on could be applied.

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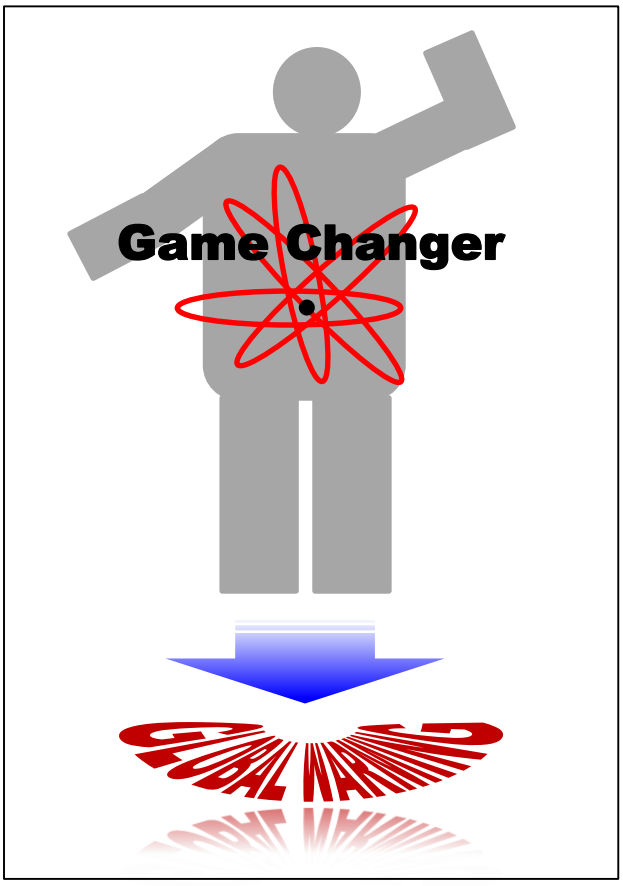
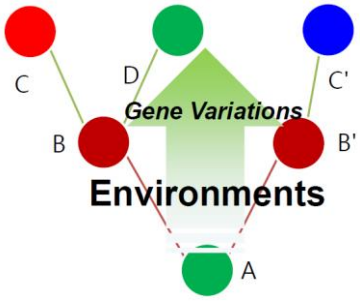
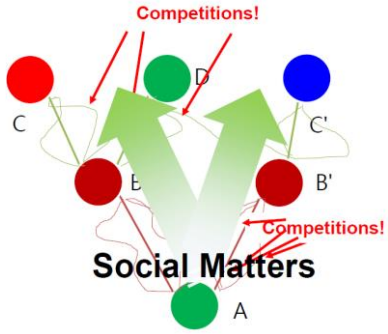


Fig. 1. A role of game changer in global warming by nuclear energy.



(a)



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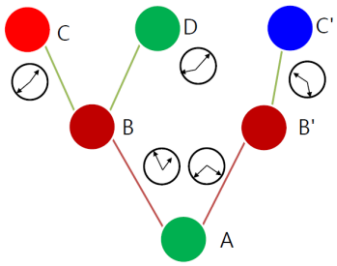
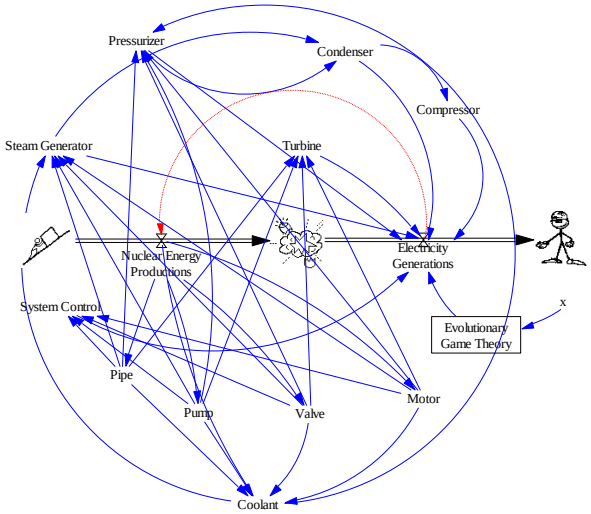


(c)

Fig. 2. (a) Typical model for phylogenetic tree in life evolutions, (b) Game theory incorporated with social evolutions, and (c) Analogy between evolution and dynamics.



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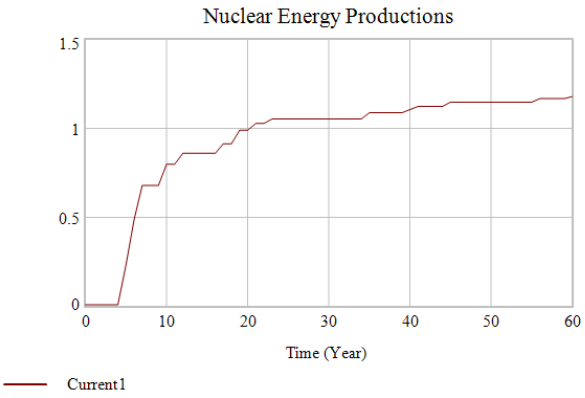
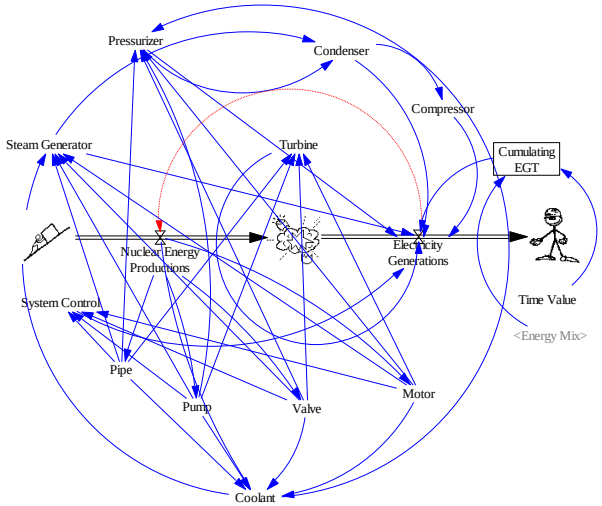
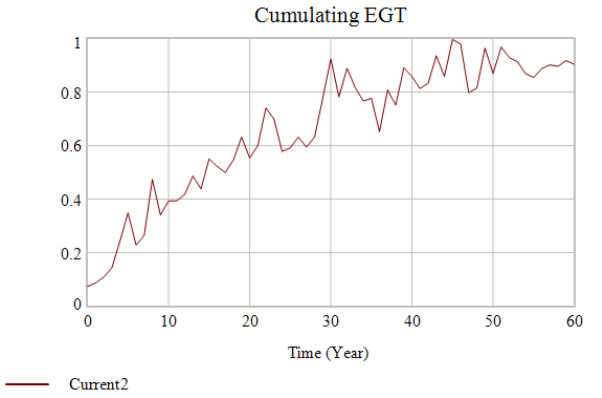


(b)

Fig. 3. Modeling of evolutionary game theory (a) Modeling graphics and (b) Nuclear energy productions.



(a)



(b)

Fig. 4. Modeling of cumulating evolutionary game theory, (a) Modeling graphics and (b) Cumulating EGT.

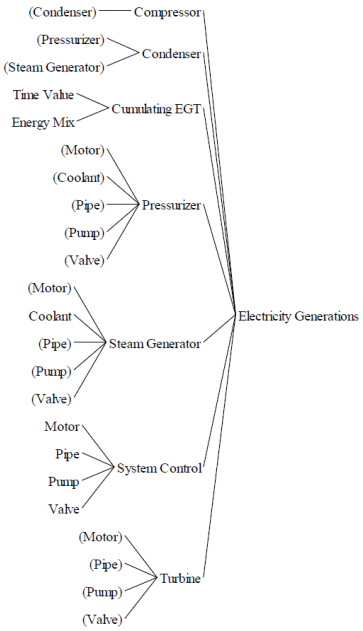


Fig. 5. Causes loops for the Electricity generations.

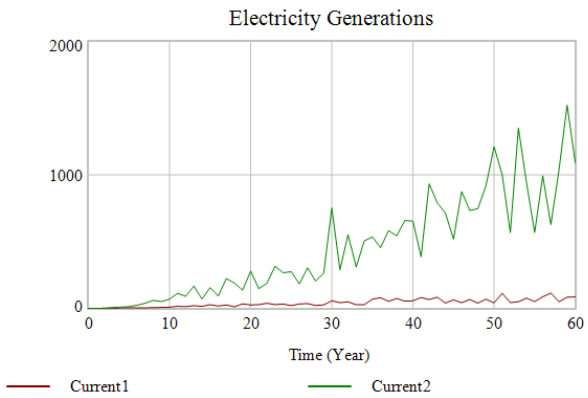


Fig. 6. Modeling of electricity generations for evolutionary game theory and cumulating evolutionary game theory.

Table I: The characteristics of evolution

	Meaning
Natural section	Organisms are changed as the heritable changes
Long time	Time more than the species lifespan
Offspring	Success in organism's attracting a mate
Genetics	Genetically mutation with random errors
Mutations	Several causes with chemical, radiation, and so on.

Table II: The pieces of factors

Factor	Value
System Control	(if then else(random 0 1 () < 0.3, 0, 1) + Motor + Pipe + Pump + Valve)
Pipe	(if then else(random 0 1 () < 0.5, 0, 1) * Nuclear Energy Productions)
Pump	(if then else(random 0 1 () < 0.2, 0, 1) * Nuclear Energy Productions)
Compressor	(if then else(random 0 1 () < 0.6, 0, 1) * Condenser)
Nuclear Energy Productions	(if then else(random 0 1 () < 0.8, 0, 1)) / Electricity Generations, Initial Value: 0.01
Evolutionary Game Theory	exp(-x/10)/10