Transactions of the Korean Nuclear Society Autumn Meeting
Changwon, Korea, October 20-21, 2022

Feasibility Analysis of On-Campus Micro-Reactor Marketing Strategy in the Univ. of Illinois at Urbana-Champaign (UIUC): Site Selection, The First Story

Tae Ho Woo
Department of Mechanical and Control Engineering, The Cyber University of Korea, Seoul 03051, Republic of Korea
**Corresponding author: thwoo@cuk.edu, thw_kor@hotmail.com*

1. Introduction

The Univ. of Illinois at Urbana-Champaign (UIUC) submitted a letter of intent to the U.S. Nuclear Regulatory Commission (NRC) to apply for a license to construct a research and test reactor facility on the UIUC campus in 2021. The Ultra Safe Nuclear Micro Modular Reactor (MMR™) Energy System by Safe Nuclear Corporation (USNC) as part of its green campus initiative [1]. Therefore, it is reasonable to analyze the site selection of Nuclear Power Plant (NPP) in the dense population area, a university campus in Fig. 1 [2].

Table 1 shows the specification of MMR™ Block 1 [3]. Thermal power is 15 ~ 30 MWth whose 30% is electrical power. Helium gas cooled and 19.77 % enriched reactor is operated by the forced circulations. Especially, there is no core meltdown safety feature. There are some dada for the Urbana and Champaign cities in Table 2 [4,5]. Champaign size is larger than that of the Urbana.

In the precious studies, Murakami studied the Japanese NPP site selection [6], Richter et al. worked for the nuclear waste facility site [7]. In addition, Omitaomu et al. studied the energy policy aspect of the NPP site selection [8]. There are Analytical Hierarchical Processes (AHP) researches [9-13].

2. Methods

The analysis for the site selection modeling in a University campus is performed by the System Dynamics (SD) method which has been used for the quantification analysis for the technological as well as social matters. There are several factors to consider in the site decision where seismic activity, population density, reactor cost, and consumer proximity are major factors in the modeling [14].

2.1. Analysis of site selection in UIUC

Regarding the NPP site selection applications, Fig. 2 shows Major factors for site selection in UIUC [14]. Fig. 3 shows the word cloud form of variables where the graphical importance of the variables is seen as letter size and color [15].

2.2. Modeling of site selection in UIUC

The SD modeling is applied to the site selection in UIUC. Fig. 4 shows the Modeling of site selection in UIUC where Site selection, Closer site, Multiple modules, Less people, and Minimized disaster are included. Table 3 shows the list of variables. In Habitat, the generated random number is lower than 0.7. it is 1.0 as Boolean value. Other variables are obtained by the designed equation. Fig. 5 is the causes loop for Seismic Activity, which shows the connectivity of event flows. In the modeling construction, the feedback algorithm, a particular characteristics of SD, is used as follows [16],

$$\frac{dA}{dt} = Cause - Result \quad (1)$$

where A and Cause are arbitrary variable values and the minus Result shows the feedback event, which is seen in Fig. 4(a). In addition, the accumulation of the event quantification is used as [16],

$$Accumulation\ of\ event = \sum(A(i) - A(i+1)) \quad (2)$$

where $A(i)$ shows the event at time of i. Hence, each interested event is calculated by the designed algorithm.

3. Results

The simulations are performed by the dynamical feature. Fig. 6 shows the simulation results of site selection in UIUC by SD. The favor value increases rapidly in early stage and then smoothly and gradually. Fig. 7 shows the Public Acceptance (PA) implicated simulation, where PA is studied for nuclear governance by Ji et al. [17], (a) PA simulation and (b) Comparisons of site selection. In 4th month, the values are same as 5.171. Then, the values differ as 85.398 in PA case compared to 24.240 in non-PA implicated one which is in Table 4.

4. Conclusions

It is analyzed for site section of the on-campus nuclear reactor where the dynamical simulations by the designed variables. The NIMBY (Not In My Backyard) phenomenon could be mitigated by the academic area as the University area in which the highly educated people live. So, it is easier to persuade the residents to take the NPP facility in their hometown. In addition, the technological quality of newly designed advanced reactor could be accepted. Hence, it is desirable to other university places of several hundreds' sites.

Acknowledgments

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea Ministry of Science and ICT (2022M2B5A108069611).

REFERENCES

[1] NPRE, 2021. Micro-reactor project continues pace toward becoming a reality. Nuclear, Plasma & Radiological Engineering (NPRE), Illinois at Urbana-Champaign (UIUC), USA, https://npre.illinois.edu/news/stories/micro-reactor-update-nov21.

[2] USGS, 2022. The National Map Viewer, The U.S. Geological Survey (USGS), https://apps.nationalmap.gov/viewer/.

[3] USNC, 2022. MMR® ENERGY SYSTEM, MICRO MODULAR REACTOR. Ultra Safe Nuclear Corporation, 2022, https://usnc.com/mmr/.

[4] Wikipedia. 2022a. Urbana, Illinois, Wikimedia Foundation, Inc., 2022, https://ko.wikipedia.org/wiki/%EC%96%B4%EB%B0%B0%EB%84%88_(%EC% https://en.wikipedia.org/wiki/Urbana,_Illinois.

[5] Wikipedia. 2022b. Champaign, Illinois, Wikimedia Foundation, Inc., 2022, https://en.wikipedia.org/wiki/Champaign,_Illinois.

[6] Murakami, T., 2021. A historical review and analysis on the selection of nuclear reactor types and implications to development programs for advanced reactors; A Japanese study. Energy Reports 7, 3428–3436.

[7] Richter, J., Bernstein, M.J., Farooque, M., 2022. The process to find a process for governance: Nuclear waste management and consent-based siting in the United States. Energy Research & Social Science 87, 102473.

[8] Omitaomu, O.A., Belles, R., Roberts, N., Worrall, A., 2022. Methods and system for siting advanced nuclear reactors and evaluating energy policy concerns. Progress in Nuclear Energy 148, 104197.

[9] Agyekum, E.B., Amjad, F., Aslam, F., Ali, A., 2021. Application of Weighted Linear Combination approach in a Geographical Information System environment for nuclear power plant site selection: the case of Ghana. Annals of Nuclear Energy, 162, 108491.

[10] Bilgiliogˇlu, S.S., 2022. Site selection for radioactive waste disposal facility by GIS based multicriteria decision making. Annals of Nuclear Energy. 165, 108795.

[11] Bowen, W.M., 1995. A Thurstonian Hierarchy Multidimensional Application to the Selection Comparison of the Analytic Process and Probabilistic Scaling Through Nuclear Waste Site Decision. Socio-Econ. Plann. Sci. 29(2), 151-163

[12] Jinq, L.Y., Basri, N.A., 2022. Sites selection for a potential radioactive waste repository in Peninsular Malaysia: GIS-based weight linear combination and multi-criteria decision-making analysis. Progress in Nuclear Energy, 149, 104252.

[13] Susiati, H., Dede, M., Widiawaty, M.A., Ismail, A., Udiyani, P.M., 2022, Site suitability-based spatial-weighted multicriteria analysis for nuclear power plants in Indonesia. Heliyon 8, e09088.

[14] Devanand, A., Kraft, M., Karimi, I.A., 2019. Optimal site selection for modular nuclear power plants. Computers and Chemical Engineering 125, 339–350.

[15] WordArt.com, 2022. WORDART, WordArt.com, 2022, https://wordart.com/.

[16] SDS. 2021. What is System Dynamics? System Dynamics Society (SDS), Littleton, USA.

[17] Ji, Y., Qi, M., Qi, W., 2022. The effect path of public acceptance and its influencing factors on public willingness to participate in nuclear emergency governance. International Journal of Disaster Risk Reduction, 71, 102806.

Fig. 1. Map of U.S.A [2].

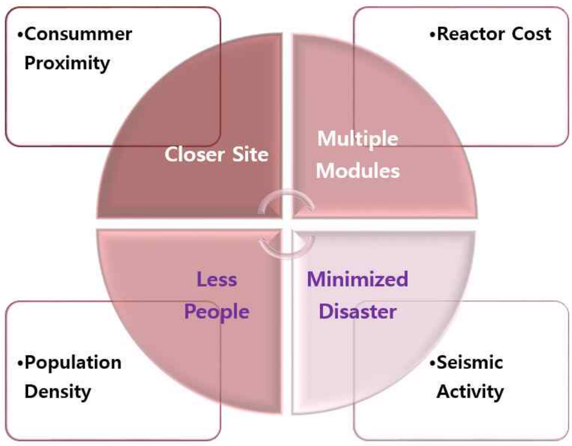
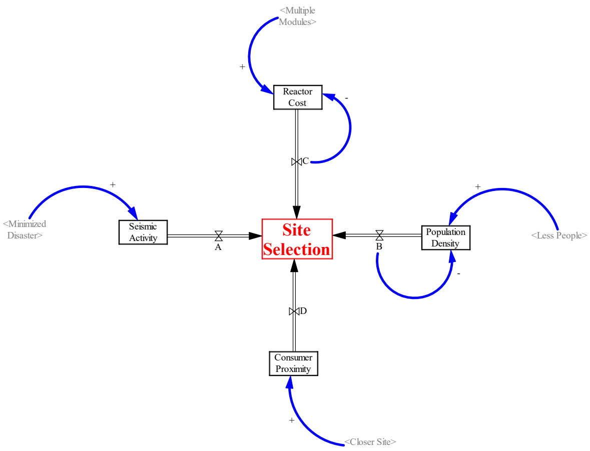
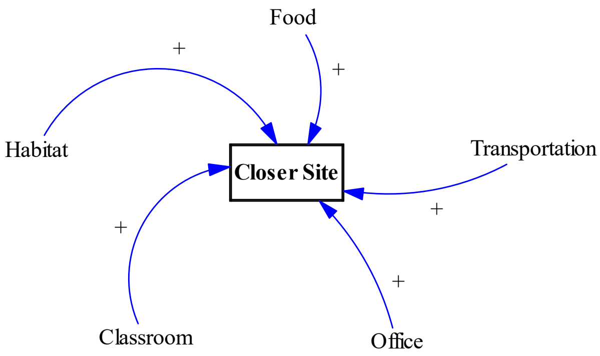


Fig. 2. Major factors for site selection in UIUC [14].

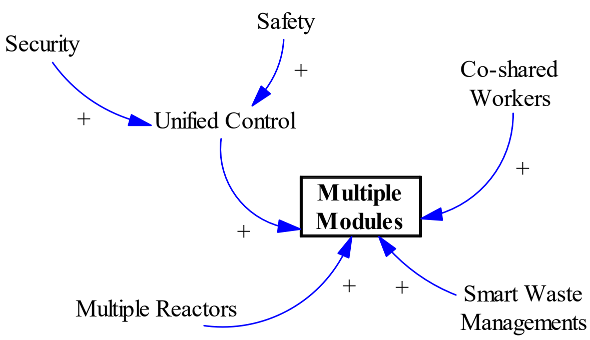
Fig. 3. Word cloud form of variables [15].



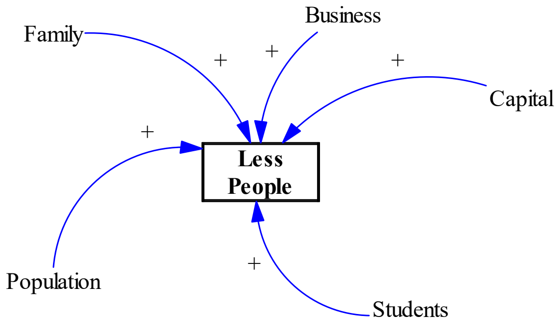
(a)



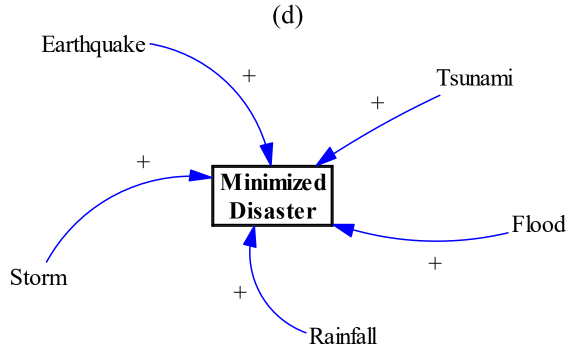
(b)



(c)



(d)



(e)

Fig. 4. Modeling of site selection in UIUC by SD (a) Site selection, (b) Closer site, (c) Multiple modules, (d) Less people, and (e) Minimized disaster.

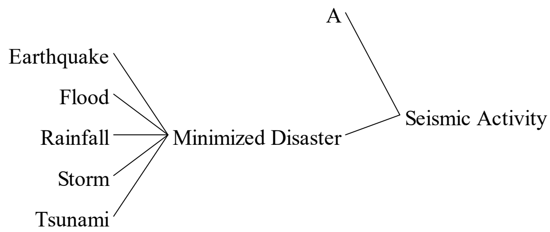


Fig. 5. Causes loop for Seismic Activity.

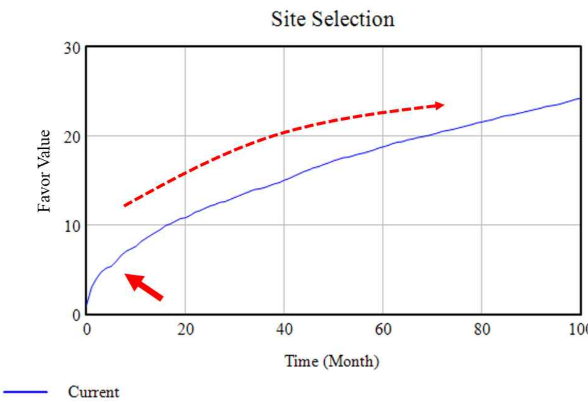
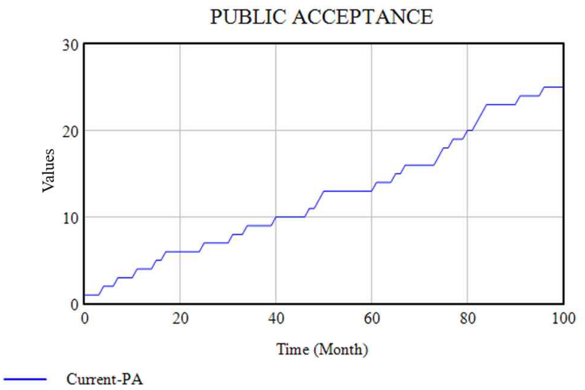
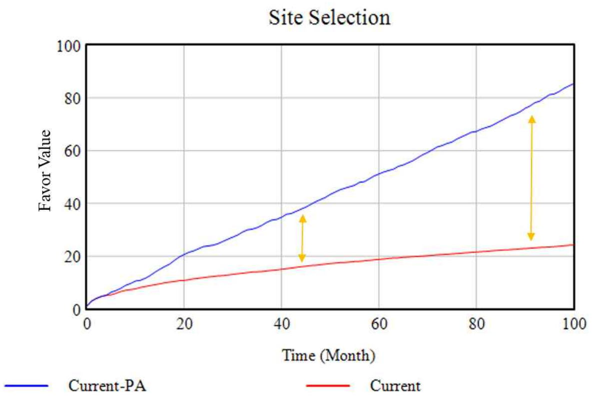


Fig. 6. Simulation results of site selection in UIUC by SD.



(a)



(b)

Fig. 7. Public Acceptance (PA) implicated simulation (a) PA simulation and (b) Comparisons of site selection.

Table I: Specification of Ultra Safe Nuclear Micro Modular Reactor (MMR™) Block 1 [2].

	Content
Thermal power	15 ~ 30 MWth
Electrical Power	5 ~ 15 MWe
Type	High Temperature Gas-cooled Reactor/micro-reactor/nuclear battery
Coolant/Moderator	Helium/Graphite
Primary Circulation	Forced Circulation
Inlet/Outlet Temperature (°C)	300/630 (Helium Primary) 275/565 (Solar Salt Secondary)
Fuel Assembly Number in Core	180 Fuel Blocks (172,800 FCM (Fully Ceramic Microencapsulated) Pellets)
Enrichment	LEU 19.75%
Refueling	Never for Lifetime
Life	20 years
RPV	13.25m (Height), 3.5m (Diameter)
Seismic Design	0.3 g
Distinguish Feature	No Core meltdown

Table II: Statistics of the city [3,4].

	Urbana	Champaign
Population	38,336 (2020)	88,302 (2020)
Pop. Dens.	1,251.15/km^2	1,482.97/km^2
Avg. Temp. (°C)	16.5(High), 5.4(Low)	16.7(High), 5.9(Low)
Elevation	222 m	233 m
Employer		13,934(UIUC) 6,921(Carle Hospital) 1,664(Unit 4 School District)

Table III: List of variables (Selected).

Variable	Content
Site Selection	(B+A+C+D)/Site Selection, Initial value = 1.0
Seismic Activity	-A + Minimized Disaster, Initial value = 1.0
Population Density	-B + Less People, Initial value = 1.0
Closer Site	Classroom * Food * Habitat * Office * Transportation
Habitat	if then else(random 0 1 () < 0.7,1,0)
Food	if then else(random 0 1 () < 0.4,1,0)

Table IV: Comparisons of Site Selection.

Time (Month)	0	1	4	5	6	50	100
PAimpl.	1	3	5.17	6.33	6.96	43.39	85.40
Non-PA	1	3	5.17	5.36	5.92	17.22	24.24