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Original Article

The acceptance of nuclear energy as an alternative source of energy among Generation Z in the Philippines: An extended theory of planned behavior approach

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ABSTRACT

Nuclear Power Plants (NPP) are widely utilized around the globe from different base forms as it is one of the most dependable renewable resources that technological advancements have offered. However, different perceptions of the usage of NPPs emerged from different generations. The purpose of this study was to investigate the acceptance of nuclear energy as an alternative source of energy among Generation Z in the Philippines by utilizing an extended Theory of Planned Behavior (TPB) approach. An online questionnaire which consisted of 31 items was distributed using a purposive sampling approach and 450 respondents of Generation Z voluntarily answered. Structural Equation Modeling (SEM) showed that the knowledge regarding NPP had significant effects on risk perception and benefit perception which subsequently led to subjective norms. In addition, perceived behavioral control and subjective norms had significant effects on behavioral intention which led to nuclear acceptance. Interestingly, the respondents perceived the benefit of NPP as slightly higher than the perceived risk. With these, it was clear that the commissioning Nuclear Power Plant must consider as an alternative source of electric energy in the Philippines. Moreover, this study is one of the first studies that investigated the acceptance of NPP among Generation Z. Lastly, the model could be a basis to strengthen the acceptance strategy of opening NPP among Generation Z, particularly in developing countries.

1. Introduction

Dependence on fossil fuels puts us on a track of rapid exhaustion of finite materials such as oil, coal, and natural gas. Providentially, the progression of alternative energy sources has been tapped to generate clean energy without global warming emissions and pollutants. Coupled with today's price hike of oil and electricity, alternative energy sources are being considered to supplement traditional electric energy sources.

Among these, Nuclear Power Plant (NPP) is recognized as one of the most viable and environmentally beneficial for its zero-carbon emission while in operation [1]. Additionally, Nuclear Power Plants (NPP) creates base-load electricity, which is deemed less expensive [2], as a result, 10% of the world's electricity (2553 Terrawatt per hour) have turned to NPPs as a mainstream source for energy [3]. Today, Asia is the world's most rapidly developing region for

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electricity generation capacity, particularly in nuclear power with over 440 NPPs running in Taiwan, Japan, South Korea, Pakistan, India, and China and around 40 under construction all over the region [4]. Despite the significant advantages of using NPPs, others remain opposed to the usage of this sort of energy for a variety of reasons; nuclear weapon proliferation, highly destructive effect, highly poisonous chemicals like plutonium and the uranium pellets used as fuel, a consequence of radiation sickness, and the risk of slipping into the hands of the wrong people, particularly in nations with high levels of corruption and insecurity [5]. One of the countries in Asia that currently raising the issues of the NPP is the Philippines.

The Philippines is among the Asian countries that have tapped into the use of nuclear energy as a response to the 1973 world oil crisis which caused a pervasive energy crisis in the country. The country strategically built an NPP in the Bataan Peninsula called Bataan Nuclear Power Plant (BNPP), with a construction cost of around 2.1 billion USD [6]. The BNPP was entirely constructed in 1980 to produce 623 MW of power [7] but failed to operate due to safety and political reasons in 1986 [8].

Today, it is considered as 1 of the 182 idle and decommissioned reactors in the world [9]. However, the Philippine Government still considers NPP to lessen the country's reliance on imported oil and coal as the energy demand has increased at an average annual growth rate of 5.5% per year since 2009, reaching a peak of 62 Mtoe in 2019 and increasing from approximately 27, 990 ktoe (kilotonnes of oil equivalents) in 1990 to 56, 355 ktoe in 2020 shown in Fig. 1 [10,11]. Lastly, it is important to note that the Philippines, like many other nations, is highly reliant on nonrenewable energy sources, which has caused economic policymakers to be concerned about their reserves and their fluctuating worldwide prices [12] (see Fig. 2).

In the country's 2008 National Energy Plan, 600 MWe NPP was anticipated to come online in 2025 with additional 600 MWe increments in 2027, 2030, and 2034 totaling 2400 MWe. For more than a decade this plan remained stagnant until July 24, 2020, when the President of the Philippines issued an ordinance under Executive Order No. 116 mandating the formation of an inter-agency committee for the nuclear energy program, the commissioning of a study to determine the national stance on a nuclear energy program, and other purposes. With these orders, the Philippine Department of Energy (DOE) established a project to examine the development of nuclear energy as part of the country's overall energy plan. Moreover, as of February 2022, the President signed Executive Order 164 mandating the DOE to establish and implement a nuclear program. Other tenements in progress on the NPP's Energy Program are the establishment of a legislative framework, alignment with international standards, and most importantly enhancing public awareness and acceptability. Currently, the present Marcos-Duterte administration is considering NPP as a potential remedy for the Philippines' rising energy demand and consumption [13].

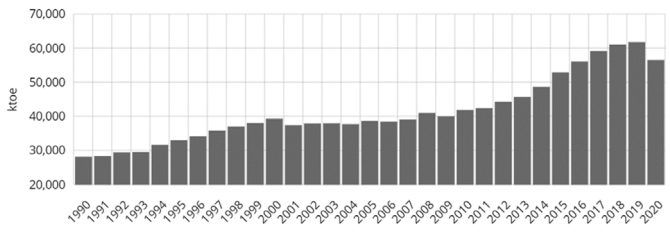

Fig. 1. The increased energy demand in the Philippines
Figure Source: Department of Energy and Enerdata source [11].

Furthermore, despite the NPP's potential power source, local citizens are far more concerned about the risks than the advantages [14]. The opinions of the citizens will impact their behavior and intention in relation to any project advancement, therefore, their opinion and approval should be considered [15]. Moreover, positive development and sustainability are attained when there is a favorable perception and acceptance from different generations. Since Generation Z is the future, it is important to understand how they perceive and accept certain circumstances, even when such perceptions shift over time, such as the NPP being an alternative source of electricity [16].

About 40 percent of the population in the Philippines belongs to Generation Z [17] which are youths born between the late 1990s and the early 2010s [18]. It is worth noting the majority of Generation Z have been exposed to global catastrophic events that shape their perception of certain affairs like 9-11 which lead to war and other catastrophic events related to nuclear technology. For example, a significant number of youths aged 17 and 18 were affected by the 2011 Japan tsunami that damaged the NPP in Fukushima Daichi. The World Nuclear Association acknowledges the Fukushima Dai-ichi power plant accident as the third significant accident connected with NPP which caused long-term psychological effects (e.g., depression, anxiety, fear, physical symptoms) [19]. It was also mainly a product of lax governmental policies that regulated the operation of nuclear power in Japan [20] which furthered the citizens' doubt about their countries' plans to use NPP as an alternative energy source. More recently, Vladimir Putin expressed plans to deploy tactical nuclear weapons in Belarus as part of his invasion of Ukraine [21] which caused the global nuclear scare.

These events all influence how Generation Z perceives the world as "unsafe" and has resulted in a generation that potentially values fiscal responsibility, tolerance of others, education, employment flexibility, and networking abilities [22]. Hence, the impact of events on this and subsequent generations, both positive and negative, should not be overlooked [23]. Thus, to explore the acceptance of this specific generation, the most utilized theory that can look into these behaviors is the Theory of Planned Behavior (TPB).

The Theory of Planned Behavior (TPB) explains different behavioral intentions according to their motivations, actions, context, and timeframe [24]. The perception of Generation Z about the nuclear power plant can be determined by using the Theory of Planned Behavior. Additionally, the behavior could be measured holistically using extended TPB, and the factors affecting people's acceptance could be identified. This theory was widely applied in many nations, notably in accepting nuclear energy illustrated in Table 1. TBP has been used to evaluate renewable energy sources and the local population's acceptability in Pakistan [25]. In Korea, Kim et al. employed T.B.P. to examine how attitudes, perceptions, and behavior related to nuclear energy policies [26]. The TPB and Technology of Acceptance Model (TAM) were used in China by Zhang et al. to assess breaches and risky conduct in nuclear facilities [27]. In the Philippines, integrating the Protection Motivation Theory (PMT) with TPB was considered to measure human behavior for investigating the acceptance of the reopening Bataan nuclear power plant [28]. Moreover, Table 1 tabulated different studies about the acceptance of Nuclear Energy in different nations, which proves that acceptability plays a vital role in nuclear energy.

This study's specific goal was to examine how the extended TPB was used to better understand factors that affect generation Z's acceptability with NPP as an alternative source of electric energy. The various factors such as knowledge about the power plant, information perception, trust, risk perception, benefit perception, attitude, perceived behavioral control, and technology acceptance,

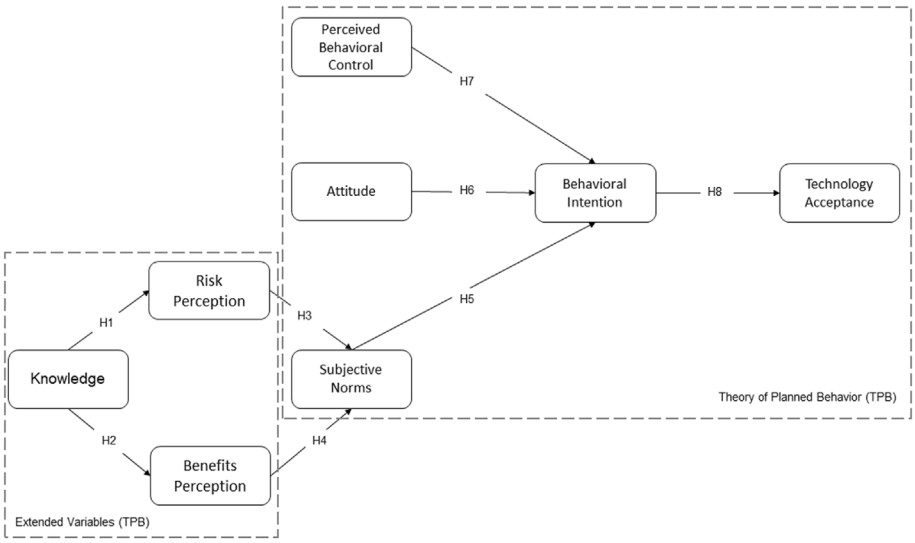

Fig. 2. Conceptual framework

were considered for this study and were assessed using the Structural Equation Modelling (SEM). First, this study is regarded as the first to thoroughly examine the variables influencing a specific Generation Z that perceives the concept of nuclear energy as an alternative source of electric energy. Second, the outcome of this study could help the government sectors evaluate their decisions about the BNPP's anticipated reopening, which is essential for its sustainability and development. Finally, the proposed framework used in this study could be a basis to strengthen the acceptance strategy of opening NPP among Generation Z, particularly in developing countries.

Lastly, the proposed framework used in this study could be a basis to strengthen youth acceptance which could be incorporated into the Comprehensive Strategic Communication Plan on nuclear energy being developed by the Country's energy sector.

2. Conceptual framework

Fig. 1 represents the theoretical framework of the study. This illustrates the various factors that were considered for the Extended TPB, which focuses on the acceptance of the Nuclear Power Plant as an alternative energy source among Generation Z. Eight (8) hypotheses were proposed.

Several studies in different countries have confirmed that an individual's knowledge about a certain event is essential as it affects their risk perception and benefit perception. For instance, Wang et al. [31] found that the knowledge of the respondents and the public about the nuclear power plant has a relevant effect on perceived benefits in China. Moreover, in Japan, Huang et al. [38] found that the respondents' knowledge about the Fukushima Nuclear Accident had a negative impact on their perceived risk. These findings suggest that the perceived risks and benefits were reduced by the respondents' knowledge of one of the variables. Furthermore, the respondent's risk perception and faith in the benefits may be reduced as their level of knowledge increases [39]. As a result, the researchers proposed the following hypotheses:

H1. Knowledge about nuclear energy had a significant impact on Risk Perception

H2. Knowledge about nuclear energy had a significant impact on Benefit Perception

Based on the concept of the TPB, subjective norm pertains to the intention to engage in or support a certain behavior that is influenced in part by the perception of the support and approval of significant individuals. Pressures from family, culture, society, and reference groups can persuade an individual to conform to behavior because the subjective norm is a perceptual behavior [34,40]. Furthermore, various studies have shown the significance of subjective norm on intention, perceived risk, and perceived benefit. A study conducted by Chi et al. [41] found that perceived risk and subjective norm both have a significant impact on usage intention, whereas, in the relationship between perceived risk and usage intention, the subjective norm acts as the moderator. Moreover, Ong et al. [28] conducted a study regarding nuclear power plants. Their results showed that perceived benefits have a direct effect on the subjective norm and that risk perception negatively affected the subjective norm. As a result, the researchers proposed the following hypotheses:

H3. Risk Perception had a significant impact on Social Norms

H4. Benefits Perception had a significant impact on Social Norms

SN pertains to the social pressure perception to engage or not to engage in the behavior [24]. SN plays a significant role in both TPB and TRA Based on TRA, people's behavioral intentions can be further predicted by factoring in their attitudes and subjective norms [41]. Additionally, the viewpoints of other significant individuals may also have an impact on a user's behavioral intention. In a study conducted by Ursavas et al. [42], it was confirmed that subjective norms have a significant effect on their behavioral intention of using technology based on the results of their study about preservice and in-service teachers' use of technology. Whereas, a study conducted by Perko et al. [43] found that residing near a nuclear facility can have varying consequences on engagement intention depending on the mediator. As a result, the researchers proposed the following hypothesis:

H5. Social Norms had a significant impact on Behavioral Intention

According to TPB, an attitude refers to an individual's assessment of the conduct of interest as either favorable or unfavorable, whereas, Perceived Behavioral Control (PBC) refers to the perception of how difficult it is to perform a behavior [24,44]. Numerous studies have concluded that attitude and PBC have a significant

Table 1
Tabulated table about the acceptance of the NPP's worldwide.

No.	Title	Year	Country	Journal	Purpose of the study	Conceptual framework	Factors	Conclusions	Source
1	Who is willing to participate? Examining public participation intention concerning decommissioning of nuclear power plants in Belgium	2011	Belgium	Energy policy	This study aims to examine public participation intention concerning decommissioning of nuclear power plants in Belgium using theoretical framework based on elements of the Value-Belief-Norm theory, psychometric paradigm, deliberative theories of democracy and in the levels of participation as defined by Arnstein's ladder,	Value-Belief-Norm theory & Arnstein's ladder of participation	1. Vicinity 2. Ideological 3. Trust 4. Attitude 5. Interest 6. Risk Perception 7. Non-participation vs. others 8. Tokenism vs. Non-participation 9. Active Participation vs. Tokenism	. This theoretical framework based on elements of the Value-Belief-Norm theory, psychometric paradigm, deliberative theories of democracy and in the levels of participation as defined by Arnstein's ladder,	[29].
2	Modeling individual preferences for energy sources: The case of IV generation nuclear energy in Italy	2016	Italy	Ecological Economics	This paper investigates its social acceptance by means of a robust methodology, employing 1) choice experiments, 2) structural equation modeling and 3) information treatments within an online nation-wide survey.	Benefit- Risk Concept	1. Egoistic 2. Altruistic 3. Biospheric 4. Benefits 5. Risks 6. Confidence 7. Acceptance	Results show a great deal of preference heterogeneity: the majority of the sampled respondents oppose new nuclear plants in Italy, with some not willing to accept any monetary compensation at all. However, another segment of respondents, more confident that fourth generation nuclear energy goals will be achieved, show a modest support towards the implementation of new nuclear projects	[30].
3	Public perceptions and acceptance of nuclear energy in China: The role of public knowledge, perceived benefit, perceived risk and public engagement	2018	China	Energy Policy	this study aims to examine public perceptions and acceptance of nuclear energy, and explore the effects of public knowledge about nuclear energy, perceived benefit, perceived risk and public engagement on public acceptance	Benefit- Risk Concept	1. Knowledge 2. Perceived Risk 3. Perceived Benefit 4. Public engagement 5. Public Acceptance	This study indicated that public knowledge is positively and significantly related to perceived benefit and public acceptance, but not significantly related to perceived risk. Perceived benefit and perceived risk are all positively and significantly associated with public acceptance. Meanwhile, this study also demonstrated the positive effect of public engagement on public acceptance.	[31].
4	Public Perception of the Nuclear Research Reactor in Thailand	2019	Thailand	2018 IEEE International Conference on Industrial Engineering and Engineering Management	This study explored perception from the public regarding the future nuclear research reactor construction in Nakhon Nayok, Thailand, using the structural equation modeling technique	Benefit- Risk Concept	1. Social Status 2. Information Perception 3. Trust 4. Risk Perception 5. Benefit Perception 6. Technology Acceptance	The results from our structure showed that trust was the main exogenous variable that affected risk and benefit perceptions and technology acceptance. Social status, on the other hand, had a very little impact on those endogenous variables. Risk and benefit perceptions also influenced the acceptance of the nuclear research reactor.	[32].
5	Predicting unsafe behaviors at nuclear power plants: An integration of Theory of Planned Behavior and Technology Acceptance Model	2020	China	International Journal of Industrial Ergonomics	This study aimed to investigate how workers' attitude and perception factors would predict errors and violations at nuclear power plants by proposing and validating an unsafe behavior model.	Theory of Planned Behavior (TPB) and Technology Acceptance Model (TAM)	1. Perceived usefulness 2. perceived Ease of Use 3. Subjective Norm 4. Attitude 5. perceived Behavioral Control	The results showed that perceived ease of use and perceived usefulness in following work regulations contributed to a positive attitude, which helped reduce the occurrence of both errors and violations. Moreover, errors were further affected by subjective norm while	[33].

(*continued on next page*)

Table 1 (*continued*)

No.	Title	Year	Country	Journal	Purpose of the study	Conceptual framework	Factors	Conclusions	Source
							6. Unsafe Behavior	violations were not. Perceived behavior control was not a significant factor of either errors or violations.	
6	Effects of information strategies on public acceptance of nuclear energy	2020	China	Energy	This study identifies the predictors of public acceptance of nuclear power plants. A comparative study of two types of information strategies, namely, interest focused and technology focused, is conducted to examine the decision-making process involved in the formation of nuclear power perception	Protective Action Decision Model (PADM) and Theory of Planned Behavior (TPB)	1. Environmental Concern 2. Energy shortage Belief 3. Perceived Risk 4. Perceived Benefits 5. Public Acceptance 6. Demographic Characteristics	Empirical results show that environmental concern and energy shortage belief are the key determinants of psychological perception and public acceptance. Innovatively, the respondents in the interest-focused group exhibit a lower acceptance level and fewer perceived benefits but more perceived risks than those in the technology-focused group.	[34].
7	Social acceptance of nuclear power plants in Korea: The role of public perceptions following the Fukushima accident	2020	South Korea	Renewable and Sustainable Energy Reviews	This study investigates public perceptions of NPPs. Moreover, it explores the effects of four factors, perceived costs, system reliability, awareness, and environmental knowledge, on the perceived benefits, risks, and public attitudes that influence the public's intention to use NPPs	Theory of Planned Behavior and Benefit- Risk Concept	1. Perceived Awareness 2. Perceived System Reliability 3. Environmental Knowledge 4. Perceived Costs 5. Perceived Benefits 6. Perceived Risk 7. Attitudes 8. Intention to use	This study finds that perceived benefits played a key role in determining the public's intention to use NPPs. Furthermore, their perceived benefits are significantly affected by the four factors listed above. Moreover, both environmental knowledge and perceived costs have notable effects on perceived risks.	[35].
8	Extending the Coverage of the Trust—Acceptability Model: The Negative Effect of Trust in Government on Nuclear Power Acceptance in South Korea under a Nuclear Phase-Out Policy	2021	South Korea	Energies	This article extends the coverage of the trust —acceptability model to a new situation of nuclear phase-out by investigating the effect of trust on the public acceptance of nuclear power, with South Korea as the research setting	Extended Trust —Acceptability Model	1. Trust in government 2. Trust in Nuclear Energy Authority 3. Trust in Nuclear Academia 4. Trust in Environmental NGO's 5. Benefit Perception 6. Risk Perception 9. NPP Acceptance	South Korea, under a nuclear phase-out policy by the government, trust in government revealed a negative impact on the public acceptance of nuclear power. Trust in environmental non-governmental groups also showed a negative effect on nuclear power acceptance. In contrast, trust in nuclear energy authority and trust in nuclear academia both had positive effects.	[36].
9	Investigating the acceptance of the reopening Bataan nuclear power plant: Integrating protection motivation theory and extended theory of planned behavior	2022	Philippines	Nuclear Engineering and Technology	this study was to investigate the perception towards the Bataan Nuclear Power Plant	Protection Motivation Theory (PMT) and Theory of Planned Behavior (TPB)	1. Knowledge 2. Perceived Benefit 3. Perceived Risk 4. Perceived Behavioral Control 5. Subjective Norms 6. Attitude 7. Intention to use. 8. Acceptance	Results showed that PBC and attitude are mediators towards the acceptance of people regarding the reopening of BNPP. If an individual's knowledge gravitates towards the perceived risk, then this can lead to the negative acceptance of the NPP reopening. On the other hand, if an individual's knowledge gravitates towards the perceived benefits, then this will lead to positive acceptance	[28].
10	A framework of examining the factors affecting public acceptance of nuclear power plant: Case study in Saudi Arabia	2023	Saudi Arabia	Nuclear Engineering and Technology	this study is to analyze the public attitudes and acceptance of nuclear energy among Saudi Arabian citizens by utilizing protection motivation theory and theory of planned behavior.	Protection Motivation Theory (PMT) and Theory of Planned Behavior (TPB	1. Knowledge 2. Trust 3. Social Influence 4. Proximity 5. perceived Risk 6. Perceived Benefits 7. Acceptance	The research concluded that the benefits of nuclear power plants were essential in determining people's acceptance of NPPs. Surprisingly, the effect of the perceived benefits was found higher than the effect of the perceived risks to the acceptance. Furthermore, the public's participation in	[37].

Table 1 (*continued*)

No.	Title	Year	Country	Journal	Purpose of the study	Conceptual framework	Factors	Conclusions	Source
								this study revealed that the NPPs location has a significant impact on their acceptance.	

impact on predicting behavioral intention [45]. For instance, Yuan et al. [46] found that PBC had an impact on project-related behavior and intention on the public acceptance of the waste-to-energy initiative. Similarly, Hua and Wang [47] stated that PBC is one of the variables that directly and significantly affected consumers' intention to purchase energy-efficient equipment. Furthermore, Foltz [44] demonstrated that behavioral intention can be predicted by attitude when they investigated the elements that affect people's behavior in regard to adjusting security settings and using social networking. Correspondingly, Hussain et al. [48] and Mamman et al. [49] showed that attitude significantly predicted the intention to use mobile health technologies among mobile users. As a result, the researchers proposed the following hypotheses:

H6. Attitude had a significant effect on Behavioral Intention.

H7. Perceived Behavioral Control had a significant effect on Behavioral Intention.

An individual's intention is a measure of their motivation for their plan to utilize or engage in a behavior. Several researchers have provided more evidence that this idea has an effect on how well a topic is accepted. A study conducted by Park and Ohm [50] discovered that many dimensional matrices can be used to explain attitudes, perceived trust, risk, and intention to use solar energy in society. Similarly, Xiao et al. [51], found that most of their respondents are inclined to accept nuclear technology since they have goodwill and competence trust. Furthermore, Lim et al. [52] and Savari & Gharechaee [53] discovered that those who are less susceptible to the risks associated with power plants are likely to accept nuclear technology. This relates to the concept of intention, in which people gravitate toward activities that they consider to be beneficial to them. As a result, the researchers proposed the following hypotheses:

H8. The behavioral intention had a significant effect on Technology Acceptance.

3. Methodology

This investigation embarks on carefully crafting and selecting the study questionnaires by the use of Likert-Scale, 5-point scale, to know the perception and prior knowledge of Generation-Z citizens towards the usage of nuclear energy as another source of alternative energy for electricity.

3.1. Research instruments design

From the conceptual framework, the respondents existing knowledge and familiarity to the use of nuclear power plants as another alternative yielder of electricity. 9 sections were utilized for the questionnaire. The sections were divided into demographics (age, gender, educational background, and region), Benefic Perception (B) had 6 items, Knowledge about Nuclear Power Plant (K) had 5 items, Risk Perception (R) had 4 items together with Technological Acceptance (T.A.), Social Norms (SN) and Attitude(A) had 3 items together with factors such as Perceived Behavioral Control(PBC), intention (I). The survey utilized a 5-point Likert scale to evaluate the different constructs. Providing the information that Linkert scales were used to apprehend the perception of participants surmised latent variables. The questionnaire was provided in English because the Philippines is an English-speaking nation, with 95% of the people that speak English [54].

To assess the validity and reliability of the survey instruments and questionnaire contents, researchers from the Philippine Nuclear Research Institute (PNRI) and the Technological University of the Philippines (TUP) were contacted through e-mail and invited to evaluate the questionnaire and look for similarities in double-barreled, perplexing, and leading queries are examples of errors. They were selected based on their Nuclear Science, Technology, and Safety Engineering expertise, which is a requirement for content validation [55].

Following that, a pilot test was performed in order to assess the questionnaire's validity and reliability using IBM SPSS statistics. The pilot test employed preliminary survey data from 165 samples that were not included in the main study. The sample size was within the allowable threshold of 5 respondents per item, or at least 155 participants for a 31-item questionnaire [56,57]. They were provided with a questionnaire to complete, and the researcher was always accessible to clarify any terminology or concepts.

Following the collection of preliminary data, an exploratory factor analysis (EFA), as well as a measure of internal consistency using Cronbach's alpha, were utilized to validate the questionnaire items. A Kaiser-Meyer-Olkin (KMO) score of >0.7 signified that the value was suitable for E.F.A. [57] and a significant p-value < 0.05 for Bartlett's test of sphericity [58] for the constructs in the questionnaire. An eigenvalue larger than 1.0 and a visual assessment of the scree plot were utilized to identify the number of factors. The primary axis factoring approach was used to determine the factors. Cronbach's alpha was employed and shown to be more than 0.70, as suggested [57]. Finally, the items utilized for the study were obtained from a variety of publications and literature. They were all integrated into a single research instrument shown are Table 2.

3.2. Sample selection

A questionnaire was used to gather the data as the research instrument in scaling the latent variables. It consists of knowledge about the power plant, attitude, perceived behavioral control, intention, risk perception, benefit perception, subjective norm, and technological acceptance. In gathering the data, researchers asked permission from generation Z citizens that are born in the year 1996–2010 and was grouped into 5 age group regardless the gender, ages 24-26, 20-23, 19-17, and 14–16 years old marking up the total 600 target respondents as the respondents of this study with a given online document generated in google forms format.

Respondents were asked to sign a consent form confirming that the survey information and any pertinent data they submitted would only be used for Research purposes, in accordance with the Data Privacy Act, also known as Republic Act No. 10173 in the Philippines [69]. A consent statement was provided in the preface section of the questionnaire, and respondents were asked to confirm the checkbox before proceeding with the questionnaire items. The researchers tabulated and tallied the results after the

Table 2
Items used to measure factors in the proposed model.

Latent variable	Item code	Items	Reference
Knowledge about Power Plant (K)	K_1	I am knowledgeable about the scientific principles of nuclear power plant generation.	[59].
	K_2	I am aware of the risk of nuclear radiation.	[60].
	K_3	I understand the policies and plans of the nuclear power plant.	[60].
	K_4	I am aware of what is Nuclear Power Plant (NPP)	[28].
	K_5	I understand that the nuclear power plant uses nuclear fission to utilize nuclear energy and can be an alternative source of energy	[28,61].
Attitude (A)	A_1	It is suitable for society to use nuclear power plants.	[62].
	A_2	Society will benefit by using Nuclear Power Plant as an alternative source of electric energy	[62].
	A_3	It is of great significance that the existing Nuclear Power plant will be rehabilitated and operated.	[63].
Perceived Behavioral Control (PBC)	PBC_1	I think rehabilitating the existing Nuclear Power Plant will help our society.	[59,28].
	PBC_2	I feel safe when a Nuclear Power Plant is near our home.	[63].
	PBC_3	I am confident in the quality and reliability of the Nuclear Power Plant technology	[64].
Intentions (I)	I_1	I plan to switch to Nuclear Power Energy as a source of electricity in the future.	[63].
	I_2	I plan to encourage others to switch to using nuclear power energy as a source of electricity in the future.	[63].
	I_3	I will acquire more knowledge of the operation of nuclear power plants.	[32,38].
Risk Perception (R)	R_1	The risk of the nuclear power plant is declining and becoming more calculated	[32,38].
	R_2	An accident accompanied by environmental pollution, property loss, or health damage may occur at the site of the nuclear power plant can be controlled.	[31,32].
	R_3	Generation Z citizens in the society that are near the power plant have many uncertainties.	[32].
	R_4	The danger is catastrophic and dreadful if a nuclear power plant accident happens.	[31,32].
Benefit Perception (B)	B_1	I know that nuclear power plants can produce cheaper electricity.	[32].
	B_2	I know that nuclear power plants can produce low-carbon electric energy	[32].
	B_3	Nuclear power plants increase local employment opportunities and revenue in the country.	[32].
	B_4	Nuclear power plants can help the economic growth of my country	[32].
	B_5	Nuclear power plants can improve the country's technological advancement and scientific status.	[32].
	B_6	It is valuable for society to use nuclear power plants as an alternative source of electricity.	[62].
Subjective Norm (S)	S_1	I think I can influence different generations around me about the rules and procedures at the operation of NPP	[65,66].
	S_2	I think my associates will follow me in supporting NPP as an alternative source of electricity.	[66,67].
	S_3	Important people around me expect me will support NPP as an alternative source of electricity	[66,67].
Technological Acceptance (TA)	AT_1	It's time that NPP should be used in the country.	[68,32].
	AT_2	I favor the NPP can be a source of alternative electric energy.	[68,32].
	AT_3	It is acceptable to have the nuclear power plant operation nearby.	[68,32].
	AT_4	There is more advantage than disadvantage of using NPP as one of the alternative sources of electricity	[68,32].

questionnaires were completed. These data served as the foundation for data analysis and interpretation.

3.3. Structural equation modeling

Structural Equation Modelling (SEM) approach was considered because it is a convenient technique to test theories of different research that can determine the correlation between latent variables, correlations between errors, and factor loadings [28,69–72].

Using Partial Least Squares analysis and Structural Equation modeling, the survey outcomes were analyzed (PLS-SEM). Using Smart PLS v_4, the collected data were analyzed to determine the acceptability of Nuclear Energy as an alternative source of Electric Energy for a particular generation. PLS-SEM is a widely used multivariate analysis technique for correlating multiple indicators and latent constructs simultaneously [57,73]. When compared to other modeling approaches, PLS-SEM, according to Fan et al., considers the effects of both direct and indirect factors on assumed causal links in scientific research and studies, it is highly prevalent [74,75]. Compared to covariance-based SEM using AMOS, PLS-SEM is also used to identify critical indicators and constructs and examine the relationships of an existing structural theory [57]. The preferred method for exploratory research is PLS-SEM. In other words, PLS-SEM is recommended when relationships must be explained, but even the theory is still being developed [76].

Several fit indices, including the standardized root mean square residual (SRMR), normal fit index (NFI), and chi-squared test, were utilized to justify the model fit in this study using PLS-SEM. A value of less than 0.08 is considered a good fit for SRMR [77]. Baumgartner and Homburg indicate that for NFI, a value of 0.80 or higher represents an acceptable fit, whereas, for chi-squared, a value less than 5.0 implies a well-fitting model [78]. Furthermore, reliability analysis was performed prior to structural equation modeling (SEM). Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) are used to analyze behavioral intention models. Cronbach's and CR require a value greater than 0.7, and AVE must be greater than 0.5 [28,79].

Also, the R^2 measurements and significance levels for the path coefficient are set, and an R^2 value of 0.20 or more will be used as a cut-off based on the study by Hair et al. [80,81]. To generate path diagram, path analysis was employed to determine the causal relationship between the variables and quantify the connection among numerous variables [57]. Path analysis typically illustrates that a variable can directly or indirectly influence an outcome through other variables [74].

Lastly, SmartPLS v_4 was utilized to compute for the extended TPB. Moreover, extended TPB was utilized to analyze the acceptance of the reopening of the Philippine Bataan Nuclear Power Plant using SEM [28]. The latent variables that were considered were the following: knowledge about the power plant, attitude, perceived behavioral control, intention, risk perception, benefit perception, subjective norm, and technological acceptance. The Extended TPB approach was used by the researchers to deeply analyze and understand the theory through the use of SmartPLS. The data was shown in an expedient manner which shows the ordered data of the given latent variables [82]. This will determine the compatibility of the emerging results from the data simultaneously. This in turn may measure the investigation toward the acceptance of the reopening of the Philippine nuclear power plant with the integration of the PMT and the extended TPB [28].

3.4. Path structure variable

The researchers have discovered paths from the different published studies that provide the researcher's hypothesis, as the extended TPB approach was used in the following paths from the study of [32,28,83] that the following latent variables have direct relationships.

1. K →R: There is a direct relationship between knowledge (K) and Risk Perception (R). [28].
2. K →B: There is a direct relationship between knowledge (K) and Benefit Perception (B). [28].
3. R →S: There is a direct relationship between perceived risk (R) and subjective (S). [83].
4. B→S: There is a direct relationship between Benefits Perception (B) and Subjective Norms (S). [28].
5. S →I: There is a direct relationship between Subjective Norms (S) and Behavioral Intention (B). [45].
6. A →I: There is a direct relationship between perceived Attitude (A) and Behavioral Intention (B). [84].
7. PBC →I: There is a direct relationship between Perceived Behavioral Control (PBC) and behavioral intentions (B). [28].
8. B →TA: There is a direct relationship between perceived Behavioral Intention (B) and Technology Acceptance (TA). [28].

4. Results

4.1. Demographics profile

Through purposive sampling, 450 valid respondents participated in this study shown in Table 3. In selecting the respondents, the researchers carefully selected Generation Z citizens as respondents to the study. The following age group was grouped into 5 regardless of gender, ages 24-26, 20-23, 17-19, and 14–16 years. This study looked at how Generation Z perceives the concept of nuclear energy as an alternative source of electric energy. A total of 450 Filipinos belonging to Generation Z voluntarily participated in this study. Table 1 presents the descriptive statistics of the responses. It could be seen that 193(42.88%) were male while 241(53.55%) were female, the majority of which were within 20–23(50.5%) years of age. There were 6.7% within the age range of 14–16 years age, 37% from 17-19 years of age, 5.4% from 24 to 26 years old, categorized by region, most of the respondents are from the National Capital Region, 69.11% and the rest are coming from the other regions of the Philippines, and with the educational background, 71.0% are in college level. Lastly, as suggested by Sethuraman et al. (2005) and due to the COVID-19 pandemic, the responses were collected via Google forms distributed through different social media platforms [85].

Table 3
Respondent's descriptive characteristics (n = 450).

Characteristics	Category	N	%	Skewness	Kurtosis
Gender	Male	193	42.88	-.620	-1.02
	Female	241	53.55		
	Prefer not to say	15	3.33		
Age	14–16 years old	22	6.7	1.110	.384
	17–19 years old	119	37.5		
	20–23 years old	160	50.5		
	24–26 years old	17	5.4		
Education	College level	225	77.9	-.210	-.955
	Senior high school level	58	18.3		
	Junior high school level	12	3.8		
Location	Rural	136	30.9	1.092	1.742
	Urban	311	69.1		

4.2. Results of cross-tabulation

Apart from gender, age, education, and geographical entities. It also provided the skewness of the data ranged between -.620 and 1.192 and the kurtosis ranged between -.955 and 1.742, with the majority of the values close to zero as shown in Table 3. According to Kim and White [86], the closer these numbers are to zero, the more normally distributed the data is. Therefore, Table 3 provides normal distribution data.

Furthermore, the results of the cross-tabulation analysis are presented in Table 4. The majority of respondents who strongly supported NPP as an alternative source of electricity were male (53.6%). Likewise, the majority of respondents who strongly accepted NPP were 20–23 years old (65.9%). This age group also represented the majority who neither agreed nor disagreed with tourism development (49.6%). The majority of respondents who strongly accepted NPP belonged to the college level (84.4%) of the sample. This group represented 77.9 of the sample. Lastly, the majority of respondents who agreed (76.2%) and strongly agreed (81.8%) to NPP as an alternative source of electric energy lived in urban areas.

4.3. Results of SEM (initial)

Fig. 3 shows all the latent variables involved and constructed based on their importance. This figure also indicates the initial results for the acceptance of the generation z-citizen as nuclear energy as an alternative source of electricity with 8 latent and 31 items.

Table 5 and Table 6 show the values of the initial and final model's reliability and validity indicators. Items with initial loading values less than 0.700 were excluded from the final loading because the factor extracts represented insufficient variance from the variable [28,57,69].

Discriminant validity is tested using the Fornell-Larcker criterion and the Heterotrait-Monotrait correlation ratio to indicate the significant correlation among each variable and to evaluate the measurement model [87]. When a value between two reflective constructs falls less than 0.85 when using variance-based SEM for the Heterotrait–Monotrait ratio and when assigned constructs have a greater value than all other loadings for Fornell–Larcker, the discriminant validity is confirmed [57,88]. As illustrated in null 7 and 8, the values lie within the acceptable range, and the results indicate acceptable reliability and convergent validity. Therefore, the constructs' overall results are accepted.

4.4. Model of fit

A model fit analysis was performed to show the validity of the suggested model.

Table 9 shows that all parameter estimates exceeded the minimum threshold value, indicating that the proposed model is acceptable.

Additionally, Bootstrap samples are derived from modified sample data. This modification involves orthogonalizing all variables and then applying the model's implied correlation matrix. If more than five percent (>5%) of bootstrap samples produce discrepancy values greater than those of the actual model, it is plausible that the sample data come from a population that behaves in accordance with the hypothesized model [87]. The SEM fit indices were calculated using the goodness of fit measures such as the NFI, and SRMR SmartPLS$_{V.4}$ was used to create these indices. Gefen et al. [90] define 0.8 as a critical NFI value. This study yielded an acceptable NFI value of 0.811. Furthermore, according to Hu and Bentler [77] and Hair [80,81], SRMR must be less than or equal to

Table 4
Cross-tabulation results (n = 450).

Characteristics	Technology acceptance of nuclear energy as an alternative source of electricity (%)				
	1- Strongly disagree	2- Disagree	3- Neither agree nor disagree	4- Agree	5- Strongly agree
Gender.					
Male	66.7	28.6	37.2	50.0	42.9
Female	33.3	71.4	56.6	47.7	53.6
Prefer not to say	0.0	0.0	6.2	2.3	3.5
Age					
14–16 years old	0.0	0.0	5.4	5.9	1.1
17–19 years old	33.3	42.9	41.1	35.1	28.4
20–23 years old	66.7	42.9	49.6	54.5	65.9
24–26 years old	0.0	14.3	3.9	4.5	4.5
Education					
College Level	82.6	57.1	78.3	89.2	84.4
Senior High School	10.0	42.9	3.9	9.4	13.1
Junior High School	7.4	0	17.8	1.3	2.4
Region					
Urban	94.5	57.1	76	76.2	81.8
Rural	5.5	42.9	24	23.8	18.8

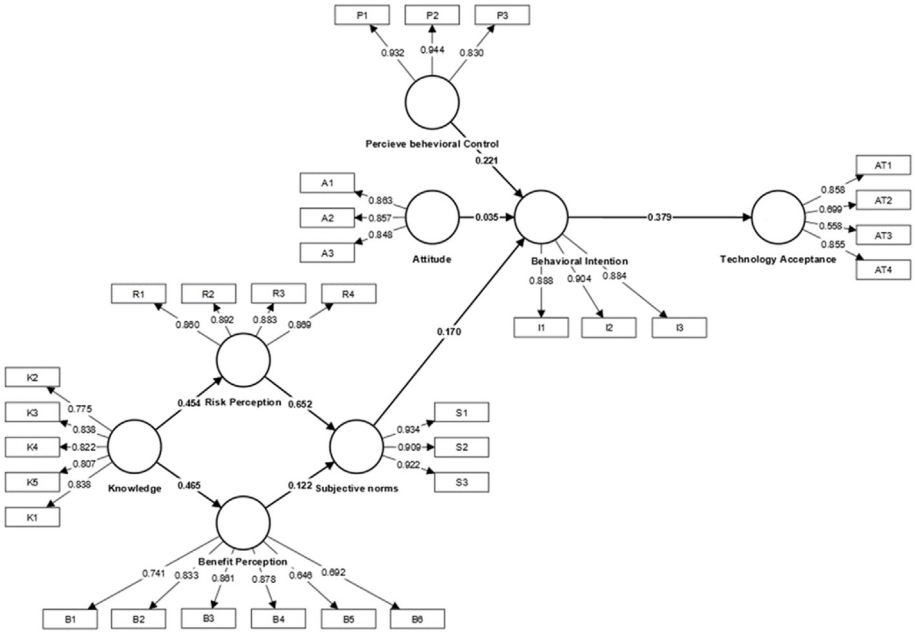

Fig. 3. The initial model.

0.08 (≤0.08) [77]. This study's SRMR is 0.077, indicating that a lower value yielded a more favorable result. As a result, the findings indicated that the data fit the final SEM framework well.

Subsequently, dG and dULS were considered to demonstrate the model's overall quality. These distance measurements can be used to calculate the difference between two matrices and contribute to the model fitness index in PLS-SEM in more than one way. The dG and dULS values were 0.603 and 1.915, respectively, indicating a perfectly matched measurement model. This implied that the model's quality was appropriate and efficient for explaining the data [91]. As shown in Fig. 3, the final SEM framework was developed based on these significant results.

4.5. Results of SEM (final)

Fig. 4 shows the final SEM results for the study acceptance of Generation Z citizens for nuclear energy as an alternative source of electricity after the deletion of unacceptable variables. The final SEM analysis for the factor of loading for the study was provided by Smart $PLS_{v.4}$ through the normal distribution of data.

The result is shown in Table 10. It could be seen that the acceptance of Nuclear Energy as an alternative source of electricity was significantly influenced by Behavioral Intention *($\beta = 0.378$, $p = 0.000$)*. Behavioral intention significantly influenced Subjective Norms *($\beta = 0.169$, $p = 0.027$)* and perceived behavioral control *($\beta = 0.222$, $p = 0.007$)*. Also, the Subjective norms significantly influence

Table 5
Initial and final model's reliability and validity indicators.

Latent variable	Scale items[A]	Mean	(s.d.)[B]	Factor loadings	
				Initial	Final[C]
Knowledge about Power Plant (K)	K1	3.640	0.924	0.775	0.775
	K2	4.104	0.842	0.838	0.836
	K3	3.656	0.922	0.822	0.826
	K4	4.053	0.896	0.807	0.809
	K5	4.071	0.888	0.838	0.834
Attitude (A)	A1	3.842	0.873	0.863	0.863
	A2	3.738	0.840	0.857	0.857
	A3	4.087	0.902	0.848	0.848
Perceived Behavioral Control (PBC)	PBC1	4.304	0.814	0.932	0.932
	PBC2	4.302	0.783	0.944	0.944
	PBC3	4.009	0.831	0.830	0.830
Behavioral Intentions (I)	I1	3.922	0.842	0.888	0.886
	I2	3.982	0.849	0.904	0.905
	I3	3.900	0.889	0.884	0.884
Risk Perception (R)	R1	3.789	0.889	0.860	0.860
	R2	4.007	0.877	0.892	0.892
	R3	3.860	0.915	0.883	0.883
	R4	3.929	0.875	0.869	0.869
Benefit Perception (B)	B1	3.149	1.140	0.741	0.747
	B2	3.600	1.006	0.833	0.871
	B3	3.716	0.967	0.861	0.891
	B4	3.604	0.992	0.878	0.909
	B5	3.329	1.044	0.646	-
	B6	3.424	0.885	0.692	-
Subjective Norm (SN)	SN1	4.009	0.831	0.934	0.934
	SN2	4.129	0.818	0.909	0.909
	SN3	3.933	0.890	0.922	0.922
Technological Acceptance (TA)	TA1	3.867	0.946	0.858	0.842
	TA2	4.171	0.883	0.701	0.768
	TA3	3.178	1.136	0.558	-
	TA4	3.889	0.937	0.855	0.853

[A]The items listed in this table are summarized for ease of presentation and comprehension, [B]s.d.: Standard deviation, [C]Tests that show that the data obtained through the questionnaire are adequate to perform the factor analysis Items with initial loading values < 0.700 were excluded from the final, α = Cronbach's (reability).

Risk Perception *($\beta = 0.656$, $p = 0.000$)* and Benefits Perception *($\beta = 0.113$, $p = 0.042$)*. Moreover, it was also revealed that Knowledge about the Nuclear Power Plant significantly influences Risk Perception *($\beta = 0.455$, $p = 0.000$)* and Benefits Perception *($\beta = 0.415$, $p = 0.000$)*. On the opposite, attitudes toward the use of NPP were discovered to have no significant effect and consider as a null hypothesis on behavioral intention *($\beta = 0.035$, $p = 0.486$)*.

Table 5 exhibits the data for the statistical indicator analysis showing the values of each latent variable to one another, revealing the final descriptive factor of loading. The reliability representation in Table 6 indicates the amalgamation reliability of the study. Moreover, Table 9 results show the effects (direct, indirect, and total effects) of the conducive relationship of the latent variables. Risk Perception relationships to Subjective Norms *(β=0.656)* present the highest direct relationship, followed by Knowledge of NPP to Risk Perception *(β=0.455)* and Benefits Perception *(β=0.415)*. Moreover, the *p*-value of 0.05 for all the paths was less than 0.05 except with the latent variable attitude towards the use of NPP to Behavioral Intention, which got the lowest effects *(β=0.035)* and considered a null hypothesis (*p*=.489). Considering the results obtained and collected in Fig. 4 and the discussion in this section, the hypotheses and results obtained are summarized in Table 11.

Fig. 4 illustrates the final SEM The beta coefficients and R^2 values were calculated to evaluate the hypothesis model. The model allocates 64.4 % of the variation to Subjective Norms, 30.7% to Risk Perception, 27.2% to Benefits Perception, 25.2% to Behavioral Intention, and 24.3% to Technology Acceptance. This proves that the model is adequate to explain or predict Generation Z's acceptance of nuclear energy as an alternative source of electricity, as an R^2 score of 20% or higher is considered high for behavioral intention research [55].

5. Discussion

Extended TPB is used to analyze Generation Z's acceptance of using nuclear energy as an alternative source of electricity. The researchers gathered 450 valid respondents throughout the country and even in the following countries, Germany, Brazil, and the Netherlands, through the online questionnaires with 31 questions. $SmartPLS_{v.4}$ was utilized by the researchers as the data analyzer to gather the SEM, enabling it to be used and interpreted to examine the relationship of each latent variable such as the knowledge about Nuclear Power Plant (K), Attitude (A), Perceived Behavioral Control (PBC), Behavioral Intentions (I), Risk Perception (R), Benefit Perception (B), Subjective Norms (S), and Technological Acceptance (AT). Direct and indirect relationships among the latent variables were divulged in the utilization of SEM in the acceptance of the Nuclear Power Plant among Generation Z citizens as an alternative source of electricity.

Table 10 illustrates the results among the relationships among latent variables showing the highest to lowest results as follows; $R \rightarrow S = 0.656^{*}$, $K \rightarrow R = 0.455^{*}$, $K \rightarrow B = 0.415^{*}$, $I \rightarrow TA = 0.378^{*}$, $PBC \rightarrow I = 0.222^{*}$, $S \rightarrow I = 0.169^{*}$, $B \rightarrow S = 0.113^{*}$ with a *p*-value of less than 0.05 and $A \rightarrow I = 0.035^{**}$ with a *p*-value of 0.489. This provides

Table 6
Composite reliability and confirmatory factor analysis.

Scales[a]		Λx	AVE	CR
Knowledge about Power Plant (K) *α=0.876*				
K_1	I am knowledgeable about the scientific principles of nuclear power plant generation.	0.775	0.667	0.909
K_2	I am aware of the risk of nuclear radiation.	0.836		
K_3	I understand the policies and plans of the nuclear power plant.	0.826		
K_4	I am aware what is Nuclear Power Plant (NPP)	0.809		
K_5	I understand that the nuclear power plant uses nuclear fission to utilize nuclear energy and can be an alternative source of energy	0.834		
Attitude (A) *α=0.818*				
A_1	It is good for society to use nuclear power plants.	0.863	0.732	0.891
A_2	The society will benefit by using NPP as alternative source of electric energy	0.857		
A_3	It is of great significance that the existing NPP will be rehabilitated and operated.	0.848		
Perceived Behavioral Control (PBC) *α=0.886*				
PBC_1	I think the rehabilitation of a Nuclear Power Plant will help our society.	0.932	0.816	0.930
PBC_2	I feel safe when a Nuclear Power Plant is near in our home.	0.944		
PBC3	I am confident with the quality and reliability of the NPP technology	0.830		
Behavioral Intentions (I) *α=0.871*				
I_1	I plan to switch to Nuclear Power Energy as a source of electricity in the future.	0.887	0.795	0.921
I_2	I plan to encourage others to switch on using nuclear power energy as a source of electricity in the future.	0.905		
I_3	I will acquire more knowledge of the operation of the nuclear power plant.	0.884		
Risk Perception (R) *α=0.899*				
R_1	The risk of the nuclear power plant is declining and become more calculated	0.860	0.768	0.930
R_2	An accident accompanied by environmental pollution, property loss, or health damage may occur at the site of the NPP and can be controlled.	0.892		
R_3	Generation Z citizens in the society that are near the NPP have many uncertainties.	0.883		
R_4	If a NPP accident happens the danger is very catastrophic and dreadful.	0.869		
Benefit Perception (B) *α=0.879*				
B_1	I know that nuclear power plants can produce cheaper electricity.	0.747	0.734	0.916
B_2	I know that nuclear power plants can produce low carbon electric energy	0.871		
B_3	Nuclear power plants increase local employment opportunities and revenue in the country.	0.891		
B_4	Nuclear power plants can help the economic growth of my country	0.909		
Subjective Norms (S) *α=0.911*				
S_1	I think I can influence different generation around me about the rules and procedures at operation of NPP	0.934	0.849	0.944
S_2	I think my associates will follow me in supporting NPP as alternative source of electricity.	0.909		
S_3	Important people around me expect me will support NPP as an alternative source of electricity	0.922		
Technological Acceptance (TA) *α=0.758*				
TA_1	It's time that NPP should be use in the country.	0.841	0.675	0.861
TA_2	I am favoring that NPP can be source of alternative electric energy.	0.768		
TA_4	It is acceptable to have the nuclear power plant operation nearby.	0.853		

AVE = Average Variance, CR= Composite Reliability, Λx = Factor Loadings, a = The scales used have been adapted from the literature shows in table 1.

Table 7
Discriminant validity: Fornell–Larcker criterion.

	Attitude	Behavioral intention	Benefit perception	Knowledge	Percieve behevioral control	Risk perception	Subjective norms	Technology acceptance
Attitude.	0.856							
Behavioral Intention.	0.214	0.892						
Benefit Perception.	0.113	0.295	0.857					
Knowledge.	0.422	0.292	0.415	0.816				
Percieved behevioral Control.	0.508	0.375	0.409	0.536	0.904			
Risk Perception.	0.254	0.332	0.749	0.455	0.595	0.876		
Subjective norms.	0.389	0.361	0.604	0.510	0.801	0.741	0.922	
Technology Acceptance.	0.368	0.378	0.593	0.457	0.642	0.657	0.731	0.822

Table 8
Heterotrait–Monotrait (HTMT) ratio.

Attitude	Attitude	Behavioral intention	Benefit perception	Knowledge	Percieve behevioral control	Risk perception	Subjective norms
Behavioral Intention	0.252						
Benefit Perception	0.141	0.332					
Knowledge	0.514	0.334	0.446				
Percieve behevioral Control	0.590	0.426	0.452	0.615			
Risk Perception	0.293	0.376	0.835	0.504	0.669		
Subjective norms	0.452	0.406	0.653	0.571	0.820	0.812	
Technology Acceptance	0.467	0.463	0.701	0.566	0.721	0.789	0.835

Table 9
Model of fit.

Goodness of fit	Estimates	Threshold	Reference
SRMR	0.077	<0.080	[77].
Chi-square (Adjusted)	3.766	<5.000	[77].
Normative Index (NFI)	0.811	>0.800	[89,90].

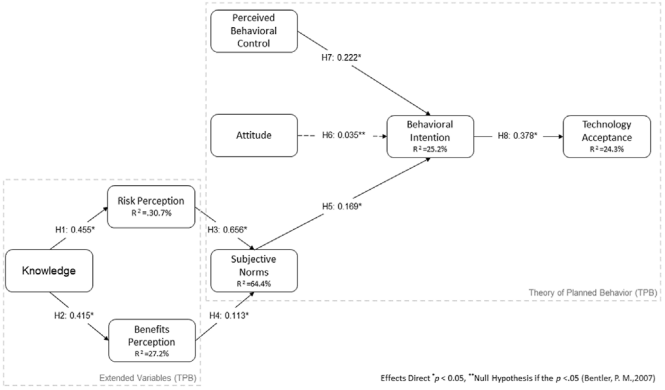

Fig. 4. The final model.

the direct causal relationship from the following latent, as the arrow suggested. Table 10 and Fig. 4 provide the data that shows the nullification of the causal relationship of A→I = 0.035**, p = 0.489**. This suggested the relation of Attitude to Behavioral Intention be nullified as the latent has resulted in significant adverse effects, thus showing its direct relationship. This indicates that the following latent hypothesis is insignificant in this study. As analyzed, the results of this study exhibit that the following (7) seven hypotheses of (8) eight were accepted as having direct and impressive effects.

The findings of this study showed that direct effect on Technology Acceptance, I→TA, (β = 0.378 and p = 0.000), thereby supporting H_8. The awareness, acceptance, and perception of nuclear energy as an alternative source of electric energy on the part of Generation Z were among the indications that revealed the causal relationship between behavioral intention and acceptance. Further, Generation Z will undoubtedly influence and encourage the adoption of this technology. Since the nuclear power plant's potential has been recognized, numerous studies have shown that an individual's comprehension of the technology can influence their social circle, resulting in a chain of influences and belief formation [92–98]. Following this, Ong et al. and Huang et al. indicated that society's acceptance of the power plant as a future energy source will improve. Acceptance of power plant positive outcomes may lead to acceptance of NPP as an alternate source of electricity [28,38]. The result showed how Gen Z is aware of the nuclear power plant, especially how it works, and understands it can be a solution to the challenge of energy shortage in the country.

The highest direct relationship between the latent was seen to exhibit in the relationship between the risk perception and subjective norms, Risk Perception (R) and Subjective Norms(S), R→S(β = 0.656; p = 0,000), thereby supporting H_3. This shows the knowledge of the generation z citizen regarding what a nuclear power plant is and the risk of this technology. Thus, this was contrary to the previous studies conducted by Ong et al. [28]. This indicates that an individual's subjective norms in accepting the NPP

Table 10
Direct, Indirect, and total effects.

No.[A]	Variable[B]	Indirect effect	p-Value	Direct Effect(β)	p-Value	Total effect	p-Value
H_1	K → R	-	-	0.455*	0.000	0.455*	0.000
H_2	K → B	-	-	0.415*	0.000	0.415*	0.000
H_3	R → S	-	-	0.656*	0.000	0.656*	0.000
H_4	B → S	-	-	0.113*	0.042	0.113*	0.042
H_5	S →I	-	-	0.169*	0.027	0.169*	0.027
H_6	A → I	-	-	0.035**	0.489	0.035**	0.489
H_7	PBC → I	-	-	0.222*	0.007	0.222*	0.007
H_8	I → TA	-	-	0.378*	0.000	0.378*	0.000
-	A → TA	0.013	0.507	-	-	-	-
-	B → I	0.019	0.153	-	-	-	-
-	B → TA	0.007	0.186	-	-	-	-
-	K→ I	0.058	0.036	-	-	-	-
-	K→ S	0.345	0.000	-	-	-	-
-	K → TA	0.022	0.067	-	-	-	-
-	PBC → TA	0.084	0.015	-	-	-	-
-	R → I	0.111	0.030	-	-	-	-
	R → TA	0.042	0.057	-	-	-	-
	S → TA	0.094	0.021	-	-	-	-

[A]Hypothesis, [B]Path Structural Variables, Effects Direct *p < 0.05, **Null Hypothesis if the p > .05 (Bentler, P. M.,2007).

Table 11
Summary of the results on hypotheses testing.

Hypothesis	Relations	Results	Significance
H_1	Knowledge about NPP → Risk Perception	Accepted	Significant
H_2	Knowledge about NPP → Benefit Perception	Accepted	Significant
H_3	Risk Perception → Subjective Norms	Accepted	Significant
H_4	Benefits Perception → Subjective Norms	Accepted	Significant
H_5	Subjective Norms → Behavioral Intention	Accepted	Significant
H_6	Attitude → Behavioral Intention	Rejected	Not Significant
H_7	Perceived Behavioral Control → Behavioral Intention	Accepted	Significant
H_8	Behavioral Intention → Technology Acceptance	Accepted	Significant

as an alternative electricity source would impact the risk perception. The study of Polat et al. [99] Cui et al. [100] and Ho S. et al. [83] explains the relationships between R and S. These studies had a result that showed a direct correlation between Risk Perception and Social Norms. It indicated that Generation Z would tend to criticize a certain behavior if they negatively perceive risk towards a particular subject matter. Concerning this study, Generation Z sees there are risk implications towards nuclear energy as an alternative source of electricity. Generation Z considered accidents that may happen upon operation such as health-related and nuclear radiation. In support, Huang et al., Wittneben and Turner indicated that Subjective Norms had a direct significant effect on Risk Perception, especially after the Fukushima nuclear accident, which influenced how Generation Z perceives the world as "unsafe" [22,38,101] However, they believe that with the existing technology and continuous innovation of NPP, the accident accompanied by environmental pollution, property loss, or health damage that may occur at the site of the nuclear power plant can be controlled.

This was seconded and supported by the relationship between the Knowledge about NPP and Risk Perception, Knowledge about NPP (K) and Risk Perception (R), K→R, ($\beta = 0.455$; $p = 0{,}000$) and followed by Knowledge (K) also had a direct and positive effect on Benefits Perception (B), K→B, ($\beta = 0.436$ and $p = 0.015$). Thereby supporting H_1 and H_2, respectively. The result demonstrated that Generation Z is aware of the power plant, mainly how it operates, and comprehends the NPP's energy generation for benefits and risks. This reflects the importance of recognizing knowledge about nuclear power plants as an alternative energy source regarding acceptability [28,38,102–104]. These constructs are illustrated by the detrimental effect of radiation, the negative impact on health and the nearby environment, and the potential for operational accidents. There may be dangers associated with the association. It is also found that if an individual's knowledge gravitates toward P.R., this can lead to nuclear power plant approval. Conversely, if an individual's information focuses on the Perceived Benefits, this will result in positive acceptance [28,38]. Furthermore, their perspective would impact the decisions of others. Then, Generation Z will accept NPP as an alternate source of Electric Energy due to their increased understanding of the technology. Salloum et al. [104], Zhu and Deng [105], and Meher and Mishra [106] stated in their studies that K is a determinant of P.B.s and P.R., which also affects the entirety of their constructs. Thus, knowledge of the NPP is the vital factor that will dictate their stance towards using NPP as an alternative source of electricity.

Consistently, in the Philippines, Ong et al. found that People's acceptance of nuclear power plants would be determined by their knowledge of this technology. People are more willing to utilize the BNPP as a green energy source that benefits society and helps the country's economic progress [28]. In South Korea, Lee found that even the Koreans identified the risk associated with NPP specifically greenhouse gas (GHG) and fine dust, however increasing the knowledge thru scientific evidence can increase their support for NPP [107]. In China, Wang et al. showed that knowledge among the public about nuclear energy significantly affected benefits. Results showed that people in China know how NPPs could benefit their country [31]. Other studies have shown that knowledge about power plants should be used to understand their benefits and influence on society. Furthermore, people's trust in the government to use renewable energy for the country's good would significantly impact their approval of the Nuclear Power Plant [38,108,109]. The findings were different from previous studies in that the Benefits Perception was the highest factor affecting Acceptance [28,38,60,110]. It is asserted that generation Z citizens know the risks of having a nuclear power plant in their country or region. As a result, they believe that the nuclear power plant as an alternative source of electricity will also improve their lives. They accepted the constructs that the Nuclear Power Plant can produce cheaper electricity, low carbon energy, employment opportunity, economic growth, sustainability, and technological advancement of their country. This concludes that, while there is a risk in this new type of technology, generation Z citizens believe it is an acceptable technological shift. Still, they see the risk as more significant than the benefits of NPP as an alternative source of electric energy. The perception of risk greatly affected the acceptability of NPP among Generation Z.

Perceived behavioral control shows a direct significant to Behavioral Intention, PBC→I, ($\beta = 0.222$; $p = 0{,}007$), thereby supporting H_7. It shows that the generation z citizen perceived and intended to use this alternative source for harnessing electricity as acceptable. It demonstrated that their perspective, understanding, and confidence in nuclear power plants as an alternative energy source influenced their willingness to embrace them. Numerous studies have found Perceived Behavioral Control to be an important component of intention. Vasquez et al. [111], Huang et al. [38] and Chen et al. [112] conducted studies demonstrating that PBC influences, decides, and predicts an individual's behavioral intention toward a particular topic. Ong et al. [28] found that people in the Philippines had good perceived behavioral control over their intention, consistent with the findings of Zhang et al. [7] and Hua et al. [47] in China and Park et al. [113] in Japan. The results revealed that knowing the benefit will lead to a positive PBC toward acceptance. This demonstrates how PBC directly impacts intention, leading to the adoption of this Generation in NPP as an alternate source of electric energy. According to the constructs, respondents intended to accept the NPP as an alternative source of electricity due to safety, technological advancement, lower electricity costs, and knowledge of how power plants operate.

The lowest direct relationship between the latent among other hypotheses was seen to exhibit in the relationship between the Subjective Norms(S) and Benefits Perception(B), B→S ($\beta = 0.113$; $p = 0{,}000$), thereby supporting H_4. Numerous studies have identified social norms as a determinant of benefit perception [28,83,114,115]. The findings revealed that a Generation Z social circle's acceptance directly impacted their comprehension of the economic, environmental, and societal benefits of the Nuclear Power Plant as an alternative source of electricity. The association with others influences the intention of using another utilizing Nuclear Energy as an alternative energy source. Subjective Norms are considered a strong component; comparative research explores how a person determines whether or not to utilize or accept an event or technology based on the preferences of those around them [116–119]. If others accept it, the individual will likely accept it as well, deciding to have positive intentions. Additionally, Ho et al. [83] and Utami C.W [120]. observed that the more favorable a behavior is, the greater an individual's intention to accept it. Subsequently, Manning claimed that people had the propensity to appreciate or criticize activity based on the disposition of risk and benefits. Consequently, this clarifies the direct relationship between Benefits Perception and Subjective Norms [121]. This supports the notion that the relationship between Subjective Norms (S) and Behavioral Intention(I) does indeed have a direct impact on the acceptance of Nuclear Energy as an alternative source of electricity, S →I, ($\beta = 0.169$; $p = 0.027$), thereby supporting H_5. Highlighted four sub-dimensions of Benefits Perception: hedonic benefit, conceive benefit, economic benefit, and variety. This pertains to the positive effect of B on S mentioned in this study.

Interestingly, H_6, Attitude (A) shows not significantly supported Behavioral Intention(I), A→I ($\beta = 0.035$; $p = 0.489$). Given the importance of the attitude variable, the result of this study shows that attitude is not supported by behavioral intention to use NPP as

an alternative source of electric energy among Generation Z. Since this was the first study to investigate the acceptance of NPP among a specific generation, this could have affected the relationship between attitudes and behavioral intention. With this, the demographic characteristics of this research sample may differ from previous studies, and this could have impacted their attitudes and behavioral intentions toward NPPs. Among other generations, Generation Z was the most tech-savvy and had easy access to information [122–124]. Also, this was supported by the results of this study, which showed that Generation Z has a high level of knowledge and is well-informed about NPPs, and as such, their attitudes towards NPPs may have been more nuanced and not directly translated to their behavioral intentions. Moreover, attitudes toward NPPs among Generation Z are more complex than in other contexts, and as such, the relationship between attitude and behavioral intention is not as strong. Generation Z has more informed views on the environmental effects of nuclear power plants and new safety and security concerns. This is one of the major contributions of this research since the role of attitude on behavior intention is a relatively less investigated area in the context of nuclear energy.

Furthermore, it was evident from the results that perceived economic growth, employment opportunities, and the effect on local electricity prices are significant determinants of perceived benefits. In addition, technological advancement creates employment, sustainability, environmental, cheaper electricity, and societal benefits are also included in the Benefits Perception. But still, in this study, it could be seen that the Risk Perception ($\beta = 0.455$; $p = 0{,}000$) outweighs the benefits of this generation's perception of using nuclear energy as an alternative source of electric energy. Surprisingly, this was contradicting with the recent study of Alzahrani, that among [125].

Lastly, Table 10 specify the indirect relationships of the following latent variables, A → TA ($\beta = 0.013$; $p = 0.507$), B → I ($\beta = 0.019$; $p = 0.153$), B→ TA ($\beta = 0.007$; $p = 0.186$), K → I ($\beta = 0.058$; $p = 0.036$), K → S ($\beta = 0.345$; $p = 0.000$), K → TA($\beta = 0.022$; $p = 0.067$), PBC → TA($\beta = 0.084$; $p = 0.015$), R → I ($\beta = 0.111$; $p = 0.030$), R → TA ($\beta = 0.042$; $p = 0.057$), S → TA ($\beta = 0.094$; $p = 0.021$). This provides that the A → T.A. ($\beta = 0.013$; $p = 0.507$) and followed by B → T.A. ($\beta = 0.007$; $p = 0.186$), having the highest indirect relation, which states that Attitude and Benefits Perception with Technology Acceptance has the highest indirect relations among the latent variables. This also indicates that the attitude of generation z citizens towards the use of Nuclear Energy as an alternative source of electricity does not partake in any relation to technology acceptance. This also signifies a firm stand of generation Z that, compared to risk perception, benefits perception does not affect how they are going to accept nuclear technology.

5.1. Practical and managerial implications

Understanding the acceptance of technology is critical, particularly in the case of nuclear power plants as an alternative source of electricity. This was the first study to examine the acceptance of Nuclear Technology utilizing a specific generation. As a result, providing insights to academic institutions, energy regulatory agencies, and industry may aid in discovering nuclear power plants' acceptability as an alternative source of electric energy among Generation Z. It is important to look at the acceptance of Generation Z since this group of age is considered the key to any nation's future and growth, in which very vital in sustainability of NPP [33]. The findings of this study may also assist the government in better understanding how to increase the acceptability of NPP as an alternative energy source. The results of this study could also help regulatory bodies, policymakers, and risk assessment managers strategize how to assess the acceptability of nuclear technology in a nation. Moreover, this study found that risks can outweigh the benefits from the perspective of technology acceptance.

5.2. Theoretical contribution

This study used the Extended Theory of Plan Behavior (TPB), utilizing other factors such as knowledge, risk perception, and benefit perception; Generation Z is considered the key to any nation's future and growth, and the findings of this study may also assist the government in better understanding the acceptability of NPP as an alternative energy source for electricity. Aside from this, Prasetyo et al. [70], Gumasing et al. [69], and Ong et al. [28] also stated that this integrated model can be utilized for the investigation of different natural disasters around the world. Mitigation plans and knowledge measurement of disasters and phenomena could also be evaluated using integrated theories [28,70,126–128]. Moreover, this model can also be used and adopted by other countries to study the acceptability of nuclear energy. Lastly, SEM as a tool could holistically measure the different latent variables that may be included in various studies.

5.3. Limitations and future research directions

Despite the study's success and outcomes, there were several limitations. First, the results are only applicable in developing countries like the Philippines, and to other generations, as they are likely not to be implemented in different first-world nations or societies due to political, social, environmental, technological, legal, and economic backgrounds, which may not be representative of a broader population.

Second, the selected factors did not capture all the variables influencing the consumers' acceptability to use an NPP as an alternative source of electricity. This indicates that subsequent future studies should examine other factors such as public trust in the government, energy costs, and environmental impacts, which influence the acceptability of NPP.

Third, Future research could develop predictive models to forecast public opinion on the acceptance of nuclear power plants based on specific social, economic, and environmental factors. Lastly, future studies might utilize different data mining approaches, such as machine learning, Artificial Neural Networks, and network analysis, to gain a better understanding of the factors impacting nuclear power plant acceptability.

6. Conclusion

Nuclear energy is one of the renewable resources harnessed in technological advancement. Thus, the risk and perception of different age groups have other intentions, knowledge, subjective norms, attitude, and technological acceptance. Still, in this study, the researchers determined that risk perception and subjective norms show the highest latent relationships. Using partial least square structural equation modeling (PLS-SEM), it was shown that Risk Perception and Behavioral Intention had the greatest impact on Nuclear Technology Acceptance. Furthermore, perceived characteristics positively affected behavioral intentions to adopt nuclear technology. Knowledge benefits perception and Risk Perception positively influences subjective norms and Behavioral Control and subjective norms.

On the contrary, attitudes were shown to have a negative effect on behavioral intentions and no significant effect on Generation Z's behavioral intentions to adopt nuclear power plants as an alternative energy source. Moreover, risk and benefit perception directly influences the adoption of nuclear technology; nonetheless, the

risk outweighs the benefits of acceptance of nuclear technology. As a result, the risk perception among Generation Z in accepting nuclear energy as an alternative energy source must be addressed by increasing knowledge transfer. Lastly, with these findings the commissioning of a Nuclear Power Plant as an alternative source of electric energy must consider in developing countries.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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