Conventional to Renewable Energy Sources - Shifting Trends: Modeling the Public Perception

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Acronyms & Abbreviation

χ^2	chi-square
Df	Degrees of freedom
χ^2/df	Chi square/ degrees of freedom
GFI	Goodness of fit
NFI	Normed fit index
TLI	Tucker Lewis Index
CFI	Comparative fit Index
RMSEA	Root mean Square error of approximation
RES	Renewable Energy Sources
SEM	Structural Equation Modeling
EFA	Exploratory Factor Analysis
CFA	Confirmatory Factor Analysis
MW	Mega-watt
NTDC	National Transmission and Dispatch Company
GHGs	Greenhouse Gases Emissions
GW	Giga-Watt
KW	Kilowatt
MW	Mega-Watt
WAPDA	Water and Power Development Authority

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Abstract

Renewable energy sources (RES) are abundant in Pakistan, however its share in the energy mix is lower than the conventional sources like the fossil fuels. The development and adoption of renewable energy technologies at small, medium and large-scale face hurdles in Pakistan like many other developing countries. One of the major hurdles is public acceptability of the RES technologies. This study has very first time in Pakistan investigated the main drivers of public acceptance of energy transition towards RES at the household level in Pakistan. The Theory of Planned Behavior provided the theoretical model, which was extended to measure the public willingness towards the adoption of RE technologies. To assess the public willingness, a large sample of 700 students was taken from National University of Sciences and Technology, Islamabad Pakistan. The empirical data was analyzed by using the Structural Equation Modelling. Self-identity, intention and price appeared as significant drivers in changing the public behavior. Based on the results, it is suggested that renewable energy policy should combine the monetary incentives to increase public awareness and acceptance at household level for a smooth energy transition in Pakistan.

Keywords:
Renewable Energy Sources, Energy Transition, Theory of Planned Behavior, Sustainable Policies, Structural Equation Modelling, Pakistan.

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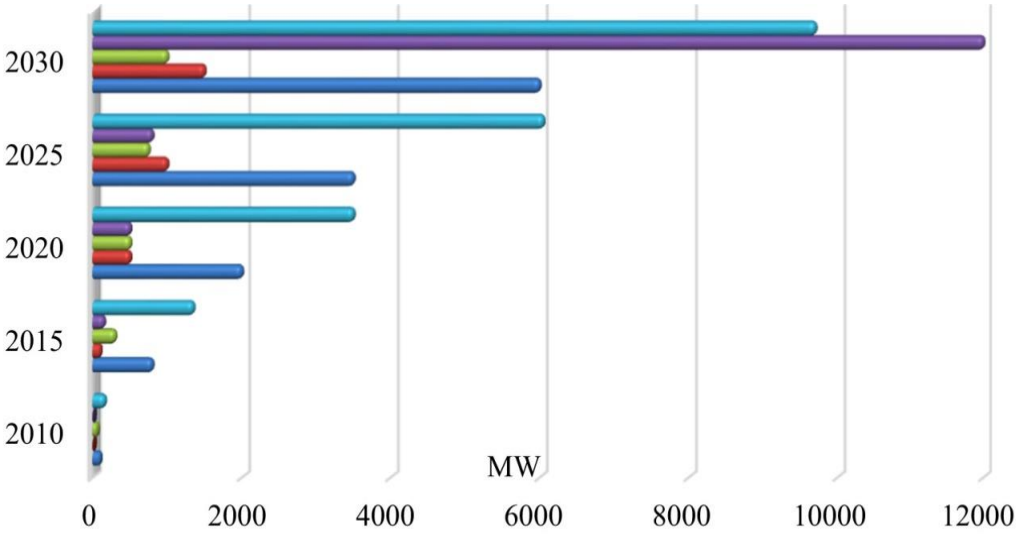
Chapter 1. Introduction

The energy transition towards renewable energy resources started in many countries, of which some have shown tremendous success. Despite increasing trend towards renewable energy adoption, public acceptance is still one of the major pre-requisites for the success of energy transition in many countries. Developed countries have also faced the problem of public acceptance in the transition process towards renewable energy technologies, for instance many energy transition projects saw a doom in Greece, Spain and the United Kingdom [13, 18, 19, 20]. The scientific research also considers this as a major factor of significant importance to study the public perception before implementing a largescale energy transition project. This factor determines the public will towards the use and development of renewable energy infrastructure[6-8].The public perception also plays a central role in any legislative initiative in the contemporary world [9]. The absence of such approach resulted in the big protest against the waste energy generation in Greece [10] and wind power plants/micro-power plants in the United Kingdom [11, 12]. Hence, the awareness, perception and acceptance by the general public are major factors of a society that must be considered for the development of future energy infrastructure and energy transition models[13, 14]. There are multiple examples of future initiatives that ignored such critical social factors, in industries like organic agriculture and modified edibles, and led to the failure and rejection of these emerging and innovative scientific ventures[15, 16].

1.1. Background and Current Situation in Pakistan

Over last couple of decades, Pakistan has relied more on fossil fuels for meeting its energy requirements which has exposed the energy sector to several issues such as the supply shortages, environmental degradation and the circular debt[1]. The energy transition towards RES is quite slow in Pakistan. The share of hydro in overall energy-mix for power generation has fallen to 27 % and the share of other renewables has restricted to 2% until 2019[2] against its approximate potential of 2.9 million MW in solar, 346000 MW in wind, 45000 MW in hydropower and above 2000MW/day from biomass[3]. Recently, the government has planned to increase

the share of renewable energy in energy mix for power generation (as shown in Figure 1.1).



	2010	2015	2020	2025	2030
Total	162	1350	3500	6050	9700
Small hydro	1	150	500	800	12000
Biomass	60	300	500	750	1000
Solar	1	100	500	1000	1500
Wind	100	800	2000	3500	6000

Figure 1.1: Pakistan Government plan for promotion and utilization of renewable energy sources[25,27]

In order to increase the share of renewable resources in energy mix, the government has initiated several projects at national grid level and decentralized level in solar, wind, hydel and biomass energy which are in the different phases of development. Currently, the contribution of wind energy in the energy mix for power generation is above 1000 MW, solar 500 MW, hydel (including micro-hydel) 8700 MW and bagasse adds 400 MW to the national power system[4], shown in Table 1.1. The focus of previous and current government towards renewables has also attracted the citizens for RES especially solar energy at homes and offices[5].

The energy transition towards renewable energy resources started in many countries, of which some have shown tremendous success. Despite increasing trend towards renewable energy adoption, public acceptance is still one of the major pre-requisites for the success of energy transition in many countries. Developed countries have also faced the problem of public acceptance in the transition process towards renewable energy technologies, for instance many energy transition projects saw a

doom in Greece, Spain and the United Kingdom [13, 18, 19, 20]. The scientific research also considers this as a major factor of significant importance to study the public perception before implementing a largescale energy transition projects. This factor determines the public will towards the use and development of renewable energy infrastructure[6-8].

Table 1.1: Total Installed Generation Capacity of Pakistan in MW [4]

Description	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Hydel						
WAPDA Hydel	6,733	6,902	6,902	6,902	6,902	8,341
IPPs Hydel	195	195	213	213	213	348
Thermal						
GENCOs with PEPCO	4,841	5,458	5,788	5,788	5,818	5,662
KE Own	2,341	2,422	1,875	2,295	2,295	2,267
IPPs						
IPPs connected with PEPCO	8,381	8,793	8,857	8,842	12,685	15,138
IPPs connected with KE	289	228	352	349	339	443
Nuclear						
CHANUPP (PAEC)	650	650	650	650	990	1,345
KANUPP (PAEC)	137	137	75	75	75	137
Renewable						
Solar	0	0	100	400	400	400
Wind	50	106	256	306	782	985
Bagasse	0	0	83	146	281	306
Total PEPCO	20,850	22,104	22,849	23,247	28,072	32,525
Total KE	2,767	2,787	2,302	2,719	2,709	2,847
Total Installed Capacity	23,617	24,891	25,151	25,966	30,781	35,372

The public perception also plays a central role in any legislative initiative in the contemporary world [9]. The absence of such approach resulted in the big protest against the waste energy generation in Greece [10] and wind power plants/micro-power plants in the United Kingdom [11, 12]. Hence, the awareness, perception and acceptance by the general public are major factors of a society that must be considered for the development of future energy infrastructure and energy transition models[13, 14]. There are multiple examples of future initiatives that ignored such critical social factors, in industries like organic agriculture and modified edibles, and led to the failure and rejection of these emerging and innovative scientific ventures[15, 16].

Few studies also exist in Pakistan that explored the transition or adoption of solar energy at household level [17] and various economic factors that might attribute to the adoption of photovoltaic electric power in Pakistan[18] but these studies are not enough. To measure the public perception towards renewable energy transition in Pakistan the research area is largely vacant. This study will try to fill that gap and put foundation to expand this research further to other areas nationally and aiding the same internationally.

The statistical data, on public acceptance of RES is largely unavailable and almost missing in Pakistan. This study aims to fill this gap to a certain level. On one hand, this will kick-start the research in this area and on the other hand will model the role of public acceptance in RES adoption for ascertaining the future of energy sector in Pakistan. It will also provide insight for renewable energy policy in Pakistan. The data for this study will be collected through a comprehensive survey which will further be used in Structural Equation Modeling (SEM) for modeling the public perception of transition towards RES in Pakistan.

1.2. Research Aim

The aim is to study this least researched area in Pakistan and put foundation for such studies in Pakistan. To derive empirical results that can guide towards the strategy and guidelines as to how should we proceed in future to inculcate the RES in our energy stream. A scientific result of the current trends of shifting from conventional to renewable energy sources in our society is targeted to be obtained and analyzed.

1.3. Research Objectives

To model the public perception of transition from conventional to renewable energy sources in Pakistan:

- To study the Attitude, Subjective Norm, Perceived Behavioral Control, Moral Norm, and Self-Identity effect on a persons' behavior of shifting from conventional to RES.
- To observe and analyze how Price and Technological Access moderates the individual's behavior.
- To provide policy implications based on our statistical results.

1.4. Research Questions

- What affect does Attitude, Subjective Norm, Perceived Behavioral Control, Moral Norm and Self-identity, has on the output behavior of the shift towards RES in Pakistan?
- How does the Price and Technological Access moderate a person's behavior to move from conventional to RES?
- Is it possible to devise and confirm a model that can be a used for future studies?

1.5. Justification for the Research Topic

For the last two decades, there has been an increased emphasis – by the scientist, governments and the policy makers – to shift from conventional and environmentally damaging energy sources towards the sustainable and cleaner renewable sources. The statistical data, as to how much the public has accepted this change and whether they are inclined towards the thought, is largely vacant and almost missing in Pakistan. This study will attempt to fill that gap (to a certain level) in Pakistan.

1.6. Significance and Scope

The scope of the study would be limited to the Graduate and Undergraduate students of NUST, Islamabad – primarily focusing on the engineering streams. The target audience of the study would mostly comprise of youth in the age group of 25 – 35. As these are the people who will shape the energy consumption trends in the coming decade. They would be the policy makers who will shape he energy future of the country in the decades to come.

The study is significant – as already discussed the absence of such studies caused major failures in many countries (developed and under-developed) Hence, for Pakistan to chart a successful energy future, such studies hold paramount importance. And must be carried out in future too, at a larger level, to ascertain the trend in major geographical scope. It would give a clear picture whether to proceed with a certain energy initiative or not.

1.7. Thematic overview

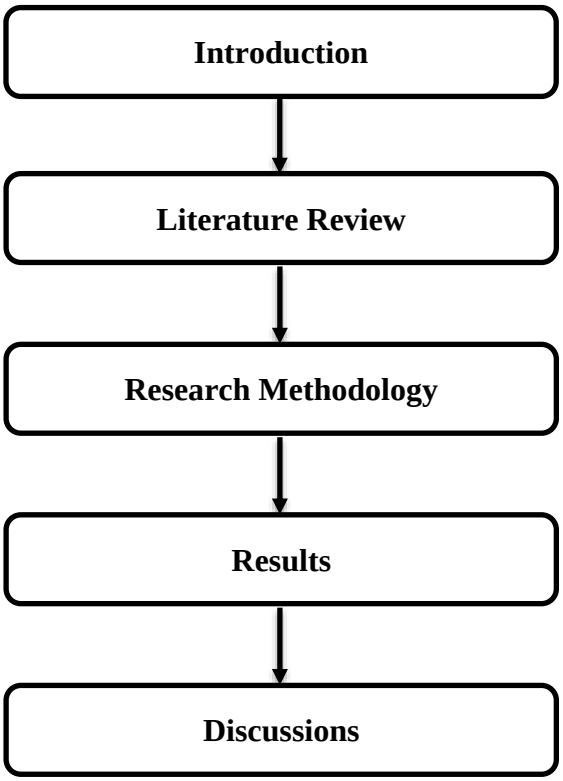


Figure 1.2: Flowchart of Research

1.8. Summary

Since its conception Pakistan has been facing energy shortfalls continually. It has been long seeking a sustainable and consistent energy supply. From hydel energy to oil/gas-based power plants to nuclear to coal generation to finally a renewed focus towards the renewable energy sources like solar, wind, waste, and biogas energy generation. There have been a lot of success and failures when it comes to the large-scale public initiatives, specially to government policy level. The RES having large upfront cost needs to be dealt with and incorporated in the society with extreme care. Without knowing the public perception towards these sources, the can be a huge set-back. Hence, it is important to study the public perception of shifting from conventional to RES. It will aid to devise policy measure to successfully plan the energy future of Pakistan and avoid the unfortunate outcome of the UK and Greece etc in wind and waste power generation etc.

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Chapter 2. Model Specifications

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According to the theory of planned behavior, *intention* determines whether a person will be willing to adapt a certain behavior or not, like shifting from conventional to renewable energy sources[21, 22]. Its feasibility depends on the way that person intends to fulfill his/her energy demands [21-23]. The intention of a person varies greatly with certain key factors like the attitude, subjective norms, perceived behavioral control (PBC), moral norms, self-identity and monetary preferences of the individual [21, 22, 24-26].

A person's response towards the overall evaluation of a behavior, as being favorable or unfavorable, is termed as the 'Attitude' [21, 27]. However, empirical research shows that both the instrumental and experiential factors of the attitude must be kept in mind while taking the response [21]. The attitude towards the society's betterment generally, and shifting to the renewable energy sources specifically, is of fundamental importance to measure this shift. Attitude has been incorporated in multiple studies and holds a fundamental importance in majority of social experiments and behavioral modelling. Such hypothesis development was supported by studies conducted by Ajzen, Woke and Yazdanpanah[21, 22]. In this study, it is intended to model how attitude of a person affects the tendency to shift from conventional to Renewable Energy Sources.

Whether a behavior is performed or not in response to the pressure or norms recognized by the society constitutes the 'Subjective norm'[24].In order to measure the subjective norm, questions from several aspects should be asked to cater the problem of significant other that might affect the respondent's answers directly and it has also been incorporated in many studies [21, 24]. Hence, the questions were designed to capture the descriptive norms too. i.e., as to how much the significant others (important others) have themselves accepted or avoided the shift from conventional to Renewable Energy Sources. It is the degree to which the people influencing the respondent's behavior have themselves adopted the shift. Also a few injunctive questions can be restructured to take on a descriptive quality, like it is important for the respondent that a certain person behavior towards adapting RES is positive or negative. Thus, taking such subjective norms under consideration.

The ease or difficulty of the people to perceive a given behavior themselves is termed as the 'Perceived Behavioral control (PBC)' [23, 26].It can be termed as to what point the behavior is under volitional control [28]. It is shown in figure 2.1. It gives a direct measure of the respondent's ability to show a certain behavior. It determines the self-efficacy of the subject. i.e. either the individual can shift from conventional to RE sources or not. In addition to self-efficacy it also shows a person's 'controllability' towards the shift. It addresses the issue of a person's belief that he/she has control over the behavior and it is not being totally influenced by some external factor[21, 22, 29].

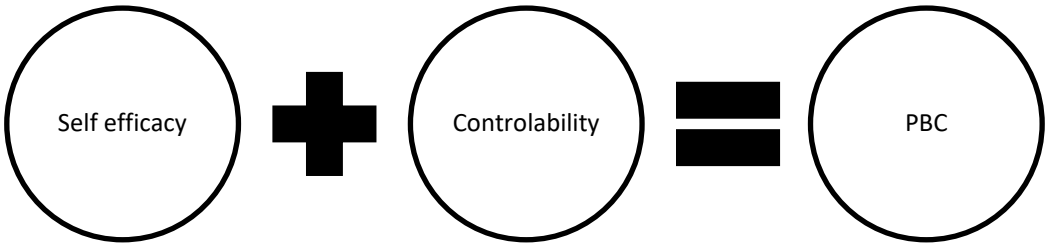

Figure 2.1: Perceived Behavioral Control

Although, the Theory of Planned Behavior has been applied in various studies for predicting behaviors [26, 30-32], the theory is still in the developing phase where researchers have been adding other constructs to enhance the behavioral predictability[33, 34]. It is also because, the ongoing research on the application of existing constructs of the Theory of Planned Behavior in predicting human behaviors is continuously exposing new predictors which may have influences over the individual behaviors[24]. Other studies have also shown that moral norms and monetary preferences influence the intention[25].This paper will also see the impact of those aspects on intention of shifting from conventional to RE.

Inner rules or values, propelled by anticipated self-directed benefit or loss, towards a behavior make up a person's "Moral Norms"[27]. The construct of moral norm, added in this study, has been conceived from the Schwartz's Norm Activation Theory [35]. Schwartz claimed that "personal moral norms" motivate individuals to pro-environmental actions. "Personal moral norms become activated when individuals believe that environmental conditions pose threats to other people, other species, or the biosphere. Environment-related threats might shape the individuals' actions for averting the consequences [36]. Kaiser and Scheuthle have found the moral norms as an important construct for predicting a person's intention for conservation [37]. The extended theory of planned behavior takes moral norm as an

individual judgment towards a behavior whether right or wrong[33, 34]. In this study, the moral norm is perceived to provide insight for individual's belief on shift from conventional to RES.

Self-identity is the way in which one perceives his/her own self. It is largely being used for the prediction of the behavioral intention in the Theory of Planned Behavior [33, 38]. The concept of self-identity was introduced by Stryker Identity Theory [39]. As per the theory, the self-identity is a set of roles – constructed and assigned by the society – which reflect upon the extent to which one fulfills its particular social role [40]. As per Stryker, different societal roles were proposed to describe different components of one's self. Thus, making it a core idea to the identity theory in both psychological and practical terms as both are intricately connected to each other [41-43]. Generally, self-identity is used by the individuals to describe themselves, in addition to having significant influence on their intention [44]. Many studies have incorporated the Self-identity to predict the behavioral intention in diverse areas [34, 45]. Also an increasing body of research signified that self-identity is an important interpreter of behavioral intentions [34]. For Example, Sparks and Shepherd [46] theoretically argued that self-identity influences the intention via attitudes. The research established that to purchase the organic produce, self-identity acted as an important independent variable of intention for green consumers. Hence, it has been incorporated as an independent construct in the research, as a predictor of the behavioral intention.

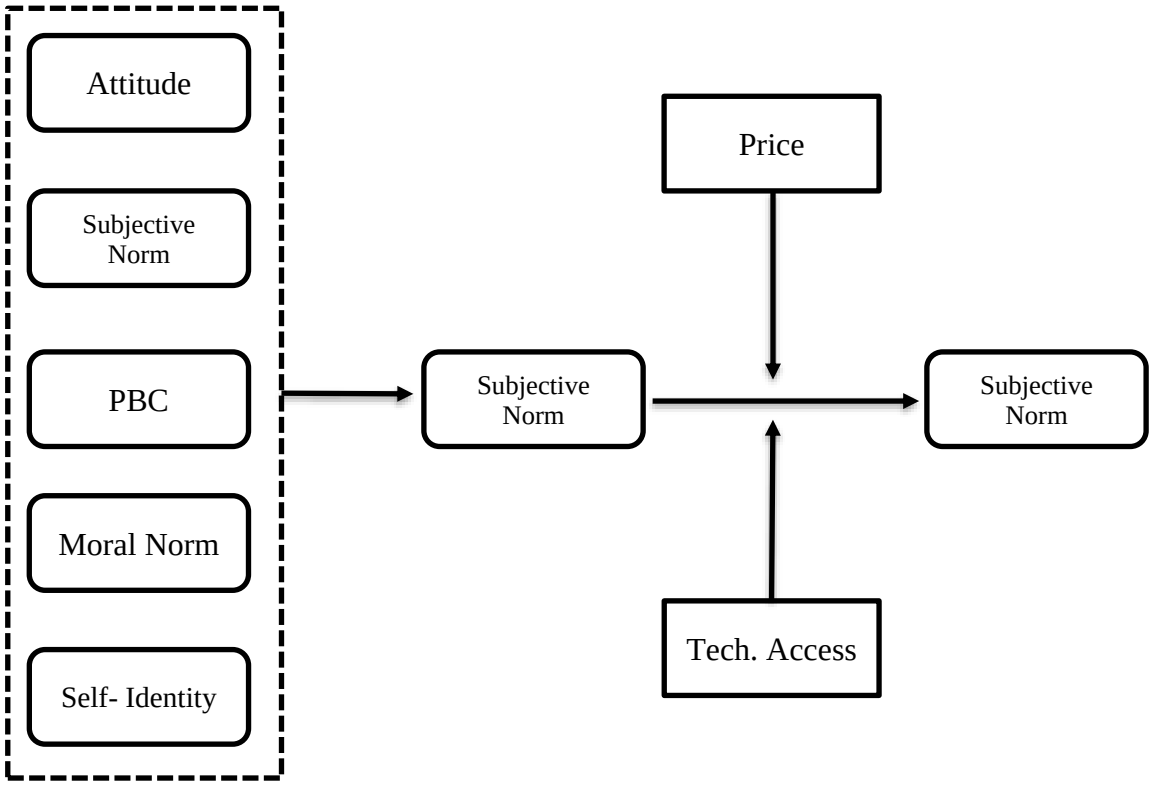

Figure 2.2: Theoretical Model

Attitude, Subjective norm, perceived behavioral control, Moral norm, and Self-Identity were the independent variables that affected the respondents' intention. After the intention is assessed, to model the output behavior that is going to be practically transcribed into the reality, a couple of moderators were introduced. It caters for their significant affect upon the respondents' behavior since they are the market/external factors and may not be in an individual control. Hence, price and technological access were intergraded into the theoretical model as the moderating variables. Researchers have included price and technological access along with or independently as the constructs to predict the individuals' behavior towards the adaptation of a certain technology [47-49].

Price is the cost incurred upon an individual for a specific activity. In this study, Price is the additional cost that is incurred by the respondent if he/she moves towards renewable energy sources. Since, the cost of RES is generally high; it is a hindrance in the way of the individual to adopt RES. Many are also of the view that the initial cost must be low rather the long term reduced operating costs. This cost bias is more prevalent in countries like India (same conditions prevail in Pakistan too), where main chunk of low income population cannot afford huge upfront costs[48, 49]. The price has been included as a moderator variable between the

intention of an individual and the output behavior (Figure 2.2). The rationale behind this is that the intention is intrinsic and a personal trait of an individual. While after having the intention to shifting towards the RES, the cost incurred to fulfill the intention is a major factor in this regard. In this study, both have been included, the principal cost and the long-term effects of the cost to get an exact impact of price upon the respondents' behavior.

Technological access corresponds to the availability of the relevant renewable energy harnessing technology in a respective region. As, RES are harnessed using latest technology and the 3rd world countries, like Pakistan, lag considerably in development and mass production of such technologies. Thus, their availability to the general public needs to be put into the perspective. The availability of renewable energy technologies in the local market depends on domestic production and incentives for importing those technologies from other countries. Due to lesser production within the country, a large volume of renewable energy technologies is imported. Those technologies are mostly available in the major cities and in some towns and rural areas to a lesser extent. Many people are not using the available technology due to the lack of information and awareness [47]. The lack of credit facilities at the micro-level is also an issue for the lower income population to get a support for the technological shift [48]. Due to its importance in the Pakistani perspective, technological access has been included in this study as a moderator variable to see the impact on the behavior of various respondents.

Based on the theoretical model shown in Figure 2.2 and dynamics of the constructs, eight hypotheses were developed and further tested for their viability (Figure 2.3). Annexure III show the possible questions from the relevant literature to enquire about the different constructs of the study.

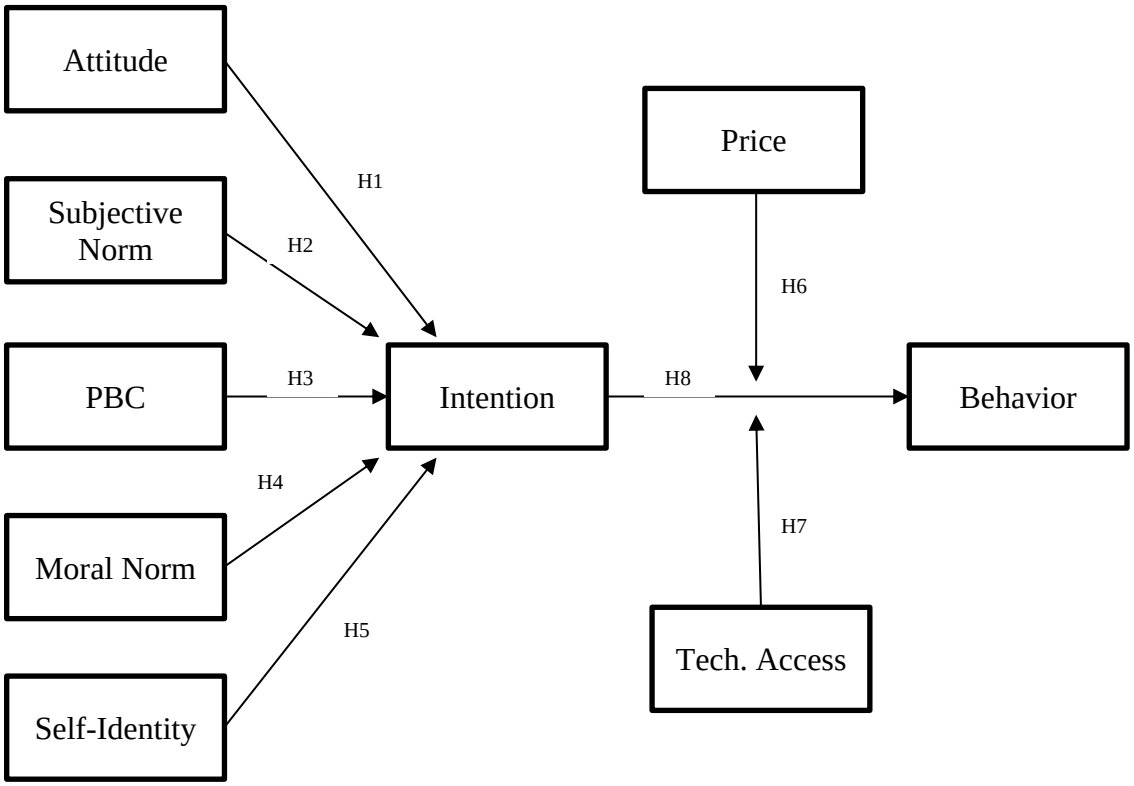

Figure 2.3: Hypothesized Research Model

The hypotheses are described as follows:

H1: Attitude of shifting from conventional to RES has a positive impact on Intention.

H2: Subjective norms towards the shift have a positive impact on Intention.

H3: PBC of tendency to shift from conventional to RES has a positive impact on Intention.

H4: Moral Norms realizing the impacts of the shift have a positive impact on Intention.

H5: A Self- Identity tilted towards the RES has a positive impact on Intention to shift.

H6: High Price would lead to less shift from conventional to RES and vice versa.

H7: Technological access increases the shift from conventional to RES and vice versa.

H8: An intention to shift has a positive impact on the actual behavior and vice versa.

2.1. Summary

This chapter presents the literature studied about successful development of our theoretical model as well as the hypothesis and questionnaire for further study. Theory of planned behavior was the basis that was further incorporated with the extended theory of planned behavior o inculcated additional variables Finally the moderator variables were included in the study to further enhance the data and get an in-depth analysis about the public perception of shifting from conventional to renewable energy sources. The literature review revealed that not much studies have been carried out in this field and specially in Pakistan the area is largely vacant. Due to the absence of precedents in Pakistan, a comprehensive effort was made to develop this model.

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Chapter 3. Research Methodology

3.1. Research Philosophy and Approach

Structural Equation Modelling (SEM) has been applied in this research for modelling the constructs and testing the hypotheses developed in Section 2. A step by step approach, from the development of the idea to the conduction of survey to the application of scientific procedures and the analysis of the results was adopted. All the steps were designed and implemented by the researchers due to the unavailability of the statistical data as no surveys for data collection were conducted earlier to assess the public acceptance of energy transition in Pakistan. In that regard, "Theory of Planned Behavior" helped to model and analyze the societal tendency towards the transition.

3.2. Analytical Research Process

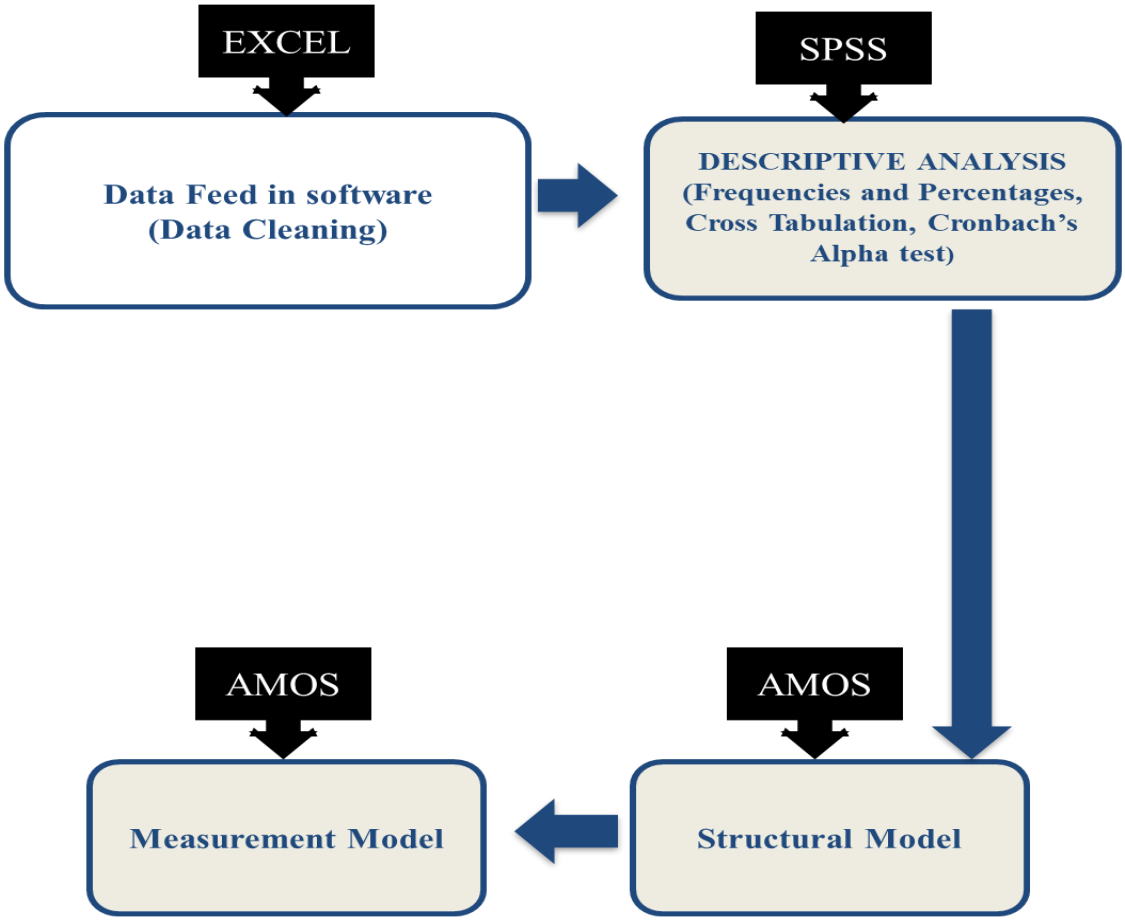

Figure 3.1: Analytical Research Process

3.3. Time of Study

The time of study was between the years 2017 – 2019. These years hold fundamental importance in the regard that Pakistan was moving from severe energy shortfalls to somewhat stability in the energy supply line. This was being done via multiple energy sources from coal, gas based to hydel, wind and solar energy generation. Hence, provided the ideal time to conduct such study and ascertain the public perception about various energy sources.

3.4. Data Collection

University undergraduate and graduate students with background in engineering, sciences and social sciences were chosen as the main participants of the study because of their expected future role in the energy industry with respect to consumption, operations, management, policy and planning. All the students were taken from National University of Science and Technology (NUST) due to a number of reasons. Firstly, NUST is Pakistan's top ranked engineering university with nine specialized schools in the various domains of engineering, seven schools in social sciences and two in sciences, which made it easier for us to access the students/study participants from different backgrounds within the premises of the university. Secondly, being in the federal capital and a premier educational institution, it attracts students from all over the country, which was helpful to include the students from different regions and income groups. An equal number of participants (38-39) were taken from all the eighteen schools of NUST, thus making a total sample of 700 participants. Also, as per Krejcie and Morgan table for sample size determination, 370 is a standard number for a population of 10,000, shown at Annex IV. The number of occupants at NUST is around 10,000 too. Hence, the number of participants in this study was far greater than the minimum requirement as enunciated in various studies employing SEM[51-53,69]. A seven-point Likert scale, ranging from strongly disagree to strongly agree was used for the responses. 590 responses were received, out of which 400 were deemed complete and fit for inclusion in the analysis. Validity of the responses was also checked by random calls to the respondents.

3.5. Analytical Procedures/Measures

The collected data was processed and analyzed for compilation, screening, descriptive statistics and reliability of the measure analysis. Exploratory Factor Analysis (EFA) was done with Statistical Package for Social Sciences (SPSS). For the mediation effect and hypothesis testing, Structural Equation Modelling (SEM) technique and Confirmatory Factor analysis (CFA) was performed in Analysis of Moment Structures (AMOS) software. To further validate our model, 3-factor and 1-factor models will also be designed and tested to confirm that our 8-factor model is the most suitable one [52, 54].

3.5.1 Descriptive Analysis

Descriptive statistics explained the respondents' responses to various aspects of the variables including attitude, moral norms, perceived behavioral control, subjective norms, self-identity, intention, price, technological access and behavior. Apart from minor exceptions, most of the responses were in agreement with our hypothesis and conformed to the required statistical thresholds of outputs like Eigen values, Cronbach's Alpha, correlations, standard deviations, root mean square and CFI values etc.

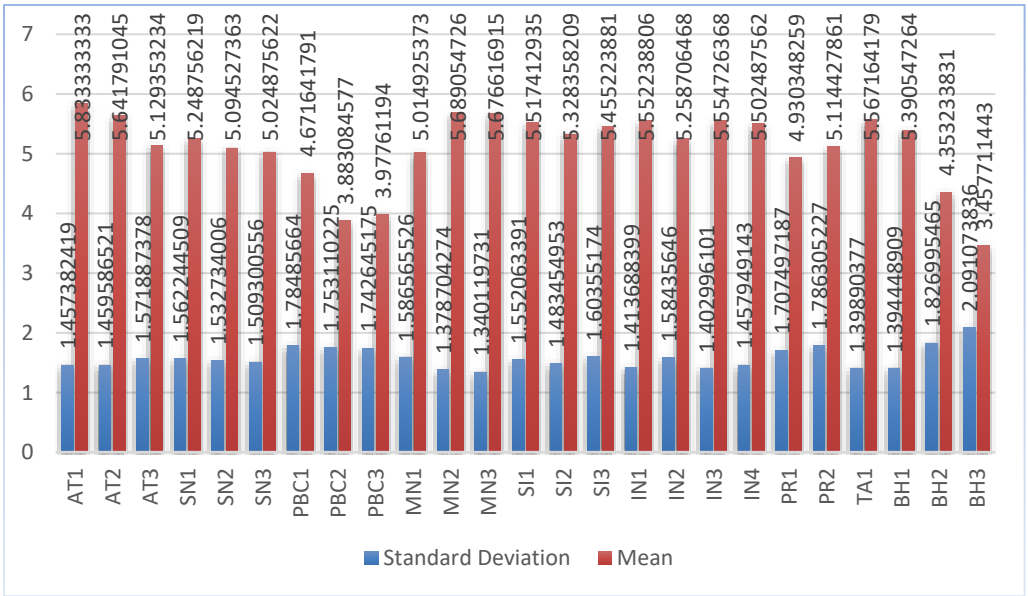

Figure 3.2: Means and Standard Deviations

NOTE: AT= Attitude, SN= Subjective Norm, PBC= Perceived Behavioral Control, MN= Moral Norm, SI= Self-Identity, IN= Intention, PR= Price, TA= Technological Access, BH= Behavior.

The standard deviation of each variable is above 1.0 generally that signifies a quality response from the respondents[52, 53]. Figure 3.2 also shows the mean values are generally above average and lied away from the neutral point, reinforcing the quality of the responses[53].

SEM is a frequently employed method due to its flexibility and generality. The SEM comprises multiple steps including Specification, estimation, evaluation, and modification of the model. Depending upon the data dynamics, all or some of these steps are employed to complete the SEM[53]. These steps are mainly comprised of two parts including Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). EFA explores factor structure i.e. variables' relation and groupings with each other depending upon the inter-variable correlations [52-54]. CFA confirms the structure of the factors extracted in Exploratory Factor Analysis. These steps follow the testing of hypothesis to specify if SEM is applicable on the given data. After cleaning/sorting the data and checking assumptions such as multivariate normality, multi-collinearity and sample size, the SEM was applied in the current research as follows.

3.5.2. Checking assumptions

The important assumptions including sample size, multivariate normality and multi-collinearity are required to be checked before applying the SEM.

Sample size

For SEM, the size of sample is determined according to the number of variables. 100 is considered an acceptable sample size as per Hair et al for an average number of attributes [55]. The sample size can vary depending on the number of variables and attributes of a given study. In our study, the sample size of 251 was suggested by the statistical calculator. Also as per Krejcie and Morgan table for sample size determination shown in Annex IV, the recommended number for our population was 370[69]. However, we selected a sample bigger than the

Table 3.1: Collinearity Statistics

Model	Tolerance	VIF
AT	.601	1.664
SN	.594	1.684
PBC	.853	1.173
MN	.627	1.594
SI	.558	1.791
PR	.744	1.344

prescribed sample size in order to increase the comprehensiveness of the study. Hence, 700 survey questionnaires were distributed, out of which around 400 were deemed fit for the analysis.

Multivariate normality and multi-collinearity

To ensure multivariate normality, data was screened to remove outliers and missing values in order to make data valid and reliable[56]. For checking multi-collinearity, regression was run to check the values of Variance Inflation Factor (VIF) and Tolerance in collinearity statistic (Table 3.1). As per Kline, the values of VIF must not be greater than 10 and value of Tolerance not less than 0.1, and if these conditions are fulfilled then the data has no multi-collinearity issue [57]. VIF and Tolerance values for this study fell in the acceptable range which showed the lack of multi-collinearity in the data.

3.6. Summary

The chapter presents the methodology to carry out this research. In this chapter it is presented that how the data was collected. It ponders upon the steps of the overall procedures and various analysis required for performing the designated analysis. Moreover, it has also been discussed the type of software used for evaluation and analysis.

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Chapter 4. Results

4.1. Model specification with Exploratory Factor Analysis(EFA)

Exploratory Factor Analysis was performed using SPSS for the confirmation of the underlying structure as well as the identification of the items, in addition to reducing the total number of items. The factors were extracted by applying the Principle Component Analysis (PCA) which were further rotated with the Varimax method for extracting the more meaningful factors. The Eigen values helped in determining the number of factors. Before the extraction of a manageable number from the items given by EFA, we checked some assumptions (as shown in Table 4.1). It was necessary to check these assumptions so that the EFA could be applied on the data[58].

Table 4.1: Assumptions for selecting items through EFA items

No	Preliminary assumption	Acceptable Range	Remarks	Model
1	Communalities[59] – Table 4.2	>0.4	Measure of perfection of questionnaire loading on the model	All values>0.4
2	Individual construct reliability Cronbach Alpha[60] – Table 4.3	≥0.7	Reliability of data and stability of items	All values≥0.7
3	Kaiser-Meyer-Olkin (KMO) – Table 4.3	0 to 1	This test measures adequacy of sample and its value should be > 0.5	0.875
4	Bartlett's Sphericity Test– Table 4.3	P < 0.05	For significant factor analysis P value should be less than 0.05	0.000
5	Cumulative variance (CV) and Eigen values & Eigen value of individual factor to be extracted should be:	CV>60% Eigen value>1	CV shows reliability of data. Eigen value shows the variance explained the item and its acceptability	CV> 60% Eigen values of 7 factors>1

Table 4.1 shows the assumptions are fulfilled for the given data and constructs of the theoretical model. This authenticated the extraction of items with Eigen values greater than 1. For our model, Varimax rotation revealed seven significant factors out of 25 with Eigen values higher than 1 and with

cumulative variance of 68.6%. The correlation among all the variables was greater than 0.01 showing good correlation among the variables and no auto-correlation. The Cronbach Alpha values were also greater than 0.7 for all the constructs except for one variable, for which it was 0.67 (~0.7) and was in the acceptable limit (as shown in Table 4.4). All these results verified the data to be reliable enough to proceed further with the analysis.

Table 4.2: Communalities

	Initial	**Extraction**
SN	1.000	.527
PBC	1.000	.749
MN	1.000	.568
SI	1.000	.626
PR	1.000	.444
TA	1.000	.565
BH	1.000	.581
AT	1.000	.550
IN	1.000	.666

Table 4.3: Bartlett's and KMO Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.875
Bartlett's Test of Sphericity	(Approx. Chi-Square)	6535.284
	df	300
	Sig.	.000

Table 4.4: Coefficient Correlation Table

	Mean	SD	1	2	3	4	5	6	7	8	9
AT	5.536	1.259	*(0.79)*								
SN	5.014	1.208	.566**	*(0.94)*							
PBC	4.175	1.420	.172**	.287**	*(0.73)*						
MN	5.463	1.171	.443**	.402**	.173**	*(0.74)*					
SI	5.243	1.268	.466**	.474**	.216**	.566**	*(0.95)*				
IN	5.471	1.189	.535**	.552**	.216**	.508**	.635**	*(0.82)*			
PR	4.750	1.349	.313**	.312**	.330**	.341**	.419**	.417**	*(0.96)*		
TA	5.573	1.402	.388**	.301**	-0.04	.439**	.381**	.405**	.334**	-	
BH	4.398	1.396	.278**	.363**	.406**	.237**	.392**	.421**	.379**	.212**	*(0.67)*

NOTE: n = 400. SN=Subjective norm, AT = Attitude, PBC=Perceived Behavioral Control, SI=Self-identity, MN=Moral Norm, IN=Intention, PR=Price, TA=Technological Access, BH=Behavior. Cronbach's α scores of each variable are in diagonal places (italic). ***p<0.00, **p<0.01, *p<0.05

4.2. Model Identification

4.2.1. Uni-dimensionality

The first step in the model identification is to assess the uni-dimensionality of the model with the help of Confirmatory Factor Analysis [61]. Items having weak loadings (< 0.5) on the main factors were required to be removed from the models. In this study, factor loadings for the model was greater than 0.5.

4.2.2. Confirmatory Factor Analysis (CFA)

The validity of the model was confirmed via Confirmatory Factor Analysis (CFA). All the factor loadings should be greater than 0.5. Two measures, the discriminant validity and the convergent validity as shown in the Table 4.5 are examined to confirm the validity of the model [62]. Table 4.5 shows that CFA assumptions were fulfilled for the given data and constructs of the theoretical model. For our model, all the values were in the acceptable range with 0.7<CR, 0.5<AVE, AVE>MSV &

ASV. This identified that the model has neither convergent validity nor discriminant validity issues.

Table 4.5: Confirmatory Factor Analysis CFA Assumption

S No.	Assumptions	Name of Index	Remarks	Range	Model
1	**Convergent[2] Validity [55]**	**AVE** Average Variance Extracted	Explanation of latent factor by its own observed variables	≥ 0.5	All AVE values >0.5 (Except 1)
		CR Composite Reliability		≥ 0.7	All CR values>0.7
2	**Discriminant Validity[3]**	**MSV** Max Shared Variance	Observed variables do not explain the Latent factor rather by its own parent's observed variables;	MSV< AVE	All MSV values < AVE
		ASV Average Shared Variance		ASV < AVE	All ASV values <AVE

Note: If the correlation between the variables is not within their parent factor, the issue of convergent validity occurs. Divergent validity arises when the correlation of variables with variables outside their parent factor is high as compared to variables within their parent factor[63].

4.2.2.1. Assessment of the model

The structural and the measurement models are the two main constituents of the model in SEM. The measurement model provides the relation among the latent variables and their indicators. While the structural model provides probable causal dependencies among the dependent and independent variables[53]. For model fit, the results should be statistically significant and within the acceptable range. In the study, when the observed p-value of a test statistic is smaller than the significance level pre-defined, a statistically significant level is attained. This study has confidence interval of 95% with 5% significance level (α). Hence for significant results, a p-value less than 0.05 should be obtained ($p < 0.05$) [52-54]. The p-values in this model coincided with the required value.

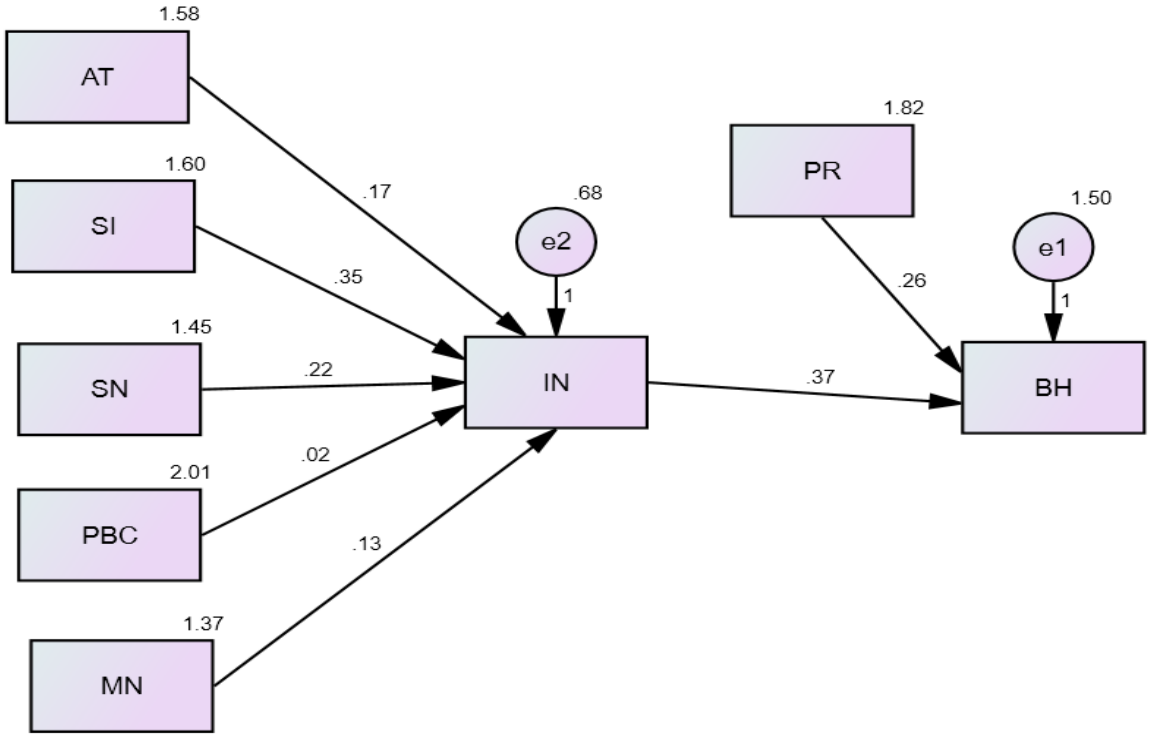

Figure 4.1: Structural Model

i. Direct effects

Direct effects are evident via multiple paths, shown in Figure 6, from Independent variable (IV) to the mediator (M) and from the mediator (M) to the dependent variables (DV). All beta (β) co-efficient and p values indicated that the direct effects were positive and significant which implies the structural model (Figure 4.1) supports the direct path effect hypotheses (H1, H2, H3, H4, and H5).

ii. Indirect effects (mediating effect)

The mediation effects of the construct intention were also examined via the Structural Equation Modeling techniques via bootstrapping [53]. The mediation effect of the constructs price and technological access were analyzed. The paths for indirect effects are as follows. The effect of intention on the output behavior of the respondent via effect of the varying price, and the technological access, of the respective source of energy. Results - as shown in the Table 4.6, 4.7 - depict a positive and significant mediation effect on behavior of the respondent via price, H6 (β=0.046). It also shows a positive and significant mediation effect of intention on the

output behavior of the respondent, H8 (β=0.61). Therefore, the hypothesis H6 and H8 were also supported.

These results show a very strong effect of Intention and Self-Identity on respondent behavior to shift from conventional to renewable energy sources. Price was among the major moderators that affected the shift.

Table 4.6: Regression Weights

	Estimate	**S.E.**	**C.R.**	**P**	**Label**
IN ← AT	.168	.033	5.142	***	par_1
IN ← SI	.347	.032	10.668	***	par_2
IN ← SN	.215	.034	6.315	***	par_3
IN ← PBC	.016	.029	.539	.590	par_4
IN ← MN	.130	.035	3.689	***	par_5
BH ← IN	.373	.061	6.090	***	par_6
BH ← PR	.256	.046	5.608	***	par_7

Table 4.7: Variance

	Estimate	**S.E.**	**C.R.**	**P**	**Label**
AT	1.578	.112	14.124	***	par_8
SI	1.603	.114	14.124	***	par_9
SN	1.455	.103	14.124	***	par_10
PBC	2.012	.142	14.124	***	par_11
MN	1.370	.097	14.124	***	par_12
PR	1.815	.129	14.124	***	par_13

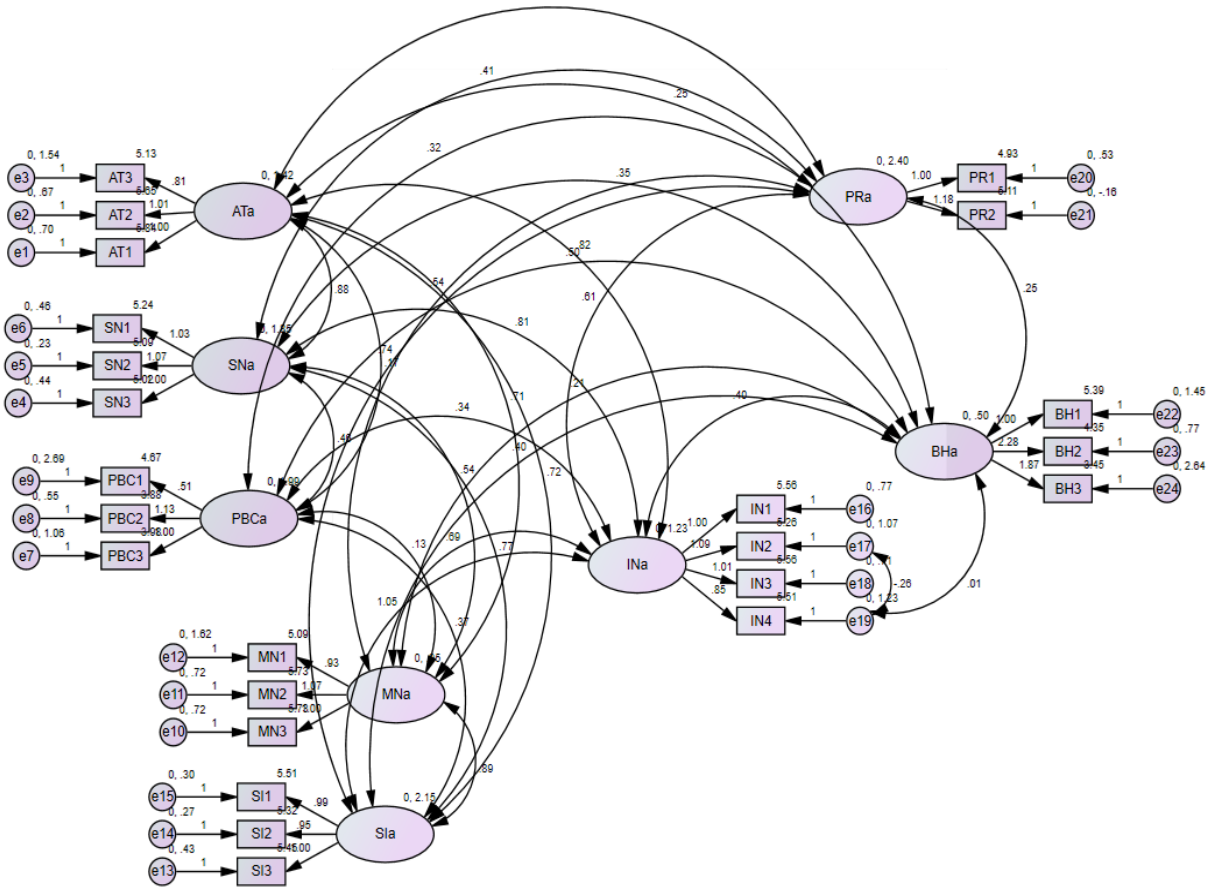

Figure 4.2: Measurement Model

4.2.2.2. Fitness of the model

Particular parameters were calculated to find the model fit indexes via measurement models in AMOS. The thresholds listed in the Table 4.8 are according to multiple researches in which CFA was employed as a statistical measurement tool [64-67]. To further validate our model fitness 3-factor model and 1-factor model were drawn and analyzed for results. This was in addition to the original 8 factor measurement model. The respective models are represented in fig 4.2, fig 4.3 and fig 4.4. The results of CFAs are presented in Table 4.8 and show that for model I all the fit indices were in acceptable range for our hypothesized model.

Table 4.8: Fit Indices of model I, II & III

Fit indices	**Perfect fit**	**Accepted fit for SEM**	**8 – Factor Model**	**3 – Factor Model**	**1 – Factor Model**
χ^2			685.818	2871.779	6502.689
Df			222	249	276
χ^2/df	χ^2/df< 3	3< χ^2/df<5	3.089	11.533	23.56
GFI	0.95<GFI<1	0.90<GFI<0.95	-	0.587	1.000
NFI	0.95<NFI<1	0.90<NFI<0.95	0.895	0.558	1.000
TLI	0.95<TLI<1	0.90<TLI<0.95	0.907	0.533	0.000
CFI	0.97<CFI<1	0.95<CFI<0.97	0.926	0.579	1.000
RMSEA	0<RMSEA <0.05	0.05<RMSEA<0.08	0.072	0.162	0.238
$\Delta\chi^2$			Baseline Model	2185.961	5816.871
ΔDf			Baseline Model	27	54

NOTE: χ^2 = Chi-Square, Df = Degree of Freedom, RMSEA: Root mean square error of approximation, CFI: Comparative fit index; NFI: Normated fit index GFI: Goodness fit index, TLI: Tucker-Lewis Index.

Furthermore, multiple CFAs were done to verify the variables' distinctiveness and their items, including AT, SN, PBC, SI, MN, IN, PR, TA and BH. In three-factor model AT, SN, PBC, SI, MN were merged. As per the CFA outputs from various models, the eight factor model provided the best fit while the results for all others models compared to the measurement model were pretty worse [68]. E.g. a good fit to the data was provided by the eight-factor model (CFI = 0.926, NFI = 0.895, RMSEA = 0.072) thus giving a good model fit; against the three-factor model where all the dependent variables were merged into one (RMSEA = 0.162, CFI = 0.579, NFI = 0.56, GFI = 0.587). The distinctive validity of measures was obtained by the results and no significant Common Method Variance (CMV) threat associated with validity concerns was found in the process. Hence, the hypothesized model was accepted as a rational depiction of the variances and covariances among the measures [64]. The higher NFI value for our 8-fator model suggests that our model is flexible enough for future studies, one of our main objectives.

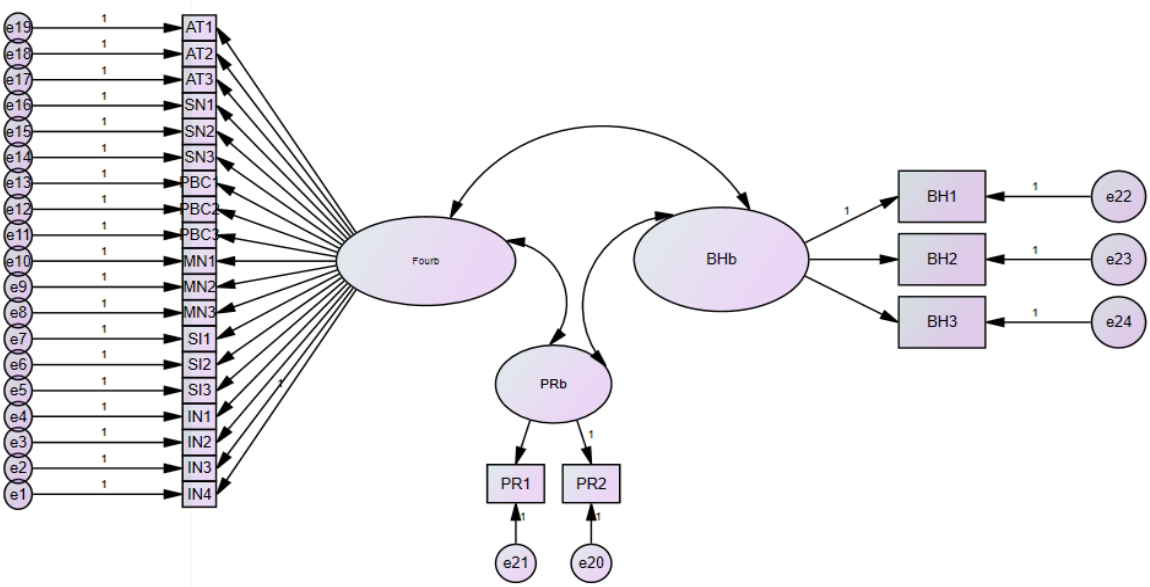

Figure 4.3: 3-factor Measurement Model

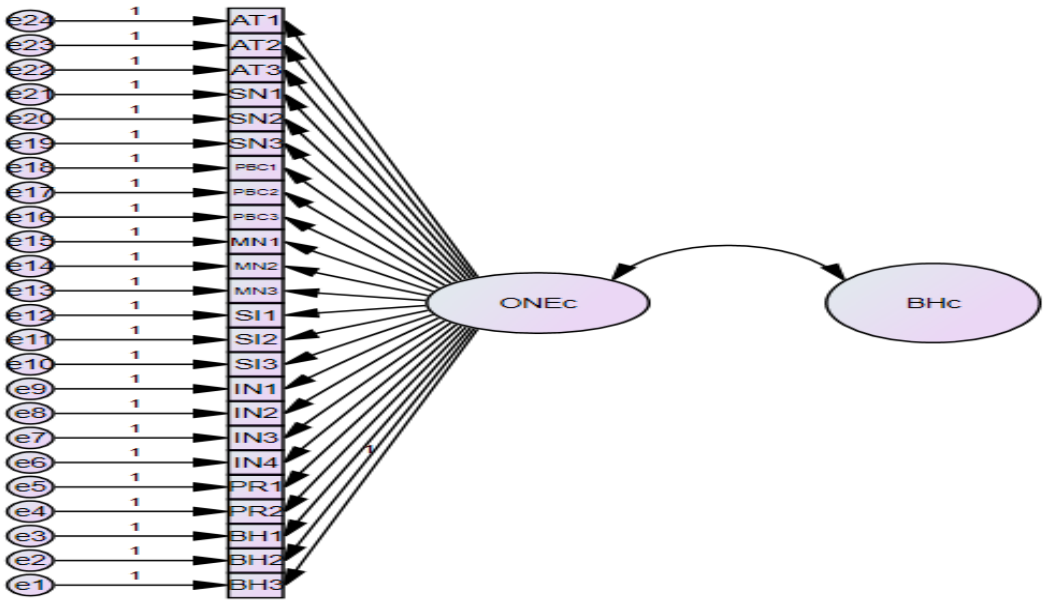

Figure 4.4: 1-factor Measurement Model

4.2.2.3. Model modification

After the models were estimated, if the result showed that fit indices of the model were not in perfect or acceptable range. Then to improve the fit indices of model, modification indices were required. Our study found that all our fit indices fell in the acceptable range.

4.3. Summary

The results confirmed the fitness of our model. All the EFA, SEM (Structural & Measurement models) results were in the desired limits. A basic theoretical model was developed that satisfied all the hypothesis (H1, H2, H3, H4, H5, H6, H7, H8).

Self-Identity and Intention followed by Price had the most significant effect on the behavior to shift from conventional to renewable energy sources. This study mapped a feasible as well as flexible model that can be expanded to further sample size or towards the inclusion of more variables. Multiple future studies can be carried out, based on this model (higher NFI values).

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Chapter 5. Discussions

The objective of the research was assessing relationship between various variables (AT, PBC, SN, SI, MN, PR, TA), independent and moderator, that influence the public behavior to move from conventional to renewable energy sources. It was also aimed at developing a flexible and workable research model that can be pursed further. The relationship was studied through mediator (IN) and moderator variables (PR, TA) that greatly influenced the adaptation of technologies related to renewable energy. There was a strong correlation between the said variables and all β-values were high. The independent variables' affect (AT, SN, PBC, MN, SI) on mediator was the basis of the model that was developed to conduct the research, which was further moderated via moderator variables (PR, TA). For this, the structural model tested in AMOS satisfied all the standard parameters for the model to be feasible (Table 4.5). Also, along with testing our structural model on defined standards, two additional measurement models (3 factor and 1 factor measurement models) were also tested to strengthen the viability of our model and screen out other possibilities. The comparison results of the results of all three models clearly showed that our original 8-factor measurement model is the most suitable fit and the parameters for it lies in the acceptable values (Table 4.8). For the 3-factor and 1-factor model, the values lied far away from the standards. Extended Theory of Planned Behavior was used to postulate several variables that helped in modeling the public perception on the issue (shifting from conventional to RES). A mediating effect of Intention was studied that ultimately forged the output behavior by incorporating the moderating effects of Price and Technological access on user behavior.

Results of our measurement model showed that variables (AT, SN, PBC, SI, MN, IN, PR, TA) have an overall significant effect on people behavior to shift from conventional to RES. All beta values were positive. Also, all the p-values were less than 0.05. These results support all the hypothesis of our theoretical model. They also showed the strongest effect between Self Identity and Intention on user behavior to shift to RES (β= 0.3+). It implied that Self-Identity and Intention are the major factors that

needs to be changed for the shift to be encouraged or discouraged, whichever way these constructs of the population will tilt, the output behavior would significantly follow. So, in order to launch any Renewable Energy initiative on public level the state must ensure that public is well aware of the pros and cons, so that an utter failure is avoided. The results from the structural model also implied significant relation among the independent and dependent variable, and of the moderator variable (PR, TA) upon the final respondent behavior. Although Technological Access was not included in the measurement as well as structural model analysis due to single question on the construct. But the EFA analysis of the variable showed an overall promising response of the respondents towards the shift, if the technology was made accessible to them. The price was one of the major constructs that moderated the final behavioral. Many of respondents showed that they are affected by the price and this would affect their shift from conventional to RES. And a majority was willing to shift even if the price of the shift was being covered in the long run. Finally, the theoretical model developed proved to be a workable and feasible model to study the shifting trends from conventional to renewable energy sources. It gave a significant insight into the major and minor factors that affect the public perception. Moreover, it can further be expanded to study a larger/different sample size and audience or to inculcate more constructs as per the dynamics of the sample population (higher NFI value). Since some factors can be important in a specific region but not in the other. For Example, price and technological access are significant factors for the population in Pakistan and other third world countries but same could not be said about the population in United States of America, where the per capita income is much higher and latest technologies are accessible to the public. But the rest of the model can be applied in the same manner.

5.1. Summary

A flexible model was developed, and the research objective were met to satisfactory extent along with research questions like studying the impact of independent, mediating and moderator variables upon the public behavior to shift from conventional to renewable energy sources here in Pakistan. In this chapter the results were discussed all the results confirmed the model and provided significant insight into the public perception, the major social factors that affect it, in moving from conventional to renewable energy sources. Also, prospects of taking the study forward are open to inclusion of more constructs or sample size. The outcome was favorable enough to chalk out some policy recommendations, along with the model being flexible enough to carry further studies on it.

Chapter 6. Conclusion and Policy Suggestions

During the past few decades a few significant changes that were observed on the global scale were the exponential increase in energy demand and a general tendency to adopt the renewable energy sources. The trend was same from first world countries like the UK to the third world like Greece. The common factors that were found among all were that there were renewable energy initiatives on public and private level. Also, some big initiative saw a doom from wind power, solar power to organic food and waste energy generation. The common cause found to this was failure to study the public perception about that particular initiative. Recently, Pakistan is also witnessing the inflow of renewable energy sources in its energy stream, in both public and private sectors. Many private companies are investing, the government also has big plans to harness the renewable energy. Hence to avoid the failures of this initiative and study the public tilt the study was conducted. The study highlighted the relation of various independent (Attitude, Subjective Norm, Perceived Behavioral Control, Self-Identity, Moral Norm), mediating (Intention) and moderating (Price, Technological Access) variable on the public perception to shift from conventional to renewable energy sources. The study concluded that Intention, Self-Identity and Price were the factors that top the list of factors affecting the shift to RES. The effect of the rest of the variables was also significant. The model developed was verified via standard tools and techniques. It also turned out to be flexible enough for future works. Keeping in view all these results and factors certain policy recommendations were made, as follows.

6.1. Policy Suggestions

After analyzing the results as per the relation of various factors on public perception o shift from conventional to renewable energy sources in Pakistan, following policy recommendations were drafted:

- Self-identity, intention and price were placed highest in terms of impacting the shift from conventional to RES. Therefore, people will be more prone to shift, if monetarily feasible solutions are provided to them that cover the upfront cost or are subsidized and do not put a high price tag over the shift.
- The intention needs to be molded via some awareness campaign that can tilt their intention towards the RES. A national awareness program inculcating the benefits of RES in the curriculum can be among the ways to mold the public intention towards RES.
- The school curriculum should ponder upon the importance of the shift to develop an individuals' self-identity at a younger age.
- Small / Medium scale BOT based units must be installed for the population generally and specifically for the individuals that have a large social circle in an area. It would lead to a general societal acceptance and trend to shift to renewable energy sources.

Annex I

Survey Questionnaire:

Dear Sir/Ma'am!

Your kind support is requested in pursuing a research that tends to study the shifts in trends of energy sources as perceived by the Pakistani people and suggesting "Policy measures" as to how we might proceed into the future based on the results. The information provided by you will be used solely for academic research purposes and your confidentiality will be valued and fully ensured. You are requested to please spare few minutes from your schedule and to please fill this questionnaire after due consideration and based on your understanding and experiences. For any suggestions or comments, please write to 09beewafzal@seecs.nust.edu.pk. Thank You!

Section A: Basic Information

Instructions: Please select and tick (✓) one option from the following:

1. **Field of work/study**
   □ Applied Sciences □ Social Sciences □ Management Studies □ Engineering
   □ Other:_____
2. **Gender**
   □ Male □ Female □ Other
3. **Residence**
   □ Rural □ Urban
4. **Age**
   □ <25 □ 25-30 □ 31-35 □ 36-40 □ 41-45 □ Above 45
5. **Education level**
   □ Undergraduate studies □ Post Graduate studies □ Other:_____
6. **Work Experience in Years**
   □ <1 □ 1-3 □ 4-6 □ 7-9 □ > 10
7. **Knowledge about Conventional/Renewable energy sources**
   □ None □ Little □ Fair □ Good □ Excellent

Section B:

Instructions: This section has been designed on a Likert Type Scale ranging from 1 to 7 with 1 = Completely Disagree, 2 = Moderately Disagree, 3 = Slightly Disagree, 4 = Neither agree nor disagree, 5 = Slightly Agree, 6 = Moderately Agree to 7 = Completely Agree. You are requested to please tick (✓) one option that most closely expresses your views against the statements.

	Completely disagree (1)	Moderately disagree (2)	Slightly disagree (3)	Neither agree nor disagree (4)	Slightly agree (5)	Moderately agree (6)	Completely agree (7)
Conventional energy sources refer to the energy (heat/electric) obtained from burning wood, coal, gas, oil etc, at home, office or power plants. While renewable energy sources are the ones that provide energy from sun (solar energy for geysers, solar panels), wind and hydro power generation etc. The following questions are about your opinion towards these:							
The shift from conventional to renewable energy sources is better for me	1	2	3	4	5	6	7
The shifting from conventional to renewable energy sources is socially beneficial for me	1	2	3	4	5	6	7
The shifting from conventional to renewable energy sources is monetarily advantageous for me	1	2	3	4	5	6	7
Many people, whose opinions I value, would approve if I shifted from conventional to renewable energy sources.	1	2	3	4	5	6	7
Many people, important to me think that I should shift from conventional to renewable energy sources	1	2	3	4	5	6	7

Many people, important to me think that my shift from conventional to renewable energy sources is desirable	**1**	**2**	**3**	**4**	**5**	**6**	**7**
It is largely up to me whether to shift from conventional to renewable energy sources or not.	1	2	3	4	5	6	7
For me shifting from conventional to renewable energy sources is easy	1	2	3	4	5	6	7
If I wanted to, I can easily shift from conventional to renewable energy sources	1	2	3	4	5	6	7
I feel or would feel it to be a moral obligation to shift from conventional to renewable energy sources	1	2	3	4	5	6	7
I would feel good if I shifted from conventional to renewable energy sources	1	2	3	4	5	6	7
If I were to decide on designing the energy supply, I would feel obligated to use renewable energy sources	1	2	3	4	5	6	7
I am the type of who would shift to renewable energy sources	1	2	3	4	5	6	7
Using renewable energy sources is an important part of who I am	1	2	3	4	5	6	7
I am not the type of person who would be bothered by using renewable energy	1	2	3	4	5	6	7
I intend to shift from conventional to renewable energy sources in future	1	2	3	4	5	6	7
I have plans to shift from conventional to Renewable energy sources in future	1	2	3	4	5	6	7
I will try to shift from conventional to Renewable energy sources in future	1	2	3	4	5	6	7
I am willing to shift from conventional to renewable energy sources in the future	1	2	3	4	5	6	7
Increased cost does not affect my shift from conventional to Renewable energy sources	1	2	3	4	5	6	7
If the price is covered in the long run I would shift from conventional to Renewable energy sources	1	2	3	4	5	6	7
If I have access to renewable energy sources, I would shift from conventional to renewable energy sources	1	2	3	4	5	6	7
I will adopt renewable energy sources instead of conventional energy sources soon	1	2	3	4	5	6	7
I am actively trying to shift from conventional to renewable energy sources	1	2	3	4	5	6	7
I have shifted from conventional to renewable energy sources	1	2	3	4	5	6	7

Thank you very much for sparing some time to complete this survey. Your feedback is valued and very much appreciated!

Annex II

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Shifting from Conventional to Renewable Energy Sources – Modelling the Public Perception.

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Abstract

Despite enormous potential of renewable energy sources (RES) in Pakistan, its share in the energy mix is lower than the conventional sources like the fossil fuels. Government has been busy in devising the policies, strategies and goals for the development of renewable energy resources over the years. Some studies have also assessed the technical and economic viability of harnessing the RES potential at small, medium and large scale. Like large and medium scales, the development and adoption of the RES technologies at the micro level is facing hurdles. One of the major hurdles is public acceptability of the RES technologies. This study is a scientific attempt to address the basic question of how much the general populace is willing to shift to RES from the conventional energy sources. This study has investigated the factors which might affect the public acceptance of energy transition towards RES in Pakistan. The theory of planned behavior provided the basic model, which was used to measure the public willingness towards RE technologies. To assess the public willingness, a sample of 250 students was taken from National University of Sciences and Technology (NUST), Islamabad Pakistan. The empirical data was analyzed by using the Structural Equation Modelling. Based on the results, certain policy suggestions were made to increase public awareness for a smooth energy transition in Pakistan.

Keywords: Renewable Energy Sources, Energy Transition, Theory of Planned behavior, Sustainable Policies, Structural Equation modelling, Pakistan.

1. INTRODUCTION AND BACKGROUND

The advent of Industrial revolution, and the shift of human civilization from agricultural to Industrial age, made the energy supply of a country a crucial parameter for the economic, social and environmental sustainability. From the United Kingdom's industrial boom till the contemporary rise of the 'Chinese Dragon', a sustainable source of energy supply has been at the very core of the

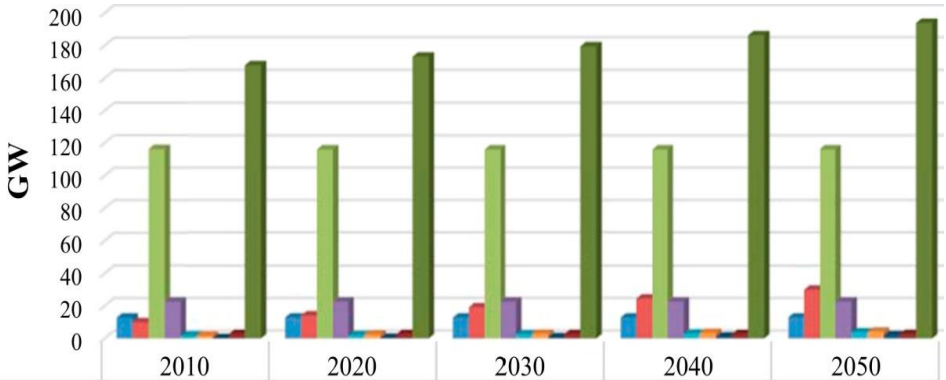
national policies that directly affected the human activities [1-4] The swift developments happening in the major economies like India, Brazil, China and others have resulted in an expected 50% increase in the global energy demand for the next 30 years[5]. With such increasing requirements, multiple new questions, challenges and research areas have emerged to cope up with the global energy requirements [6, 7]. The traditional energy sources (coal, oil, gas) have been the major contributors to meet the energy needs of various nations. Currently, the awareness on the environmental degradation and anthropogenic/greenhouse emissions, the efficacy of these sources have come under question [4, 8-10].Given the circumstances, renewable energy sources like solar, wind, hydel, bio and geo thermal energy sources can fill the gap without the repercussions of increasing carbon footprint in the environment [11, 12]. The recent international efforts (COP24, COP23, Paris agreement etc) have led to the development of a consensus towards environment friendly policies – RES holding a central position. Some countries have put tremendous efforts to implement the measures towards a complete transition to the RES but a large scale implementation is still required [9, 13].

Although an increasing trend has been observed towards the support of renewable energy development and likeliness to be used by the general populace. Still the acceptance by the public is a major pre-requisite since the increased cost and perceptive job lost in the conventional energy generation sector can cause the failure towards the transition, as opposition towards renewable energy infrastructure and its transmission in a European country put its development on hold [13]. The scientific research also considers this as a major factor. This factor determines the public will towards the use and development of renewable energy infrastructure[9, 14, 15]. This not only provides the technical perspective for the establishment of renewable energy infrastructure but generally any initiative needs the acceptance of the citizenry [16]. The public also plays a central role in any legislative or technical initiative in the contemporary world and the initiative cannot be implemented without the social acceptance [17]. The absence of such approach resulted in the big protest against the waste energy generation in Greece [18] and wind power plants/micro-power plants in the United Kingdom [19, 20]. Hence, the awareness, perception and acceptance by the general public are major factors of a society that must be considered for the development of future energy infrastructure and energy transition models[11, 21]. There are multiple examples of future initiatives that ignored such critical social factors, in industries like organic agriculture and modified edibles, and led to the failure and rejection of these emerging and innovative scientific technologies[22, 23].

Pakistan is facing a severe energy crisis in the form of a lack on energy security as well as failure to meet the climate change demands alongside. The major factors that contributed to such a state are the unfavorable policies made over the last two decades and a lack of comprehensive effort to meet the ever-increasing demand with a proportionate supply.

There is an increasing demand and shortfall in supply of energy in Pakistan. Load shedding in electricity and natural gas sectors are frequent. The transition to RES can not only fill the gap but also is a better solution towards it. In case of Pakistan, it also serves the purpose of overcoming the problem of massive up-gradation to the transmission network, since RES are mostly comprising of standalone units (operating independently). Also, they can be readily integrated to the grid, whenever

the transmission network becomes capable enough. Consequently, solving issues of the energy shortage and inefficient transmission network.



	2010	2020	2030	2040	2050
Wind (grid connected)	12.8	12.8	12.8	12.8	12.8
Solar PV (DCNT)	9.9	14.1	19.1	24.5	29.9
Solar PV (CNT)	116.2	116.2	116.2	116.2	116.2
Solar thermal (CNT)	22.6	22.6	22.6	22.6	22.6
Biomass (field residues)	1.7	2	2.5	3	3.7
Biomass (animal waste)	1.6	2.3	2.8	3.4	4.1
Biomass (MSW)	0.2	0.4	0.7	1.1	1.9
Small Hydro	2.7	2.7	2.7	2.7	2.7
Total	167.7	173	179.3	186.1	193.9

Figure 1 Estimated potential of dif*ferent renewable energy sources for electricity production in Pakistan, 2010–2050 [25, 26]*.

RES is the natural and ultimate choice for the world in energy production, since it's clean, sustainable and environmentally friendly. Most of the first world countries are shifting towards the RES and shying away from the conventional energy source due to the grave environmental concerns. Many international agreements have been irked in order to support this shift like Paris Agreement and United Nations Framework Convention for Climate Change – both primarily deals with shifting to RES, at a large scale, for energy generation in order to decrease the carbon footprint and revert the climate change effects. Iceland and Costa Rica have totally moved to RES for energy production. While the UK, Germany, Canada are moving fast towards it. The USA and China are also major players that have plans to shift to the RES. Hence, if Pakistan moves towards RES to fulfill the energy lag, it would be a huge leap forward into the future. There is a whole industry in RES that has evolved in last couple of decades (*Table-1*). Many local and foreign companies and agencies are investing for the promotion of shift towards the RES, reinforced by the huge natural potential available in the country.

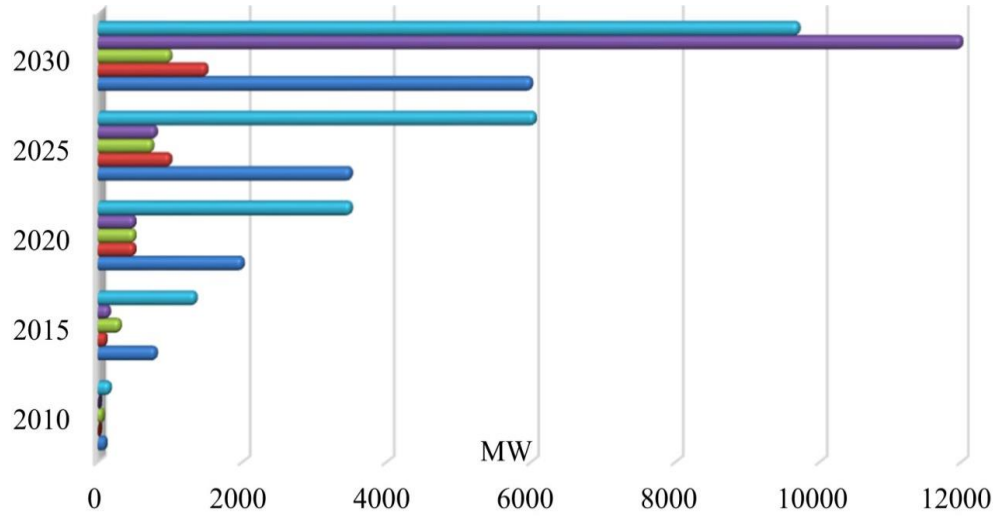
Also, many learned citizens are increasingly adopting RES, especially solar energy, at homes and workplaces. Multiple RES based generation projects are being developed, phase wise and there are many competitors for such projects in the market (*Table1*). For Example: Quaid-e-Azam Solar Park Bahawalpur is a 1000 MW Solar power-based generation project, being developed by a Chinese firm.

Sr.	**Name**	**Capacity**	**Location**
1	JDW Sugar Mills, Co-generation Power Plant	26 MW	Rahim Yar Khan and Ghotiki
2	FFC Energy Limited, Wind Farm	50 MW	Jhimpir, Sindh
3	FWEL Foundation Wind Power Plant I & II	50 MW	Thatta, Sindh
4	Quaid e Azam Solar Park	1000 MW	Bahawalpur, Punjab
5	ZORLU Enerji Wind Farm	56.4 MW	Jhimpir, Sindh
6	Chanar Bagasse based Cogeneration PP	22 MW	Faisalabad, Punjab

Table 1: On-Going Projects

100 MW installation is operational and further work is being chalked out. The government is also making policies regarding the development of RES like duty free import of Solar Panels etc. Government is also planning a major share of RES in the country's energy mix and move towards the sustainable future ultimately (*fig 2*).

For the last two decades, there has been a recent emphasis – by the scientist, governments and the policy makers – to shift from conventional and environmentally damaging energy sources towards the cleaner renewable sources. The statistical data, as to how much the public has accepted this change and whether they are inclined towards the shift, is largely unavailable and almost missing in Pakistan.



	2010	2015	2020	2025	2030
Total	162	1350	3500	6050	9700
Small hydro	1	150	500	800	12000
Biomass	60	300	500	750	1000
Solar	1	100	500	1000	1500
Wind	100	800	2000	3500	6000

Figure 2 ***:*** *Pakistan Government plan for promotion and utilization of renewable energy sources[25, 27]*

To fill that gap in this realm in Pakistan, that might kick-start the research in this arena and set a well-studied and researched foundation for Pakistan future energy needs as well as the respective energy policy formulation would be the aim of the study.

2. METHODLOGY

According to the theory of planned behavior, i*ntention* determines whether a person will be willing to adapt a certain behavior or not [28, 29], like shifting from conventional to renewable energy sources. Its feasibility depends on the intention of the person resulting in the fulfillment of his/her energy demands in a given way [28-30]. The intention of a person varies greatly with certain key factors like the attitude, subjective norms, perceived behavioral control (PBC), moral norms, self-identity and monetary preferences of the individual. [28, 29, 31-33].

A person's response towards the overall evaluation of a behavior, as being favorable or unfavorable, is termed as the 'Attitude' of that person [28, 34]. However, empirical research shows that both the instrumental and experiential factors of the attitude must be kept in mind while taking the response [28]. The attitude towards the society's betterment generally, and shifting to the renewable energy sources specifically, is of fundamental importance to measure this shift towards a desirable outcome. Attitude has been incorporated in multiple studies and holds a fundamental importance in majority of social experiments and behavioral modelling. Such hypothesis development was supported by studies conducted by Ajzen [28, 29], Woke and Yazdanpanah. In this study, we intend to model how attitude of a person affects the tendency to shift from conventional to Renewable energy.

Whether to perform, or not to perform, a behavior in response to the pressure or norms recognized by the society constitutes the 'Subjective norm'[31].In order to measure the subjective norm, questions from several aspects should be asked to cater the problem of significant other that might affect the respondent's answers directly and it has also been incorporated in many studies [28, 31]. Hence, the questions were designed to capture the descriptive norms too. i.e., as to how much the significant others (important others) have themselves accepted or avoided the shift from conventional to RE. It is the degree to which the people influencing the respondent's behavior have themselves adopted the shift. Also a few injunctive questions can be restructured to take on a descriptive quality, like it is important for the respondent that a certain person behavior towards adapting renewable energy is positive or negative. Thus, such subjective norm should be taken into account.

The ease or difficulty of the people to perceive a given behavior themselves is termed as the 'Perceived Behavioral control (PBC)' [30, 33]. It can be termed as to what point the behavior is under volitional control [35]. It gives a direct measure of the respondent's ability to show a certain behavior. It determines the self-efficacy of the subject. i.e. either the individual can shift from conventional to RE sources or not. In addition to self-efficacy it also shows a person's 'controllability' towards the shift, addressing the person's belief that he/she has control over the behavior and is not totally influenced by some external factor [28, 29, 36].

Theory of planned behavior has shown considerable achievements while predicting behaviors [33, 37-39], the theory is developing, and many researchers have added other constructs to enhance the predictability[40, 41]. It can be stated about the theory that, "in principle, its open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variation in intention or behavior after the theory's current variables have been taken into account"[31]. It is open for future research to include multiple variables to further refine the behavioral results for the shift. For now, the study is being restricted to the Theory of Planned Behavior to put a foundation of such studies here in Pakistan and fill the research vacuum.

It is a fundamental requirement of any initiative is to have knowledge about its public acceptance level. The statistical data about the transition from conventional to RES and the level of its acceptance by the Pakistani populace is largely non-existent. Almost no such study has been conducted so far in the country, a basic reason to fill the research gap in this field. Also, the current situation in Pakistan calls upon the researchers to take a step towards such studies and this study would act as a step for further analysis and researches in this field. Due to these and numerous other such reasons, it is necessary to model and analyze the societies' tendency to shift to the RES instead of the conventional energy sources. And make policy suggestions accordingly, for the ultimate shift to RES.

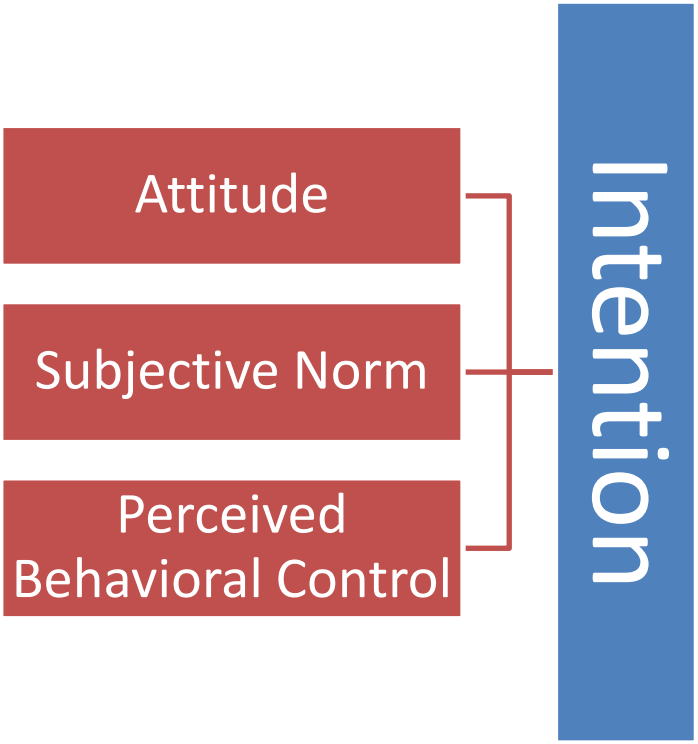


Figure 3 : Theoretical Model

Theory/calculation

As already discussed, the research was carried out specifically to fill the gap in this area of modelling the public perception towards renewable energy. A step by step approach was adopted from the start till the end: from the development of the idea to the conduction of survey to the scientific procedures' application and analysis of the results. The research was designed primarily around National University of Sciences and Technology, Islamabad. It was due to the sheer diversity, quality and perceived future leadership roles of its students, in the energy sector of Pakistan. Multiple reasons forge the way for the conduct of this study in Pakistan. The time of study was mainly circled around the year 2018. It was an important period since the country was seeing the start of a transition from acute energy shortages to the development of future energy policies and demand/supply balance.

University undergraduate and graduate students were the primary participants of the study since they are the future users of energy as well as the planners that would define the future shift of energy sources from conventional to renewable. They will be a part of lead policy makers of the future that would dictate the country's energy mix – let it be renewable or conventional. Due to such factors the major chunk of the responses was taken from engineering disciplines, although some input was also sought from social sciences disciplines too. Almost 350 surveys were disseminated for responses. The questions were required to be responded on a seven-points Likert scale, ranging from strongly disagree to strongly agree. About 300 were received back from the respondents and among these 256 were deemed fit for inclusion in the analysis. Rests were set aside due to missing data and inconsiderate responses. Counter questioning was also employed to further strengthen and refine the data collection. A favorable response towards the shift to RES was observed. The primary focus was

kept on the students of the NUST Islamabad due to the aforementioned reasons. Overall a positive response was obtained, signaling towards a better prospect for RES in Pakistan.

The composed data was processed and analyzed with several methods and software. First the data was compiled and cleaned in MS Excel. And for further compilation and screening of data, descriptive statistics and reliability of the measure items, along with Exploratory Factor Analysis (EFA) was done with Statistical Package for Social Sciences (SPSS). For the mediation effect and hypothesis testing Structural Equation Modelling (SEM) technique and Confirmatory Factor analysis (CFA) was performed in Analysis of Moment Structures (AMOS) software.

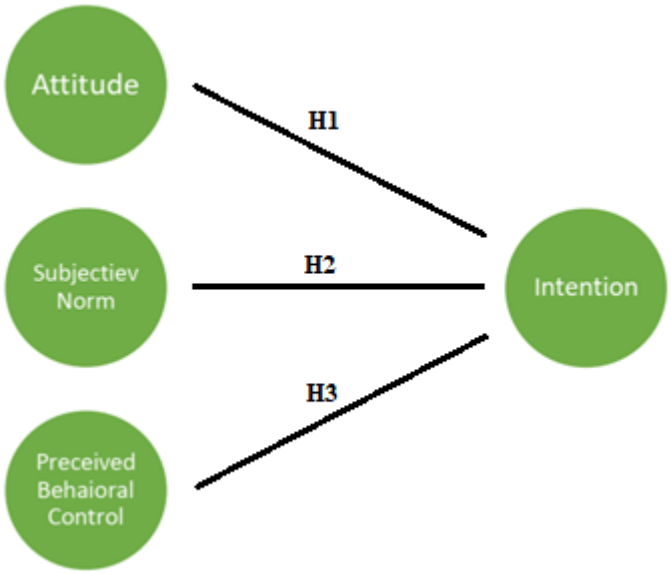


Figure 4 Proposed Research Model

Based on the theoretical model shown in figure 4, following hypothesis were developed for further analysis and testing:

H1: Attitude of shifting from conventional to RES has a positive impact on Intention.

H2: Subjective norms towards the shift have a positive impact on Intention.

H3: PBC of tendency to shift from conventional to RES has a positive impact on Intention.

3. RESULTS & DISCUSSIONS

4.1. Descriptive:

Responses to various aspects of the variables, including Attitude, Perceived behavioral control, Subjective norms and Intention, was elaborated via descriptive statistics. Apart from minor exceptions, most of the responses fell in agreement with our hypothesis and conformed with the required statistical thresholds of outputs like Eigen values, Cronbach's Alpha, correlations, standard deviations, root mean square and CFI values etc.

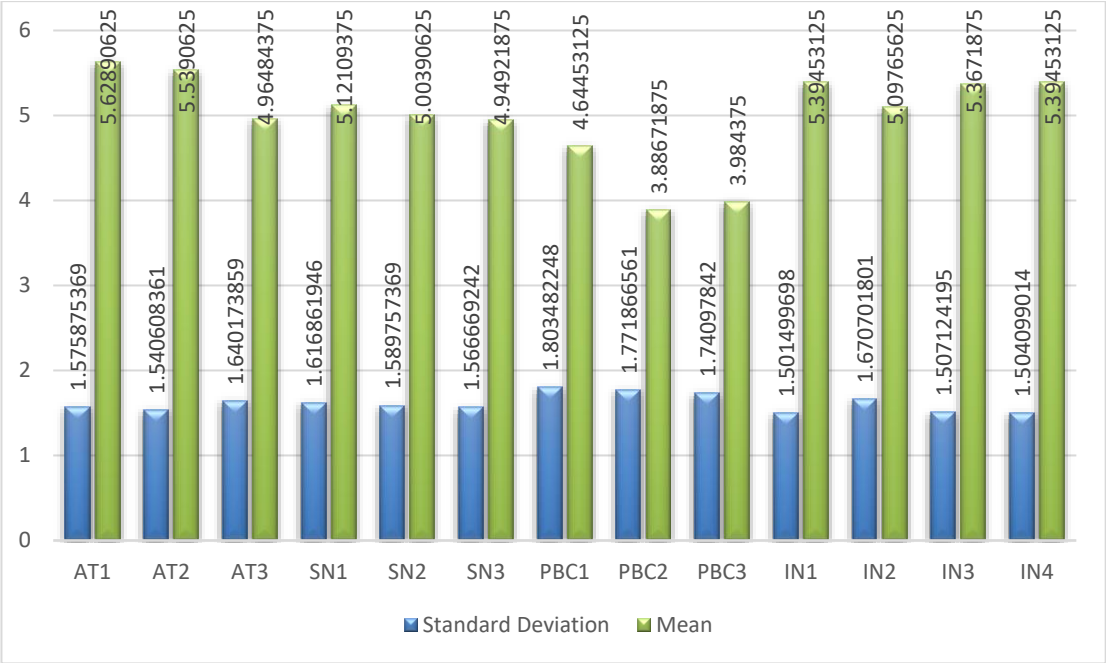


Figure 5 Means and Standard Deviations

The standard deviation for each variable and response was above 0.5 strictly and above 1.0 generally that signifies a quality response from the respondent. The mean values were also above average generally and lied away from the neutral point, reinforcing the quality of the responses (*fig 5*).

4.2. Results from Structural Equation Modeling (SEM):

SEM is a frequently employed method due to its flexibility and generality. The SEM comprises multiple steps including Specification, estimation, evaluation, and modification of the model. Depending upon the data dynamics, all or some of these steps are employed to complete the SEM. These steps are mainly comprised of two parts including Confirmatory Factor Analysis (CFA) and Exploratory Factor Analysis (EFA). EFA explores factor structure i.e. variables' relation and groupings with each other depending upon the inter-variable correlations. CFA confirms the structure of the factors extracted in Exploratory Factor Analysis. These steps follow the testing of hypothesis to specify if SEM is applicable on the given data. After cleaning/sorting the data and checking assumptions such as multivariate normality, multicollinearity and sample size, the SEM was applied in the current research as follows.

4.2.1. Checking assumptions:

The important assumptions including Correlations, Cronbach Alpha values, Multivariate normality, Multicollinearity and Sample size, should be check as per the required standards, to apply the SEM.

4.2.1.1. Sample size:

For SEM, the size of sample is determined according to the number of variables. 100 is considered an acceptable sample size as per Hair et al for an average number of attributes [56]. The sample size can vary depending on the number of variables and attributes of a given study. In our study, sample size of 251 was suggested by statistical calculator; although, a sample of 256 was chosen for the study. Hence, 350 survey questionnaires were used, out of which around 256 were deemed fit for the research.

Model	Collinearity Statistics	
	Tolerance	VIF
SN	.616	1.624
PBC	.911	1.097
AT	.660	1.515

Table 2 Collinearity Statistics

4.2.1.2. Multivariate normality and multi-collinearity:

To ensure multivariate normality, data was screened to remove outliers and missing values in order to make data valid and reliable[57]. For checking multi-collinearity, regression analysis was run to check the values of Variance Inflation Factor (VIF) and Tolerance in collinearity statistic. As per Kline, the values of VIF must not be greater than 10 and value of Tolerance not less than 0.1, if these conditions fulfilled then we don't have multi-collinearity [58]. If there is multicollinearity in the data, then one or more independent variables are highly correlated, and one cannot get a linear relation on such variable with the dependent variable – undermining the statistical significance of an independent variable. VIF and Tolerance values for this study fell in the acceptable range which showed the lack of multi-collinearity in the data, as shown in the Table 2.

4.2.2. Model specification (EFA):

Exploratory Factor Analysis was performed using SPSS. Confirmation of underlying structure of as well as identification of the items was achieved via Exploratory Factor Analysis, in addition to reducing the total number of items. Factor extraction was done by applying Principle Component Analysis (PCA) with varimax rotation. The number of factors were determined using Eigen values. Before extraction of a manageable items' number from the items given by EFA, we checked some assumptions (as shown in Table 3). It was necessary to check these assumptions so the EFA can be further applied on the data[59].

	Preliminary assumption	Range	Remarks	Model
1	Communalities[60] – Table 3.1	>0.4	Measure of perfection of questionnaire loading on the model (less PBC)	All values>0.4
2	Individual construct reliability Cronbach Alpha[61] – Table 4	≥0.7	Reliability of data and stability of items	All values≥0.7
3	Kaiser-Meyer-Olkin (KMO) – Table 3.2	0 to 1	This test measures adequacy of sample and its value should be > 0.5	0.701
4	Bartlett's Sphericity Test–Table 3.2	P < 0.05	For significant factor analysis P value should be less than 0.05	0.000

Table 3 Assumptions for selecting items through EFA items

	Initial	Extraction
SN	1.000	.726
PBC	1.000	.167
AT	1.000	.673
IN	1.000	.618

Table 3.1: Communalities

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.701
Bartlett's Test of Sphericity	Approx. Chi-Square	235.543
	df	6
	Sig.	.000

Table 3.2: KMO and Bartlett's Test

Table 3 shows that all the assumptions are fulfilled for the given data and constructs of the theoretical model. This authenticated the extraction of items with Eigen values greater than 1. The correlation among all the variables was greater than 0.01 showing great correlation among the variables. The Cronbach Alpha values were also greater than 0.7 (as shown in Table 4).

	AT	SN	PBC	IN
AT	1	*(0.798)*		
SN	.583**	1	*(0.939)*	
PBC	.151**	.297**	1	*(0.720)*
IN	.525**	.520**	.137*	1

Table 4: n = 256. SN=Subjective norm, AT = Attitude, PBC=Perceived Behavioral Control, IN=Intention. Cronbach's α scores of each variable are in diagonal places (italic) in respective. ***p<0.00, **p<0.01, *p<0.05

4.3. Model Identification

4.3.1. Uni-dimensionality

Before checking the validity and reliability of the model, the first step was to assess the uni-dimensionality of model - via the application of confirmatory factor analysis [62]. Items having weak

loadings (< 0.5) on the main factors were required to be removed from the models. In this study, factor loadings for the model was greater than 0.5.

4.3.2. Confirmatory Factor Analysis (CFA)

The validity of the models was confirmed via Confirmatory Factor Analysis (CFA). All factor loadings should be larger than 0.5. Two validity measures are examined to confirm the validity of the model: *Table 5* shows the Discriminant validity and Convergent validity[63]. If the correlation between variables is not within their parent factor, the issue of convergent validity occurs [64]. If the correlation of variables with variables outside their parent factor is high as compared to variables within their parent factor, then issue of Discriminant validity occurs.

S No.	Assumptions	Name of Index	Remarks	Range	Model
1	**Convergent[2] Validity [56]**	**AVE** Average Variance Extracted	Explanation of latent factor by its own observed variables	> 0.5	All AVE values >0.5 (Except 1)
		CR Composite Reliability		> 0.7	All CR values>0.7
2	**Discriminant Validity[3]**	**MSV** Max Shared Variance	Observed variables do not explain the Latent factor rather by its own parent's observed variables;	MSV< AVE	All MSV values < AVE
		ASV Shared Variance (Average)		ASV < AVE	All ASV values <AVE

Table 5 Confirmatory Factor Analysis CFA Assumption

Table 5 showed that assumptions of CFA were fulfilled for the given data and constructs of the theoretical models. For our model, all the values were in acceptable range with 0.7<CR, 0.5<AVE, AVE>MSV & ASV. This identified that the model has neither convergent validity nor discriminant validity issues.

4.3.2.1. Assessment and fitness of Model

Structural and measurement model are the two main constituents of model in SEM. The measurement model provides the relation among the latent variables and their indicators. While the structural model provides probable causal dependencies among the dependent and independent variable. For model fit the results should be statistically significant and within acceptable range. For the study, when the observed p-value of a test statistic is smaller than the significance level pre-defined, a statistically significant level is attained. This study has confidence interval of 95% with 5% significance level(α), hence for significant results a less than 0.05 p-value must be obtained ($p < 0.05$).

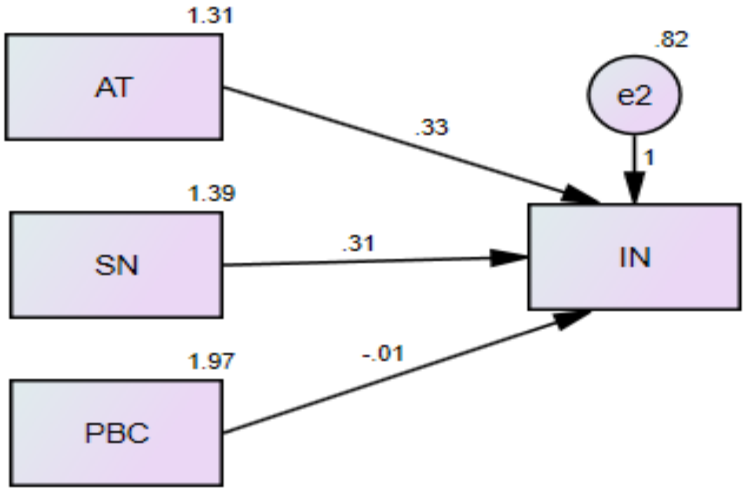


Figure 6: Structural Model

i. Direct effects:

Direct effects are evident via multiple paths, shown in fig. 6, from Independent variable (IV) to the dependent variable (DV). All beta (β) co-efficient and p values showed that all the paths showing direct effects were positive and significant which implies that structural model support all hypothesis (H1', H2', H3') of direct path effect.

ii. Indirect effects (mediating effect)

The mediation effects of the construct intention were examined. The paths for indirect effects are as follows: Effect of intention on the output behavior of the respondent. Results as in the Table 6, show a positive and significant mediation effect between intention and behavior.

	Estimate	S.E.	C.R.	P	Label
IN <--- AT	.329	.050	6.638	***	par_1
IN <--- SN	.311	.048	6.463	***	par_2
IN <--- PBC	-.009	.040	-.217	.828	par_3

Table 6: Regression Weights

	Estimate	S.E.	C.R.	P	Label
AT	1.310	.116	11.292	***	par_4
SN	1.389	.123	11.292	***	par_5
PBC	1.970	.175	11.292	***	par_6
e2	.822	.073	11.292	***	par_7

Table 7: Variances

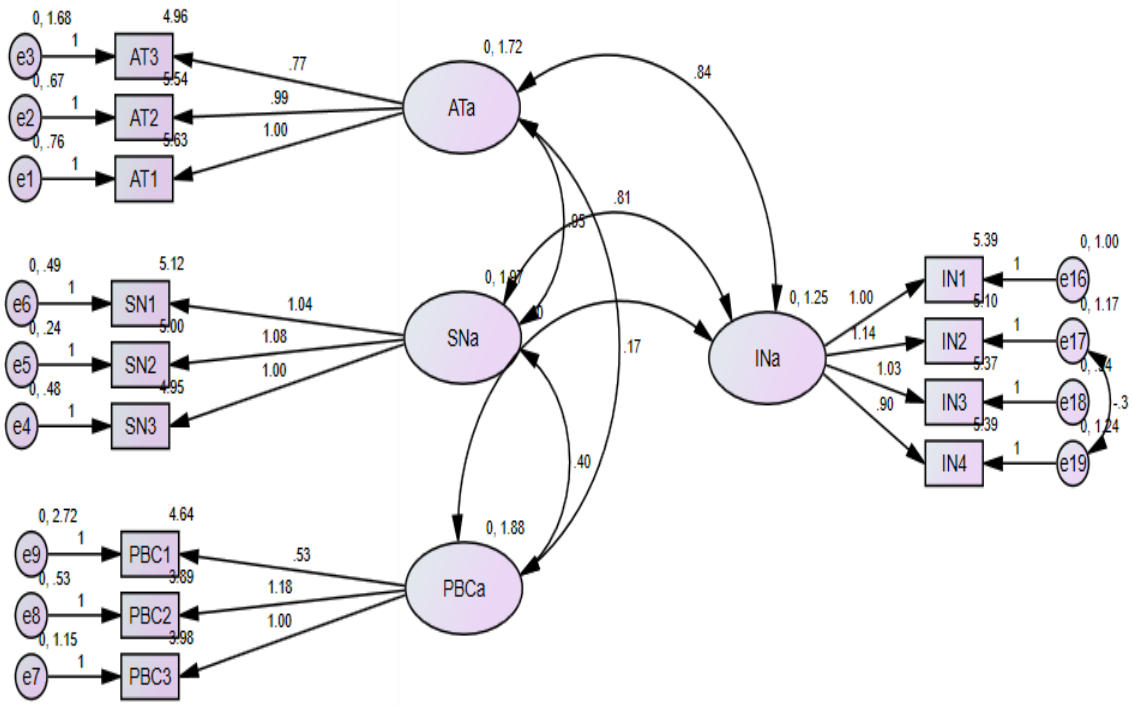


Figure 8: 4-factor Measurement Model

4.3.3. Fit indices

Particular parameters were calculated to find the model fit indexes via measurement models in AMOS. The thresholds listed in the Table 8 were according to multiple researches conducted[65-68]. To further strengthen our model fitness a 2-factor model was drawn and analyzed for results, in addition to the original 4-factor measurement model. The respective models are represented in fig 7 and fig 8. The results of CFAs are presented and compared in Table 8. It clearly shows that for model-I (4-factor) all the fit indices were in acceptable range for our hypothesized model.

Fit indices	Perfect fit	Accepted fit	4– Factor Model	2 – Factor Model
χ^2			135.227	1838.153
Df			58	78
χ^2/df	χ^2/df< 3	3< χ^2/df<5	2.331	23.566
GFI	0.95<GFI<1	0.90<GFI<0.95	-	0.379
NFI	0.95<NFI<1	0.90<GFI<0.95	0.926	0.000
TLI	0.95<TLI<1	0.90<TLI<0.95	0.941	0.000
CFI	0.97<CFI<1	0.95<CFI<0.97	0.956	0.000
RMSEA	0<RMSEA <0.05	0.05<RMSEA<0.08	0.072	0.297
$\Delta\chi^2$			Baseline Model	1702.926
ΔDf			Baseline Model	20

Table 8 Fit Indices of model I, II

Multiple CFAs were done to verify the variables' distinctiveness and their items, including AT, SN, PBC and IN. In two-factor model the independent variable (AT, SN, PBC) were merged. As per the CFA outputs from various models, the four factor model provided the best fit while the results for all others models compared to the measurement model were pretty worse [69]. E.g. a good fit to the data was provided by the four-factor model (CFI = 0.956, NFI = 0.926, RMSEA = 0.072) thus giving a good model fit; against the two-factor model where all the dependent variables were merged into one (RMSEA = 0.297, CFI = 0.000, NFI = 0.000). The distinctive validity of measures was obtained by the results and no significant Common Method Variance (CMV) threat associated with validity concerns was found in the process. Hence, the hypothesized model was accepted as a rational depiction of the variances and covariances among the measures [65].

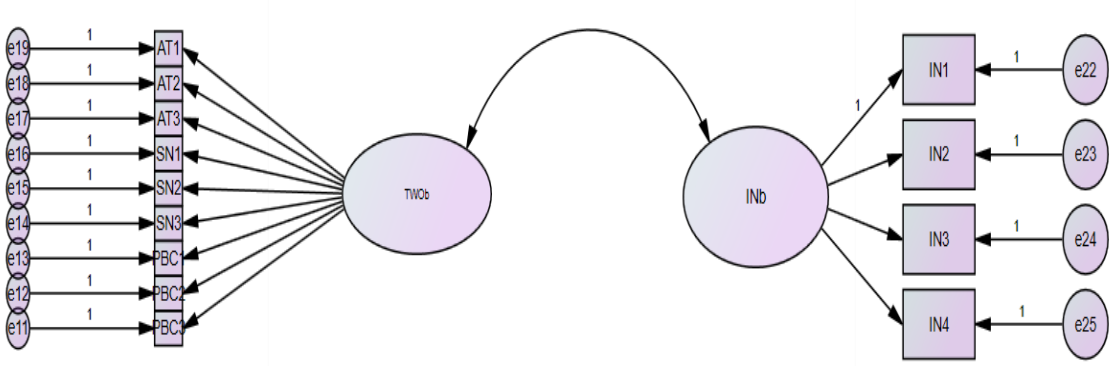


Figure 9: 2-factor Measurement Model

4.4. Model Modification

After the models were estimated, if the result showed that fit indices of the model were not in perfect or acceptable range. Then to improve the fit indices of model, modification indices were required. Our study found that all our fit indices fell in the acceptable range.

4.5. Discussion and Conclusion:

Objective of the research was assessing relationship between various variables (AT, PBC, SN) that influence the public intention to move from conventional to renewable energy sources, here among the university students of NUST Islamabad, Pakistan. The relationship was studied through conduction of a comprehensive survey to access the factors that greatly influence the acceptability towards adaptation of technologies related to renewable energy. For this, along with testing our theoretical model on defined standards, an additional model (2 factor) was also tested to strengthen the viability of our model and screen out other possibilities.

Results of our measurement model showed that variables (AT, SN, PBC) have a positive effect on people intention to shift from conventional to RES, as all beta values were positive. Also, all the p-values were less than 0.05. These results support all the hypothesis of our theoretical model (H1', H2', H3'). The results also showed that strongest effect between Attitude and Subjective Norm had more effect on a person's Intention to shift to RES (higher β-values) as compared to the PBC. In a previous study, it has been shown that such constructs had a positive effect on moving from conventional to

RES in Pakistan. The results from the structural model also implied significant relation among the independent and dependent variable, upon the final respondent behavior on shifting from conventional to renewable energy sources. Although the Extended Theory of Planned Behavior can be further incorporated, and more variables can be inculcated in the study to increase the scope of study, for now only theory of planned behavior was focused to lay down a groundwork for future studies. The overall response implicated that the public attitude and subjective norms are the major factors and need to be molded first to tilt the public support for the shift in a sector.

4.5.1. Policy Suggestions:

Self-identity, intention and price were placed highest in terms of impacting the shift from conventional to RES. Therefore, people will be more prone to shift, if monetarily feasible solutions are provided to them that cover the upfront cost or are subsidized or mad e cheap overall is technology and do not put a high price tag over the shift. Also, their intention needs to be molded via some awareness campaign that can tilt their intention towards the RES. A national awareness program or inculcating he benefits of RES in the curriculum can be among the ways to mold the public intention towards RES.

Construct	No. of Questions	Question	Source
Attitude	3	The shift from conventional to renewable energy sources is better for me	[2, 29]
		The shifting from conventional to renewable energy sources is socially beneficial for me	
		The shifting from conventional to renewable energy sources is monetarily advantageous for me	
Subjective norm	3	Many people, whose opinions I value, would approve if I shifted from conventional to renewable energy sources.	[29, 30]
		Many people, important to me think that I should shift from conventional to renewable energy sources	
		Many people, important to me think that my shift from conventional to renewable energy sources is desirable	
PBC	3	It is largely up to me whether to shift from conventional to renewable energy sources or not.	[29,30]
		For me shifting from conventional to renewable energy sources is easy	
		If I wanted to, I can easily shift from conventional to renewable energy sources	

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Annex III

Construct	No. of Ques.	Question	Source
Attitude	3	The shift from conventional to renewable energy sources is better for me.	[29]
		The shifting from conventional to renewable energy sources is socially beneficial for me.	
		The shifting from conventional to renewable energy sources is monetarily advantageous for me.	
Subjective norm	3	Many people, whose opinions I value, would approve if I shifted from conventional to renewable energy sources.	[29]
		Many people, important to me think that I should shift from conventional to renewable energy sources.	
		Many people, important to me think that my shift from conventional to renewable energy sources is desirable.	
PBC	3	It is largely up to me whether to shift from conventional to renewable energy sources or not.	[29]
		For me shifting from conventional to renewable energy sources is easy.	
		If I wanted to, I can easily shift from conventional to renewable energy sources.	
Moral Norm	3	I feel or would feel it to be a moral obligation to shift from conventional to renewable energy sources.	[39, 42]
		I would feel good if I shifted from conventional to renewable energy sources.	
		If I were to decide on designing the energy supply, I would feel obligated to use renewable energy sources.	
Self-Identity	3	I am the type of who would shift to renewable energy sources.	[39, 41, 52]
		Using renewable energy sources is an important part of who I am.	
		I am not the type of person who would be bothered by using renewable energy.	
Intention	4	I intend to shift from conventional to renewable energy sources in future.	[29]
		I have plans to shift from conventional to Renewable energy sources in future.	
		I will try to shift from conventional to Renewable energy sources in future.	
		I am willing to shift from conventional to renewable energy sources in the future.	
Price	2	Increased cost does not affect my shift from conventional to Renewable energy sources.	[55]
		If the price is covered in the long run I would shift from conventional to Renewable energy sources.	
Technological Access	1	If I have access to renewable energy sources, I would shift from conventional to renewable energy sources.	[50]
Behavior	3	I will adopt renewable energy sources instead of conventional energy sources soon.	[29]
		I am actively trying to shift from conventional to renewable energy sources.	
		I have shifted from conventional to renewable energy sources.	

Annex IV

EDUCATIONAL AND PSYCHOLOGICAL MEASUREMENT
1970, 30, 607-610.

DETERMINING SAMPLE SIZE FOR RESEARCH ACTIVITIES

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The ever increasing demand for research has created a need for an efficient method of determining the sample size needed to be representative of a given population. In the article "Small Sample Techniques," the research division of the National Education Association has published a formula for determining sample size. Regrettably a table has not bee available for ready, easy reference which could have been constructed using the following formula.

$$s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P).$$

s = required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

1.96 x 1.96 = 3.8416

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.05).

No calculations are needed to use Table 1. For example, one may wish to know the sample size required to be representative of the opinions of 9000 high school teachers relative to merit pay increases. To obtain the required sample size enter Table 1 at N = 9000. The sample size representative of the teachers in this example is 368. Table 1 is applicable to any defined population.

The relationship between sample size and total population is illustrated in Figure 1. It should be noted that as the population increases the sample size increases at a diminishing rate and remains relatively constant at slightly more than 380 cases.

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TABLE 1

Table for Determining Sample Size from a Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.
S is sample size.