Energy Conservation Through Changing Human Behavioural Approach; Challenges And Way Ahead For Sri Lanka Navy

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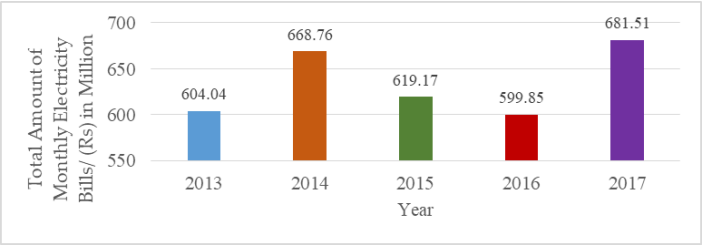
Abstract- Sri Lanka Navy (SLN) spends a considerable amount of capital on monthly electricity bill payments, which, if saved, could be expended for the benefit of the Navy. The present human strength of the Navy is approximately 55,000, and this figure directly influences the electricity consumption in the Navy. Owing to the fact that, the human behaviour can play a vital role in conserving energy, this study is focused on investigating and analysing the challenges influencing energy conservation through a behavioural approach of SLN personnel. The study followed a qualitative approach and necessary data was obtained from the officers and sailors serving at Sri Lanka Navy Ship (SLNS) Rangalla through an open-ended questionnaire and also through structured interviews. The study revealed that, awareness, supervision, restriction, coercion, referent power, attitudes, responsibility, feedback, and motivation are the factors affecting human behavioural approach. The absence or presence of these factors affect the behavioural intention and thereby influences the changing of human behavior. The results could be used in developing a theory that would promote energy conservation by altering the human behavioural approach.

Index Terms- Energy Conservation, Behavioural approach, Challenges

I. Introduction

Sri Lanka is gradually converting into a globally competitive country with a middle-income economy. The energy crisis has become a major issue throughout the world and it directly affects the national security of a country; this applies to Sri Lanka as well. The country mainly uses biomass, hydro, and fossil fuel to cater to the energy requirement. Hydro plants were considered as a viable solution for the power requirement in Sri Lanka, since the country is rich with many waterways. However, hydro power has been tapped to its maximum by now and thus the country has to depend mainly on imported fossil fuels to balance the energy requirement. According to the information available at the Ministry of Power and Energy, this includes 02 Million Metric Tons (MMT) of crude oil, 04 MMT of refined petroleum products, and 2.25 MMT of coal to the country annually, expending almost USD 5 billion in foreign exchange. The average total bill of annually imported fossil fuel is around 25% of the country's import expenses, and close to the 50% of total export revenue [1].

SLN daily consumes three main forms of energies; fossil fuels (mainly Diesel and Petrol), electricity, and LP Gas. Fossil fuels are consumed by ships, craft, and vehicles of the SLN. While LP gas is exclusively used for cooking, electricity is consumed for all daily activities. In comparison, the daily consumption of electricity is very high. Therefore, the present study focuses on the electricity usage, which will be denoted by the term 'energy' in the paper. The information obtained from the monthly electricity bills, revealed that the total annual cost of monthly electricity bills is approximately Rs. 600 Million. Graph 1 illustrates the electricity consumption of the Navy from the years 2013 to 2017. SLN pays a substantial amount of capital for the monthly electricity bills, which could be saved for the benefit of the Navy, if energy conservation practices are implemented.



Graph 1: Electricity Consumption in the Navy from 2013 to 2017

Numerous studies have recognised that change of human behaviour is highly effective and is a lasting resolve for energy conservation. Significant number of studies have attempted to ascertain the relationship between the behavioural approach and energy conservation, however, the contribution to recognise the factors influencing the conservation of energy through human behaviour approach is minimal. Furthermore, since the SLN has a considerable work force, this study is more appropriate to comprehend the behavioural change towards energy conservation. Therefore, the current study is focused on recognising the challenges against the conservation of energy through the behavioural approach, with the objective of investigating and analysing the challenges affecting conservation of energy and to make recommendations to mitigate the

challenges to conserve energy. So far, not a single study has attempted to identify the challenges regarding conservation of energy in the military context through a behavioural approach.

II. LITERATURE REVIEW

Energy conservation can be defined as 'any attempt made to decrease the consumption of energy to conserve energy resources for the future and reduce the effect on the environment' [2]. Energy conservation is achievable via two methods; 'technology-fixed' and 'behavioural approach.' The technology-fixed method is purely based on improving, developing, installing energy efficient systems, and devices and machinery to decrease the energy consumption [3]. Though it is highly effective and short-term solution for energy conservation, it is a costly process. A behavioural approach is a successful way towards energy conservation since the outcome is efficient and also it is a long-term solution to conserve energy. The behavioural approach towards energy conservation is a complicated process influenced by various factors and can be considered as the leading pillar of the successful energy conservation [4,5].

Behaviour change is defined as an exploration-oriented review process to address any specific knowledge, attitude, behaviour, and practices those are interconnected to achieve any goal [6]. Similarly, the behavioural approach includes the changes in stimulus conditions that influence the change in human behaviour [7]. There are a couple of factors identified as attributes for behavioural change towards energy conservation, namely; awareness, economy and environment, supervision, feedback, motivation and interventions. The change of consumer behaviour towards energy conservation is the key to saving energy; this is a complicated process influenced by various factors [5]. Behavioural approach could be accomplished by changing human attitudes, whereas attitudes can be influenced by motivating and raising public awareness [3, 6].

Knowledge on energy conservation is identified as a significant obstacle, and the economic and operational factors, and frustration due to non-availability of energy-efficient equipment act as certain impediments for energy conservation in laboratories [5]. Various investigators have recognised the applying of behaviours towards energy conservation at home is highly motivated, primarily by economic factors and secondly by environmental factors. Another study revealed both factors are equally crucial and positively correlated, since attitudes and valuing of the environment with the energy saving habits in the home leads to use energy saving appliances, thereby ultimately benefitting the economy [8, 9].

Supervision has a significant impact on a person's behaviour and directly affects the change of behaviour. If someone is knowledgeable on the impact of energy conservation, close supervision leads him/her towards energy conservation. However, the abusive supervision directly influences someone's behaviour negatively [10]. Supervision determines a person's behavioural intention positively or negatively, and ultimately it changes the human behaviour. Similarly, various feedback methods and interventions influence energy conservation via human behavioural changes. The indirect and direct feedback methods provide a compelling motivation factor to actively conserve energy and possible to save energy from 3% to 20% [11]. The feedback system on energy consumption, plays a significant role rather than merely implementing measurement programmes. Accordingly, a study has revealed that the users have saved energy from 3.5% to 22% due to real-time feedback [12]. The behaviour on energy consumption in a household primarily depends on habits and routine practices. A constructive correlation was identified between energy saving and changing of behaviours towards energy saving in households. These behaviours and routine procedures can be changed by enhancing knowledge, setting targets, and energy feedback, thereby allowing households to conserve energy significantly [8, 13].

Motivation is another critical factor that changes human behaviour. It is proved that motivation is critical for the performance of behaviour, and therefore for behaviour change [14]. According to various studies, a person can be motivated in different ways to act in a way that is expected. Behavioural change can be achieved through the attitudes and motivation can influence the attitudes [3, 6]. Motivation implements self-regulation which involves superseding existing habits over time until achieving a specified goal [15, 16, 17]. Finally, it is identified that most successful interventions are the interventions that create physical and social opportunities for the employees to conserve energy. Those are the six intervention functions of "Behaviour Change Wheel (BCW)", education, environmental restructuring, persuasion, modelling, and incentive and enablement. They have been examined in each research approach towards energy saving indirectly or directly, and either alone or in combination with two or more interventions [18]. The BCW is a methodical review of behaviour change interventions, especially for health research, based on popular behaviour theories such as *Theory of planned behaviour*. According to the BCW, motivation, opportunity, and capability are the causes of behaviour. Somebody's physical and mental capacity to engage in the particular behaviour is considered as the 'capability' whereas motivation includes all mental processes that empower a particular behaviour and clear decision-making. Opportunity is the factor that makes the individual's behaviour possible [18].

As illustrated in Figure 1, functions of nine interventions are located around the central hub, and a study has identified six interventions, i.e., education, incentive, enablement, environmental restructuring, persuasion, and modelling to understand the influence of behavioural interventions towards energy conservation [18]. However, to date, no investigations have been made on the other three functions, i.e., Coercion, Restriction, and Training. These three interventions are highly related to the military setup, because military tasks are accomplished through these functions. Within this context, it is possible to assume that applying these three functions may help to conserve energy in a military context, which will be a catalyst to conserve energy. Coercion is the expectancy of penalty or cost. Applying penalties against employees in a workplace for energy conservation may be impractical, but salary-related penalties may be the most effective penalty type [18]. The restriction includes orders, regulations, and rules targeting a specific behaviour to restrict or reduce the effect of engagement.

Training intervention in the BCW is imparting skills. It is crucial to train on new smart technologies and use them efficiently to save energy. The absence or lack of training directly affects the employees' control of functioning such as lighting, heating…etc. More often, an employee might operate the air conditioning system without any knowledge on how to use the system in the best way, such as keeping the doors and windows sealed when the air conditioning system is functioning [18].

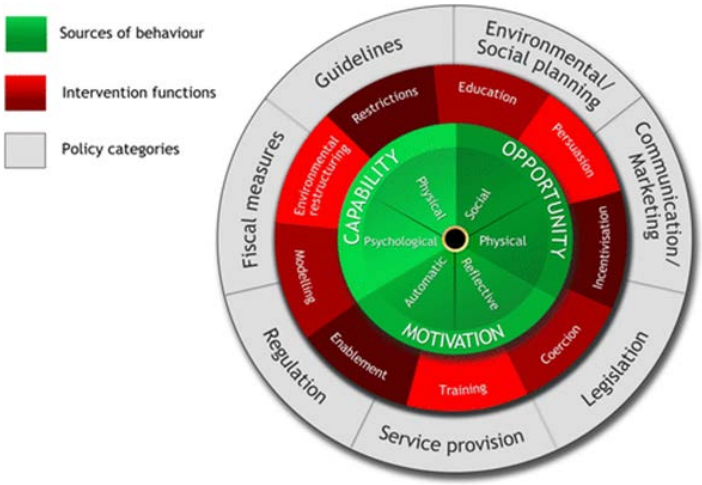


Figure 1: Behaviour Change Wheel [18]

"Theory of planned behaviour" is a development of the "Theory of reasoned action". According to the theory, there is a complicated psychological process behind each individual's behaviour, and the behaviour is an outcome of a sequenced psychological process. The theory states that, the actual behaviour is decided and influenced by the behaviour intention, which is affected by three factors, i.e., Perceived behavioural control, Subjective norms, and Behavioural attitude. Behavioural attitude is the leading attitude of a person that assists or not assists in executing a specific behaviour. Subjective norm indicates the pressure and influence of the society that persuades someone to decide when to perform and whether to perform the particular behaviour. Perceived behavioural control includes the ability of an individual to perform a behaviour, and it reflects the actual control conditions of that behaviour. Therefore, perceived behavioural control has a straight influence on the behaviour [19].

The factors identified through the literature review, which influence the behaviour related to the energy conservation, can be explained and applied to the theory of planned behaviour as illustrated in Figure 2. The factors that influence behavioural intention; awareness of energy conservation, training, motivation, feedback, and the impact on the economy and the value of the environment, are grouped under behaviour attitudes. Restriction along with supervision and coercion, the controlled beliefs, are grouped under the perceived behavioural controls. These interventions build the ability to perform the expected behaviour. However, the literature does not reveal a relationship between the identified factors and subjective norms, since they do not force or persuade someone to decide when and whether to perform a particular energy conservation behaviour.

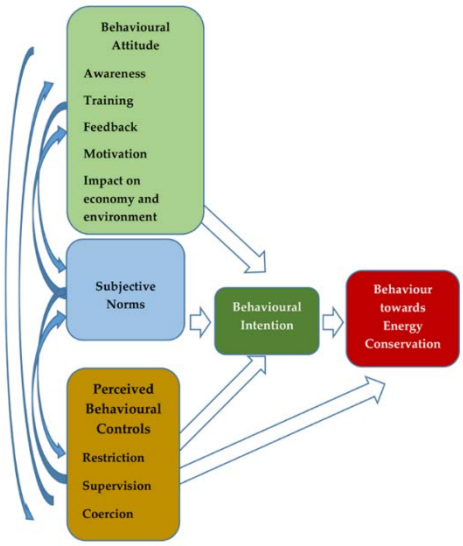


Figure 2: Theory of Planned Behaviour and factors identified

Behavioural approach plays a significant role in the effective energy conservation, since it depends on human behaviour significantly. Therefore, any factor or challenge affecting the behaviour intention can be recognised as a sub-challenge to achieve behavioural change to reach energy conservation. This study focuses on identifying the consequences of all factors discussed in the literature review, to recognise the challenges of electricity conservation through the behavioural approach in the Navy. Most previous studies on similar topics have been conducted overseas, and only a limited number of research is performed regionally. Investigations on energy conservation through changing human behavioural approach in Sri Lanka, or in the SLN was not found. Hence, a wide gap exists in the knowledge between available studies and what remains to be studied in the subject. Therefore, the objective of this study is to identify the factors or challenges affecting human behavioural approach towards energy conservation in the SLN.

III. METHODOLOGY

The study followed an inductive approach since it is designed to derive a theory based on observations from specific to general. An open-ended questionnaire and structured interviews were used to understand the challenges and barriers affecting energy conservation through human behavioural approach. Qualitative method was used since such analysis helps to understand the challenges affecting energy conservation through human behaviour change. The research is outlined in a cross-sectional time zone because the study is limited to a specific time frame. As shown in Figure 3, the independent variable represents the behavioural intent that influences the behavioural change towards energy conservation as identified by the literature. The awareness, impact on economy and environment, feedback, supervision, motivation, coercion, restriction, and training are the main contributing factors to the behaviour intent that influence the behavioural change, according to the literature review.

Therefore, the contributing factors to the independent variable are considered as barriers or challenges, and the behaviour towards energy conservation represents the dependent variable of the study.

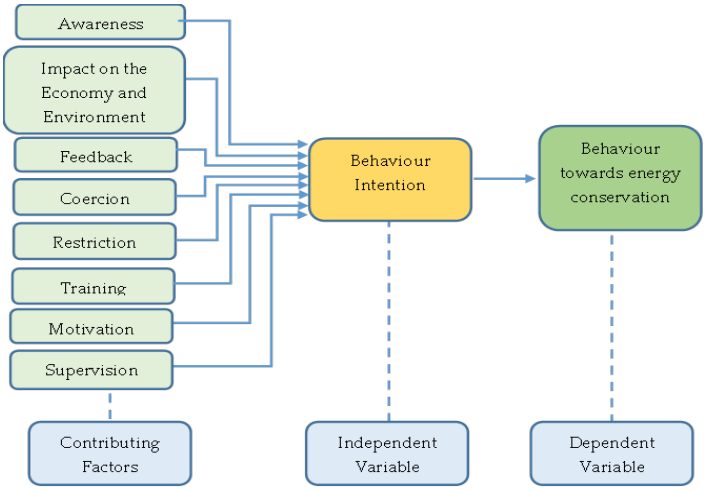


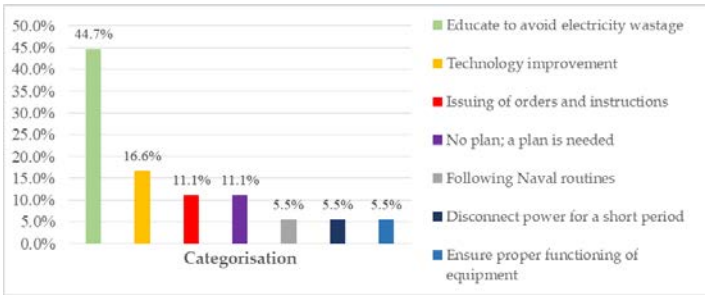
Figure 3: Relationship of factors affecting behaviour intention to change behaviour towards energy conservation

Structured in-depth interviews and an open-ended questionnaire produced the primary source of data. It helped to explore the topic and the factors affecting the behavioural change of participants profoundly, and finally analysed the research questions. Open-sources such as research documents, journal articles, books, and websites provided the secondary data to identify the research problem and construct a conceptual framework. The population was the ship's crew at SLNS Rangalla with 1395 persons as at 16 Apr 2018, and the samples were selected based on purposive sampling/judgemental sampling. The primary objective of the judgemental sampling method is to focus on specific characteristics of the population that will best assist in answering the research questions [20]. The homogeneous sampling procedure was used to select sample units based on their similar characteristics. Initially, the sample size was not pre-determined because it depends on the data saturation concept [21]. Data were collected from 15 personnel, because data saturation was observed after distributing the questionnaire and conducting 10-12 interviews.

Content analysis, which is a process of categorising verbal and written data to classify, summarise, and tabulate, was used for data analysis [22, 23]. In content analysis, interviews and answers were examined to identify the keywords, paragraphs, or themes [24]. Interviewed data and answers for the open-ended questionnaire were analysed under three stages using a manual method and the MS Excel software; open coding process, categorisation process and recognition of categories [25]. The questionnaire was pilot tested to identify the suitability and reliability to refine the questionnaire, and assure the absence of any doubt when answering the questions during the interview and facilitate data recording. The grounded theory analytical procedure was followed to generate a theory based on the central theme developed from the data. The data display and analysis procedure were also employed to organise and assemble data into diagrammatic visual displays.

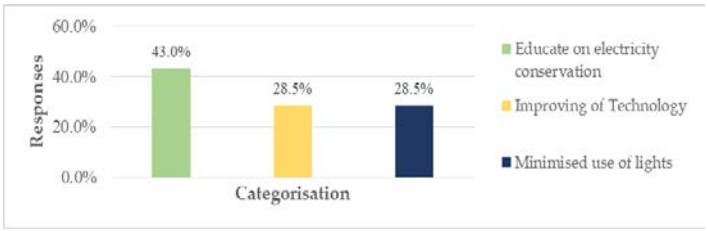
IV. RESULTS

Based on the analysis of data, the following results were derived. Graph 2 to 7 depicts the responses received through the open-ended questionnaire, which were subjected to initial coding for easy interpretation, and Table 1 summarises the final themes identified by the study. The avenues of contribution of SLNS Rangalla towards energy conservation as an individual organization was derived through data and shown in Graph 2.



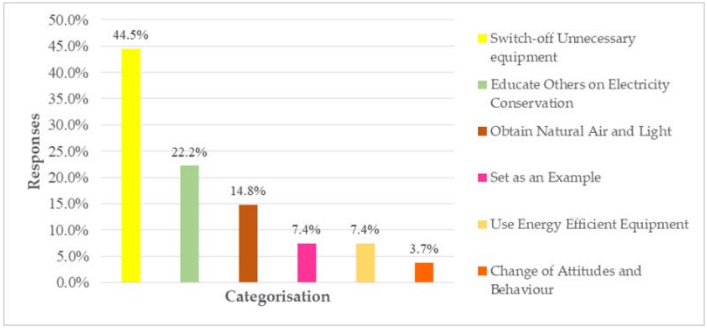
Graph 2: Contribution of SLNS Rangalla for electricity conservation

Existing electricity conservation practices in the SLN, indicated by the respondents, are depicted in Graph 3.



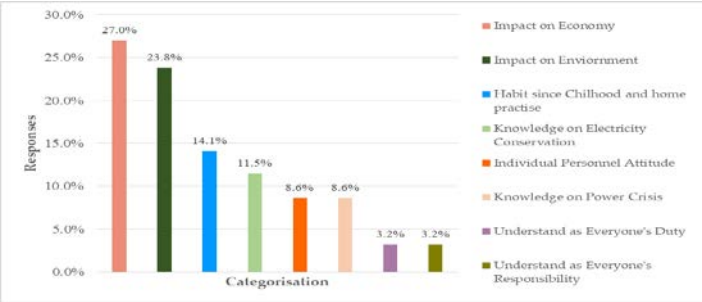
Graph 3: Existing electricity conservation practices in the SLN

The personal contribution towards electricity conservation in SLNS Rangalla is summarized as shown in Graph 4.



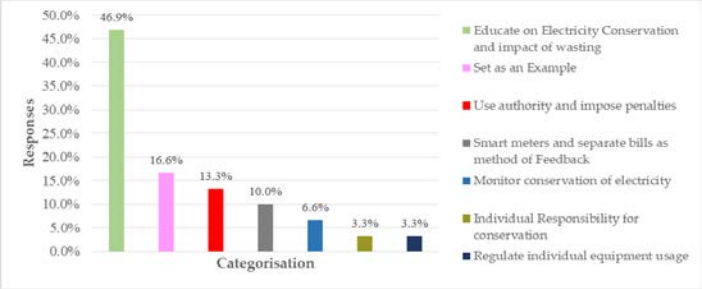
Graph 4: Respondents' contribution towards electricity conservation

Factors behind such behaviour to initiate energy conservation, those were indicated by the respondents, are shown in Graph 5.



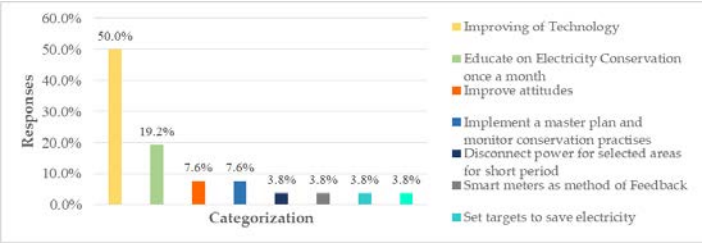
Graph 5: Factors underlying the electricity conservation behavior

The approaches of the respondents, to influence others' behaviour towards energy conservation is summarized in Graph 6, which was used to identify the factors affecting behavioural change of naval personnel towards energy conservation.



Graph 6: The way of influencing other's behaviour towards electricity conservation

In order to derive possible recommendations and solutions to enhance energy conservation in the Navy, the avenues suggested by the respondents to enhance conservation of energy in the SLN are depicted in Graph 7.



Graph 7: Enhancing electricity conservation in the Sri Lanka Navy

After recognising the initial coding, similar coding/categories were identified. These categories were further refined and reduced by grouping similar and overlapped categories together. Finally, a few inductive categories/themes were derived through the data interpretation, as depicted in Table 1.

Table 1: Final themes after reduction and grouping of initial coding

S/No	Grouping of Initial Coding	Inductive Categories /Themes
1	Educate on electricity conservation and the impact of wasting Knowledge on power crisis Impact on economy Impact on environment Obtain the maximum advantage of natural light and air	Awareness
2	Ensure proper functioning of equipment by human Monitor electricity conservation practises	Supervision
3	Disconnect power for a short period Minimise usage of lights Regulate individual equipment usage Issuing of orders and instructions	Restriction
4	Use authority and impose penalties	Coercion
5	Set as an example to others	Referent Power
6	Switch-off unnecessary equipment when not in use Habit since childhood and home practise Individual personnel attitudes	Attitudes
7	Understand as everyone's duty Understand as everyone's responsibility Individual responsibility for conservation Set targets for responsible personnel to save electricity	Responsibility
8	Smart meters and separate bills for individual rooms and offices	Feedback
9	Reward who achieve the set electricity saving targets	Motivation

V. DISCUSSION

As the results of the study shows, awareness of energy conservation influences the behavioural intention, and thereby behaviour of the naval personnel could be directed towards energy conservation. Supervision also has a significant impact on a person's behaviour and directly affect the change of behaviour. If someone is knowledgeable on the impact of energy conservation, close supervision leads him towards energy conservation.

Furthermore, coercion is the expectancy of penalty or cost. Though it is difficult to practice, coercion in a typical working environment, in a military context, this could be easily adopted, since every place and equipment has a responsible person. Authority can supervise whether employees follow the conservation practices, and if not, can impose penalties for those who violate in a military environment. Therefore, coercion may carry a significant impact on human behaviour change. Awareness, supervision, restriction, and coercion were identified as inductive categories/themes. These inductive categories were derived through the existing energy conservation practices of the SLN and have proved that the present conservation practices are directly and indirectly influence the change of human behaviour towards energy conservation. The Theory of Planned Behaviour forms the basis for explaining the relationship between categories and behavioural change.

The factors affecting behavioural change of naval personnel towards energy conservation were also identified. Since enhancing awareness of energy conservation directly influences the behavioural attitude under the theory of planned behaviour, it is a successful approach towards energy conservation. Apart from that, referent power promotes the behavioural attitude of a person and leads him towards the expected behaviour.

The underlying factors of a person's energy conservation practices were identified as a part of this study. Awareness on impact of wasting energy on the economy and environment, energy conservation, and existing power crisis could be categorised under the awareness of energy conservation with significant impact on behavioural attitude. The study further proved that habits and attitudes also lead towards energy conservation. Furthermore, conservation of energy is a prime duty and responsibility of all citizens, and individual responsibility has forced their behaviour positively towards energy conservation. It depicts that, when a person becomes responsible, his/her behaviour change significantly towards the expected direction. The responsibility related to a person's belief that others think he or she should engage in such behaviour, which could be grouped under subjective norms. It is interrelated with factors of behavioural attitude as explained above, awareness of the impact on economy and environment resulting from wasting electricity, power crisis, and electricity conservation practices.

Ways in influencing others behaviour towards energy conservation are, educating others on energy conservation and the impact of wasting and setting an example to others. Furthermore, conservation practices could be monitored and even authority can be used to impose penalties for the personnel who violate. Restriction and supervision are interconnected with coercion and carry a significant impact on human behaviour change. Feedbacks such as, providing smart meters for individuals' rooms, and display bills of previous months, have a direct impact on behavioural attitude.

The study also derived possible recommendations and solutions to enhance energy conservation in the Navy through behavioural change, which includes enhancing the awareness on energy conservation from top to bottom, restricting electricity for selected areas, implementing a master conservation plan with an efficient monitoring mechanism and rewarding system. All inductive themes derived in this study, i.e., awareness, supervision, restriction, coercion, referent power, habit, responsibility, feedback, and motivation, are summarised according to the theory of planned behaviour as depicted in Figure 4.

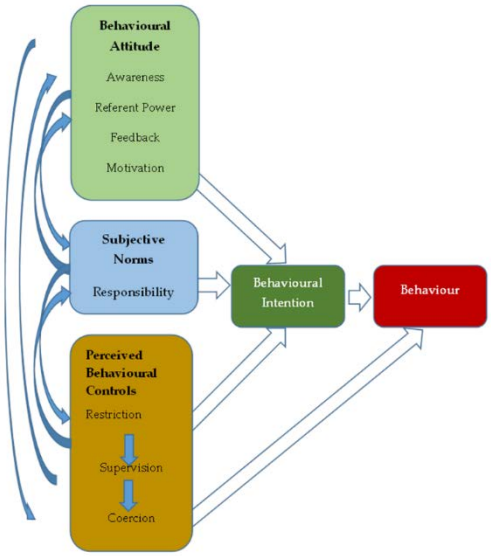


Figure 4: Theory of planned behaviour and all inductive categories derived

VI. CONCLUSION

Behavioural change is a long-term solution for energy conservation, and thus, this study was mainly focused on identifying the factors affecting the behavioural change towards the said purpose. Considering the human strength of the Sri Lanka Navy, the study aimed to recognise the factors influencing human behavioural change. The Theory of Planned Behaviour was utilised to further investigate how the identified factors influence human behaviour. The study revealed that changing human behaviour through these factors is challenging and implementing a suitable and effective mechanism is a need. This study identified the following inductive categories as the contributing factors that stimulate the behaviour intention towards behavioural change; awareness, supervision, restriction, coercion, referent power, habit, responsibility, feedback and motivation.

It was revealed that, the present energy conservation practises in the SLN address the contributing factors, i.e., awareness, supervision, restriction, and coercion to apply electricity conservation practices through the change of human behaviour. Further, the referent power, habit, and responsibility emerged as new knowledge. The absence of a factor directly affects the behaviour intention and subsequently influence the expected behaviour. Therefore, these factors could be contemplated as the challenges to human behavioural change for energy conservation. In conclusion, a central theory could be developed, i.e., 'Energy conservation could be achieved through a human behavioural change in the SLN, and the SLN has to identify a suitable effective mechanism to achieve the expected result through the identified factors.'

Following major recommendations are made to enhance the energy conservation through human behaviour change in the SLN.

a. Implement an effective awareness programme on energy conservation.
b. Provide a feedback to limit the consumption, by installing electricity meters in distinct places inside the naval base with the consultation of Ceylon Electricity Board.
c. Set energy conservation targets for the personnel occupying a particular space and reward the personnel achieving the set targets.
d. Implement a proper energy conservation action plan with the consultation of energy auditors and specialists in the field. It should be a detailed action plan that includes the following: mission, aim, energy conservation opportunities, daily energy conservation guide, energy audits, recommended lighting settings and energy consumption and cost information.
e. Establish an energy audit team for monitoring the correct implementation of energy action plan.
f. Implement necessary orders and instructions to execute the action plan and relevant conservation practices.

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