NEET eMagazine

Naval Electrical and Electronic Engineering Technology

April 2023 Edition

Directorate of Electrical & Electronic Engineering
Sri Lanka Navy

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PREFACE

Naval Electrical and Electronic Engineering Technology (NEET) e-Magazine is the entity established to coordinate and streamline research related activities in the Directorate of Electrical and Electronic Engineering, Sri Lanka Navy. Its main endeavor is to promote and uplift the research culture by stimulating, implementing and monitoring research and research related activities of the Directorate. In this context, the Directorate has compiled this collection of published research papers and new articles by the staff of the Directorate of Electrical and Electronic Engineering. The NEET e-Magazine is comprised of a collection of peer-reviewed research papers already published in journals and conference proceedings under different fields of Engineering. This e-Magazine will serve as effective resource material for both senior and Junior staff. Furthermore, it will reflect the commitment of staff of the Directorate towards conducting high quality research as one of the main duties as Engineers and technical staff. The Directorate sincerely hope that this material will be beneficial for all stakeholders concerned.

MESSAGE FROM THE DIRECTOR GENERAL ELECTRICAL AND ELECTRONIC ENGINEERING

With a deep sense of pride and honour, I am delighted to compose this message on the momentous occasion of the launch of the e-magazine on Naval Electrical Electronic Engineering Technology (NEET) in April 2023 at Navy Headquarters. The NEET e-magazine comprises a collection of meticulously crafted articles on Electrical and Electronic Engineering Technology. These insightful contributions have been authored by our esteemed officers and sailors, who have extensively referred to technical literature, online resources, and printed references to ensure the accuracy and comprehensiveness of the content.

The magazine comprehensively addresses various topics within the realm of naval technology, including shipborne electrical and electronic systems, weapon/missile engineering, power generation and distribution, telecommunications, data communication, RF communications, radar, sonar, and other relevant areas.

Having successfully overcome terrorism through a three-decade-long conflict, the Sri Lanka Navy stands prepared to uphold its status as a professional and technologically advanced organization in the years ahead. In this regard, I express my genuine anticipation that NEET e- magazine will serve as a platform to facilitate the exchange of knowledge and foster enhanced analytical thinking among the officers and sailors of the Electrical & Electronic Engineering department within the Sri Lanka Navy.

Furthermore, I would like to extend my heartfelt gratitude to all the officers and sailors who have dedicated their valuable time and effort towards the publication of this magazine. Their unwavering commitment and contributions have made this endeavour possible. I wholeheartedly wish them good luck and a prosperous journey ahead.

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Rear Admiral
Director General Electrical and Electronic Engineering

MESSAGE FROM THE SENIOR SUPERVISING OFFICER
NEET e-MAGAZINE

It is indeed a great honour to serve as the Senior Supervising Officer NEET e- Magazine and it is an immense pleasure to launch 2023 April edition as per the guidance given by DGL. I hope this message finds you well and that you are enjoying the valuable content and insights provided by the NEET e-magazine.

In today's rapidly changing world, it's more important than ever to keep up with the latest developments in your field of expertise. Reading technical e-magazines is an excellent way to stay informed and gain knowledge about new technologies, innovations, and industry trends.

I would like to take a moment to acknowledge all participants' hard work and commitment to launching this edition of the NEET e- magazine in a successful manner. Further, I encourage you to make the most of this valuable resource and engage with the content to deepen your understanding of your area of interest. Whether you are a seasoned professional or a newcomer to the field, there is always something new to learn.

I strongly believe that NEET e- magazine is an excellent in-house platform to broaden our horizons in the field of electrical and electronic engineering aspects and modern technology in the Navy. A big thank you to all the naval personnel who contributed to writing the wonderful and inspiring articles and papers to make NEET e-magazine issue more resourceful and relevant.

I wish you all the best in your continued learning journey.

CAP ANTHONY, USP, ndc, psc, MSc (DS) Mgt, BTech EE Eng, CEng (SL), CEng (I), MIE (SL), MIE (I)
Commodore(L)
Senior Supervising Officer (NEET E-Magazine)

MESSAGE FROM THE CHAIRMAN OF THE EDITORIAL BOARD
NEET e-MAGAZINE

A warm welcome to all readers to the first edition of Naval Electrical and Electronic Engineering Technology (NEET) e-magazine under the Directorate of Electrical and Electronic Engineering, Sri Lanka Navy.

The main objective of this NEET e-Magazine is to establish an in-house platform / forum for the Officers and Sailors of the Directorate of Electrical and Electronic Engineering to enhance their research skills, technical writing, presentation skills and also to share their knowledge by publishing their papers, articles, case studies, reviews, discussions and essays etc. and I wish and hope they will achieve the intended objective through this edition of the magazine and editions to come in the future.

The topics covered in the magazine include but not limited to: Power Generation and Distribution, Electronic, Telecommunication and Data Communication, Naval Fleet Electrical Systems, Navaids and Surveillance Systems, Weapon Engineering, Cyber Security / IOT / Latest Technologies, Research and Development, Renewable Energy Technologies, Technical Management. It is with profound pleasure, I shall mentioned that the response / contribution received from our Officers and Sailors for the magazine was wonderful as we have received 33 Nos. of articles and only 09 Nos. of articles were selected for this 2023 April edition after screening them for plagiarism / reviewing and the rest will be considered for the next edition.

On behalf of the editorial team, I would like to offer a word of thanks to our readers, contributors, authors, editors, DGL/DNLs/CLDs/CLOs/HODs/SLOs and all of whom have volunteered to contribute to the success of the NEET e-Magazine 2023 April edition and I wish and hope you will offer the same or more support / contribution in the future editions too.

Finally, if you have any comments, suggestions, or concerns, please address them to neet.dgl@gmail.com as they will help to improve the quality of the magazine.

Thank you and I hope you will find **NEET e-Magazine 2023 April edition** informative.

IDD NISHANKA, BSc(DS)EE Eng., CEng., MIE(SL)
Commander (L)
Chairman Editorial Board (NEET e-Magazine)

EDITORIAL BOARD

"The opinions expressed within the journal are solely the author's and do not reflect the opinions of the Directorate of Electrical and Electronic Engineering or the Sri Lanka Navy"

Chairman NEET Editorial Board

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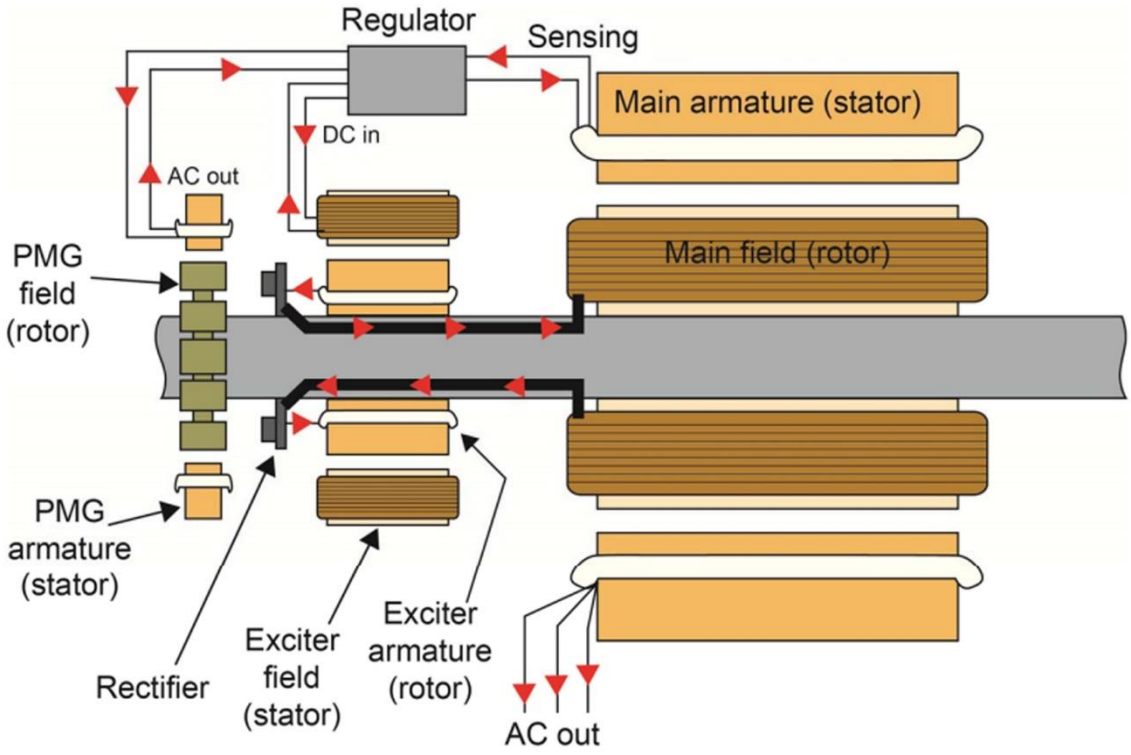
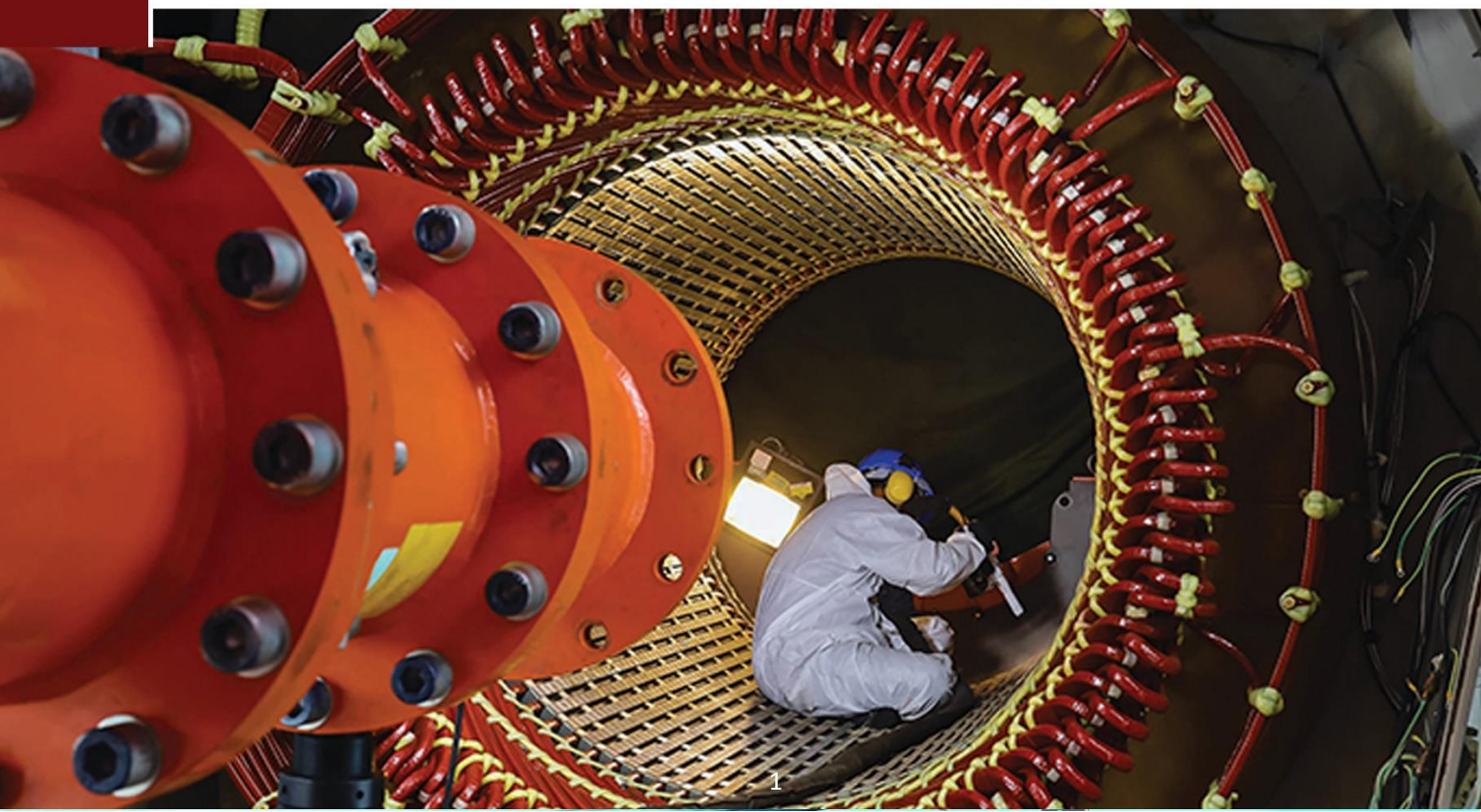
Captain(L), RT Hettiarachchi
NRL 1084





PROTECT GENERATOR WINDING AGAINST UNBALANCE CURRENT INCLUDING PHASE FAILURE AT LOAD END BY SHUNT ACTIVE POWER FILTER

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***Abstract*. Having a well-balanced three phase power distribution system is a miracle in actual scenario even it has been designed properly. The unbalance current creates adverse impact on power quality and energy loss. In this paper, simplified 3 legs six IGBT and split DC Capacitor Shunt Active Power Filter (SAPF) with Voltage source invertor topology is proposed to mitigate energy loss by balancing the power source output current irrespective of unbalanced load current including phase failure at load end. SAPF was used to obtain neutral point and the Synchronous reference frame theorem used for reference current calculation. To balance the current drown from source has been implemented by the sequence current method. Hysteresis current controller method is the tool to generate gating signals for driving the Thyristor. The simulated result was obtained by the MATLAB R16/ Simulink.**

Keywords: SAPF, load balancing, power quality, generator winding.

1. Introduction

Electricity is one of the most important blessings that science has given to humankind and it has also become a most essential part of modern life. The electricity has dominated in almost every field which includes domestic, medical, transport, production, industry, military are few. In Sri Lanka Navy, main power source for the ships and craft and standby power for establishment have been provided by generators. Also most of the establishments have obtained power from the national grid through transformer as a bulk supply. It has been observed the phase unbalance in power distribution network especially in establishment with large scale workshop comprising the industrial loads. Majority of these loads have nonlinear behavior at AC power source and these loads draw the harmonic currents, the current of reactive power component, fluctuating current, and unbalanced currents from AC mains. Thus, these currents create adverse effects on power quality. Besides that, this paper mainly concerned the unbalanced current effect on the high current in neutral wire and energy loss by the reactive power component.

The prime objective of this paper is to study and design SAPF and verify the result by simulating the model. Two main parts of the filter is controller and the inverter. The Voltage Source Inverter (VSI) with six IGBT has been used in this application. As the power system is 3 Phase four wire, it is necessary to provide Neutral point at the inverter. Same can be achieved by introducing another pair of Thyristor. Though it gives a solution but considering the cost factor and the complexity, split capacitor method has been chosen. In order to balance the source current obtain from the source supply, sequence method has been introduced to the model. By using this method, amplitude of source current in all 3 phases can be mealy balanced with the change of load current and even at the single phasing condition. Current in the neutral wire also need to be minimized. Thereby control and reduce the reactive power in the system.

The instantaneous active and reactive components of load current are used to produce the reference compensation currents in this I_d-I_q control method with Clark & Parks transformation and inverse transformation. Also PI controller

algorithm is used to eliminate DC side error. The gating signals for the Thyristor are generated using hysteresis current controller. Matlab/Simulink is the tool utilized for the simulation.

2. Active Power Filter Topologies

There are three main members in this APF family, which are Shunt, Series and Hybrid APF. The APF system is a complex system that has to be configured in a suitable way and it is done in three steps; selection of the converter, topology and controller. The first step is to choose the converter type, either Current Source Inverter (CSI) or Voltage Source Inverter (VSI), in a CSI, an inductor is used as the main energy storage device and a capacitor is used in the VSI case. The VSI is the most dominant and frequently implemented because it is less expensive and easier to control in comparison to the CSI. The second step is to determine the topology which can either be series, shunt or hybrid connection. The final step is to select a controller and switching mode suitable for the selected topology.

Upon selecting the converter type, there is another point to be considered which is to have the neutral point as most of domestic and office equipment are used single phase power supply. Same can be achieved by 3 leg or 4 leg converter. In 3 leg method split capacitors with 3 thyristor and 4 leg method one capacitor with 4 thyristor been used. It is observed that 3 legs split capacitor method is more economical and controlling technique is easy with compares to other method. With all above SAPF in 3 leg six IGBT with two split capacitor method has been chosen.

3. Shunt Active Power Filter

The shunt APF is one of the most popular topologies used for mitigating harmonics as well as balancing source current. The controller monitors the current consumed by the load (I_L) and then creates a compensation current reference (I_F) which generates the compensation current (I_{AF}) and it goes back into the system. The reference is used as the input to the power converter which then reproduces the inverse of the harmonics by switching in a certain pattern determined by the controller.

In general, the shunt APF consists of three main blocks, the power stage circuit with a connected storage capacitor (C), pulse width modulated (PWM) controller and the APF controller. The compensation current that should be consumed by the system is determined instantaneously in real time by the controller and passed further to the PWM converter. The controller works in a closed-loop manner, continuously sensing the load current and simultaneously calculating the compensation current reference for the PWM converter. The power stage is responsible of supplying the compensation current and to be able to reproduce the current in a proper way, a switching frequency (f_{PWM}) should be selected which is at least 10 higher than the highest order of harmonic current that is to be compensated. The energy to supply the load with current is stored in the storage capacitor connected to the converter. The block concept of SAPF is shown below.

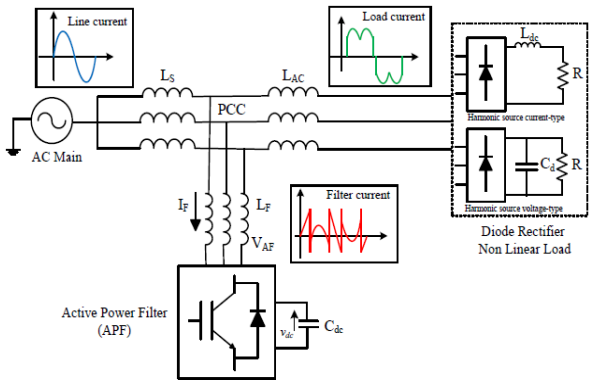


Fig 3.1. Block concept of SAPF

4. Control of Three-Phase SAPF

There are two main techniques can be used to determine the reference for the

controller. Those are instantaneous reactive power method (p-q) and synchronous reference frame method (d-q). Both the main methods utilized Peak & Clark transformation and inverse transformation to generate reference current signal. In this paper, d-q method has been selected and block concept is as below,

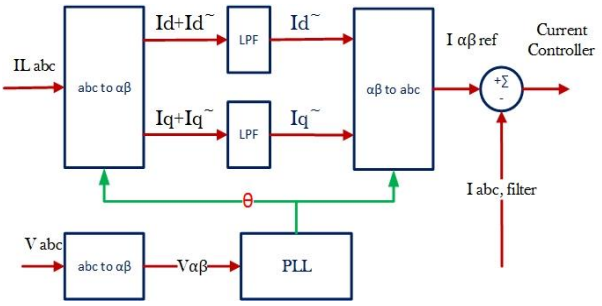


Fig 4.1. Synchronous reference frame method (d-q)

5. Hysteresis Current Controller

Among various PWM current control strategies for shunt APFs, the hysteresis current controller (HCC) is a simple, robust and high bandwidth method used for generating the switching patterns for the VSC. The HCC maintain the compensation current within a desired hysteresis band (HB). The HB directly affect the switching frequency, a lower value of HB gives less ripple but higher average switching frequency and vice versa. The switching logic in Figure 5.1(a) for leg A is given by

If $i_{ca} < (i_{ca,ref} - HB)$ - the upper switch is off and the lower switch is on.

If $i_{ca} > (i_{ca,ref} + HB)$ - the upper switch is on and the lower switch is off.

Where i_{ca} and $i_{ca,ref}$ are the line current and reference line current respectively for leg A. The current and voltage waveforms for phase A is shown in Figure 5.1(b), similar waveforms and switching logic also applies to phase B and C but shifted in time.

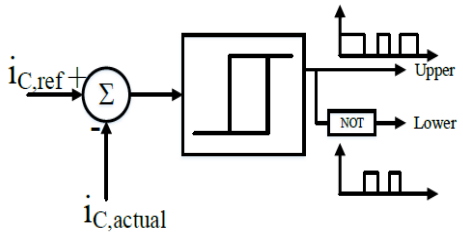


Fig 5.1(a). Block concept

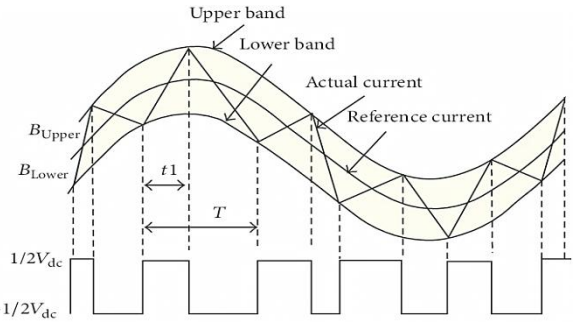


Fig 5.1 (b). Principle of Hysteresis Controller

6. Phase Locked Loop

A Phase Locked Loop (PLL) circuit is commonly used method to obtain frequency and/or phase information of the measured waveform. Among many PLL algorithms, the synchronous reference frame (SRF) PLL is more popular. The three-phase voltage waveforms are transformed into the αβ frame using the Clarke transformation and then to the SRF (dq frame) using the Park transformation. A block diagram showing the conventional SRF-PLL is shown in Figure 6.1

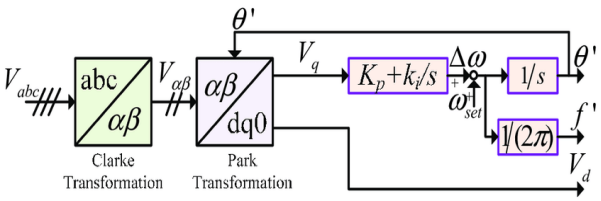


Fig 6.1. Block diagram of PLL

7. Calculation, Algorithms and the Simulation for Proposed SAPF Design

Design parameters, mathematical calculations and relevant algorithms used for the SAPF are described here.

a. ***The Load***: At the initial stage, a 3phase unbalanced linear resistive load has considered for the simulation. Thereafter different types of nonlinear loads connecting to the power source in different time intervals. At the end phase A (Red) disconnected to simulate phase failure. Simulink model of relevant load is shown in Figure 4-1 and the detail description of parameters is tabulated to Table 4-1. The voltage for this simulation is 400VAC, 3 phase with Neutral connection.

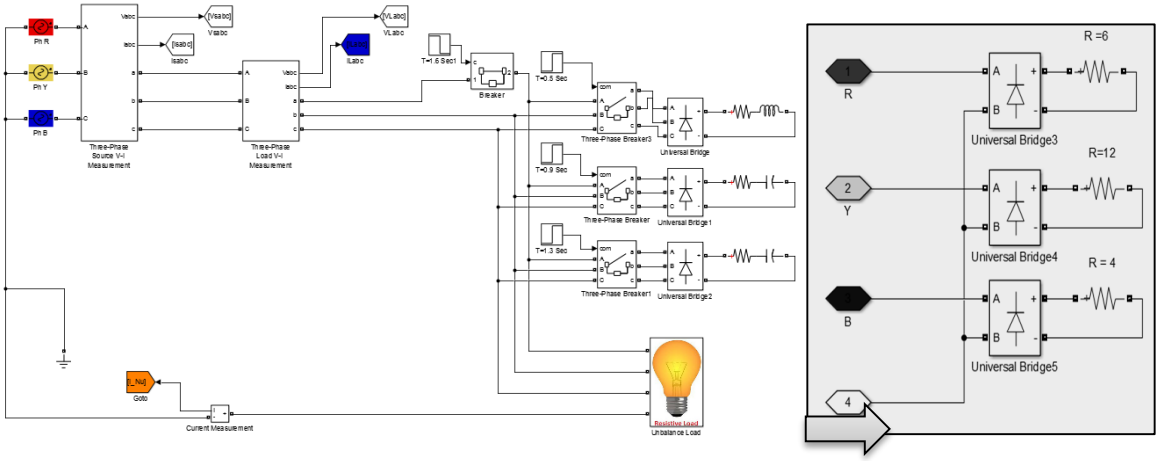


Fig 7.1. Simulink model of loads with Expansion of Unbalanced Resistive load.

Description	Value	Time Delay
Resister in Load 1	7Ω	
Resister in Load 2	5Ω	
Resister in Load 3	4Ω	
Resister in Phase R in unbalanced load	6Ω	
Resister in Phase Y in unbalanced load	12Ω	
Resister in Phase B in unbalanced load	4Ω	
Inductor in Load 1	20mH	
Capacitor in Load 2	2500µF	
Capacitor in Load 3	1500µF	
3Ph Circuit Breaker for Load 1		On at 0.5 Sec
3Ph Circuit Breaker for Load 2		On at 0.9 Sec
3Ph Circuit Breaker for Load 3		On at 1.3 Sec
1Ph Circuit Breaker for Phase R		Off at 1.6 Sec

Table 4-1. Description of load

b. ***The Controller:*** The d-q method can separate the harmonic components from its fundamental components. PLL block is for calculating theta θ by αβ coordinates. Park transformation does the conversion of stationary 'abc' frames to rotating 'dq' frames with the calculated θ. Reference DC voltage and capacitor DC voltage (V_{dc}) compiled by PI controller and then use of inverse Park Transformation reference frame current has been generated. Relevant calculation and Simulink models are described below,

V_α and V_β has been calculated by the following matrix with 3 phase line voltages V_a, V_b & V_c.

$$\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

The theta θ is the angular deviation or rotation angle of the synchronous frame from three phase orthogonal system. The Theta θ can derive from following formula,

$$\theta = \tan^{-1}\sqrt{\frac{V_\beta}{V_\alpha}}$$

c. ***Computation of Instantaneous***

Active (I_d) and Reactive Current (I_q) Current: In this d-q method instantaneous active current (Id) and instantaneous reactive current (Iq) components of the load current used to generate compensation current (I^*_{RYB}). The three-phase quantities are translated from the three-phase reference frame to the two-axis orthogonal stationary reference frame using Clarke transformation by the following equations,

$$I\alpha = \frac{2}{3}I_R - \frac{1}{3}(I_Y - I_B)$$

$$I\beta = \frac{2}{\sqrt{3}}(I_Y - I_B)$$

The two-axis orthogonal stationary reference frame quantities are transformed into rotating reference frame quantities using Park transformation by the following equations,

$$Id = I\alpha\cos(\theta) + I\beta\sin(\theta)$$
$$Iq = I\beta\cos(\theta) - I\alpha\sin(\theta)$$

At the end of computation, inverse transformation has been utilized for obtaining the three-phase reference current and matrix used for simulation is shown herewith,

$$\begin{bmatrix} I^*_R \\ I^*_Y \\ I^*_B \end{bmatrix} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ cos(\theta - 2\pi/3) & -sin(\theta - 2\pi/3) \\ cos(\theta + 2\pi/3) & -sin(\theta + 2\pi/3) \end{bmatrix} \begin{bmatrix} I_d \\ I_q \end{bmatrix}$$

d. +Ve, -Ve & Zero Sequential Current:

Sequential current is required for computing the natural point in order to achieve the load balancing and relevant formulas for +Ve, -Ve & Zero Sequential Current as given below,

$$\begin{bmatrix} I_{d+ve} \\ I_{q+ve} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos(\theta) & cos(\theta - 2\pi/3) & cos(\theta + 2\pi/3) \\ -\sin(\theta) & -sin(\theta - 2\pi/3) & -sin(\theta + 2\pi/3) \end{bmatrix} \begin{bmatrix} I_R \\ I_Y \\ I_B \end{bmatrix}$$

$$\begin{bmatrix} I_{d-ve} \\ I_{q-ve} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos(-\theta) & cos(-\theta - 2\pi/3) & cos(-\theta + 2\pi/3) \\ -\sin(-\theta) & -sin(-\theta - 2\pi/3) & -sin(-\theta + 2\pi/3) \end{bmatrix} \begin{bmatrix} I_R \\ I_Y \\ I_B \end{bmatrix}$$

$$I_{Zero} = \frac{1}{3}\left(I_{Lr} + I_{Ly} + I_{Lb}\right)$$

e. DC Link Voltage: The PI technique is used to compute DC Link voltage and maximum voltage (V_{max}) was found to be 650.54V, hence 800V used for the simulation as per following equation,

$$V_{DC} \geq 2\sqrt{2}V_{\max}$$

f. Generating the Gating Pulses

Hysteresis band controller method has been used for generation of gate signals for six IGBT. Subtraction of calculated three phase reference current and feedback current has used as shown below

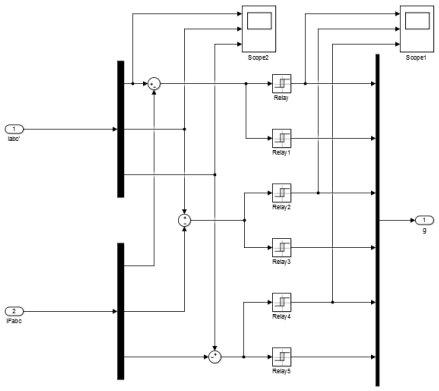


Fig 7.1. Gating Signal Generator in Simulink

8. **Simulation and Result** The simulation has been done initially without SAPF and following are the current in neutral line and Source current & Load current respectively,

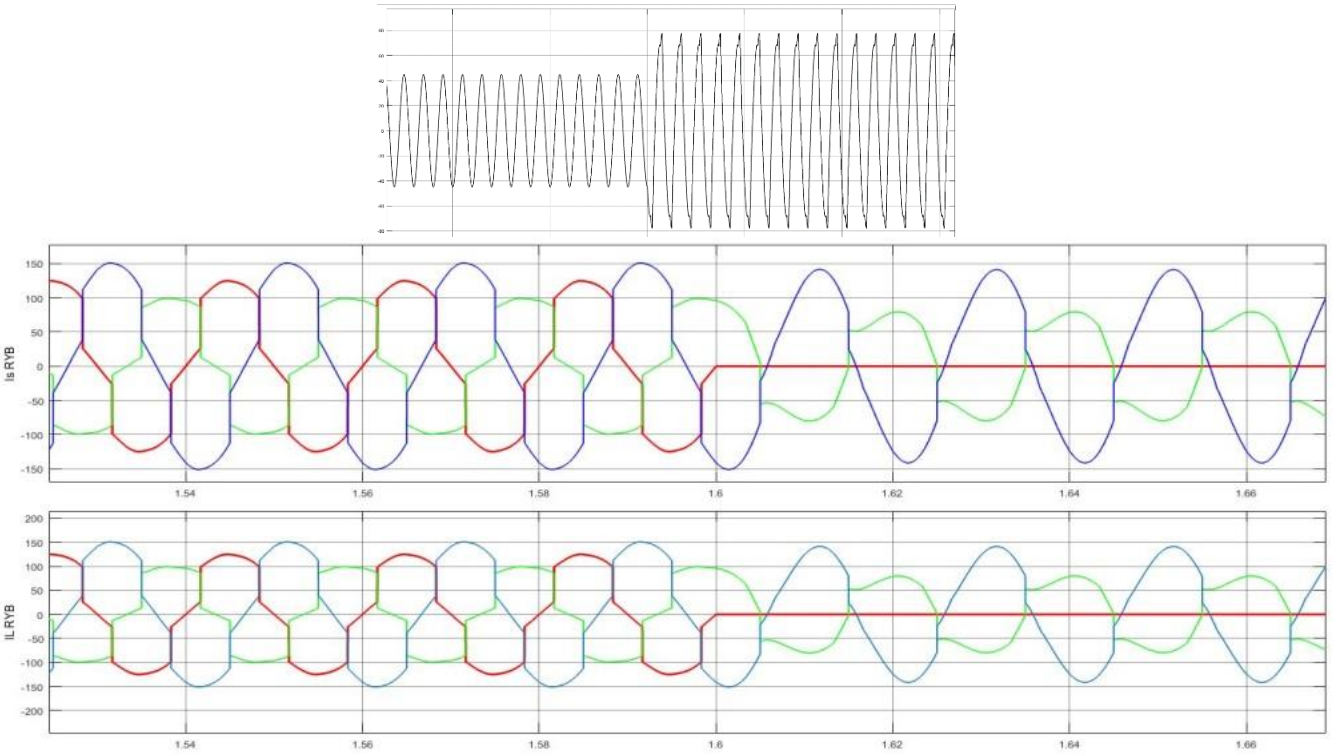


Fig 8.1. Current in Neutral Line

Thereafter simulation is done with proposed SAPF and the controller and VSI is shown below,

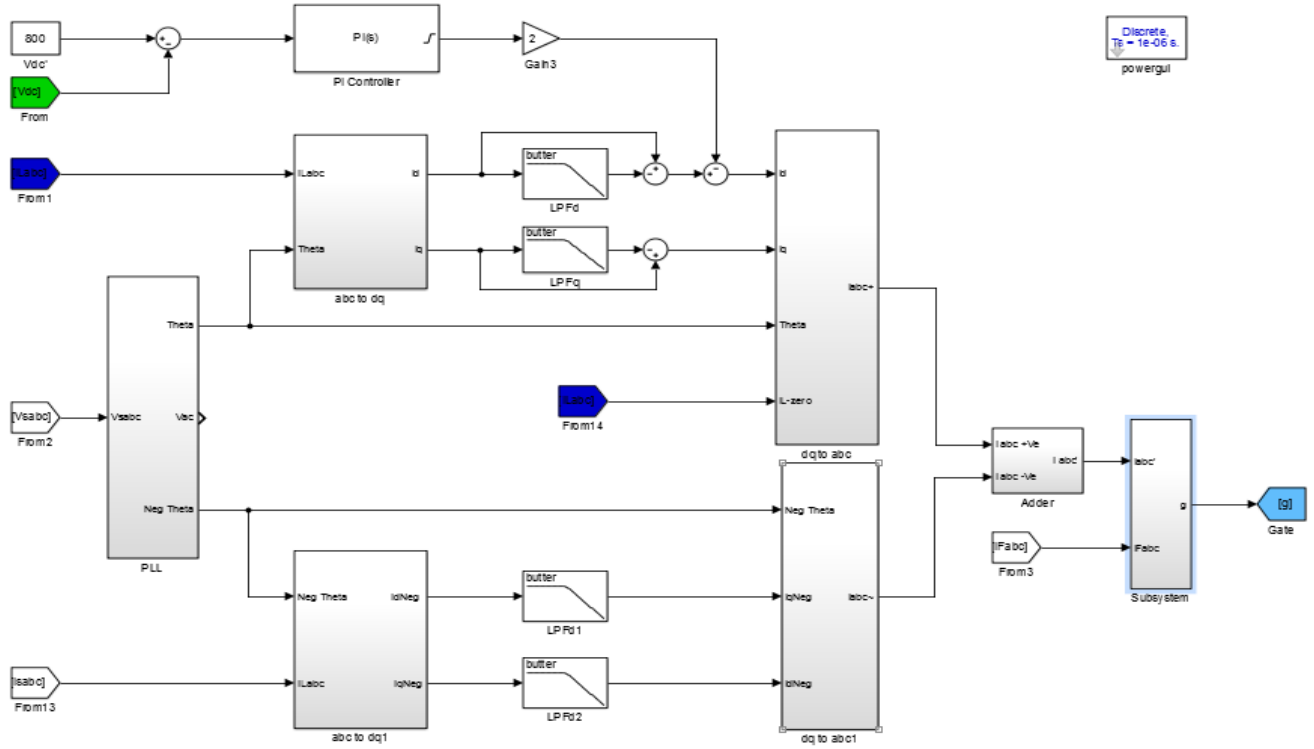


Fig 9-1. Simulink model of the controller

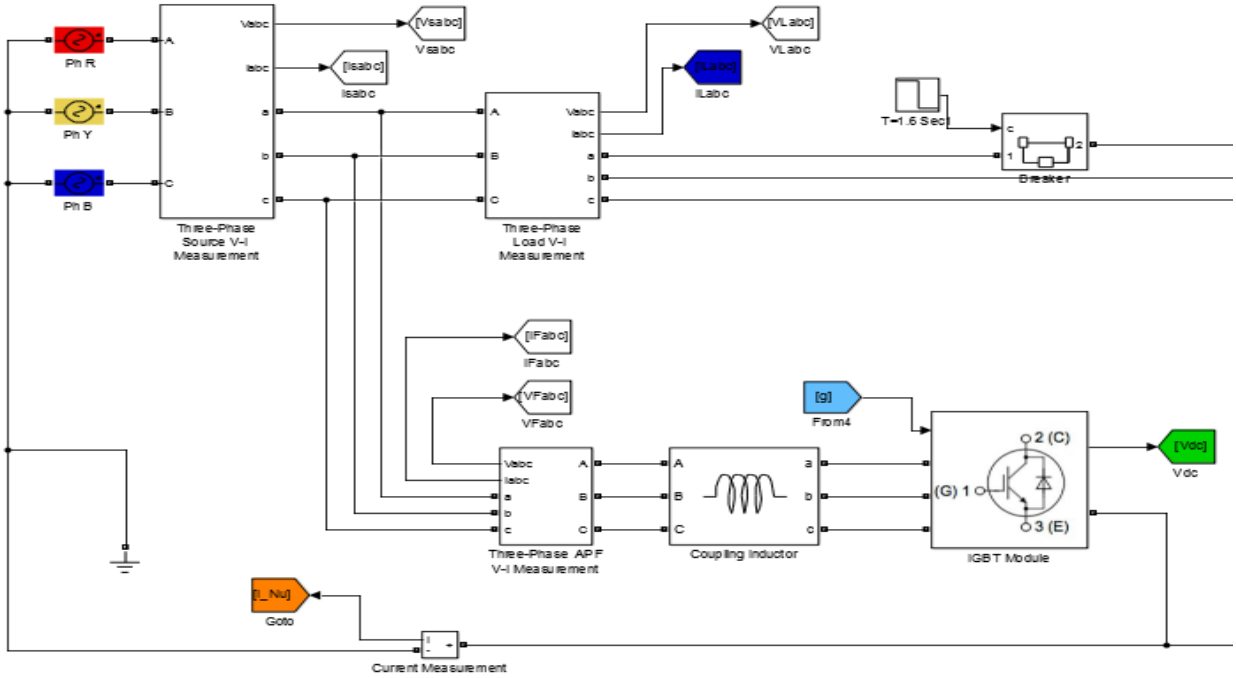
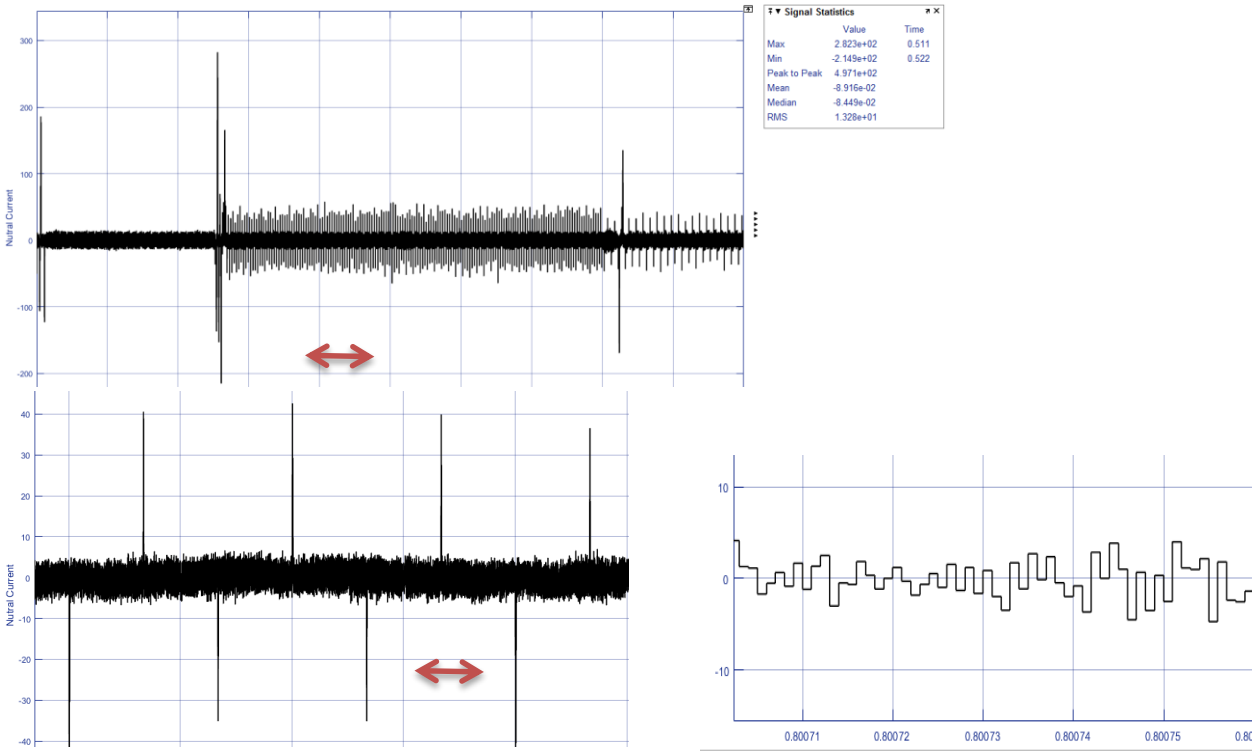


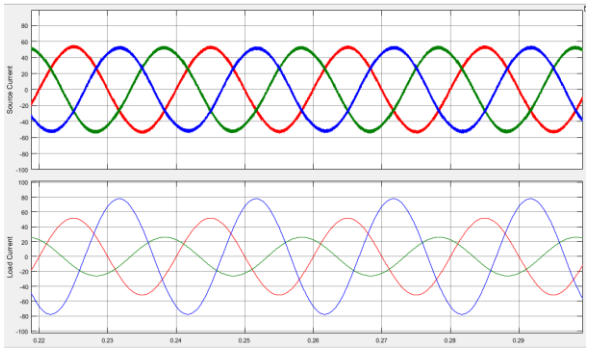
*Fig 9**Error! No text of specified style in document.**2. Simulink model of inverter*

On simulation with the proposed SAPF following results have been obtained.

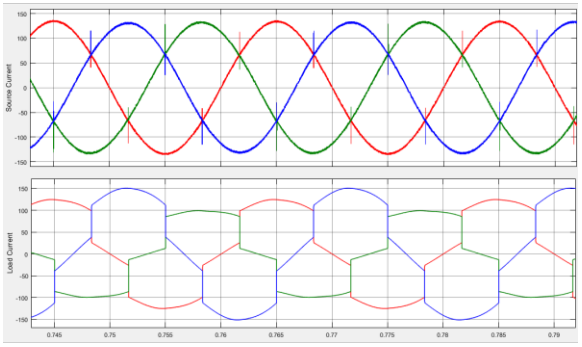
a. Current in Neutral Line



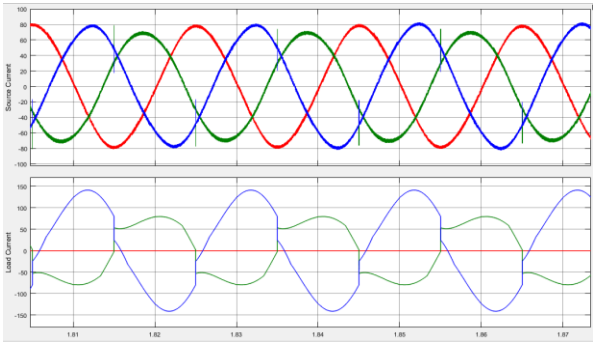
b. Waveforms of Source and Load Current



(b) at 0.25 sec



(c) at 0.8 sec



(d) at 1.8 sec (when Phase R fails).

c. Result of Minimizing the current in Neutral

The presence of the current in neutral wire is shown in the Figure 5-17 without SAPF. It is approximately 31.62A and 53.75A before and after the phase R failure (at 1.6 sec). The current has been reduced to 2.21A and 3.46A after introducing the SAPF on aforesaid time.

d. Result of Source Current Balancing

The other objective of the paper is to balance thee phase current drawn from the source irrespective of instantaneous changes in load current including phase failure. The source current and load current details are tabulated below,

Current	Parameter	R	Y	B
Without SAPF				
Source	Max	135.5	134.8	136.3
Load	Max	125.0	99.40	151.11
With SAPF				
Source	RMS	92.96	95.42	94.23
Load	RMS	94.24	78.35	113.0

Table.8.2. Result of Source Current Balancing

e. Mitigation of Current Harmonics.

FFT analyses has been done and found the percentage of Total Harmonic Distortion (THD%) with and without SAPF at each stages and result is tabulated herewith,

Phase	THD% without APF	**With APF**					
		THD% at 0.2S	Gain	THD% at 0.8S	Gain	THD% at 1.8 S	Gain
R	18.86	3.53	81.28%	2.56	86.43%	3.33	83.34%
Y	23.43	3.62	84.55%	3.24	86.17%	4.98	78.74%
B	15.76	3.52	77.66%	2.71	82.80%	3.71	76.46%

Table 8.3.Mitigation of Current Harmonics.

9. Conclusion

In this paper, the synchronous reference frame algorithm has been used to determine the reference current, sequence current method also utilized for balancing the current drown from the source, six IGBT voltage source inverter has selected with split capacitor method to obtain neutral point and hysteresis band controller method used for generating the required gate signal to drive the Thyristor. With the result depicted in the Tables 5-1 and 5-2, the simulation results proved and concluded that the following ultimate objective has achieved.

a. Current in the neutral wire has minimized.

b. The amplitude of current obtained from the source made mealy equal by balancing in all condition including phase failure

In addition by mitigating harmonics, the THD% of source current has brought down below the recommended level by classification societies, thus improve the power quality. Also reduce the power loss by minimizing the reactive power component.

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Development of Remote Controlled Appliance for Medical Support and Assistance - Covid-19

MEDIMATE

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DEVELOPMENT OF SMART APPLIANCE FOR MEDICAL SUPPORT AND ASSISTANCE - COVID-19 (MEDiMATE)

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***Abstract*— At the beginning of the year 2020, COVID-19 created International Public Emergency and caused a worldwide outbreak. The Social Distancing became the effective solution as an important remedial action to be adopted against the impact of coronavirus on mankind. This paper depicts the design and implementation of control methodologies for specific Remote Controlled Smart Appliance for Medical Support and Assistance (Medimate), which is abundant in combating with the pandemic of COVID-19. These appliances reduce the risk of spreading the corona virus to the hospital staff from the COVID-19 infected patients. This appliance significantly reduces the risk of infectious disease transmission to frontline healthcare professionals by making it possible to visual inspection, triage, evaluation, monitoring, and treating patients being at a safer distance from patients. Also, this facilitates transfer foods and goods to locations near to the patients which indirectly save the cost of personnel protective kits (PPE) to be worn by healthcare workers. The contribution of the medical and engineering come together to aid the healthcare system, healthcare workers and society to cater the COVID-19 situation**.

Keywords*— Covid-19, Safety, Social Distancing*

I. INTRODUCTION

The World Health Organization (WHO) on 30th January 2020, publicly declared the COVID-19 pandemic as a "global emergency" because of the rapidity at which it had spread worldwide including Sri Lanka. Scientists have deliberated that COVID-19 is far more transmittable and lethal than the ordinary flu. It has identified that Virus is a respiratory illness and the primary transmission route is through person-to-person contact and through direct contact with respiratory droplets generated when an infected person coughs or sneezes. Health workers are at the front line of the COVID-19 outbreak response and as such are exposed to hazards that put them at risk of infection. Hazards include pathogen exposure, long working hours, psychological distress, fatigue, occupational burnout, stigma, and physical and psychological violence. To ensure the occupational safety and health of front line workers, many methods and tools managed by health care facilities that to prevent the risk of COVID-19 virus for all HCWs who have been exposed to a COVID-19 patient considering the level of risk. The safety of hospital and other frontline healthcare workers is paramount to preventing high nosocomial transmission as has been reported in several other countries. Focused on the safety of all healthcare worker, personal protective equipment (PPE) have utilized without considering the cost of each and some of the researchers have found with varies of low- cost solutions. However, another important strategy to prevent nosocomial transmission is to implement "social distancing" or avoiding close contact with patients and it ensures the health and welfare of the workforce to meet the challenge.

Accordingly, many researchers are engaged in finding solutions to protect frontline workers from the virus by implementing social distancing. Many news agencies around the world highlighted that hundreds of medical professionals have affected by Covid19 due to shortage of PPE and few medical professionals have resigned from the duties. The WHO and Heath department in Sri Lanka released risk alert, required guidelines for the medical professionals involved with Covid19 patients.

Sri Lanka has been under a continuous lockdown since March 20, a week after the first local victim of the pandemic was reported. Initially, a nationwide blanket curfew was imposed but it was later eased up for about two-thirds of the country. Supply chains were shut down completely due to the curfew situation. Considering this disastrous situation, remote control vehicles are well-suited solution for the COVID-19 patients thus replacing or at least sharing the workload of the medical professionals in hospitals as done in China to support and motivate medical professionals.

This research study is to develop remote controlled smart appliance which is to transfer medicine, cloth, food and assisting and monitoring of the patient by avoiding close contact and entertaining social distancing from the time of a patient is admitted to the ward. In Sri Lankan context, developing a low budgetary design within the shortest possible time with limited professional staff and available resources (due supply chains shut down) are objectives in this research. It was decided to design and develop a remote-controlled smart appliance called 'Medimate' to achieve above identified objectives.

Fig 1. 3D model of Remote-controlled smart appliance.

Medimate consists with two main units named as 'remote controlled vehicle' and 'patient monitoring & control unit'.

Fig 2. Main systems of remote controlled vehicle.

Video transmission system allows medical professionals to view real time remote monitoring of the patient without close contact and simultaneously it allows to assist the patient through full duplex wireless communication system. Further, it is capable of transporting medicine, meals and cloth to the patients by maintaining safety distance. Patients are also facilitated as it allows them to clean their hand (which is a mandatory requirement at that time) by using sanitizing liquid through automatic sanitizer spray system installed on remote controlled vehicle. Monitoring parameters in 'patient monitoring system', inspection body temperature of the patient are additional features of this design which allow consultants to diagnose the patients even through their mobile phones. 'Patient monitoring & control unit' is integrated with steering controls of remote vehicle, patient monitoring system and audio transmission system.

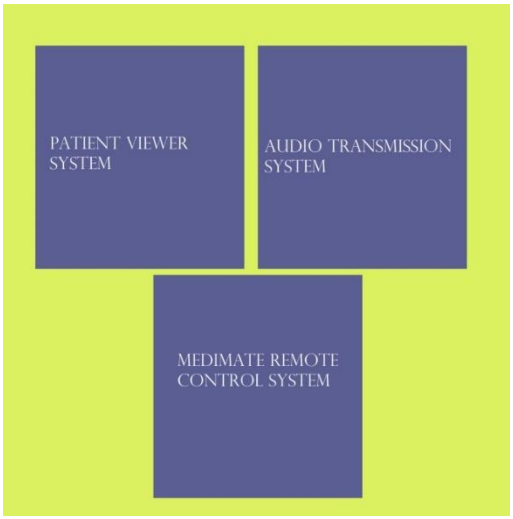

Fig 3. Main systems in patient monitoring & control unit.

II. **Limitations**

Supply chain shut down due to curfew situation resulted limitation of purchasing required components from few possible contactable suppliers. Selection of the components are to be done from those suppliers. Design of indigenous remote control vehicle rover will require more time & sufficient studies. Also more resources will be needed to utilize. Considering the limited time available to complete the development, commercially available RC vehicle will be used as a rover to develop the Medimate.

Fig 4 . RC Vehicle utilized as Medimate rover.

III. Materials and Methods

The main part of the design consist with RC vehicle, 3 trays, Wireless video transmission and receiving unit, UHF Full duplex Audio Communication and Automatic sanitizer spray system. Commercially available 20 kg transferable RC Vehicle was utilized as a rover and 3 Nos Aluminum trays were included as a structure. All other systems in the design were fitted within the available space of commercially obtained rover to get the maximum outcome from limited available spaces. Four (4) liter sanitizer can was fitted in the rover with two 75Ah batteries to increase the design stability. Aluminum material was used as the body of the Medimate rover designed with the aim to increase the durability and ease of cleanliness.

Fig 5. Aluminum body design of rover.

Within 15 minutes, both batteries can be charged with domestic supply and total operational time of Medimate is 2 days after one charge. Further, Medimate operates with voice and video without any interruption within a radius of 50m.

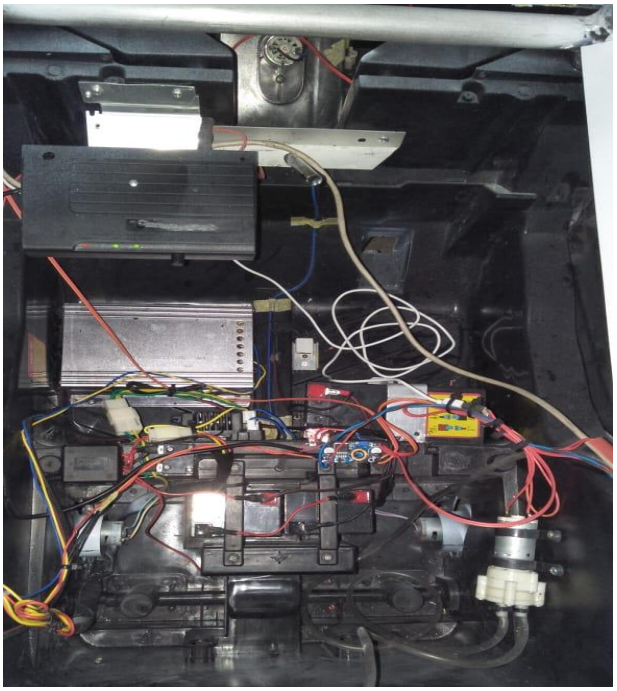

Fig 6. Assembling circuit component in side rover.

A. RC Vehicle specifications

RC vehicle utilizes as rover and powered with two 12-Volt 7.2AH rechargeable Sealed Lead Acid (SLA) batteries in paralleled. It provides 15 hours continuous operational time. Vehicle body design in Aluminum with unique design and concerning on safety while in operation.

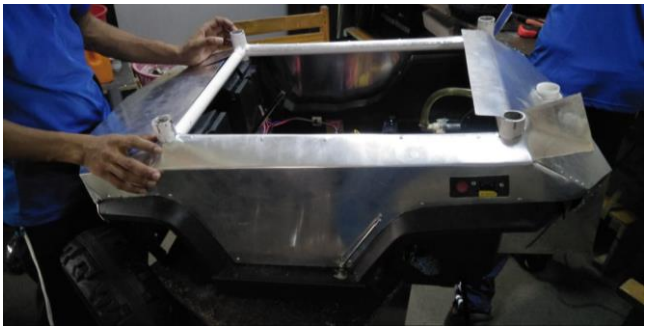

Fig 7. Development of rover body.

Six channel 2.4 GHz frequency ready to run radio transmitter and receiver model was utilized to steer the vehicle. It provides 50m distance control radius. Available motors in rover were replaced with two Nos. 12V DC brushless motors and a servo motor. Brushless motors and servo motor are connected to Electronic speed controls rated as 10 ampere (ESC) utilizes as motor control driver and ESC connected with radio receiver. Both the motors are connected to back wheels and total four(04) wheels have been designed with plastics to improve durability.

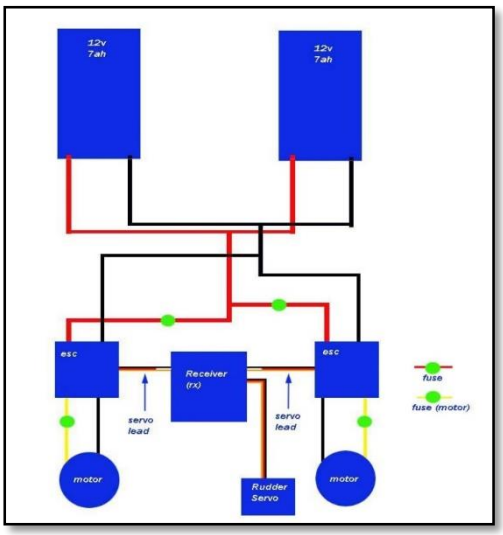

Fig 8. Connection diagram of Motors.

B. Structure specification

Total three(03) Nos. Aluminum trays with special medical tray included in the structure with total height of 596.9mm. 25mm Aluminum pipes were utilized for main structure and 1.2mm Aluminum sheet was utilized for tray designing. Medical tray design was extended 266.7mm out of the main structure for easy access to patients and to improve the stability of structure. Each side of Aluminum structure is connected to rover with Aluminum bars. Top tray includes with two handles to take structure out from the rover when it is required hard cleaning and maintenances.

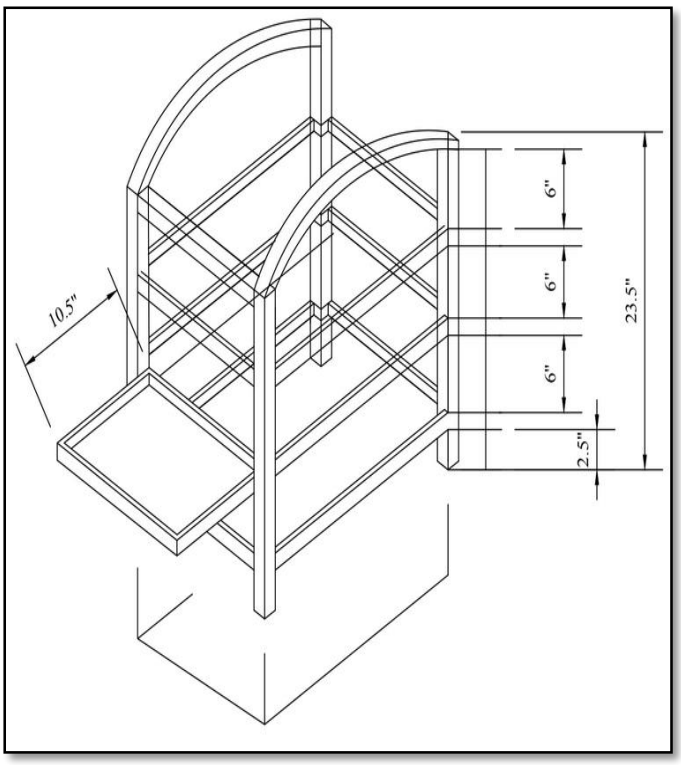

Fig 9. Drawing of structure.

265 µm and 708 µm grit sizes Sandpapers were used to remove material from surfaces and 05 Nos white color spray paint were used for coloring the structure.

Fig 10. Development of structure.

Fig 11. Completion of structure welding work.

Fig 12. Aluminum structure with 3 trays.

C. Video system specification

Ezviz ez360 IP based wireless camera was selected to install in remote controlled vehicle due to specification (Full HD 720p/1080p, 360º Field of view (FOV), Two-Way Audio, and Infrared Night Vision- Up to 10 meters) of camera. To achieve close and wide view in the camera, it was selected to install in front-top of the structure. Camera was directly connected to Wi-Fi router through 1 meter length CAT 6 Ethernet cable to minimize the transmission delay over wireless medium. Local area network was defined with the range of 10.10.10.0/30 to avoid IP interferences to other Wi-Fi networks surrounding the area and avoid unwanted connections to router. Wi-Fi router was installed inside the rover and both camera and router were powered from the same battery pack used by RC vehicle. Video system switched on together with RC vehicle and take 3 minutes to establish connection to local area network successfully.

10 inch android based tablet installed in patient monitoring and control unit as a video display. Tablet also configured in to same local area network and within 3 minutes of time, tablet establishes connection with the network. Controls of camera such as zooming, rotating and voice enabling are provided in Ezviz open source camera viewer software installed on tablet. Further, this software allows all camera controls capabilities over the public network and it has modified to enable camera controls over the local area networks by using Visual Basic software. After configuration of video network, it is observed a 2 second delay of two way audio communication between camera and tablet. Therefore, this is kept as an optional feature, when only consulting from public network.

Fig 13. Basic connection diagram of camera, router and tablet.

D. *Audio system specification*

Dual channel wireless UHF audio transmission with two microphone systems were selected to avoid delay of two way communication through camera network. It was able to establish real time two-way communication between remote controlled vehicle and control unit without any delay and specification (Channel Bandwidth: 300KHz, Frequency Response: 30-20KHz/±2dB, Receiving Sensitivity: -95dBm, digital 16 bit ID pilot, range up to 70m) of the system completely fulfill the communication requirement of the design.

UHF voice controller was installed inside the RC vehicle with one microphone and audio out of voice controller connect with 4" speaker which produce sufficient sound waves audible to patient without any harmonic and interferences.

Audio system switched on together with RC vehicle and enable communication with 3ms acceptable delay. The size of 3" speaker was installed inside the control unit through 9VDC audio amplifier with 10k volume controller.

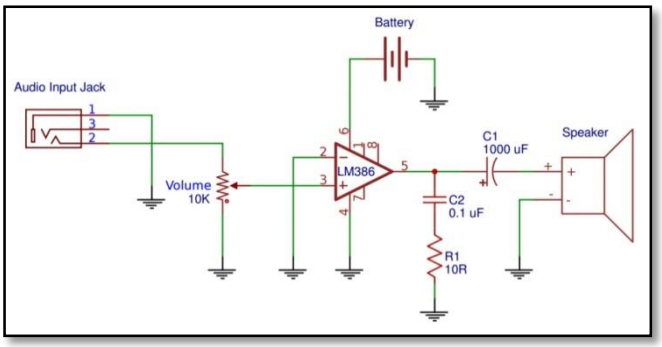

Fig 14. Circuit diagram of amplifier.

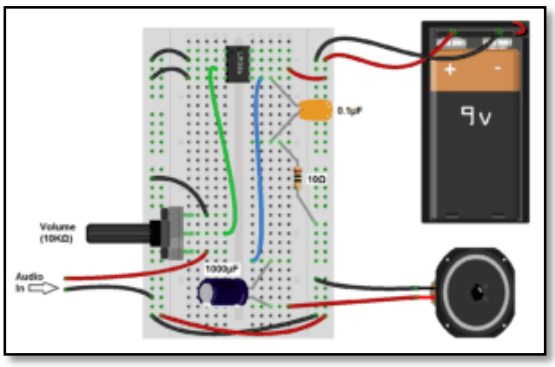

Fig 15. Breadboard testing of amplifier circuit.

As required, it is able produce sufficient sound waves with clear audio.

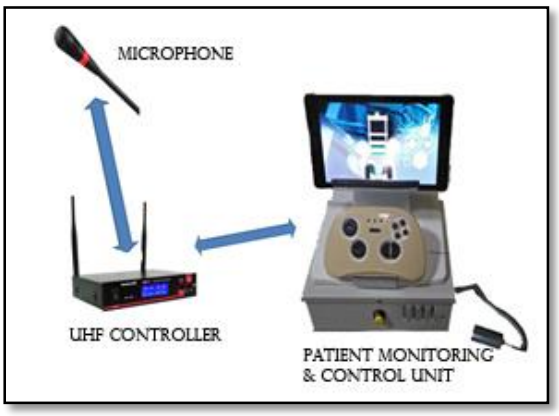

Fig 16. Basic connection diagram of dual channel wireless UHF audio components.

Performances were monitored in the range of 50m with various conditions and system was proven satisfactorily as per design expectation without harmonics and interferences.

E. *Hand Sanitizer spray system specification*

Requirement of hands cleaning mechanism was highlighted during planning process in order to avoid further spreading the virus via patient. Many developers have selected Arduino microcontrollers to design various auto hand sanitizer systems during this period due to low cost, easy programming, readily availability of circuit components. Hence, same microcontroller was utilized to achieve objectives of the design. HC SR04 model ultrasonic sensor programed with Arduino Uno microcontroller was used to achieve automatic switching function. When the patient brings his hand 25cm close to sensor, microcontroller switches ON the 5VDC pump up to 5 seconds. Pump is able to pump out sanitizer from the container installed in the rover to spray nozzle installed in remote controlled vehicle.

Green and Red color indication lights are installed near the nozzle to indicate 'ready' and 'wait' signal to user respectively.

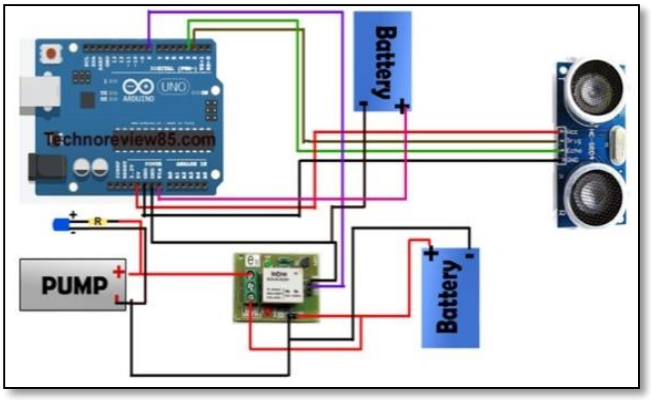

Fig 17. Circuit diagram of hand sanitizer .

After 5 second spray time, system was configured to wait another 3 seconds to come back to ready condition.

Fig 18. Nozzle and indication of Sanitizer system.

Four (04) liters capacity sanitizer container was installed rear side of rover with level indicator.

Fig 19. Sanitizer container with level Indicators.

F. Remote patient monitoring & Controller Unit

This unit is integrated with steering controls system, patient viewer system and audio transmission system. Ten (10) inch Android tablet was selected as a patient monitoring display to obtain clear view of the patients. Remote controller was installed in the front space of the design and microphone was installed right side of the design with flexible cable to achieve easy access. Amplifier circuit and 10000mAh battery bank were installed inside the unit with available space without any changes to design parameters. All the controls of RC vehicle can operate remotely from the distance of 50m. Power bank provides required power supply to all accessories in the control unit. Ezviz camera viewer software was installed in tablet for monitoring patient remotely. However, all controls of software allows only for public network configuration. Therefore, software was modified to achieve all controls with local area network. Performances of camera control and monitoring were proven as per the design parameters during the testing with various different environments and without any interference. It covers maximum 50m range of radius with high quality video.

Fig 20. Remote patient monitoring & Controller Unit.

One push button was installed to switch ON all units at once and separate three (03) Nos USB charging ports were installed rear side of the unit for charging purpose. Tablet operate 28 hours continuously with 100% battery life and power bank is capable to fully charge the tablet within three (03) hours and maximum of three (03) times.

IV. **Operating procedure**

As first step, ensure the both units were fully charged. Remote control vehicle required 20 minute to fully charge whereas control unit required three (03)

hours. Remove the charging cable as per the indications of over charge. Full charge and low power indicators available on the rear side of Medimate. Ensure the camera network and audio network are established properly.

Remote controller on control unit can be used for drive near the patient as required. In the same time, operator can operate Medimate by looking at the patient through monitoring display. Rotation feature of camera allows medical staff to monitor patient and check parameters on 'patient monitoring system' by rotating and zooming the camera.

Fig 21. Front view of Medimate.

Further, if medical professionals can assist the patient via UHF communication system and they can instruct the patient to access medicine on medicine tray, foods at food tray and cloth on third tray. The patient can able to clean their hands by using automatic hand sanitizer system prior to touch medicine, cloth and foods. As per the given instructions, the patient can manually monitor body temperature using infrared forehead thermometer and same can be notified to medical staff via video network. As a safety method, the patients have to clean their hands prior to touch thermometer. If consultants were out of the local area network, they can assist the patient via public network.

V. Testing and result

Medimate was able to drive in to any hospital ward without any difficulties. The testing personnel has observed that, medical staff operate Medimate from the distance of maximum 35 to 40m and Medimate was already designed with maximum distance of 50 meters.

Fig 23. Testing with COVID patient (General Hospital-Colombo)

Further, audio and video systems were capable of operating within the range without any interferes and disturbances. Medical staff transferred the cloths (bedsheet, towel etc.) weight of around 14 kg and Medimate designed to handle maximum of 20 kg. In practically, Medimate consumes 60% of battery power to operate five (05) times per day in hospitals and it has been designed with approximately for nine (09) times. Medimate was tested in Navy General Hospital and it has given 100% performances without any further improvement.

VI. Conclusion

Development of Medimate achieved all the objectives as described above. Design was costed below 1 lakh and total time involvement to complete design was 40 hours with utilizing three (03) technicians.

Fig 24. Handing over to Ragama National Hospital by Cmde(L) KK Bombugalage, Director Naval Electrical & Electronic Engineering

"Medimate" improves the safety and entertain the social distancing for the health care professionals who have closely worked with Covid-19 patients and it helps to control the virus spreading among the medical staff in Sri Lanka. Medimate essential services by reducing work load of healthcare workers and giving extra confidence of safety. Considering the performance and demand, total five (05) Nos. "Medimates" units were developed and handed over to Dr. Neville Fernando Teaching Hospital, Kalubowila (Colombo South) Teaching Hospital, Negombo District General Hospital, Navy General Hospital at Walisara and Theldeniya District Hospital.

VII. **Acknowledgement**

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Boosting the relative energy harvesting efficiency of a solar panel

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BOOSTING THE RELATIVE ENERGY HARVESTING EFFICIENCY OF A SOLAR PANEL

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Abstract

In this paper, describe the boosting the harvesting efficiency using two flat mirrors as concentrator of solar PV system. The mirrors up the concentration of solar ray on the solar PV module. A new model of solar panel system is designed by best possible inclination angle of the concentrator that improves the performance of the solar panel.

Keywords: solar panel, concentrators, flat mirror concentrator.

1. Introduction

Today the world constraint of energy conversion from renewable sources has become a norm due to various problems of fossil fuels. Renewable energy is a clean energy source the essential development to the safe future. Among various of natural resources, solar is the most recognised energy of radiant that produced by the sun. The solar energy incident on able to converted to electricity by photovoltaic (PV) or to thermal energy by solar collectors.

The module of PV consists of solar cells electrically connected together in order to increase the power output. Most of the vast majority of solar cells, whether industrial or residential, are based on either a polymorphic or amorphous or polycrystalline or mono-crystalline silicon and boost the output of a typical solar panel by using a solar concentrator. It consists of a single semiconductor junction laid flat across the solar cell's surface. These solar cells will harvest a relatively narrow portion of the full solar spectrum and produce an efficiency conversion efficiency between 18 and 22 percent.

During last few decades, there were an increasing effort to improve the solar cell or PV cell efficiency by researchers. Today there are more efficient technologies have been introduced. One of them is called a multi-junction solar cell. Effectively what they do is they make several layers of different semiconductor junctions across the surface, and each one of them is designed to harvest a different part of the spectrum; when the light passes into them it is absorbed in one layer, passes to the next layer, is absorbed in the next layer, and by doing so it's able to harvest a much broader part of the solar spectrum. And these things can achieve efficiencies upwards of 50%. However, they're quite expensive, and therefore they're quite rare.
One of economical and efficient method is concentrator photovoltaic systems, which use concentrating optics to increase the intensity of sunlight.

2. Efficient technologies

A new type of technology is at the forefront of research in solar cells based on a perovskite crystal design. It's a mineral, where the name comes from, but it can involve a number of different types of atoms and molecules. The major advantage of this technology is the cost, but there are some varieties of perovskite technology that do not

use any heavy metals like cadmium. There are others that can exceed the solar harvesting efficiency, essentially the conversion efficiency of a typical solar cell built on silicon. But most importantly, this doesn't involve the very high-temperature synthesis necessary to produce silicon and anneal silicon and work with silicon photocells. They can be made by effectively spraying a very thin layer of this material at near room temperature across narrow surfaces producing an inexpensive solar cell. The limitation at this point and what they're working on is the fact that they don't last very long, they don't have good durability, but they're working on that and as they improve that this is going to be a very competitive technology with silicon-based solar cells.

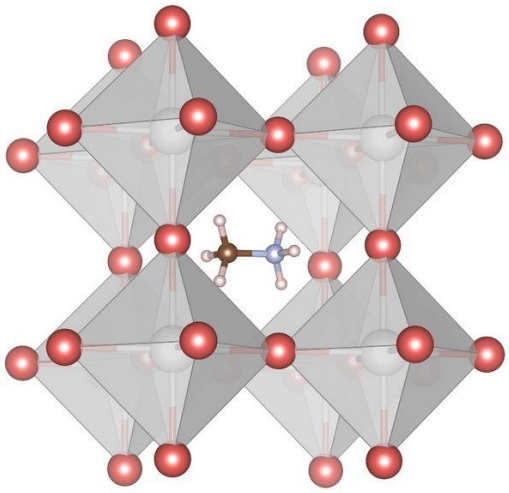

Fig 1. solar cells based on a perovskite crystal design

3. Concentrator-type solar cell

The final design technique is based on a high flux or a concentrator-type solar cell. What those solar cells are able to do is to convert, whether mono-junction or poly-junction, a far higher flux of light than just one cell, get on the surface of the earth as much as a thousand-fold increase in concentration they're still able to operate. They are also rare and expensive, but it doesn't need many of them to tile a surface area in order to harvest all the heat that passes through it. So as a result, they can be cost-effective, and one of the most expensive components of them is the imaging optics necessary to concentrate that light down to a very small point and the very sophisticated tracking that's necessary to keep that very small point of light bull's -eyed on that very small cell. Nevertheless, they're close and depending on the improvements in solar concentrator technology and making them less expensive, they could be a viable alternative. However, those types of solar concentrators depend on what's called imaging or imaging solar concentrators. What makes a solar concentrator imaging is the fact that when the light rays come in from the Sun, like in a lens, which is an imaging concentrator, the rays on the left side stay on the left side, and the rays on the right side stay on the right side as they are brought to a focus. Even if they pass through the focus and the image inverts, their relative position remains the same. They actually generate an image of the source. As a result, they can reach very high concentration levels. Now with a mirror, it's obvious how that would happen. If the light hits the centre of a mirror, it just reflects right back up toward the focus. But as the light rays are moving farther and farther laterally from the centre axis of the mirror, the angle of the mirror is changing, and so they bounce at more acute angles all to reach the same focus. The advantage of using a lens is that it doesn't have to mount solar cells sort of in reverse facing a mirror. Everything can be done in one pass without any kind of reflection.

4. **Fresnel lens.**

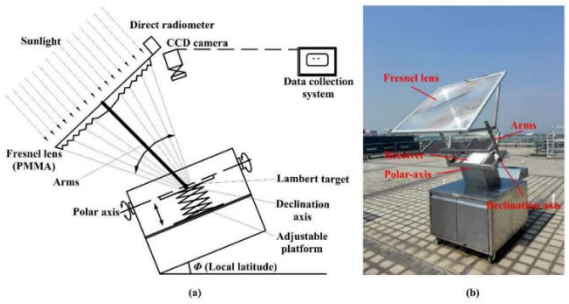

Fig 2 (a). Schematic diagram of the experiment platform; and (b) a photo of the fixed-focus Fresnel lens solar concentrator using polar-axis tracking.

The operation of a lens is actually as simple as a mirror, but it's not as obvious.What happens is when the light ray passes into the lens from a low-index medium, like vacuum or air, into a high refractive index medium, like water or plastic or glass, the light bends. And what the light attempts to do is it tries to line up with the normal to the surface, or in other words, sort of the perpendicular line at the surface at the point that it enters the glass. All lines representing all the perpendiculars from the surface, if the light ray goes right through the centre, it doesn't get bent, and it goes right down to the focus. But as the light ray moves farther and farther from the centre axis of the lens, it encounters perpendiculars that are ever more acute to the surface and make a larger bend as they go through the lens, again all reaching the focus. The problem with lenses like this is that they're expensive and heavy. A better design for an imaging concentrator, It's called a Fresnel lens. And what this does is exactly what the lens does. It's exactly the same process. When the light enters, it's bent. But what they do to make the lens so much lighter and more inexpensive is that if you can imagine around the centre portion of the lens, they cut out little rings, little annuli, homocentric rings about the centre. The front surface of each of those rings is angled just like it would be at that point in a typical lens. And so then they take that ring and they move it all the way to the back. They get rid of all that dead wood, all that extra glass, and they basically put the ring all the way to the rear surface. As you progress outward and the rings become larger, their facets become ever more acute, bending the light toward the focus. This is also an imaging concentrator, and it's very light and inexpensive. You can see them available on overhead projectors and on lighthouses. They're very good lenses and it's a good idea if you're going to be doing imaging concentration. Now a well designed imaging concentrator can nearly approach a concentration level that equals the intensity of the source. Therefore in this case, the surface of the Sun or 5 ,500 degrees. That is in excess of what even a high-flux solar cell would tolerate, and it would literally burn a hole right in a typical solar cell. Nevertheless, flux does matter.

5. **Harvesting efficiency boosting using two flat mirrors**

To demonstrate the method using 100 watts rated, produces about 18 .5 volts at about 5 .5 amps, that's its nominal rating giving about 32 watts located at a high altitude at the equator at noon. So clearly, a panel like this could benefit from substantially higher flux just to get to spec. And as long as the panel stays cool enough, it can actually pump these things up to well over double the flux level, and they will work just fine and already tested it. So the question is, can it get additional flux without going to thousands of times higher? And there is an easy way to do it, a much easier way to do it than using these curved surfaces. If placed a board facing to sun little tilted, it will get quite bright, but if I

take a flat mirror-like Figure 3 and place it into the rays that would never otherwise touch this panel and angle it properly like in the figure, you can see that what happens is it becomes substantially brighter where this mirror is sending the light. This is not an imaging concentrator. These rays are coming in at an arbitrary angle and they're going to mix. All we care about is packing as many light rays as many photons onto the surface as possible. And if we follow up with a second mirror on the other side and do the same sort of thing, you can see that we can get even brighter yet by adding two of these mirrors.
Based on the angle and based on the size of the mirrors, you can go to two, three, four-fold concentrations simply using these lightweight mirrors. And that is the technology which is simple in order to build a solar concentrator for one of these large panels.

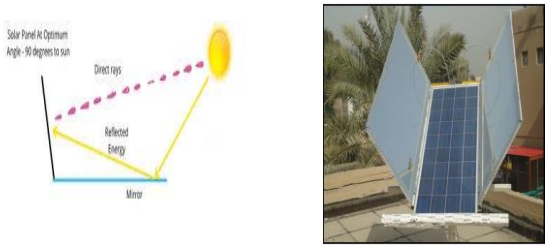

Fig 3 (a). Schematic diagram of the flat mirrors as concentrator of solar PV system; and (b) a photo of the fixed flat mirrors as concentrator

6. Conclusion

Solar energy becoming the most popular renewable energy in the world today. The limitation is efficiency as the solar cells harvest a relatively narrow portion of the solar spectrum . Now a days researchers are working on that to overcome the limitations in f solar PV systems. Multi-junction solar cells are one of the most efficient technologies, as they involve several layers of different semiconductor junctions that are allowing for the harvesting of a much broader part of the Solar spectrum and increase efficiency. They are rare due to expensive, A new type of technology, called perovskite crystal design, is also being developed, can be made by spraying a thin layer of this material at near room temperature. The limitations of these technology include not having good durability, but they are working on it to become a competitive technology with silicon-based solar cells.

Solar concentrators are a cost-effective boosting method that can convert a far higher flux of light than one cell. The efficiency of solar concentrators depends on a tracking system of the sun.

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REDUCING WORKLOAD AND IMPROVING DECISION MAKING: A SIMULATION-BASED APPROACH TO OPERATIONS MANAGEMENT FOR ENGINEERS

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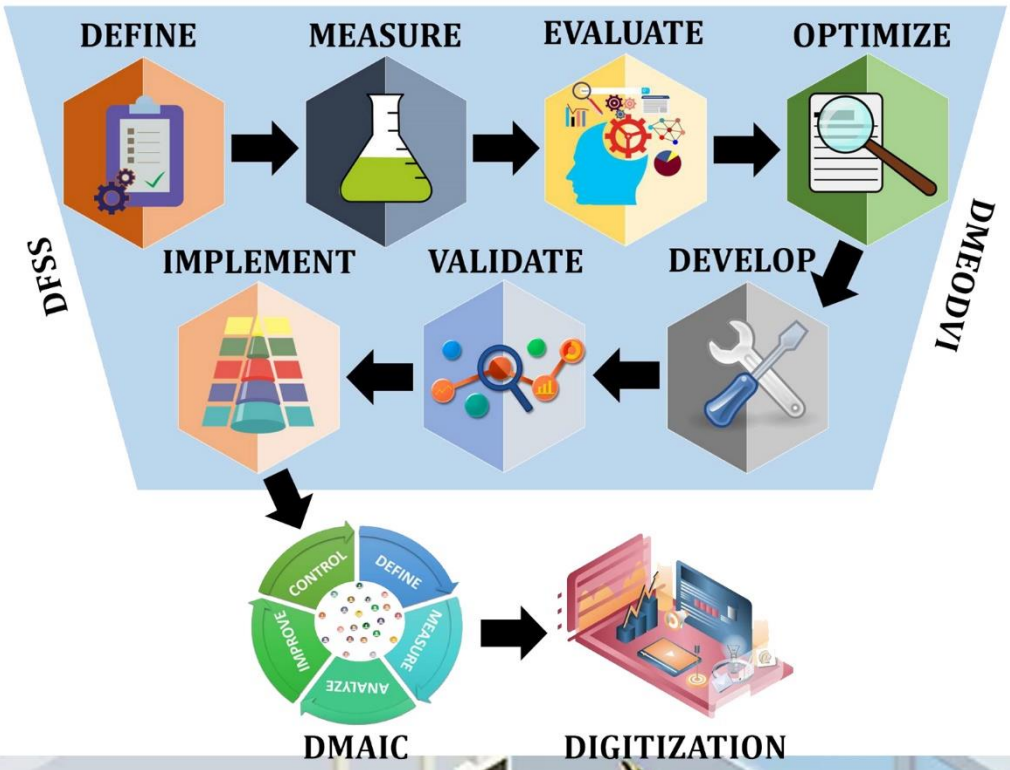

REDUCING WORKLOAD AND IMPROVING DECISION MAKING: A SIMULATION-BASED APPROACH TO OPERATIONS MANAGEMENT FOR ENGINEERS

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Introduction

From simple wooden machines to interplanetary spaceships, the field of 'Engineering' has evolved in many ways, shaping the world into what we experience today. The progression of science and technology has significantly impacted engineering, leading to the development of various engineering disciplines. The introduction of standards and regulations has helped engineers improve engineering practices by ensuring safety, reliability, and consistency in engineering practices, resulting in higher-quality products and systems. Further stretching the scope of engineers, they are not just designing and developing products, but also managing their production and delivery. To survive in this new normal environment, an engineer must not only know the subject and standards but must also master Operations Management skills, which help them become more effective in their roles and enable them to create better value for their organizations.

Fig 1. Aspects of Operations Management (Source: https://www.netsuite.com/portal/resource/articles/erp/operations-management.shtml)

Operations Management involves an extensive range of activities, including process design, quality management, supply chain management, inventory management, and process improvement. Engineers must work closely with managers and other stakeholders to develop and implement effective Operations Management strategies that meet the needs of the organization and its customers. The ultimate goal is to ensure that resources are used effectively and efficiently while maintaining high standards of quality and reliability of the output. It is a misconception that Operations Management is only relevant to industrial engineering or production engineering. According to academic sources, Operations Management is essential to all fields of engineering as it involves maximizing efficiency, reducing costs, and improving decision-making. Hence, engineers must apply Operations Management techniques to optimize their working environment and increase productivity.

I. Supply Chain Management: An engineers need to work with suppliers to obtain the necessary components and materials for their projects. Understanding the principles of supply chain management can help you to make better decisions about sourcing and logistics.

II. Quality Management: Quality is critical in all engineering disciplines, and understanding the principles of quality management can help you to improve your products and processes.

III. Production Planning and Control: This subtopic focuses on the management of resources to meet production targets. An engineers can benefit from this knowledge to optimize the production process.

IV. Project Management: Engineers often work on complex projects with multiple stakeholders, and project management principles can help you to keep the project on track and within budget.

V. Lean Manufacturing: Lean manufacturing is a methodology that aims to reduce waste and improve efficiency in production processes. Engineers can benefit from this knowledge to optimize their manufacturing processes.

VI. Six Sigma: Six Sigma is a methodology that focuses on process improvement and reducing defects. Engineers can use this methodology to improve the quality of their products and processes.

There is a widely held misconception that operations management principles and techniques are more applicable to industrial engineering or production engineering roles than other engineering disciplines. However, in reality, these principles are equally relevant to a wide range of engineering disciplines, as they can be applied in various project and workshop environments to enhance productivity and efficiency.

Simulation-Based Approaches to Operations Management

Simulation is not a stranger to engineers, as it is a valuable tool used to test and validate designs, optimize processes, and analyze complex systems without actually implementing the system, thus saving resources. For example, electrical engineers use simulation to model the behavior of power electronics, control systems, and communication networks. This enables them to evaluate the performance of a system under different operating conditions, identify potential problems, and improve system design before implementation, leading to cost savings, increased efficiency, and improved safety. Similarly, simulation-based approaches to operations management involve the use of computer simulations to model and simulate real-world scenarios.

Many simulation software and tools are available for simulating system processes, layouts, process flows, workflows, and supply chain/logistics processes, to determine the best possible solution, thus improving efficiency and reducing costs. Simulation-based approaches to operations management have several benefits.

I. It allows engineers to test different scenarios without having to implement them in the real world reducing the risk associated with making decisions based on untested scenarios.

II. It allows engineers to automate some of the decision-making processes, reducing the workload associated with manual decision-making.

III. It allows engineers to test different scenarios and predict the outcomes of different decisions. This improves decision-making by providing engineers with more information about the consequences of their decisions.

Case Study: A Simulation-Based Model for Cost Reduction through Workflow and Layout Improvements in a Naval Electrical Maintenance Facility

The case study was conducted in 2022 to reduce the costs associated with the maintenance process at the Winding Workshop of Sri Lanka Naval Dockyard, Trincomalee. The workshop undertakes corrective maintenance of different types of alternators and motors available

onboard naval ships and craft. Previous research data shows that the cost of maintenance is greatly associated with the time to perform the corrective action or repair as labour cost and the cost of operations loss increase with time.

Based on the above, an approach was made to simulate the current workflow and layout through Tecnomatix™ Plant Simulation, a Discrete-Event Simulation (DES) developed by Siemens AG, Germany. The initial model of the facility was developed by analyzing the data of the physical layout, workflow followed, worker arrangement, work schedule, and job parameters.

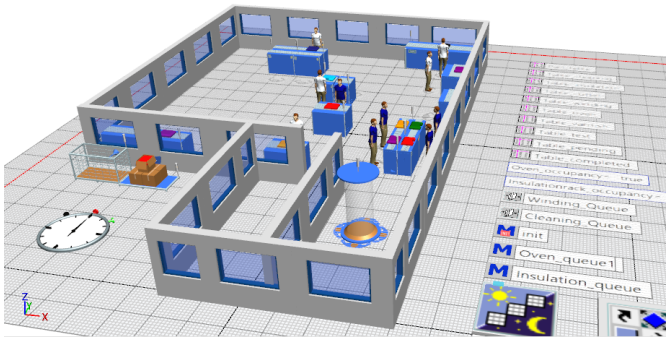

Fig 2. 3D Representation model of the Winding Workshop

The simulation model underwent face validation and black-box testing, two of the most common validation techniques used in simulation verification and validation. The tests showed positive results in the validation of the initial model associated with the current arrangements of the facility.

The developed initial simulation model was run until the completion of 200 jobs, selected in proportion to the average of actual jobs received in recent years. The time to complete was recorded, and data related to resource utilization, material flow, and worker movement was extracted for analysis.

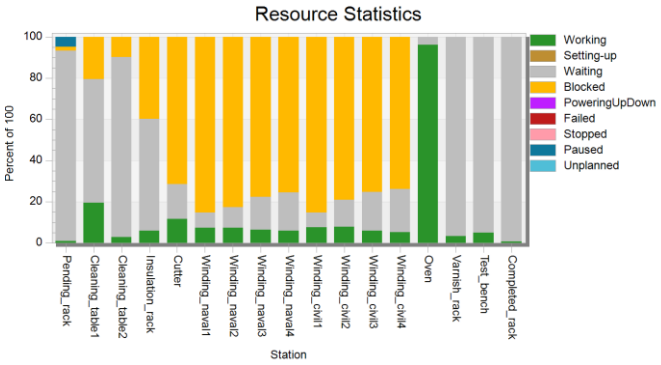

Fig 3. Resource utilization of current facility

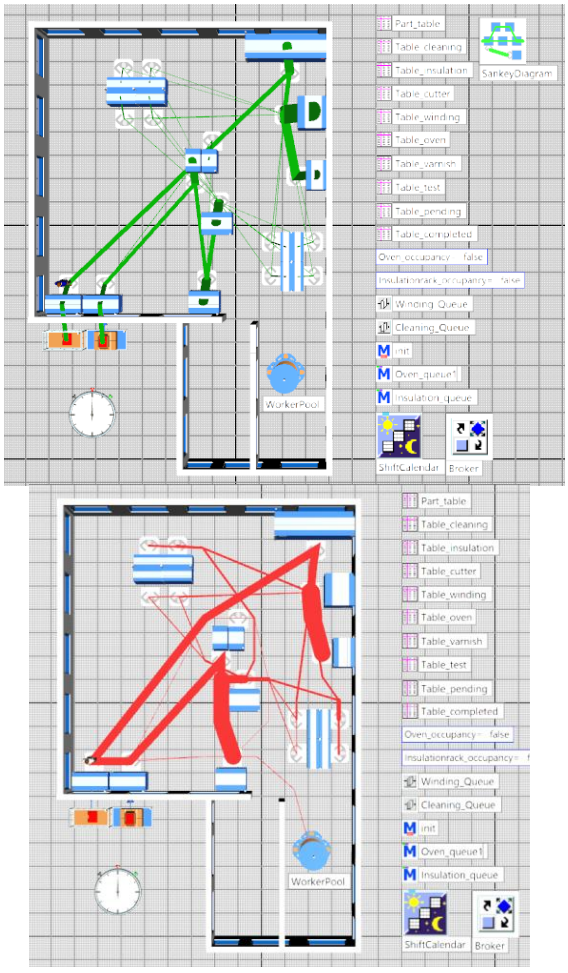

Fig 4. Material flow and worker movement of current facility

The initial analysis showed significant "bottlenecks" with process flow and an inaccurate layout arrangement. The case study suggested

the following optimizations based on related researches and studies:

- Workflow balancing by changing the number of workstations.
- Layout optimization by adjusting workstation arrangements to provide the lowest material flow.

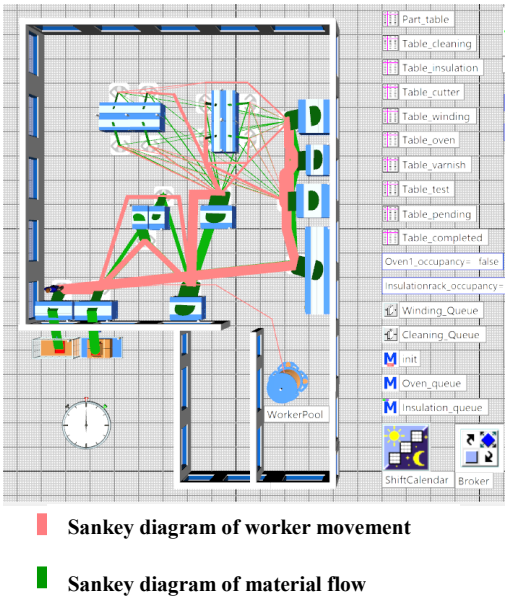

Fig 5. Material flow and worker movement of proposed facility after optimization

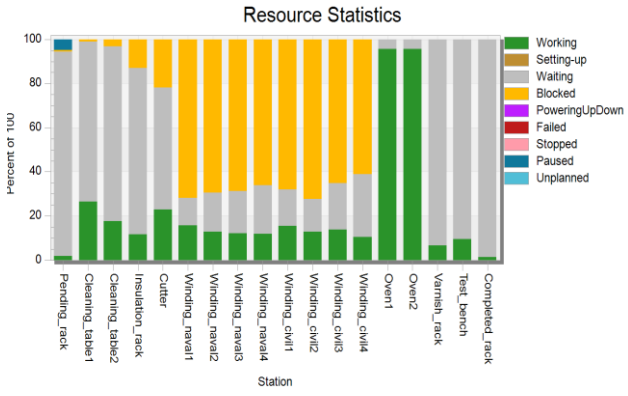

Fig 6. Resource utilization of proposed facility after optimization

Calculations were done as per the defined equation related to corrective maintenance, where the cost reduction expected from the proposed optimization is calculated to be approximately 49.7%.

This case study focused solely on improving the workflow and layout, as other parameters of the facility and repair process, such as the process of winding, the number of technicians employed, and implementing alternative maintenance processes, are outside the scope of the workshop engineers and fall to the policy decisions of the Sri Lanka Navy. The study can be considered an example of how a workshop engineer could evaluate and optimize their working environment using a simulation-based approach with risk-free decision making.

Conclusion

In conclusion, the engineering field has continued to evolve and become increasingly complex. As a result, it has become necessary for engineers to adopt operations management as a necessary working skill. The use of simulation-based approaches in operations management is expected to become more prevalent in the practice of engineering. It enables engineers to reduce their workload, improve decision-making, and optimize resource allocation, leading to increased efficiency and productivity. Engineers who can effectively leverage these approaches will be better equipped to succeed in their roles, remain competitive and contribute to the success of their organizations.

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APPLICATION OF

Smart Power

SKILLS BY

THE Leadership

AT THE STRATEGIC LEVEL

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APPLICATION OF SMART POWER SKILLS BY THE LEADERSHIP AT THE STRATEGIC LEVEL

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1. INTRODUCTION

1.1 POWER

In the simplest form, "power is the ability to influence the behavior of others to get the outcomes one wants. There are several ways to affect the behavior of others.

a. You can coerce them with threats.
b. You can induce them with payments.
c. Or you can attract or co-opt them.

Practical politicians and ordinary people often simply define power as the possession of capabilities or resources that can influence outcomes. Someone who has authority, wealth, or an attractive personality is called powerful. In international politics, it can be considered a country powerful if it has a relatively large population, territory, natural resources, economic strength, military force, and social stability" (HBR.org, 2022).

1.2 THEORIES OF POWER

Various power theories will be introduced in this section.

a. Class Theory: Karl Marx propagated the concept which is known as Marxism. It says that in each society there are two classes, Rich (which owns the means of production and is the dominant economic class) and the poor (which is the class of economically weak and poor workers who are economically, socially and politically exploited and dominated by the class of the rich)

b. Elite Theory: asserts that a small group of individuals known as the elite, control all power in a society and utilize that authority to rule the society.

c. Pluralist Theory: According to this theory, power in any society is actually employed by a number of distinct groups rather than just one class or elite. These factions compete with one another for control over societal influence.

d. Gender Theory: In reality, men hold the power because they outnumber women in society as a whole.

1.3 HARD POWER, SOFT POWER, AND SMART POWER

Nye suggested the idea of separating hard power from soft power more than 20 years ago (1990). He characterizes hard power to be

coercive authority used through inducements or threats and defines power as the "capacity to affect people to attain the outcomes one desires" (2009, p. 61). “Hard power, which relies on observable power resources like armed troops or economic means, is based on military intervention, forceful diplomacy, and economic sanctions” (Wilson, 2008). A few examples of hard power, are the German invasion of Poland in 1939 and UN economic sanctions on Iraq in 1991 on completion of the first gulf war.

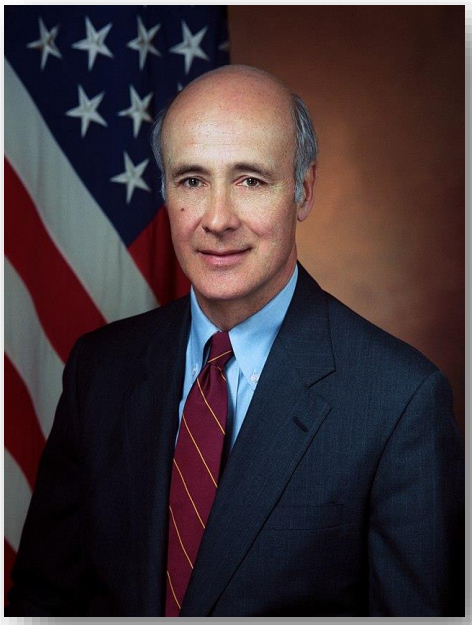

Fig 1. Joseph S. Nye Jr, Former United States Assistant Secretary of Defense for International Security Affairs (Source: hks.harvard.edu, 2022)

Co-optive power, on the other hand, is the “ability to get others to do what you desire” (Wilson, 2008, p. 114). According to Nye, influence is "connected with intangible power resources like as culture, ideology, and institutions" and is built on attraction and emulation (2009, p. 63). Cooper highlights how crucial legitimacy is to the idea of soft power (2004, p. 173). To increase soft power, government actions must be seen as reasonable and legally bound. The extent of American culture all the way through the “Eastern Bloc” during the Cold War is evidence about soft power possessed by the United States, while more recent EU enlargement efforts are indicators of soft power possessed by the EU (Nye, 2009). The idea of "smart power combines both soft and hard power. With a continuum of tools that have varying degrees of coercion or persuasion, smart power mixes soft and hard power. These tools include coercion, inducement, creating goals, persuasion, and attractiveness” (Smith-Windsor, 2000).

1.4. AIM

The aim of this research is to study the application of smart power skills that need to be followed by Military leadership at the strategic level.

2. APPROACHES RESULTS OF THE RESEARCH

2.1 CONCEPTUAL FRAMEWORK OF THE STUDY

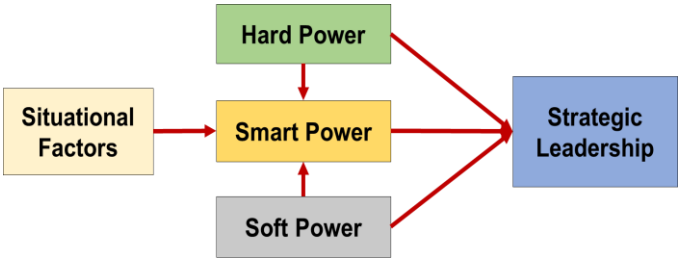

Fig 2. Conceptual framework (Source: Literature Survey 2022)

The conceptual framework of the study is shown in figure 2. The moderating variable is situational factors. The Independent variable is smart power which is defined as the alternate use of hard and soft power according to the situational factors. The dependent variable is the strategic leadership skills of military leaders.

2.2 HARD POWER

Hard power seems to be more tangible, quantifiable, and predictable. In this context, having power is similar to having the “best cards in a card game”. People occasionally run into the paradox that individuals with the most power do not necessarily achieve the results they seek when they describe power as being identical to the means that produce it. For instance, in 2001, the United States was thought of as the only superpower in terms of resources, but it was unable to stop September 11. Effective strategies and capable leadership are necessary to transform resources towards recognized power in the sense of achieving anticipated results. But leaders frequently make mistakes, as evidenced by Hitler during the Second World War or Saddam Hussein during the Gulf War.

2.3 SOFT POWER

The foundation of “soft power” is the capacity to influence others' preferences. Power can be measured by the resources, which is a crude but effective shortcut. Understanding which resources serve as the strongest foundation for power behavior in a given situation is equally crucial. Both oil and Uranium were insignificant energy sources prior to the industrial age and the nuclear age, respectively. Without understanding the context, power resources cannot be assessed. In some circumstances, persons who wield authority, have wealth or hold high office are not the most dominant. That is the purpose of revolutions. Hard power is a term most are accustomed to. It is evident that military and financial pressure frequently persuades people to modify their opinions. Threats or inducements can be the basis for hard power ("sticks").

However, there are situations when you can achieve your goals without using real threats or rewards. It has been referred to as "the second face of power" to obtain what you desire by indirect means. Because other nations love its principles, follow its lead, and aspire to its degree of prosperity and openness, a country may achieve the results it desires in international politics. This soft power co-opts individuals rather than forces them, getting them to want the results that you want.

2.4 SMART POWER

Because both concepts are components of the capacity to accomplish one's objectives through persuading the behaviour of others, hard and soft power are related. The difference between them is one of degree, both in terms of the behavior's type and the resources' palpability. The ability to command someone to do something can rely on compulsion or incentive. Co-optive power, or the capacity to influence what others want, can be based on the allure of one's culture and beliefs or on the capacity to influence political agendas in a way that prevents others from expressing certain preferences because they appear to be too idealistic.

2.5 EFFECTIVENESS OF SMART POWER

According to Joseph S. Nye, Jr., a professor at Harvard University's John F. Kennedy School of Government, it will require a thorough understanding of how to combine American strength with the tools of "soft power," a concept he coined in his 1990 book "Bound to Lead." Nye is the author of twelve books, including The Powers to Lead, which was just published.

He formerly served as the National Intelligence Council's director, the assistant secretary of defense for international security issues, and the deputy undersecretary of state for science and technology. He believes that the biggest challenge the future administration will face is establishing an agenda that goes beyond the current armed forces and political challenges. Hillary Clinton, Sec of State USA, 2009 said during her confirmation speech, “We must use what has been called smart power, the full range of tools at our disposal, diplomatic, economic, military, political, legal, and cultural, picking the right tool, or combination of tools, for each situation. With smart power, diplomacy will be the vanguard of foreign policy”. She became a prominent politician who practically used what Nye proposed as smart power.

2.6 COMBINING SOFT POWER AND HARD POWER

Power is basically the capacity to influence others in order to achieve your goals, and this requires a set of instruments. Some of them can be used for compulsion, reward, or hard power, while others shall be used for allurement or soft power. Key soft-power abilities for people include charisma (emotional appeal), vision, and communication; for nations, soft power is expressed in their culture, values, and legal regulations. Figure 3 denotes the relations vs results graph with regards to the case of soft power, hard power, and smart power.

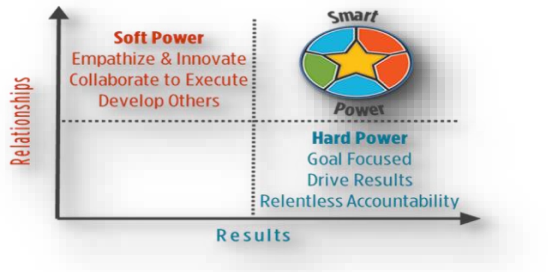

Fig 3. Relationship Vs Results (Source: Brand finance, 2022

3. ISSUES AND CHALLENGES OF USING SOFT POWER AND SMART POWER IN THE NATIONAL SECURITY CONTEXT

"A prince should make himself feared in such a way that, if he does not acquire love, he at any rate avoids hatred," wrote Niccol Machiavelli five hundred years ago. That advice seems especially pertinent as the incoming American government gears itself to deal with an increasingly multipolar political landscape, one in which grave threats to international harmony, the world economy, and the environment exist. The United States' military and economic might alone won't be enough to bring about peace and prosperity. The nation must be presented as an example of democracy and free enterprise, and the president must make these ideals appealing.

3.1 EMPLOYMENT OF SMART POWER CONCEPTS IN THE REGIONAL AND GLOBAL CONTE

Power is essentially the capacity to influence others in order to achieve your goals, and this requires a set of instruments. Some of these are coercion or payment tools, or hard power, while some are soft power tools. “Key soft-power abilities for people include charisma (emotional appeal), vision, and communication; for nations, soft power is expressed in their culture, values, and legal regulations”. It's difficult to imagine anyone who had the capability to govern with soft power alone, except for Dalai Lama and a small number of others. On the other hand, we frequently discuss hard power without taking into account the strength of attraction. Ignoring it would be wrong. People are starting to understand the importance of soft power as they take a closer look at the Middle East problem and start to realize that using hard power alone won't be enough to bring it to an end. Understanding the situation is necessary to determine how to use both hard and soft power. Experience plays a significant role in what I refer to as contextual intelligence, but there is more to it. Mark Twain said it best, As Mark Twain put it, “a cat that sits once on a hot stove will never sit on a hot stove again, but the cat won’t sit on a cold stove, either”. Using the tools of power properly need experience and analysis both.

3.2 DEMOCRACY VS TERRORISM

There are undoubtedly situations where using hard power is necessary. When Al Qaeda was being protected by the Taliban administration in the 1990s, President Bill Clinton tried to

diplomatically resolve the issue. He was trying to persuade the Taliban, yet his tactics weren't working. This indicated that all things considered, the United States had not done enough to destroy the terrorist safe zones that the Taliban has built for Al Qaeda. In that instance, soft power was unsuccessful and rather made it take the US longer than it should have to retaliate with more force than was necessary. Soft power may consequently be useless if it prevents you from acting as is required.

However, the Osama bin Ladens of the world are able to recruit more people with their soft power than you are able to dissuade with your hard power if the way a government uses the hard power antagonizes the mainstream. The United States is currently engaged in a conflict for the hearts and minds of the majority of Muslims. To keep Americans from being recruited by terrorists, the United States must employ soft power. Iraq was a terrible decision because of this. Hard power alone was President Bush's attempt to impose democracy in Iraq, and the resultant backlash has hurt America. Undoubtedly, a democracy needs to use coercion—hard power—to confront terrorists. However, there are occasions when attraction—soft power—is the most important element. Young people may be attracted by soft power to alternatives other than terrorism. That cannot be accomplished through coercion.

US President Theodore Roosevelt is credited with saying that we should carry a large stick and speak gently. Theodore Roosevelt was the perfect example of smart power, which combines soft and hard power in the right proportions and with the right background. Leaders who want to comprehend the issues that the United States and balance world powers are currently experiencing would be well advised to read Teddy Roosevelt.

Look at his admiration for the military to see how acutely aware he was of the use of hard power. He understood the value of soft power, though. Making the United States more desirable was Roosevelt's primary goal in negotiating important accords like the Portsmouth Treaty of 1905, which put an end to the conflict between Russia and Japan. When he dispatched the nascent American navy's Great White Fleet on a tour of the world. He intended to promote America as a force for good while also showcasing the nation's new military might, so he sailed the New American Navy known as “Great White Fleet”, on a tour across the globe. The US President effectively exploited the navy—a hard-power tool—as a soft-power emblem. Teddy Roosevelt frequently appears on rankings of the top 12 or so presidents in

American history because of this type of clever power play.

3.3 SMART POWER IN THE USA IN THE 21ST CENTURY

An effective smart power narrative for the United States in the twenty-first century, Nye argues, will not obsess over power maximization or the preservation of hegemony. Mostly it will derive "ways to combine resources into successful strategies in the new context of power diffusion and the 'rise of the rest. A successful smart power strategy will provide answers to the following questions: 1) what goals or outcomes are preferred? 2) What resources are available and in which contexts? 3) What are the positions and preferences of the targets of attempts at influence? 4) Which forms of power behavior are most likely to succeed? 5) What is the probability of success?" With these questions answered and delved upon, the leaders of 21st century can deploy soft or hard power as the situation demands.

3.3.1 HILLARY CLINTON STRATEGY

Smart power became an important tenet of President Obama's foreign policy agenda in 2009. Hillary Clinton popularized it during her Senate confirmation hearing for the position of Secretary of State on January 13, 2009. "We must use what has been called smart power, the full range of tools at our disposal, those are diplomatic, economic, military, political, legal, and cultural. Picking the right tool, or combination of tools, for each situation. With smart power, diplomacy will be the vanguard of foreign policy". She became the mainstream politician who utilized smart power practically in dealing with foreign policy matters under President Obama of the USA.

This modern-day use of smart power strategy is probably the most effective compared to the traditional hard power usage in solving problems on an international scale. President Bush's President's Emergency Plan for AIDS Relief (PEPFAR), the President's Malaria Initiative, and the work of the Millennium Challenge Corporation (MCC) to promote economic growth as a means of combating global poverty are all "smart power" successes.

3.4 SRI LANKAN MILITARY AND POLICE USING SMART POWER

Sri Lankan Military and Police have used many programs and activities to successfully achieve national security and defense objectives after the completion of the humanitarian operation in May 2009. Some of them are:

a. MOD - Api Wenuven Api advertising campaign to obtain support of general public, Ranawiru Real Star reality show to showcase Military singing talent.

b. SL Army - Gajaba, Foxhill, Gunners, Vijayaba Super Cross for the national level competitors, CIMIC club project on leisure, education and entertainment for children of Kopai, Various other Community projects such as tank cleaning, church and temples renovation.

c. SL Navy - Social Responsibility Projects – 350 RO Plants in North Central Province, Schools refurbishment project, Thalassemia infusion systems at a low cost to patients, various community renovation and construction projects at temples, churches and hospitals, and schools.

d. SL Air Force - Guwan Papadi Sawariya, Seegiriya Super Cross, Reconstruction of Kanugaswewa Village

e. SL Police – Police Cadetting for school children, Life Saving courses for the general public.

These programs have served the purpose of winning the hearts and minds of the public and smoothing the civil-military relations in the zone of conflict and other general areas.

4. WAY FORWARD STRATEGY (RECOMMENDATIONS)

Policy options for the application of smart power skills in strategic leadership can be fourfold.

a. Development of Soft power skills such as "Communication, Persuasion, Negotiation, Relationship building, Empathy, Positive Attitude, Teamwork, Conflict Resolution, Emotional intelligence, Time management, and Work ethics" by Military& Police leaders at Junior, Middle, and Senior levels training programs

b. Initiate projects on increasing the reputation of the military & Police, building ties, networking, making allies and partners, and encouraging leaders in taking up appointments in key institutions locally and internationally.

c. Employing soft and hard power combinations (Smart power) and the ability to use it according to the situation such as Public Diplomacy, Exchange programs, Development assistance, Disaster relief, Propaganda, Military-to-military contacts, Reputation management, marketing the organization

d. Device successful smart power strategies for organizations to be used in appropriate situations based on goals or outcomes, resources, targets of influence,

power behavior, and probability of success.

5. CONCLUSION

Leadership has always relied heavily on soft power. The ability to draw others to you, structure the conversation, and set the agenda has its origins in thousands of years of human history. Effective leaders have always known that legitimacy and credibility are the foundations of appeal. Even the most violent dictators have relied on both attractiveness and fear to hold power; it has never only come from the barrel of a pistol.

Surveys revealed a sharp decline in American soft power when the country's approach to Iraq failed to give enough consideration to concerns of legitimacy and credibility. Although it did not stop the United States from going into Iraq, it did force it to spend more money and blood than it would have otherwise.

Similar to how Yasser Arafat could have recruited moderate Israelis and established a Palestinian state by now if he had chosen the soft power paradigm of Gandhi or Martin Luther King instead of the hard power of terrorism. Power and leadership are inexorably linked. Leaders must make key judgments about the types of power they use. The followers who downplay or neglect the importance of soft power will be missing a fruitful mechanism.

Smart Power is a combination of soft and hard power and the ability to use it properly in accordance with situational factors. The smart power concept which was tried and tested in international relations can be practically used as an effective leadership strategy for senior leaders in the Military and Police. Changing times and evolving threat perception has resulted in approaching leadership decision-making differently with more focus on results, outcome, and the impact of the solutions given to problems.

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NECESSITY OF ENERGY SECURITY ENHANCEMENT, CHALLENGES AND WAY AHEAD FOR SRI LANKA NAVY

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INTRODUCTION

1. Challenges in the 21st Century in terms of security aspects will be difficult to counter if we are not capable of utilizing our assets in the best possible way to yield optimum results. The fundamental changes occurring in the fields of technology are increasingly having an impact on modern warfare. Sri Lanka Navy (SLN) plays a vital role in the national military sector with much more capabilities incorporate with modern technologies, because of that reliable and qualitative energy requirement is of utmost importance in military establishments where it helps to provide meticulous command and control in the military operation.

2. The existing electricity generation arrangement in military command centers is mainly supported by the national grid and diesel-generated power. Continuous fuel supply is compulsory to avoid power shedding and blackouts. This logistic issue is adding up the highest security threat where fuel escort can be easily destructed by terrorists at any time. Power outages in military establishments incur major operational failures, economic costs, and time wastage. In the present scenario when redundancy is provided, generators often run underutilized. Overutilization for a few/single generator is also a problem. Both cases waste fuel. If the existing system can be upgraded towards Distributed Energy Resources (DER) concept with renewable energy integration will ultimately help to strengthen up the energy security, cost-saving, and operational capabilities of the Sri Lanka Navy. Because of these facts, energy security enhancement initiatives can be seen as more trending and essential in the military sector in the present context.

AIM

3. The aim of this paper is to logically evaluate the necessity of energy security enhancement and discuss challenges, opportunities and appraise emerging technologies for Sri Lanka Navy being a primer and sophisticated stakeholder in national security.

ENERGY SECURITY CONCEPT

Definition

4. The concept of energy security is claiming a very longstanding history as fire. Fire transformed raw meat into roasted meat. Our ancestors had to find out a reliable and secured source of fire such as wood for their survivability. They utilized it for cooking, heating, and protection, which met the bare necessities of life at that time. With the civilizations, new sets of needs and essentials had escalated. Socio-cultural behaviors and developments created new routes, Innovations, Science and technology development, industrialization demand fuels, and modes of transport were adopted. With all these things energy security became increasingly complex.

5. Energy security is best understood as a concept, not a plan or policy, in which improving energy security helps society move toward sustainable development. Energy is a valuable resource that is necessary to meet fundamental human requirements. Increasing one's own and the country's energy security is a step toward freedom of choice and the ascent to self-actualization in Maslow's hierarchy of needs. The first available record of a definition of energy security can be seen after the energy crisis of 1973, and a part of the 'environmental awakening' witnessed in the 1970s and the 1980s. It defined energy security as: 'Assurance of sufficient energy supplies to permit the national economy to function in a politically acceptable manner' (Azzuni, 2018). Furthermore, Energy security consists of five main indicators namely Energy Surety, Survivability, Supply, Sufficiency, and Sustainability.

Evolution of the Concept

6. The academic reflection on energy security dates back to the 1960s and aged with the oil crisis of the 1970s. Study interest in energy security waned in the 1980s and 1990s after oil prices stabilized and the threat of political sanctions eased. (Yergin, 1991) It re-emerged in the 2000s due to rising demand in Asia, disruptions to gas supplies in Europe, and pressure to decompress energy systems. Since the oil crisis of the 1970s, they have incorporated various energy sectors and different concepts since their inception. This perspective contributes to re-examining the meaning of energy security with this expansion. Energy security is generally an example of security, so any concept should address three questions: "Whose security?", "Security for what values?" and "Protection from what threats?" (Aleh Cherp, 2014)

National Energy Security Perspective

7. Sri Lanka Sustainable Energy Authority (SLSEA) being the apex body of the country for formulating energy policies in a strong viewpoint that Reducing dependence on imported fuels and diversifying energy sources is an important policy direction to enhance energy security. SLSEA has identified that promoting renewable energy generation within the country help to reduce the foreign currency expenditure, and improve environmental sustainability in the country. Implementation of small and medium-scale renewable energy projects which can also be adopted as an off-grid solution. And also as per their vision authority expects Sri Lanka to transition to the usage of modern energy technologies soon. (Lanka, 2000)

Military Perspective

8. Defense of a country and its interests is the primary responsibility of the national military, which consists of the army, navy, and air force. They are also responsible for carrying out rescue missions, providing humanitarian relief, and upholding law and order. The military's significant efforts in recent years have resulted in a sharp increase in the usage of all fossil fuels. The delivery of fuels to forward operations, bases, ships, and other craft for the purpose of generating electricity and other uses is a difficult and expensive process that costs and risks the lives of the people involved. As military forces, energy security which is composed of Energy Surety, Survivability, Supply, Sufficiency, and Sustainability needs to be addressed to achieve national security objectives where ultimately secure the national interests. The development of technology, such as intelligent power management systems and energy-storing technologies, has been accelerated in

other countries' militaries, driven by the need to increase energy security and efficiency. The US Department of Defense (DOD) currently consumes the most energy in USA. In an effort to decrease the use of fossil fuels as the primary source of energy, the DOD is in charge of technological research and progress in intelligent power management.

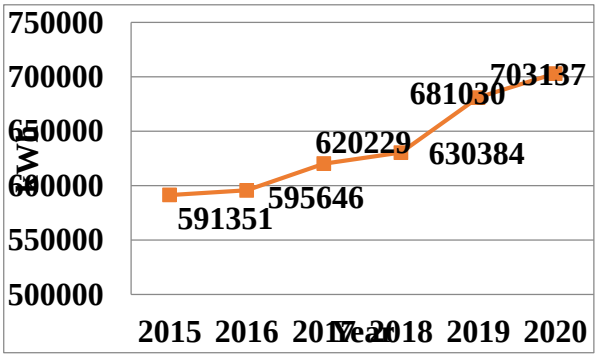
9. As Energy security is directly proportional to the sustainable development of the country, military forces being the prominent stakeholders need to concentrate on their energy generation, supply, and consumption in a well-organized manner. In military operations, energy demand, consumption data can be used to develop realistic sustainable plans and allocate adequate energy distribution resources within the forces. This data is essential not only for budget planning and expense reporting but also for strategic-level analysis and decision-making related to the role of defense operations such as force development, strengthening operational readiness, and construction more efficiently.

PRESENT ENERGY PATTERN OF SLN

10. SLN being a prime technical organization in national security, operating its communication & Data networks, energizing military facilities carried out from national utility supply from CEB, and diesel-driven generator network. As a modernizing military force in the country as well as the region, energy demand is increasing along with the development of the force. By studying the energy pattern of SLN it can be observed that the necessity of energy security towards SLN establishments required to maintain meticulous command and control. As an example, electrical energy consumption data of Eastern Naval Command Headquarters being one of the premier command centers in SLN has been utilized to develop the argument in this paper.

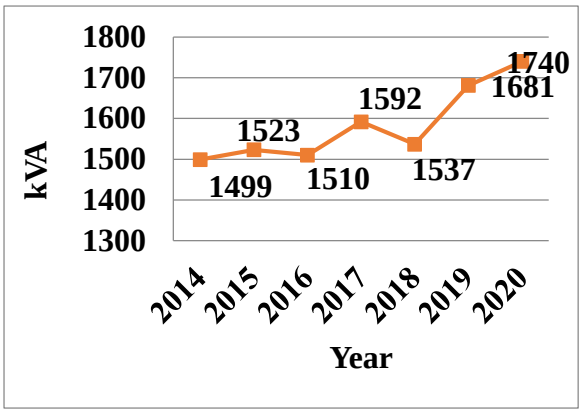
Energy Demand.

11. An electrical energy supply system is compulsory to provide operational and administrative demand for the smooth function of the military force. Energy demand management is one of the most essential factors to establish energy security. Poor energy management will cause multiple direct and indirect operational failures. Electrical energy consumption and maximum demand of Eastern Naval Command Headquarters for the year 2015 to 2020 as shown in Graph -I and II respectively.



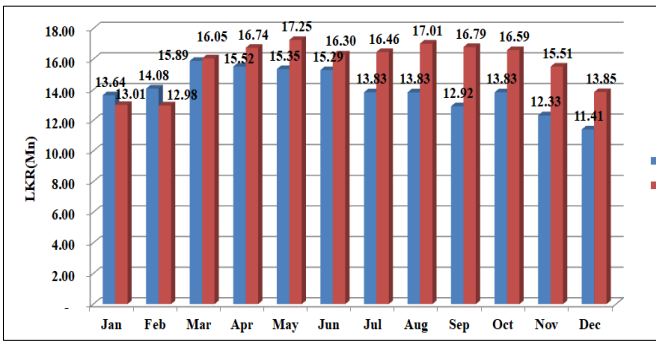
Graph I: Electrical Energy Consumption (kWh) (CLD(E), 2020)

12. Electrical energy consumption for the year 2015 to 2020 in Eastern Naval Command Headquarters indicates a high rate of growth and the causes for the growth can be identified as the development of the infrastructure facilities in the area. With this expansion, it can be identified that consumption will be automatically increased with time. Graph -II is indicating the maximum electrical demand for the year 2014 to 2020.



Graph II: Maximum Electrical Energy Demand (kVA) (CLD(E), 2020)

13. **Energy Cost Analysis**. CEB electrical energy bills of Eastern Naval Command Headquarters for recent two years (2019 and 2020) scrutinized to identify the energy cost expenditures of the area.



Graph III: CEB Electricity Bill for year 2019 and 2020 (CLD(E), 2020)

14. **Power Interruptions**. Power interruptions per year can be taken as an indicator for evaluating the quality and reliability of the available energy system. Table -1 indicates the no of power interruptions for the last three years.

Year	No of Interruptions
2018	139
2019	118
2020	145

Table -1: No of Power Interruptions per Year (2018-2020) (CLD(E), 2020)

15. Technically and economically analyzing the above data sets provide a clear understanding of energy security within the organization. With the development of the forces, energy consumption patterns also increased and energy cost will become a major component in the military budget. Furthermore, the number of interruptions due to various reasons is triggering the necessity of energy reliability as a military force where command and control components are directly interconnected with energy security. Therefore next chapter of this paper focuses on emerging technologies and solutions to enhance energy security with technological and economic benefits.

EMERGING TECHNOLOGIES AND OUR POTENTIALS

Military Microgrid

16. A technological concept known as a Microgrid combines the production of electricity from both renewable and non-renewable resources. Energy sources and loads are interconnected and work as one programmable unit. Among its many favorable attributes, the Microgrid can run independently (Islanding Mode of Operation) or as a component of a centralized Utility grid (the Ceylon Electricity Board), which will be more useful for military purposes. The grid is made up of a variety of energy sources that operate independently across loads, ensuring that the possible failure of some sources to produce power won't have an impact on the grid system as a whole. This technology's distributed generation concept has demonstrated to be an effective and adaptable way to utilize renewable energy sources. The need for fuels, the expense of transporting fuels, and most crucially the

amount of carbon emissions are all drastically reduced by this technique.

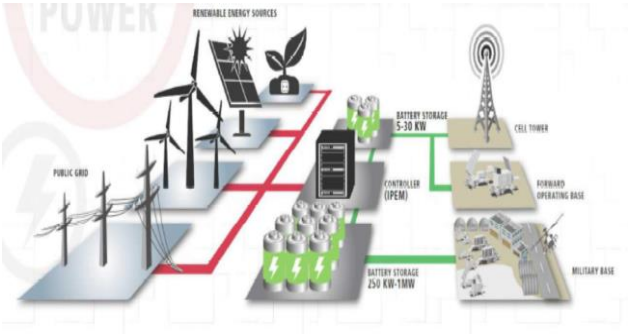


Figure 1 Concept of Military Microgrid (Kashem, 2018)

17. Modeling of a military Microgrid can be conducted by using MATLAB software and simulation results will provide a better understanding of the behavior of the Microgrid. Figure 2 shows the simulation results of energy-saving and reliability comparison detail between the conventionally energized military establishment and Microgrid installed military establishment. In this model, three generators were installed at the facility where 3 different colours define the respective energy supply of each generator. At the conventionally energized arrangement, no 2 and 3 generators emphasized energy wastage due to overutilization. Significance of Microgrid arrangement is that automatic optimum power source selection facility can be provided and in this model, only Generator no 2 along with

Generator no 1 provide energy supply to the required demand and energy saving can be experienced. (Kashem, 2018)

18. In this model, an attack to Generator no 2 simulated at the second instance, and conventional model results indicate load shedding (power interruption) to certain loads of the facility. But in Microgrid installed facility does not have any power interruption at that movement where it has seamlessly transfer its energy to Generator no 3. Further modeled system itself providing facility to penetrate renewable energy to the installation and it shows further energy saving through that integration.

Renewable Energy (RE) Concept

19. Research on alternative energy sources goes from the late 1990s to the time when rising oil prices began to affect the world. (Aleh Cherp, 2014) Substituting fossil fuel-based energy sources for renewable energy sources is clear from the literature: direct solar energy, geothermal energy, wind, and ocean (tidal) energy will help the world gradually achieve ideas. Governments, intergovernmental organizations, stakeholders, and the people of the world today hope for a sustainable future due to the opportunities that have arisen in recent decades to replace fossil fuels with renewable energy sources from fossil fuels based on fossil fuels.

Selection of Optimum Renewable Energy Source

20. Selecting optimum renewable energy resources to integrate with available conventional sources needs to be selected by considering the national energy potential levels of the respective area. Solar and Wind indicate higher energy potential in Sri Lanka. By considering affordability, security concerns, and economic factors, implementing solar power systems is having greater advantages than Wind Power in military establishments.

Solar Energy Potential in Sri Lanka.

21. The National Renewable Energy Laboratory (NREL) of the United States created the first solar atlas of Sri Lanka, in 2005 (Dave Renné, 2003) and a recently updated image of

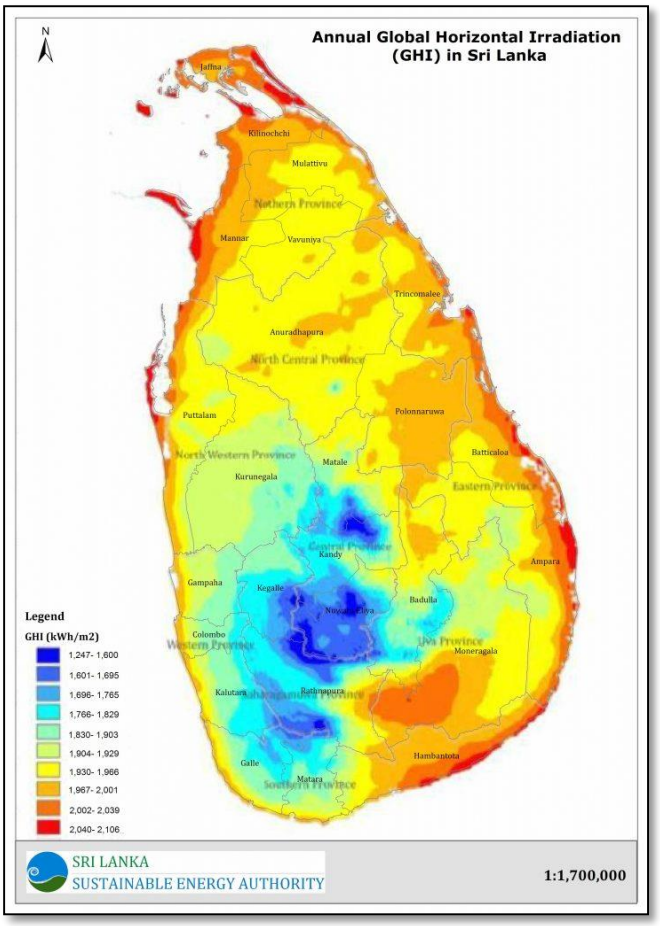


Fig 2. Solar Energy Potential of Sri Lanka (Authority, 2016)

the solar map is shown in figure 2. It provides information leading to gross estimates of solar potential. All the geographical regions in Sri Lanka receive a significant amount of solar radiation. As per Figure 3, The Global Horizontal Irradiance (GHI) fluctuates between 1,247 kWh/m2 to 2,106 kWh/m2. Due to the ongoing presence of clouds in mountainous locations and the shadowing effect of mountains, it can be seen that the intensity of solar irradiation in lowland areas is higher than that in mountainous regions. As most of the Naval establishments are located in the lowland area, solar harvesting can be easily utilized in clean energy generation.

22. As per the government promoted sustainable development project "Battle for Solar Power" which known as "Sooryabala Sangramaya", surplus energy exported to the grid can either be carried forward or at a tariff of 22.00 rupees per kWh during the first seven years and 15.50 rupees per kWh during the balance thirteen years. (Authority, 2016) Because of the high Internal Rate of Return (IRR) and less complexity in solar power generation projects, it can be observed as a viable solution for military installments compare with wind power systems where it required high-end technology and huge capital expenditure.

CHALLENGES AND LIMITATIONS

23. Microgrids are more renowned technology among other nations all around the world where multiple numbers of research and developments are conducted for further expansions. Because of the slow trending in technology transferring, few projects can be seen in Sri Lanka.

24. The main disadvantage in the renewable energy concept can be identified as intermittence in nature. As an example, solar energy generation is limited up to day time and the output of the solar panel depends on the cloud coverage. This challenge can be mitigated by using a battery storage system to store energy during a productive period and used that energy when necessary. However, oversizing the battery storage system will increase the capital expenditure of the installment.

25. Other than the renewable energy projects, developed countries in the present world invest more money in nuclear energy generation projects due to obtaining more energy security and a higher range of energy outputs. Geography, high-end technology, and a non-affordable range of capitals will be a greater challenge to Sri Lanka being a developing country.

DISCUSSION

Selection of optimum Energy Security Model for SLN Establishments

26. Conventional energy supply system infrastructures have already available in each SLN facility; hence complete infrastructure development toward energy security cannot be affordable with the available budget. However, the system needs to be developed integrating new technology with existing sources to uplift energy security capabilities. The following steps to be adopted to select optimum energy security models for the selected locations.

a. Identifications of critical energy demands (consumers) such as Ops rooms, Data and communication links, Sensor platforms, and Weapon control systems. This segregation helps to demarcate the energy priority and reduce the technological complexity of the system. And also this will increase the energy sustainability factor.

b. The best possible model comprising available resources will be selected based on the techno-economic feasibility analysis results for each location.

c. The integration of different renewable energy sources to be identified according to the respective energy source potential at that location.

27. According to the scrutinized literature, the reliability factor is an essential factor in military energy applications. When military establishments are compatible with multiple power redundancies, mitigation of vulnerability to attack and risks of unforeseen cascading failures can be achieved. Furthermore, identification of the root cause of outage and repair works may take a long time and distributed energy resources will overcome energy interruptions. The adaptability of a Microgrid to function on islanding mode of operation provides optimum energy security in admin and operational functionality of military establishments. On the other hand, self-sustainability of energy requirement within the establishment strategically protects the national grid and power plants around the country. Renewable energy penetration will further reduce the energy cost and intelligent energy management systems will decide on the suitable energy source to deliver the power supply to respective demand when necessary.

28. Considering the intermittent nature of renewable energy, a standalone power supply system cannot be recommended to energize military facilities where it reduces sufficiency, surety, and survivability. But Hybrid systems can tremendously overcome these issues with more advantages.

CONCLUSION

29. The national military could benefit significantly from the implementation of renewable energy-based Microgrid systems as a primary source of power at the bases. This paper reviews the concept of energy security, emerging Microgrid technology, an off-grid energy generation system used by military forces in efforts to face the energy crisis that is beginning to gain momentum in today's world. It also discusses the energy potentials and optimum model selection procedures. The economic feasibility also has to be considered while meeting the energy security policy and budgetary requirements. Each naval establishment has a precise set of energy requirements for various military activities, hence existing systems need to be designed to obtain maximum energy security with diversification of generating sources where energy surety, survivability, supply, sufficiency,

and sustainability will be full filled. By careful planning, this technology would serve SLN establishments as well as other military facilities, and ultimately command and control capabilities of national security forces will be established and enhanced.

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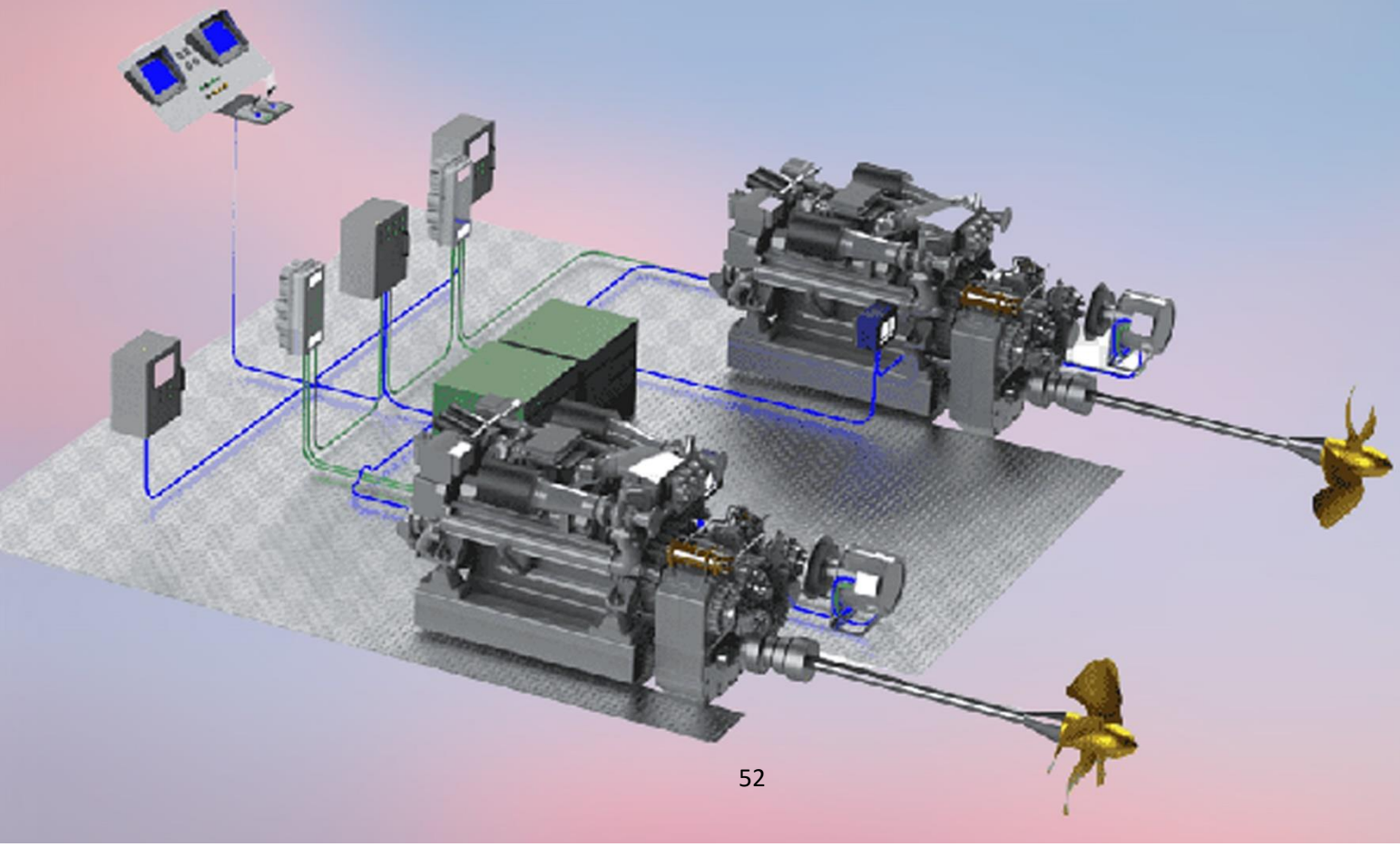
NAVAL FLEET ELECTRICAL SYSTEM

APP WASC THILAKARATHNA
AL 116965



NAVAL FLEET ELECTRICAL SYSTEM

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QA & T (East) Section

1. Introduction

Naval Fleet Electrical System is a topic that can be analysed in different ways. But we talk about the following electrical system in FACs,

1. Engine Control System
2. Steering Control System
3. Generator Control System
4. Fire Alarm system
5. Bilge Alarm System

About the steering control system in sub number Two. Currently there are 11 types of FACs used in the Navy. It has 54 crafts under 11 serious. The steering control system currently used in those crafts is also different. They can be described as follows.

I. ELECTRO HYDRAULIC
II. MJP
III. KAMEWA
IV. ASD
V. LIPS
VI. NPSC
VII. NSC
VIII. ACS

Now let us look into the above topics separately.

1. Electro Hydraulic System.

Electro Hydraulic is a simple steering control method. Here, according to the command we give, the solenoid is powered and the valve opens. Therefore, the rudder turns with hydraulic pressure in the relevant direction.

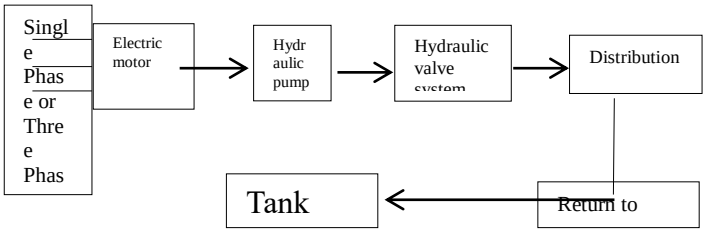

Fig 1. Electro Hydraulic System

2. Marine Jet Power (MJP) Control System
   I. MJP stands for Marine jet power
   II. MJP was created in 1986 in Sweden
   III. MJP first water jet delivery in 1987

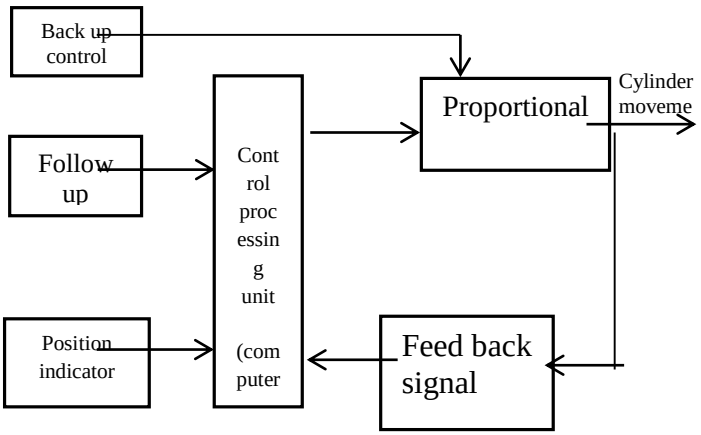

Fig 2. Marine Jet Power (MJP) Control System

I. When jet system is at follow up position steering, bucket, trim command is go through computer to proportional valve & release hydraulic oil to cylinder.

II. Every time position of the nozzle, bucket & trim will detect by feedback sensors & operate proportional valve.

III. It use tow sensors for feedback & indication.

IV. If system is at back up mode give supply to proportional valve by using liver. In this only indication is take.

ALARM & COMAND PANEL (ACP)

The **ACP** is main control for choice of operational mode's and main alarm supervising.

Fig 3. Alarm & Comand Panel

INDICATION UNIT

Fig 4. Indication Unit

There are two indicators in the system one for Port and one for Stbd side.

Features:-

I. Bar graphs for Bucket and Nozzle
II. Alarm indication for bucket, Nozzle and RPM.
III. Back up control switches for Bucket, Nozzle and RPM including Status indication

Three switches for on the side for calibration

CENTRAL UNIT

Fig 5. Central Unit

The central unit is mounted in a plastic box, one for each side.

Features :

I. Bucket control 4-20mA
II. Nozzle control 4-20mA
III. RPM signal 4-20mA
IV. Neutral indication
V. Auto Pilot interface (in Stbd unit)
VI. Watch Dog

AZIMUTH CONTROL

Fig 6. Azimuth Control

As standard is the system equipped with two Azimuth Controllers,

I. Stbd Azimuth Controller
II. Port Azimuth Controller

The Azimuth controls Bucket, RPM and Nozzle position. Back upp and Indication Unit(BIU)

The BIU includes backup relays and indication amplifiers for one Jet. There is one unit for each side.

Fig. 7. Back Up And Indication Unit

MANEUVERING AND FEEDBACK UNIT

The MFU includes power stages and feedback amplifiers for one Jet. There is One Unit for each side.

PATCH PANEL

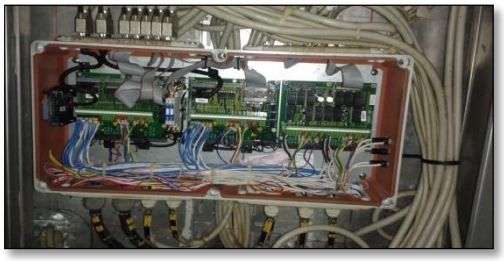

Fig. 8. PATCH PANEL

The patch panel is the connection point between the different units in the system.

BUCKET & NOZZLE ARRANGEMENT

When clutch in of the engine jet system is push the water stream to back some pressure, when boat will move**.**

BUCKET ZERO

Bucket neutral position, when water stream divide in to two path by bucket (one stream path is push to front & other stream path is push to back) BUCKET AHEAD POSITION

Fig. 9. Bucket Ahead Position

When bucket is go up, from the bucket will give water stream to back then craft will go ahead.

BUCKET ASTERRN POSITION

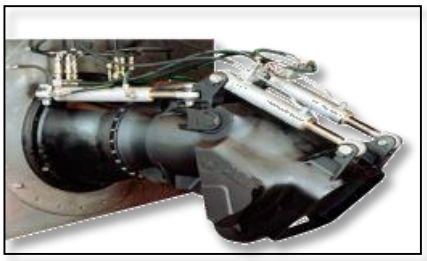

Fig. 10. Bucket Asterrn Position

when bucket is go to down from the bucket will give water steam to back then craft will go to astern

STEERING NOZZLE

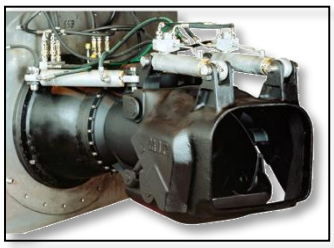

Fig. 11. Steering Nozzle

when nozzle move stbd side or port side ,then we can be turn any side.

MJP IMPELLER

Fig. 12. MJP Impeller

I. **W**ater jet impeller is consist of equal weight of rotating plane balance properly

II. Impeller shaft is connect to gear box. It will be rotate and depend upon engine rpm.

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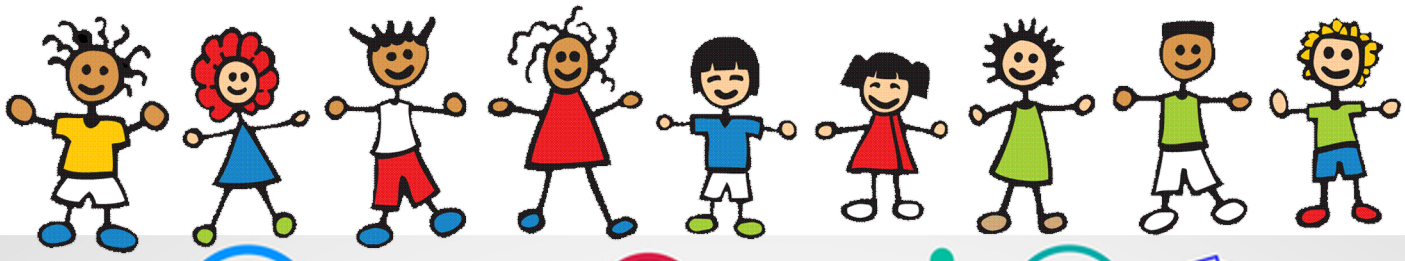
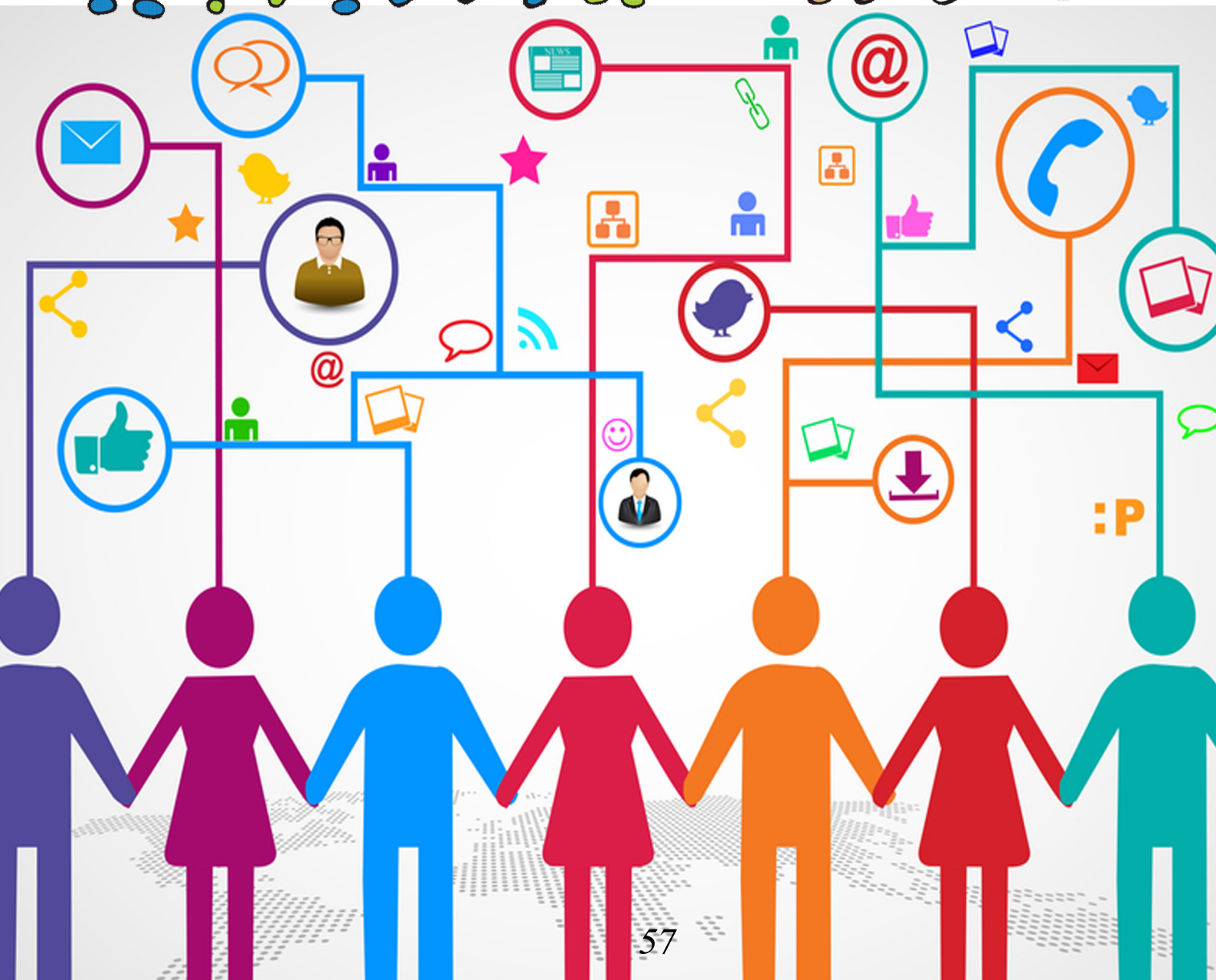
නායක ගුවන්විදුලි කාර්මික ඒඑච්ඩී ෆොන්සේකා
එල්ආර් 103067





සමාජ සංවර්ධනය තුලින් අපරාධ මර්ධනය

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අපරාධ නම් වූ ප්‍රපංචය නෛතික හා සමාජ විද්‍යාත්මක දෘෂ්ටීන් ඔස්සේ හඳුනා ගනිමින් අපරාධ වර්ධනය වීමට හේතු සහ අපරාධ මර්ධනය කිරීමට ගත හැකි පියවරයන් පිළිබඳව අධ්‍යනයකල හැකියග නීති ශාස්ත්‍රයට අනුව අපරාධයක් යනු, නීතියෙන් සුවිශේෂීව තහනමට ලක්කොට ඇති යම් ක්‍රියාවක් හෝ පැහැර හැරීමකිග අපරාධ හා නීතිය අතර පවතින්නේ වෙන්කල නොහැකි සම් බන්ධ තාවයකි. නෛතික රාමුව තුල අපරාධ මැඩලීම සඳහා භාවිතා කරනුයේ ද'වමයි. යම් අපරාධයක් කරනු ලැබූ පුද්ගලයෙකුට එම අපරාධයට අදාල ද'වම නීතියේ අන්තර්ගතය තුල පවතී. නීති ශාස්ත්‍රයට අනුව නීතියක් නොමැතිව අපරාධයක් සිදු නොවේ. යම් ක්‍රියාවක නොවැදගත්කම, මරණ සංඛ්‍යාව හා සාපරාධී භාවය කෙතරම් වුවද එය නීතියෙන් තහනමට ලක් කර නොමැතිනම් එය අපරාධයක් නොවේ .

සමාජ විද්‍යාත්මක දෘෂ්ඨියෙන් අපරාධ හඳුනාගත හැකි වන්නේ දීඝපගාමිත්වය" වශයෙනි. සමාජයමය වශයෙන් පවත්නා ධර්මතා, අගයන් බිඳ දමමන් සමාජ සම් මතයට පටහැනි චර්යාවන්ගේ නිරත වීම දීඝපගාමිත්වය" වශයෙන් හැඳින්විය හැකිය. සමාජයේ යහපැවැත්ම තහවුරු කිරීම සඳහා සමාජය තුලින්ම ජනිත වී ඇති ආගම, සදාචාරය, සංස්කෘතිය, චර්යා ධර්ම වැනි අංගයන්ට පටහැනිව සිදුකරන ක්‍රියාවන් අපරාධ ගණයට අයත්වේ ග

නීතිය මගින් ද'වම් ලැබෙනුයේ අපරාධ කරුවන් හට පමණක්ද යන්න වමසා බැලිය යුතු කරුණකි. අපරාධ යුක්තිය පිළිබඳව ඕ නෑ තරම් කතා ඇතත් නිවැරදි කරුවන්, වැරදි කරුවන් කර මරණ දණ්ඩනය ලබා දුන් අවස්ථාද නැතුවාම නොවේ . දීඝාශාවේ පලපෑම නොලත් තාර්කික බුද්ධිය නීතියයි" වශයෙන් ඇරිස්ටෝටල් විසින් නීතිය හඳුන්වා ඇත. නීතිය ක්‍රියාත්මක කිරීමේ දී තාර්කික බුද්ධිය උපයෝගි කර ගනිමින් අපරාධ කරුවන් හඳුනා ගැනීම තුළින් සත්‍ය අපරාධ කරුවන් හටම ද'වම් ක්‍රියාත්මක වන්නේද ප්‍රශ්ණාර්ථයකි. නීතිය ක්‍රියාත්මක කිරීමේ යාන්ත්‍රනයේ පාරිශුද්ධ භාවය කෙලෙසීමද අපරාධකාරී ක්‍රියාවක්ව පවතී. අපරාධයක් සිදු වුවාට පසුව අපරාධ කරුවාට එරෙහිව නීතිය ක්‍රියාත්මක කිරීම වෙනුවට අපරාධ සිදු වීමට මූල බිජ වන හේතූන් සමාජයෙන් ඉවත් කිරීම සුදුසුය. ඒ සඳහා හොඳම උපකරණය වනුයේ සමාජ සංවර්ධනයයි.

පුද්ගලයින්ගේ පීව ගුණය පවතින තත්ත්වයට වඩා යහපත් යැයි අපේක්ෂිත තත්ත්වයකට පත්කිරීමේ ක්‍රියාවලිය සමාජ සංවර්ධනය ලෙස හැඳින්විය හැකිය. සමාජයක් සතු සම් පත් වඩාත් සාධාරණ වශයෙන් බෙදී යාමක් එහිදී අපේක්ෂා කරනු ලබයි. ප්‍රධාන ප්‍රවාහයෙන් බැහැර කරන ලද පුද්ගල කණ්ඩායම් වලට සමාජයන්හි සුභසාධනය කෙරෙහි වැඩ අවස්ථාවක් ලබා දීම සමාජ සංවර්ධනයෙහි ප්‍රධාන දර්ශකයකි. ස්තරීකරණය හෙවත් පංති ක්‍රමයට භාජනය වූ සංකීර්ණ සමාජයේ ආර්ථික, පාරසරික සහ සමාජයීය යන ප්‍රවාහයන් තුලනාත්මකව සංවර්ධනය කිරීමෙන් සමාජයේ පවතින අපරාධ මර්ධනය කල හැකිද? යන්න වමසා බලමු.

අපරාධ රැල්ලේ කලලය වන්නේ ජනගත ප්‍රවණ්ඩත්වයයි. එය ගර්භාෂගතව ඇත්තේ දිළිඳු බාවය තුලය. ලෝකයේ සම් පත් වලින් 65% ම පාරිභෝජනය කරනුයේ ජනගහනයෙන් 20% පමණ වූ ධනපති පංතියයි. ශ්‍රී ලංකාවේ ගෙවී ගිය 50 වසර තුල ගැම දිළිඳු බාවය තෙගුණයකටත් වඩා වැඩිය. ආදායම් බෙදී යාමේ විශමතාවය 1- 60 කි. සමාජ, ආර්ථික අසාධාරණය හේතුවෙන් ඇති වන නුගත්කම, දුප්පත්කම, විරුකියාව, මන්දපොෂණය, ලෙඩ රොග, ආර්ථමාර්ථය හා ධණවතුන් කෙරෙහි එල්ල වන වෛරය වැනි ප්‍රති විරෝධයන්ගේ උච් ජතම අවස්ථාව වී ඇත්තේ අපරාධයයි.

අපරාධ වර්ධනය කෙරෙහි බලපාන ප්‍රධානතම හේතුව වන්නේ සමාජ අසාධාරණයයි. සමාජ මනෝ විද්‍යාඥ රොබට් ඒ මඩ් න් තමන්ගේ අනෝමිය න්‍යාය විග්‍රහ කරමන් සමාජයක් තුළ සමාජ අසාධාරණයක් ඇති විට බිඳුණු පවුල් වල දරුවන් අපගාමී පෞරුෂයන්ට ගොදුරු වන බව විග්‍රහ කර ඇත. පාසලක් වැනි සමාජ ඒකකයක සිටින දරුවන් පිරිසක් අතුරින් පහළ පාන්තික, අගහි"කම් සහිත දරුවන් හට අවධානය අඩු වීම ස්වභාවයයි. එසේ අවධානය අඩු වීමකට ලක් වන දරුවන් අතර ඉවි ජාහංගත්වය ගොඩනැගේ. ආදරය, අවධානය ලබන කණ්ඩායම වේ ගයෙන් සමාජ ධර්මතා සමග ඉදිරියට යද්දී අනෙක් අය පීවත් වීමේ අරමුණ උදෙසා වැරදි

මාර්ග ඔස්සේ ජීවිතය සොයා යාමට උත්සාහ දරයි. එවැන්නන් තම ජීවන වෘත්තීය, සමාජ විරෝධී පෞරුෂයකින් යුතුව තෝරා ගනී.

මව් පිය සෙසෙනෙහස අහිමි වූ දරුවන් අපරාධකාරී ක්‍රියාවන්ට යොමු වීමේ ප්‍රවනතාවය ඉහළය. පහළ ස්තරයේ ග්‍රාමීය පවුල් මූලික අවශ්‍යතා සපුරා ගැනීම සඳහා ජීවන අරගලයක නිරතව සිටී. තම පවුලට නිවසක් තනා ගැනීමේ සිහිනය පමණක්ම කැටකර ගනිමින් කාන්තාවෝ විදේශ රැකියා සඳහා පිටත්ව යන අවස්ථා ඕ නෑ තරම් ඇත. මව විදේශගත වීමත්, පියා මත්පැන් සඳහා ඇබ් බැහි වීමත්, හේතුවෙන් මාපිය සෙනෙහස අහිමි වූ නිසි සමාජානුයෝජනය නොලත් දරුවන් මත් ද්‍රව්‍ය වලට ඇබ් බැහි වීම සහ එයට අවශ්‍ය මුදල් සපයා ගැනීම සඳහා විවිධ අපරාධ කාරී ක්‍රියාවන්ට යොමුවේ . මෙසේ මාපිය රැකවරණය අහිමි වන දරුවන් අපයොජනයට ලක්වීමේ ප්‍රවනතාවය අතිමහත්ය. ග්‍රාමීය සමාජවල ළමා මව් වරුන් ඇති වන්නේ මෙහි ප්‍රථිපලයක් වශයෙනි. මව් පිය සෙනෙහස අහිමි වන තරුණ දියණියන් සෙනෙහස සොයා යාමේ ප්‍රථිපලයක් ලෙස මෙය හඳුනා ගත හැකිය.

ශ්‍රී ලංකාවේ පවතින විභාග පදනම් කරගත් අධ්‍යාපන රටාවේ ප්‍රධානතම ලක්ෂණය වනුයේ තර" කාරීත්වයයි. මේ හේතුවෙන් පාසල් හැර යන ළමයින් ප්‍රමාණය වැඩි වෙමින් පවතී. විභාග ක්‍රමය තුළින් උසස් අධ්‍යාපනයට සුදුසුකම් නොලබන හා පාසල් හැර යන තරුණයින් නව ඉගෙනුම් අවස්ථා නොලැබීම හේතුවෙන් සමාජමය වශයෙන් අසහනකාරී තත්වයට පත්වේ . ස්වාධීන බලාපොරොත්තු මත පදනම් ව තමන්ටම ආවේණික වූ ජීවිතයක් නිර්මාණය කරගැනීම සෑම තරුණයෙකුගේම අපේක්ෂාවයි. ඔවුන් තම ජීවන ක්‍රමය හෝ විලාසිතාව ගොඩනාගා ගන්නේ කුඩා කාලයේ සිටම ඔවුන් වටා පවතින පරිසරය පදනම් කර ගනිමිනි. නිවැරදි සමාජානුයෝජනයකට ලක්වූ තරුණ පිරිස්, අවස්ථාවන් හඳුනා ගනිමින් නිවැරදි ජීවන රටාවක් ගොඩනගා ගත්තද නිසි සමාජානුයෝජනයෙන් තොර වූ තරුණයින් කණ්ඩායම් වශයෙන් විවිධ සමාජ විරෝධී ක්‍රියාවලට යොමුවේ . මෙසේ කල්ලි ගැසෙන තරුණ කණ්ඩායම් නාගරික මෙන්ම ග්‍රාමීය සමාජයන් තුළත් හඳුනා ගත හැකිය. මෙම දීකල්ලිදී සමාජයේ පවතින උප සංස්කෘතියකි. වර්ථමාන සමාජයේ පවතින පාතාල කල්ලි වලට මූලාරම්භය මෙම කල්ලි සංස්කෘතිය මගින් බිහිවන බව හඳුනා ගත හැකිවේ . මත්ද්‍රව්‍ය ජාවාරම, අවි ජාවාරම, පුද්ගල ඝාතන, මංකොල්ල කෑම සහ කප්පම් ගැනීම වැනි දරුණු අපරාධ මෙම පාතාල කල්ලි විසින් සිදු කරයි. මොවුන් නීතියෙන් ආරක්ෂා කරමින් මෙම සංස්කෘතිය හසුරවනු ලබන්නේ ධනපති ප්‍රභූ පංතිය විසිනි. දූෂිත දේශපාලකයින්, රාජ්‍ය නිලධාරීන් සහ ව්‍යාපාරිකයින් පාතාල කල්ලි හැසිරවීමේ හස්තයේ සාමාජිකයින් බව නොරහසකි. මොවුන් ධනයෙන් පෝසතුන් වන නමුත් චින්තනයෙන් දුප්පතුන්ය. එයට හේතු වන්නේ කුඩා කල නිසි ආදරයක්, රැකවරණයක් සහ සමාජානුයෝජනයක් නොලද බැවින් වය හැක.

සමාජ අකටයුතුකම් , අසාධාරණකම් ඉවසා සිටිය නොහැකි තත්ත්වයට පත්වන විට තව දුරටත් තමන් වෙනුවෙන් යුක්තිය ඉටුකර ගැනීමට නොහැකි යැයි තේරුම් ගැනීමෙන් පසුව මනිසා අපරාධකාරී වන බව හඳුනා ගත හැකිය. මෙම පුද්ගලයින් අපරාධ කරුවන් ලෙස ලේබල් කිරීම හේතුවෙන් හා අපරාධ කිරීමට සමාජමය වශයෙන් ඇති බය හෝ නීතියට ඇති බය හීන වීම හේතුවෙන් දිගින් දිගටම අපරාධ වලට යොමුවීමේ ප්‍රවනතාවයක් පවතී. ශ්‍රී ලංකාවේ 2020 වසරේදී වැරදි කරුවන් වී සිරගත කරන ලද පිරිසෙන් 46ග2 ම මීට පෙර එක්වරක් වත් සිරගත වූ පුද්ගලයින් වීම එයට නිදසුන් සපයයි.

අපරාධ සමාජ ක්‍රියාවලියක් බවට පෙන්වා දෙන නව මාක්ස්වාදී සමාජ විද්‍යාඥයෙකු වන විලියම් චැම් බලිස් ධනේෂ්වර සමාජ ක්‍රමය තුළ අපරාධ සිදුවන ආකාරය පෙන්වා දෙයි. ධනේෂ්වර පංති ක්‍රමය තුළ පවතින ලාභ අරමුණු කරගත් ආර්ථික ක්‍රමයේ නිෂ්පාදන පිරිවැය අඩු කිරීම සඳහා කම් කරුවන් හට අඩු වැටුප් ගෙවීමට සිදුවේ . යන්ත්‍ර සූත්‍ර භාවිතය මගින් නිෂ්පාදන ක්‍රියාවලිය කාර්යක්ෂම කිරීම හේතුවෙන් රැකියා සහ ආදායම් අහිමි වීම අපරාධ වර්ධනයට සාධකයකි.

නිසි රැකවරණය, ආදරය, සෙනෙහස, අධ්‍යාපනය, පෝෂණය සහ සමාජානුයෝජනය වැනි ප්‍රමුඛ වශයෙන් පවුල නම් වූ සමාජ ඒකකය මගින් පුද්ගලයෙකුට ලැබය යුතු සාධකයන් නිසි ලෙස නොලැබීම අපරාධ වර්ධනයට ප්‍රධාන හේතුවකි. එක්සත් ජාතීන්ගේ සංවිධානයේ අපරාධ සංරක්ෂණ වාර්ථාවට අනුව ලොව අවම අපරාධ ප්‍රතිශතයන් සහිත රටවල අපරාධ අඩුවීමට බලපාන විවිධ වූ සමාජමය සාධක හඳුනාගත හැකි වුවත්, පවුල් සම් බන්ධතාවයන්ගේ තීව්‍ර භාවය පොදු ලක්ෂණයක් ලෙස හඳුනා ගත හැකිය. ජපානය, නේපාලය, ස්විට්සලන්තය සහ අයර්ලන්තය වැනි රටවල් එයට නිදසුන් වේ .

දිනෙන් දින වර්ධනය වන අපරාධ රැල්ල මර්ධනය කිරීමට කලයුත්තේ උක්ත ජේදයන්ගෙන් ප්‍රකාශිත අපරාධ වර්ධනය වීමට බලපාන සමාජ සාධකයන් ඉවත් කිරීමයි. ඒ සඳහා යොදාගත හැකි හොඳම උපකරණය වනුයේ සමාජ සංවර්ධනයයි. සමාජ සංවර්ධනය නම් වූ සංකලනයේ

තාක්ෂණික අන්තර්ගතය පිළිබඳව නිසි අවබෝධයක් ලැබීමෙන් තොරව එය සාර්ථක කර ගත නොහැක.

සෑම පුරවැසියෙකුගේම මූලික අවශ්‍යතා සපුරා ගැනීමේ හැකියාව මත සමාජය කෙතරම් දුරට සංවර්ධනය වී ඇත්ද තීරණය වේ . එය පීවන තත්ත්වය වැඩිදියුණු කිරීමට හා සමාජ ආර්ථික සංවර්ධනය ප්‍රවර්ධනය කිරීමට මූලික පදනම නිර්මාණය කරයි. සෑම රටකම ජනගහනය මූලික අවශ්‍යතා සපුරා ගැනීමේ ප්‍රමාණය හඳුනා ගැනීම සඳහා යොදා ගන්නා සමාජ සංවර්ධන දර්ශකයේ අන්තර්ගතය අධ්‍යනය කිරීමෙන් සමාජ සංවර්ධනය නම් වූ සංකලනයේ තාක්ෂණික අන්තර්ගතය හඳුනා ගත හැකි වේ . මෙහි මූලික සංරචක පහත පරිදි දැක්විය හැක.

01 මූලික මිනිස් අවශ්‍යතා

- පෝෂණය හා මූලික වෛද්‍ය ප්‍රතිකාර සඳහා ප්‍රවේ ශය
- ජලය හා සනීපාරක්ෂාව සඳහා ප්‍රවේ ශය
- පීවත්වන ස්ථානය
- පුද්ගලික ආරක්ෂාව

02 සුවතාවයේ මූලික කරුණු

- මූලික දැනුමට ප්‍රවේ ශය
- තොරතුරු හා සන්නිවේ දනය සඳහා ප්‍රවේ ශය
- පාරසරික ගුණාත්මක භාවය
- සෞඛ්‍ය හා සුවතාවය

03 අවස්ථාවන්

- පුද්ගලික අයිතිවාසිකම්
- පුද්ගලික නිදහස
- ඉවසීම සහ ඇතුලත් කිරීම
- උසස් අධ්‍යාපනයට ප්‍රවේ ශය

සමාජයන් තුළට මෙම සංරචකයන් ගුණාත්මකව සංකලනය කිරීම මගින් අපරාධ වර්ධනයට හා සමාජය තුළ අපරාධ කරුවන් ජනිත කරවීමේ බීජයන් විනාශකල හැකිය. සමාජ සංවර්ධනය තුලනාත්මක ලෙස සිදු කිරීමට රාජ්‍ය මැදිහත්වීම අත්‍යාවශ්‍ය වේ . සමාජයක ප්‍රධාන ප්‍රවාහයෙන් බැහැර වූ කණ්ඩායම් වල සහ ප්‍රජාවන්හි සුභසාධනය කෙරෙහි වැඩි අවධානයක් යොමු කරමින් සමාජයේ පහළ ස්තරයේ මූලික මිනිස් අවශ්‍යතා සපුරාලීමටත්, පුද්ගල සුවතාවය නගාසිටුවීමට සහ පීවන තත්ත්වය නගා සිටුවීමටත් ඇති අවස්ථාවන් සංවර්ධනයට අවශ්‍ය ප්‍රතිපත්ති නිර්මාණය කිරීම සහ කාර්යක්ෂම ලෙස ක්‍රියාත්මක කිරීම සෑම රජයකම වගකීම විය යුතුය. සමාජ සංවර්ධන ක්‍රියාවලියේදී පහත සඳහන් අංශයන් වෙත අවධානය යොමු කිරීම වඩාත් වැදගත් වේ.

01 ආධ්‍යාත්මික හා සමාජ සංවර්ධනය

එකිනෙකාගේ සහයෝගීත්වය, සහජීවනය හා සදාචාරය සංවර්ධනය කරවීම සඳහා සමාජය සංවිධානය කරවීමට අවශ්‍ය භෞතික හා මානව සම් පත් යෙදවීමත් විශමාචාර ක්‍රියාවන් අවම කිරීමට සමාජය පෙළඹවීමත් මෙම්න් සිදුකල හැකිය. මේ සඳහා ප්‍රදේශයේ ආගමික ස්ථාන හා ආගමික නායකයින්, උගතුන්, බුද්ධිමතුන් මෙහෙයවීම සමාජ සංවර්ධන කාර්යයයේ යෙදෙන රාජ්‍ය ආයතන වල කාර්යය විය යුතුය.

02 පීවනෝපාය සංවර්ධනය

සෑම පවුලකටම නිශ්චිත ආදායම් මාර්ගයක් ඇතිකිරීම සඳහා ස්වයං රැකියා අවස්ථාවන් සහ නව රැකියා අවස්ථාවන් බිහි කිරීම මගින් සමාජයේ වරුකියාව අවම කිරීම.

03 ක්ෂුද්‍ර මූල්‍ය සංවර්ධනය

දුගී භාවයේ විශම චක්‍රයෙන් මිදීම සඳහා ඉතිරි කිරීමට ජනතාව පෙළඹවීම සහ අවශ්‍ය යටිතල පහසුකම් සංවර්ධනය කිරීම.

04 අලෙව් සංවර්ධනය

අලෙව් කරණය, නිෂ්පාදන සඳහා අගය එකතු කිරීම වැනි විෂයයන් සම් බන්ධව නවීන දැනුම හා පුහුණුව ලබා දීම සහ ගබඩා පහසුකම් , ප්‍රවාහන පහසුකම් අලෙව් මධ්‍යස්ථාන පහසුකම වැනි යටිතල පහසුකම් සංවර්ධනය කිරීම.

05 ප්‍රජා මූල සංවර්ධනය

ප්‍රජා මූල සංවිධාන ගොඩනැගීමෙන් පුරවැසි ආකල්ප, දැනුම, කුසලතා හා සහයෝගීත්වය සංවර්ධනය කිරීම.

සමාජ සංවර්ධන කාර්යයේදී සමාජයේ සිටින සෑම පුද්ගලයෙකුම ඒ සඳහා කැපවීම තුළින් සංවර්ධන ඉලක්කයන් සපුරා ගැනීමට පහසුවේ. සමාජයේ පහළ ස්තරයේ පුරවැසියන්ගේ පීවන තත්ත්වය නගා සිටුවීම සඳහා ස්වේ ච් ජාවෙන් ක්‍රියාත්මක වීම මගින් අපරාධ මර්ධන ක්‍රියාවලිය කාර්යක්ෂම කල හැකි වේ .

වර්ථමානයේ ශ්‍රී ලංකාව තුළ දිනෙන් දින වර්ධනය වන අපරාධ රැල්ල මර්ධනය කිරීම වෙනුවෙන් සමාජ සංවර්ධන කාර්යයට එකා මෙන්ව පෙළ ගැසීමට කාලය එලඹව ඇත.

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An overview of design specifications for the shipboard power system integrated with solar energy

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AN OVERVIEW OF DESIGN SPECIFICATIONS FOR THE SHIPBOARD POWER SYSTEM INTEGRATED WITH SOLAR ENERGY

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1. INTRODUCTION

Solar energy has the potential to be an ideal energy source for the Sri Lankan Navy's shipboard power systems. The main benefit of using solar energy is that it is a renewable and sustainable energy source, with no carbon emissions or pollution. This makes it an eco-friendly and cost-effective alternative to traditional energy sources such as fossil fuels.

The Sri Lankan Navy could install photovoltaic (PV) panels on the deck of its ships to harness thepower of the sun. These panels would convert sunlight into electrical energy, which could then bestored in batteries for use as needed. The Navy could also install solar water heaters to provide hotwater for various day-to-day tasks on ships.

Apart from being environmentally friendly, the use of solar energy reduces the dependence on fossil fuels. This means the Sri Lankan Navy can reduce operating costs, as they would not have to buy or ship fuel to power their ships. Additionally, the use of solar energy would increase the range and endurance of the Navy's ships since they would not have to make as many stops to refuel. In conclusion, solar energy is a promising energy source for the Sri Lankan Navy's shipboard power systems. It is renewable, sustainable, and cost-effective, making it an eco-friendly alternative to traditional energy sources. By leveraging solar energy, the Navy can reduce its carbon footprint and operating costs while increasing its range and endurance.

The global PV system market has been expanding steadily during the last few years. As the cost of PV comes down due to the economy of scale effects and the development of new technologies, applications such as building integrated PV systems are becoming increasingly popular and cost-effective . In this article, design considerations that needed to be taken into account for laying photovoltaic solar panels and incorporating photovoltaic systems into the power system to reduce ship emissions of greenhouse gases are discussed. To successfully build and run the actual systemmust be provided for the integration of solar power systems ship modeling and simulation analysis.

2. EVOLUTION OF SOLAR SHIP

In 2006, the 14-meter “sun 21” catamaran, which was a Swiss-built solar vessel, became the first sun powered boat that sailed across the Atlantic. The solar energy captured by mounted PV panels was provided to power the boat's electric motors and the surplus energy was stored in batteries, allowing it to travel at a constant speed of 56 sea miles each day.

For instance, “Auriga Leader” (60,123 gross tons), which is a Japanese-built solar-power-assisted car carrier, installed 328 solar panels in 2008 which can generate electrical power up to 40 kW. This power could meet the power requirement of the ship lighting plant. However, it adopted off- grid mode which was not connected to the ship power system. So, the off-grid mode needs many batteries to store energy. Then, compare with grid-connected mode, the cost of inputs in off-grid mode was much higher.

Fig. 1. 14-meter "sun 21" catamaran

In 2014, China Ocean Shipping Group Company’s (COSCO) “tengfei”, which is the world’s largest solar hybrid PV power generation system, was developed by Wuhan University of Technology and COSCO. This ship is installed with 540 solar panels and the value of the design capacity is 143.1 kWp. But above all, it adopted the standalone mode and grid-connected mode. So it can not only directly supply energy for direct-current loads, but also connect with the ship power system (SPS) to provide energy for AC loads.

3. DESIGN SPECIFICATIONS FOR THE SHIPBOARD POWER SYSTEM

A Shipboard Power System (SPS) is an autonomous, small-scale electric network that powers a ship's propulsion system and other loads, as opposed to traditional terrestrial power networks. Compared to traditional terrestrial power networks, SPS is more vulnerable to unforeseen disturbances and physical damages because of the specialized roles and nature of warships' responsibilities. Additionally, due to the close physical and electrical proximity of a large number of electric and mechanical components in a constrained area and the lack of external support from a relatively stronger grid, SPS has several unique properties, such as limited generation capacities, a propensity for disturbances, and high stiffness for containing a wide range of dynamics of various origins. All of these traits demonstrate a potential to create interactions between SPS components, in contrast to the terrestrial power grid.

So, to improve the system's stability, survivability, security, and economics, many design elements and

system specifications must be taken into account at the same time. They must also be strictly maintained under all operating scenarios.

There are various design specifications for the shipboard power system which needed to be considered when designing an alternative energy source for the power system. They are:

1. Power output: The shipboard power system should be capable of producing a steady and reliable power output that is sufficient to support the operational needs of the vessel.

2. Efficiency: The system should be designed for high efficiency, with minimal energy losses during power generation, transmission, and distribution.

3. Redundancy: The power system should be designed with redundancy in mind, providing backup power in case of primary system failure.

4. Safety: The system should be designed to prevent electrocution and short circuits, and it should be tested and certified to all applicable safety standards.

5. Reliability: The system should be highly reliable, with minimal downtime and maintenance requirements, to avoid disruptions in shipboard operations.

6. Scalability: The power system should be designed to scale up or down depending on the size of the vessel and its operational needs.

7. Sustainability: The system should be designed to minimize its environmental impact, use renewable energy sources where feasible, and minimize waste and emissions.

8. Monitoring and control: The power system should be equipped with advanced monitoringand control tools, enabling operators to monitor power consumption, diagnose problems, and adjust operations as needed.

4. MOTIVATION FOR SOLAR ENERGY RECONSIDERATION

Solar energy is a plentiful, clean-burning, and cost-free resource. The two primary methods for utilizing solar energy are PV production [3] and solar thermal conversion. Methods for converting solar energy and their uses were researched by Mukrimin. According to its driving force and development trends, Nadarajah, outlined the outstanding research done in solar thermal and photovoltaic (PV) generation and reviewed how solar energy will be used in the future. As the conversion efficiency of PV cells has increased over the past few decades, so has the application of PV generation.

In recent years, several nations have made using clean energy and following the path of sustainable development part of their national plans due to the increased emphasis on energy saving and emissions reduction. On the other hand, the MARPOL Convention added the Energy Efficiency

Design Index (EEDI) and Ship Energy Efficiency Management Plan (SEEMP) in 2011. As a result, the situation for the shipping industry in terms of energy conservation and carbon reductionis getting worse. As a result, many maritime nations must take a keen interest in creating "Green Ships" that make use of cutting-edge energy sources including wind, solar, nuclear, biomass energy, fuel cells, etc.

In this sense, solar ships are among the green ships that are most promising and are developing quickly both domestically and internationally. A popular type of green ship is the solar ship, which incorporates a solar PV system into its propulsion system. Also, the fundamental idea behind the solar ship is to use PV power in the PSPS to reduce the standard Diesel Generator's (DG) fuel consumption and gas emissions. As a result, the DG is configured as a standby electric power unitduring navigation, and the gas emissions of this solar ship are fully avoided. This is true for some solar electric propulsion ships, where the load power needed can even be covered by the power source of the PV system alone.

There are several other reasons why reconsidering solar energy as an alternative to shipboard power systems. Here are some of the primary motivations:

1. Environmental concerns: Solar energy is a clean and renewable energy source, which makes it a great alternative that can reduce the carbon footprint of ships. The shipping industry is one of the biggest contributors to greenhouse gas emissions and air pollution, and the use of sustainable alternatives like solar energy can significantly reduce these emissions.

2. Cost savings: The use of traditional fuels for shipboard power systems can be very expensive. Solar energy, on the other hand, has become increasingly affordable as the technology matures and economies of scale are achieved. Additionally, the use of solar energy can reduce the need for costly refueling stops, which can save time and money.

3. Reliability: Solar energy systems have come a long way in terms of efficiency and reliability. Today, solar panels are very durable and can withstand harsh marine environments. Moreover, solar energy systems are relatively easy to maintain, requiring little to no maintenance, unlike traditional power generation systems.

4. Compliance with regulations: Many countries and international organizations are introducing regulations that mandate the use of clean energy sources. By adopting solar energy as an alternative power source, ships can easily comply with these regulations and avoid penalties and fines.

Overall, solar energy as an alternative source of power for ships can offer a range of benefits, including environmental sustainability, cost savings, high reliability, and regulatory compliance. These factors make it a potentially attractive

option for the shipping industry.

5. FEASIBILITY OF SOLAR ENERGY INTEGRATION TO POWER SYSTEMS

Solar energy integration to ship power systems is a feasible solution with significant benefits. However, several technical, economic, and regulatory aspects need to be considered before implementation.

Technical feasibility:

1. Space availability: Ships have limited space to install solar panels. However, the latest thin-film solar panels are not only efficient but also lightweight and can be installed on every available roof.

2. Weather conditions: The efficiency of solar panels is influenced by weather conditions. Therefore, the design of the solar power system must be considering various weather conditions.

3. Power requirement: Ships consume a large amount of energy, so the solar panel system should be powerful enough to meet the power demand.

Economic feasibility:

1. Initial investment: Solar panel installation requires a significant initial investment. However, the reduced dependency on fossil fuels and the cost savings over time can offsetthe initial cost.

2. Maintenance and operation costs: Solar panels require regular cleaning and maintenance, which adds up to the operational costs.

3. Fuel cost savings: The use of solar energy reduces reliance on fuel, which leads to substantial cost savings in the long term.

Regulatory feasibility:

1. Legal framework: The installation of solar panels on ships requires compliance with international and national standards and regulations.

2. Safety regulations: The system design, installation, and operation must comply with safety standards to ensure the safety of the crew and passengers.

In conclusion, the integration of solar energy into ship power systems is technically, economically,and regulatory feasible. It is a promising solution for the shipping industry to reduce greenhouse gas emissions and promote sustainable development.

6. STABILITY OF POWER SYSTEMS INTEGRATED WITH SOLAR ENERGY

The integration of solar energy into power systems has become increasingly popular due to the many environmental and economic benefits that come with renewable energy. However, the intermittent and unpredictable nature of solar energy can pose significant stability challenges for power grids.

When solar energy is integrated into the grid, it can cause fluctuations in voltage and frequency that affect the stability of the power system. These

fluctuations can lead to overloading and result in power outages if not managed properly.

To ensure the stability of power systems integrated with solar energy, grid operators must implement advanced monitoring and control technologies that can anticipate and respond to changes in solar output in real time. This requires the deployment of smart grid technologies, suchas advanced metering infrastructure, distribution automation, and energy storage systems.

Furthermore, proactive grid management strategies can help stabilize power systems and avoid disruptions caused by fluctuations in solar energy. These strategies may include load shedding anddemand response programs that reduce power consumption during peak solar output hours or temporarily disconnect certain loads from the grid.

Overall, while the integration of solar energy into power systems presents challenges, the use of advanced technologies and proactive management strategies can help ensure the stability and reliability of these systems.

7. DESIGN OF POWER SYSTEMS INTEGRATED WITH SOLAR ENERGY

The typical structure of a PV generation system is shown in Figure 2. PV maximum power point tracking (MPPT) controller is used to increase electricity yield. The PV electricity is distributed and transmitted to the public grid via distribution controllers. Moreover, the only way for PV electrical energy to be sent to public networks is through the DC-to-AC conversion. The two primary operating modes for the PV generation system are stand-alone and grid-connected. In some unique situations, these two operation modes can also be used together; this is known as thehybrid mode.

The design of power systems integrated with solar energy involves several steps and considerations:

1. Assessment of energy demand: The first step is to assess the energy demand of the system. This involves identifying the appliances and devices that will be powered by the system and estimating their power requirements.

2. Sizing of solar panels: Once the energy demand has been assessed, the next step is to determine the size of the solar panel array that will be required to meet the energy needs. This involves considering the location and orientation of the panels to ensure maximum efficiency.

3. System configuration: The system configuration will depend on the energy demands and the resources available. The system can be configured as a standalone system, grid-tied system, or hybrid system.

4. Battery storage: Battery storage is an essential component of a solar power system as it allows energy to be stored for use when the sun is not shining. The size and type of batterystorage will depend on the energy demand and system configuration.

5. Inverter selection: The inverter is responsible for converting the DC power generated by the solar panels into AC power that can be used by appliances. The inverter selection willdepend on the size of the solar panel array and the energy demand.

6. Electrical safety: Electrical safety is a critical consideration in the design of solar power systems. The design must comply with local electrical regulations and safety standards to ensure safe operation.

7. Maintenance: Maintenance is essential to ensure the efficient and reliable operation of the solar power system. The design must include provisions for periodic maintenance and inspection.

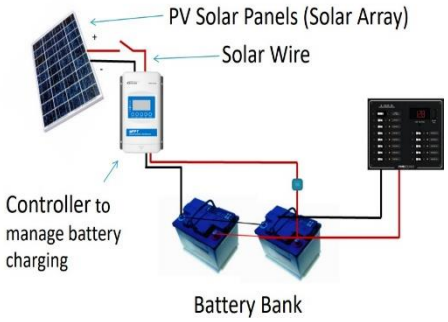


Fig 2. Typical structure of a PV generation system

Operation Mode of PV

The applications of solar energy on the ship can be divided into two patterns, which are main power energy and auxiliary energy. Using PV power as the main power energy means that the ship's main propulsion plant is mainly powered by a PV system, and a diesel generator is put intouse only in the special situation, for example, in rainy weather for a long time or PV system failurewhen PV power is applied as an auxiliary energy due to its own relatively low capacity, thereshould be more than two kinds of power sources set in the ship power system to balance the power supply and load demand. From the point of PV operation mode, this kind of solar ship canbe further divided into grid-connected mode and off-grid mode.

The operation mode of a PV (photovoltaic) system depends on the type of PV system and its application. As was already established, the two basic PV operation modes are off-grid and grid-connected. Each modality has benefits and drawbacks of its own. They can thus satisfy the various needs of SPS. The two types of modes can occasionally be used in the same PV power system to meet the unique needs of SPS. The hybrid off-grid/grid-connected mode is the name of this operating mode.

7.1. OFF-GRID MODE

In an off-grid PV system, PV panels charge a battery bank during daylight hours. The batteries are then used to power appliances and lights at night. The system also uses an inverter to convert the DC power to AC power. An off-grid system requires adequate battery capacity to store the energy produced by the PV panels, as well as a backup generator, which can be used if the battery bank gets depleted.

The PV power system's stand-alone mode is

analogous to the off-grid mode. Moreover, the stand- alone PV power system is made up of PV arrays, a DC/DC converter, an energy storage device, aDC load, a DC/AC inverter, and an AC load. The DC/DC converter is connected to the PV arrays (a solar controller). The purpose of the battery banks that make up the energy storage unit is to store the energy generated by PV arrays. The energy storage unit serves as both the DC loads' energy supply unit and the source of the proper input voltage for the DC/AC converter. AC loadsare connected to the DC/AC inverter's output. Off-grid mode is distinct because it isn't linked to SPS.

So, there is no need to think about any synchronization procedure issues. The advantage of a PV power system is that its design concept is straightforward. However, the energy storage device will have enough capacity if the electrical load runs continuously. Also, as battery capacity increases, the system's investment grows as well. The electrical loads are occasionally coupled with a diesel generator and a photovoltaic power system. However, the PV power system is not integrated with the SPS. Either an energy storage device or a diesel generator can supply the electrical loads in ships, depending on how well the PV power system is operating.

7.2. GRID-CONNECTED MODE

In a grid-connected PV system, the PV panels are connected to the utility grid via an inverter. During daylight hours, the PV panels produce electricity, and the excess power is fed back into the grid. If there is no sunlight, the system functions just like a conventional grid-tied system, drawing power in from the utility grid. Typically, net metering is used, where the utility company credits the homeowner for any excess electricity fed into the grid, which can be used later. The grid-connected PV power system comprises PV arrays, a DC/DC converter, and a DC/DC inverter. The DC/DC converter adjusts for the proper input voltage of the DC/AC inverter by using the Boost Converter and Buck Converter to achieve the maximum power point (MPP). Moreover, the output current of the DC/AC inverter shares the same voltage, frequency, and phase alignment as the SPS. So, in grid-connected mode, SPS is the only source of power for AC loads.

7.3. HYBRID OFF-GRID/GRID-CONNECTED MODE

In a hybrid PV system, the PV panels are connected to both the utility grid and battery bank. During daylight hours, the PV panels produce electricity and charge the batteries. The excess power is fed back into the grid. At night, the system switches to battery power, which can be used to power appliances and lights. A hybrid system requires both a battery bank and an inverter to convert the DC power to AC power.

Fig 3. Semi-Flexible Solar Panels

Fig 4. Flexible Solar Panels

The hybrid off-grid/grid-connected mode can operate both in off-grid and grid-connected modes. Energy storage unit input and a grid-connected inverter can be used to quickly switch the operation mode. The operation mode may be chosen in accordance with the requirements of electrical loads. A grid-connected inverter can be used to use the additional Solar power once the battery is fully charged. The hybrid system, therefore, has the maximum energy efficiency. Indisputably, the hybrid in Photovoltaic-ship power systems is frequently used (PSPS).

8. SOLAR PANELS

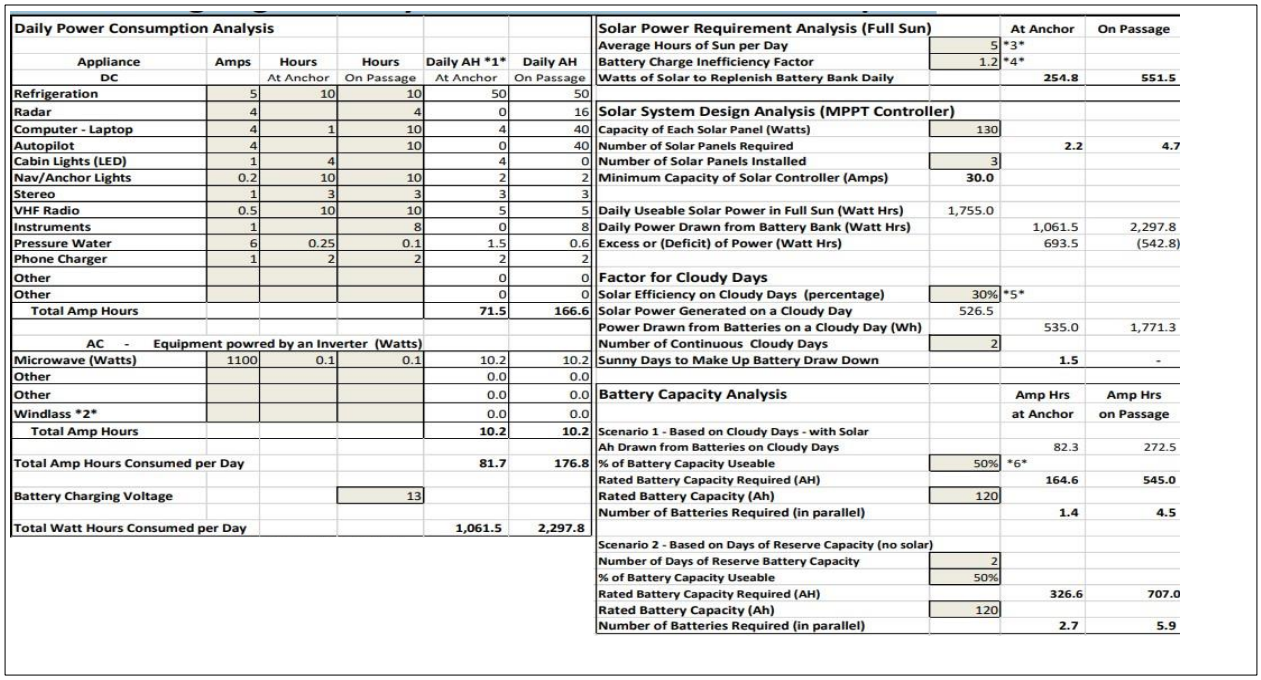
Higher-performance solar cells produce more power at sub-optimal sun angles than lower-performance solar cells. A lower-performance 100-watt panel will produce up to 500-watt hours in a day (considering an average of 5 hours of sun in a typical day). A higher-performance 100- watt panel will produce up to 650 watt hours in a day. There are various types of panel such as Rigid, Semi-rigid, or Semi-flexible. As the name suggests their malleability suits the application.

The marine solar panel is specialized for their operation by several characteristics such as the junction box being filled with inert silicone to prevent corrosion, rigid panels having strong frames and extra sealants, and panels having high output power performance – Grade A+ cells. Further, the output is compatible with 12 or 24-volt battery bank systems, and the panel is wired toaccommodate shading.

9. PROPOSED METHODOLOGY

1. Determine daily power consumption
2. Determine the solar generation capacity needed
3. Select solar panel(s) and controller
4. Determine the optimum size of your battery bank

The Spreadsheet below can be used for designing a Solar System Based on Power Consumption.



Daily Power Consumption Analysis

Appliance	Amps	Hours At Anchor	Hours On Passage	Daily AH *1* At Anchor	Daily AH On Passage
DC					
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				71.5	166.6
AC - Equipment powred by an Inverter (Watts)					
Microwave (Watts)	1100	0.1	0.1	10.2	10.2
Other				0.0	0.0
Other				0.0	0.0
Windlass *2*				0.0	0.0
Total Amp Hours				10.2	10.2
Total Amp Hours Consumed per Day				81.7	176.8
Battery Charging Voltage			13		
Total Watt Hours Consumed per Day				1,061.5	2,297.8

Solar Power Requirement Analysis (Full Sun)

			At Anchor	On Passage
Average Hours of Sun per Day	5	*3*		
Battery Charge Inefficiency Factor	1.2	*4*		
Watts of Solar to Replenish Battery Bank Daily			254.8	551.5
Solar System Design Analysis (MPPT Controller)				
Capacity of Each Solar Panel (Watts)	130			
Number of Solar Panels Required			2.2	4.7
Number of Solar Panels Installed	3			
Minimum Capacity of Solar Controller (Amps)	30.0			
Daily Useable Solar Power in Full Sun (Watt Hrs)	1,755.0			
Daily Power Drawn from Battery Bank (Watt Hrs)			1,061.5	2,297.8
Excess or (Deficit) of Power (Watt Hrs)			693.5	(542.8)
Factor for Cloudy Days				
Solar Efficiency on Cloudy Days (percentage)	30%	*5*		
Solar Power Generated on a Cloudy Day	526.5			
Power Drawn from Batteries on a Cloudy Day (Wh)			535.0	1,771.3
Number of Continuous Cloudy Days	2			
Sunny Days to Make Up Battery Draw Down			1.5	-

Battery Capacity Analysis

			Amp Hrs at Anchor	Amp Hrs on Passage
Scenario 1 - Based on Cloudy Days - with Solar				
Ah Drawn from Batteries on Cloudy Days			82.3	272.5
% of Battery Capacity Useable	50%	*6*		
Rated Battery Capacity Required (AH)			164.6	545.0
Rated Battery Capacity (Ah)	120			
Number of Batteries Required (in parallel)			1.4	4.5
Scenario 2 - Based on Days of Reserve Capacity (no solar)				
Number of Days of Reserve Battery Capacity	2			
% of Battery Capacity Useable	50%			
Rated Battery Capacity Required (AH)			326.6	707.0
Rated Battery Capacity (Ah)	120			
Number of Batteries Required (in parallel)			2.7	5.9

Fig 5. Spreadsheet for designing a Solar System

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"The world awaits
a generation.
A generation that
will embed knowledge
and thoughts to its will.
A generation that
will perform great things
for the benefit of
humankind. You are
that generation.
Your focus will one
day determine
your reality.Your mind
has the agility
of an acrobat. In it, lies
the strength to
perform incredible feast.
Nurture your
mind with knowledge.
Train it with
diverse skills. Place it
at the core of your
existence"

Directorate of Electrical & Electronic Engineering
Sri Lanka Navy