Energy Strategy for the Indian Navy: Need, Scope and a Roadmap

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Abstract: ‘Energy’ is a key enabler of military combat power and it should be considered a strategic resource for the Indian Navy (IN). This article justifies the necessity of ensuring energy security for the IN in the backdrop of emerging energy challenges. It also discusses certain recent developments that point to the growing relevance of an energy policy for the IN. The article then discusses the contours and the scope of an integrated energy policy and proposes a roadmap for implementing an energy strategy for the IN. The article concludes that a well-executed energy strategy will ensure a sustainable and energy-secure future for the IN in the coming decades.

Introduction

Energy’ security is gaining significant attention and is becoming increasingly relevant in today’s changing world scenario. ‘Energy security’ can be defined as ‘the availability of energy at all times in various forms, in sufficient quantities at affordable prices, without unacceptable or irreversible impact on the environment’. The issue of energy security is equally relevant for the nation as a whole and can be applied to all its smaller entities—geographic/political (regions, states, districts, villages, households) or specific organisations such as railways, defence services and large-scale commercial industries. India as a nation and the Indian Navy (IN) as a part of the Indian defence forces therefore face similar challenges on energy security.

The increasing use of and dependence on conventional energy sources has led to a sharp increase in the demand for electricity and fossil fuels across the globe. On the other hand, the world seems to be running out of cheap sources of energy and the steep increase in the price of energy is hindering the development of energy-dependent countries like India. Added to this are the environmental concerns and growing world pressure on reaching an international consensus for curbing greenhouse gas (GHG) emissions. It is also evident that the uncertainty of energy supplies will only grow in the near future due to the complex dynamics of demand and supply which adds to the volatility of oil prices in world energy markets. Coupled with this is the long lead time and large investments required for energy exploration, drilling, extraction and for developing infrastructure for transportation of oil and natural gas. Past trends reveal that energy insecurity is growing in India and the gap between demand and supply of energy is steadily increasing despite the addition of new energy infrastructure. Literature on energy security thereby concludes that there is no immediate solution...
diversify our fuel mix, develop alternate technologies for harnessing renewable sources of energy and undertake a conscious shift in energy policy to reduce our dependence on fossil fuels.

As with other arms of the defence forces, the IN is a large consumer of fossil fuels, which has resulted in an ever increasing energy bill. Apart from the high energy costs, the liberal use of energy (directly, by burning of fuel in ships and indirectly, by use of electricity) has led to huge GHG emissions and pollution at sea, causing irreversible environmental damage. But the strategically most significant effect of this excessive dependence on oil is the lack of suitable energy alternatives for the IN in the immediate future. Coupled with this is the long lead time necessary for the introduction and adoption of new technologies, which makes the problem of energy insecurity an extremely challenging and urgent one for the IN.

**Aim**

This article has the following main objectives in the context of the IN:

(a) To highlight the need for energy security.
(b) To list the potential benefits and relevant developments in this area.
(c) To outline the broad contours and the scope of an integrated ‘energy policy’.
(d) To suggest a roadmap for implementing an ‘energy strategy’.

**Overview**

The importance of considering energy as a strategic resource and the relevance of energy security for the IN is established in the next section. The article then goes on to briefly highlight the potential benefits and the recent developments which point to the growing need for an energy strategy for the IN. The contours and scope of an integrated energy policy, with ‘tactical’ and ‘shore’ energy strategy as its components, form the next section of the article. In the penultimate section, the article proposes a roadmap for implementing an energy strategy for the IN and presents the methodology for accomplishing the first step in the roadmap. Lastly, the article sums up the efforts of the US navy towards energy security before reaching a conclusion that a well-formulated energy strategy will ensure a sustainable and energy-secure future for the IN in the coming decades.

**Need for energy security for the IN**

One of the important roles of the Indian navy, as outlined in India’s maritime military strategy, is to provide ‘security of energy’ by safeguarding the energy assets (imported and indigenous) in the littoral waters, energy sea lines of communication (SLOC) and energy storage and distribution networks. Therefore the IN has a vital role in ensuring the availability of energy for India, in times of peace or war. Although energy security is determined from the perspective of a country, the concept can be extended to any entity which uses a significant amount of energy and is critically dependent on various forms of energy for its operations. Hence the concept of energy security is equally relevant for the IN. Energy security is also becoming increasingly important for the IN for the following reasons.
'Energy’ is a key enabler of military combat power. However, it has traditionally been treated as a commodity that will always be readily available, regardless of the strategic, operational and tactical costs. Hence, no attention is paid to the cost associated with it. However, it is not likely to remain so in the near future. Currently, the IN is 100 per cent dependent on refined petroleum products for its tactical platforms\(^5\) and is therefore extremely vulnerable to disruptions in oil supply (India’s oil imports are projected to rise to 92 per cent by 2031). It also faces financial uncertainty on account of revenue outflow due to high volatility in international crude oil prices. Furthermore, the entire Command, Control, Computers, Communications, Intelligence, Surveillance and Reconnaissance (C4ISR) structure and infrastructure in the repair yards is totally dependent on the civilian electricity grid and is therefore susceptible to attacks, natural disasters and malfunction. Hence, it is crucial that the risks associated with energy supply disruption should be mitigated by effectively managing supply and demand of energy (akin to other combat enablers like logistic supplies).

**(b) Complete dependence on government-owned utilities**

The IN is completely dependent on public sector and state-owned companies for supply of oil and electricity respectively. Therefore, the emerging energy insecurity for India directly translates into energy insecurity for the IN. This complete energy dependence on sources which are beyond the control of the IN and the lack of any fall-back options in case of supply chain disruptions (particularly oil) may have serious consequences for the IN in a warlike situation.

**(c) Threats due to lack of diversification of fuel mix**

Today, all strategic platforms of the IN use oil as their primary source of energy. As there is no diversification of fuel mix for the IN (except for nuclear submarines), and in the absence of any planned additions of alternate energy-based platforms, the IN will have to restrict the usage of its entire fleet in case of an energy crisis. This scenario is a threat to the operational efficiency of the IN and makes it vulnerable to external supply side shocks. It is therefore imperative that the IN adopts new emerging technologies which can use alternative fuels (such as natural gas, synthetic fuels and biofuels) in order to diversify the primary energy sources for its tactical platforms.

**(d) Emissions at sea**

Emissions by ships at sea and the environmental impact of sea pollution are also receiving significant attention. International shipping, which uses heavy (bunker) fuels currently accounts for 3.3 per cent of the total global CO\(_2\) emissions.\(^6\) Concerned by the unregulated rise of seaborne CO\(_2\) emissions, efforts are being made to put in place legally binding treaties for international shipping. It is therefore only a matter of time before laws for limiting carbon emissions for the shipping industry will be equally applicable for the IN.
resilient to the flow and cost of energy, which is clearly becoming more uncertain. Adopting a well-defined energy policy with a clear focus and objectives could therefore emerge as a possible long-term solution for the IN to achieve energy security.

**Potential benefits of adopting an energy policy** and **an energy strategy**

The end goal of an energy policy for the IN would be to reduce the consumption of energy and to seek alternative sources of energy without compromising on its operational efficiency. This can be undertaken by focusing on the three pillars of energy security: energy efficiency, energy conservation and renewable energy generation. A clear-cut energy strategy then needs to be outlined in line with the adopted energy policy. The potential benefits of adopting the same are mentioned below.

**(a) Cost saving**

It is evident that an important consideration in deploying a fleet is the cost of operations, of which fuel accounts for the major share of the total expenses. If the IN can control its consumption of fuel, it will lower the outflow of annual energy costs, thereby freeing up capital for other productive purposes. From a purely commercial aspect, the return on investment in energy-efficient technologies is high, which translates into a shorter payback period and makes the investment commercially attractive.

**(b) Increasing strategic reach of tactical platforms and avoidance of refuelling**

Energy-efficient technology on board ships will result in lowering of on-board fuel consumption. This will translate into increased strategic reach of the platforms (for the same quantity of fuel) and will reduce the frequency of refuelling during long sorties. This will effectively result in the higher availability of the platform and longer-range strategic missions.

**(c) Increased operational efficiency**

Efficient use of energy by adopting technological changes and better energy management practices will lead to greater efficiency in usage of energy. This will result in increased operational efficiency and will improve the combat and operational effectiveness of various sea-going and shore-based units.

**(d) Robust and resilient solutions**

The proposal for an energy policy for the IN is driven by the key concern of adapting to future energy challenges and developing robust solutions in the face of growing uncertainty and rapid transformation in the energy sector. Hence, having adequate energy alternatives and ensuring availability of well-diversified energy sources would lead to higher resilience for the IN.

**(e) Environmental stewardship**

Apart from the mandatory regulatory requirements on control of emissions, the ‘greening’ of ships and naval bases is an area where the IN can demonstrate
scenario gives the IN an unparalleled opportunity to position itself as a role model for other arms of the defence forces such as the army and the air force and also as a leader amongst other navies of the world.

(f) Preparing for the future
An early starter essentially has an advantage over other competitors. It is evident that energy resources will become scarcer in the future, which will force the IN to adopt various measures for prudent and efficient use of energy in the long term. The correct strategy would therefore be to prepare to undertake a voluntary and smooth transition in a planned way rather than implementing drastic measures at a later date which are likely to affect the operational efficiency of the IN.

Recent developments
Recent developments to meet the forthcoming energy challenges are highlighted below.

(a) Shift in India’s energy policy to a low carbon strategy
Changes in India’s energy policy and the shift towards a low carbon strategy in the forthcoming 12th Five Year Plan indicate a significant shift in India’s stance to efficiently use its energy resources. The introduction of the ‘Electricity Act’ in 2003 has made ‘energy audits’ mandatory for designated industries which are major consumers of energy (including ports). It can be safely said that it is just a matter of time before the armed forces are directed by the defence ministry to synergise with India’s energy policy and become accountable for the energy they consume.

(b) Growing international consensus for limiting seaborne emissions
The International Maritime Organisation (IMO)—the governing body of international shipping—is currently leading the drive to curb CO2 emissions by international shipping. The seventeenth session of the Conference of the Parties (COP 17) discussed a proposal to tax carbon emissions by international shipping at the rate of $25/ton CO2. While the proposal was not adopted at the meeting, COP 17 has invited the IMO to future conferences and encouraged them to seek other ways to reduce GHG emissions. Subsequently, various Market Based Mechanisms (MBMs) including emissions trading, emission-related charges and taxes and emissions offsetting were considered in UNFCCC COP 18 held in Doha, Qatar in Dec 2012 and the forum committed to continue the discussion of all possible market-mechanisms in May 2013. Meanwhile, the MEPC continued its intensive consideration of GHG MBMs and debated on the impact of nine of the current proposals for international shipping, including an impact assessment on the effects of MBM, establishment of the method and criteria for assessment in MEPC 63. Although they did not reach a consensus on a suitable analysis method, the proposals were further discussed in MEPC 64 which was held at IMO headquarters in London from 01 Oct –05 Oct 2012.
The Marine Pollution (MARPOL) 73/78\textsuperscript{19} convention was aimed at minimising pollution from ships at sea, including waste dumping, oil and exhaust pollution. Annexure VI of this convention deals with prevention of air pollution from ships and was enforced on 19 May 2005. This annexure covers emissions of ozone depleting substances (ODS), nitrogen oxides (NOx), sulphur oxides (SOx), particulate matter (PM), volatile organic compounds (VOC) and so on, and sets limits for emissions\textsuperscript{20} for prevention of air pollution by ships as well as the percentage of sulphur which is permissible to be used as fuel on board ships. An important development in this area is the introduction of energy efficiency measures on board all merchant ships by an agreement signed on 15 July 2011. These measures comprise the Energy Efficiency Design Index (EEDI) (which is applicable to new ships) and the Ship Energy Efficiency Management Plan (SEEMP) (which is applicable to all ships), which are now mandatory. These are further elaborated below.

(i) Energy Efficiency Design Index (EEDI)

The EEDI is a non-prescriptive, performance-based mechanism that specifies an energy efficiency baseline which is to be achieved while leaving the choice of technologies to the ship designers and builders. The EEDI standards are expressed as per cent emission reductions from reference baselines established for each class of ship. As long as the specified baseline is attained, ship designers are free to use the most cost-efficient solutions to enable the ship to comply with the regulations. The EEDI proposes a minimum energy efficiency level (measured in CO\textsubscript{2} emissions per ton capacity mile)\textsuperscript{21} for different ship type and size segments. Phase 0, beginning in 2013, calls for new ships to attain EEDI values at or better than the applicable reference line while Phase 1 will require ships built between 2015 and 2019 to improve their efficiency by 10 per cent. This will be raised to 20 per cent between 2020 and 2024 in Phase 2, and to 30 per cent for ships delivered after 2024 in Phase 3. It is therefore expected that the EEDI will continuously improve the energy efficiency of a ship, thereby reducing oil consumption and achieving lower CO\textsubscript{2} emissions.\textsuperscript{22} When this programme is fully phased in, new ships are expected to be 30 per cent more efficient than today.

(ii) Ship Energy Efficiency Management Plan (SEEMP)

The SEEMP establishes a mechanism for measuring the operational energy efficiency of the ship, setting targets and monitoring the performance against the set targets over time. The IMO has suggested using an Energy Efficiency Operational Indicator (EEOI) as a monitoring and/or benchmark tool. However, the EEOI itself is not mandatory and operators can choose other key performance indicators which may be more suitable to their ships and operation. Hence the SEEMP urges the ship owner and operator at each stage of the operation of the ship to review and consider operational practices and technology upgrades in order to optimise the energy efficiency performance of a ship.

Both these measures are designed for improving efficiency and reducing GHG emissions from ships and these have come into force from 01 Jan 2013. India is also a signatory of the treaty and various measures are now being incorporated in newly constructed merchant ships to make them MARPOL compliant. It is therefore imperative that the above developments should be noted and may be integrated in ship design for future ships being built for the IN.
Efficient use of energy has already struck a chord in the higher echelons of the defence ministry. An integrated committee has been formed under the Integrated Defence Staff (IDS) with representation from various defence services including the navy, the air force and the army with an aim of overcoming energy challenges facing the defence services. This is an important beginning which reflects the growing energy concern in policy-making circles. As a fallout of this development, the Ministry of Defence (Navy) has directed the Eastern and Western Naval Commands to undertake an ‘energy audit’ of the naval dockyards (ND) in Visakhapatnam and Mumbai. These audits were offloaded and conducted by an external agency in 2010. In addition, in order to reduce energy consumption, the Military Engineering Services (MES) have also started using Compact Fluorescent Lamps (CFLs), solar geysers, solar street lighting and other technologies in its new installations.

Contours and scope of an integrated energy policy

In view of the emerging need to ensure energy security for the IN, the potential benefits of an energy strategy and, in the light of recent developments, adopting an integrated energy policy for the IN will be a step towards achieving energy security. Some of the related key aspects are described below.

(a) Need for a policy backing

Taking a ‘systems approach’ to energy issues and addressing them holistically is essential for any organisation because of the inherent interdependencies in the energy chain. A bird’s eye view reveals that various energy-related issues such as energy management, energy planning, energy use, energy efficiency in ship design, energy-efficient technology, alternative energy platforms and emissions from energy use would self-organise to solve the jigsaw puzzle once the IN accepts that energy is a strategic resource and adopts an energy policy. A systems approach would therefore be to adopt a well-conceived, comprehensive, long-term and sustainable energy policy with a clear focus and objectives which will address the operational and strategic goals of the IN over the next few decades. As the IN is a large organisation with geographically and operationally independent entities, various aspects of energy can be addressed in an integrated manner if the IN adopts an energy policy which is soundly backed by the existing legal framework. A suggested energy policy for the IN is given in Appendix 1.

(b) Defining an energy strategy

In order to achieve the goals as defined by the energy policy, the IN would need to follow an energy strategy which is integrated with India’s maritime strategy. It is also important that the strategy for tactical platforms and shore establishments should be separate in view of the vastly differing roles, theatre of operations and accompanying limitations. The adopted energy strategy thereafter has to be backed by specific plans, which have to be implemented across various establishments and operational units. This will lead to a secure, reliable and sustainable energy future for the IN.
There are two distinct aspects of a well-designed naval energy strategy.

(i) Tactical energy security

Tactical energy security is protection from vulnerabilities related to the energy requirements of tactical platforms by reducing risk associated with a logistics tail, volatile petroleum prices and the instability of unfriendly petroleum suppliers. Tactical energy security can be increased by decreasing overall fuel consumption, increasing the fuel efficiency of tactical platforms and by using alternative fuels. Apart from technical solutions such as installing energy-efficient equipment, monitoring of energy consumption, better resource management practices and changes in operating procedures and exploitation policy can also reduce on-board fuel consumption. Lastly, sensitisation of personnel and treating energy as a strategic resource can also play a critical role in reducing energy consumption on board ships, submarines and aircraft. A long-term approach could be to develop new technologies for naval applications, in collaboration with other countries and research groups.

(ii) Shore energy security

Shore energy security is protection from vulnerabilities related to the commercial electrical grid, which is susceptible to physical and cyber attack, natural disaster and malfunction. In addition, it would curb a rise in revenue outflow for meeting the energy requirements of shore establishments. This includes expenses incurred on account of petrol/diesel consumption for transport, and use of electricity in offices, residential areas and workshops. It is well established that demand side management (DSM) of energy is the fastest and most cost effective, efficient, easy and reliable means of reducing energy consumption today. DSM can be effectively accomplished by adopting strategies such as energy conservation and energy efficiency. Energy consumption in shore establishments can be lowered relatively easily as such solutions are commercially available and have already been implemented in various organisations. Some of the ways to lower energy consumption on shore include: adoption of networked energy management technologies; sustainable infrastructure such as green buildings; converting to alternative fuel (CNG) vehicles; and generating renewable energy in order to make IN establishments net zero energy consumers. There is also a need to increase the reliability of the electricity supply and to ensure alternative supplies for critical assets in shore establishments.

A roadmap for implementing an energy strategy in the IN

In order to address various issues in a comprehensive, logical and effective manner, a roadmap for implementing an energy strategy for the IN is suggested below:

(a) Undertaking an assessment of the need for an energy policy.
(b) Developing awareness on energy issues.
(c) Formulating an energy policy and outlining an energy strategy.
(d) Setting targets and financial outlays to achieve set goals.
(e) Creating an organisational structure with assigned responsibilities.
(f) Undertaking training and capacity building at various levels.
requirement is the first vital step for undertaking an assessment of the possible energy and financial risks to which the IN may be exposed in the near future. A brief methodology for assessing the same is presented in Appendix 2.

**International experience: the case of the US navy**

There are certain cues that can be taken from the US navy (arguably the largest and most forward-looking navy in the world) to highlight the forthcoming challenges and the possible solutions that may be considered by the developing navies of the world. The US Department of the Navy (DON) has realised that energy security is critical for its success and they have taken a leadership role in energy reforms by adopting a well-defined energy strategy. The DON in its recently released *Operational Energy Strategy*\(^2\) has set aggressive goals to reduce the amount of energy needed for military operations, expand the portfolio of available energy options (from fossil fuels to renewable technologies) and ensure their timely delivery via a reliable electricity grid. In line with this strategy, the US navy has set a goal to deploy the 21st-century ‘great green fleet’ by 2016.\(^2\) At the end of 2005, renewable energy accounted for 8.3 per cent of all electricity used by US military installations\(^2\) and the US navy has set a target of increasing it to 25 per cent by 2025. To meet these goals, an organisational structure with clear responsibilities and earmarked funding has been put in place. Apart from this, the DON has an energy programme which ensures energy-efficient acquisition, energy management (governance, planning, programming, budgeting) and technology development, implements behavioural changes (training, awards and incentives) and forges strategic partnerships with industry and research organisations.\(^3\) It is evident that the US navy is comprehensively planning to overcome energy-related challenges and is aggressively implementing various steps to meet this objective.\(^3\) The multi-faceted approach adopted by the US navy to move towards ensuring energy security is noteworthy and is worth emulating by all growing navies of the world.

**Conclusion**

Energy is a key enabler of military combat power and it should be considered a strategic resource in the Indian navy. The volatility and rising cost of energy, the emerging insecurity due to risks associated with energy supply disruption and the lack of energy alternatives for tactical platforms in case of an oil crunch may leave the IN in a vulnerable position in times of war. The IN therefore stands at the crossroads of a new era where it can choose to adapt to the changing energy and climate scenario by adopting an energy strategy of fuel diversification, increasing renewable energy generation, energy conservation and increased energy efficiency. Additional benefits of this approach will be savings on fuel costs, increasing the strategic reach of tactical platforms and controlling emissions at sea, thereby demonstrating environmental leadership of the nation.

This can be achieved by formulating an energy strategy for tactical platforms and a separate shore energy strategy for bases. Adopting standards like the EEDI and the SEEMP on naval ships will reduce energy consumption on ships without compromising their operational efficiency. Similar technological solutions can be adopted by naval bases to reduce their dependence on fossil fuels. However, this can only be accomplished by developing awareness regarding energy issues and outlining an energy strategy to achieve the end goals as defined in the energy policy. In order to
ing of funds to achieve set goals, create an organisational structure with assigned responsibilities and undertake training and capacity building at various levels.

It is clear that decisions made today will have a huge impact on developing resilience for meeting future energy challenges. A well-defined energy policy could therefore emerge as a long-term solution to ensure a sustainable and energy-secure future for the Indian navy over the coming decades.

Notes
2. Conventional energy sources are ‘traditional’ energy sources which consist primarily of fossil fuels such as coal, oil, biomass, nuclear etc., while non-conventional energy sources are relatively new forms of energy conversion which include solar, wind, geothermal, tidal, biofuels, biogas etc.
3. Different from ‘energy security’
5. Tactical platforms include ships, naval aircraft and submarines.
7. A policy is a guide to thinking and action which is adopted by an organisation in an effort to promote the best practices to achieve the desired results.
8. Strategy is the methodology that is adopted in an effort to successfully achieve an overall goal or objective and is typically used to accomplish a target as prescribed by a policy. A strategy deals with the allocation and deployment of physical and human resources so as to achieve the desired goals in the face of various emerging situations.
9. In 2010, the US Department of Defense (DoD) spent $15 billion on fuel, 75 per cent of which was for military operations.
10. The cost saving achieved by Mumbai dockyard in 2004–2005 was approximately Rs 86 lac which was 4.2 per cent of the total electricity bill of Rs 20 crore. By a conservative estimate, implementation of demand side management in various dockyards and establishments has the potential to save 10–15 per cent of the total electrical energy cost.
12. ‘Defence’ is currently exempted under this act.
13. COP 17 took place from 28 November to 9 December 2011 in Durban, South Africa.
15. This tax would raise $26 billion a year, which would contribute to the United Nations Framework Convention on Climate Change (UNFCCC) ‘Green Climate Fund’.
19. The International Convention for the Prevention of Pollution from Ships (1973) was modified by the Protocol of 1978 and is therefore commonly known by the acronym MARPOL 73/78. It entered into force on 2 October 1983.
20. Mostly from engines used for main propulsion and power generation.
21. Transport work is calculated as a function of the cargo capacity of the ship and the design ship speed.
multiplied by a fuel carbon factor.


25. The IN may look into developing fuel cells and renewable energy-based marine applications including using natural gas and blended (biofuel) fuels as the source of main propulsion in naval ships.


28. The intermediate target is to demonstrate a ‘green strike group’ in local operations by 2012.


31. More information about the US navy’s stand on energy, the environment and climate change can be found at http://greenfleet.dodlive.mil/energy/acquisition/.

**Appendix 1. Suggested energy policy for the IN**

The Indian navy is committed to reduce energy consumption across all its units by adopting an energy management programme with the active participation of all personnel. It will strive to make continuous improvements in energy efficiency, energy conservation and harnessing renewable energy resources without compromising on the operational efficiency of the organisation.

**Appendix 2. Methodology for assessing and forecasting energy usage in the IN**

The methodology for assessing the present energy usage and future energy consumption of the IN is proposed below.

(a) **Energy modelling**

An exercise in energy modelling has to be undertaken, to establish the flow and pattern of usage of energy in the IN, by developing a reference energy system (RES). The block diagram of such an RES is presented in Figure 1.

![Block diagram of a Reference Energy System (RES) for the IN.](image-url)
istrative units such as naval bases and residential areas; industrial units such as naval dockyards; and other support units whose energy costs are budgeted under the financial heads of the Indian navy. The input to the system consists of fossil fuel and electricity which are impacted by the rising cost of energy and exogenous supply constraints. The output of the system can be the total time spent by the operational units at sea. This is the objective function that needs to be optimised in view of the limited supplies of energy and the budgetary constraints of the annual naval allocation for energy. This model can be further built up (as per user requirement) to vary input energy costs and to account for GHG emissions from use of primary and secondary energy sources.

(b) Quantifying the use of energy and data collection
After the model is validated, the next step is to collect energy consumption data from various units. Ideally a time series of at least 10 years should be available for establishing a trend in energy consumption. These data should be readily available from individual units in terms of expenses and invoices of fuel and electricity consumption. Along with this, the activity logs of various operational units in terms of time spent at sea and harbour should be made available for correlation with energy usage.

(c) Establishing trends in consumption of energy
An econometric analysis based on selected input and output variables will then reveal the relationship between the variables and the trends in energy consumption. It is recommended that a separate analysis be undertaken for operational units and establishments as they have different characteristics and patterns of energy consumption. Further detailed analyses can be carried out by clubbing similar units such as repair organisations and training establishments into one sub-group, which will ensure the homogeneity of units and lead to more accurate results.

(d) Forecasting of energy demand and energy costs
Once the coefficients between dependent and independent variables are obtained from the above econometric analysis, we can generate forecasts of future energy requirements, energy costs, financial implications and cumulative emissions by changing the input variables according to the envisaged growth of the IN.

(e) Scenario analysis based on simulations
In order to assess the impact of the volatility of oil prices, future escalation in the cost of energy and restricted availability of oil, various scenarios can be envisaged and simulation runs can be undertaken. The results of the simulations will lead to a clear assessment of the financial implications and cost overruns, operational limitations and other related impacts in case of energy supply chain disruption. The results of the model runs can then be analysed and a qualitative assessment can be made to facilitate the formulation of an energy strategy for the IN.

Notes
1. Major Head 2077: Defence services (Navy); Minor Head 110: Stores; Oil and Fuel (FFO): LP (640/01), Central Purchase (640/02); Minor Head 111: Works (Maintenance and operation of installations) (658), electricity and gas tariff bills (658/03).
2. The weights on the units are to be arrived at by attaching strategic and operational importance to the availability of the units.