



**Topic : Energy Auditing Of Ship**

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**By: Apurv Rao, Tejas Paranjape, Karan Rathod**

**MANET, Pune**

**1. Introduction**

The continuous rise of the prices of petroleum in the last years, has increased the fuel bill on operating costs and it has forced many shipbuilders to reconsider the ship operation because units that were formerly profitable are not so any more. Fuel accounts for about 35% to 65% of a ship's total operational costs, while its consumption leads to exhaust emissions that can contribute to poor air quality and climate change. Therefore, finding ways to reduce the impact of fuel use, by reducing consumption or using alternative technologies, is a high priority. Ship Energy Audit can help to reduce fuel consumption and improve ship's energy efficiency.

**2. Energy Audit**

As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption". Energy audit is a holistic and systematic assessment of ship. This targets the areas where energy can be saved while identifying corresponding corrective actions. Since an audit can result in reduced exhaust emissions, it helps increase the sustainability of operations and supports in complying with environmental best practice. A ship's performance is normally only partially tested and verified during commissioning trials. However, under normal operation, overall ship performance is influenced by a number of technical and non-technical factors.

Technical factors include:

- The condition of the hull and main machinery
- Sea and ambient conditions and
- Ship and machinery control settings.

Non-technical aspects relate to how the ship is utilised and operationally managed.

The energy audit examines all of these to identify areas of inefficiency and to propose technically feasible and cost-effective corrective actions.

The energy audit is carried out through a combination of data analysis, review of operational processes, and a shipboard audit.

The outcome of the shipboard audit is a specific list of energy efficiency actions or objectives. Each of these objectives is then analyzed, from both a technical and an economical point of view, in order to demonstrate which ones are feasible.

The ultimate result:

- a detailed and tailored action plan to help you reduce fuel consumption
- cut emissions and increase efficiency while complying with the constraints.

Depending on the ship, companies can save up to 40% of their fuel costs by slowing down from 24 knots to 20 knots. But that is just the start. Hundreds of other smaller [innovations](#) can save additional fuel ranging from new designs of ship hulls, to engines and propellers.

Use of **Alternative Energy Resources** seems to be important for the sake of energy as well as environment which is also an outcome of energy auditing of a ship. Hyundai Heavy Industries, Daewoo Shipbuilding and Marine Engineering have created new energy-efficient "**thrust fins**" (Fig 1) which are mounted to the ship's rudder. They reduce water turbulence from the propellers and convert it into extra thrust, reducing fuel use up to 6%.



**Figure Thrust fins**

A conventional VLCC uses ballast water for two different parts of its operation. In unloaded transit condition, the ballast is needed to obtain both a fully submerged propeller and enough forward drift to avoid bottom slamming. During cargo operations ballast water is used to reduce bending moments and compensate for trim and heel. The tankers ballast operations give rise to two main effects.

(i) Ballast water contains organisms that may cause damage when released to foreign eco-system.

(ii) Additional fuel is needed to transport the ballast water.

For this, **DNV's TRIALITY** innovation project have introduced

(i) inert gas system(IGS)

(ii) Crude Oil washing(COW)

(iii) Segregated Ballast Tanks(SBT)

(iv) Double Hulls

(v) Common structural Rules(CSR)

Which have enabled fulfil

(i) It is environmentally superior to conventional VLCCs

(ii) Has technically feasible solutions

(iii) Is more economical than conventional VLCCs

### ***2.1 Objectives of Energy Auditing***

The shipboard audit has three main objectives

- To assess the status of the ship and its major machinery
- To assess the ship's operational management processes

- To validate the quality of measured data so as to:
  - Reducing rationally the fuel cost
  - Reducing rationally atmospheric emission
- To reduce ship emissions to give the maritime industry a timely opportunity to improve its green credentials.
- The overall increase in capital and running costs for the shipping industry would be between 3 to 14 %.
- Only a small part of the energy embarked is effectively used for propulsion and power;
- Most of the energy consumers are not energy efficient as they should
- Equipments are often operated out of their optimum efficiency
- Some equipments are not adequate to the service condition required
- Systems often work out of their optimal range, leading to poor performance
- Most ships are presently experiencing a number of failures on theirs electronic control and navigational systems

Energy Audit incorporates a wide range of technical assessments, including:

- Ship performance (hull)
- Main engine performance
- Auxiliary engine performance
- Auxiliary loads balance
- Fuel quality and fuel supply systems
- Management of ship operations
- Lighting system
- Rotating machinery
- Boiler and steam system
- Equipment retrofit
- Personnel training.

## ***2.2 Type of Energy Audit***

The type of Energy Audit to be performed depends on:

- Function and type of industry
- Depth to which final audit is needed, and
- Potential and magnitude of cost reduction desired

Thus Energy Audit can be classified into the following two types.

- i) Preliminary Audit
- ii) Detailed Audit

### 2.2.1 Preliminary Energy Audit Methodology

Preliminary energy audit is a relatively quick exercise to:

- Establish energy consumption in the organization
- Estimate the scope for saving

- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

### 2.2.2 Detailed Energy Audit Methodology

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.

This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost. In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

Detailed energy auditing is carried out in three phases: Phase I, II and III.

Phase I - Pre Audit Phase

Phase II - Audit Phase

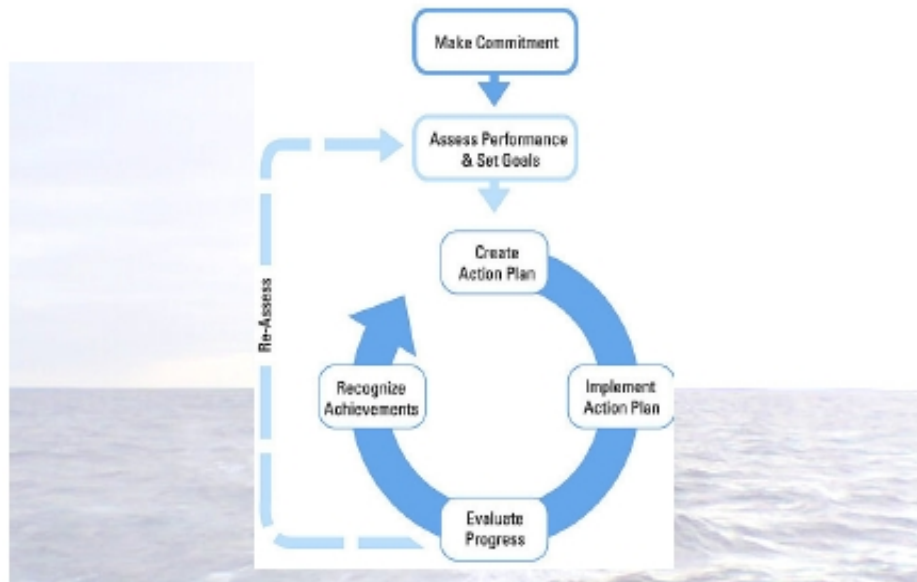
Phase III - Post Audit Phase

### **2.3 Method**

First of all, the physical magnitudes to be controlled must be identified and then measurement sensors must be installed in order to register them. All this information will be recorded for its later analysis and thus to draw up concrete intervention proposals according to the type of boat and its operative profile. Reaching the main objective which is improving ship's energy and profit. The improvements allowing an increase in the power efficiency of a certain ship, might not be applicable to another one, and so therefore there is no single path to follow and each ship needs a customized study.

- Typically an energy audit is dependent upon the ship type, size, data organization on board and systems to be audited
- Three to five working days, are usually required for measurements and data gathering for two energy auditors
- The final report is usually submitted within one month after the audit.

## The energy audits cycle



### ***2.4 The information to be collected during the detailed audit includes:***

1. Energy consumption by type of energy, by department, by major items of process equipment, by end-use
  2. Material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use in other industries, etc.)
  3. Energy cost and tariff data
  4. Process and material flow diagrams
  5. Generation and distribution of site services (eg.compressed air, steam).
  6. Sources of energy supply (e.g. electricity from the grid or self-generation)
  7. Potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation).
  8. Energy Management procedures and energy awareness training programs within the establishment.
- Existing baseline information and reports are useful to get consumption pattern, production cost and productivity levels in terms of product per raw material inputs.

### ***2.5 The audit team collects the following baseline data:***

- Technology, processes used and equipment details
- Capacity utilisation
- Amount & type of input materials used

- Water consumption
- Fuel Consumption
- Electrical energy consumption
- Steam consumption
- Other inputs such as compressed air, cooling water etc
- Quantity & type of wastes generated
- Percentage rejection / reprocessing
- Efficiencies / yield

## **2.6 Need for Audit**

In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the above components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction.

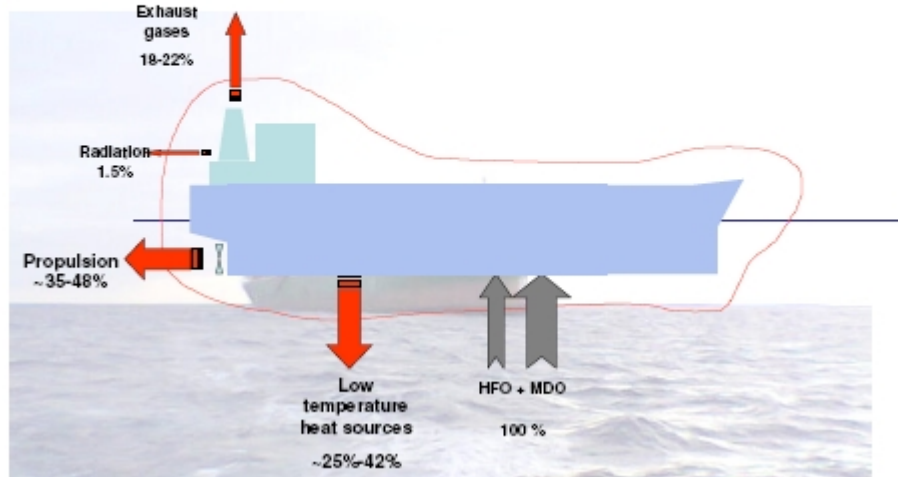
Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a "bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

## Onboard Energy Fluxes



### 3. Some points that are worth to check!

- Auxiliary Diesels engines are very often operated below 50% load, for reasons of safety or tradition?
- A Diesel alternator presents a higher specific fuel consumption when operated at low loads than when operated above 80%, clogging the turbochargers diffusers, piston rings, deteriorating the specific fuel consumption and its capability to develop the maximum power
- The emissions increase drastically, specially when operated with MDO or HFO
- The maintenance expenses increase exponentially for low loads.
- When you buy a ship project, the shipyard will sell you the cheaper cooling water system, i.e., a big sea water circulating pump and a small central heat exchanger
- So you will pay less on the first investment but you will be paying through all vessels life

### 4. Applications & Examples

- By introducing a variable speed drive to control the water flow, and adding some more plates, you can recover as much as 50% of the energy actually spent on your cooling water system. This is a lot of money, and much less pollution.
- Suitable emission measures would improve the lot of people suffering from asthma, bronchitis and heart disease.
- Vessels hull painting schemes, propeller polishing etc have been investigated to cut operation costs.

- Cost cutting.
- Higher Fuel efficiency
- Environment friendly voyages.

### **5. Typical Analysis Results**

It is observed (Ref. Hydrocomp.Ltd) that for a fishing ship change in a propeller design may result as per the following table.

Annual fuel cost	900,000€
Current propeller efficiency	0.58
Newly designed propeller efficiency	0.62(+4%)
Propulsive efficiency improvement	+4%
Cost of hull & prop. Design analysis	10000€
Cost of propeller manuft. & installations	42000€
Total cost of change	52000€
Savings made by improvements	36000€
Depreciation Period	<18 months

This demonstrates that an improvement of small apparent efficiency that could seem very expensive initially, it has a short depreciation period, compared to the life of a ship, reducing the ship's running cost considerably.

### **6. Factors Affecting Non compliance of Energy Audits:**

- Political Barriers
- Personal interest of industries developing new technologies.
- Neglecting long term benefits for short term reimbursement
- Managerial Barriers
- Monotony(variedness to implement new innovations)

### **6. Concluding Remarks**

Ship Energy Audit pinpoints the areas that are leading to unnecessary fuel consumption and identifies practical measures to save energy. An audit can assist in cutting emissions and demonstrating compliance with energy management best practice. It encourages ship safety and maintainability. Improves operational performance. Audit feedback can be used to promote energy efficient ship construction.

### **Reference:**

1. BP Shipping Pvt.Ltd.

2. TechnoVista Pvt.Ltd.
3. DNV Triple-E Pvt.Ltd.
4. Lloyd's Register
5. HydroComp Pvt.Ltd.

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