OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

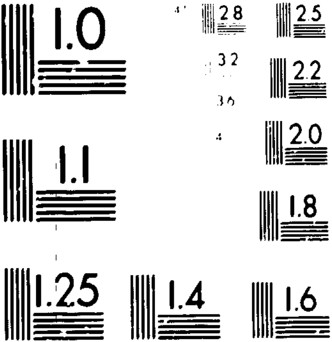
Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

ANSI and ISO TEST CHART No. 2

13316

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.417/3
13 February 1984
ENGLISH

Expert Group Meeting on Exchange of Experiences on Energy Conservation in Small and Medium Industries for ASEAN Countries

Kuala Lumpur, Malaysia, 5-7 December 1983

ENERGY CONSERVATION IN SINGAPORE*

* This document has been reproduced without formal editing.

V.84-81599

Energy Situation

Annual oil consumption in Singapore is between 3 to 4 million tonnes. About half of this oil is for electricity generation.

Almost half of the electricity produced goes to the manufacturing sector while a quarter goes to the commercial. The domestic sector accounts for about a fifth of the total sales.

Energy Conservation Policy

With no indigenous energy resource, Singapore's main strategy on energy conservation is to promote the rational and efficient use of energy without impeding economic growth. This is implemented through persuasion, examples, incentives and disincentives.

Energy Conservation Measures

Campaigns have been organised to promote and enhance energy saving awareness.

There is no subsidy in the pricing of energy and derived products.

Industrial companies which can demonstrate that they have been efficient in using energy may apply for exemption from the 10 per cent tax on electricity charges.

Approved energy saving expenditure on machinery and equipment incurred by non-industrial enterprises are allowed to be depreciated at an accelerated pace.

Building regulations are continually being updated to incorporate energy conservation features and measures.

An Energy Conservation Division has been established by the Public Utilities Board. One of the main tasks of the Division is to advise firms on energy conservation measures and the implementation of proper energy management. The Energy Conservation Centre under the Division provides a permanent exhibition and information centre on energy and water conservation to consumers.

A. CASE STUDY OF ENERGY CONSERVATION BY AN INDUSTRIAL GAS MANUFACTURER

1. Introduction

Energy cost has always been of major concern in industrial gas industry. Although there have been many technologioal improvements, the thermodynamics of the process is basically unchanged. For instance, until 1974 Company had been producing CO2 by burning diesel oil. Now CO2 is produced by purifying waste gas from industry. Similarly, until 1978, hydrogen was produced from the electrolysis of water. Today, it is obtained from waste with a high hydrogen content.

2. Energy Saving Consideration

The best criterion used is the specific energy necessary to produce 1 unit of product at the usage point. As the Company produces different types of products, the standard unit used is a m3 of gaseous oxygen and all the products are converted into equivalent amount of this unit. The objective is to lower as much as possible the specific energy. Product losses are a very important point to monitor particularly all along the distribution chain and mostly for the gases distributed in a liquid form. For these produots, special equipment has to be used for transport and storage. They are basically vacuum insulated vessels where the heat in leaks from the surrounding atmosphere are reduced to a minimum and it is essential to monitor the vacuum in these vessels. Any deterioration in the vacuum will mean higher heat in leaks and therefore higher evaporation losses.

3. Air Separation Unit (ASU)

Basically there are 2 types of plants:

a. High pressure plant

b. Low pressure plant

Over the years, the trend has been to utilise more and more low pressure plant - the main reason being mainly due to the increase in size of plant.

In the past the Company has been running high pressure plants of various sizes - the biggest being able to produce 50tpd of oxygen. These plants are perfectly adapted for small requirements and become uneconomical to operate when the size reaches around 2,000 m2/hr of oxygen product.

In 1981, the Company istalled 2 new low pressure plants having a capacity of 150tpd of oxygen.

4. Energy Consumption between High Pressure and Low Pressure Plants

From the energy consumption point of view, a comparison between the 2 types of plants shows a big improvement in specific energy consumption with the 2 new plants.

Main reasons for this improvement are:

a. Utilisation of better designed machinery -
From the mechanical point centrifugal machines can achieve efficiency of 95% to 98% whereas with reciprocating machines it is difficult to exceed 85%

From the thermodynamic point, it is easier to get close to the isothermical conditions with a centrifugal machine than with a reciprocating machine.

b. Less interruption of production due mostly to the reduction in maintenance work between centrifugal and reciprocating machines. Centrifugal air compressors can easily operate for 2 years without requiring any major overhead.

c. A greater flexibility in the operating pattern which enables us to follow better the market requirements. In fact, with centrifugal machines, one can adjust the flow and pressure quite independently within a wide area. Reciprocating air compressors do not allow such flexibility.

5. Air Compressor

The ideal air compression would be the isothermic compression. In practice however, this cannot be realised. The actual compression of air can only approach the isothermic condition by using a larger number of inter-coolers.

In low pressure plants however more than 3 inter-coolers are not an advantage as the improvements obtained are cancelled by the pressure drop due to the additional piping. At the design stage, it is very important to select carefully the air compressor. Experience shows that power consumption of 2 compressors of similar design built by 2 different manufacturers can differ widely on the specific energy.

The compressors are working at actually the same condition of pressure ratio but the power consumption differs considerably. The difference in the power consumption is due mostly to a better design of the flow path and of the gear and can result in a substantial money saving. The additional cost of a better design compressor will be recovered in approximately 3-4 years'time which is very acceptable in this type of industry. Once the machine is installed an interesting possibility to reduce the energy consumption is to decrease the temperature of the cooling agent.

6. Heat Exchanger and Condenser

In the cryogenic process of an air separation plant, the energy consumption can be reduced by improving the following equipment.

a. enlarging the main heat exchanger
b. enlarging the surface of the main condenser

It is more economical to enlarge the surface of the main condenser because the cost of the main condenser is about 5% of the total cost of the cold box. On the other hand, the enlargement of the main heat exchanger is not economical as these parts amount to about 30% of the total cost of the cold box. The important way of saving cost is to operate the air separation plant close to the optimum.

B. CASE STUDY OF ENERGY CONSERVATION BY A SHIPYARD

1. Introduction

Company started its programme about 4 years back in view of its importance as the major form of energy used.

Company receives its power from PUB (Public Utilities Board) at 6600 volts and this power is transmitted to various substation.

Distribution of this voltage to various consumer units may then entail the conversion of this voltage to various other voltages and frequencies. There is therefore a large variety of types and forms of electrical equipment used in the shipyard. Conservation measures are therefore correspondingly varied.

Company's conservation effort has paid off. Before 1978, the electricity units imported increased at an average of 5% p.a. This trend was reversed as effort was applied in the control and conservation of energy usage. The reduction was achieved despite increase in workload.

2. Lighting

Previously the lighting system used was exclusively tungsten incandescent bulbs and halogen lamps. These have been changed to sodium, mercury and flourescent light fittings which are more energy efficient. Savings in this respect for buildings and workshops ranged from a few kw to tens of kw.

3. Load Demand Control

As a ship repair yard, the loading pattern is highly irregular and is dependent entirely in the varying level of activity of ships' consumption. Moreover, the shipyard is not like a manufacturing plant where the number of products is closely related to the power demand. Therefore the simple switching off of consumers of electricity to control demand is not practicable. Nevertheless, some control is achieved in maximum demand by timing the switching operation of larger consumer units where the main electrical switchboard attendant monitor and coordinates with the operators of the various equipment. In this way, Company manages to keep its demand over 15% below the projected maximum.

Local demand reduction was also achieved by some other operational measures including the use of "Loading and Unloading Bay" whereby the larger cranes make use of luffing and slowing actions instead of travelling along the tail which consumes relatively more power.

Local demand is closely monitored by the extensively installed kilowatt hour meters throughout the shipyard. Monthly readings obtained from these meters are analysed and circulated to all concerned personnel. Explanations for excessive consumption in all areas are examined and remedial actions taken wherever necessary.

With the help of the accumulated consumption history for the various consumers, further consumption controlling means are being developed. Each major electricity consumer will have a formula to calculate its electricity consumption budget. This is to ensure that corrective action can be taken immediately if something goes wrong. Furthermore, new target may be set to improve the efficiency of energy usage in relation to production.

4. Compressed Air

About half of the shipyard's electricity consumption was used to generate compressed air. This was therefore one of the first areas where conservation effort was directed. Strict control of compressed air usage was implemented. Operation of compressor units was regulated such that pressure in the air line was maintained at fixed level (80psi) and compressors were switched off or changed over to lower capcity units when demand reduced.

Regular maintenance of the pipeline and equipment were carried out to reduce losses through leakages. Extensive studies were done to find ways and means to prevent wastages and improve efficiency. Measures taken and being implemented included redesigning of air manifolds, changing air fans to electric driven ones, recommending standards branch line diameters and educating users to participate in identifying defective and inefficient appliances.

5. Direct Current Rectifiers

Direct current supply is produced in the shipyard by converting the 50 Hz PUB mains. This was done by using motor generator sets. There were 11 motor generator sets for supplying d.c. power to ships when the study to rationalise the system was initiated. These machines were installed when the majority of ships calling at the shipyard were having d.c. drives. Efficiencies of these machines were low compared with modern equipment.

Studies showed that only 4 units of silicon rectifiers were required to replace all the motor generator sets. A payback period of about 4 years was indicated when other factors like repair and maintenance savings were indicated in the consideration.

Replacement during the interim period with both motor generator sets and silicon rectifiers were in operation.

6. Other Improvements

Upgrading of machine efficiency was not limited to the replacement of equipment.

For motors which were found uneconomical to be replaced outright owing to among other things, operational constrains, revitalisation processes were carried out. Motors undergone such treatments included the frequency changers, gravity dock pumps and air compressors.

Parallel operation of transformers at various substations are also practised. Out of the total of 24 units of 50 Hz transformers, about 80% of them can be connected in parallel to achieve load sharing and reduced overall losses.