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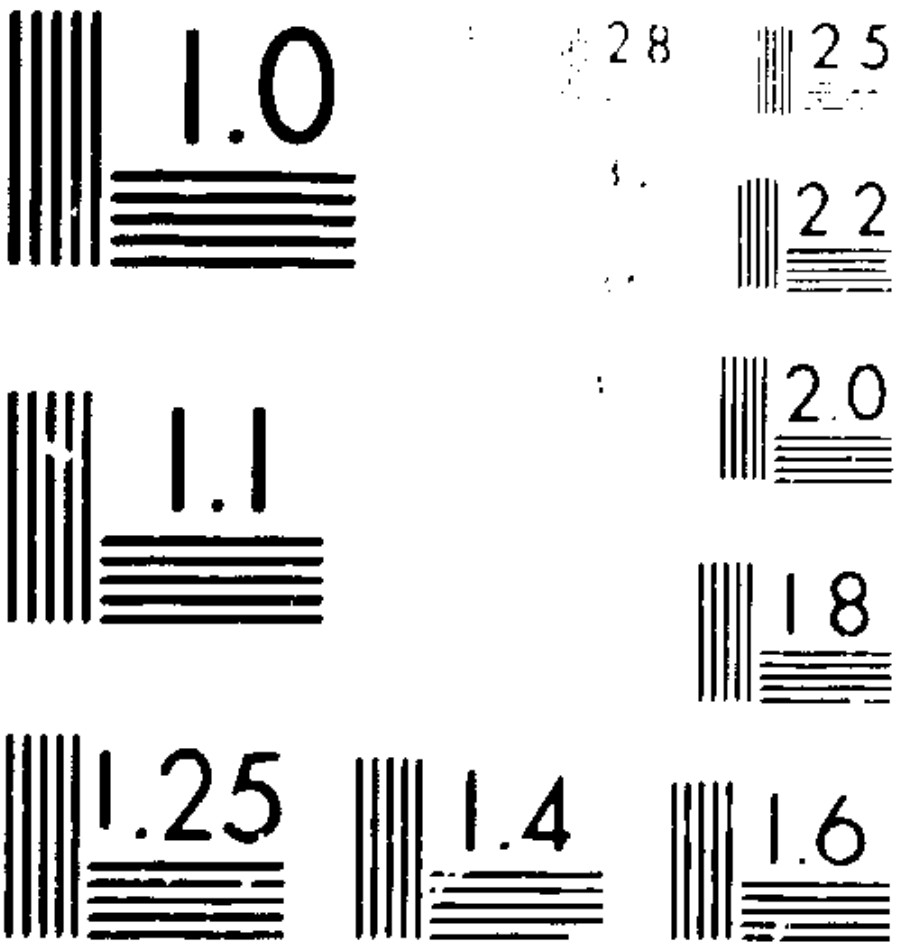
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ASSISTANCE TO THE

TANZANIA INDUSTRIAL RESEARCH AND DEVELOPMENT ORGANIZATION
(TIRDO)

DP/URT/78/019
TANZANIA

Technical report: On Energy Audits and Plant Refurbishments Projects*

Prepared for the Government of the United Republic of Tanzania
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of S. Rick, B. Cunningham,
UNIDO Consultant

970

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Finally, grateful acknowledgement must be rendered to Mr. C.L. Tarimu, Director General, TIRDC and his staff who have assisted us, particularly Mr. Nindie, Mr. Victus and Mr. Chando.

Table of Contents

1.0. INTRODUCTION

This mission, DP/URT/78/019/11-54 is the result of recommendations made at the conclusion of a previous UNIDO Mission DP/URT/78/019/11.09 in which the Tanzania Industrial Research and Development Organisation (TIRDO) sent two of its engineers to the Institute for Industrial Research and Standards in Dublin, Ireland for training in Energy Conservation theory and techniques. They then returned to carry out Energy Audits in Tanzania along with a UNIDO/IIRS energy expert.

The purpose of the current mission was to extend their training and work experience into more detailed Energy Surveys, to include cost benefit analyses, costing techniques and engineering sketches of proposed energy saving plant refurbishment projects.

Two UNIDO/IIRS energy experts commenced the 5 week mission in May 1983 and audits of four companies were carried out. It had originally been intended to carryout audits of six companies but, due to production difficulties in some of the companies and time limitations on the mission, it was agreed to concentrate on four companies.

2.0. Detailed Energy Audits

2.1. Description

This series of energy audits was carried out in greater detail than has previously been the case in Tanzania. In the previous case a half day or one day visit was paid to the company by the three team members, around two further days were spent in preparing the report which dealt with the overall energy situation in the company.

In the present case up to three or more days were spent on site by the five team members and a further five or six days were spent preparing the report. The areas of major energy saving potential were examined in detail including taking measurements and recordings.

In many cases detailed discussions were held with technical management concerning both their problems and the teams' ideas.

Detailed calculations were carried out on the energy reduction potential of the various projects proposed including the resulting financial savings and the costs of the supply and installation of the necessary equipment.

Illustrative engineering sketches were provided in many cases in order to assist the company's staff to assess the possibility of carrying out the refurbishment work themselves.

A simple form of financial appraisal was employed to indicate to the companies the rapid return on investment that would be provided by virtually all the projects recommended.

Finally each report included a section on the monitoring of energy performance within the company. This system gives management an early warning of any reduction in energy efficiency and enables early corrective action to be taken.

2.2. General Summary of Results

Total Annual Fuel Bill of Audited Companies: T.Sh. 14,301,926/-

Approximate Exchange rate applicable during field visits:

1 US $ = 10 T. Sh. (Tanzanian Shillings)

Item	Annual Potential Savings	Estimated Cost	Savings as % of Total Fuel	Annual Savings in litres of fuel oil
	T.Sh	T.Sh.		
Install Insulation	1,227,000	910,000	8.6%	421,000
Improve Maintenance and Boilerhouse Practice	892,750	510,650	6.2%	306,261
Heat Recovery Projects	2,9000,000	3,000,000	19%	1,010,000
Power Factor Improvement	118,800	68,800	-	-

Figure 1. Summarised Findings of Audit Team

A summary of the findings in the individual companies appears in Annex 2.

2.2.1. Insulation

There was little or no insulation in any of the sites visited. The reason for this appears to be the difficulty in obtaining suitable insulation from abroad rather than any lack of knowledge on the part of management. The losses due to lack of insulation amounted 8.6% of the fuel bill of the four companies visited. The payback period for the installation of insulation was invariably one year or less. The savings would be reflected in lower foreign imports of crude oil and the amount would be significant if the findings were extended to industry throughout Tanzania. A home manufactured insulation material if it were available would immediately solve the problems of foreign exchange for insulation, provide a new industry and reduce oil imports nationwide. This is considered further in Section 5.

2.2.2. Maintenance

Another area of energy loss found by the audit team resulted from maintenance problems. In many cases steam supplies could not be shut off, leaks could not be repaired and control equipment could not be rectified due to a lack of both expertise and materials.

A poor level of boiler house management was apparent. Burners were sometimes out of adjustment, controls were manual rather than automatic and there was a virtually complete lack of appreciation of the importance of boiler feedwater treatment. This was emphasised by the fact that three of the six boilers examined in the Dar es Salaam region were out of order due to water corrosion problems. The energy losses associated with these and other maintenance problems represent 6.2% of the fuel used in the participating companies. An approach to solving these problems is discussed in Section 5.

2.2.3. Heat Recovery Projects

A number of heat recovery projects were identified, the largest resulting in savings worth around 2.7m/-. Unfortunately almost all of the cost associated with these projects would be in the form of foreign exchange.

2.2.4. Power Factor Improvements

Despite the existence of regulations to the contrary, some plants were found to have very low power factors. It is not appreciated by

industry that the Tanzania Electric Supply Company's (TANESCO) tariff includes an inherent penalty for a low power factor. This penalty was evaluated for the individual companies along with the costs of improving the power factor. It is recommended that TANESCO publicize the existence of this inherent charge in their billing system.

3.0 Training and Work Experience

The purpose of this mission was to extend the training already received by the two TIRDO engineers, in the subjects of Energy Conservation and Plant Refurbishment to a level that would enable detailed Energy/Audits to be carried out by the TIRDO Energy Unit.

A third member of the TIRDO engineering staff was included in the audit team during this training period, as well as an observer from the Ministry of Industry.

3.1 Scope of Training

Four plants were selected for auditing during this mission, details of these audits may be found in Section 2.0 and Annex 2 of this report.

In the time available it was not possible to cover every aspect or technique related to such audits. Instead aspects which are particularly relevant to the conditions and requirements of industry in Tanzania were emphasized. These subjects can be broadly classified as follows:-

Boiler House

- General layout and sizing of major plant.
- Water treatment.
- Boiler/Burner condition.
- Combustion efficiency.
- Operational schedules and aspects of routine maintenance.

Steam System

- Correct installations and specifications for equipment.
- Insulation of pipework and valves.

Process Plant and Equipment

- Operational schedules for equipment and maintenance.
- Insulation of plant.
- Heat recovery projects.

Electrical Systems

Power factor correction.
Monitoring of plant loads.
Considerations related to load factor and load scheduling.

Costing of Energy Conservation Projects

How to develop cost indexes and standard costs for installations.

Adjustments necessary for conditions in Tanzania.
Location of suppliers, use of telex.

Project Assessment

Use of simple payback method.
Consideration of practical difficulties related to refurbishment, and installation including disruption to production.

3.2 Areas of Difficulties

During the training, certain concepts were particularly difficult to get across. First was, the practical considerations necessary for the implementation of change, in an on-going production situation. The second was the necessary compromises which must occur between the theoretical concept and the final practical solution.

To resolve these difficulties, experience operating as engineers in a production environment would be necessary. The experience of working in an electrical and/or mechanical design office would be useful to assist in formulation of practical projects.

The level of familiarity with electrical installations and equipment is poor. In order to install electrical monitoring equipment for the energy audits it is necessary to make connections directly to live busbars. From a safety point view this must be regarded with concern.

The standard of report writing is also a problem to which attention should be given. Technical reports containing detailed specifications and recommendations require a more precise standard of writing than is being achieved at present.

3.3. Recommendations for Development of the TIRDO Energy Unit

3.3.1. Senior Engineer

It must be recognised that any development of the Energy Unit will be directly linked to the development of the Engineering division as a whole. For the unit to begin to function properly there is need for the appointment of a senior engineer to control and supervise the activities of the unit. It would necessary be necessary in view of the comments made in 3.2 that this engineer should have considerable experience in the process and production industry and be able to communicate effectively. Of special concern would be report writing skills.

3.3.2. Work Experience

The Energy Unit is not seen as just having an Auditing function in industry. Many aspects of maintenance, plant operation etc. require detailed recommendations, and in some cases may involve the engineers in carrying out,or supervising alteration to equipment, or it's repair.

The demand for such services from the TIRDO engineers is beyond the scope of the Energy Audit training received to date.

To be effective and confident in making these recommendations and carrying out alterations of this type, it is imperative that work experience is gained in those areas where demand for these services exists. Table 3.1. contains a list of courses which will be required. Sponsors are suggested on the basis of suitability, but contact would be required with these companies to determine training facilities and suitability of course content offered.

TABLE 3.1. WORK EXPERIENCE

PLANT/EQUIPMENT	POTENTIAL SPONSORS OF PRACTICAL COURSES	DURATION
BOILER/BURNER	DEUTCHE BABCOCK (GERMANY)	4 WEEKS
PLANT AND AUXILLIARY EQUIPMENT	HAMWORTHY ENGINEER LTD FLEETS CORNER POOLE DORSET BH17 7LA ENGLAND	TO 8 WEEKS
STEAM DISTRIBUTION CONTROL	SPIRAX SARCO CHARLTON HOUSE CHELTENHAM GL538ER ENGLAND	2 WEEKS
WATER TREATMENT	LOCALLY AVAILABLE FROM CHEMICAL AND EQUIPMENT SUPPLY COMPANIES	4 WEEKS
ELECTRICAL PLANT AND INSTALLATIONS	LOCALLY AVAILABLE FROM ELECTRICAL CONTRACTORS OR ASEA/TANESCO	4 WEEKS

4.0. Energy Related TIRDO Projects

Based on the findings of the audit team, a number of recommendations for future energy related activities at TIRDO are put forward.

4.1. Development of a Home Manufactured Insulation

As identified in Section 2.0. of this report insulation of pipework and process equipment is a major contributor to energy savings in the four audits conducted during this mission. Development of an insulation product from locally available raw materials would create employment, provide savings in foreign currency expenditure on both oil and imported insulation materials.

Discussions with Dr. Haule, Principle Research Officer of the Chemistry Department at TIRDO, indicate that a wide variety of raw materials are locally available which could be processed to form suitable insulation materials.

Raw materials which could become starting points for such processes include:

Carbonate, and sulphates of calcium, magnesium or possibly aluminium. Others also available are gypsum and Bauxite.

These could be used to produce silicate or carbonate based insulations. To achieve light weight and good physical strength properties the mineral would have to be combined with a fibreous material, any of the many forms of cellulose fibre available locally would probably be be suitable e.g. sisal, hessian, banana plant fibre.

Investigations into the costs of labour and materials during this mission, have led us to the conclusion that the most cost effective form in which to produce the material would be a powder.

Application can then be made to the pipe work in two ways.

a) Chopped cellulose fibre and water added to form a paste and the paste would then be applied to the pipe.

b) Apply alternate layers of paste and loosely woven fibre mat to the pipe work to the required thickness.

Labour for this type of application need not be skilled, only the thickness of the material applied need to be controlled.

TABLE OF DESIRED PROPERTIES

CHARACTERISTIC	DESIRED LEVEL OF PERFORMANCE
TEMPERATURE APPLICATION RANGE	0 TO 300^{o}C
THERMAL CONDUCTIVITY	0.04 TO 0.08 w/mk
DENSITY	250 Kg/m^{3} MAX.
ALKALINITY pH	6.5 TO 8.0
COMPRESSIVE STRENGTH FOR RIGID MATERIAL	300 kN/m^{2}
EXPOSURE TO SUNLIGHT	NO AFFECT
EXPOSURE TO WETTING	NO AFFECT

Both the Chemistry and Engineering Departments at TIRDO could play a key role in the development of this material. The Chemistry Department would be needed to research all aspects of the material and its production while Engineering Department could assist with development of a prototype production process and study application techniques.

4.2. Extended Energy Audit Service

It is recommended that efforts are made by TIRDO to carry out a detailed energy audit in as many plants as possible throughout the country in the next few years. The pattern of dealing with the most energy intensive companies first should be continued.

With adequate practical training as discussed in Section 3, the energy unit could provide an additional service such as burner adjustment.

There is a severe shortage of competent equipment service companies in the country and most industries have experienced difficulty in this area.

4.3. Instrumentation Maintenance Activity

There is scope for the TIRDO Instrumentation Department to assist industry with maintenance problems of controls. In many cases controls were inoperative because of the lack of a simple mechanical part which could have been manufactured in a modern fabrication workshop. Figure No.1 indicates the resulting energy losses but, of course, production losses must be even more severe. A future situation is envisaged where the Energy Unit would identify control system or instrumentation faults in industry and the Instrumentation Department could investigate, repair and recalibrate. The areas of expertise required in the Instrumentation Department could investigate, repair and recalibrate. The areas of expertise required in the Instrumentation Department would be mechanical, electrical, electronic, pneumatic and, to some extent, hydraulic systems. This may require the extension of the existing department or the development of a new plant maintenance unit.

4.4. Energy Training Role for TIRDO

There is a need to increase the awareness and consciousness of industry in relation to energy conservation possibilities and techniques.

This can be achieved by developing the capability at TIRDO to conduct short seminars or courses. The co-operation of the Information Department may be useful in this respect. The courses should be aimed at technical management in industry and should be directed towards industry in general rather than specific sectors.

The need for Boiler Feedwater Treatment information in industry has already been referred to. This is an area where the Chemistry Department could either run a course or prepare a small booklet for distribution to industry. The booklet would outline the need for and the techniques of water treatment.

There appear to be several companies in Dar es Salaam involved in the water treatment business. These companies could be approached for sponsorship in the production of the booklet.

ANNEX 1

JOB DESCRIPTIONS

DP/URT/78/019/11-C9/C 31.3.J

Post title	Energy Audit Expert
Duration	Six weeks
Date required	As soon as possible
Duty station	Dar es Salaam, with possibility of travel within country
Purpose of project	To assist the Tanzania Research and Development Organization
Duties	The expert will work under the general supervision and guidance of the Senior Technical Adviser to TIRDO and in close co-operation with TIRDO management and staff and with the Ministry of Industries and other project experts. The expert will specifically be expected to: 1. Organize and supervise the conduct by TIRDO engineers of at least six in-depth audits in Tanzanian industries to be specified by TIRDO. 2. Train TIRDO engineers in advanced energy audit methods; 3. Oversee the preparation and editing of individual audit/refurbishment reports for each industry; 4. Assist in refurbishment specification and costi as required. The expert will also be expected to prepare a final report, setting out the findings of his mission and his recommendations on further action which may be taken.
Lanugage	English
Qualifications	University degree in mechanical, chemical or electrical engineering or equivalent, with experience in energy audits including measurement techniques, and in industrial energy conservation methods.

JOB DESCRIPTION
DP/URT/78/019/11-09/b 31.3.J

Post title	Plant refurbishment Expert
Duration	Six weeks
Date required	As soon as possible
Duty station	Dar es Salaam with possibility of travel within the country
Purpose of Project	To assist the Tanzania Research and Development Organization
Duties	The expert will work under the general supervision and guide the Senior Technical Adviser to TIRDO and in close co-operation with TIRDO management and staff and with the Ministry of Industries and other project experts. The expert will specifically be expected to: 1. Prepare specifications, materials lists, costs (local and foreign) and engineering sketches for major conservation opportunities identified by energy audits; 2. Develop suggested implementation schedules to minimize production losses; 3. Train TIRDO engineers in energy refurbishment design/cost estimating techniques; 4. Assist in energy audits as required.
Language	English
Qualifications	University degree in mechanical, chemical or electrical engineering or equivalent, with experience in energy audits including measurement techniques, and in industrial energy conservation methods.

Tanzania Breweries Ltd.

Synopsis

The recommendations of the original report were examined to greater detail. Costs were associated with each recommendation and payback periods were derived.

A system of monitoring the Brewery's energy performance relative to production level is detailed. Data from the past year is used as an example.

The boilers combustion efficiency was found to be satisfactory.

A faulty condensate pump noted in the initial report has now been replaced and the resultant losses have been eliminated.

Energy Saving Measures

The following energy saving projects were examined.

Project	Savings	Cost	Payback
Heat Recovery from Refrigeration	2.74m/-	3.2m/-	1.2
Cost of Standby Boiler	350,000/-	239,000/-	0.7
Repair Condensate Pump	-	-	-
Flash Steam Recovery	39,000/-	2,500/-	1 Month
Repair Steam Leaks	34,000/-	20,000/-	0.6
Recovery of Coffer Vapours	-	-	-
Insulation of Cold Air Ducts	23,580/-	29,500/-	1.25
Power Factor Improvement	46,800/-	27,000/-	0.5
Pipe Insulation	365,000/-	127,700/-	0.35

Tanganyika Packers Ltd.

Synopsis

An examination of the plant was carried out.

Ratios of energy relative to production were developed to assist management in monitoring fuel and electricity use.

Recommendations were made for insulation of pipes and vessels for repair of control valves and for improved energy 'house keeping'.

Boiler efficiency can be improved by simply notating air and oil control positions and it is proposed that this work be carried out by TIRDO engineers in the near future.

Boiler corrosion causes are identified and recommendations are made.

Savings amount to 37% of the present oil bill and 3% of the electricity bill were identified.

Energy Savings Options

Option	Savings T.Sh.	Total Cost TSh.	Simple Payback Years	Foreign Exchange Content Cost
Pipe Insulation	207,409	238,753	1.15	91%
Process Vessel Insulation	52,846	90,405	1.7	91%
Steam Leaks	172,500	131,400	0.76	96%
Live Plant	138,400	147,220	0.43	96%
Condensate Return	5,850	8,000	1.4	NIL
Boiler Efficiency	85,060	Small	-	NIL
PF Correction	14,400	23,800	1.7	79%

37%

Coast Textiles Ltd.

Synopsis

The audit team examined the process and service plant in the factory.

Problems in the boilerhouse were identified and solutions recommended.

A proposal was made to recover heat from the dyeing process.

Attention was drawn to the possibility of heat recovery from the stenter machine but as this was not operational no measurements were possible.

Energy Saving Projects.

The following energy saving projects were examined

Project	Report Section	Savings	Cost	Payback
Condensate Return	6.3	58,300/-	71,000/-	1.2 yrs
Dye Process Heat recovery	7.1	149,000/-	200,000/-	1.3 yrs
Stenter Control	7.2	15,000/-	-	-
Pipe insulation	8.1	85,537/-	34,872/-	½ year
Insulation of some dyeing machines	8.2	16,694/-	16,800/-	1 year
Power Factor Improvement	9.0	30,600/-	10,000/-	⅓ year

Morogoro Tanneries

Project	Savings	Cost	Payback
Pipe Insulation	499,620/-	401,325/-	
Dryer Controls	48,636/-	61,250/-	
P.F. Correction	27,000/-	NIL	-
Vessel Insulation