Developing Institutional Framework for the Energy Efficiency Act and Regulations targeting energy intensive sector in Nigeria

Deliverable 4

Activity 4.2: Templates for Energy Auditing

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1. Energy Auditing

Energy audits are essential tools for identifying opportunities to improve energy efficiency and reduce costs in buildings and facilities. They generally fall into three levels: preliminary, general, and detailed audits. Preliminary audits, often referred to as walk-through audits, involve a quick visual inspection of the facility and a review of utility bills to identify obvious areas of energy waste. This level aims to pinpoint immediate, low-cost energy-saving opportunities and provide a rough estimate of potential savings. General audits, or standard audits, go a step further by involving more thorough data collection and analysis. These audits include detailed site inspections, the use of data loggers and submeters, and a comprehensive review of energy consumption patterns. The objective is to identify cost-effective energy-saving measures with a reasonable payback period and provide a more accurate estimate of savings and implementation costs.

Detailed audits, also known as comprehensive audits, are the most exhaustive level of energy assessments. They involve extensive site visits, advanced diagnostic tools, and sophisticated simulation software to perform in-depth analysis of energy use. These audits provide a highly accurate estimate of potential energy savings, implementation costs, and payback periods, making them suitable for large or complex facilities where significant energy savings are expected. Detailed audits examine all feasible energy-saving opportunities, including long-term investments, and consider the interactions between different systems. The outcome is a comprehensive report with detailed recommendations, technical specifications, and an implementation plan that includes timelines and assigned responsibilities. By choosing the appropriate level of energy audit, organizations can effectively manage their energy use and achieve substantial savings.

1.1. Level 1 - Preliminary Audit (Walk-through Audit)

A Level 1 energy audit, often referred to as a preliminary or walk-through audit, is a basic assessment designed to quickly identify obvious opportunities for energy savings with minimal investment. This audit involves a brief visual inspection of the facility, a review of historical utility bills, and interviews with facility personnel to understand operational practices and maintenance routines. The primary goal is to pinpoint immediate, low-cost or no-cost measures that can reduce energy consumption, such as turning off lights in unoccupied areas, adjusting thermostat settings, and addressing easily fixable maintenance issues like leaks or insulation gaps. The outcome of a Level 1 audit is a high-level report that includes a summary of observed energy inefficiencies, a rough estimate of potential savings, and straightforward recommendations for improving energy performance. This type of audit is ideal for organizations looking to quickly identify and implement basic energy-saving measures without the need for detailed analysis or significant investment.

Scope:
A preliminary audit is a basic assessment focusing on quickly identifying obvious areas of energy waste. This audit is often the first step in understanding the energy performance of a facility.

Objectives:

- Identify immediate, low-cost, or no-cost energy-saving opportunities.
- Provide a rough estimate of potential energy savings.
- Determine if a more detailed audit is needed.

Methodologies and Tools:

- Visual inspection.
- Review of utility bills and energy consumption data.
- Basic diagnostic tools like light meters or infrared thermometers.

Activities:

- Conduct a brief site visit to observe major energy-consuming equipment such as HVAC systems, lighting, and machinery.
- Review historical energy use data, including electricity, gas, and water bills.
- Identify areas where energy is visibly wasted, such as poorly insulated areas, unnecessary lighting, or equipment running when not needed.

- Interview facility personnel to understand operational practices and maintenance routines.

Examples of Findings:

- Lights left on in unoccupied areas.
- Equipment running during non-operational hours.
- Poorly maintained HVAC systems leading to inefficient operation.
- Leaks in compressed air systems.

Outcome:

- A preliminary list of energy-saving measures.
- High-level recommendations for further action.
- Basic analysis of energy consumption patterns and potential savings.

1.2. Level 2 - General Audit (Standard Audit)

A Level 2 energy audit, also known as a general or standard audit, provides a more detailed examination of a facility's energy use compared to a Level 1 audit. This audit includes a thorough site inspection, detailed data collection, and analysis of energy consumption patterns. It involves the use of diagnostic tools such as data loggers and submeters to capture real-time energy use across various systems and equipment. The primary objective is to identify cost-effective energy-saving opportunities with a reasonable payback period. The audit evaluates the efficiency of major energy-consuming systems like HVAC, lighting, and motors, and assesses operational practices for potential improvements. The outcome is a detailed report that presents specific recommendations for energy-saving measures, accompanied by a cost-benefit analysis that includes estimated savings, implementation costs, and payback periods. This comprehensive approach helps organizations prioritize and implement energy efficiency projects that offer significant savings and operational improvements.

Scope:

A general audit is more detailed than a preliminary audit and involves a thorough examination of energy use across the facility. It includes data collection and analysis but is not as exhaustive as a detailed audit.

Objectives:

- Identify cost-effective energy-saving measures with a reasonable payback period.
- Provide a more accurate estimate of potential energy savings and implementation costs.

Methodologies and Tools:

- Detailed site inspection.
- Use of data loggers and submeters to collect energy consumption data.
- Analysis software for energy use pattern identification.
- Thermal imaging cameras for detecting insulation issues.

Activities:

- Conduct a detailed site visit to inspect equipment, operations, and control systems.
- Collect data on energy consumption, including submetering specific areas or equipment to isolate energy use patterns.
- Analyze historical energy use data to identify trends and anomalies.
- Assess the efficiency of lighting, HVAC, motors, and other energy-intensive systems.
- Develop a prioritized list of energy-saving measures based on potential savings and implementation costs.

Examples of Findings:

- Inefficient lighting systems, such as outdated fluorescent bulbs.
- HVAC systems operating outside optimal ranges.
- Motors and pumps running at full speed regardless of demand.
- Poor building envelope insulation leading to heat loss.

Outcome:

- Detailed report with specific recommendations for energy-saving measures.
- Cost-benefit analysis of proposed measures, including payback periods and return on investment.
- Action plan for implementing energy-saving projects, with timelines and responsibilities.

1.3. Level 3 - Detailed Audit (Comprehensive Audit)

A Level 3 energy audit, known as a detailed or comprehensive audit, is the most exhaustive type of energy assessment, designed for large, complex facilities where significant energy savings are anticipated. This audit involves an extensive site visit, detailed data gathering over an extended period, and advanced diagnostic tools such as power quality analyzers, thermal imaging cameras, and flow meters. It also employs sophisticated simulation and modeling software to analyze the performance of various systems and predict the impact of potential energy-saving measures. The goal is to identify all feasible energy-saving opportunities, including those requiring substantial investment, and to provide highly accurate estimates of energy savings, implementation costs, and payback periods. The resulting report is comprehensive, offering detailed recommendations, technical specifications, and a thorough cost-benefit analysis, including life-cycle costs and sensitivity analysis. It also includes a detailed implementation plan with timelines, milestones, and assigned responsibilities. This level of audit ensures that organizations can make informed decisions about long-term energy efficiency investments and achieve substantial and sustainable energy savings.

Scope:
A detailed audit, or comprehensive audit, involves an in-depth analysis of energy use, employing advanced diagnostic tools and simulation software. This audit provides the most thorough assessment and is suitable for large or complex facilities where significant energy savings are expected.

Objectives:

- Identify all feasible energy-saving opportunities, including long-term investments.
- Provide highly accurate estimates of potential energy savings, implementation costs, and payback periods.

Methodologies and Tools:

- Extensive site visit and data collection.
- Use of advanced diagnostic tools such as power quality analyzers, data loggers, and flow meters.
- Building energy simulation software to model energy use and savings from various measures.
- Computational fluid dynamics (CFD) for analyzing airflow and thermal performance.

Activities:

- Conduct an extensive site visit, including multiple visits if necessary, to gather detailed data on energy consumption and operational practices.
- Install monitoring equipment to gather high-resolution data over an extended period.
- Perform detailed analysis of energy consumption patterns, system performance, and operational inefficiencies.
- Use simulation tools to model the impact of potential energy-saving measures, considering interactions between different systems.
- Evaluate potential upgrades and retrofits, such as installing energy-efficient equipment, optimizing control systems, and improving the building envelope.

Examples of Findings:

- Inefficient chiller operation leading to excessive energy use.
- Suboptimal building automation system settings causing unnecessary energy consumption.
- Potential for energy savings through the integration of renewable energy sources.
- Detailed analysis of process energy use, identifying opportunities for optimization.

Outcome:

- Comprehensive report with detailed recommendations for energy-saving measures, including technical specifications and implementation strategies.
- Detailed cost-benefit analysis, including life-cycle cost analysis and sensitivity analysis.
- Implementation plan with timelines, milestones, and assigned responsibilities.
- Recommendations for continuous monitoring and verification of energy savings.

1.4. Report Preparation

Drafting reports for different levels of energy audits requires tailoring the content and depth of analysis to match the scope and objectives of each audit. For preliminary audits, the report should be concise and focused on immediate, low-cost energy-saving opportunities identified during the quick visual inspection and utility bill review. This report typically includes a high-level summary of energy consumption patterns, a list of obvious inefficiencies, and straightforward recommendations for operational adjustments or maintenance improvements. The goal is to provide a clear and actionable overview that can prompt immediate energy-saving actions without extensive analysis.

In contrast, reports for general and detailed audits require more comprehensive and nuanced content. A general audit report should include detailed findings from site inspections, data analysis from submeters and data loggers, and a prioritized list of recommended energy-saving measures. Each recommendation should be accompanied by a cost-benefit analysis, including estimated savings, implementation costs, and payback periods. For detailed audits, the report should delve even deeper, providing extensive data from advanced diagnostic tools and simulation models. This report should offer a thorough examination of all feasible energy-saving opportunities, detailed technical specifications, and a comprehensive implementation plan. The detailed audit report might also include life-cycle cost analysis, sensitivity analysis, and recommendations for continuous monitoring and verification of energy savings. By aligning the depth and detail of the report with the specific level of the energy audit, organizations can ensure that the information provided is both relevant and actionable.

Level – 1 audit report	Level – 2 audit report	Level – 3 audit report
• Executive Summary • Brief facilities description • Scope of audit/ Methodology • Preliminary Analysis Findings, including benchmark and end use results • List of no-cost and low-cost energy measures • Potential measures for further consideration	All items from Level I Audit • More comprehensive energy end use analysis • Description of building systems and major equipment • Financial analysis of EEMs • Description of energy efficiency measures considered and not recommended or not financially viable • Description of energy efficiency measures recommended • Summary table with measure name, installed cost, energy savings by utility, and O&M savings • Capital Intensive measures requiring Level III audit • Detailed energy analysis calculations • Measurement and verification (M&V) plan for verifying energy savings	All items from Level II Audit • Detailed information on capital intensive measures – including schematics, equipment lists, equipment specifications, design sequences and costs • Highly detailed financial evaluation

2. Data Collection Questionnaire

2.1. General Information

1.	**Name of the facility**	
2.	**Postal address**	
3.	**Year of establishment**	
4.	**Website (if any)**	
5.	**Name of the facility in-charge** **Email ID** **Telephone**	
6.	**Co-ordinating officers:** **Name** **Position** **Email ID** **Telephone**	
7.	**Capacity of the facility (Sitting area)**	
8.	**Production**	
9.	**Operating hours per day**	
10.	**Working days/year**	

11. Details of Facility*
Brief description of Facility

2.2. Energy Profile

1. Annual Energy consumption :				
Fuel *	**Unit**	**Quantity**	**Unit price (NGN)**	**Annual Expenditure (NGN)**
Coal	tonne			
LPG	m^3			
Liquid fuel oil	tonne			
Natural gas	m^3			
Diesel	kL			
Electricity				
▪ Purchased	kWh			
▪ Captive	kWh			
Others (Please specify such as biomass, biofuels, solar)				

** Strike out whichever is not applicable*

2. Electricity:		
Total connected load (kW)	kW	
Contract demand (kVA)	kVA	
Maximum demand registered in last 12 months	kVA	
Average power factor in last 12 months	Pf	

**Please attach last 36 months electricity bill copy

3. Electricity tariff (if purchased from GRID)		
Tariff category	Kv	
Demand charge	NGN/kVA	
Capacity charge	NGN/kVA	
Peak time energy charge	NGN/kWh	
Off-peak time energy charge	NGN/kWh	
Power Factor rebate or penalty		
4. Electricity tariff (if sold to GRID)		
Demand charge	NGN/kVA	
Capacity charge	NGN/kVA	
Average energy charge	NGN/kWh	
Peak time energy charge	NGN/kWh	
Off-peak time energy charge	NGN/kWh	

2.2.1. Utility equipment

Name of the Equipment	Available (Yes/No)	No. of units	Design Capacity
Boiler			
Turbine			
Kiln			
Furnace			
Chiller/HVAC			
Air compressor			
Pump			
Cooling tower			
Fans/blowers			
Air handling units/Air washers			
Electric motor			
Transformer			
Diesel generator set			
Lighting			
Filtration			
Conveyer Belts			
Please add subsequent rows for any other equipment			

2.2.2. Captive Power Plant*

S. No.	Description	Value	Remark
Boiler System			
1	Type of Boiler (Fluidized bed/Pulverized boiler/any other type)		
2	Type of fuel (Diesel/Gas/Coal/Husk/any other)		
3	Fuel specification (GCV, moisture, Ash etc)		
4	Ash specification (unburnt carbon, temperature etc.)		
5	Rated parameters of steam outlet (Temperature and Pressure)		
6	Rated parameters of water inlet (Temperature and Pressure)		
7	Flow rate of water inside boiler		
8	Flue gas and water/steam path layout		
9	Types of mills		
10	Temperature and pressure of steam/water at inlet and outlet of each heating surface		
11	Inlet air temperature		
12	Primary air Temperature at inlet and outlet of APH		

S. No.	Description	Value	Remark
13	Flue gas Temperature at inlet and outlet of APH		
14	Differential pressure at APH for both primary air and flue gas		
15	Oxygen at APH outlet		
16	Type of draft in the boiler (Balanced/forced/natural)		
Turbine System			
1	Rated generation capacity		
2	Total stages of turbine		
3	Number of HP, IP and LP heaters		
4	Type of governing of turbine		
5	Number of extraction from the turbine and rated temperature and pressure of the same		
6	Temperature and pressure of steam at inlet of turbine		
7	Average Plant load Factor		
8	Rated condenser vacuum		
Auxiliary System			
1	Type of ash conveying both bottom and fly ash		
2	Compressors and their rated capacity		
3	Fans specification (FD, ID, PA etc.)		
4	Pumps details (BFP, CEP, Cooling Pump etc.)		
5	Number of Cooling tower and average operating CTs		
* Please attach HBD, Flow diagram, Key parameters sheet from DSC at full load and other relevant design details of boiler, turbine and BOP.			

2.2.3. Process Boilers

Boiler ID	Make	Type	Serving area	Design Data		Rated fuel consumption (T/hr)	Rated efficiency (%)	Annual operating hours (hours/year)
				Steam generation (T/hr)	Steam pressure (Kg/cm^2)			

Total no. of steam traps installed : Type of steam traps:

2.2.4. Electric Water heaters

Heater ID	Make	Type	Serving area	Design capacity (kCal/hour)	Rated capacity (kW)	Annual operating hours (hours/year)

2.2.5. Refrigeration/Air-conditioning

Machine ID	Make	Type	Serving area	Rated Capacity (TR)	Rated Comp. motor capacity (kW)	Rated specific energy consumption (kW/TR)	Annual operating hours (hours/year)

2.2.6. Air compressors

Machine ID	Make	Type	Serving area	Design		Motor capacity (kW)	Annual operating hours (hours/year)
				FAD (cfm)	Pressure (kg/cm^2)		

2.2.7. Pumps

Pump ID	Make	Type	Serving area	Rated flow ($m^3/hr.$)	Rated head (meters)	Rated Motor capacity (kW)	IP kW at rated flow and head (kW)	Rated efficiency (%)	Annual operating hours (hours/year)

2.2.8. Cooling towers

Tower ID	Make	Type	Serving area	Capacity (TR)	Fan		Annual operating hours (hours/year)
					(Blade material)	Motor capacity (kW)	

2.2.9. Fans/Blowers

Fan ID.	Make	Type	Serving area	Capacity (m^3/hr.)	Motor capacity (kW)	Annual operating hours (hours/year)

2.2.10. Air handling unit/air washers

Washer ID	Make	Type	Serving area	Capacity (TR)	Fan motor capacity (kW)	Annual operating hours (hours/year)

2.2.11. Motor details***

Location	Make	Rating (H.P.)	No.	HV/LV/MV	Annual Operating hours (hours/year)	Rated motor efficiency (%)

****Please attach separate sheet if space is found insufficient.*

2.2.12. Transformer details

Rating (kVA)	Make	No.	Location	Voltage Ratio

2.2.13. DG Sets

Rated capacity (kVA)	Make	Type	No.	Generation voltage (kV)	Average operating hours (hours/year)	Rated specific energy consumption (kWh/litre)

2.2.14. Lighting

Sr. No.	Area	Type of lamp	Power rating (W)	Number of fixtures	Annual Operating hours (hours/annum)	Method of switching (Proximity sensor if any)

2.2.15. Capacitor details

Rating (kVAr)	Location	Type/make	Rated voltage (volts)

2.2.16. Water Filtration details/Reverse Osmosis system

Sr. No.	Make	Type	Capacity (m^3/hr.)	Filters Change Duration	Annual operating hours (hours/year)

2.2.17. Conveyer Belt

Sr. No.	Make	Area of Application	Motor Capacity (kW)	Loading	Annual operating hours (hours/year)

2.2.18. Other process equipment

Sr. No.	Make	Type	Motor Capacity (kW)	Type of usage	Annual operating hours (hours/year)

2.3. Renewable Energy Potential

1. Solar rooftop potential assessment:		
Total roof area	m^2	
Roof slope (approximately)	degree	
Average roof shaded	% or m^2	
Roof construction (Concrete, metal sheets, polycarbonate, etc.)		
Latitude and longitude of facility location	degree	
Elevation	m	
Daily solar radiation (average, maximum, minimum)	kWh/m2/day	
Connected load at the facility	kW	
Distance from nearest distribution transformer	m	
Regulatory framework of the state for rooftop PV connectivity	Yes/No	
2.Biomass potential assessment:		
Is there any biomass as by-product of process	Yes / No	
Facility location/process area		
Type of biomass (Woody, non-woody, waste, any other)		
Quantity generated, tonne per month		
Is biomass utilised for energy generation	Yes / No	
If YES what is the type of usage?		
Quantum of energy generated		
3.Any other renewable potential?	**Yes / No**	
If Yes, provide details		

Request additional information including the following:

- Electrical single line diagram
- 36 months electricity bill
- 36 months fuel bill
- Facility layout
- Equipment inventory
- List of motors
- Any other relevant information
- Photographs of facility

2.4. Other relevant information

2.4.1. GHG emissions

Q1. How do you measure and track GHG emissions from your facilities?

Q2. What are your total annual GHG emissions (Scope1 & 2) in CO_2 equivalent for the past three years?

2.4.2. Process information

Q1. Describe your current manufacturing processes.

Q2. Whether any section wise energy monitoring system is in place

if yes give details:

Q3. When was the last energy audit conducted in the past?

Q4. What are your short-term and long-term goals (decarbonization initiatives/energy conservation measures) for reducing Scope 1 and Scope 2 emissions?

Short term goals	**Target date**
Improving energy efficiency of equipment	
Implementing renewable energy sources	

Enhancing energy monitoring and management systems	
Reducing fuel consumption	
Other (please specify)	

Long term goals	**Target date**
Achieving net-zero emissions	
Transitioning to 100% renewable energy	
Implementing advanced carbon capture technologies	
Upgrading to low-carbon or electric machinery	
Other (please specify)	

Q4. What were the major decarbonization initiatives /energy conservation measures implemented?

List major initiatives implemented	**% Savings achieved**	**Savings Achieved NGN**
Achieving net-zero emissions		
Transitioning to 100% renewable energy		
Implementing advanced carbon capture technologies		
Upgrading to low-carbon or electric machinery		
Other (please specify)		

Q5. What challenges have you encountered in implementing your energy efficiency initiatives? (Select all that apply)

Challenges	**Yes/No**
High costs of new technology	
Lack of expertise or knowledge	
Resistance to change within the organization	
Limited availability of suitable technologies	
Regulatory or compliance issues	
Other (please specify)	

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