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Danish Energy Agency

Background Document
Training Programme on Project Development for Certified Energy Auditors and Energy Managers in Vietnam

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Developed in collaboration with:

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Content

Foreword

The Danish-Vietnamese Partnership Program 2020-2025 (DEPP3) aims at strengthening the green transition of the energy sector in Vietnam. The objective is to support the Government of Vietnam in reaching the national target of net-zero carbon emissions by 2050, while maintaining a high level of security of supply of affordable energy for all.

The industrial sector in Vietnam offers a substantial potential to reduce carbon emissions while at the same time increasing the competitiveness of the industries and improve the security of energy supply.

The industrial sector accounts for about 50% of total final energy consumption in Vietnam. Comparing with similar countries in the region, the industrial sector of Vietnam is among the most energy intensive.
The potential for energy efficiency in the industrial sector in Vietnam is still very considerable, with estimates ranging from 20 to more about 30%[1]. Considering that the industrial sector accounts for about 50% of final energy consumption, implementation of the full potential of energy efficiency could amount to 10-15% of total final energy consumption.

The VNEEP program has already provided significant support to implementation of a part of the EE potential, particularly the potential related to utility services such as production and distribution of steam, compressed air and cooling. A range of energy efficient solutions, which were previously little known and used, are now mainstream in the market, such as LED lighting, variable speed drives on motors etc. However, such kind of energy efficiency measures only account for a limited share of the total potential. The remaining potential is mostly associated with optimization of the production processes themselves, including the core manufacturing processes. This potential involves a very large variety of solutions, such as recovery of waste heat, optimization of process parameters (such as temperatures, pressure, concentration etc.), upgrading production technology, and many, many more.

The DEPP3 program has successfully demonstrated how a consistent approach to energy mapping as well as identification and development of project opportunities can lead to real investment opportunities that can be endorsed and implemented by industrial enterprises. A total of 19 high-quality energy audits has been conducted leading to 7 feasibility studies completed or ongoing. Until now four investment projects have been implemented already while others are under consideration by the management.

During implementation of the program, a number of local energy audit companies have been trained to identify and develop energy efficiency projects.

To scale up the Technical Assistance support to industries, the DEPP3 program has developed this training program. The training program is based on the results of the program, including a number of guidelines developed, and introduces the methodologies and build capacity of energy experts in applying the methodologies. The training program is targeting energy auditors as well as industrial energy managers. This background document includes the basic training material for the trainees.

New regulation on energy auditing

Following the approval of the revised energy efficiency law in June 2025, a revision of the existing energy audit regulation is under revision at the time of writing this text. It is expected that the new regulation will include requirements to energy audits, including application of a systematic approach to mapping and identification of energy efficiency opportunities. Energy auditors would need to be trained in application of these methodologies.

[1] A recent World Bank study estimates a potential of 29% energy savings from energy and material efficiency improvements alone, with an average economic cost savings of 120 USD per ton of CO_2 emission reduced.

The ”new” energy auditor
From the point of view of the energy auditors, this would constitute a significant change in the role. First of all, in addition to existing expertise in energy utility technologies, that energy auditors have already good experience in, they need to focus their services on the systematic approach being taught in this course.

First of all, the energy auditor must secure a solid mapping of energy use and consumption across main energy end-uses.

Second, the energy auditor must systematically review the energy consumption with main focus on the significant energy users and apply a systematic approach to assessing losses and inefficiencies.

Thirdly, the energy auditor must be able to identify relevant solutions to existing inefficiencies. Clearly, the energy auditor cannot be expected to know about all and any kind of energy efficient solutions across all industrial processes. Therefore, the auditor must know how to seek advice from relevant expert sources, including but of course not limited to the internet, as well as sector experts from universities etc. The auditor must then be able to present the suggested solutions identified and provide clear and useful recommendations to the enterprise management. Especially for large energy efficiency potentials involving much uncertainty, the energy auditor should be able to outline these uncertainties and recommend the way forward to clarify these, for example through a pre-feasibility study. Ideally, the energy auditor should even be able to execute such a study, possibly assisted by a relevant technology expert.

The ”new” energy manager
The developed methodology mainly focuses on energy auditors, but the training program is also highly relevant for Certified Energy Managers, who must ensure that energy efficiency is integrated into company operations. By understanding the same tools as external energy auditors - such as energy mapping and feasibility studies - energy managers can:

- Deliver the right data to support audits.
- Apply audit results effectively in their own organization.
- Continue updating energy mapping.
- Identify and implement additional projects

In addition, the material equips energy managers to link technical insights with strategic planning, communicate results to management, and oversee implementation of both technical and organizational measures.

Thus, the program helps Certified Energy Managers act as a vital bridge between external expertise and internal decision-making, ensuring that identified energy savings are translated into real and lasting improvements.

The training program and this Trainers Guide are built on top of the knowledge and training already gained through the official MOIT training program for certified energy auditors and energy managers and thus don’t go into details on specific technologies or sectors, since it is expected that the trainees in the training program will be familiar with the energy efficiency of specific technologies

To strengthen capacity building on process optimization, a Training of Trainers program has been developed, and a number of experts have been trained in teaching the new methodologies. It is our hope that the training will be widely offered in its full scope or in parts hence contributing with its many benefits to the industrial enterprises as well as to the Vietnamese nation.

The Training program has been developed under the DEPP3 program by a team of international experts from Viegand Maagoe A/S with the support from professors and lecturers at HUST and in a good dialogue with the Agency for Innovation, Green Transition and Industry Promotion (IGIP), Ministry of Industry and Trade of Vietnam (MOIT) and the Danish Energy Agency (DEA).

Section 1: Introduction

This document forms the Background Document to assist the trainees participating in the CoE Training Program on Project Development for Certified Energy Auditors and Certified Energy Managers.

The training program is designed as a 5-day training program for Vietnamese certified energy auditors and energy managers. The course introduces a structured and methodical approach to identifying, developing, and presenting energy efficiency (EE) projects, based on practical tools such as energy mapping, data analysis, and systematic feasibility studies.

This methodology has been developed within the framework of the Energy Partnership Programme between Vietnam and Denmark and is aligned with best practice approaches from international and regional industrial contexts. The training program has been developed in close collaboration between Vietnamese and Danish experts in training and energy efficiency.

The training program and this Background Document are built on top of the knowledge and training already gained through the official MOIT training program for certified energy auditors and energy managers and thus don't go into details on specific technologies or sectors, since it is expected that the trainees in the training program are familiar with energy efficiency of specific technologies.

This document will be handed out to the trainees before attending the 5-day training program on Project Development. The core of this document is section 3-8. These sections consist of relevant technical guidelines develop in the Vietnamese Danish Partnership on Energy Audit, Energy Mapping, Project Development, Pre-Feasibility Study, Feasibility Study, and Loan Application. Each technical area is assisted by an introduction to relate to the Vietnamese context and the lessons learned from numerous energy audits conducted at Vietnamese DEU's as part of the Vietnamese Danish Partnership. Additionally, a list of references is included for all the technical areas. During the training program additional material, e.g. case studies and supporting excel tool, will be handed out to the trainees.

1.1. Learning Objectives of the Training Program

The Training Program has been developed with the overall aim to acquire new skills to the certified energy auditors and energy managers that enables him/her to carry out and use high quality energy audits, pre-feasibility studies, and feasibility studies not only focusing on technologies one by one or only focusing on utility technologies but also identify cross cutting energy efficiency projects and additionally be able to present the projects to final investment decision.

The overall learning objectives of the training program is to make the certified energy auditors and energy managers able to develop energy efficiency projects from creating the first idea to final investment decision in a structured way using the following three steps and methods:

1. Identify relevant energy efficiency opportunities from a more holistic approach by:
    a. Conduct an energy mapping of industrial processes
    b. Identify technical energy efficiency project opportunities based on the mapping
2. Develop energy efficiency projects for final investment decisions using the tools:
    a. Pre-feasibility study – to assess and select from alternative project opportunities
    b. Feasibility study – to identify direct and indirect financial and other cost and benefits of the project
3. Present the findings for the relevant target group by:
    a. Preparing a report/presentation that will sum up the conclusions, providing a clear overview and recommendations for decision makers, that could be industrial managers (CEO, CFO, CTO etc.) or investors (banks and others).

1.2. Minimum required skills and experience of the trainees

The training program is designed in a way that makes it possible to include it in a future new and reformed total training program for certified energy auditors. Based on a training needs assessment and lessons learned from the Vietnamese Danish Partnership the certified energy auditors and energy managers in general have skills and experiences on i) General knowledge of "cross-cutting" energy technologies (boilers, motors etc. etc.), ii) Fundamental energy technology understanding (calculating energy savings potential), and iii) Financial analysis of a project. And thus, the training program focuses on training in project development and not the more basic understanding of energy and energy consumption.

The minimum required skills and professional experience of the trainees that are expected to participate in the training program on project development is:

- Certified energy auditor or certified energy manager

Professional experience for certified energy auditors:

- At least one (01) year of documented experience with conducting energy audits at Designated Energy User's (DEU's)

Professional experience for certified energy managers:

- Employed as an internal energy manager at a (DEU)
- Minimum one (01) year of experience working with energy management, technical operations, or implementation of energy-related projects within an industrial company

1.3. The 5-day training program – overall structure

The training program is designed as a 5-day training program each day being a full-day program. The program is based on a physical training program to be conducted in a classroom.

The training program will consist of lectures, exercises, and discussions. Especially the trainees will have to work on a common case based on international experiences. During the training the trainees will be introduced to several supporting tools to enable them to make and use a structured and high-quality energy audit. For the trainees to finalize the training program they will have to pass the examination.

The overall structure of the 5-day training programme is:

- Day 1: Energy mapping. Deep dive in why and how to make an energy mapping.
- Day 2: How to use the energy mapping to develop potential technical projects.
- Day 3: Finalize the energy mapping and development of technical projects. Preparing for pre-feasibility study.
- Day 4: Pre-feasibility study. Introduction to feasibility study.
- Day 5: Feasibility study, financing of project. Conclusions on lessons learned and examination.

Preparation

The trainees are expected to study this Background Document that will be provided to them before attending the physical training course.

Section 2: Project development - from energy mapping to final investment decision – methods on technical aspects

This section explains the Danish approach to turning insights from energy mapping into bankable projects. The objective is to keep the technical work data-driven and to let the financial case rest on a solid technical foundation, so that non-technical decision-makers can approve investments with confidence. The section introduces a “road map” that gives an overview from identifying an EE opportunity all the way until a bankable investment project. In later sections each development phase is described further in more detail.

2.1. Mindset: start at the core (the onion diagram)

Project development begins at the core of the process, where energy services are demanded for production. Using the onion diagram mindset, the analyst first examines the need for heating, cooling, compressed air and other services that requires energy, then moves outward to process equipment, and only after this examine the utility systems and site-wide operations. This order avoids treating utilities in isolation and ensures that solutions address the real drivers of energy consumption.

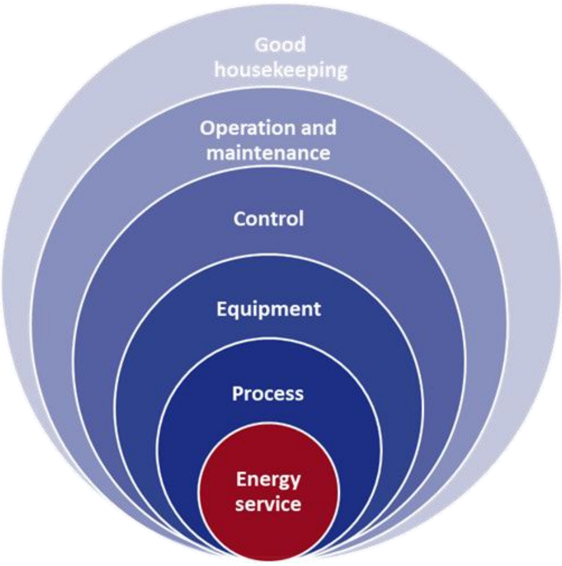


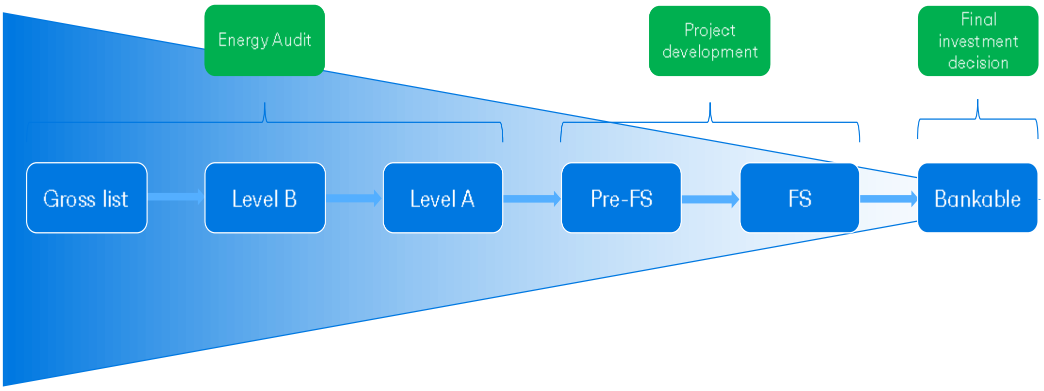
Figure 2-1: The Onion Diagram – It is crucial to start at the core by examine the need for any energy service when investigation possible energy efficiency projects.

The energy mapping provides the first integrated picture of where and why energy is used. Because not every flow can be measured, the first iteration may include reasoned assumptions.
Typical sources of data include meters and BMS data, production records, equipment nameplates, spot measurements, and short campaigns with portable loggers.

Based on the energy mapping and site visits, a gross list of EE opportunities can be created. The gross list should capture all ideas identified during the audit and mapping and will be the basis for starting the project development process.

2.2. The “road map” of project development

An overview of the entire project development process is shown below. The development is divided into six individual steps which can be grouped into three main phases. The triangular shape indicates how the number of opportunities and solutions being considered narrows into one final investment decision.



During the Energy Audit, EE opportunities from the gross list are further developed into Level B (basic) and Level A (advanced) projects based on their potential. The output of the auditing process is a list of project opportunities from which a single project can be chosen for the actual project development phase. This phase starts out with a Pre-feasibility study which will clarify whether the chosen project is the right one in terms of reaching the specific goal set by the company. It is therefore also the first time the technical opportunities from the energy audit are “translated” into more management-ready solutions. The Pre-feasibility study creates the basis for spending additional time (and money) on developing the project further in the feasibility study.

The feasibility study validates the preferred option with site data, refined designs and vendor input. It consolidates the technical case and presents a complete business case: discounted cash-flow analysis, sensitivity tests for prices and production, integration impacts, utility and process control strategies, and an implementation plan with timeline, responsibilities, permitting and commissioning needs. Non-energy benefits are quantified where possible, such as quality improvements, throughput gains, maintenance reductions, or safety and environmental benefits. Findings must be framed for management so that a final investment decision can be made with great confidence.

Following this roadmap keeps the analysis systematic, connects technical engineering to financial decision-making, and increases the likelihood that strong ideas progress from energy mapping to a final investment decision.

Section 3: Energy Audit

3.1. Introduction

The regulation mandates regular energy audits for Designated Energy Users (DEUs) to identify potential energy-saving projects. However, the impact of these audits has been limited due to a lack of clear methodology. The DEPP3 program has introduced a systematic approach to energy audits, which has proven effective in identifying diverse energy efficiency projects. Key elements of the EA methodology include a DEU strategic perspective, energy mapping, project identification, inclusion of non-energy benefits, and a summary of findings.

The EA guideline for intensive industries in Vietnam, developed by the Ministry of Industry and Trade and the Danish Energy Agency, aligns energy audits with international best practices, especially when funded by Danish companies. Key methodologies include challenging energy service needs, creating energy balances, performing Level-2 mappings, exploring heat recovery schemes, assessing large fan and pumping systems, evaluating Best Available Technology solutions, improving maintenance procedures, and implementing robust energy management systems and KPIs. The guideline also outlines the essential contents of an energy audit report, including a summary of findings, in-depth analyses of energy demands, supply capacity, and potential energy-saving solutions.

3.1.1. Definition of energy audit

An energy audit is a systematic study to determine the quantity and cost of each form of energy consumed by a facility, process, manufacturing unit, piece of equipment, or site over a specified period. It involves an inspection, survey, and analysis of energy flows to identify opportunities for energy savings without negatively affecting outputs. The primary objective is to help industrial companies or facilities understand their energy usage, pinpoint areas where waste occurs and discover opportunities for improvement. It can also evaluate the effectiveness of existing energy efficiency projects or programs. For the audited facility, the overall objective is to support the outlining of an action plan to achieve higher energy efficiency or lower energy costs, or both.

In Vietnam, energy auditing is essential for counteracting rising energy prices, particularly electricity, reducing manufacturing costs, lessening pollutant emissions, and conserving energy resources. The Law No. 50/2010/QH12 on Energy Efficiency and Conservation (EE&C), approved on June 17, 2010, made energy audits mandatory for state-owned agencies and intensive energy-consuming enterprises. This includes industrial facilities with annual energy consumption of 1,000 Ton of Oil Equivalent (TOE) or more, and commercial entities with annual consumption of 500 TOE or more. These organizations are required to develop a plan to conduct energy audits in accordance with existing regulations and procedures to identify energy-saving opportunities. The law is currently under revision and a new law is expected to be in force during 2026.

3.1.2. Types of energy audit:

Audits Based on the function, size, industry type, desired depth of the audit, and potential for energy savings, industrial energy audits can be classified into two main types: preliminary energy audits (walk-through energy audits) and detailed energy audits (diagnostic energy audits). Normaly, walk-through energy audit is implemented before decide conducting Detailed Audit (if needed). The other Audit methodology may also categorize audits into walk-through, standard, and simulation audit operational levels.

3.1.2.1. Preliminary Energy audit (Walk-through Energy Audit):

- Primarily uses readily available data for a simple analysis of energy use and performance.
- Requires minimal measurement and data collection, making it relatively quick to complete (on-site only several days and often about 1-3 days).
- Provides general results, highlighting common opportunities for energy efficiency.
- Economic analysis is typically limited to calculating the simple payback period, which is the time required to recoup the initial capital investment through energy savings.

Advantages:

- Quick to complete due to minimal measurement and data collection.
- Provides general results and common opportunities for energy efficiency.
- Economic analysis is typically limited to simple payback period calculations, making it straightforward.

Challenges:

- Results are general and may not provide in-depth analysis.
- Limited to easily identifiable and low-cost opportunities.
- Accuracy may be lower due to reliance on readily available data and minimal measurements.

Steps Involved:

- **Introductory Meeting:** Begins with a meeting with industry management to understand the industry, major processes, and align on audit goals. Historical energy consumption (electricity and fuel bills for 12 months) and corresponding production data are collected.
- **Walk-through:** An on-site tour with plant personnel to identify key issues, gather input, record observations, note nameplate and meter readings, and identify low-cost, easily implementable energy-saving measures.
- **Closing Meeting:** A brief wrap-up meeting to review observations, highlight immediate concerns, and set a date for report presentation.
- **Analysis & Report Preparation:** Analyze collected data and notes to prepare energy-saving recommendations. Recommendations should be specific, supported by data, and prioritize based on monetary savings or shortest payback period. Estimated costs, savings, and simple payback calculations are included.
- **Report Presentation and Action Plan:** Present the report to management, explaining recommendations and helping to prepare an action plan with timelines for implementation.

Expected Outcomes:

- Identification and basic evaluation of low-cost opportunities that can be easily implemented.
- Improved awareness of energy costs and potential benefits of energy management.
- Understanding the extent of more capital-intensive opportunities.
- Indications of potential savings and benefits from undertaking more detailed investigations.
- Preparation of a more effective audit plan for subsequent targeted or detailed audits.

3.1.2.2. Detailed Energy Audit (Diagnostic Energy Audit):

- Requires more detailed data and information.
- Involves measurements and a comprehensive data inventory, with detailed assessment of various energy systems like pumps, fans, compressed air, steam, and process heating.
- Takes longer to complete than preliminary audits (onsite period can last form weeks to months).
- Yields more comprehensive and useful results, providing a more accurate picture of the plant's energy performance and specific recommendations for improvements.
- Economic analysis typically extends beyond simple payback to include other methods like net present value or life-cycle cost analysis.

Advantages:

- Yields comprehensive and accurate results due to detailed data collection and analysis.
- Provides specific and actionable recommendations for improvements.
- Allows for in-depth economic analysis beyond simple payback.
- Can identify complex interdependence and systemic inefficiencies.

Challenges:

- More time-consuming and resource-intensive due to extensive data collection, measurements, and analysis.
- Requires specialized expertise and instrumentation.
- Higher cost compared to preliminary audits.

Steps Involved:

- **Scoping (Energy Audit Planning):** Scoping is a crucial preliminary step that defines the parameters and objectives of the energy audit (Define the scope, boundaries, and objectives of the audit…). This involves agreeing on the level of detail, time period, criteria for evaluating opportunities, and resources required. Preliminary information and historical data are collected.
- **Energy Mapping (to be started before the walk-through):** Energy mapping involves systematically understanding how energy flows through the facility, beginning even before the on-site walk-through.
  - **Preliminary Data Collection:** Gathering historical energy consumption data (electricity and fuel bills for at least 12-24 months) and corresponding production or activity data. This also includes site plans, building layout drawings, and inventories of major plant and equipment.
  - **Initial Analysis:** Constructing a preliminary flowchart to show overall energy flows, identifying unit operations, important process steps, areas of material and energy use, and sources of waste. This helps to get a general picture of the plant's energy use, operation, and losses, and may lead to adjustments in the audit plan.
  - **Understanding Energy Inputs and Outputs:** Listing all energy inputs (purchased and otherwise, like electricity, fuel, steam) and outputs (like flue gas, water to drain, vented air), including less obvious flows such as heat loss through the building envelope.
  - **Energy Accounting:** Quantifying energy streams into discrete functions and determining unit energy cost and trends
- **Walk-through: as presented in section 3.1.2**
- **Measurement Plan:** Develop an agreement for on-site data measurement, including measurement points, equipment, accuracy requirements, duration, frequency, and responsibilities.
- **Conducting the Site Visit:** Observe energy uses, evaluate consumption, understand the impact of routines and behavior, and generate preliminary ideas for improvement. Measurements are taken, and past data are verified to be representative.
- **Analysis (using the Mapping and other information gained before and after the walk-through):** Evaluate the validity of data, use transparent calculation methods, and document assumptions. This phase establishes current energy performance, breaks down consumption by use and source, and identifies improvement opportunities based on expertise, design options, operating conditions, technology, and best practices. Opportunities are evaluated for energy and financial savings, investment, and non-energy gains.
- **Develop possible projects:** This step focuses on creating a comprehensive, prioritized list of implementable energy efficiency solutions with clear justifications.
- **Energy Audit Reporting:** Prepare a comprehensive report detailing audit findings, including measurements, analysis, assumptions, and a prioritized list of energy performance improvement opportunities with suggested implementation programs.
- **Presentation to the management of the industry (Closing Meeting):** Present the audit results to the organization, explain findings, and address questions.

The final presentation is critical for ensuring that the audit results lead to action and successful implementation of energy efficiency measures.

Expected Outcomes:

- More comprehensive and useful results, providing an accurate picture of the plant's energy performance.

- Specific recommendations for energy efficiency improvements.
- Economic analysis extending beyond simple payback to include Net Present Value (NPV) and Internal Rate of Return (IRR).
- Detailed technical and financial assessments of relevant investment projects.

3.1.3.Advantages and Challenges to Energy Audit Implementation in Vietnam

3.1.3.1. Advantages

- **Legal Mandate:** The Law on Energy Efficiency and Conservation (EE&C) makes energy audits mandatory for intensive energy-consuming enterprises, driving implementation efforts.
- **Rising Energy Prices:** Increasing electricity prices and fuel costs provide a strong financial incentive for industries to identify and implement energy-saving measures.
- **Reduced Manufacturing Costs:** Energy audits help pinpoint inefficiencies, leading directly to lower operational costs and increased competitiveness for businesses.
- **Environmental Benefits:** By reducing energy consumption, industries can lessen pollutant and greenhouse gas emissions, contributing to environmental protection and climate change mitigation goals.
- **International Alignment:** Guidelines like the one provided help align Vietnamese energy audit practices with international best practices (e.g., ISO 50001, ISO 50002), which can attract foreign investment and partnerships.
- **Potential for Non-Energy Benefits:** Beyond direct energy cost savings, audits can identify benefits such as increased production capacity, improved product quality, reduced maintenance costs, enhanced workplace comfort, and compliance with corporate social responsibility goals (see examples below).

3.1.3.2. Challenges

- **Lack of Awareness and Ownership:** Despite mandates, some companies may lack full awareness or internal ownership of energy efficiency, viewing audits merely as a compliance exercise rather than a strategic tool.
- **Data Availability and Quality:** Companies often lack adequate energy metering infrastructure, leading to reliance on estimated or aggregated data rather than precise measurements, which can affect the accuracy of audit findings.
- **Technical Expertise:** While the guideline emphasizes involving experts, finding or training in-house personnel with specialized knowledge in complex industrial processes (e.g., food & beverage, chemical, pharmaceuticals) and advanced energy management techniques can be a challenge.
- **Financial Constraints:** Implementing recommended energy-saving measures, especially those requiring significant capital investment (e.g., BAT solutions), can be challenging for businesses, particularly Small and Medium-Sized Enterprises (SMEs).
- **Integration with Existing Systems:** Integrating energy management into existing business processes and other management systems (e.g., quality, environmental) can be complex and require significant organizational effort.
- **Monitoring and Verification:** Ensuring sustained energy performance improvement requires robust monitoring and verification protocols post-audit, which can be challenging to implement and maintain without dedicated resources and expertise.
- **Behavioral and Cultural Resistance:** Achieving energy efficiency often requires changes in operational routines and employee behavior, which can face resistance within an organization.

3.2. DE3 Guideline on Energy Audit

3.2.1. Annotated Energy Audit Report

This guideline follows the main sections of an energy audit as defined in Circular 25, see Table 3:1 below, that also includes a few requirements described later in the guideline.

Content of audit report	Requirements
Chapter 1: Summary	
Summary of results from audit	Overall annual energy consumption data and costs should be presented A table with identified energy efficiency projects, related savings and investments and payback-period. The identified energy efficiency projects shall be given priority and should be ranked in terms of importance Proposed further steps should be described
Chapter 2: Introduction	
Introduction to the energy audit	Overall company information (name, address etc.) Break down of company structure and production modes Definition of scope and success criteria for the energy audit
Chapter 3: Affairs of the company	
Overall history of the company, their products and operating data	Annual production outputs Overall annual energy consumption (3 years) Overall assessment of focus areas for energy audit and necessary competences and specialists to involve
Chapter 4: Description of procedures in technology processes	
Introduction to manufacturing process and production equipment	Principle diagrams for significant energy users Flow diagrams for production flow and energy usage
Chapter 5: Energy demands and supply capacity	
Mapping of energy consumption and breakdown of energy usage	Equipment lists, significant energy users Breakdown of energy usage by end-use
Chapter 6: Financial – technical obligations	
Economic framework for energy efficient solutions	Energy prices and relevant taxation Legal framework for energy efficiency

	Fuel and energy data
Chapter 7: Energy-saving solutions	
Assessment of energy efficiency potentials	Technical analysis of saving potentials via a variety of methodologies Technical and financial assessment of relevant investment projects Overview of non-energy benefits Proposal for energy management systems and KPI-structures

Table 3:1: Checklist of requirements for energy audits

The column "Requirements" in the table above is described in detail in relevant sections below.

In this guideline, mainly methodologies for identifying energy saving solutions (section 3.2.8) is expanded, but also in other sections, additional requirements are added.

3.2.2.Summary

Below, a few additional requirements to the summary of the energy audit report is described.

3.2.2.1. Annual energy consumption, costs and CO_2-emissions

A table with overall annual production outputs and overall energy usage should be present for the past 3 years so as overall trends in energy consumption can be understood. The overall energy consumption should also include any use of biomass.

Also, overall annual costs for energy should be presented as well as annual CO_2-emissions.

3.2.2.2. Recommended energy efficiency projects

In addition to direct investments projects as stipulated in circular 25, recommendations from an energy audit can concern other aspects of energy efficiency, by example:

- Further analysis to investigate certain complicated areas in more detail
- Improved maintenance procedures for significant energy users
- Better use of energy management procedures and energy-KPIs
- Etc.

Such recommendations should be considered in the overall assessment of energy efficiency potentials.

It should be stated which CO2-emission reductions the individual energy efficiency projects can achieve.

It should be described which non-energy benefits that have been identified during the energy audit – if any (see Annex 3.2 for an overview of non-energy benefits).

3.2.2.3. Further steps

The report shall describe recommended further steps and conclude for which areas pre-feasibility and feasibility studies is to be elaborated in order to prepare the company management for Final Investment Decisions (FID) for significant energy efficiency projects.

Recommended suppliers to be involved in further work to assess precise investment levels should be identified.

3.2.3.Introduction

Next to immediate description of the company, the following sections should be added:

3.2.3.1. Scope of the energy audit

It shall be clearly described which motivation the management of the company has to participate in the energy audit, by example:

- Is CO_2-neutrality an important parameter for success of the energy audit? – does the company have a strategy to reduce CO_2-emission – is phase out of fossil fuels a key question to investigate?

- Are clients to the company requesting action to reduce energy consumptions and CO_2-emissions? – is supply chain questions important in the management's priority of investments

- Are non-energy benefits like increase of production capacity or improved product quality important parameters when assessing benefits from energy efficiency projects

Such questions are important to clarify and describe in order to secure ownership to the energy audit at management level.

3.2.4.Affairs of the company

From the description of the company and the products it produces, overall focus areas to improve energy efficiency should be assessed and details of the energy audit planned.

3.2.4.1. Competences and organization of the energy audit

For many companies, a majority of the energy saving potentials is to be found inside the production processes and not equally important in related utility systems. The energy audit team must include experts with knowledge and experience of the main energy consuming processes in the enterprise audited. In addition, the people responsible for the processes in the industrial enterprise should be involved in the energy audit.

The relevant experiences of the audit team as well as the inclusion of relevant operation and management staff in the industrial enterprise must be documented in the report.

3.2.5.Description of procedures in technology processes

The energy audit report must include details of how the production processes takes place in the company as well as the utility systems like steam boilers and compressed air systems. Depending on the context, the description must be supported by diagrams.

3.2.5.1. Simple process flow diagrams

Flow diagrams can be simple diagrams following the production flow including main components like furnaces, conveyors, silos etc. This will most often be enough for relatively simple production flows in by example cement industry, in brick production etc.

Simple production flow diagrams shall be supplied with illustrations for the main components in the plant, by example for furnaces and driers etc. like illustrated in Figure 3-1 below.

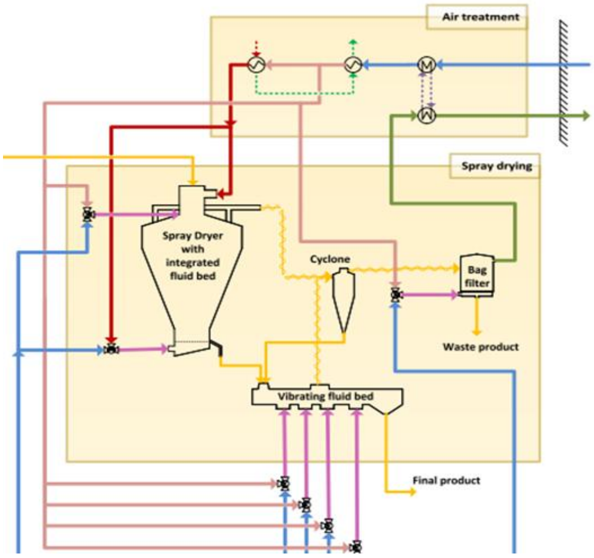


Figure 3-1: Example of a process flow diagram for an individual process (spray dryer)

Such diagrams provide a good understanding of the energy flows and often also of important process parameters like air flows, temperatures etc.

3.2.5.2. Advanced process flow diagrams

For sectors like food & beverage, chemical industry and pharmaceuticals etc., the production flow is much more complex and the energy usage distributed across many different end -users. In such companies the production flow should be described in more detail to provide an understanding of how energy is used at the facility.

Figure 3-2 below shows a complete production flow diagram for a milk processing plant illustrating all product mass flows and supplied heating and cooling in the individual steps of the process.

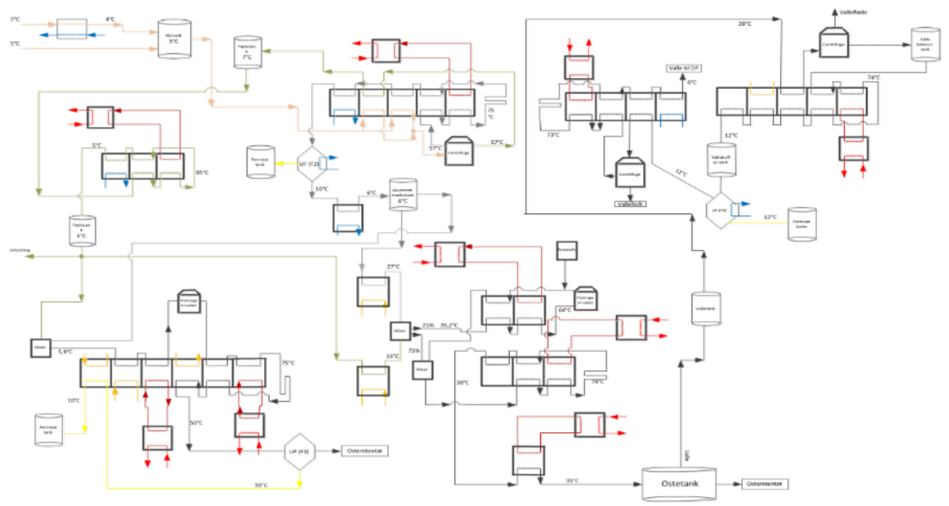


Figure 3-2: Example of an overall production flow sheet for a dairy plant including hot and cold utility

Such detail is important to understand the overall energy balance of the facility and assessing potentials for recovering heat between individual process steps.

3.2.5.3. Screen dumps from control rooms

Often screen dumps from control rooms (process supervision) provides valuable information on specific process parameters, see the example in Figure 3-3 below.

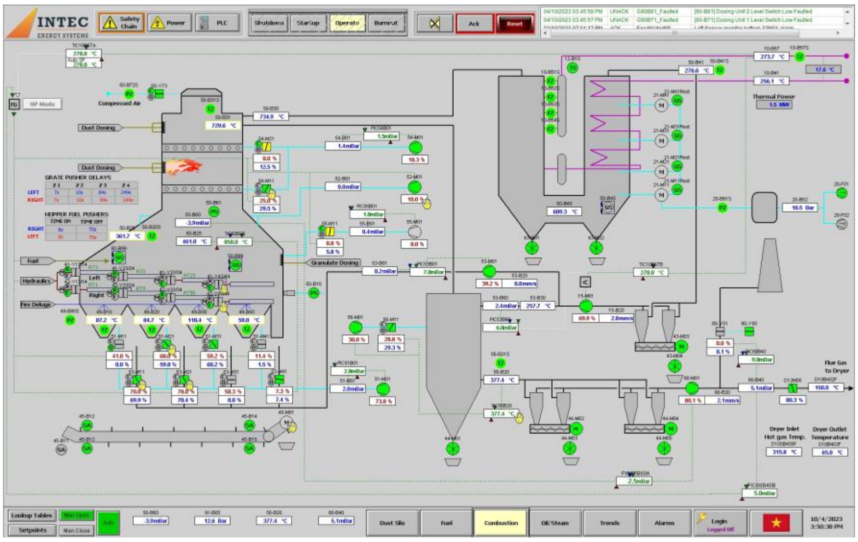


Figure 3-3: Example screen dump from control room

Such information shall be included in the energy audit report.

3.2.6. Energy demands and supply capacity

A good understanding of the present energy usage is crucial for identifying any relevant energy efficiency project.

3.2.6.1. Equipment lists

As a part of the energy audit, tables with design and capacity data for the most important installations must be prepared, first of all for:

- Boilers
- Refrigeration systems
- Large exhaust fan systems (>25 kW)
- Large air-conditioning systems (>25 kW)
- Compressed air systems
- Process equipment and other equipment with installed capacity > 25 kW)

For each of such systems, the following data should be provided:

- Installation ID
- Name of manufacturer
- Year of installation
- Design capacity
- Rated efficiency (where relevant)
- Operating parameters (flows, temperatures, pressures etc.)

It is important that this mapping not only targets energy supply systems but also collects data for major processes.

3.2.6.2. Significant energy users

In addition to requirements set out in Step 4 of Annex III of Circular 25, energy and water consumption must be broken down into categories of significant energy users. A significant user may be one particular installation, a set of installations forming a specific manufacturing process (such as paper machine) or a number of installations of similar category (such as lighting; ventilation etc.)

From the initial mapping of equipment, it should be determined which energy users in the facility that should be considered as "significant". Any installation or category of installations consuming more than 5% (?) of the total energy consumption must be mapped.

Examples of such significant end-users is listed in Table 3:2 below.

Thermal end-users (steam, hot water etc.)	Electrical end-users	Water end-users
– drying – process heating – evaporator lines – boiling – distilling – kilns & furnaces – building heating/HVAC – CIP/SIP – water heating – conversion losses – distribution losses	– refrigeration – natural cooling – compressed air – process air – fans/HVAC – air-conditioning – production machinery – pumps – hydraulics – small motors – lighting	- process (additives) - steam injection (heating) - water for injection (WFI) - RO-plants - humidification of air - cleaning of premises - CIP/SIP - condensate losses - cooling towers - showers - accommodation

Table 3:2: Examples of significant energy and water users in the industrial sector

For companies with high water usage, also significant water end-users should be identified as much energy usually is bound into heating, cooling and evaporation of water.

3.2.6.3. Overview of energy consumption by end use

Companies always lack energy meters to monitor a precise distribution of energy usage, both in terms of thermal energy usage, electricity usage and other resources like for example water.Mapping of energy consumption should to the extent possible be based on existing meters. In the absence of meters, a significant element of energy audit work shall therefore be to calculate an estimated distribution of energy end-users.

Assessment of end-uses not covered by the strategic spots of measurements in Step 5.1. of the circular, energy consumption should be assessed from the following parameters:

- Installed capacity (kW)
- Estimated load factor (%)
- Annual run-hours (hours)

From such calculations, the importance of significant end-users of energy (Table 3:2 above) can be assessed and tables or pie-charts for usage of thermal energy, electricity and water can be estimated.

3.2.7.Financial - technical obligations

For each technical solution proposed, in addition to technological and environmental issues, also other significant non-energy benefits, such as implications on production output capacity, product quality, operational costs etc. must be described. If feasible, the financial implications of these benefits must be quantified, and the value must be included in the financial assessment. A list of frequently observed non-energy benefits is shown in Annex 2.

3.2.8.Energy saving solutions

The analysis of energy consuming processes should follow the approach illustrated in the below onion diagram. Each step must be considered, and a conclusion of the findings must be reported.

3.2.8.1. Challenging the energy service

An advanced understanding of the energy consumption in a company can often be described via the "onion diagram" illustrated below.

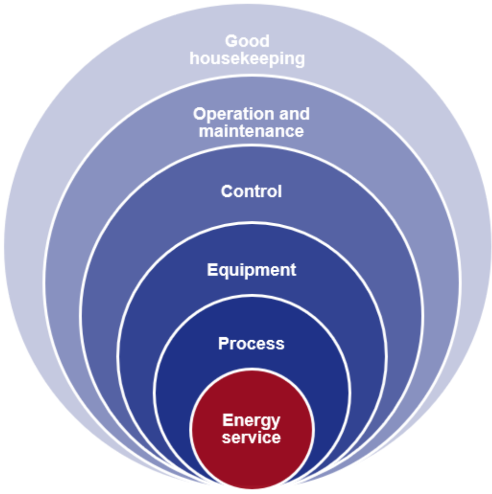


Figure 3-4: The "Onion diagram" for advanced understanding of energy consumption.

This diagram illustrates, that for any significant energy user there is a reason for why significant amounts of energy is needed, by example:

- For large fan- and ventilations systems, the energy service by example can be:
    - A need for cleaning air in combustion areas via air change and filtration of air
    - A need for maintaining a fair working environment in terms of temperature and humidity

- For autoclaves, the energy service by example can be:
    - Sterilization of product
    - Heat treatment of product

- For large furnaces, the energy service by example can be:
    - Drying of a product
    - Chemical processing of a product (by example sintering or calcination)

The basic idea of understanding the energy service is that the need for this sometimes can be challenged – if by example an air change rate is reduced, then the demand for energy is reduced similarly.

An example such a discussion is illustrated in Figure 3-5 below for the milk reception in a dairy.

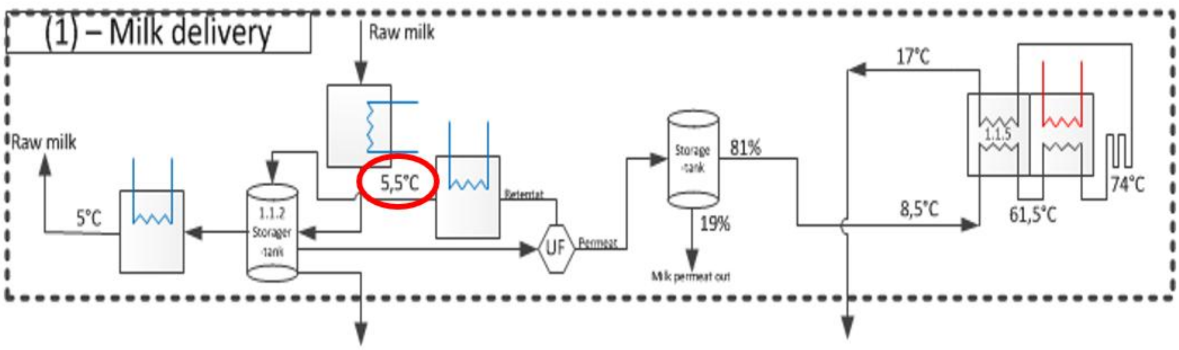


Figure 3-5: Target temperatures in the milk reception-section of a dairy.

The example shows that all milk received in the dairy by tradition is cooled down to a target temperature of 5.5°C (or even lower), which can lead to the following questions:

- Is the target temperature the same for all products received?

- Is the target temperature the same for all products to deliver?

Such questions might be difficult to answer and bounded in SOPs (Standard Operational Procedures) and any further dialogue should be taken with key-staff in the company able to make decisions on any change of SOPs. The benefit can best-case be that SOPs can be changed and energy savings achieved without any investment.

The energy auditor shall in the energy audit report present an understanding of these questions, ie. for the most significant energy users it shall be described which overall process parameters that defines the energy consumption. It should further be assessed if these parameters can be challenged and with which benefit.

3.2.8.2. Energy balances – Sankey diagrams

For the most significant energy users, an energy balance should be established to illustrate the total energy balance and which losses that occur in the operation. The energy balance must quantify all energy and mass flows to and from a certain process. The energy balance should be represented in a diagram such as a Sanky diagram like illustrated below for a drying process in a paper mill.

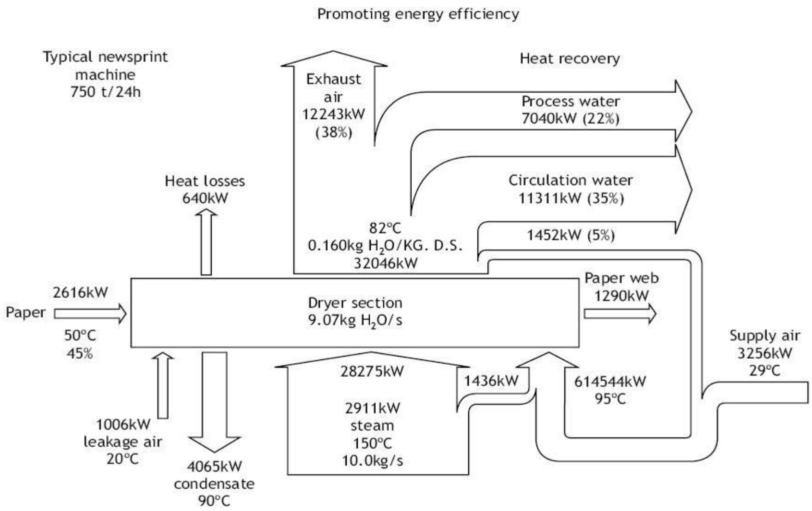


Figure 3-6: Example of Sankey diagram of the energy balance of a drying process

The benefit from such an analysis is a throughout understanding of the losses in operation and by that an assessment of the efficiency of the process. The analysis can further identify possible opportunities to recover waste heat into the process in order to reduce energy consumption.

Reduction of losses or opportunities for waste heat recovery should be assessed in the energy audit report

3.2.8.3. “Level-2”-mapping

In case of processes, where there can be observed large temperature differences between the source and the sink of heating or cooling (for example the temperature difference between the steam supply and the air heated by the steam), the energy audit must perform a level-2 mapping. The purpose of this is to identify potential energy savings potentials through modification of processes or the energy supply systems.

Especially in sectors like food & beverage, chemical industry and pharmaceuticals, it is often seen widespread heat and cooling distributions systems supply heating and cooling to many areas of the facility, with widely different requirement for temperatures – by example steam at 8 bars and 160°C can be used for heating of low temperature heat demands – by example heating of cleaning water or process water to 60°C.

Similarly, it is seen that high quality cooling – by example glycol at minus 6°C – is used for cooling of high temperature cooling demands – by example cooling hydraulic oil at 60°C.

It is important to understand that such large differences in delta-T, i.e. differences in process demand-temperature and delivered utility-temperature, can represent significant energy saving potentials.

To enable such an understanding, companies with such energy supply patterns should carry out a “level-2”-mapping, where any thermal energy demand (heating and cooling) should be mapped by energy demand and temperatures like illustrated in Table 3:3 below.

Process	Temperature Start (°C)	Temperature Target (°C)	Amount (kg/year)	Heat capacity (KJ/kg/°C)	Heat demand (KJ/year)
1					
2					
3					
4					
5					
Etc.					
Total					

Table 3:3: Data to collect in a level-2-mapping.

The data collection should further collect data for waste heat ventilated to the surroundings, by example hot exhaust from a furnace or a dryer and categorize these as a cooling demand in Table 3:3 above.

The idea of such a data collection is two-fold:

- To assess whether the current energy supply structures is energy efficient
- To assess whether heat recovery relevant option for the company

To illustrate such potentials, a temperature vs. load-curve as illustrated in Figure 3-7 below should be established.

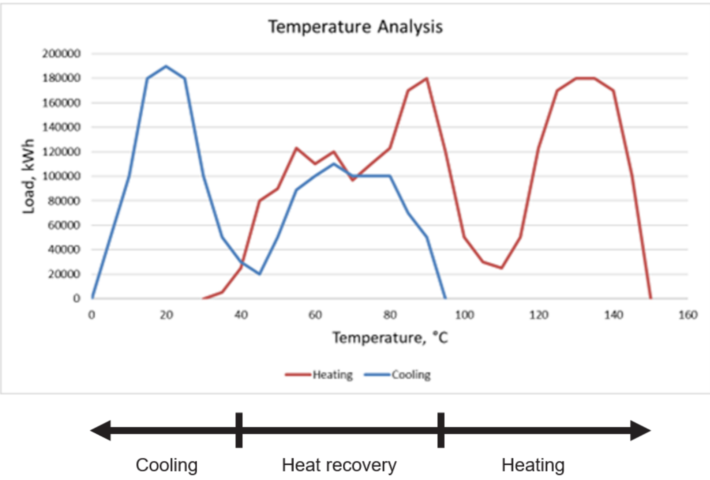


Figure 3-7: Example temperature/load-curves for cooling demand (blue) and heating demand (red)

This figure shows all heating demands (red) and cooling demands (blue) in a facility integrated into 2 curves by temperature and load. Overlaps in temperatures can be illustrated in such Figure 3-8– in this case indicating a significant potential to recovery heat and thus save hot and cold utility.

3.2.8.4. Utility structures

The understanding of hot utility requirements with the Level-2-mapping can also be illustrated in a diagram like below

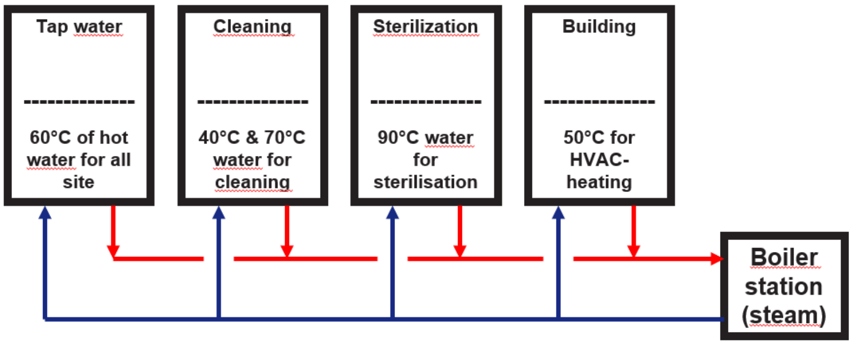


Figure 3-8: Example how hot utility is supplied across a facility.

In cases where steam is used for many heating demands at low temperatures (< 100°C), the following options to save energy shall be considered:

- Will a hot water system be much more efficient to operate?
- Can heat pumps – eventually driven with solar PV – supply hot water to significant energy users?
- Can waste heat be used to cover certain energy demands

For cooling demand, similar analysis should be performed like illustrated in Figure 3-9 below.

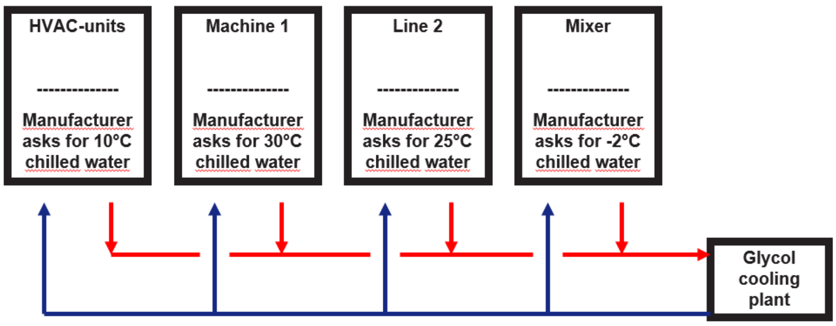


Figure 3-9: Example how cold utility is supplied across a facility

In cases, where cooling like brine or glycol at temperatures < 0°C is used for many cooling demands across the facility, the following options to save energy shall be considered:

- Can separate cooling systems at higher temperature – by example +6°C - be applied?
- Can natural cooling (cooling towers) be applied to cover certain cooling demands at high temperature?
- Can internal heat recovery reduce the demand for utility cooling?

Such opportunities are described further below.

3.2.8.5. Heat recovery schemes

In most facilities heat recovery schemes represent significant energy saving potentials and overall, the following options are to be considered:

- Improved efficiency of already existing heat recovery systems
- Installation of new heat recovery systems internal at significant energy users
- Heat recovery systems across multiple energy consumers

The first of these options address the fact that many existing heat recovery systems have bad performance – either because of fouled heat exchangers with poor heat transfer or because of significant change in operating parameters – by example flows – since the original installation.

The second of these options address the fact that many unit operations/processes have been designed without heat recovery thus impairing the efficiency of the process significantly.

The third option addresses the fact that many industries have waste heat available at many sources across the site and that a collection of these waste heat streams can cover a significant part of the heat demand (heat demands below by example 60°C).

In annex 3, some examples of such solutions are presented.

3.2.8.6. Large fan and pumping systems

In certain sectors like cement, iron & steel, paper & pulp and chemical industry (fertilizers) comprehensive fan- and cooling water systems are operated. Such systems are often complex and with low efficiency, which shall be assessed carefully.

For large fans like the one shown in Figure 3-10 below, the control strategy as well as the total fan efficiency must be assessed – often such fans are old with low design efficiency and often the capacity is controlled with dampers and not efficiently with VSDs.

Figure 3-10: Large exhaust fan in an iron & steel industry

Figure 3-11 below shows the benefit from controlling capacity of fans and pumps with VSD vs. damper-control.

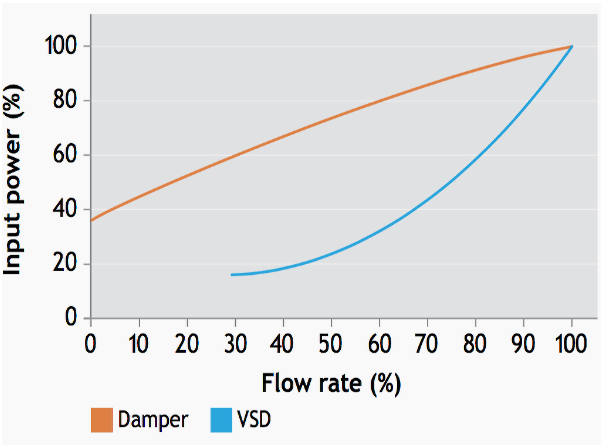


Figure 3-11: Efficiency of damper- vs. VSD-control for large fans and pumps.

For large cooling water systems like the one shown in Figure 3-12 below, the situation is the same.

Figure 3-12: Cooling water system in an iron & steel industry

For such large cooling water systems, a careful comparison of delivered cooling and consumed electricity for fans and pumps should be monitored continuously and the COP-system shall be calculated and mapped over longer time-spans as illustrated in Figure 3-13 below.

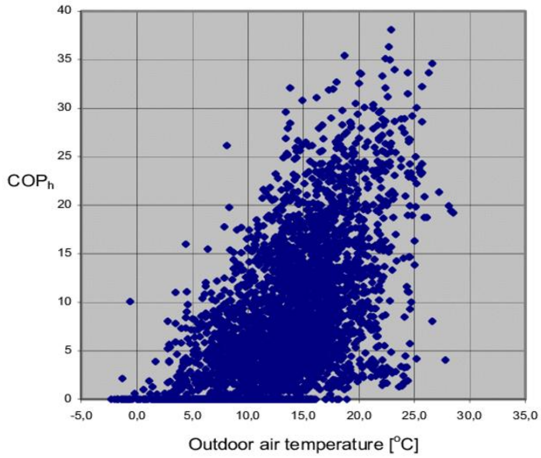


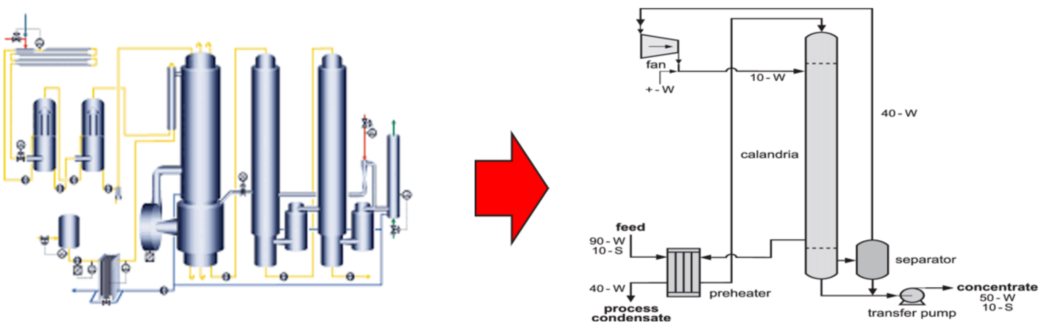
Figure 3-13: COP monitored for large cooling tower system

The benefit from such COP-surveillance is that large variations in system efficiency can be discovered thus identifying large potential energy savings via better control of fans and pumps.

3.2.8.7. BAT-assessments

A throughout understanding of Best Available Technology (BAT) can provide important information on potential energy savings in existing plants.

Detailed information on BAT-solutions can be found in the link to the European Union's BAT-library provided below[2] and illustrated with an example below.



Thermal vapour recompression (TVR)

Mechanical vapour recompression (MVR)

[2] *https://eippcb.jrc.ec.europa.eu/reference*

Figure 3-14: Traditional and BAT-solutions for evaporator systems.

In Figure 3-14, a traditional evaporator system (TVR) is illustrated on the left side and a best-practice MVR-plant is illustrated on the right side – a solution that via electrification might save up to 80% of the supplied energy.

It is important to stress that BAT-solution often will address the core unit operations in a facility and therefore is to be considered as a major and very expensive rehabilitation of these. Such changes are most often only possible if other benefits than energy savings can be achieved, by example increase production capacity, improved product quality, better flexibility of operation etc (see Annex 2 for an overview of “non-energy”-benefits.

It is requested that the energy auditor during the initial phases of the energy audit identifies any need to address non-energy benefits of the facility and then address opportunities for BAT-solution from conclusions in this area.

3.2.8.8. Maintenance procedures

The sections above have mainly addressed more complex assessments of process energy usage and it should be emphasized that most industries have significant energy saving potentials simply via improving maintenance procedures for the most important energy users, by example:

- Regular control of boiler efficiency (02-% and temperature in exhaust gas)
- Repair or installation of missing insulation at all hot surfaces (piping, valves etc.)
- Repair of leaks in compressed air piping systems
- Cleaning of fouled heat exchangers
- Monitoring of water content in ammonia in refrigeration systems
- Removal/purging of air in condensers in freezing plants
- Repair of steam traps in steam distribution systems
- Etc.

The energy audit must assess if such simple improvements will provide significant energy savings in a company.

3.2.8.9. Operational control and KPIs

Added for related section of DEPP 3’s document

Key Performance Indicators (KPIs), in the context of energy management are referred to as Energy Performance Indicators (EnPIs), are crucial for monitoring and driving energy performance improvements. KPIs are quantifiable measures used to track and assess an organization's performance in achieving its operational and strategic objectives. In the context of energy management, energy KPIs specifically measure energy-related performance, including energy consumption, energy efficiency, and progress towards energy targets.
An EnPI is a measure used to quantify energy performance. If an EnPI is used to demonstrate energy performance improvement, it relates to energy efficiency or energy consumption. EnPIs can be calculated using an energy model, a simple metric, or a ratio. They help establish and quantify improvements in energy performance and identify situations where performance deviates from expected values. Organizations define their own EnPIs. Along with EnPIs, Energy Baselines (EnBs) are crucial. An EnB is a quantitative reference for comparing energy performance. An EnB is based on data from a specified period or conditions. Energy performance improvement is measured as an improvement in measurable results of energy efficiency or energy consumption related to energy use, compared to the energy baseline. Relevant variables that affect energy consumption and efficiency should be considered when evaluating energy performance under equivalent conditions, often through normalization. These concepts are central to ISO 50001 (Energy Management Systems) and further detailed in ISO 50006, which focuses on measuring energy performance using EnBs and EnPIs.

Importance of Energy KPIs:

- **Performance Tracking:** KPIs provide a clear and measurable way to track energy performance over time, identify trends, and detect anomalies.
- **Decision-Making:** They offer data-driven insights for management to make informed decisions regarding energy investments, operational adjustments, and resource allocation. The operational KPI’s can also be used by process operators to adjust the process to be aligned with the specific KPI.
- **Goal Alignment:** KPIs link energy management efforts directly to organizational objectives and energy targets, ensuring alignment and accountability across different levels of the company.
- **Motivation and Awareness:** Visible KPIs can raise awareness among employees and motivate them to contribute to energy-saving initiatives and operations.
- **Benchmarking:** Energy KPIs enable internal and external benchmarking, allowing comparison of performance against industry best practices, other facilities, or “last years” performance.

Examples of Energy KPIs:

- **Specific Energy Consumption (SEC):** Energy consumed per unit of production (e.g., kWh/ton of product, kWh/batch of product, kWh/production line, MJ/m³) or other references (e.g. time (kWh/hour)). This is a widely used KPI for industries to normalize energy use against output.
- **Energy Intensity:** Total energy consumption per unit of area (e.g., kWh/m² for buildings).
- **Coefficient of Performance (COP):** For refrigeration and HVAC systems, the ratio of cooling/heating output to energy input (e.g., TR/kW).
- General System/Component Efficiencies: The overall efficiency of a system can be considerably lower than the sum of individual component efficiencies due to various losses within the system, such as electrical resistance in distribution systems, friction in motors and bearings, fluid and mechanical friction in pumps, and losses in valves and piping networks
- **Power Factor (PF):** A measure of how effectively electrical power is being converted into useful work. Improving PF can reduce energy losses and utility charges.
- **Waste Heat Recovery Rate:** Percentage of waste heat recovered and reused in processes.
- **Energy Cost per Unit of Production:** Financial KPI linking energy expenditure to output.
- **GHG Emissions per Unit of Production:** Metric for environmental performance related to energy use.

For detailed guidance on developing and applying energy KPIs and baselines, refer to ISO 50006, "Energy management systems – Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI) – General principles and guidance".

During the course of an energy audit, is shall therefore be identified if losses from inefficient operation of processes and utility systems occur and how such losses can be prevented.

It shall further be assessed if technical instrumentation and automation systems can prevent these losses or whether specific groups of personal employed in the facility should be trained, by example:

- Operators in control rooms responsible for daily operation of the processes
- Personal responsible for cleaning of equipment and process installations
- Process people responsible for adjusting process parameters
- Etc.

Figure 3-15 below show an example of the operating pattern for a large evaporator system with indication of how many hours each day the evaporator is processing product (blue), is under clearing (pink), is operated “water-mode” without product but with full energy consumption (green) etc.

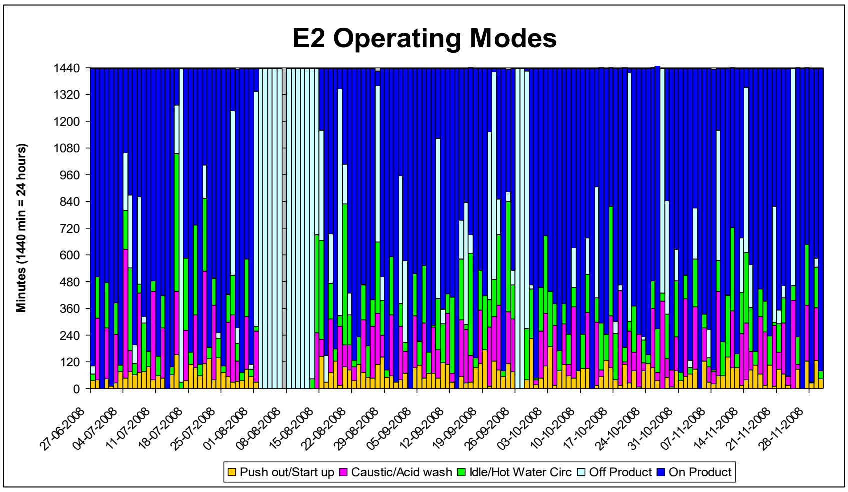


Figure 3-15: Example of operating modes in large evaporator systems.

A detailed analysis of this diagram shows that operators often clean the evaporator system much to many hours per days and that the evaporator often is operated long hours in “water-mode” – in both cases with significant losses of used energy.

3.2.8.10. Energy Management Systems

Organization of energy management shall be proposed including identification of relevant staff requirements to cover the necessary positions (e.g. energy managers, boards for energy management).

A proper organisation of an energy management system should further most likely involve different staff at the facility, i.e... technical department, process responsible, QA-department etc. As an integrated part of these assessments, overlaps with other management systems should be identified, first of all:

- ISO50001: Energy Management
- ISO14001: Environmental Management
- ISO9001: Quality Management

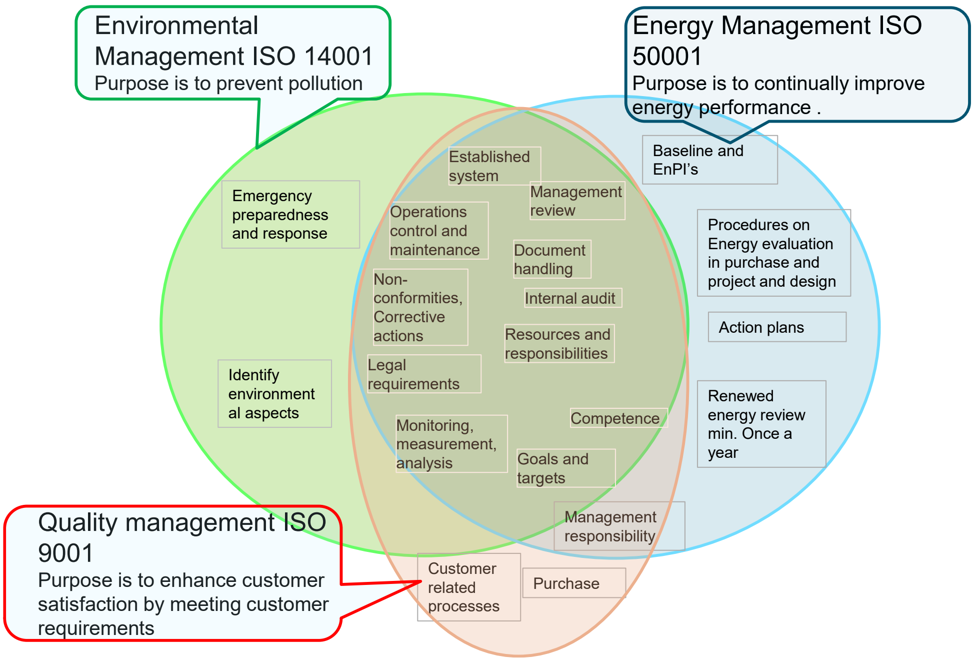


Figure 3-16: Elements of commonly used management standards

TCVN ISO 50005:2024 (based on ISO 50005:2021) as it provides **guidance for organizations on establishing a phased approach to implementing an energy management system (EnMS)** should be referred. This phased approach is particularly designed to **support and simplify EnMS implementation for all types of organizations, especially small and medium-sized organizations (SMOs)**. It outlines **twelve core elements with four levels of maturity for each element** to establish, implement, maintain, and improve an EnMS, leading to continuous energy performance improvement. The relevance for Small and Medium-scale Industries (SMI) is that it offers a practical and hands-on method for businesses to leverage their internal capacity to achieve energy performance improvements. A well-planned phased implementation can reduce costs and resource usage while delivering near-term success, helping to overcome common implementation barriers for organizations with limited resources. This document is consistent with ISO 50001:2018 but does not cover all of its requirements, acting as a stepping stone for organizations to build a strong foundation that can later be extended to meet ISO 50001 requirements.

The energy audit shall describe the expected outcomes of such EMS-systems and define which observations and cornerstones the system should be build on.

3.3. Annex

Annex 3.1. Circular 25

Circular 25 (2020) - Planning and Reporting the Implementation Plans for Energy Efficiency; Implementation of Energy Audit

Link to UK version (60 pages): vepg.vn/wp-content/uploads/2020/12/Circular-25-2020_EN.pdf

Annex 3.2. Non-energy benefits

M-Benefits: D2.2 Guidelines for Protocols, Interventions and Evaluations

BENEFITS OF ENERGY-EFFICIENCY PROJECTS (This list is based on proven benefits of past projects in Europe and the US)	**IMPACT ON RISKS**	**IMPACT ON COSTS**	**IMPACT ON VALUE PROPOSITION**
Waste			
Reduced waste heat		X	
Reduction hazardous waste	X	X	
Reduced sewage volume	X	X	
Reduced sewage pollution level	X	X	
Reduced product waste	X	X	
Emissions			
Reduced dust emissions	X	X	X
Reduced CO, CO2, NOx, SOx emissions	X	X	X
Reduction of refrigerant gases emissions	X	X	X
Production			
Reduced malfunction or breakdown of machinery and equipment	X	X	X
Improved equipment performance	X	X	X
Longer equipment life (due to reduced wear and tear)		X	
Improved product quality	X	X	X

BENEFITS OF ENERGY-EFFICIENCY PROJECTS (This list is based on proven benefits of past projects in Europe and the US)	IMPACT ON RISKS	IMPACT ON COSTS	IMPACT ON VALUE PROPOSITION

Increased production reliability (due to better control)	X	X	X
Larger product range			X
Reduced customer service costs (due to better quality)		X	X
Improved flexibility of production	X	X	X
Improved temperature control	X	X	X
Improved air filtration system	X	X	X
Reduced raw material need	(X)	X	
Reduced water consumption	(X)	X	
Reduced consumables	(X)	X	
Shorter production cycle (shorter process cycle time)		X	X
Increased production yields		X	X
Operations and maintenance			
Reduced maintenance cost		X	
Reduced machinery and equipment wear and tear	X	X	
Reduced engineering control cost		X	
Working Environment			
Reduced noise	X	X	X
Air quality improvement	X	X	X
Improved temperature control (thermal comfort)	X	X	X
Improved lighting (visual comfort)	X	X	X
Improved workforce comfort	X		X
BENEFITS OF ENERGY-EFFICIENCY PROJECTS (This list is based on proven benefits of past projects in Europe and the US)	IMPACT ON RISKS	IMPACT ON COSTS	IMPACT ON VALUE PROPOSITION
Improved workforce productivity	X	X	X
Reduced absenteeism	X	X	X

Reduction of health costs		X	
Reduced need for protective equipment		X	
Risk Reduction			
Reduced risk of accident and occupational disease	X	X	
Reduced CO2 and energy price risks	X	X	
Reduced water price risk	X	X	
Reduced commercial risk	X	X	
Reduced legal risk	X	X	
Reduced disruption of energy supply risk	X	X	
Others			
Increased installation safety	X	X	X
Improved staff satisfaction and loyalty	X	X	X
Reduced staff turnover	X	X	X
Delayed or reduced capital expenditure		X	
Reduced insurance cost		X	
Additional space		X	X
Simplification and automation of customs procedures		X	X
Contribution to company's vision or strategy			X
Improved image or reputation	X		X

Source: Killip, G., Cooremans, C. & Fawcett, T. (2018). *M-Benefits: D2.2 Guidelines for Protocols, Interventions and Evaluations.*
Report link:
https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bd4f4af7&appId=PPGMS

Annex 3.3. Decree 119/2025/ND-CP and Circular 38/BCT/2024 (LC added)

Decree No. 119/2025/ND-CP, issued by the Government of Vietnam on June 9, 2025, amends and supplements Decree No. 06/2022/ND-CP, focusing on mitigating greenhouse gas emissions and protecting the ozone layer. The Decree introduces new definitions for carbon market mechanisms, including the Article 6.2 and 6.4 mechanisms under the Paris Agreement, and establishes a National Registry System for greenhouse gas emission allowances and carbon credits. It outlines greenhouse gas emission mitigation goals, responsibilities for various ministries and provincial People's Committees in data collection, reporting, and verification of greenhouse gas inventories and reductions, and details the allocation, exchange, borrowing, transfer, and offsetting of greenhouse gas emission allowances and carbon credits. The Decree also sets forth regulations for domestic and international carbon credit exchange and offset mechanisms, including project registration and carbon credit issuance procedures. Furthermore, it addresses the management and phase-out of controlled ozone-depleting substances, setting out import and production quotas, and responsibilities for their collection, recycling, reuse, and disposal. The Ministry of Finance and the Ministry of Agriculture and Environment are assigned key roles in developing and operating the carbon market, with various other ministries and provincial People's Committees coordinating implementation. Incentives are provided for research, technology development, and transformation aimed at greenhouse gas emission mitigation, sustainable cooling, and ozone layer protection.

Mandatory GHG Inventory: Mention that certain facilities are required to conduct annual GHG inventories. Energy consumption data from audits are crucial inputs for these inventories.

- **GHG Emission Reduction Measures:** The regulations encourage and may mandate the implementation of GHG reduction measures. Energy efficiency projects identified in energy audits are prime candidates for these measures.
- **Monitoring and Reporting:** Discuss the importance of accurate measurement and reporting of energy consumption, which underpins verifiable GHG reductions.

Role of Energy Auditors: Position energy auditors as key enablers for industries to comply with GHG mitigation regulations by:

- Providing data for GHG emission calculations.
- Identifying and quantifying GHG reduction potentials through energy efficiency.
- Supporting the development of action plans that integrate both energy and GHG reduction targets.

Link to English version of Decree 119/2025/ND-CP (32 pages):
https://static3.luatvietnam.vn/uploaded/vietlawfile/2025/6/119_2025_nd_cp_incom_140625101846.pdf

On December 27, 2023, Vietnam issued Circular No. 38/2023/TT-BCT, which focuses on the Measurement, Reporting, and Verification of Greenhouse Gas Inventory and Greenhouse Gas Emission Reduction within the Industry and Trade Sectors. This Circular, effective February 11, 2024, serves as a supporting regulation to Decree No. 06/2022/ND-CP. It specifically outlines the methodology for calculating greenhouse gas emissions for manufacturing plants and other facilities. Key sections directly impacting plant operations include Articles 15-24, which detail the preparation of GHG inventories, and Articles 29-32, which cover the preparation of GHG emission reduction plans. Additionally, Annex 2 provides guidance on GHG inventory preparation, while Annex 3 addresses the measurement, reporting, and verification of GHG reductions.

- Highlight that a significant portion of an industry's GHG emissions comes from energy consumption (e.g., burning fossil fuels for heat and power, electricity consumption from the grid).
- Emphasize that energy audits, by identifying opportunities to reduce energy consumption and improve energy efficiency, directly contribute to the reduction of GHG emissions.
- Explain that the data collected during an energy audit (e.g., fuel consumption, electricity use) can serve as foundational data for GHG emission calculations required by these regulations.

Link to Vietnamese version of (32 pages):
Kihttps://moit.gov.vn/upload/2005517/fck/files/KiYm_ke_khi_nha_kinh_c9ff2.pdfYm_ke_khi_nha_kinh_c9ff2.pdf

Annex 3.4. Examples of heat recovery systems

Figure 3-17 below shows an example of a pasteurizer in a whey processing plant, where efficiency can be improved significantly be re-designing heat transfer area in the individual sections thus saving both hot- and cold utility.

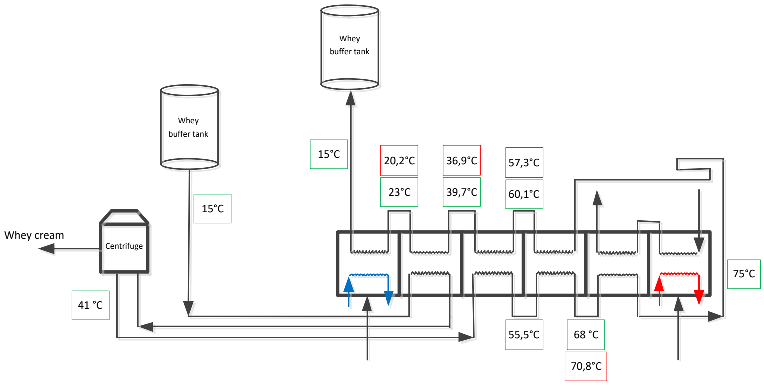


Figure 3-17: Re-design of pasteurizer in whey-processing plant

The second of these options address the fact that many process installations like furnaces, kilns and dryers ventilates significant amount of waste heat into the surroundings instead of using the heat to pre-heat inlet to the process like illustrated below for a spray dryer system.

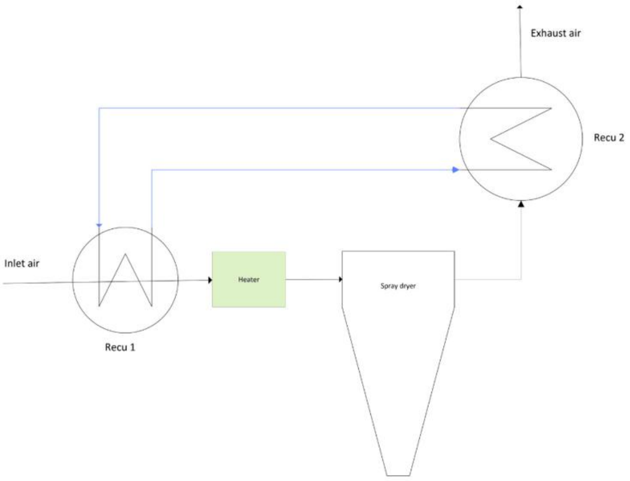


Figure 3-18: Internal heat recovery outlet-to-inlet in a spray dryer system.

The third of the options listed above address the opportunity to collect waste heat across many sources in a facility, by example from compressed air plants, oil cooling, hot outlets to the surroundings and use this waste heat – eventually boosted with heat pumps – to supply heat to hot water circuits covering certain heating demands in a facility.

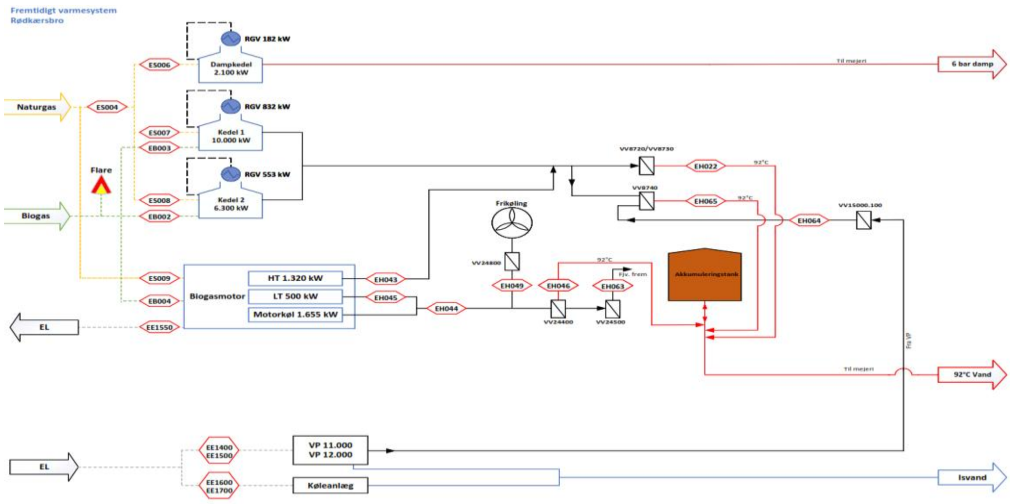


Figure 3-19: Heat recovery loop with heat pump supplying hot water for certain heating demands.

Such solutions are relevant in food & beverage, in chemical industry and pharmaceuticals and will often cover up to 50% of the total heating demand.

For these sectors such a solution must be considered, while sectors such as cement, paper & pulp and bricks & ceramics only should assess heat recovery options at individual process installations.

In sectors like textile and garments, also heat recovery across energy users should be considered, while mechanics, plastics and electronics most often only can apply waste heat for building heating (seldomly relevant in Vietnam).

Appendix 3.5. Example of Energy Audit Report

The Danish Energy Agency

Anonymous Audit Report
from a Beverage production company

XX/XX/2025

VIEGAND MAAGØE

Content

Introduction to the context

On March 13, 2019, the Decision No. 280/QD-TTg on approval of the National Energy Efficiency Programme (VNEEP) for the period of 2019-2030 was issued by the Prime Minister.

The VNEEP implements synchronously activities in the field of economical and efficient use of energy, showing commitments of all levels of government, associations, businesses, organizations, individuals to energy efficiency in particular and to climate change resilience and environmental protection in general.

The Vietnam-Denmark Energy Partnership Program Phase 3 (DEPP3) for the period 2020-2025 implement a number of activities, making substantial and effective contributions to help Vietnam's energy sector transition towards green growth, reduce carbon emissions through the development of a green energy system, operate a flexible power system, efficiently enforce policies and measures promoting energy efficiency and conservation.

One of the very important activities of promoting energy efficiency through Energy Audit in a broad variety of industrial sectors in Vietnam.

This document contains an anonymised summary of a specific energy audit report conducted as a part of the DEPP3 program. The audit has been conducted on on a Beverage production plant, by Polytechnical Energy and Environment Joint Stock Company (Polytee), in collaboration with an international expert from Viegand Maagøe.

Summary

The energy audit conducted at Beverage production plant from August to November 2024 focused on identifying energy-saving opportunities, mapping energy consumption, and assessing the costs and benefits of proposed solutions tailored to the beer production sector. Key findings include a significant reliance on coal, contributing to rising CO2 emissions, and an energy consumption rate exceeding industry benchmarks. The audit identified seven economically viable energy-saving solutions, ranging from low-cost maintenance improvements to high-investment projects like converting to a biomass boiler. These solutions could save 250,090 kWh of electricity and 587.9 tons of coal annually, reducing CO2 emissions by 1.274,5 tons and yielding 4,003.2million VND in savings. The proposed implementation plan spans 2024–2026, prioritizing low-cost, high-impact measures in the initial phase.

1 About the enterprise

1.1 Description of the company

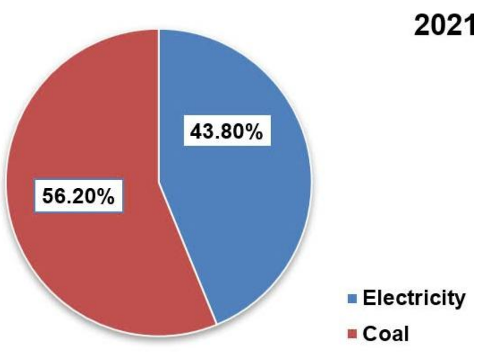
- Sector: Beverage production (Beer)
- Main raw materials (2023 data):
  - Rice: 2,219 tons/year
  - Malt: 2,983 tons/year
  - Hops: 4,470 kg/year.
- Main products (2023 data):
  - Draft Beer: 158,952 hl/year
  - Canned Beer: 219,897 hl/year
  - Total Output: 378,849 hl/year
- Annual energy total consumption.
  - Electricity Consumption: Electricity consumption shows a relatively stable trend. The total electricity consumption was 4,194,009 kWh in 2021; 4,343,405 kWh in 2022; and 4,157,014 kWh in 2023.

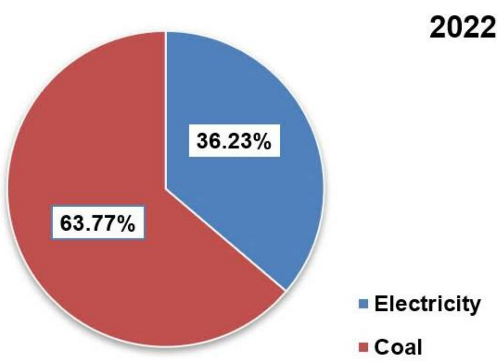
- Coal Consumption: Coal consumption shows a continuous increasing trend from 2021 to 2023. The total coal consumption was 2,028.1 tons in 2021, 2,348.9 tons in 2022, and 2,593.3 tons in 2023.
- Energy Consumption in TOE (Ton of Oil Equivalent): The total converted energy consumption was 1,236.2 TOE in 2021; 1,249.3 TOE in 2022, and 1,222.8 TOE in 2023.
- Annual carbon footprint: Emissions of CO_2eq were 5,535.30 tons in 2021, increased to 6,039.60 tons in 2022, and further rose to 6,207.00 tons in 2023.

Table 1. Energy consumption in each process

Contents	**Energy** *(kWh)*		
	Heat	**Cooling**	**Electricity**
Mashing	-	-	936,958
Cooking	9,933,770	-	362,669
Cooling	-	1,204,119	633,705
Fermentation	-	2,068,896	895,887
Filtration/ Packaing	620,861	1,379,264	641,479
Pasteurization/CIP	1,862,582	-	217,215
Warehouse	-	820,990	469,088
Total total energy of each power source	12,417,212	5,473,269	4,157,000

The table.1 shows that the cooking stage dominates heat energy use (9,933,770 kWh), while fermentation and cooling stages are significant for cooling energy. Electricity consumption is distributed across all processes, with mashing and fermentation being the highest consumers. These insights guide the prioritization of energy-saving measures, particularly targeting heat recovery and cooling system optimization.





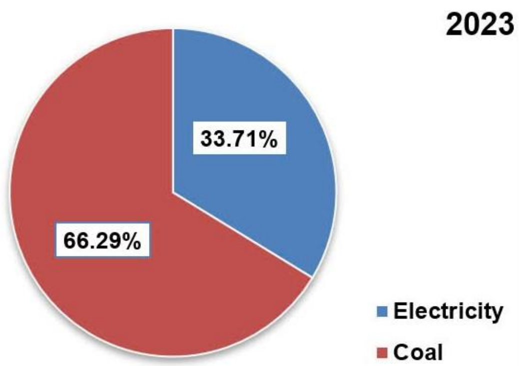


Figure 1. Energy Cost Ratio of the brewery (2021-2023)

The pie charts (Fig. 1) depict the proportional breakdown of total energy expenditure between electricity and coal from 2021 to 2023, complementing the absolute financial data presented previously. The analysis reveals a pronounced trend of increasing reliance on coal as a primary energy source. Specifically, the contribution of coal to total energy costs escalated from 56.20% in 2021 to 63.77% in 2022 and ultimately reached 66.29% in 2023. This growing proportional share is directly correlated with the significant surge in absolute coal expenditure observed over the same period.

In 2023, Specific Energy Consumption (SEC) reached 228.1 MJ/hl, significantly exceeding the official industry benchmark of 196 MJ/hl for its production category. This performance indicates a clear need for the company to prioritize implementing measures to improve its energy efficiency and meet the regulated standard.

1.2 Description of the process

The beverage production plant specializes in beer production, with a 2023 output of 378,849 hl, comprising 158,952 hl of draft beer and 219,897 hl of canned beer. The production process involves several key steps, primarily conducted on a single main production line, supported by auxiliary systems. Below is a summary of the main process steps:

1. Mashing: Rice and malt are mixed and milled, then combined with water to convert starches into fermentable sugars.
2. Cooking/Boiling: The mash is heated with steam (6–8 bar) to break down starches, and hops (4,470 kg/year) are added to impart flavor and bitterness. Wort is boiled at 95–105°C, with steam recovered for energy savings.
3. Cooling: Wort is rapidly cooled from 95–98°C to 4–6°C using a plate heat exchanger with glycol at -4°C, critical for maintaining beer quality.
4. Fermentation: Cooled wort undergoes primary fermentation to convert sugars into alcohol and CO_2, followed by secondary fermentation/maturation for flavor stabilization.
5. Filtration and Storage: Beer is filtered to remove yeast, stored in bright beer tanks (BBTs), and diluted with sparging water to adjust sugar content.
6. Pasteurization and Packaging: Beer is pasteurized at ~60°C for 45–60 minutes, then bottled or canned, labeled, and packed for distribution.

Process Lines: Beverage production plant operates one main production line, with parallel equipment (e.g., multiple fermentation tanks) to handle batch processing. The line is supported by utility systems for steam, cooling, and compressed air.

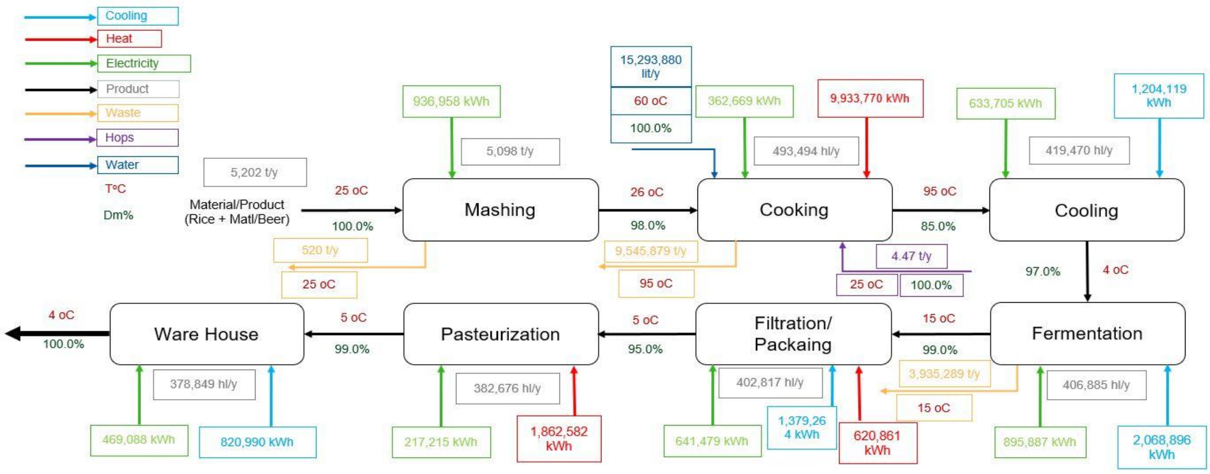


Figure 2. Simple process flow diagram

Energy mapping was a core activity of the system energy audit, conducted in compliance with Circular 25/2020/TT-BCT and followed a structured methodology that included energy balancing, creating composite curves, and identifying potential projects. This detailed process yielded several key outputs that formed the basis for evaluating efficiency and identifying savings opportunities. A process flow diagram (Figure 2) was created to visually represent all energy and material flows, while a quantitative breakdown (Table 1) detailed the specific consumption of heat, cooling, and electricity for each stage. This analysis highlighted the cooking process as the largest heat consumer (9,933,770 kWh) and the substantial overall demand for cooling energy (5,473,269 kWh), making them priority areas.

1.3 Description of the utility systems

Beverage production plant relies on several utility systems to support its beer production. Below is a detailed overview of the main systems, their capacities, operational parameters, and key end-users, based on the 2024 energy audit data.

- Boiler System:
  - Description: Two fixed-grate coal-fired boilers, each with a capacity of 8 tons/hour, produce saturated steam at 6–8 bar and 165°C.
  - Fuel: Coal (983 kg/h, calorific value 4,501 kcal/kg), manually fed with large-sized pieces (~5 cm).
  - Actual Operation: Boiler efficiency is ~73%, with steam generation of 5,000 kg/h. Equipped with flue gas heat recovery to preheat feed water (30°C) and condensate recovery from heat exchangers.
  - Main End-Users:
    - Brewing (Hop Boiling Kettle): Requires steam at 6–8 bar to heat wort from 92°C to 100–105°C for boiling.
    - Pasteurization: Uses steam at ~60°C for 45–60 minutes in the sterilization tunnel.
    - Cleaning-in-Place (CIP): Steam for sanitation processes.
- Chiller System:
  - Description: Comprises three screw chillers (150 kW each, NH_3 refrigerant) and three cascade chillers (45 kW each, NH_3 refrigerant), cooling glycol to -4°C for various processes.
  - Actual Operation: Screw chillers operate in four load modes (25%, 50%, 75%, 100%), with a COP of 4.02–4.64. Cascade chillers cool glycol to 9°C, 6°C, or 3°C, operating 1–3 units based on demand. Glycol is stored in a 110 m³ tank and circulated via pumps (3.7–11 kW, some with VFDs).
- Main End-Users:

- Wort Cooling: Rapid cooling of wort from 96–98°C to 6–8°C using glycol at -4°C via plate heat exchanger.
- Fermentation: Maintains primary fermentation at 7–9°C and secondary fermentation at 5°C to -1°C.
- Filtration: Keeps beer at 0–1°C during filtration.
- Sparging Water Production: Cools water from 50°C to 3–4°C for dilution.
- CO2 Recovery: Condenses CO2 into liquid form.
- Storage: Maintains hop, yeast, and filtration rooms at low temperatures.

- Air Compressor System:
  - Description: Three Ingersoll Rand compressors (55 kW each), divided into two clusters:
    - Cluster 1: Two oil-free compressors (9.37 m³/min, 5.5–6.5 bar).
    - Cluster 2: One oil-lubricated compressor (9.8 m³/min, 6.0–7.0 bar).
  - Actual Operation: Operate 24/7, with oil-free compressors supplying air for control and cleaning, and the oil-lubricated compressor serving the brewery (e.g., pushing spent grain, valve control). Load/Unload mode results in 45–50% unloaded time, wasting energy.
  - Main End-Users:
    - Brewery: Compressed air at 6.0–7.0 bar for spent grain handling and valve control.
    - Production Line: Air at 5.5–6.5 bar for extracting, pouring, controlling, and cleaning.
- Water and Wastewater Treatment Systems:
  - Description: Groundwater is treated and supplied via VFD-equipped pumps. Wastewater treatment uses four air blowers: two with VFDs (37 kW) and two without (22 kW).
  - Actual Operation: Typically, one VFD and one non-VFD blower operate simultaneously, with only the VFD blower used during peak hours to save electricity.
  - Main End-Users:
    - Production: Treated water for brewing, sparging, and CIP.
    - Wastewater Treatment: Blowers supply air for aeration in treatment processes.

The utility mapping diagram, as shown in Fig. 3 shows energy flows from coal (boilers) and electricity (chillers, compressors, pumps) to end-users, highlighting distribution pathways and consumption areas like brewing, cooling, and pasteurization.

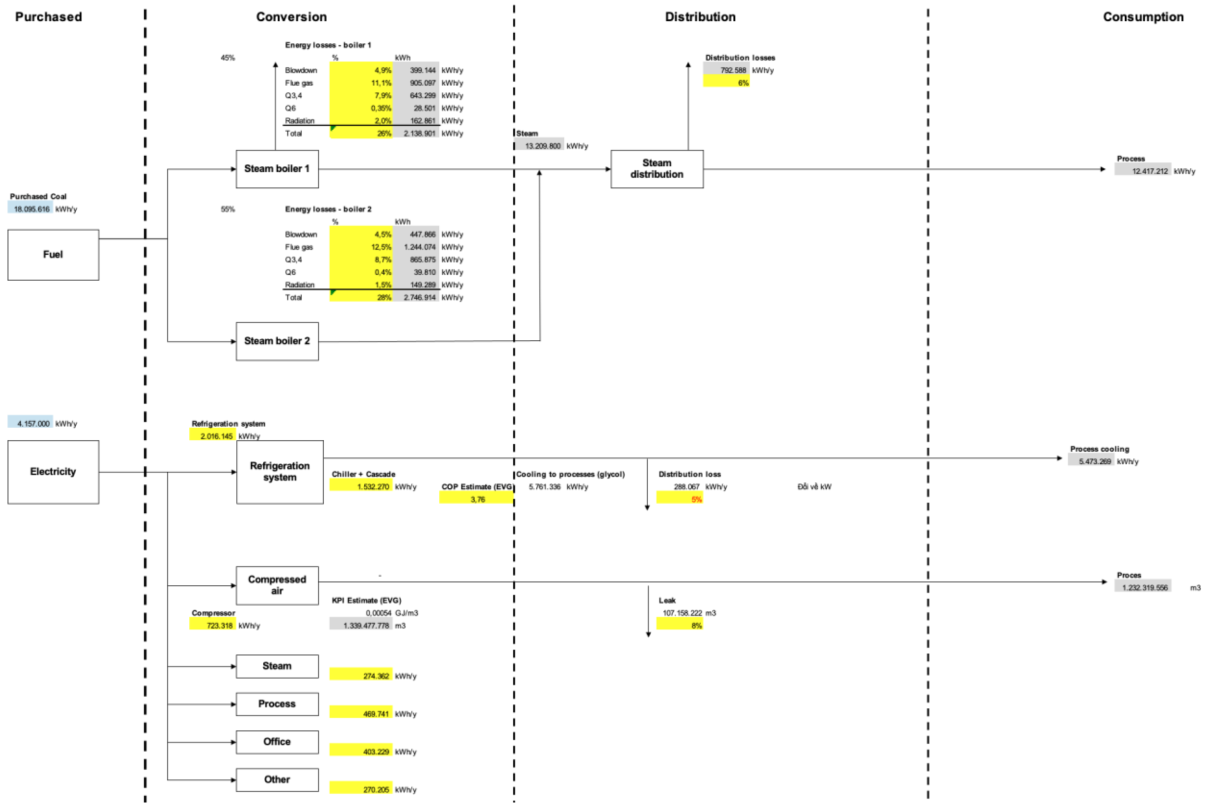


Figure 3. Utility Mapping

Current Energy Management

The company's energy management system is considered good compared to the general level of enterprises in Vietnam. The company places a strong emphasis on energy efficiency due to energy costs being a high proportion of the final product cost. Key aspects of the current system include:

- Dedicated Personnel: The company has appointed a certified "Energy Manager" as required by law and has established a formal Energy Management Board to oversee all energy-related issues.
- Policy and Standards: An energy policy has been issued that is well-suited to the company's operational characteristics. The company is also actively implementing energy-saving activities in accordance with the ISO 50001:2018 standard.
- System Evaluation: An assessment using the Energy Management Matrix (EMM) scored the company highly in most areas, including Policy, Organization, Motivation, and Investment (all 3 out of 4). The area for "Communication and Marketing" was identified as needing improvement (scored 2 out of 4).
- Monitoring: The company has a relatively good system for monitoring energy-consuming equipment, with detailed sub-metering in place for different areas.

2. Methodology used to identify EE projects

2.1 How EE projects have been identified and developed

The identification and development of energy efficiency (EE) projects for Beverage production plant were conducted in accordance with Circular 25/2019/TT-BCT (guidelines for energy auditing in Vietnam) and the Energy Audit (EA) guidelines provided by the Danish Energy Agency and Polytee. The process adhered to sector-specific guidelines for the beer production industry, ensuring compliance with best practices.

- Key areas/equipment/systems audited: The audit covered the boiler system, chiller system, air compressor system, cooling tower system, refrigeration and CO2 recovery system, lighting system, wastewater treatment system, and production lines (mashing, boiling, fermentation, filtration, pasteurization, and packaging).

- Key methods used to provide necessary data: Data was collected from energy bills, receipts, and operational logs (2021-2023). Where data was not readily available, methods included energy balances, on-site measurements (e.g., temperature, pressure, flow rates), power quality assessments, and ultrasonic leak detection for compressed air systems.
- Use of energy mapping to develop projects:
  - Identify major energy-consuming processes: Mapping highlighted boiling (coal-based), cooling (electricity-driven), and fermentation as major energy users.
  - Temperature analysis: Assessed heat losses in steam valves and cooling systems.
  - Energy losses analysis: Identified thermal losses (e.g., uninsulated steam pipes) and electrical losses (e.g., compressor unload time).
  - Calculated and compared KPIs: Key Performance Indicators (KPIs) like specific energy consumption (SEC) were calculated and benchmarked.
  - Theoretical and practical heat recovery potential: Evaluated waste heat from boiler flue gas and cold recovery from CO2 evaporation.
  - Other approaches: Included stakeholder interviews and process flow analysis.
- Quantitative SEC indicator: The Specific Energy Consumption (SEC) indicator measures energy use per unit of production (e.g., kWh/hl or GJ/hl). It was compared to the Circular Energy Benchmarking data, which provides industry averages for beer production, revealing Beverage production plant performance gaps (e.g., higher coal use per hl in 2023).
- Other ways of identifying projects:
  - Onion diagram approach: Prioritized energy-saving opportunities from outer layers (e.g., lighting) to inner core processes (e.g., boiler efficiency).
  - Modification of process parameters: Adjusted cooling system temperatures and air pressure to optimize efficiency.
  - Reduction of idle losses: Targeted compressor unload time reduction.
  - Improved control of processes and utilities: Proposed variable frequency drives (VFDs) and better scheduling.
  - Other approaches: Included employee feedback and BAT (Best Available Techniques) assessments, noting that some processes (e.g., fermentation) align with BAT standards.

The process narrowed projects from a gross list (initial ideas) to Project Level B (feasible with preliminary analysis) and finally to Project Level A (prioritized, cost-effective solutions) based on technical feasibility, energy savings potential, and financial viability.

2.2 EE Project evaluation

Projects were evaluated based on:

- Energy saving: Quantified as kWh (electricity) or tons (coal) saved annually (e.g., 41,570 kWh from management improvements).
- CO2 saving: Calculated using Vietnam's emission factor (0.6766 tons CO2/MWh), e.g., ~28 tons CO2 saved from electricity reductions.
- Financial saving: Estimated costs (e.g., 265.8 million VND/year from internal management) against investment costs (e.g., 300 million VND initial).
- Other benefits: Included improved equipment lifespan, safety (e.g., insulated valves), and employee comfort (e.g., 25-28°C office temperature).

2.3 EE Project prioritisation

Projects were prioritized using criteria such as:

- Company priority: Alignment with Beverage production plant goals and sustainability commitments.
- Investment cost: Preference for low-cost solutions (e.g., insulation, leak repairs).
- Payback period: Short-term returns (e.g., <2 years) favored.
- Energy saving potential: Higher savings (e.g., VFD installation) ranked higher.

2.4 Enterprises feedback

The summary of the energy audit for the brewery identifies key issues in thermal efficiency and proposes specific solutions. The analysis shows the boiler operates at only about 73% efficiency, with significant energy loss through high-temperature flue gas (180-200°C). Meanwhile, the central cooling system's performance is reduced by 10-30% due to scaling in the cooling tower, which lowers the chiller's Coefficient of Performance (COP). The report also points out that a large amount of cold energy is being wasted during the CO_2 vaporization process. Key proposed solutions include installing an economizer and converting to a biomass boiler to improve boiler efficiency, using an EWater descaling system to enhance the cooling tower's heat exchange efficiency, and utilizing the waste cold from the CO_2 system to increase the chiller's COP by 1.37%.

The brewery provided positive feedback, accepting most recommendations and committing to adopt an ISO 50001 energy management system by 2026, while also planning for quarterly audits to scale successful pilot projects.

3. EE Projects identified

The Gross list represents an initial compilation of energy efficiency (EE) projects identified during the energy audit of Beverage production plant, conducted by Polytee. This list, mapped at Project Level B, includes preliminary assessments of feasibility, energy savings, CO2 reductions, and financial benefits. The overall saving potential from the Gross list is estimated at approximately 250,000 kWh of electricity and 587 tons of coal annually, translating to around 1.274,5 tons of CO2 reduction and financial savings of approximately 4,003.2million VND. Trends observed include a focus on low-cost interventions (e.g., maintenance and process optimization) with quick payback periods (1-2 years), alongside higher-investment projects (e.g., boiler conversion) offering significant long-term savings.

Table 2: Gross list (level B mapping)

Gross list							
Project no.	**Name of Project**	**Energy form (Gas, electricity, oil...)**	**Investment Cost** (10^6 VND)	**Saving**			**Simple Payback [Years]**
				Energy [kWh/year]	**CO_2 [ton/year]**	**Financial** (10^6 VND/year)	
1	Activities to enhance internal management and regular maintenance	Electricity, Coal	300	41,570	114.6	265.8	1.1
2	Install a water heater (economizer) utilizing waste heat from boiler flue gas	Coal	375.5	-	38.3	125.8	2.8
3	Conversion of coal-fired boiler to biomass boiler	Coal	15,000	-	980.5	3,214.8	4.7
4	Removing scale and enhancing heat exchange efficiency for cooling tower	Electricity	364.6	83,409	56.4	158.7	2.3

5	Utilizing waste cold from CO2 evaporation to cool NH3	Electricity	120.0	22,829	15.4	43.4	2.8
6	Using solar energy lights for campus lighting system	Electricity	96.0	19,710	13.3	37.5	2.6
7	Install VFD and control system to reduce unload time of compressor No. 2	Electricity	301.3	82,571	55.9	157.1	1.9

4. Selected EE Projects for further supports

Project information		
Project: Installation of a water heater utilizing waste heat from boiler flue gas	**Project no. 2**	**Date:**
Enterprise: Beverage production plant	**Auditing company: POLYTECHNICAL ENERGY AND ENVIRONMENT JOINT STOCK COMPANY**	**Auditor: Pham Van Tuyen**

Project description

Current situation

The company is currently operating two boilers with a rated capacity of 8 tons/hour each. This boiler primarily supplies steam for cooking rice, malt, and wort in their brewing operations. The cost of fuel (lump coal) for the company's boiler is quite high, making energy saving a crucial concern. The boiler operates based on a set pressure. When steam is required, the steam pressure drops until it reaches 6 bar, at which point the feed water pump activates to supply additional water to the boiler. When the steam pressure reaches 7 bar, the feed water pump automatically shuts off. Our survey found that the temperature of the boiler's flue gas ranges from 180°C to 200°C, which indicates significant energy waste.

For boiler systems, the biggest heat loss is through the flue gas. The higher the flue gas temperature, the greater the heat loss. The supplementary feed water passes through a water treatment system (to prevent scaling and corrosion in the pipes) before entering the boiler. The temperature of this supplementary feed water is quite low. If this water is preheated before entering the feed water tank, it will significantly increase the temperature of the water entering the boiler.

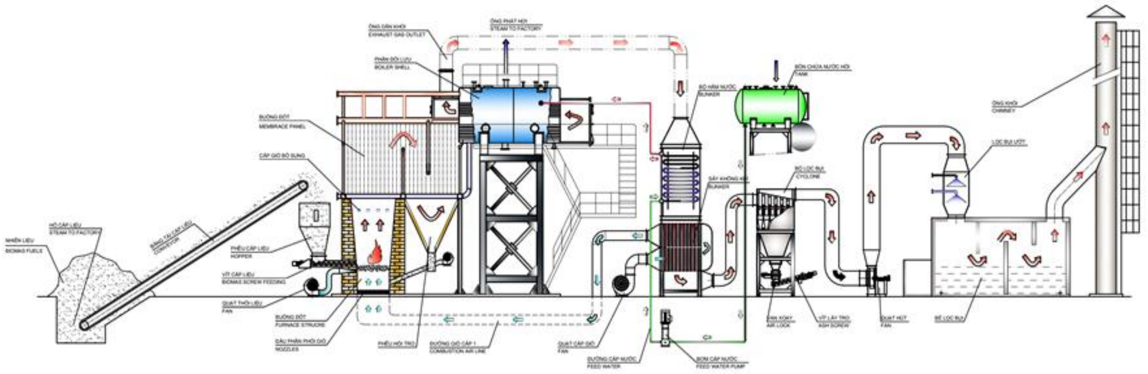
Proposed project

- Based on the current situation, we propose the following energy-saving solution: "Installation of a water heater utilizing waste heat from the boiler flue gas." This boiler water heater will preheat the feed water, increasing its temperature by approximately 10°C.
- The boiler water heater installation consists of:
- A heat recovery unit installed in the flue gas duct.

- A system of pipes, valves, fittings, and other auxiliary equipment.
- The boiler water heater operates based on the principle of convection. Water enters the lower water header and then flows through the tubes of the heat recovery unit. From the boiler feed water tank, the water passes through the heater, absorbing heat and increasing in temperature. A pressure relief valve is installed on the boiler feed water tank to maintain the pressure in the supplementary feed water tank equal to atmospheric pressure.
- Principle of energy saving
- The energy saved by implementing the solution "Installation of a water heater utilizing waste heat from the boiler flue gas" is the energy required to heat the water. This saves the amount of heat used to heat the water, thereby reducing fuel consumption.

Project illustration (PFD)

System Circulating fluidized bed boiler



Water heater

Water heater installation location diagram

- The process uses an Economizer to recover heat from flue gas for preheating feedwater or air. The system components include a flue gas source, the Economizer, a feedwater or air supply system, pumps, and control valves.
- Key Equipment in the PFD:

Flue Gas Source: Boiler/Furnace

Economizer: Heat exchanger for flue gas

Feedwater Pump: To circulate feedwater

Control Valves: Flow regulation

Chimney/Stack: For exhaust gas

Process Steps:

- Flue Gas Inlet:
  High-temperature flue gas (e.g., 200°C) from flue gas enters the Economizer.
- Heat Exchange in Economizer:
  Heat is transferred from the flue gas to feedwater or incoming air.
- Cooled Flue Gas Outlet:
  After transferring heat, the flue gas is cooled down to 130°C and discharged through a stack.
- Feedwater/Air Heating:
  The feedwater or air is heated using the recovered energy and directed to its respective use in the system (e.g., to a boiler or combustion chamber).
- Pump:
  A pump is used to circulate the feedwater through the Economizer.
- Control Valves:
  Valves are installed to regulate the flow of flue gas and feedwater/air to ensure efficient heat recovery.

Project Budget			
Element	**Units**	**Unit costs**	**Costs (Million VND)**
Water heater	1	250.0	250
Accessories	1	75.0	75
Labor	1	33	33
Total			**358**

Time schedule												
Activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Project Planning												
Design and Engineering												
Procurement of Materials												
Manufacturing & Fabrication												
Installation Preparation												
Installation & Assembly												
System Testing & Commissionin g												
Final Review and Handover												

Saving	
Energy(annual): 9.4 TOE	**Financial (annual):** 125.8 million VND
CO_2 (annual): 38.3 tons	**Simple Payback (years):** 2.8

Risk Analysis

- Potential risks include:
- System malfunction requiring repairs
- Variability in fuel cost savings due to fluctuating coal prices
- Mitigation measures will be detailed in the risk management plan

Non-Energy benifits

- Reduction in boiler maintenance costs
- Improved sustainability and corporate environmental performance

Project information		
Project: Conversion of coal-fired boiler to biomass boiler	**Project no. 3**	**Date:**

Enterprise: BEVERAGE PRODUCTION PLANT	Auditing company: POLYTECHNICAL ENERGY AND ENVIRONMENT JOINT STOCK COMPANY	Auditor: Pham Van Tuyen

Project description

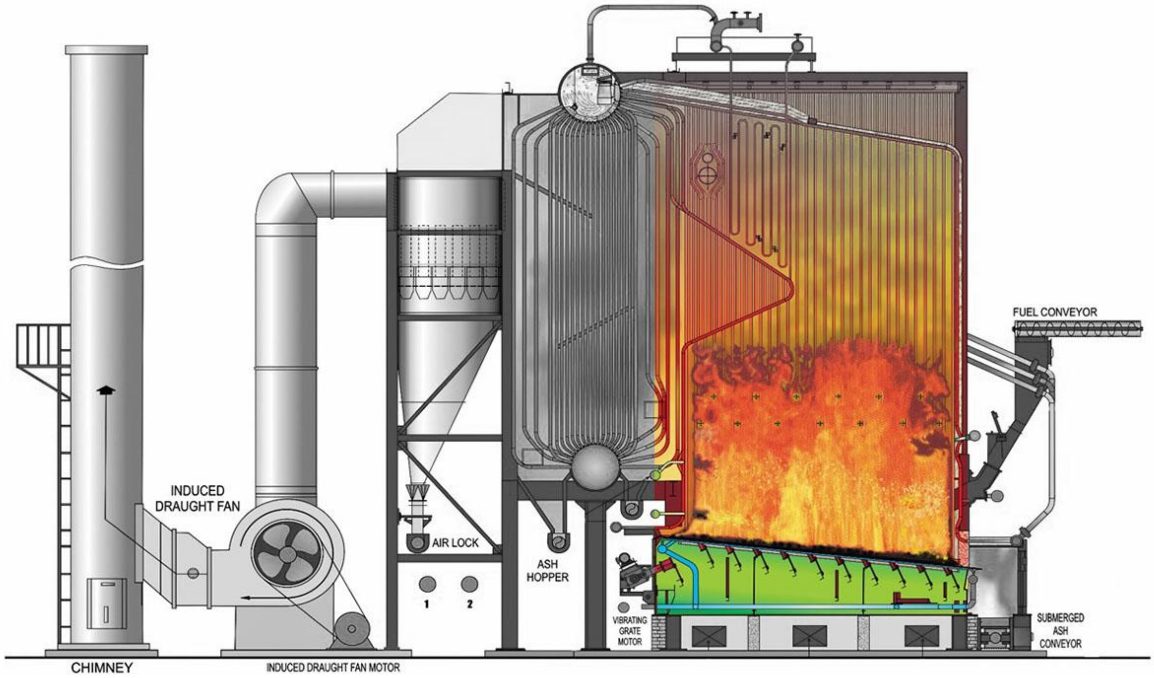
Current situation

The company is currently using a coal-fired boiler installed in 2006. Based on data surveys and calculations, the current boiler's efficiency is only about 73%. The heat exchangers, water pumps, blowers, and fans of the boiler system have deteriorated over time, further reducing the system's overall efficiency.

Proposed project

To save on coal fuel and the electricity consumed by the auxiliary systems for the boiler, the company should consider replacing the old boiler with a higher-efficiency biomass boiler. This upgrade will involve replacing the existing coal-fired boiler with a state-of-the-art biomass boiler system, including all necessary auxiliary components. The new system will be designed to optimize combustion efficiency, reduce emissions, and improve overall energy efficiency.

Project illustration (PFD)



Use Biomass fuel

Fuel Handling

- Biomass fuel (e.g., wood chips, rice husk) is delivered to the facility and stored.
- A fuel handling system transports the biomass to the boiler house.
- Fuel is prepared (e.g., chipped, ground) to an appropriate size for combustion.

Combustion:

- Biomass fuel is fed into the boiler furnace.
- Air is supplied for combustion.
- Combustion of biomass generates heat.

Heat Transfer:

- Heat from combustion is transferred to water in the boiler, generating steam.
- Flue gases from combustion pass through a heat recovery system (e.g., economizer, air preheater) to improve efficiency.

Steam Generation:

- Steam is generated at the desired pressure and temperature.
- Steam is supplied to the process or application (e.g., heating, power generation).

Flue Gas Treatment:

- Flue gases are treated to remove particulate matter and other pollutants before being released to the atmosphere.

Ash Handling:

- Ash generated from combustion is collected and disposed of.

Water Treatment:

- Feedwater is treated to remove impurities and prevent scaling in the boiler.

Control System:

- A control system monitors and regulates the boiler operation, ensuring optimal efficiency and safety.

Project Budget

Element	**Units**	**Unit costs** (mil. VND)	**Costs** (mil. VND)
Boiler	unit	12,800	12,800
Fuel supply system	set	800	800
Feed water softening system	set	170	170
Water softener tank, deaerator	set	480	480
Boiler blowdown system, boiler control, oxygen concentration control	package	750	750
Total			**15,000**

Time schedule

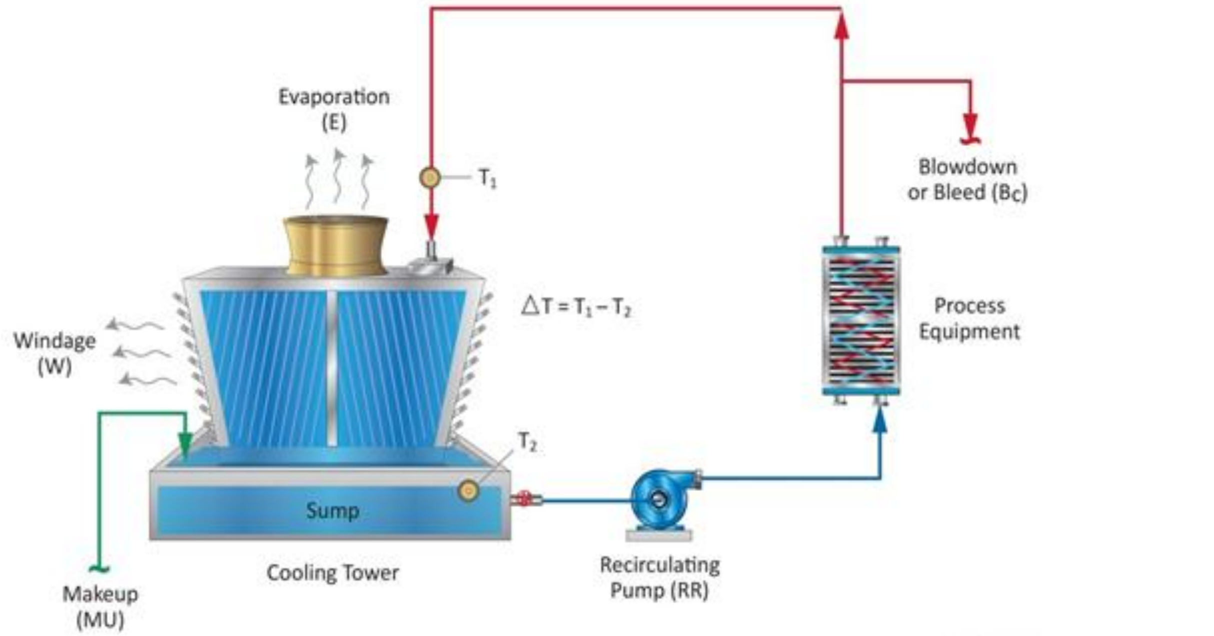
Activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Planning and Design: Define project requirements, select a supplier and technology, and design the boiler system in detail.												
Site Preparation: Leveling, excavation, and construction of drainage systems. **Permitting**: Complete necessary legal procedures.												
Infrastructure Development: Electrical, water, compressed air systems, and fuel pipelines. **Equipment Ordering**: Biomass boiler, fuel supply												

system, and emission treatment system.												
Equipment Receiving and Inspection: Verify quality and quantity. **Boiler Installation**: Lifting, positioning, and connecting to the infrastructure.												
Auxiliary Equipment Installation: Fuel supply system, emission treatment system, pumps, and fans. **System Connection**: Electrical, water, compressed air, and pipeline connections.												
Commissioning and Adjustment: Test the operation of each component and adjust the system. **Operation Training**: Provide user training on operation and maintenance.												
Acceptance and Handover: Final inspection, acceptance, and handover to the customer. **Official Operation**: Start using the boiler for production activities.												

Saving	
Energy (annual): 536 TOE	**Financial (annual):** 3,215 million VND
CO_2 (annual): 981 tons	Simple Payback (years): 4.7
Risk Analysis	
This project, while promising, is not without potential risks. One major concern is the fluctuation of biomass fuel prices. Since we're transitioning away from coal, dependence on biomass means we're susceptible to market changes. To mitigate this, we need to secure long-term supply contracts with reliable suppliers and explore alternative fuel sources, potentially even hedging strategies. Another risk lies in potential disruptions to the biomass supply chain. Factors like weather patterns, logistical issues, or even changes in agricultural practices can affect the availability of biomass. Therefore, diversifying	

our supplier base is crucial. We should establish strong partnerships with local farmers and forestry companies and maintain a strategic fuel reserve to ensure a consistent supply. Finally, there's the risk of operational challenges with the new technology. Training our personnel on the operation and maintenance of the new biomass boiler is vital. A robust maintenance program and ongoing support from the technology provider will ensure smooth operation and minimize downtime.
Non-Energy benifits
Beyond the significant financial savings, this project offers several non-energy benefits that strengthen its overall value proposition. First and foremost, it significantly reduces our environmental impact. By switching to biomass, we drastically reduce greenhouse gas emissions compared to the old coal-fired boiler. This aligns with our commitment to sustainability and potentially improves our environmental compliance. Furthermore, the new biomass boiler enhances safety. Modern boilers are equipped with advanced safety features, minimizing the risk of accidents and providing a safer work environment for our employees. Another key benefit is increased reliability. The old coal-fired boiler is nearing the end of its lifespan and prone to breakdowns. Replacing it with a new, more reliable system ensures a consistent steam supply for our operations, minimizing disruptions and reducing maintenance costs associated with the aging equipment. Finally, this project enhances our company image. Investing in sustainable energy solutions demonstrates our commitment to environmental responsibility and strengthens our reputation as a forward-thinking organization. This can be a valuable asset in today's increasingly environmentally conscious market.

Project information		
Project: Removing Scale and Enhancing Heat Exchange Efficiency for the Cooling Tower Using EWater Scale Treatment Equipment	**Project no. 4**	**Date:**
Enterprise: BEVERAGE PRODUCTION PLANT	**Auditing company: POLYTECHNICAL ENERGY AND ENVIRONMENT JOINT STOCK COMPANY**	**Auditor: Lai Tien dat**
Project description		
Current situation The company uses two cooling towers for its central refrigeration system. These towers condense refrigerant after compression. The cooling towers depend on circulating water quality, which is sourced from groundwater and municipal water, treated before use. However, scaling still occurs, leading to the company regularly cleaning the towers and discharging water to reduce scaling substances. Despite this, scaling and algae still affect heat exchange efficiency.		
Proposed project The proposed solution is to install an EWater scale treatment system to prevent scaling from affecting the cooling tower's efficiency. The EWater system removes scale buildup using physical methods, enhancing heat exchange efficiency, extending the lifespan of the cooling tower, and reducing maintenance, chemical, and water consumption costs. It is also environmentally friendly.		
Project illustration (PFD)		



Cooling tower

Cooling Tower:

- The cooling tower receives hot water from the refrigeration system.
- Water is sprayed over fill media to increase contact with air.
- Evaporation cools the water.
- Cooled water is collected in the basin and returned to the refrigeration system.

EWater Scale Treatment Unit:

- The EWater unit is installed in the cooling water circulation line.
- Water passes through the EWater unit, where it is treated to prevent and remove scale.
- The treated water flows to the cooling tower.

Makeup Water:

- Makeup water is added to the system to replace water lost due to evaporation and blowdown.

Blowdown:

- Blowdown is the process of removing a portion of the circulating water to control the concentration of dissolved solids and impurities.

Circulating Water Pump:

- The pump circulates water through the cooling tower and EWater unit.

Cooling Tower Fan:

- The fan forces air through the cooling tower to enhance evaporation.

Project Budget

Element	**Units**	**Unit costs** (mil. VND)	**Costs** (mil. VND)
EWater Scale Treatment System	set	100.0 (x3)	300.0
Accessories (pipes, cables, electrical cabinets, etc.)	set	18.0 (x3)	54.0
Installation and system adjustment costs	package		10.6
Total	**364.6**		

Time schedule

Activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

Project Initiation and Planning												
Detailed Engineering and Procurement												
Site Preparation and Installation												
Commissioning and Training												
Monitoring and Optimization												

Saving	
Energy(annual): 12.9 TOE	**Financial (annual):** 158.7 million VND
CO_2 (annual): 56.4 tons	**Simple Payback (years):** 2.3

Risk Analysis

While EWater systems generally have a good track record, there's a risk that the specific equipment chosen might not effectively remove scale or prevent its formation in the unique operating conditions of BEVERAGE PRODUCTION PLANT cooling towers. This could result in lower-than-expected energy savings and a longer payback period.
The EWater system may require unexpected maintenance or repairs, leading to additional costs and potential downtime for the cooling towers.
There may be unforeseen challenges in integrating the EWater system with the existing cooling towers and refrigeration system, potentially requiring modifications or adjustments.
Changes in the quality of the makeup water (groundwater or municipal water) could affect the performance of the EWater system and potentially lead to increased scaling.

Non-Energy benefits

Extended Equipment Lifespan: By preventing scale buildup, the EWater system can help extend the lifespan of the cooling towers and other components of the refrigeration system, reducing the need for premature replacement.
Reduced Maintenance Costs: Scale buildup can lead to increased maintenance requirements, including frequent cleaning and repairs. The EWater system can help reduce these costs by minimizing scale formation.
Improved Water Efficiency: By improving heat transfer efficiency, the EWater system can reduce the amount of water required for cooling, leading to water conservation and lower water bills.
Environmental Benefits: The EWater system is a chemical-free solution, reducing the environmental impact associated with traditional chemical-based scale treatment methods.
Enhanced Sustainability: Implementing the EWater system demonstrates the company's commitment to sustainability and environmental responsibility.

Project information		
Project: **Utilizing the waste cold released during the evaporation of CO2 to cool NH3 after the condenser**	**Project no. 5**	**Date:**
Enterprise: BEVERAGE PRODUCTION PLANT	**Auditing company: POLYTECHNICAL ENERGY AND ENVIRONMENT JOINT STOCK COMPANY**	**Auditor: Lai Tien dat**
Project description		

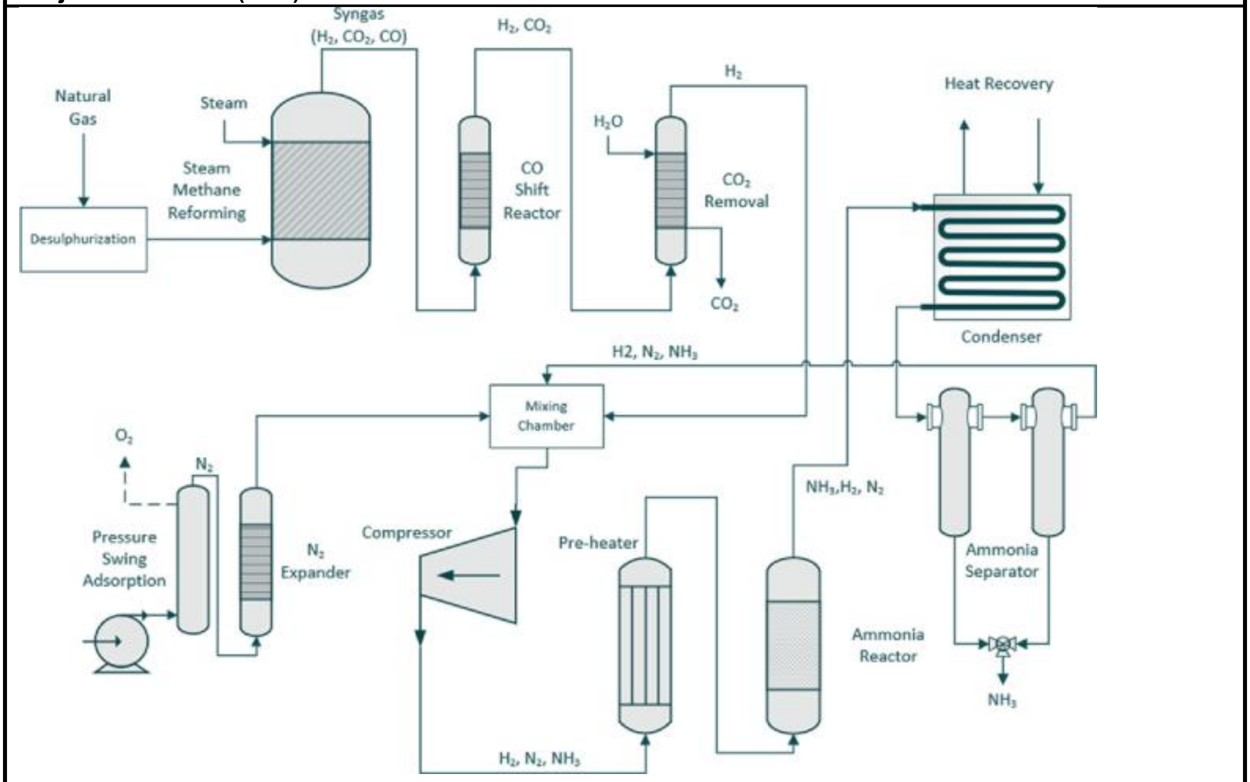
Current situation

The company recovers CO_2 from fermentation, purifies it, and stores it in liquid form. When needed, liquid CO_2 is vaporized using air at -25°C and supplied to various areas. The cold energy generated during this evaporation process is currently wasted.

Proposed project

The proposed solution involves utilizing the cold energy released during CO_2 evaporation to cool NH_3 after the condenser in the central refrigeration system. This will be achieved by installing a shell-and-tube heat exchanger where high-temperature NH_3 exchanges heat with liquid CO_2, pre-cooling the NH_3 before it enters the compressor. This process improves the efficiency of the refrigeration cycle, leading to energy savings.

Project illustration (PFD)



NH3 cooling system diagram

Process Flow:

1. Liquid CO_2 at -25°C is drawn from the CO_2 storage tank and enters the CO_2 evaporator.
2. In the evaporator, CO_2 absorbs heat from the surroundings and evaporates.
3. A portion of the liquid NH_3 exiting the NH_3 condenser is diverted to the heat exchanger.
4. Inside the heat exchanger, the warm NH_3 transfers heat to the cold CO_2. This cools the NH_3 and causes the CO_2 to evaporate.
5. The cooled NH_3 flows to the NH_3 receiver tank and then to the compressor.
6. The evaporated CO_2 flows from the heat exchanger to further processing or storage.

Project Budget

Element	**Units**	**Unit costs** (mil. VND)	**Costs** (mil. VND)
Shell-and-tube heat exchanger	set	80.0	80.0
Accessories (pipes, insulation, wiring, electrical cabinet, etc.)	set	16.0	16.0
Installation, pipe renovation, system adjustment cost	complete set		24.0
Total			**120.0**

Time schedule

Activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Project Definition and Preliminary Design												
Detailed Engineering and Procurement												
Procurement and Site Preparation												
Installation												
Commissioning and Testing												
Training and Optimization												
Monitoring and Documentation												

Saving

Energy(annual): 3.5 TOE	**Financial (annual):** 43.4 million VND
CO_2 (annual): 15.4 tons	**Simple Payback (years):** 2.8

Risk Analysis

Integration Challenges: Integrating the new heat exchanger into the existing CO2 and NH3 systems may pose technical challenges, potentially requiring modifications and adjustments.

- Mitigation: Engage experienced engineers and technicians to ensure proper integration and conduct thorough testing to ensure compatibility.

Performance Risk: The actual energy savings may deviate from the projected values due to variations in operating conditions or the performance of the heat exchanger.

- Mitigation: Conduct a pilot test to validate the projected energy savings before full-scale implementation. Continuously monitor system performance and optimize operating parameters.

Maintenance Requirements: The heat exchanger may require regular maintenance or repairs, potentially leading to additional costs and downtime.

- Mitigation: Establish a preventive maintenance plan for the heat exchanger, including regular inspections and cleaning.

Non-Energy benifits

Improved Efficiency: Utilizing waste cold improves the overall efficiency of the refrigeration system, reducing energy consumption and operating costs.

Environmental Benefits: Lower energy consumption translates to reduced greenhouse gas emissions, contributing to environmental protection.

Enhanced Sustainability: Implementing this solution showcases the company's commitment to sustainability and resource optimization.

Project information

Project:	**Project no. 6**	**Date:**
Using Solar Energy Lights for the Company's Campus Lighting System		

Enterprise: BEVERAGE PRODUCTION PLANT	Auditing company: POLYTECHNICAL ENERGY AND ENVIRONMENT JOINT STOCK COMPANY	Auditor: Pham Van Tuyen

Project description

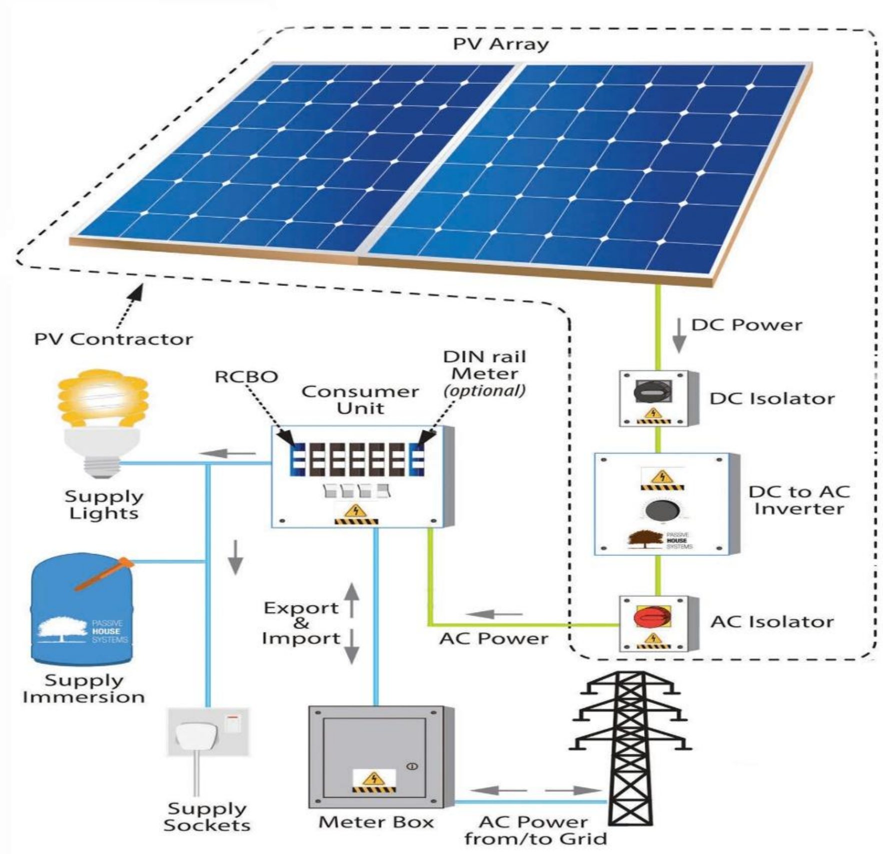
Current situation

The company currently uses 200W LED bulbs for campus lighting, which are efficient but rely on grid electricity. The increasing popularity of renewable energy and its potential for cost savings and environmental benefits have prompted the exploration of solar-powered lighting solutions.

Proposed project

The proposed solution involves replacing the existing LED lights with solar-powered lights, such as the MD-76100B1 model. These lights offer high power, long lifespan, and minimal maintenance, utilizing solar energy to reduce electricity consumption and costs.

Project illustration (PFD)



Solar Panels

- Solar Panels: These will be strategically placed throughout the campus to capture sunlight. The PFD should indicate the number, location, and orientation of solar panels.
- Charge Controllers: These regulate the voltage and current from the solar panels to efficiently charge the batteries. The PFD should show the connection between the solar panels and charge controllers.
- Batteries: Batteries store the energy generated by the solar panels to power the lights during nighttime or cloudy conditions. The PFD should indicate the type, capacity, and location of the batteries.
- LED Lights: The PFD should show the number, type, and wattage of the LED lights used for campus illumination.
- Wiring and Connections: The PFD should illustrate the wiring connections between the solar panels, charge controllers, batteries, and LED lights, ensuring a clear representation of the electrical flow.
- Control System (Optional): If the system includes any automated controls, such as timers or light sensors, these should be included in the PFD.

General PFD Outline:

1. Sunlight is captured by the solar panels.
2. The charge controllers regulate the energy flow from the solar panels to the batteries.
3. Batteries store the energy for use when sunlight is unavailable.
4. The LED lights are powered by the batteries, providing illumination to the campus.
5. (Optional) Control systems manage the operation of the lights based on ambient light conditions or pre-set schedules.

Project Budget

Element	**Units**	**Unit costs** (mil. VND)	**Costs** (mil. VND)
Cost for solar-powered lighting	pcs	3	90
Labor cost for replacement	labor	0.2 (x 30)	6
Total			**96**

Time schedule

Activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Assessment and Planning												
Design and Procurement												
Installation												
Testing, Commissioning, and Training												

Saving

Energy(annual): 3.0 TOE	**Financial (annual):** 37.5 million VND
CO_2 (annual): 13.3 tons	**Simple Payback (years):** 2.6

Risk Analysis

Sunlight Dependence: The performance of solar lights is dependent on sunlight availability, which can be affected by weather conditions and seasonal variations.

- Mitigation: Select solar lights with adequate battery capacity to ensure sufficient illumination even during periods of reduced sunlight. Consider installing a backup system for critical areas.

Initial Investment Cost: The initial investment cost for solar lights can be higher than traditional grid-connected lights.

- Mitigation: Conduct a thorough cost-benefit analysis to evaluate the long-term financial benefits of solar lighting, considering reduced electricity costs and maintenance.

Technology Obsolescence: Rapid advancements in solar technology could lead to newer, more efficient options becoming available in the future.

- Mitigation: Select modular and upgradable solar lighting systems to allow for future upgrades and expansions.

Non-Energy benifits

Reduced Environmental Impact: Solar lighting reduces reliance on grid electricity, which often comes from fossil fuels, thus lowering greenhouse gas emissions and promoting environmental sustainability.
Cost Savings: Solar lights eliminate ongoing electricity costs associated with traditional lighting, resulting in significant long-term cost savings.
Improved Safety: Well-lit campus areas enhance safety for employees and visitors, especially during nighttime hours.
Enhanced Aesthetics: Solar lights can improve the aesthetic appeal of the campus, creating a modern and sustainable environment.

Project information

Project: Install a variable frequency drive (VFD) and control system to reduce the unload time of compressor number 2	**Project no. 7**	**Date:**
Enterprise: BEVERAGE PRODUCTION PLANT	**Auditing company: POLYTECHNICAL ENERGY AND ENVIRONMENT JOINT STOCK COMPANY**	**Auditor: Lai Tien Dat**

Project description

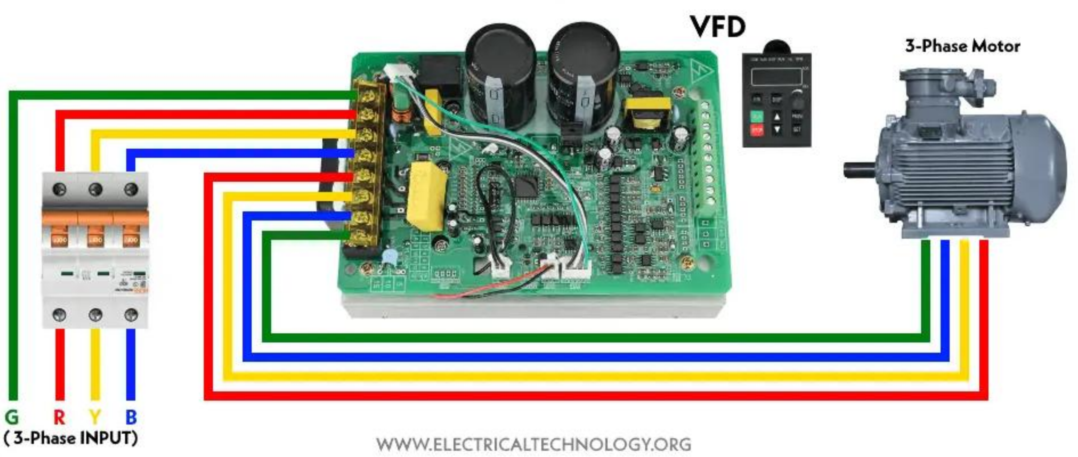
Current situation

The company utilizes two 55 kW Ingersoll Rand oil-free compressors for compressed air production. Compressor No. 2 experiences significant idle time due to low demand, resulting in wasted energy consumption.

Proposed project

To address the idle time of compressor No. 2, the proposed solution involves installing a variable frequency drive (VFD) and a control system. This system will adjust the compressor's speed based on demand, reducing energy consumption and improving efficiency.

Project illustration (PFD)



variable frequency drive

- Air Compressors: The PFD should depict all air compressors in the system, including their power ratings, operating pressures, and flow capacities. In this case, it should show both compressor No. 1 and compressor No. 2.
- Air Receiver Tank: The PFD should include the air receiver tank, which stores compressed air for use in the factory. The tank's capacity and operating pressure should be indicated.
- Variable Frequency Drive (VFD): The PFD should clearly show the VFD connected to the motor of compressor No. 2. The VFD's power rating and control functions should be labeled.

- Control System: The PFD should depict the control system, including pressure sensors, control valves, and the control panel. The control logic and setpoints for pressure regulation should be indicated.
- Piping and Connections: The PFD should illustrate the piping connections between the compressors, air receiver tank, VFD, and control system, ensuring a clear representation of the compressed air flow path.
- Valves and Instrumentation: The PFD should include relevant valves (e.g., isolation valves, check valves) and instrumentation (e.g., pressure gauges, flow meters) to provide a comprehensive view of the system.

General PFD Outline:

1. Air compressors compress air and discharge it into the air receiver tank.
2. The VFD and control system monitor the pressure in the air receiver tank.
3. Based on the pressure feedback, the VFD adjusts the speed of compressor No. 2 to match the demand for compressed air.
4. Compressed air is distributed to various end-use points in the factory.

Project Budget			
Element	**Units**	**Unit costs** (mil. VND)	**Costs** (mil. VND)
Variable frequency drive	set	154.0	154.0
Controller	set	80.0	80.0
Electrical cabinet	set	15.0	15.0
Accessories (switches, fuses, starters, contactors, wiring, etc.)	complete set	1	24.9
Installation and system calibration costs	complete set	1	27.4
Total			**301.3**

Time schedule												
Activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Project Planning and Design	■											
VFD and Control System Procurement		■	■									
Site Preparation and Installation			■	■								
Commissioning and Testing				■	■							

Saving	
Energy(annual): 12.74 TOE	**Financial (annual):** 157.1 million VND
CO_2 (annual): 55.9 tons	**Simple Payback (years):** 1.9

Risk Analysis

Compatibility: The VFD and control system must be compatible with the existing compressor and electrical system. • Mitigation: Engage qualified engineers to ensure proper selection and integration of the VFD and control system. Performance: The actual energy savings may vary depending on operating conditions and the effectiveness of the VFD in reducing idle time. • Mitigation: Conduct thorough testing and monitoring to optimize the VFD's performance and ensure maximum energy savings. Maintenance: The VFD and control system may require regular maintenance and potential repairs, incurring additional costs. • Mitigation: Establish a preventive maintenance plan for the VFD and control system, including regular inspections and servicing.
Non-Energy benifits
Reduced Equipment Wear: Reducing idle time minimizes wear and tear on the compressor, potentially extending its lifespan. Improved Reliability: The VFD can provide smoother operation and reduce stress on the compressor, improving overall system reliability. Reduced Noise: Operating the compressor at lower speeds can reduce noise levels in the surrounding environment.

Annex 3.6. More examples of energy audit reports

As part of the Vietnam-Denmark Energy Partnership Program 2020-2025 a **Center of Excellence for Energy Efficiency** (CoE) has been established.

The CoE serves as a hub for information provision, capacity-building activities, technical support, and stakeholder connections to realize energy efficiency solutions and projects for industrial enterprises. More anonymized energy audit reports can be found at the **Center of Excellence for Energy Efficiency:** The Center of Excellence (CoE) for Energy Efficiency

Section 4: Energy Mapping

4.1. Introduction

4.1.1. Energy mapping definition

Mapping of an object or event, in its most general definition, is the representation of the relationship between a database of real-time activity of that object or event and the space in which it exists.

With the above concept, energy mapping is the establishment and visual analysis of the energy flows in a system to detect energy use. Based upon on that basis, opportunities to use energy more efficiently can be identified. The energy mapping will also reveal energy loss and waste. This makes energy mapping one of the most important cornerstones in a solid and data driven energy audit.

Energy mapping is more than just conducting an energy audit of a specific energy-using area (commercial, industrial, transportation). Energy audits typically uncover opportunities to improve energy efficiency within an individual facility. While an energy mapping is the first and the most important step in the energy auditing process, energy mapping is a more comprehensive approach, with the ultimate goal of identifying integrated energy solutions for as many end-users as possible.

For example, to effectively integrate waste energy into an existing energy supply, it is necessary to make some trade-off calculations between the available waste energy and the energy required by the consumer to be received. Both the quantity and quality of the waste energy stream must be matched to the needs of the potential consumers of that energy source. In terms of waste heat, quality is usually measured in terms of temperature, with higher temperatures offering greater potential for redeployment. It is also necessary to consider the geographical proximity of the waste heat source to areas of heat demand.

Energy mapping is often of interest and applied in the following contexts:

- Complexity of production and business activities: enterprises can operate many production processes;

- Diversity of products: enterprises can produce many different types of products. Each type of product might have its own energy consumption, depending on the speed and quantity of products created;

- Specificity of production: enterprises use a lot of heat (heating, drying, cooling) and compressed air with different energy qualities.

Therefore, energy mapping will provide a comprehensive picture of energy use in production and business activities at an industrial facility, pointing out energy use but also inefficiencies and weaknesses in energy management and use, on that basis, it is possible to identify and propose improvement opportunities.

4.1.2. Benefit from energy mapping implementation

Energy mapping may provide many kinds of insights into the energy efficiency potential, such as

- Amount and quality of energy used for different processes.
- Specific energy consumption of a certain process per unit of product output. Such KPI can be compared to those of similar production processes in other enterprises to assess whether the overall efficiency of the process is efficient
- Quantification of energy losses, for example from poor insulation, or waste heat not being recovered. Such information helps understand whether measures need to be taken to reduce losses, and what would be the expected savings to be obtained.

- On the basis of the mapping, it will be possible to quantify possible energy savings that could be obtained from any suggested energy savings measure.

Results of the mapping will support the energy auditor prioritising which of the processes or technologies to pay particular attention to in the energy audit. Whitout a comprehensive energy mapping the energy auditors tend to take a (single) technology focus when conducting an energy audit, i.e. review the specific technology in the factory to identify equipment which based on experience would often offer opportunities for energy efficiency improvements. This approach often limits the audit to only cover a small share of the total energy consumption and additional often only take the utility into consideration, and thus overlook major opportunities for energy efficiency, not directly discernible from an inspection of the machinery.

Starting out with an energy mapping informs the energy auditor about how energy consumption is distributed on processes and how much is lost. Very often, the results of an energy mapping come as a surprise to the management of the enterprise and shows how they need to pay more attention to certain processes which are clearly not as efficient as they thought them to be.

Once a process has been identified as inefficient, the auditor may decide to pay extra attention this process, for example using the onion diagram principle of EE opportunity analysis (make reference to it in the audit guideline).

Energy mapping can provide different benefits to stakeholders (individuals, businesses, organizations, industries) depending on their specific needs and goals.

Individuals

For individuals, energy mapping can provide insight into their personal energy use in their residential environment. By visualizing their energy consumption, individuals can identify opportunities to reduce energy waste and make informed decisions about energy-saving activities and technologies in their homes.

Businesses

Businesses can leverage energy mapping to gain a comprehensive view of their energy usage across a variety of operations, including manufacturing, supply chains, and facilities. This insight allows businesses to optimize processes, reduce operating costs, and enhance sustainability efforts.

Organizations

Nonprofits, educational institutions, and government agencies can use energy mapping to track and manage energy consumption across their facilities and projects. This allows these entities to align with sustainability goals, reduce their environmental impact, and allocate resources efficiently.

Industry

Energy mapping is of significant value to industries such as manufacturing, transportation, and utilities. By visualizing energy usage at a granular level, industries can identify specific use, inefficiencies, streamline processes, and reduce resource consumption.

For the energy manager of an industrial enterprise the energy mapping is also a crucial tool for the energy manager to be able to take control of the energy use and also be able to find possible opportunities for energy efficiency.

The energy manager should update the energy mapping on a regular basis and at least ones every year and whenever major changes in the production or facility are made.
When used by the energy manager the energy manager takes responsibility and control over the energy use. The mapping can be used to determine EnPI and thus detect any changes in energy use etc.

If the energy manager is in control and use the energy mapping regularly it enables also the energy auditor to give better suggestions for possible energy efficiencies.

4.1.3.Major steps of energy mapping implementation

Implementing energy mapping in industry involves several key steps:

Step 1: Define Scope and Objectives

Clearly define the boundaries and objectives of the energy mapping, outlining the specific areas to be analyzed and the desired outcomes. This step sets the foundation for a focused and efficient mapping process.

Step 2: Collect Energy Data

Collect comprehensive energy consumption data across the designated areas, including electricity usage, gas usage, and any other relevant energy sources. Use energy meters, utility bills, and IoT devices to collect accurate and real-time data. For a start there will typically be a need to also make good estimations if accurate data is not available. It is important to start with a rough energy mapping and detail it when and where needed. The aim is not to map 100% of the energy but to get a data-driven (and estimated when needed) knowledge of the use of the energy.

Step 3: Analyze Energy Consumption Patterns

Use data analytics and visualization tools to interpret energy consumption patterns and trends. Identify peak usage periods, high consumption areas, and potential inefficiencies that require further attention.

Step 4: Identify Improvement Opportunities

Based on the analysis, identify opportunities for energy optimization, efficiency upgrades, and sustainable operations. This may include replacing outdated equipment, implementing energy-saving technologies, or optimizing work- or process flows.

Step 5: Develop Energy Mapping Reports

Compile findings and insights into comprehensive energy mapping reports that outline the current energy landscape, identify improvement opportunities, and recommend strategies to improve energy efficiency and sustainability.

During the energy mapping process, the interest and involvement of stakeholders, such as facility managers, energy analysts and operations staff, is essential to ensure that diverse perspectives are considered and integrated, leading to more comprehensive insights and more actionable strategies.

4.1.4. Advantages and challenges of energy mapping implementation

Understanding the advantages and limitations of energy mapping is essential to making informed decisions when implementing this activity.

Advantages of energy mapping

- Data-driven decision making: Energy mapping provides data-driven insights that help make informed decisions regarding energy efficiency and optimization.
- Cost savings: Identifying and addressing energy inefficiencies through mapping can result in cost savings, contributing to overall financial sustainability.
- Environmental impact: Energy mapping supports environmental sustainability efforts by uncovering opportunities to reduce carbon emissions and minimize resource consumption.

Limitations and challenges of energy mapping

- Data availability: Limited access to comprehensive energy data can pose challenges to accurate and comprehensive energy mapping.

- Complexity of analysis: Analyzing and interpreting energy consumption data can be complex and resource-intensive, requiring expertise in data analysis and energy management.
- Implementation costs: The initial implementation costs for energy mapping tools and technologies can be a barrier, especially for small-scale entities.

4.2. The following DE3 Guideline on Energy Mapping

4.2.1. Introduction

A careful mapping and understanding of the energy usage in an industrial company is a crucial baseline in project development.

However, in numerous international projects it has been observed that energy auditors face severe challenges in such important work, partly because the work is not very well structured and well defined in terms of outputs, and partly because energy auditors are reluctant to build conclusions on other than detailed and precisely measured data.

With this background, this guide aims to establish a well-defined mapping methodology, that delivers clear outputs phase by phase and supports and instructs energy auditors on specific activities to be carried out.

The guide consists of an energy mapping template in Excel format which is accompanied by the present user guide which describes how to set-up such a mapping in practice and how to utilize the results for developing projects. The data and process flow within the energy mapping template are only for illustrative purposes and do not represent actual data from an actual production site.

Figure 4-1 shows a flow chart of the overall energy mapping process which can be used to keep track of the steps in the energy mapping process. It also highlights the iterative process of setting up the energy balance, where the mapping degree is used as an indicator for when to move on to analyze the results. This simplified approach can save auditors a lot of time on carrying out many very time-consuming measuring programs on all equipment and instead focuses on first getting a full overview of the actual energy demands based on available information and assumptions. This enables the auditor to prioritize the more time-consuming analyses and measuring programs on the processes and equipment that is initially shown to have the greatest saving potential. Having set up energy- and mass balances for a process will often also be a necessary step for identifying which parameters to measure.

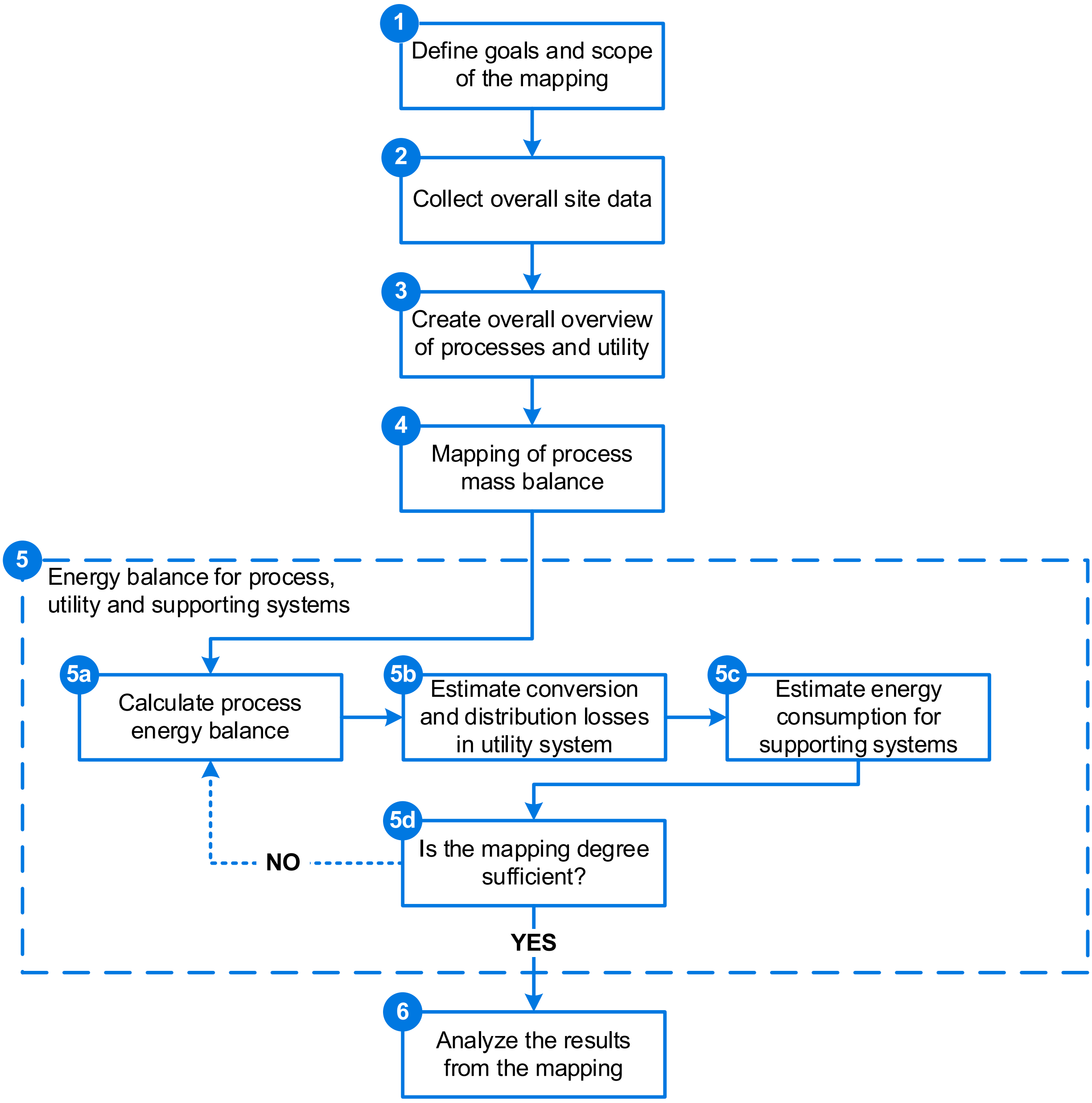


Figure 4-1: Flow chart of the energy mapping process

4.2.2. Defining a scope and goal

This first step of the energy mapping is to clearly define a scope and purpose for the energy mapping. Depending on the size of the company and timeline for the energy mapping and the overall strategy of the company, which is being mapped, the scope and goals of the mapping could vary. The following questions should therefore be considered before starting the energy mapping:

- Is the goal to map the entire facility or should the mapping focus on certain areas?
  - Geographic areas?
  - Certain production areas of higher interest?
- What level of detail can be achieved with the given timeline for the energy mapping?
- What is the main driver for conducting the energy mapping?
  - Is it only to achieve a detailed overview of the energy consumption?
  - Is it economical? Should the model be prepared to handle economic evaluations? Is it environmental? Should the model be prepared to handle CO_2 savings as well?

4.2.3. Overall site data

When the scope is defined, the next step of the energy mapping is to get an overview of the overall site data. This data should be easily available at most sites. The overall site data covers all purchased primary energy consumption and the amount of production output. In addition to the outputs the main inputs (i.e. raw materials) to the production process should also be achieved at this step. In the Energy mapping template, an example of such overall data collection is shown in the sheet "Yearly data".

This sheet will function as an input sheet for the mass balance and utility mapping sheets later on. Therefore, all unit conversions should be carried out in this sheet to avoid unnecessary calculations in the later sheets. It is important to secure consistency of the units within all data types. For time, energy and mass, the recommended units are:

1. Time: Year
2. Mass: Tons
3. Energy: kWh

Being consistent about all units will ease further work and comparisons.

The overall site data should be collected as soon as possible and many times even before an actual site visit, in order to give a better understanding of the size of the production company and their overall energy demands.

Yearly data

Energy Data	**Year**	
Purchased Electricity	20.000.000	kWh/y
Purchased Natural Gas Steam boiler	20.000.000	kWh/y
Purchased Coal	18.000.000	kWh/y
Total Purchased Energy	**58.000.000**	**kWh/y**
Production data		
Material X	160.000	Ton/y
Material Y	20.000	Ton/y
Material Z	40.000	Ton/y
Material W	5.000	Ton/y
Material V	10.000	Ton/y
Material Q	15.000	Ton/y
Total Raw materials	**250.000**	**Ton/y**
Additives production line 1	10.000	Ton/y
Additives production line 2	-	Ton/y
Total Additives	**10.000**	Ton/y
Final product data		
Final product 1	100.000	Ton/y
Final product 2	80.000	Ton/y
Total final product	**180.000**	**Ton/y**

Figure 4-2: Overview of collection of overall site data. See sheet "Yearly data" in the Excel template

Creating an overview of processes, utilities and supporting systems

Once the overall site data has been gathered and goals and scope have been defined, an overall overview of the production processes, utilities and supporting systems should be created. These are essentially the first drafts of what will become the mass flow balance and utility mapping in the Excel template.

The overviews should be made on the basis of screenshots, flow diagrams, previous audits, production trends, site walks, etc. This first overview can also be carried out on paper or a drawing program such as Visio to then later be carried over to the Excel spreadsheets. An example of a simple Visio sketch of the example from the Excel template is shown in Figure 4-3.

For the production processes the goal is to create a basic overview of the entire production flow at the site. At this step, the focus is to include all processes in the right order in relation to each other, but not necessarily to get numbers on inputs and outputs of each step. Every process should be labelled and each process stream should.be numbered to keep a good overview of the system. The production flows are mapped in the sheet "Mass flow balance" in the Excel template.

In addition to creating an overview of the production processes, an overview of the utility structures at the site should also be prepared. Once again focus on this stage is more to qualitatively achieve the full overview rather than quantifying losses and efficiencies. This should be done for all utility systems at the site (i.e. heating, cooling, compressed air, etc.). The utility structures are mapped in the sheet "Utility mapping" in the Excel template.

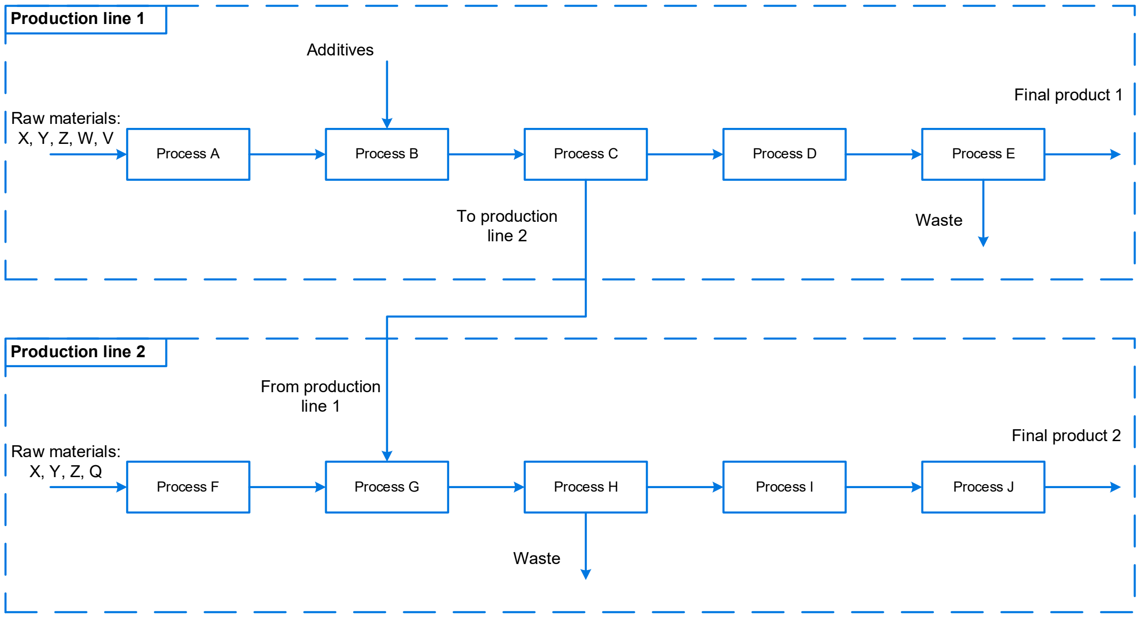


Figure 4-3: Simple Process flow overview of the template example.

4.2.4. Process mass balance

The next step is to set up the process mass balance based on the previously created process flow diagram. This is shown in
Figure 4-4 below and is done in the "Mass flow balance" sheet in the mapping template. Each process step is indicated by a box. The example shows a site with two different production lines that are creating two different products from a list of raw materials. Each production line consists of 5 processes with varying inputs of additives and energy. It is also seen that a biproduct from production line 1 is used directly in production line 2. To carry out the mass balance the following steps should be followed:

1. The yearly data for raw materials are imported from the "Yearly data" sheet.

2. For each process it is evaluated whether there is any addition or extraction of material.
3. If any product or additive is added or removed during a process, data should either be collected from the company if possible or it should be estimated.
    a. Estimation can often be done by consulting the operating personnel at the site.
    b. For some processes calculating the mass balance could require more information about the product. In the energy mapping template such an example is given for production line 2, where the mass balance is set up from knowing the Dry Matter percentage between process steps.
    c. This process can require a more detailed understanding of the process than the auditor has, and it can therefore be an advantage to involve operational or production personnel with extensive knowledge on the process in this step.
4. All streams with additions or removal of product are numbered.
    a. It is important remember to include waste streams since these might become interesting for later analysis
5. It is important to keep progressing with the energy mapping and not get stuck in trying to achieve a value in a very detailed way that takes too long at this stage. If the uncertainty of a value is deemed very high this should be noted by the energy auditor as a potential focus point for later analysis.
6. When all processes have been mapped, the calculated amount of final product can be compared to the actual data for final production. This can be used to indicate if there are significant errors in the mass balance.
    a. In addition to this, a check should also be done for each production line on all incoming materials and outgoing products, making sure it equals out (In the Excel template this is carried out in cells T25 and T52 for the two production lines respectively).

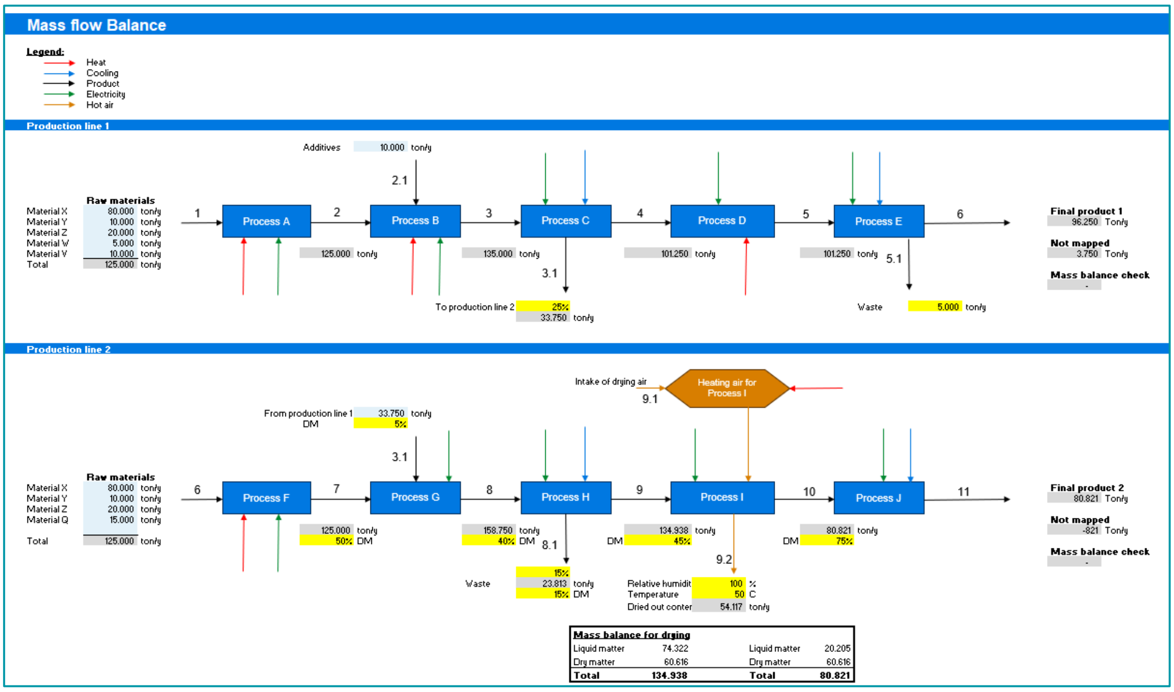


Figure 4-4: Overview of the process mass flow balance. See sheet "Mass flow balance" in Excel template.

4.2.5. Energy balance for process, utility and supporting systems

In addition to the mass flow balance, energy balances for process, utility and supporting systems should be set up. The goal is to set up tables for each utility type where all the energy consumers are listed. This is shown in Figure 4-5 and can be seen in sheet “Process mapping” in the Excel template.

Starting with the process energy balances the recommended approach is described below:

1. The first step is to evaluate the energy inputs for each process on a qualitative level, considering both the thermal and electrical energy consumption. This is most easily done by drawing ingoing energy flows on the previously created mass balance. This can also be seen in Figure 4-4.
2. After this, the specific energy consumption in each process step should be calculated. Each process is listed in the respective energy consumption tables and some basic information on “Section”, “Media” and “Stream No.” is noted for easy reference later.
3. For thermal energy mapping additional information on the process stream might be required. In any case temperature information is needed and, in some cases, pressure and heat capacity or enthalpy could also be needed. The mapping itself can be carried out with three different approaches (examples of all three approaches are given in the Excel template):
   - **Flow**: With the flow approach, the energy demand is calculated with the following equation. This approach is based on information of the mass flow and temperature difference over a specific unit.

$$(T_{out} - T_{in})[K] \times c_p \left[\frac{kJ}{kg * K}\right] \times \dot{m}_{in} \left[\frac{ton}{year}\right] \times 1000 \left[\frac{kg}{ton}\right] \times \frac{1}{3600} \left[\frac{h}{s}\right] = \dot{Q} \left[\frac{kWh}{year}\right]$$

   - **KPI**: With the KPI approach, the energy demand is calculated based on a KPI for the specific unit, if such information exists.

$$KPI \left[\frac{kWh}{ton}\right] \times \dot{m} \left[\frac{ton}{year}\right] = \dot{Q} \left[\frac{kWh}{year}\right]$$

   - **Measurement**: With measurement approach, the energy demand from a component will be measured over a period of time and the measured value will be extrapolated to a yearly consumption. It can also be that the energy consumption for a given process is logged by the production company.
4. It is important to keep in mind that the potential energy content of the process waste streams should also be mapped during the thermal energy mapping.
5. For the electrical energy mapping, the electricity consumption of the process equipment is calculated. This calculation can also be based on three different approaches (examples of all three are once again shown in the Excel template):
   - **Power**: with the power approach then the electricity demand is calculated by the knowledges of the power capacity, the operating hours and a load estimate.

$$\gamma[-] \times t\,[h] \times p[kW] = \dot{P}_{unit} \left[\frac{kWh}{year}\right]$$

     t = annual operational time in hours [h]
     γ = Load factor
     p = effect in kW [kW]
   - **KPI**: This approach is the same as for the thermal part.

$$[KPI] \left[\frac{kWh}{ton}\right] \times \dot{m} \left[\frac{ton}{year}\right] = \dot{P}_{unit} \left[\frac{kWh}{year}\right]$$

   - **Measured**: This approach is the same as for the thermal part.

$$\dot{P}_{unit} \left[\frac{kWh}{year}\right] = measured$$

6. The template is set up with conditional formatting to indicate the largest consumers in each energy type. Cell E6 can furthermore be utilized to define a threshold for Significant Energy Users. This can vary depending on the size of the facility and the number of process streams.
7. In column CO to MK a temperature analysis is set up for analyzing results in the later stage.
8. Once again it is important to keep progressing with the energy mapping and not get stuck in trying to achieve a value in a very detailed way that takes too long at this stage. If the uncertainty of a value is deemed very high this should be noted by the energy auditor as a potential focus point for later analysis
9. The tables in the Excel template are set up to be able to handle up to 100 processes within each category. Most of these are hidden to keep a better overview. For a guide on how to unhide a number of rows Appendix **Fejl! Henvisningskilde ikke fundet.** should be reviewed.

Process Mapping

NB: See Appendix in User guide for help on how to add additional rows to the tables

Definition of Significant Energy User: 15%

Heating consumption

Section	Proces	Medium	Stream no	Utility system	Temp. In	Temp. Out	Mass flow	Dry matter	Cp	KPI	Flow approach	KPI approach	Measurement	Total	Share of total
					°C	°C	t/yr	%	kJ/KgK	kWh/ton	kWh	kWh	kWh	kWh	
Production line 1	Process A	Product	1	Steam	20	50	125.000	5,0%	4,06		4.228.440			4.228.440	14,6%
Production line 1	Process B	Product	2	Steam	50	100	135.000	5,0%	4,08	100,00		13.500.000		13.500.000	46,6%
Production line 1	Process D	Product	4	Hot water	45	50	101.250	5,0%	4,07				800.000	800.000	2,8%
Production line 2	Process F	Product	6	Steam	20	60	125.000	50,0%	3,00		4.168.389			4.168.389	14,4%
Production line 2	Heating air for Process I	Product	9.1	Steam	20	80	134.938	44,9%	3,17	40,00		5.397.500		5.397.500	18,6%
Support system 1	Support system 1	Water	11	Hot water	20	50	26.000	0,0%	4,18		905.667			905.667	3,1%
									4,18					-	0,0%
									4,18					-	0,0%
									4,18					-	0,0%
									4,18					-	0,0%
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									4,18					-	0,0%
									4,18					-	0,0%
									4,18					-	0,0%
	TOTAL										9.302.496	18.897.500	800.000	28.999.996	100%

Cooling consumption

Section	Proces	Medium	Stream no	Utility system	Temp. In	Temp. Out	Mass flow	Dry matter	Cp	KPI	Flow approach	KPI approach	Measurement	Total	Share of total
					°C	°C	t/yr	%	kJ/KgK	kWh/ton	kWh	kWh	kWh	kWh	
Production line 1	Process C	Product	3	Glycol	75	20	135.000	5,0%	4,07		8.386.860			8.386.860	37,7%
Production line 1	Process E	Product	5	Glycol	30	12	101.250	5,0%	4,05	30,00		3.037.500		3.037.500	13,6%
Production line 2	Process H	Product	8	Glycol	55	15	158.750	5,0%	4,06				9.000.000	9.000.000	40,4%
Production line 2	Process J	Product	10	Glycol	50	15	80.821	75,0%	2,35		1.845.256			1.845.256	8,3%
									4,18					-	0,0%
									4,18					-	0,0%
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									4,18					-	0,0%
									4,18					-	0,0%
	TOTAL										10.232.115	3.037.500	9.000.000	22.269.615	100%

Waste heat potential

Section	Proces	Medium	Stream no		Temp. In	Temp. Out	Mass flow	Dry matter	Cp	KPI	Flow approach	KPI approach	Measurement	Total	Share of total
					°C	°C	t/yr	%	kJ/KgK	kWh/ton	kWh	kWh	kWh	kWh	
Production line 1	Process E	Product	5.1		50	20	5.000	0,0%	4,18		174.167			174.167	6,4%
Production line 2	Process H	Product	8.1		40	20	23.813	0,0%	4,18		552.979			552.979	20,3%
Production line 2	Process I	Air	9.2		50	20	54.117	0,0%	1,01				2.000.000	2.000.000	73,3%
									4,18					-	0,0%
									4,18					-	0,0%
									4,18					-	0,0%
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									4,18					-	0,0%
									4,18					-	0,0%
									4,18					-	0,0%
	TOTAL										727.146	-	2.000.000	2.727.146	100%

Electricity consumption

Section	Proces	Medium	Stream no		Effect	Operation hours	Mass flow	Load factor		KPI	Flow approach	KPI approach	Measurement	Total	Share of total
					kW	h/y	t/yr	%		kWh/ton	kWh	kWh	kWh	kWh	
Production line 1	Process A	Product	1		500	6.500	125.000	90,0%			2.925.000			2.925.000	24,8%
Production line 1	Process B	Product	2		300	6.500	135.000	50,0%		8,00		1.080.000		1.080.000	9,1%
Production line 1	Process C	Product	3		100	7.000	135.000	60,0%			420.000			420.000	3,6%
Production line 1	Process D	Product	4		300	6.500	101.250	70,0%		3,00		303.750		303.750	2,6%
Production line 1	Process E	Product	5		50	7.000	135.000	75,0%					400.000	400.000	3,4%
Production line 2	Process F	Product	6		400	6.500	125.000	90,0%			2.340.000			2.340.000	19,8%
Production line 2	Process G	Product	7		400	6.500	125.000	50,0%		20,00		2.500.000		2.500.000	21,2%
Production line 2	Process H	Product	8		200	7.000	158.750	60,0%			840.000			840.000	7,1%
Production line 2	Process I	Product	9		300	6.500	134.938	70,0%		3,00		404.813		404.813	3,4%
Production line 2	Process J	Product	10		50	7.000	80.821	75,0%					600.000	600.000	5,1%
														-	0,0%
														-	0,0%
														-	0,0%
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														-	0,0%
														-	0,0%
														-	0,0%
														-	0,0%
														-	0,0%
	TOTAL										6.525.000	4.288.563	1.000.000	11.813.563	100%

Figure 4-5: Overview of the process energy mapping. See sheet "Process mapping" in Excel template

When the process level energy balances are set-up, the utility level energy balance can be set-up. The utility mapping covers all the utility systems that support the process energy demand. The utility systems can be boilers, coolers, chillers, air compressors, wastewater etc. The scope is to cover the purchased energy, conversion of energy, distribution of energy and finally the process energy. An example is shown in Figure 4-6 and can furthermore be seen in the Excel template. This system consists of two steam boilers using coal and natural gas to supply the main heating consumption, while a small hot water boiler and waste heat from air compressors is used in a 60°C system to supply hot water for supporting systems and one low temperature heating process. Cooling is supplied by one central chiller. The Excel template is prepared to handle up to three heating and cooling systems respectively. If more systems are present, the later results will have to be expanded by the user. The utility mapping can be carried out by the following steps:

1. All purchased energy is imported into the “Purchased” column
2. All major utility equipment is added to the “Conversion” column e.g. in the example the system consists of two steam boilers, chillers and air compressors.
3. For each type of equipment, the efficiency is estimated, and energy losses are calculated.
   - In the example losses are estimated for the boilers and air compressors
   - For chillers a Coefficient-of-Performance (COP) and known electricity consumption is used to estimate the amount of cooling that is produced. The COP value is not always known by the site in which case it might have to be estimated based on an assessment of the present equipment.
4. Next, the distribution losses are estimated in the “Distribution” column based on an overall assessment of the distribution system (level of maintenance, insulation, steam traps etc.)
5. Then the utility is connected to the end-users in the “Consumption” column.
6. Finally, the overall mapping degree can be calculated. As shown in Figure 4-6 in the beginning, the mapping degree is now used to evaluate whether the mapping is done to a sufficient degree or whether an extra iteration is required to.
   - If the mapping degree is deemed too low the energy balances are reevaluated.
   - If the mapping degree is deemed sufficient the auditor can move on to setting up and analyzing the results.
   - The sufficient level can vary a lot depending on the size of the facility and level of detail. Based on international experience a mapping degree of at least 90% is most often considered sufficient. However, no matter the degree it is very important to critically reflect on the reasons why it is not exact and what the potential consequences can be.

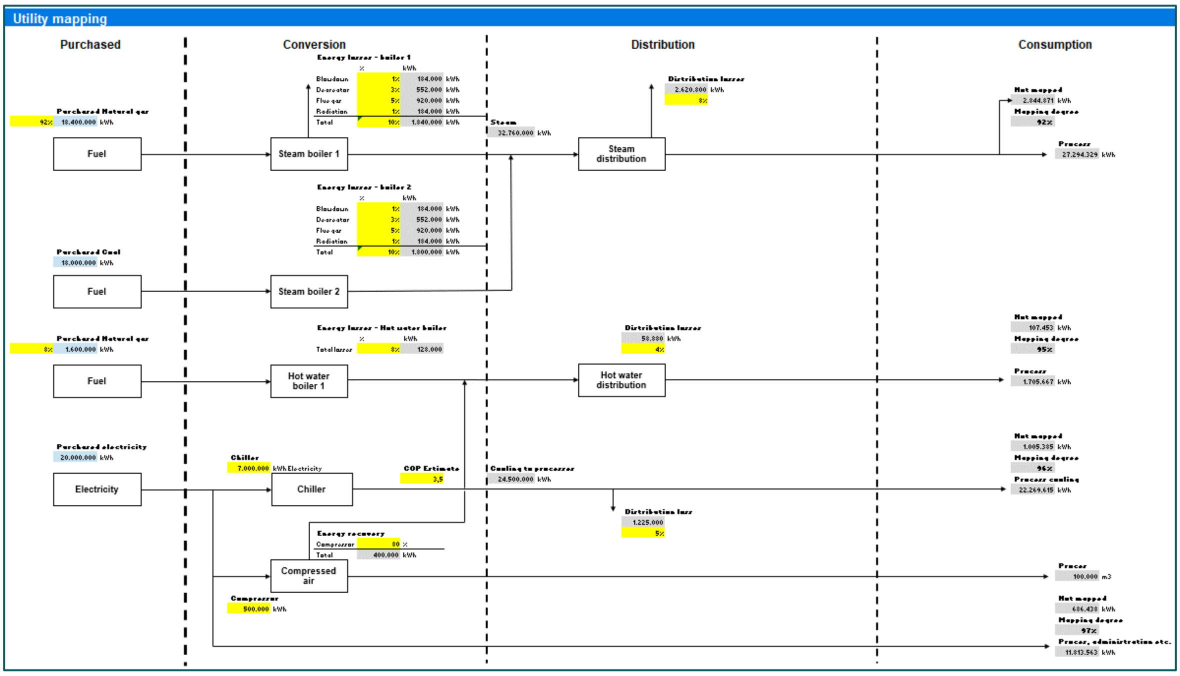


Figure 4-6: Overview of the utility mapping. See Excel template sheet "Utility mapping".

In addition to process and utility level energy balances, many production facilities also have several supporting systems. These systems are also required to be mapped, to get the full overview of energy consumption at a site. Examples could be, Cleaning-In-Place, washers (containers, boxes, bottles etc.), ventilation, packaging units etc. Since these will not be visible in the process flow, a separate sheet in the Excel template is kept for handling of these systems "Supporting systems". In the Excel template one example is given which is shown in Figure 4-7 below. In this example steam is used for heating up water for a washing machine at the site. This energy consumption is also carried over to the process mapping overview tables.

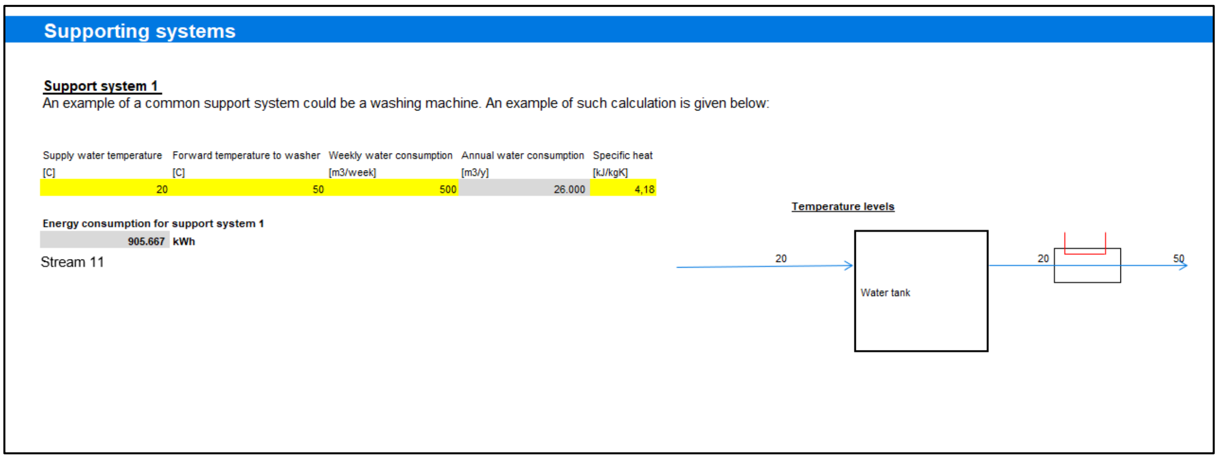


Figure 4-7: Overview of the supporting systems. See the sheet "Supporting systems" in the Excel template

4.2.6. Analyzing and understanding the results

When a sufficient mapping degree is achieved, the next step is to set up the results in an easily understandable way. To use the energy mapping properly it is important to consider how to present the results and how to use the results efficiently develop energy saving projects. It is emphasized that the development of projects should start by understanding the energy consumption of the processes before moving on to the utility systems. A full understanding of the actual energy service or purpose of using energy in the specific processes is therefore required.

To easily get a full overview of the entire facility pie charts and bar charts are made for each utility type at the site. As an example, an overview of the heating consumption for the given example is shown in Figure 4-8. These plots provide a good overview of the distribution of heat consumption for the entire site and make it easy to identify the main energy consumers at the site. In the example these are only created on site level, but for larger sites they can also be created on a production line level or section level, to have an even more detailed overview of where the energy is consumed. The overviews are created for each utility system at the site.

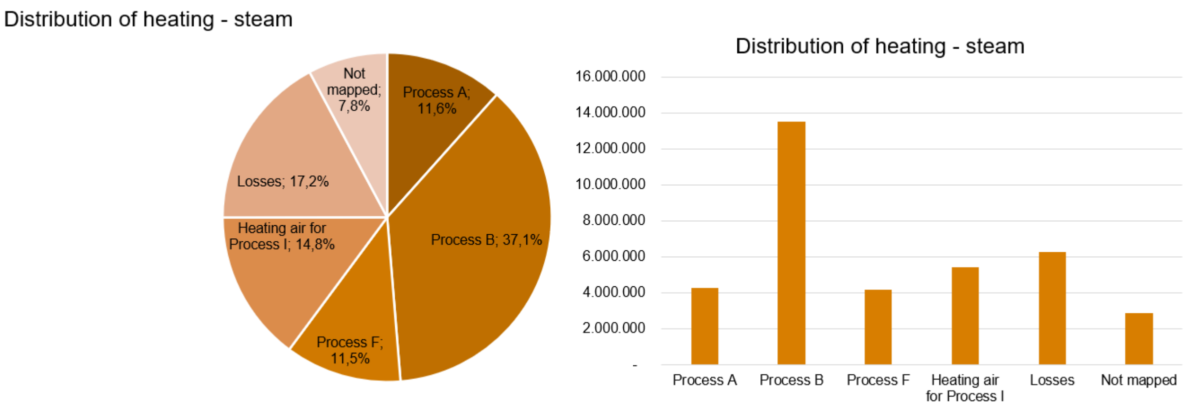


Figure 4-8: Charts for presenting the results of overall heat consumption. See Excel template sheet "Result Overview".

In addition to the overall overviews, it is often also useful to connect the consumption to temperature. This can help assess the potential for heat recovery and integration of, for example heat pumps. The graphs help give a good overview of what temperature levels the heating is utilized at. An example from the template is shown in the figure below. Conclusions from these plots could for example be that:

- 80% of the heating is used for processes below 80°C (about 23 GWh) and all heating is below 100°C.
  - Can hot water be used instead of steam?
  - Any good heat sources for heat pumps?
- 20% of the cooling is used above 50°C (about 4 GWh).
  - Are there any potentials for heat recovery?

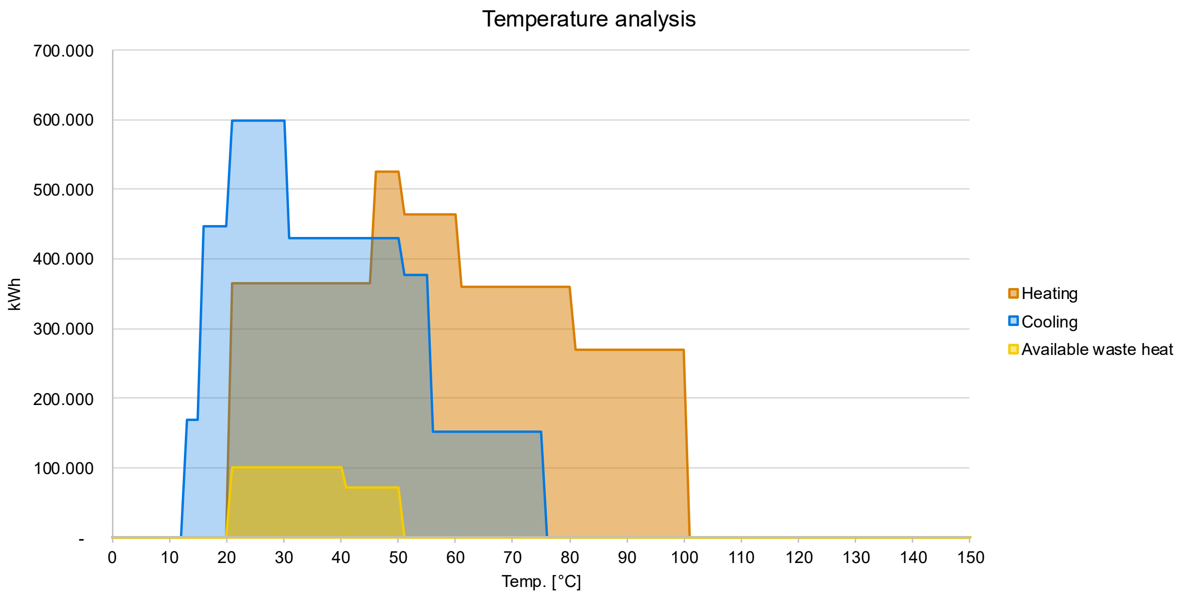


Figure 4-9: Example of a temperature analysis. See Excel template sheet "Result Overview".

In the example from the Excel template, it is seen that there is a high potential for implementing heat recovery between 20-75°C. Next step is to identify processes from the “Process mapping” tables with overlapping temperature requirements. In this example it can be seen that Process C for example can be matched with Process A and F:

Process	Temperature in [°C]	Temperature out [°C]	Energy consumption [MWh]
Process A	20	50	4.228
Process F	20	60	4.168
Process C	75	20	8.387

Table 4:1: Potential heat recovery opportunities

In terms of energy these streams almost match exactly, however, it will not be possible to cool Process C all the way to 20°C. A pinch temperature should therefore be introduced to reflect the physical limitations. Assuming a pinch temperature of 5°C, this means that process C can be cooled to 25°C and that 7.627 MWh can be recovered for heating. Cooling and heating utility will therefore still have to be used in both ends.

It should be noted that the above is exercise is fully theoretical. In the real world there are many more elements to consider when analysing the heat recovery potentials such as:

- **Matching operation times**: Are the processes running at the same time or are they batch controlled? Do we need a buffer tank?
- **Geographical location**: How far away are the processes from each other? Do the potential energy savings justify the piping investments?

It is therefore necessary to make a techno-economical analysis, estimating full investment costs and calculating payback times.

Once the energy consumption has been optimized, the utility system should be evaluated. From the utility mapping sheet, it should be evaluated whether the energy losses from the equipment can be minimized or recovered. In the Excel template, it is seen that waste heat from air compressors is already utilized in a 60°C hot water system. However, no heat is recovered from the chillers. There is a possibility to install an oil cooler or de-superheater on the chillers to supply more energy to the 60°C system. A lot of heat is also lost in the condensers of the chillers which could potentially be upgraded to higher temperatures with a heat pump. For the boilers it is seen that both boilers have an estimated flue gas loss of 5%. Recovering this in an economizer should therefore also be considered.

4.3. Annex

4.3.1.Adding additional rows Process mapping tables

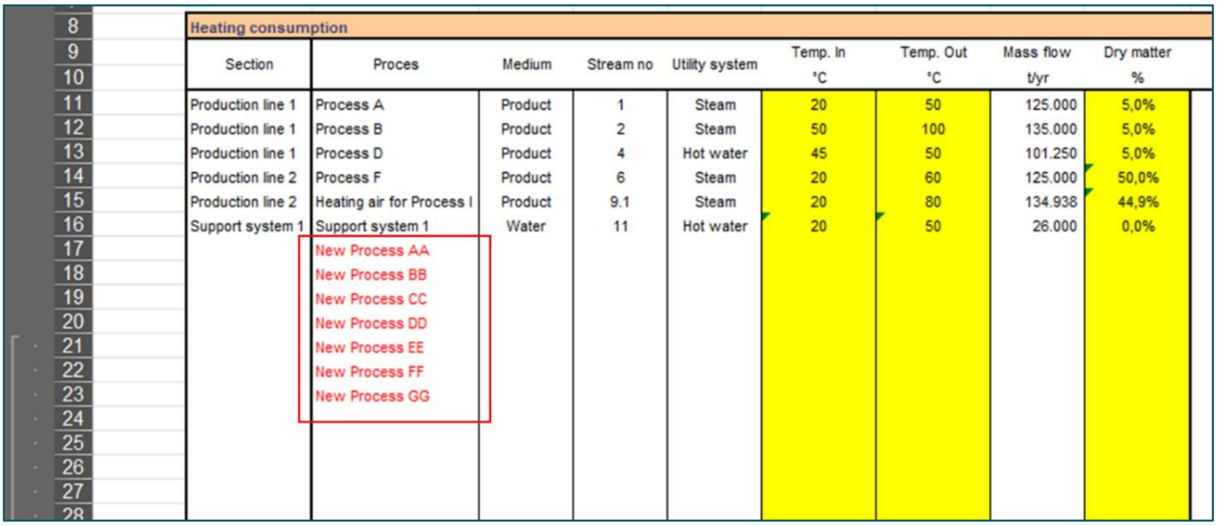
The following describes how to practically add extra rows to the Excel template. Each Process mapping table contains 100 rows of which most are left empty for the user to fill in if required. To add rows for the energy mapping the following steps should be followed:

1. Click on the “+” sign to the left of the table to open up the empty rows:

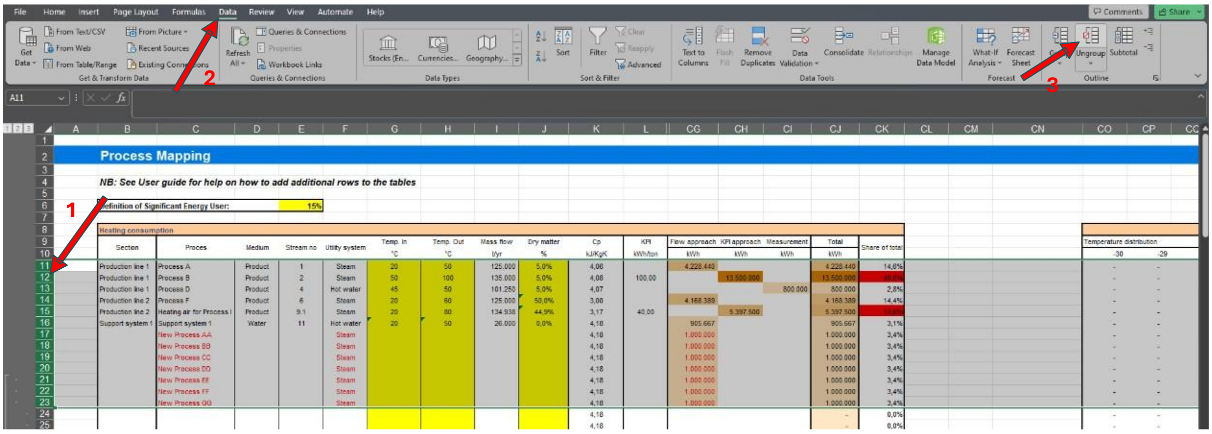
Row	Section	Proces	Medium	Stream no	Utility system	Temp. In °C	Temp. Out °C	Mass flow t/yr	Dry matter %	Cp kJ/KgK	KPI kWh/ton	Flow approach kWh	KPI approach kWh	Measurement kWh	Total kWh	Share of total
8	Heating consumption															
11	Production line 1	Process A	Product	1	Steam	20	50	125.000	5,0%	4,06		4.228.440			4.228.440	14,6%
12	Production line 1	Process B	Product	2	Steam	50	100	135.000	5,0%	4,08	100,00		13.500.000		13.500.000	46,6%
13	Production line 1	Process D	Product	4	Hot water	45	50	101.250	5,0%	4,07				800.000	800.000	2,8%
14	Production line 2	Process F	Product	6	Steam	20	60	125.000	50,0%	3,00		4.168.389			4.168.389	14,4%
15	Production line 2	Heating air for Process I	Product	9.1	Steam	20	80	134.938	44,9%	3,17	40,00		5.397.500		5.397.500	18,6%
16	Support system 1	Support system 1	Water	11	Hot water	20	50	26.000	0,0%	4,18		905.667			905.667	3,1%
17										4,18					-	0,0%
18										4,18					-	0,0%
19										4,18					-	0,0%
20										4,18					-	0,0%
111		TOTAL										9.302.496	18.897.500	800.000	28.999.996	100%

Row	Section	Proces	Medium	Stream no	Utility system	Temp. In °C	Temp. Out °C	Mass flow t/yr	Dry matter %	Cp kJ/KgK	KPI kWh/ton	Flow approach kWh	KPI approach kWh	Measurement kWh	Total kWh	Share of total
114	Cooling consumption															
117	Production line 1	Process C	Product	3	Chillers	75	20	135.000	5,0%	4,07		8.386.860			8.386.860	37,7%
118	Production line 1	Process E	Product	5	Chillers	30	12	101.250	5,0%	4,05	30,00		3.037.500		3.037.500	13,6%
119	Production line 2	Process H	Product	8	Chillers	55	15	158.750	5,0%	4,06				9.000.000	9.000.000	40,4%
120	Production line 2	Process J	Product	10	Chillers	50	15	80.821	75,0%	2,35		1.845.256			1.845.256	8,3%
121										4,18					-	0,0%
122										4,18					-	0,0%
123										4,18					-	0,0%
124										4,18					-	0,0%
125										4,18					-	0,0%
126										4,18					-	0,0%
217		TOTAL										10.232.115	3.037.500	9.000.000	22.269.615	100%

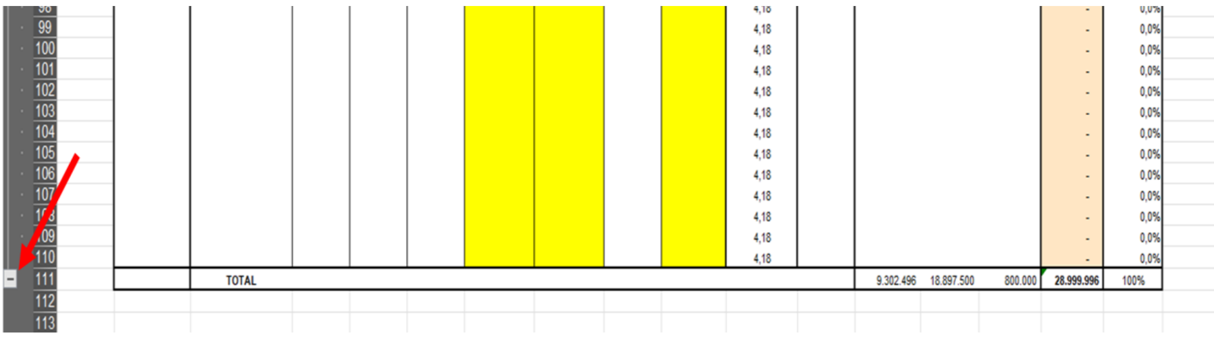
2. Add the new processes to the table:



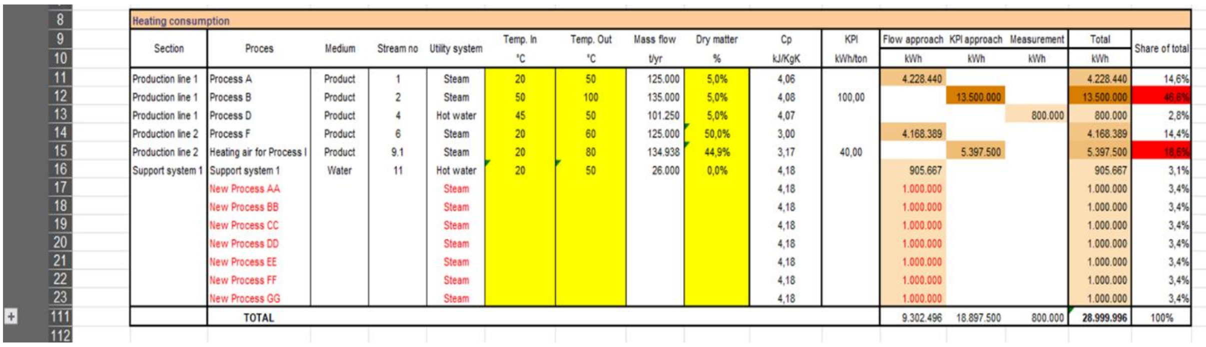
3. When the new processes have been added, all the rows that have been filled out are marked. From the top ribbon navigate to "Data", and click the "Ungroup" button to the right side:



4. All the filled-out rows are now ungrouped, and the remaining empty rows can be hidden again by scrolling to the bottom of the table and clicking the "-" sign to the left:



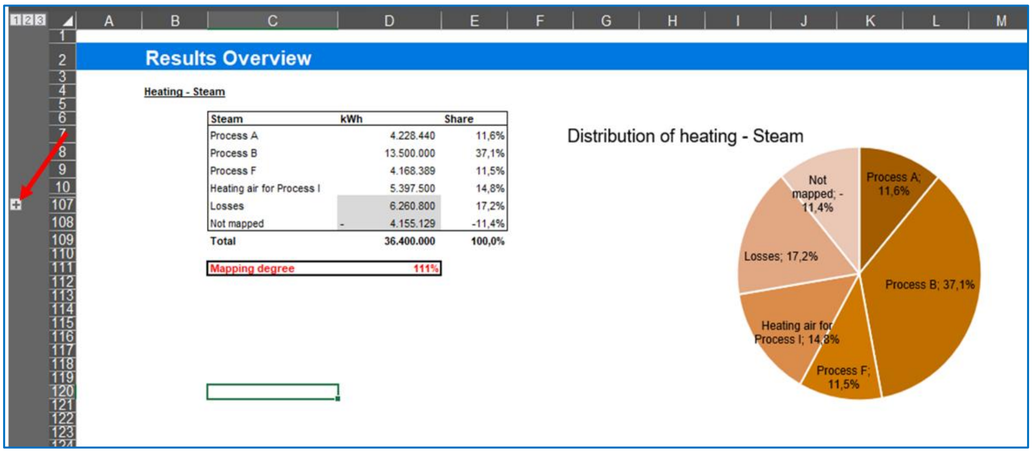
5. You are now left with a table containing all the new processes:



Heating consumption															
Section	Proces	Medium	Stream no	Utility system	Temp. In °C	Temp. Out °C	Mass flow t/yr	Dry matter %	Cp kJ/KgK	KPI kWh/ton	Flow approach kWh	KPI approach kWh	Measurement kWh	Total kWh	Share of total
Production line 1	Process A	Product	1	Steam	20	50	125.000	5,0%	4,06		4.228.440			4.228.440	14,6%
Production line 1	Process B	Product	2	Steam	50	100	135.000	5,0%	4,08	100,00		13.500.000		13.500.000	46,6%
Production line 1	Process D	Product	4	Hot water	45	50	101.250	5,0%	4,07				800.000	800.000	2,8%
Production line 2	Process F	Product	6	Steam	20	60	125.000	50,0%	3,00		4.168.389			4.168.389	14,4%
Production line 2	Heating air for Process I	Product	9.1	Steam	20	80	134.938	44,9%	3,17	40,00		5.397.500		5.397.500	18,6%
Support system 1	Support system 1	Water	11	Hot water	20	50	26.000	0,0%	4,18		905.667			905.667	3,1%
	New Process AA			Steam					4,18		1.000.000			1.000.000	3,4%
	New Process BB			Steam					4,18		1.000.000			1.000.000	3,4%
	New Process CC			Steam					4,18		1.000.000			1.000.000	3,4%
	New Process DD			Steam					4,18		1.000.000			1.000.000	3,4%
	New Process EE			Steam					4,18		1.000.000			1.000.000	3,4%
	New Process FF			Steam					4,18		1.000.000			1.000.000	3,4%
	New Process GG			Steam					4,18		1.000.000			1.000.000	3,4%
	TOTAL										9.302.496	18.897.500	800.000	28.999.996	100%

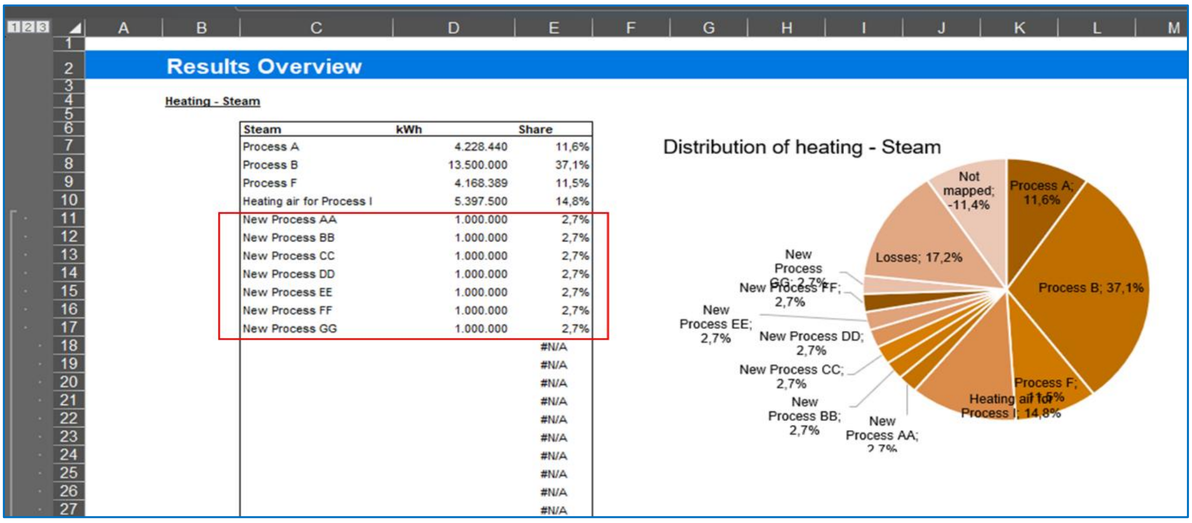
Next, the same procedure should be carried out in the "Result Overview" sheet. The formulas in the tables update automatically, but to make the plots show the correct values the new processes have to be unhided.

1. Click on the "+" sign to the left of the table to open up the empty rows



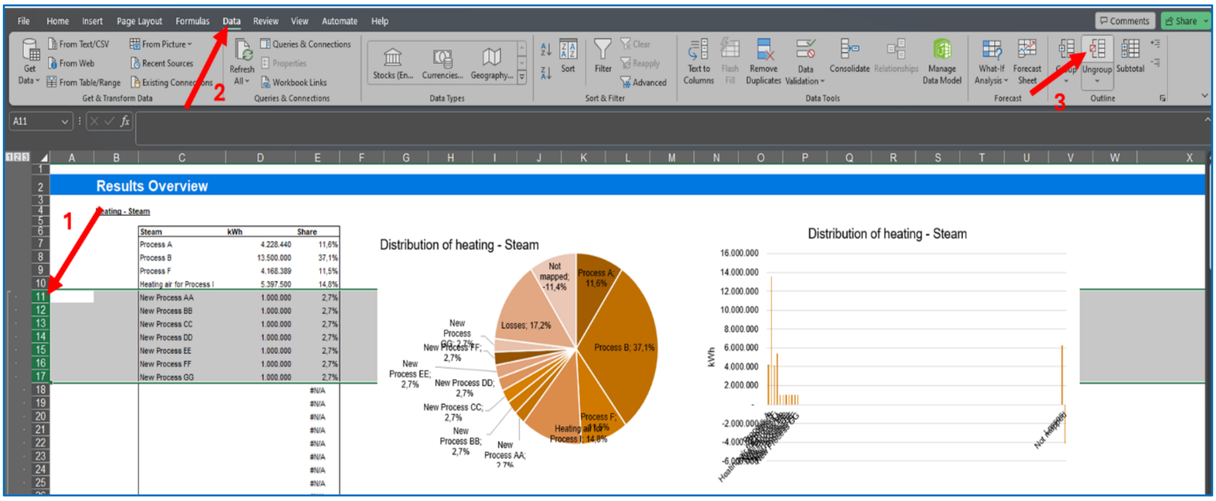
Steam	kWh	Share
Process A	4.228.440	11,6%
Process B	13.500.000	37,1%
Process F	4.168.389	11,5%
Heating air for Process I	5.397.500	14,8%
Losses	6.260.800	17,2%
Not mapped	- 4.155.129	-11,4%
Total	36.400.000	100,0%

2. Scroll up to the top of the table and check that the new processes have been imported correctly:

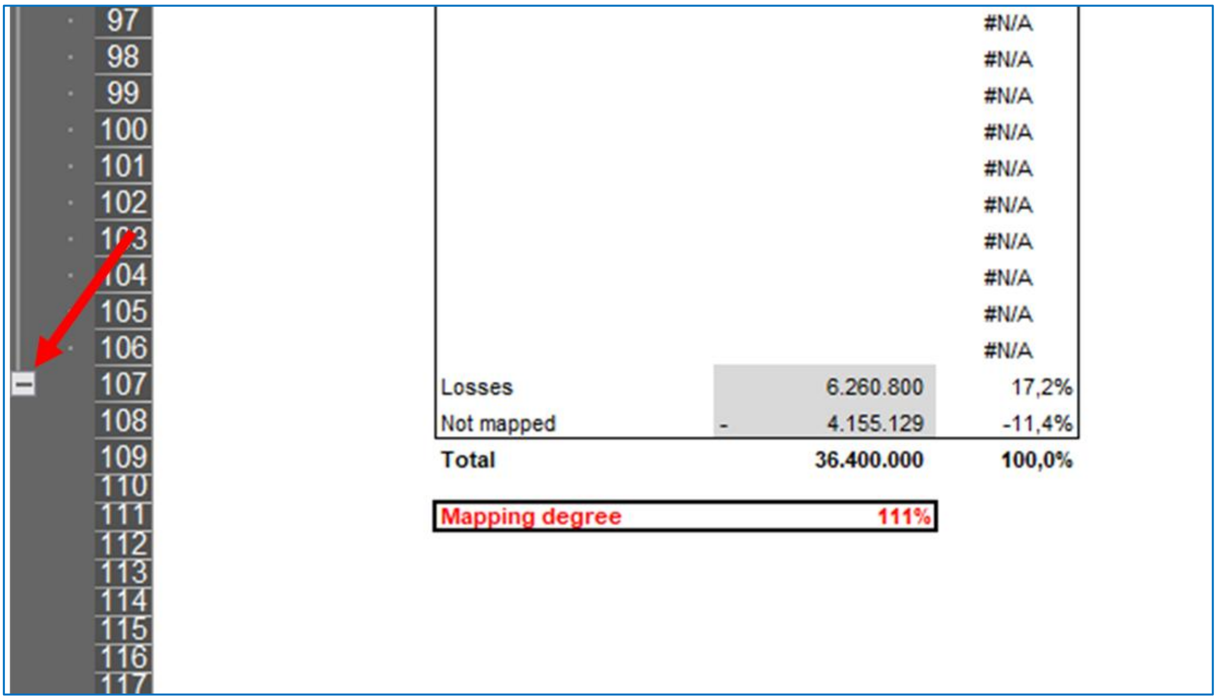


Steam	kWh	Share
Process A	4.228.440	11,6%
Process B	13.500.000	37,1%
Process F	4.168.389	11,5%
Heating air for Process I	5.397.500	14,8%
New Process AA	1.000.000	2,7%
New Process BB	1.000.000	2,7%
New Process CC	1.000.000	2,7%
New Process DD	1.000.000	2,7%
New Process EE	1.000.000	2,7%
New Process FF	1.000.000	2,7%
New Process GG	1.000.000	2,7%
		#N/A
		#N/A
		#N/A
		#N/A
		#N/A
		#N/A
		#N/A
		#N/A
		#N/A
		#N/A

3. Similar as for the process mapping – mark all the new process rows. From the top ribbon navigate to “Data”, and click the “Ungroup” button to the right side.
(NB: The bar chart will show all the unhidden empty cells during this step, but will become normal once the empty cells are hidden again.)



4. All the filled-out rows are now ungrouped and the remaining empty rows can be hidden again by scrolling to the bottom of the table and clicking the “-“ sign to the left:



Section 5: Project Development

5.1. Introduction

5.1.1.Definition of project development

Project development is a process of converting ideas into a project plan, which includes organizing and planning all the elements of a project, such as resources, budgets, and tasks for project team members. It also includes all the steps required to complete a project, such as adjusting the plan throughout the project implementation and identifying potential areas for improvement to help the project run more smoothly.

Here are some points to keep in mind during project development:

- Project objectives: are the expected outcomes of a project that include long-term / overall and short-term / specific objectives;
- Project implementation time is the time schedule of a project that all project team members need to follow and coordinate when performing their specific project tasks to ensure that the project is completed on time and meets the required quality;
- Project implementation resources are of the human resources and the equipment needed to implement and complete the project;
- Project implementation budget is the total amount of money that the project team needs to pay for the project. This usually includes the cost of materials and personnel to implement the project

5.1.2. Major phases of project development

Typically, project development divides projects into five phases:

- Initiation
- Planning
- Execution
- Controlling
- Closing

Phase 1: Initiation

Project initiation is defined as the first phase in the project development, where the project objectives, scope and deliverables are defined by stakeholders and authorized to proceed. The initiation phase is critical for any project development and management because it establishes the groundwork for all subsequent activities, ensuring that the project aligns with strategic business goals and addresses the right problems or opportunities. The outcome of project initiation is often a written statement that formally authorizes the project and assigns responsibilities.

Phase 2: Project Planning

Project planning is essentially the creation of a project implementation roadmap that includes the scope and tasks that each member of the project team needs to perform, coordinate and complete according to a specific timeline of each project taks to ensure that the implementation of the entire project does not take longer time than expected.

Phase 3: Project Implementation

During the implementation phase, the workflows that were initiated during the project planning phase are conducted. The project manager's job is to ensure that everyone involved in the project is working towards their goals while staying on budget, resources, and schedule earlier approved.

Phase 4: Project Control

During the control phase, the project team are to review what worked, what didn't work, and what lessons can be learned from the project implementation. Some of the things the team might consider include: i) Areas where resources were wasted; ii) Any project delays and the factors that led to the delays; iii) Cost overruns and why the original budget estimate was incorrect; and iv) Risks that occurred and how they were handled.

Phase 5: Project closing
During this phase, a detailed report on the project progress and lessons learned will be prepared. It is also expected that the feedback from different project stakeholders needs to be collected and analyzed to see the overall effectiveness of the project implementation.

5.1.3. Best Practices for Project Development

Maintain regular and effective communication with project stakeholders
It is essential to keep all project stakeholders informed at every stage of project development and implementation. This will help them understand the benefits of the project, feel more involved and be aware of the progress of project development and implementation. As a results, they can actively support the project team to realize the project.

Maintain active participation of project team members
Unity and effective cooperation amongst project team members play an important role in the success of the project. The project lead needs to create favorable conditions for project tem members to participate in the project development process, promptly appreciate their opinions on developing a successful project.

Collect and analyze feedback from project management board
The input of project management board is also critical to the successful implementation of a project. Although the project management board may not be directly involved in the project development, their feedback on the project development plan initiated by the project lead can help the project team identify areas for improvement before the project implementation phase begins. With their feedback, the project development team can make the necessary changes to help the project run smoothly.

5.1.4. Specific steps involved in an energy efficiency project development

Out of the above-mentioned phases, some more specific steps for the implementation of the first phase (ie. initiation) of an energy efficiency project development are given below

- Step 1: Identify EE opportunities
- Step 2: Develop an action plan

Step 1: Identify EE Opportunities: This step includes collecting and analyzing the historical and current data on energy (fuel, electricity) and water consumption at the utility in consideration. The results obtained from energy audit and energy mapping can help identify opportunities for energy and water savings.

Step 2: Develop an EE action plan: This plan includes three (03) elements namely: i) Selecting and ranking / Prioritizing appropriate energy efficiency and water conservation measures, and if applicable, renewable energy measures; (2) Building project partnerships amongst different units concerned within the utility and/or with independent Energy Service Companies (ESCOs) to implement these identified measures; and (3) Exploring financing opportunities for realizing the identified measures. One way to set priorities among several energy and water efficiency measures is to roughly compare them on the basis of their cost-effectiveness as well as on how they will affect each other.

5.2. DE3 Guideline on Project Development

5.2.1. Introduction

The purpose of this guideline is to assist energy auditors in identifying, developing, and prioritizing energy efficiency projects based on the information gathered during the audit and the baseline energy mapping developed as part of the audit process. The guideline is prepared in the context of the Energy Partnership Programme between Vietnam and Denmark.

The guideline consists of separate sections going through the different steps of an energy audit process and gives ideas and general guides of the approach and what to take into consideration. It is not an audit guideline, but a guide to support the energy auditor in identifying project opportunities.

The guideline includes the following sections:

Project checklist

This section consists of a checklist assisting the energy auditor to verify that the audit report considers and analyses all relevant aspects of the specific technologies as well as general operations of aspects of the industrial enterprise that effects the energy use.

General approach to identification of EE opportunities

This section describes the general approach the auditor should use to address possible projects. The method ensures that the auditor looks at the need for the energy service and not only focus on the utility.

Before the audit

This section outlines key considerations before conducting the physical walkthrough.

During the walkthrough

This section highlights important observations to look for and note during the physical walkthrough of the enterprise.

Using Energy Mapping

This section escribes how the energy mapping can and should be used as an important tool to develop projects effectively.

Other ways of identifying project

This section explores other relevant methods to use when develop energy efficiency projects

Project development approach

This section description an overall approach on how to prioritize the projects securing only to spend time on detailing selected projects.

These guidelines are focusing on the approach and overall guidelines and checklist for the auditor to consider throughout the energy audit process. They are to be used as an overall guide and thus additional details should be found in the audit guideline and the energy mapping guideline prepared as in the context of the Energy Partnership Programme between Vietnam and Denmark.

5.2.2. Project checklist.

The checklist should be used by the energy auditor as a quality check of all energy audits conducted. The checklist is a tool to ensure the energy auditor that he/she has carefully considered all major EE opportunities throughout the production processes, the utility systems, the maintenance practices, operator behaviour etc. as well as energy management organisation and practices.

The following chapters provide more details on each of the aspects in the checklist.

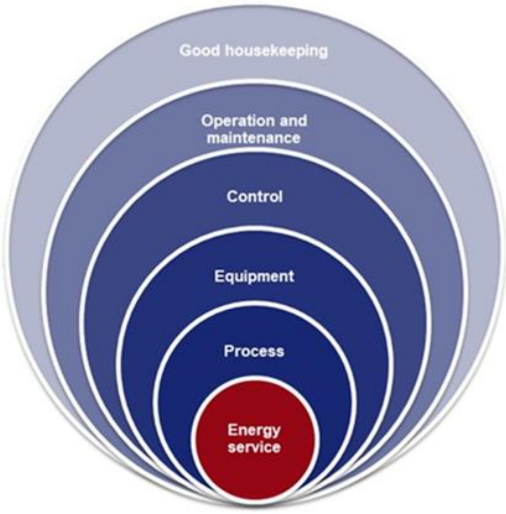
When relevant, the audit report should include the conclusions of these analysis steps in the energy audit report. In particular for significant energy consuming processes and utility systems, even if the conclusion of the audit would be that the specific significant energy user is very efficiency and no viable improvement opportunities are identified.

Sub-category	**Actions**	**Included in the audit**
General approach to identification of EE opportunities		
The Energy service	Is the energy service mapped? Are there options for reducing the energy service, temperatures, load duration etc.	
The Process	Are alternative processes considered?	
The Equipment	Is the equipment efficient?	
The Control	Is the equipment controlled efficiently?	
The operation and maintenance	Is the equipment operated and maintained as efficient as possible?	
The good Housekeeping	Does the company have a good strategy for continuously improve the energy performance?	
Before the audit, for each major production process		
Creating an overview of main energy users	Try to create an overview of the main energy users related to the production processes.	
Specifying/clarifying what is the actual energy service	See above	
Outline which unit operations that are involved.	Overview of unit operations and research of possible improvements	
Clarify who have an influence on the energy consumption	Identity who has an influence on the energy consumption	
Compare overall KPIs with KPIs from similar production facilities	Generate and compare KPIs of the entire production or on specific units and compare with similar production facilities	
Plans for future investments etc.	Create an overview of the companies plan for future changes that might influence the energy use.	
Energy management	Create an overview of the energy management system	
Start building up your screenings list	Create the screenings list template covering the different arears of the company and include the first find	
During the walkthrough – for each production process / major utility installation		
Look for inefficiencies	Identify the different inefficiencies related to the process and utility systems	
Maintenance status	Create an overview of the how maintenance is being performed and what is the state of maintenance	
Operation	Create an overview of how operators are influencing the operation	
Equipment status	Create an overview of the status of equipment	

Using the energy mapping		
Electricity • Focus on significant users • Improve standard for efficiency • Cooling systems • Motor type • Types of motor drives • Light • Ventilation • Other electricity users Thermal • Focus on significant users • What is the demand • Delta T • Identification of losses and efficiencies • Heat recover potential • Potential for rearranging the utility system • System design Specific KPI's Difference between the difference mapping approaches: Mapping degree	Identification of significant electricity users Are there special areas where the efficiency standard should be improved (e.g. VLT on all motors)? Evaluate the performance of the cooling systems Evaluate the motors on site Evaluate the different types of motor drives on site Evaluate the light on site Evaluate the ventilation on site Consider if there are other electricity users that can be grouped and evaluated together Identification of significant electricity users Consider whether there are alternative ways of covering the thermal energy demand? Evaluate how the delta-T in the heat exchangers is optimal Evaluate losses and efficiencies (processes and utility systems) Analyze the heat recovery potential Evaluate whether there is a potential for alternative design of the utility systems Evaluate how the utility systems are matched to the process demand. Generate Specific KPI's and evaluate the performance of the system or sub-systems Use the different mapping approaches to identify discrepancies Use the mapping degree actively to evaluate the quality of the mapping or to identify underestimated consumptions or losses	
Other ways of identifying projects		
Energy management • Evaluating the base line • Future targets Experiences from other similar production sites Company strategy	Evaluate the base line Set targets for energy use, energy reduction etc. for short and long term. Compare with similar sites Make sure that the identified projects support the companies' strategies	
Project development approach		
Gross list Project level B Project level A	Develop the Gross list (screening list) and prioritize which projects to move on to the next project level B and A. It is important to involve the representatives from the company in the prioritization process.	

5.2.3. General approach to identification of EE opportunities

When identifying projects, it is very important to start with identifying the **energy service** — the basic purpose of the energy usage. Optimization of energy use should always begin with understanding the energy service itself. When the energy service is understood and determined the next steps in the identification of EE opportunities can progress through all the supporting functions and systems. This structured approach is known as the **Onion Diagram Approach**.



The layers in the onion diagram:

The Energy Service:

The "energy service" refers to the specific requirement that a process must fulfil. Example: In the production of a medical device, e.g. a needle, the energy service is to sterilize the product (the needle). However, in the specific example the needle is sterilized in bags filled with sterile water. The energy service demand can be reduced if only the finished product (the needle) is sterilized and not also the sterilized water in the bags.

The Process:

The "process" refers to the type of method chosen to deliver the energy service. Alternative processes can often be considered to improve energy efficiency. Example: Currently, sterilization is performed via autoclaving, i.e. by heating the product (the needle) to more than 100°C. It should be considered and examined if the same energy service could be achieved using alternative methods such as other forms of thermal sterilization, chemical sterilization or radiation sterilization?

The Equipment:

The "equipment" relates to the energy efficiency of the tools and machinery used to execute the process. Some equipment may be inherently less efficient, while others are designed to optimize energy use. One way to evaluate equipment efficiency is by using the Total Cost of Ownership (TCO) approach.

Example:

Different autoclaving systems may have varying efficiencies depending on their design - both in terms of mechanical design and control system design.

The Control:

The control system used to manage the process plays a significant role in achieving energy efficient operations. Processes often operate under varying conditions with fluctuating outputs, so control systems must adapt to maintain efficiency.

Example:
Proper planning during the design phase is crucial to ensure the installation of suitable transmitters for energy efficient operation. Additionally, using frequency control for motors, pumps, and similar equipment is often essential for optimizing energy efficiency during regulation.

Operation and Maintenance:

Operation and maintenance procedures are critical for sustaining energy efficiency both in daily operations and over the long term. Focus on regular maintenance and proper operation will often lead to non- or low investment EE projects.

Example:
Operators make decisions that significantly impact energy efficiency. Equipment efficiency can degrade over time due to lack of maintenance, fouling, leaks, or other issues. Regular maintenance and proper operational practices are essential to prevent these losses.

Good Housekeeping:

A company's culture and approach to energy management significantly influence overall energy consumption.

Example:
Implementing an energy management system aligned with **ISO 50001** ensures systematic energy efficiency practices. Energy awareness among all personnel involved in energy use is crucial.

For each layer of the **Onion Diagram**, it is important to assess whether more energy efficient solutions and practices can be adopted. Reducing energy consumption at the core layer has a cascading effect on secondary energy consumption, maximizing overall efficiency.

5.2.4.Before the audit

Before starting an industrial energy audit, it’s essential to gather key information to ensure the audit is as efficient and effective as possible. This preparation helps the audit team understand the facility’s energy needs, operational requirements, and potential areas for improvement.

Having this information in advance streamlines the audit process, allowing the team to focus on key areas, tailor recommendations to the facility’s needs, and deliver actionable, cost-effective results aligned with organizational goals.

Main consumption:
Create an overview of the main consumption. E.g. which of the production process are using a large share of the energy consumption.

Specifying/Clarifying the Actual Energy Service:
A clear understanding of the specific energy service related to the process enables the auditor to begin considering the elements in the onion diagram.

Outlining Unit Operations Involved:
Identify the unit operations involved in the facility’s processes. This provides an overview of the types of equipment the auditor can expect to encounter. With this information, the auditor can make initial research on energy efficient improvements that already have been implemented at the facility or by others in similar facilities.

Identifying Who Influences Energy Consumption:
Understanding who influence the energy consumption the most helps the auditor to identify the key personnel to engage during the walkthrough. The auditor should also consider the most common operational practices to be able to analysis both negative and positive impacts on the energy performance.

Comparing KPIs with Similar Facilities:
By comparing the facility's key performance indicators (KPIs) with similar production facilities (both globally and regionally) the auditor can identify areas of focus for developing energy efficiency projects.

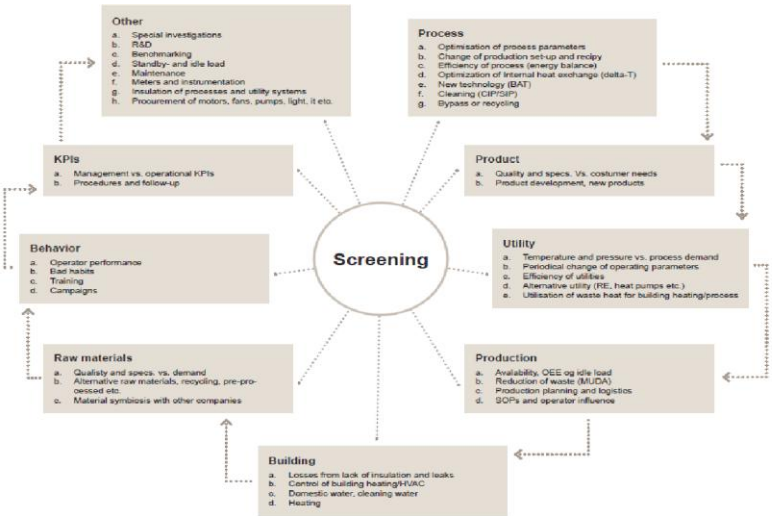
Assessing Future Needs:
It is important for the auditor to understand the facility's future requirements. Energy efficiency activities should ideally be integrated with planned changes, such as new equipment installations, capacity expansions, or the introduction of new production lines. Implementing energy improvements during these changes is often more feasible and cost-effective than retrofitting afterward. This approach can also facilitate the adoption of new technologies or new production processes.

Reviewing Energy Management Status:
The current status of the facility's energy management efforts provides valuable insights into how the company has been addressing energy performance.

Building a Screening List:
Developing a comprehensive screening list ensures the auditor examines all relevant elements and avoids focusing exclusively on areas of personal interest. The list should be prepared before the audit and developed further as part of the audit making sure that all areas of interest, and not only e.g. the utility, are covered during the audit.

Elements than might be considered in the screenings list:

- Process
- Product
- Utility
- Production
- Building
- Raw material
- Behaviour
- KPI's
- ….



5.2.5. During the walkthrough

During the walkthrough audit, there are several elements for the energy auditor to investigate:

- **Look for inefficiencies:** There are many signs of inefficiencies that the auditor should be aware of:
    - **Thermal losses:** These include combustion losses, radiation and convection losses from operating units and pipes, high delta-T on heat exchangers, etc.
    - **Idle load:** Equipment running without production, such as conveyors operating without products or evaporators evaporating water while on "hot standby."
    - **Regulating losses:** Are motors, pumps, fans, etc., controlled by belts, gears, valves instead of a variable speed drive?
    - **Loss of condensate:** Is condensate not being returned to the boiler? This could indicate malfunctioning steam traps or poor system design. Makeup water will need to

compensate for the condensate losses, which reduces energy performance and increases water consumption.
  - **Design:** Equipment that are poorly designed, e.g.

- **Maintenance status:** What is the current status of maintenance? For example: Are filters blocked?
  - Is transport equipment dirty, increasing friction?
  - Are there insulation damages?
  - Are electrical terminals not tightened?
  - What is the extent of leakages (air, steam, water, etc.)? These issues often result in temperature increases, which can be identified with a thermal camera.

- **Operation:**

To what extent do the operators influence energy performance on site?
  - Is the operator responsible for and aware of determining the extent of idle load?
  - Is the operator responsible for and aware of setting the Cleaning-In-Place (CIP) time?
  - How are temperatures, pressures and flows managed?
  - How is performance monitored?

- **Equipment status:**
  - What is the overall impression of the equipment? Is it worn down or in near-new condition?
  - What is the overall impression of operations? Do the operators prioritize energy performance?

All the questions above can help identify potential project opportunities.

5.2.6. Using the energy mapping

Based on the initial data collection, it is recommended to conduct an energy mapping, as described in the Energy Mapping Guideline.

There are various ways to use the information within the energy mapping, with a primary focus on identifying project opportunities.

It is essential to always keep in mind the purpose of the project when identifying opportunities. When considering potential projects, it is important to categorize the approach into Electricity and Thermal, as each will require different strategies.

Electricity:

Electricity consumption is mapped based on parameters such as power, operating hours, load, mass flow, and key performance indicators (KPIs) or measurements. With this information, a wide range of questions can be raised, forming the basis for further investigation aimed at project development. Some ways to identify projects include:

Focus on significant users:

Energy mapping helps identify the most significant energy consumers. These major users give the auditor a clear focus area. For example, if 70% of energy consumption is related to motors, it is recommended to focus on motor standards, drives, controls, etc.

Where to set new standards:

Are there specific areas that require particular attention? For instance, should the company establish motor purchasing guidelines or a maintenance strategy?

Motor type:
What is the status of the motor installations? Should specific motors or groups of motors be replaced or upgraded?

Drive type:
What is the standard of motor drives? Should attention be focused on specific drives, or is a more general approach needed?

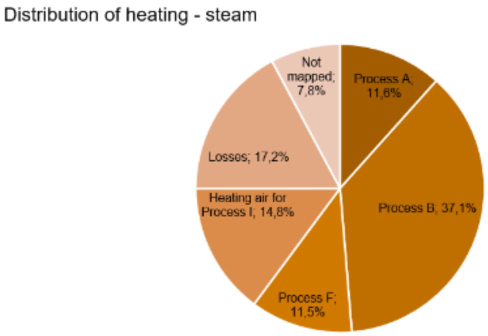
Electrical unit operation:
The energy consumption for different unit operation like transport systems, cooling and chillers (see the thermal section below), ventilation, agitation, etc. should be determined. If the specific unit operation is associated with a large share of the energy demand special attention should be given to that specific unit operation. E.g. is the agitation controlled according to the demand and are the agitators designed for the specific product?

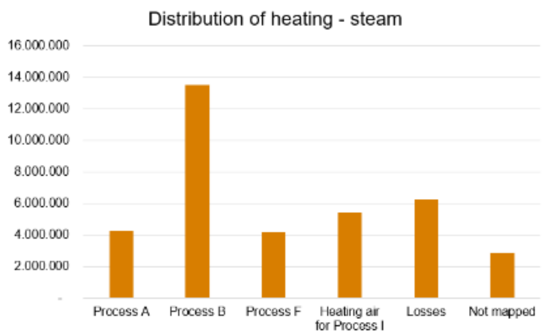
Lighting:
What is the current status of the lighting at the site? Should specific areas of lighting be upgraded, or should a company-wide lighting strategy be implemented?

Other electricity users should be analysed using the same approach as outlined above.

<u>Thermal:</u>

- **Focus on significant users:**
  Energy mapping also identifies significant thermal energy users, helping the auditor to determine where to focus the effort to develop EE projects. For example, if 50% of energy consumption is related to a particular unit operation, the auditor should focus on improving the energy performance of that operation.





There are different ways to present energy usage. Two common methods include showing energy distribution in relative terms (percentages) or in absolute terms (kWh/year). By examining these figures, the auditor can pinpoint areas to target. For instance, if the process area consumes 37% of energy, accounting for 14 GWh/year, even a small improvement could significantly impact total energy consumption. The mapping also highlights losses (e.g., 17.2%), which often represent relatively easy areas to improve.

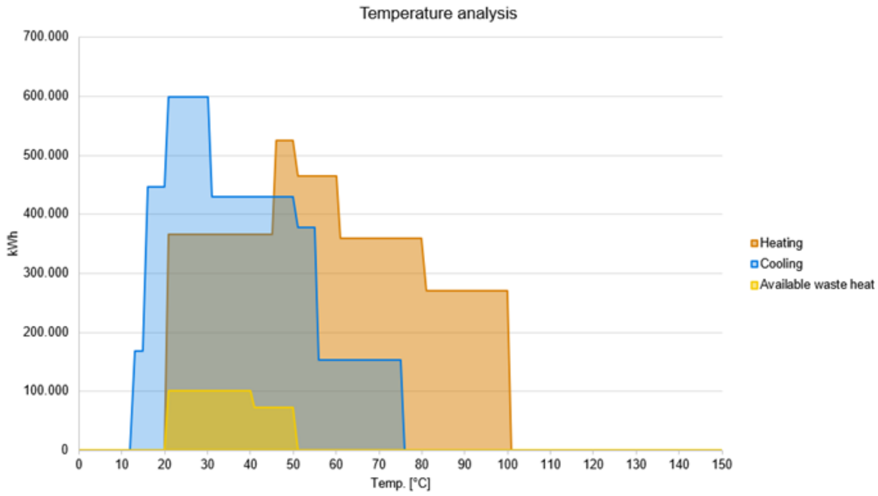
Demand analysis:
Energy mapping clarifies the specific energy demand from a process perspective. This data can be used to tailor energy systems to meet demand more efficiently. For example, it should be investigated if a large could be met by a low-temperature system powered partly or entirely by waste heat?

Delta T (Temperature Difference):
The energy mapping can reveal thermal efficiencies by showing temperature differences across heat exchangers. This information can be used to optimize existing thermal systems. For example, improving return temperature in the heating system could reduce thermal losses and thus improve boiler efficiency.

Identification of losses and efficiencies:
Energy mapping identifies losses in utility systems, providing opportunities for improvement. For example, if boiler losses are higher than those of similar installations, the auditor can explore ways to improve the boiler's energy performance. The same applies to distribution systems - if losses are higher than expected, improving thermal insulation should be considered.

Additionally, the mapping may include the **Coefficient of Performance (COP)** for chillers, refrigeration, and heat pumps. Comparing this data with best practices can provide insight into areas for improvement. The mapping will also show how much heat is recovered from boilers, chillers, air compressors, etc., helping the auditor to determine whether further improvements can be made.

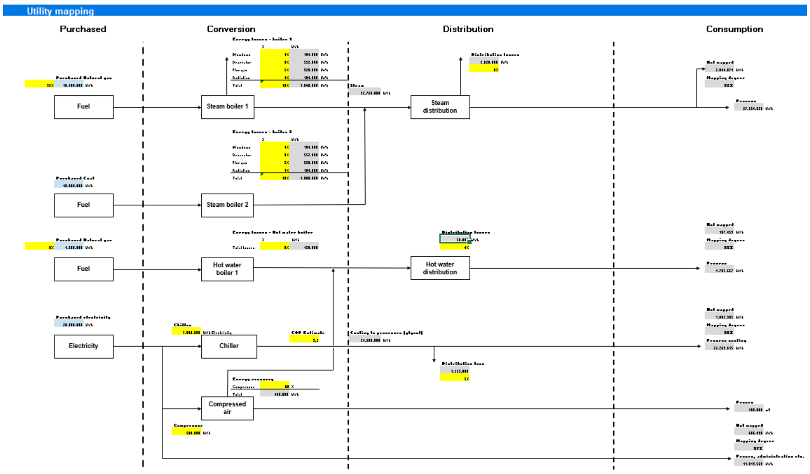
Heat recovery potential:
Heat recovery projects are often cost-effective. For example, the energy mapping output might display energy consumption by degree for cold, hot, and waste heat recovery thermal systems.



The overlap between cooling (blue) and heating (orange) demand indicates potential for direct heat recovery between the two systems. However, this is a first and theoretical approach as the real potential will be influenced by factors like temperature differences, timing, sizing, and distance.

The yellow area shows the available waste heat, which could potentially meet some heating demand but has no impact on cooling demand. If the heating and cooling areas don't overlap, it may be worthwhile to consider using a heat pump to transfer heat from the cooling system to the heating system using electricity.

Potential for rearranging the utility system:
Several questions can be raised when analysing the setup of utility systems.

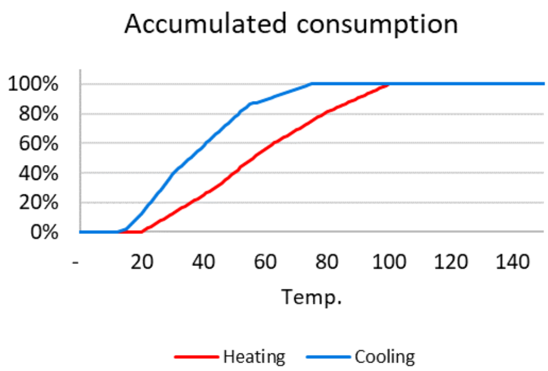


Some examples are:

- Instead of having one single steam system, could a differentiated system with different steam pressures be implemented. Lower steam pressure uses less energy and thus different steam pressures could improve energy performance by reducing losses and increasing unit efficiency?
- Could a hot water system be introduced to meet part of the current steam demand? This would open opportunities to integrate different heat recovery systems.
- Could more heat be recovered from chillers or air compressors compared to best practices?
- Are there significant distribution losses?
- Are conversion losses, such as boiler losses, higher than expected? Is the COP of the chillers within the range of best practice?

System design considerations:

Looking at the energy distribution data, it may be apparent that e.g. some of the heating demand can be delivered at a lower temperature that the existing system is set for. In the illustrated example below, it is evident that 55% of heating demand is below 60°C. This raises the question: why use steam to cover such a low-temperature demand? Similarly, in the example 50% of cooling demand is above 30°C, could this demand be met with other technologies, rather than chillers? Why not tailor the energy system to match the actual demands of the users?



- **Specific KPIs:**

  Energy mapping allows for the generation of mass-based KPIs for all energy uses, which can be used to compare different units against best practices. This comparison is a powerful tool for identifying opportunities for improvements.

- **Differences in Mapping Approaches:**

  Multiple mapping approaches can be used in energy mapping (flow, KPI, and measurements). Using more than one approach can help validate the accuracy of the data and identify discrepancies.

- **Mapping Degree:**
  The mapping degree or detailing of the energy mapping indicates how accurately energy consumption is accounted for. A low mapping degree may suggest:
  - Some energy users have unconsciously been overlooked.
  - Losses may be higher than initially estimated.
  - Idle or standby loads are not included.
  - There may be inefficient control systems, either automated or manual.

  These issues could indicate opportunities for improvement.

  On the other hand, a high mapping degree (>100%) suggests that some estimates may be too high, potentially leading to overestimated project opportunities.

5.2.7.Other ways of identifying projects.

Besides the method to identify EE projects described in the previous sections of this guideline, a few other ways of identifying projects can be mentioned.

- **Energy management:** Energy management is the company's tool to ensure that all relevant activities and decisions related to the efficiency of energy consumption is considered. Energy management is the proactive and systematic monitoring, control, and optimization of an organization's energy consumption to conserve use and decrease energy costs. And Energy Management is thus more a good way of securing the continues work with energy efficiency. The method described in the sections above can be part a natural part of the energy management system securing that all EE projects are considered.

Experience shows that energy management can provide significant energy savings in the first year. The vast majority of companies can make their energy consumption more efficient, even if they didn't think it was possible.

Energy consumption also means climate impact. With energy management, the company ensures that it does not affect the climate more than necessary and signals a "green" profile in relation to customers and business relationships.

Energy management is much more than technology. It is a management tool on same level as environmental management and quality management. The systematic work with energy savings provides experience and skills for a possible later certification in energy management.

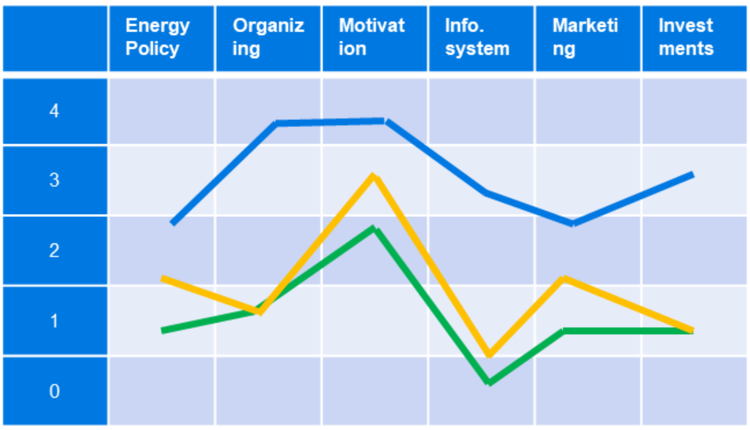
Energy management leads to operational optimization. Focusing on energy consumption will often lead to better utilization of machinery and raw materials, as idle losses and waste are minimized. At the same time, the company gets better key figures on operating costs.

To improve the energy management system a matrix evaluation like the one shown below can be used. The matrix can both be used to evaluate the present status of the energy management system, and it can be used to recommend and decide how the company should develop the energy management system in a short term and in a long term.

Level	Energy policy	Organize structure	Training & awareness	Measure, monitor	Communication	Investment
4	There is an energy policy, an action plan, and a commitment from the CEO.	Energy management is one of the contents of the plant management	There are regular channels of information on energy management at the plant.	There is a system to set energy consumption, complete monitoring for factories, workshops and large	There is always information, advertising about the plant and energy efficiency activities both inside and	There are specific and detailed plans for new investments and improvement

Leve l	Energy policy	Organize structure	Training & awareness	Measure, monitor	Communicatio n	Investment
				energy users.	outside the plant.	s to existing equipment.
3	There is an energy policy, but without CEO commitme nt	There is an energy management committee/group at the plant.	The Energy Department has always had direct contact with the key energy users.	There are measureme nt and monitoring systems for factories and workshops.	Regular campaigns to raise awareness about energy management throughout the plant.	Use the return on investment criteria to grade investment activities
2	No clear energy policy	Energy management responsibilities are not clearly defined.	Contact the main consumers through a temporary manageme nt board	There is only measureme nt and monitoring system for the plant level.	There is regular communication but only in a few parts of the plant.	Considering investment only in terms of quick payback.
1	There are no written energy efficiency guidelines.	The energy manager has a limited role in the plant.	Informal contact between engineers and users	Data analysis based on energy bills	There are not often communication activities	Only implemented low-cost measures.
0	There is no energy policy	There is no organization/individ ual responsible for energy consumption at the plant.	No contact with users	There is no information and measureme nt system.	No communication about energy efficiency	No investment plan to improve energy efficiency

The evaluation and the development can graphically be illustrated as in the figure below (green= present status, yellow= short term development and blue=long term development).



Example of the energy management matrix

When suggesting for improvements it is important to consider the following questions:

- What is the value of the new target?
- What is the investment in the new target?
- What resources are needed to obtain the new target?
- How will the target be maintained?
- How will the target be monitored?

Experiences from other similar production sites:
It is important that the auditor also include experiences from other sites that have similar production or are using some of the same unit operation.

Company strategy:
The company's strategy can also be very determined on how to develop projects. Should the projects be developed based on targets for energy savings, carbon savings, financial savings, potential for increasing the production capacity or a mix of these aspects. E.g. if an oil boiler is replaced with an electrical boiler the energy savings in terms of kWh are minimal, but the carbon savings are large if the electricity is produced by solar PV.

BAT notes:
In the BAT (Best Available Technology) notes a lot of inspiration can be found related to standard systems, KPI's, energy improvement projects, and emergent technologies:
https://eippcb.jrc.ec.europa.eu/reference

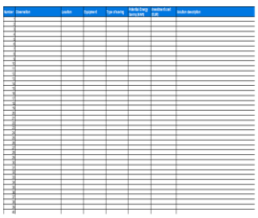
5.2.8.Project development approach

In order not to spend too much time on developing details of projects that turns out not to be feasible it is recommended to narrow down the number of projects before increasing the level of details.

The starting point will be the **Gross list**, containing all projects, both good and poor ones. It is important to keep all the projects on the list, because a project that might be relatively poor today micht turn out to be good in a few years e.g. if the boundary conditions changes. The **project level B** (Basis) develops the project to a certain extent and then finally the project is developed to a **project level A** (advanced) where more details are added to the project evaluation.

Gross list

- All project ideas



Project B (Basic)

- Project description (one or two lines)
- Energy savings
- Financial savings
- Investment (based on experience)

Level A (Advanced)

- Project description
- Energy savings
- Financial savings
- Investment
- Payback time
- Simple system process flow diagram (PFD)
- Simple Risk analysis
- Non energy benefits

Between each project development level, the projects are prioritized based on the company's strategy, ensuring the most attractive project for the company will be prioritized and further developed, and thus supporting the company's strategy. Finally, the list of proposed projects will be narrowed down to a limited number of projects that can be examined through feasibility studies leading to final investment decisions.

Section 6: Pre-feasibility Study

6.1. Introduction

6.1.1. Pre-feasibility studies definition

This section introduces the pre-feasibility study (pre-FS) guideline, which is designed to help enterprise assess whether to proceed with potential energy efficiency (EE) investments. A pre-FS is most relevant for projects above a certain investment size, where there are still major uncertainties, risks, or opportunities that an energy audit alone has not fully clarified. If these factors prove unfavourable, they could render the project unfeasible.

The main purpose of a pre-FS is to elaborate on alternative technical and operational options for improving the energy efficiency of an industrial process, to identify the cost and benefits, to determine the risk and uncertainty of each option. These should include not only energy savings and costs, but also wider impacts on the enterprise, such as production capacity, product quality (now and in the future), operational reliability, and maintenance requirements. Non-energy factors can be just as critical as direct cost-benefit considerations when making investment decisions.

A pre-FS differs from a full feasibility study (FS) in both purpose and depth. While a pre-FS explores and narrows down alternative solutions at a conceptual level, a FS focuses on the precise definition of the preferred option. Thus, the pre-FS acts as a decision filter: it provides management with enough information to select a preferred solution and decide whether it merits the more detailed and more resource-intensive feasibility study. The output of a pre-FS should therefore be a clear comparison of viable alternatives and a recommendation on which option, if any, should move forward to a full FS. The detailed requirements and structure for a full FS are presented later in Chapter 7.

Under Vietnamese law, a pre-FS is a legal requirement for certain large-scale projects in the public investment, public–private partnership (PPP), and electricity sectors. The Public Investment Law, PPP Law, Construction Law, and Electricity Law collectively define the PFS as a basis for the competent authority to approve a project’s investment policy—an essential step before a full feasibility study and implementation. These rules mainly apply to major projects, such as National Important Projects or Group A, with high investment thresholds (e.g., over 2,300 billion VND for the power industry). For most industrial energy efficiency projects, these legal requirements do not apply; however, the framework provides useful reference points for structuring PFS content and approval processes.

6.1.2. Benefit of Pre-Feasibility Studies

A pre-FS provides an early, structured examination of an investment project before committing substantial resources. It helps establish a clear investment case and ensures that subsequent efforts are focused on the most promising project pathways.
A pre-FS, offers several significant benefits:

- **Foundation for Policy or Management Decisions** – it provides senior management or corporate boards with the evidence needed to endorse or reject a project concept.

- **Early Clarity on Project Direction** – By mapping out high-level technical, financial, and environmental considerations, a PFS enables decision-makers to quickly determine whether further investigation is warranted, helping avoid wasted effort on unviable ideas.

- **Strategic Alignment and Risk Awareness** – The study ensures that the proposed project is consistent with the strategy of the enterprise. By conducting preliminary analyses of economic-social effectiveness and environmental impacts, it helps reduce the level of uncertainty regarding project costs and benefits at an early stage before spending a lot of time and resources on more detailed design of the project.

- **Efficient Use of Resources**– By assessing the necessity, feasibility, and effectiveness, the study aids management in determining whether to proceed with further, more detailed investments, such as a full feasibility study. The PFS ensures that time, funding, and internal expertise are invested only in projects with strong potential.

6.1.3. Major steps of pre-feasibility study

While the following process primarily applies to large national public investment projects and public-private partnership (PPP) projects, it is important to note that the general procedure is largely the same for enterprises. The main differences lie in the scale, complexity, and level of authority involved. Smaller-scale enterprise projects typically follow a streamlined and adjusted version of this process, the detail of which is presented later in this section.

The implementation of pre-feasibility studies generally follows the same structured sequence no matter what the project is of large-scale (national scale) or small and medium scale. Below are the steps involved in conducting a Pre-fs for large-scale project. PPP projects:

1. Preparation of the Pre-Feasibility Study Report:

For PPP projects, the PPP project preparation unit is responsible for drafting the pre-feasibility study report. For projects proposed by investors, the investor prepares the dossier, including the pre-feasibility study report. For construction investment projects not involving PPP, the decision to prepare a pre-feasibility study report is made by the investment decision-maker.

The report's content must detail the necessity, objectives, scale, location, duration, resource needs (e.g., land), preliminary design, technical/technological solutions, preliminary assessment of socio-economic and environmental impacts, preliminary total investment, financial plan, and expected contract types (for PPP). Its preparation is based on national socio-economic development strategies and plans, relevant master plans, and applicable laws.

2. Submission for Appraisal:

The prepared report is submitted to the competent authority for appraisal. For some projects, it's also sent to the Ministry of Planning and Investment.

3. Appraisal of the Pre-Feasibility Study Report:

An appraisal council (e.g., State Appraisal Council, inter-sectoral appraisal council, grassroots-level appraisal council) or a specialized unit is established or assigned to appraise the report. The appraisal focuses on the suitability of the project with selection conditions and legal bases, its investment effectiveness, financial viability, appropriateness of contract type (for PPP), revenue sharing mechanisms, and the source and balance of state capital (if applicable).

For construction projects, the appraisal also covers compliance with construction laws, design solutions, project organization, and risk analysis.

4. Finalization and Submission for Decision:

Based on the appraisal opinions, the project preparation unit or investor finalizes the pre-feasibility study report and related dossiers.

The finalized dossier is then submitted to the competent authority for review and decision on the investment policy.

5. Decision on Investment Policy:

The National Assembly, Prime Minister, Head of a Ministry/Central Agency, or Provincial People's Council decides on the investment policy, depending on the project's criteria, scale, and nature. The investment policy decision specifies key elements like project name, objectives, estimated scale, location, duration, land use, expected contract type (for PPP), preliminary total investment, and financial plan.

For small- and medium-scale project (at the utility level), the same steps mentioned above should be followed but with a simpler procedure: i) the preparation step will focus on the project's viability in terms of technical, financial and environmental aspects at the utility's level that help the decision-makers understand the project's advantages and potential risks before committing significant resources to a full feasibility study.

For energy efficiency (EE) projects, the purpose of a pre-feasibility study (pre-FS) is to support the enterprise in deciding whether to proceed with a full feasibility study (FS) for a selected solution. The pre-FS helps narrow down potential energy-saving options and provides an early-stage understanding of their technical, financial, and environmental viability.

Nevertheless, the process for enterprises is somewhat similar to the process for national investments. The process begins with a brief analysis of the current situation. This includes defining the type of industrial facility, its scale, and geographic location. An overview of energy consumption patterns, operational status, and production volumes is conducted. Additionally, the study assesses the age, efficiency, and operational characteristics of key energy-consuming equipment.

Based on the energy mapping previously conducted at the utility, a number of energy efficiency measures are thus identified for the pre-fs study. As a result of conducting Pre-fs, a list of potential EE solutions can be proposed for full feasibility study towards EE investment decision.

Next, the study describes energy-saving opportunities by identifying areas with high energy use or inefficient operations. A list of potential EE solutions—such as equipment replacement, process optimization, and automation—is compiled. Preliminary estimates of the energy savings associated with each solution are made to prioritize options.

A preliminary technical assessment follows, evaluating the applicability and local availability of the proposed EE technologies in the Vietnamese context. The compatibility of these technologies with existing systems is also analyzed to determine potential implementation challenges or required modifications.

The financial analysis component estimates both capital expenditures (CAPEX) and operational expenditures (OPEX) for the proposed solutions. Key financial indicators such as the Payback Period, Net Present Value (NPV), and Internal Rate of Return (IRR) are calculated to assess the economic attractiveness of the investment. Access to financing, including green loans or collaboration with energy service companies (ESCOs), is also considered.

The study also evaluates the environmental and other non-energy impacts of the potential investment. This includes estimating the reduction in greenhouse gas (GHG) emissions, as well as identifying improvements in working conditions, environmental compliance, and overall production performance and capacity.

Based on the findings, the study proposes viable implementation options. The most promising EE solutions are selected, and a preliminary roadmap for investment and implementation is outlined. Importantly, the pre-feasibility study also provides a clear conclusion on the overall feasibility of the project — which may include a recommendation to proceed with a full feasibility study or, alternatively, to stop the project if it is found to be unviable, even if technically possible. Some of unviables may include: i) Resource and cost issues: the utility may no longer have the necessary resources (funding, budget, or personnel) to complete the project, unexpected increases in project costs or significant schedule slips can make the project financially unsustainable; ii) Technical Difficulties: while the project may be technically feasible, unforeseen complexities that are beyond the company's expertise can arise, and iii) Social and/or Environmental Impact: the social or environmental consequences of the project may become unacceptable. discontinue the project if it is found to be unviable, even if technically possible. This ensures that resources are not expended on further studies where investment is not justified.

6.1.4. Advantages and challenges of pre-feasibility studies implementation

For industry the pre-FS is most often an internal process and the report or result of the pre-FS is often kept internally.

6.1.4.1. Advantages of pre-feasibility studies implementation

Pre-feasibility studies (Pre-FS) offer several important advantages including:

Early and Informed Decision-Making

Pre-FS enables project developers and authorities to make informed choices on whether to pursue a full feasibility study. This helps reduce the risk of committing resources to projects with unclear viability.

Risk Identification and Mitigation

Pre-FS provides early insight into potential technical, financial, market, and environmental risks. This allows for the development of mitigation strategies at the early stages, improving the resilience of the project planning.

Optimized Resource Allocation

Evaluating alternative technical and financial options supports the selection of the most viable solution, minimizing the chance of investing in low-impact or high-risk solutions.

Stakeholder Engagement and Transparency

A pre-FS serves as a useful reference for discussions with investors, government authorities, and other stakeholders. In regulated sectors, it also contributes to transparency and public accountability in investment decision-making.

Legal Compliance and Policy Support

The pre-FS process often aligns with regulatory requirements, and contributes to national goals for energy efficiency and emissions reduction.

6.1.4.2. Challenges of Pre-Feasibility Studies Implementation

Despite its advantages, the implementation of pre-FS also presents several challenges that must be managed effectively:

Complexity and Scope

A pre-FS must address multiple dimensions—technical, financial, environmental, legal, and social. Balancing these aspects without turning the pre-FS into a full feasibility study can be challenging and resource intensive.

Data Availability and Quality

Reliable data on energy consumption, operational characteristics, environmental impacts, and financial benchmarks may not be readily available, especially in sectors lacking strong data collection systems. In these cases, good assumptions are needed and crucial, and it is highly important to mention/highlight the assumptions made.

Inter-agency Coordination

The implementation of energy efficiency (EE) projects may also involve multiple layers of internal management, including operational teams, finance departments, and in some cases, international boards or corporate headquarters. This internal complexity can lead to delays in decision-making or misalignment between technical and strategic priorities. Moreover, it is essential to consider the budgeting cycles of private enterprises—larger investments are often planned and approved during annual budget preparations for the following fiscal year. Therefore, proposals for significant EE investments should be aligned with the annual budget plan timeline to increase the likelihood of securing approval and timely implementation.

Stakeholder and Regulatory Navigation

Identifying all relevant permits and stakeholders at this early stage can be difficult. Delays or oversights here may impact downstream approvals and project timelines.

Financial Risk for Proposing Parties

Private investors initiate the pre-FS, they may bear the full cost of the study. If the project is later rejected or modified, this may result in financial losses.

Need for Adjustments

Changes in project scope, location, or policy priorities after the pre-FS may require significant revisions and new approvals, potentially delaying implementation.

6.2. DE3 Guideline on Pre-feasibility Study

6.2.1. Introduction

The summary shall report main findings and conclusions from the pre-feasibility (pre-fs) study of particular relevance to the enterprise management and possible external stakeholders.

The summary should outline the alternative solutions investigated and summarize the features of each solution, including all the characteristics of major importance for the decision-making on any next steps.

The section should provide a strategic overview of the results of the individual sections of the report, including key financial indicators as well as other important impacts, such as:

- Impacts on the competitiveness of the enterprise in the market, for example as a result of a reduced environmental footprint of the production process
- Impacts on the pollution levels in the local environment
- Impacts on working environment

The summary must also make clear the level of risks and uncertainty of the findings. If for example the project involves a novel application of a specific technology or if there is a considerable uncertainty around investment costs and similar, such information should be provided in the summary.

Based on this information, the summary should provide a recommendation for selection of preferred solution as well as next steps. Especially when developing complex projects, the pre-fs may still leave several issues open regarding the preferred solution. These should be clearly listed, and if relevant, a feasibility study could be recommended in order to resolve these issues.

6.2.2. Background

As basis for the pre-feasibility study, the background, specific purpose and scope of the project shall be described.

The background section of the pre-fs should include at least the following elements:

Justification of the study

This section should briefly summarize the background for the decision to undertake the pre-fs, for example findings of a preceding energy audit or screening etc.

Existing situation

Brief introduction to the part of the enterprise relevant to the pre-fs, including

- Process diagram(s),
- Technologies used (observations regarding age, efficiency etc.)
- Operation schedule (number of hours per day/week/year)
- Availability of the existing system: Planned and unplanned outages
- Possible issues with capacity, quality of product output, working environment or others.

Expected enterprise developments relevant to the project

The section should outline the development plans of the industrial enterprise. Such plans could have an important impact on the feasibility of a given energy efficiency project. If for example the enterprise plans to expand the production capacity to an extent where the capacity of the current boiler will not be sufficient, it might not be relevant to upgrade the existing boiler, even if it is very inefficient. On the other hand, replacement of an existing boiler with a new, bigger and more efficient would provide two benefits: increased capacity and reduced energy supply costs. This would increase the attractiveness of such investment significantly.

The chapter should also briefly explain the policy and priority given to energy efficiency.

Outline of relevant alternative interventions

In many cases, a given set of objectives, including increased energy efficiency, may be obtained on various different ways. For example, a drier system can be optimized in several different ways.

First step should be to consider whether the steam consumption could be reduced. This could be achieved from such measures as improved process control, insulation of hot surfaces, or use of waste heat from other sources, such as air compressors.

In some cases, the use of steam can be efficiently replaced by other processes. For example, low-temperature processes may more efficiently be supplied by heat from a heat pump.

If steam will still be needed, the option of improving the efficiency of the boiler, or replace it by another boiler with higher energy efficiency and possibly for use of a different fuel (such as biomass).

As shown, many different solutions can contribute to the same aim, but with very different implications. In some cases, the best solution is more or less obvious, but in other cases, the choice of solution needs a closer investigation.

The pre-fs should take a full-system perspective on the opportunities to unfold all relevant opportunities and to be able to identify the best solution. For example, if the heat supply system is inefficient, the analysis should not only include an optimization of the heat supply system. It needs to consider also the consumption of heat:

- Are the thermal processes in the facility efficient – consider energy losses and assess based on expert experience and of needed: measurements and analysis
- Could the process temperatures be reduced, for example through improved process control
- Could part of the process heat be met by use of waste heat from other parts of the facility
- Could input materials be modified (for example with reduced water content)
- Etc.

If such assessment identifies important improvement opportunities in the process itself, the solutions suggested should include both the heat supply system as well as the thermal processes supplied.

When identifying alternative interventions, due consideration should also be given to not only energy efficiency but also the possible non-energy benefits. For example, replacing a boiler with heat pumps would eliminate emissions of SOx and NOx into the environment, helping to comply with current environmental regulations. Improving the control system of a drier could reduce drying time and perhaps improve product quality.

From this analysis, the report will list the options that could be relevant to consider – based on expert experience. At this stage, each option will be described just very briefly to be sure, that all relevant options have been taken into consideration.

The report will then select 1-3 options, which at this point in the analysis could all be preferred options, depending on the results of the more detailed analysis.

From this list, the report will identify one as the preferred solution to be examined in detail first as the base case.

In some cases, the preferred solution could be obvious. In such case, the analysis should consider possible variations over the solutions. If for example it is obvious that there is no alternative to steam supply for the processes, and if the current boiler needs to be replaced, alternative options could include such elements as selection of fuel, implementation of a heat exchanger to recover waste heat in the process etc.

6.2.3. Analysis of baseline project

The level of detail of the description of the business case should be decided based on the situation. Remember that the purpose of the pre-fs is to allow the enterprise to decide whether to invest in a feasibility study of one selected solution. The analysis should only take the steps necessary to facilitate such a decision.

The analysis should be designed to reduce the level of uncertainty regarding the costs and benefits of the project.

If for example the preferred solution has already been implemented in several other facilities and if the data of costs etc. are available, this could be key information, possibly supplemented with analysis of possible specific concerns if implemented in the enterprise. On the other hand, if there is no strong reference case, the pre-fs may have to involve quite detailed analysis of the entire process to establish the capacities needed, investment costs, the energy consumption required maintenance costs etc.

6.2.4. Purpose of project

What are the reasons behind and origin of the project, i.e.

- for which purpose is the project proposed, for example
- improved energy efficiency
- replacement of existing worn-out equipment
- capacity expansion
- reduced CO_2-emission or other environmental objectives
- Etc.

Often energy efficiency projects will meet several of such purposes. The defined purpose of the project should guide the pre-fs, and the conclusions of the report should include an assessment of how well the proposed solutions meet the purposes.

6.2.5. Scope of the project

The scope of the project includes all physical and logistic elements that will be affected by the proposed project.

- List all the main areas, installations etc. to be affected by the project, such as indoor or outdoor space, equipment etc.
- List the utilities (electricity, water, heating, cooling, ventilation, compressed air) that could be affected by the project, for example changes in the need for utilities.
- List the adjoining processes, buildings etc. that might be affected by the project.
- List any possible relation to development plans of the enterprise, (expansion; new products or processes etc.).

If the project has a major impact on systems supplying other parts of the enterprises, such as a cooling system, compressed air systems etc., it should be considered to expand the scope of the project to include the whole of such system, not only the supply to the project area. For example, the new project might involve a reduced temperature requirement on a refrigeration plant, possibly enabling an increase in cooling compressor suction pressure, which in turn would increase efficiency of cooling throughout the plant.

6.2.6. Design basis for the project

Any development of energy efficiency projects shall at best be founded on a clear and solid understanding of current and future energy consumption and operating situation for a facility (baseline situation), assuming that the project under investigation in the fre-fs report will not be undertaken.

The pre-feasibility study as such shall present a design basis for the project in the following areas.

Present and projected capacities

Depending on the character of the proposed project, an expected future production volume for the facility and the impact from this on the project area in focus should be described. This might be a question of capacity of relevant processes and equipment, but it might also be a question of introducing new process and utility parameters to meet a future energy demand.

Present and projected baseline data

The pre-fs report shall describe current and projected energy and projected consumption and – if relevant – also water consumption at the facility in total and for the specific project area in focus. First the total annual consumption of each fuel / energy carrier (electricity, steam) should be summarized for the last 3 years and – if needed data is available – the projected energy consumption for the coming years.

Then, for the area and installations to be affected by the project, all relevant costs to be affected by the project.

Next to direct costs for energy and water, other operating costs for the area in focus might be relevant for the project development, for example, costs of labor, maintenance, raw materials, utilities, taxes etc.

Regarding projection of energy prices, it might be relevant to include an assumption on prices of carbon credits, which are expected to be implemented from 2028.

In addition, the baseline data should include current and projected CO2 emission data, including direct emissions from combustion of fossil fuels as well as indirect emissions from electricity consumption. MONRE updates annually the average CO2 emission factor for electricity3.

If relevant, also other greenhouse gas emissions should be accounted for, such as methane or refrigerants with high global warming potential.

	2023	2026	2030
Annual product output (tons)			
Annual operation hours (hours)			
Fuel consumption			
Electricity consumption			
Water consumption (m3)			
Cooling consumption (MWh)			
Compressed air consumption (Nm3)			
Fuel price (VND/ton)			
Electricity price (VND(MWh)			
Water price VND/m3)			
Annual fuel costs (million VND)			
Annual water costs (million VND)			
Annual utility costs (million VND)			
Annual labor costs (million VND)			
Annual maintenance costs (million VND)			
(Other costs affected by the project) (million VND)			
Annual CO2 emissions (tons)			

Table 6:1: Outline of summary of projected product output and related costs of energy, utilities and other costs.

[3] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiDofGC-baFAxW62QIHHdHKDG8QFnoECBIQAQ&url=http%3A%2F%2Fwww.dcc.gov.vn%2Fupload%2Fservices%2F1352148718_4.%2520Bao%2520cao%2520cuoi%2520cung_EF2022.pdf&usg=AOvVaw107535cGjvXERrbxnJIXMt&opi=89978449

The current and projected situation is to be considered as a baseline for the project.

Other relevant data
The key process data should be reported when relevant. These are parameters critical to the process itself, which should be maintained (and – if relevant optimized) in the proposed project. Such parameters could include pressure, temperature, mass flow etc.

Other relevant data might include possible expected upcoming regulation, that could affect the facility, such as environmental regulation, international market developments and many more.

The areas listed above might not be complete and will depend highly on the project in focus.

Other relevant environmental impacts
Typically, EE projects would have a number of environmental impacts, which could be grouped into the below categories. For any given project, only a few of the categories may be of relevance.

Pollution of air. This relates to emissions of dust, particles, carbon monoxide, NOx and other substances potentially harming the health of people in the facility as well as in the surroundings and/or plants and animals

Pollution of water,This relates to harmful substances into water streams or into the ground. Also, thermal pollution in the form of heating up water in a stream, for example when using this water for process cooling, can be harmful to life in the stream.

Impacts on extraction / production of raw material / input material: If the project involves adding or removing input material, which have considerable environmental impacts during production and transport, such impacts should be at least mentioned in the report. In many cases

6.2.7.Solution description

The planned project (base case) should be described in more detail. If there is more than one possible solution to be assessed, one specific solution should be selected for detailed assessment. The alternative solutions should then be described by the ways in which they differ from the main solution (chapter 5).

For the base case, the following should be described:

- The solution principle
- Main equipment and installations to change and/or install
- Assessment of necessary investments (CAPEX)
- Assessment of changes in operating costs (OPEX)
- Assessment of environmental impacts
- Assessment of non-energy benefits

In addition, the project's impact on other areas and activities in the facility should be described.

6.2.7.1. Solution principle

The overall principle of the base case should be described and outlined graphically, indicating the main installations as well as the main operation parameters, see example in *Figure 6-1*.

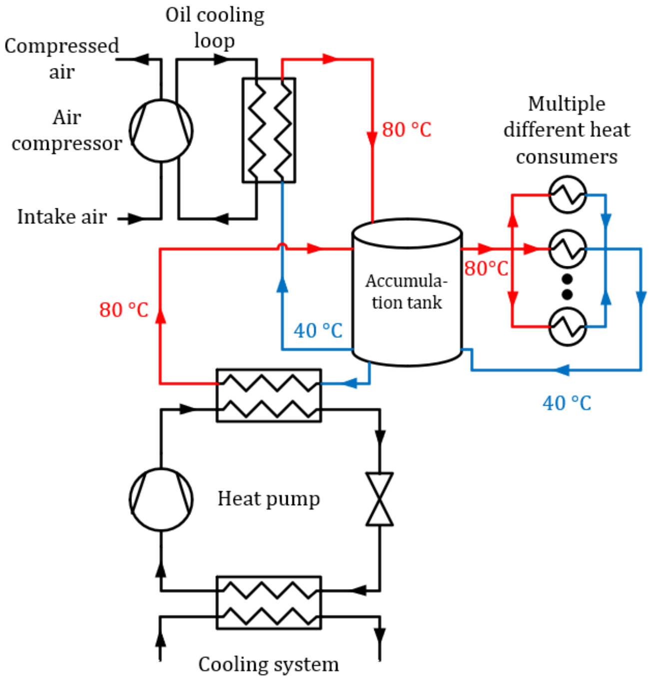


Figure 6-1: Example of principle diagram for heat recovery project

6.2.7.2. Key equipment

A summary of the key equipment to install or change should be provided to describe key elements of the project – first of all for the solution itself, including process equipment, utilities, process control systems etc., secondly for other works regarding electrical installations, buildings construction, foundations etc.

An overview table with key equipment and capacities and data for each of these can establish a good overview of the project.

Equipment	**Technology**	**Capacity**	**Operating data**	**Comment**
New boiler	Steam boiler	8 ton/hour	6 bars	Additional capacity needed and with a new boiler the energy efficiency will increase
Building modifications	-	-	-	Necessitate changes in the building for installing the new boiler.
New stack				New stack for condensing operation and including noise reduction
New steam distribution	…	…	…	Supply to new workshop
Water treatment	…	…	…	Additional capacity needed and a better water quality is desirable
Project costs				Management, design, construction site, insurance etc.

Table 6:2: Example of summary of key elements for project (example new larger boiler installation)

Often energy efficiency projects necessitate changes in other areas than the key equipment itself, i.e. electrical works, changes of control and automation systems etc. An overview of such implications shall be presented in this section of the pre-fs report.

6.2.7.3. Assessment of necessary investments (CAPEX)

Based on the overview of the solution and related works as summarized above, an estimate for the expected investment level (CAPEX) shall be established, as illustrated in *Table 6:3*.

Equipment	CAPEX (Mill. VND)	Source of information	Level of certainty of assessment	Comments
New boiler	30,000	Quotation	+/- 5%	Cheapest from three bidders
Building modifications	2,000	Estimate	+/- 40%	Own estimate
New stack	4,000	Quotation	+/- 5%	Quotation from one vendor
New steam distribution	6,000	Budget prices	+/- 25%	From one contractor based on a site visit
Water treatment	5,000	Quotation	+/- 5%	Cheapest from two bidders
Project costs	5,000	Estimate	+/- 25%	Estimation of all costs related to the project
Contingency	6,000			Chosen greater than uncertainty
Total	**58,000**		**+/- 11%**	Weighted uncertainty

Table 6:3: Example of overview of CAPEX-elements (hardware)

The sources of this information can be inputs from suppliers of equipment, experiences from previous facility projects, inputs from service partners and electricians etc. or inputs from experienced specialists and consultants.

No matter what, the project has not been engineered in detail at this stage and uncertainties should therefore be included in the CAPEX-budget as “contingencies”.

Next to expected hardware costs, it is however important also to include an overview of other project related costs, by example:

- Own resources for project management
- Assistance from consultants and specialists
- Fees and costs related to approvals etc.
- Other non-energy related cost impacts

The total costs of the project (CAPEX) should be presented with an accuracy of +/- 25% or better at this stage of the project. In any case, the level of accuracy must be indicated in the report.

6.2.7.4. Energy savings

Information about energy consumption after implementation of the base case project may again be obtained from reference cases. If such are not available, the report must provide an assessment based on assumptions regarding efficiency and other key parameters. Again, the report should clearly state the assumptions and indicate the level of uncertainty.

Energy cost savings

Future energy costs should be calculated based on the projected energy prices as outlined in chapter 3. The energy cost savings should be assessed for the economic lifetime of the project (the number of years of writing off the investment). Often, assumptions regarding future energy prices may have a significant impact on the financial viability of the project. In such case, the report should show a few different scenarios of price development (sensitivity analyses), indicating how they affect the cost savings.

Assessment of changes in operating costs (OPEX)

Most often, energy efficiency and CO2-reduction projects aim at reducing energy consumption and therefore are associated with a cost saving and a payback period/return of investment.

As a result of the pre-fs work, results for change of operating costs (OPEX) should be reported summarizing all major elements of the cost picture, i.e.:

- Savings from reduced energy consumption (Mill. VND/year)
- Changed costs from change of energy supply source (Mill. VND/year)4
- Changed maintenance costs, within as well as outside of the project area, such as utilities
- Savings from reduced consumption of water (Mill. VND/year)
- Etc.

Quantification of the value of non-energy benefits

An energy efficiency project might have a number of non-energy benefits, for example:

- Improved sustainability profile - Reduced CO2 emissions might increase the competitiveness of the enterprise in a market where clients are expecting sustainable manufacturing. Possibly the market division of the enterprise can quantify the value of this.
- Reduced outage hours - Replacement of outdated equipment may reduce planned or unplanned outage hours of the production. The value of this may be quantified by the enterprise.
- Competences – a solution might necessitate new skills and competences of operators, purchasers of raw materials etc., which should be stated as a part of the basis for the project. The associated costs should be quantified.

To the extent that the value of these impacts can be quantified, those values should be included in the financial analysis of the project.

6.2.7.5. Financial analysis of the solution

In order for the management to be able to evaluate the financial benefits of the project, the pre-fs should make a calculation of the key financial indicators: Simple pay-back period, Net Present Value (NPV) and Internal Rate of Return (IRR). In addition, the analysis could show the cash flow, but this may not be required at the pre-fs stage.

A detailed guide to financial analysis can be found in the Guidance for Feasibility Studies.

6.2.7.6. Other non-energy benefits

In addition to the above-mentioned non-energy benefits that can be valued, there may be a number of impacts which cannot easily be monetized, but which may nevertheless be of great importance to the final decision on how to move forward.

Examples of such impacts are:

- Capacity gains directly on the specific system, but also on related systems
- Quality gains
- Flexibility improvements
- Space requirements
- Reduced labor costs
- Future expansion opportunities

[4] In case fossil fuel is substituted with electricity for heat pumps, an increased cost for energy can be seen. This could be offset by cost savings from improved product quality, increased production capacity and others.

- Extension of lifetime
- Reduced waste
- Compliance with regulation
- Space requirements – new installations might require more or less space
- Etc.

More details regarding non-energy benefits can be found in this guideline[5].

6.2.8. Alternative solution strategies

It is a central part of a pre-fs project to consider and document alternative solutions strategies:

- Are widely different solution technologies available seen from a "helicopter view"?
- Is the scope of the project defined too narrowly?
- Are solutions with higher energy efficiency available?
  - In terms of boundaries for the project?
  - In terms of solution scope?
  - In terms of auxiliary equipment (motors, fans etc.)?
- Can capacity demand for energy-using equipment be reduced by expanding project scope?
- Is the project scope too narrow to also include efficiency in related processes and equipment
- Can new technologies (BAT) be considered to cover the whole or parts of the project scope
- Etc.

The assessment of each of the alternative solutions should follow the same principles as described in chapter 4.

The summary should present any relevant alternative solution strategy and which impact this will have on the business case with special attention to investment costs, long-term operating costs and net-present value: NPV, IRR and payback period. The key-data for alternative solutions should be compared directly to the base-case ("no project situation").

Scenario	Investment costs /CAPEX (VND)	Operating costs /OPEX (VND/year)	IRR (VND)	NPV (VND)	CO2 emission reductions compared to baseline	Other impacts compared to base case
Main solution						
Alternative A						
Alternative B						
…						

Table 6:4: Economic and CO2-comparision of alternative solution strategies

6.2.9. Other project development questions

Depending on the character of the project, many other questions might be relevant to address in the pre-feasibility phase. Below, some of these are described.

[5] https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5bd4f4af7&appId=PPGMS

6.2.9.1. Risk assessment and sensitivities

For the preferred base case and – if relevant – selected alternative scenarios risks associated with the business case shall be assessed – i.e. if the business case will be significantly impacted by:

- Changes in energy prices
- Changes in production volumes and production mix
- Introduction of CO2-abetement costs
- Increasing complexity
- Introducing new technology
- Education of staff or lack of knowledgeable staff
- Etc.

For the most important areas, sensitivity analysis should be carried out to assess to which degree the business case will be affected by changing pre-conditions.

The project may also involve certain other risks that the management needs to be aware of before making a decision. For example, there could be technology risks associated with the new technology, if the application of the technology is not tested under the specific conditions. Such risks could include impact on the product quality, the costs and time for maintenance and more.

For long-term investments, there may be the risk that the market situation makes the technology obsolete before end of economic lifetime.

The pre-fs should carefully address all such risks that could be foreseen.

6.2.9.2. Stakeholders and permits

The pre-feasibility report shall report any relevant stakeholder question that need to be addressed in the feasibility study, for example, any question related to:

- Neighbors
- Customers
- Supply chain
- Local and governmental authorities

Stakeholder questions can be related to:

- Increased emissions of dust
- Wastewater
- Noise
- Traffic

For certain projects, required building permits, environmental permits etc. should be assessed in the pre-feasibility phase and described in the report.

6.2.10. Financing strategy

For large projects, a financing strategy shall be assessed if the company cannot cover investments via its own funds.

The project developer should be aware that sustainability projects with high CO2-saving potentials might have access to more attractive loan-schemes in banks than projects based on fossil fuels.

6.2.11. Conclusions on preferred solution and further steps

The conclusions from the pre-feasibility phase shall be described, first to conclude on a preferred project scope and the most attractive alternative solutions.

Along with these conclusions, recommended further work shall be described comprising by example:

- Plan for further activities and technical clarifications
- Which resources are necessary in the feasibility phase
- Which competences are to be involved in further work

- Should external experts and specialists be involved
- Should preferred supplies take a role in further project development
- Final decision on project scope
- Clarification of financing questions
- Dialogue with stakeholders and authorities regarding approvals and permits
- Clarification of own resources and funds for project development
- Clarification of internal milestones and approvals
- Clarification of internal project owner in further project development
- Etc.

An expected time schedule for further project development shall be presented.

Section 7: Feasibility Study

7.1. Introduction

7.1.1. Feasibility studies definition

A feasibility study is a process that involves the full and comprehensive study of an investment project. It serves as a prerequisite for making investment and financing decisions. This study entails in-depth research into the investment concept across various dimensions, including technical, organizational-management, socio-institutional, commercial, financial, and economic aspects. Its primary objective is to comprehensively assess the feasibility of a project. To achieve this, it necessitates the collection of all essential information related to market conditions, the natural environment, raw material sources, relevant policy regulations, and the socio-economic and cultural characteristics of the local population.

For an industrial energy efficiency (EE) project, a feasibility study assesses the project's implications within the broader objectives and operational context of the enterprise. This includes analysing potential impacts on production capacity, product quality. Such impact analysis is particularly specific for FS of an industrial EE project because of the following reasons: i) more energy efficient processes allow equipment to run at higher capacity, utilizing resources more effectively and thus potentially increasing overall production output; ii) Energy-efficient systems often provide more stable and predictable operating conditions, which is crucial for maintaining consistent product quality and reducing variations in the final product, and iii) Implementing EE projects often involves collecting more data on energy consumption and operational parameters through energy mapping. These data can reveal insights into production processes, helping identify areas for further quality improvements

The FS should also evaluate how the project aligns with the company's strategic goals, competitiveness in the market, and compliance with internal standards or corporate sustainability commitments. By considering these factors alongside financial and technical viability, the study ensures that proposed EE measures contribute positively to both energy performance and the overall business objectives of the enterprise.

7.1.2. Benefits of Feasibility Studies

Implementing a thorough feasibility study offers several key benefits:

- Reduced Implementation Difficulties: By providing good preparation and detailed analysis, a feasibility study helps to mitigate challenges during the project implementation phase.
- Accurate Assessment of Effectiveness and Success: It allows for a more precise evaluation of the project's potential for success and overall effectiveness.
- Financial Planning: It aids in determining the appropriate scale of investment, the structure of different capital types, and the potential sources of funding for the project. It facilitates the calculation of anticipated revenues, expenditures, and profitability, as well as the identification of tangible benefits for both the investor and the broader community.
- Foundation for Decision-Making: It provides a detailed plan that acts as a crucial basis for subsequent investment and financial decisions.

7.1.3. Major steps of feasibility study

In the overall project development process, the feasibility study (FS) is typically conducted after the completion of preliminary stages such as energy mapping, energy audits, and—where applicable—a pre-feasibility study (pre-FS). The FS serves as a bridge between these early assessments and the final investment decision (FID), providing the detailed analysis required before tendering and project implementation. In some cases, the pre-FS stage may be omitted if the scope and nature of the proposed project are already well defined and no significant technical, financial, or operational risks have been identified that could render the project unfeasible. By positioning the FS in this sequence, it ensures that decision-makers have a robust basis for committing resources and moving forward confidently toward execution.

The main contents that are typically included in a feasibility study report, indicating the steps involved in its implementation, are:

Assessment of Investment Necessity:
This section establishes the rationale for the proposed investment, outlining the foundational needs and strategic significance of the project.

Technical and Construction Solutions:
For EE projects, the section should cover the identification and evaluation the most suitable technical solutions and process modifications to achieve the project’s objectives, ensuring alignment with the enterprise’s production requirements, quality standards, and long-term operational plans. It includes documentation of site selection criteria and proposes measures to minimize negative environmental and social impacts. Preliminary architectural concepts, construction methods, and design alternatives are presented.
If a pre-feasibility study has been conducted, this section should provide a detailed description of the shortlisted solutions identified in the pre-feasibility phase.

Financial Analysis and Capital Planning:
This includes the identification of funding sources, evaluation of financial capacity, estimation of total investment costs, and planning of capital disbursement based on project progress. Key financial indicators such as Net Present Value (NPV) and Internal Rate of Return (IRR) are analyzed to assess the project's economic viability.

Environmental Assessment Considerations:
Evaluate the environmental impact in terms of emissions and assess the environmental benefits of each proposed solution.

Risk Assessment and Sensitivity Analysis:
Potential risks related to technical, financial, environmental, or market conditions are evaluated. Sensitivity analysis is conducted to understand the effects of key variable changes on project outcomes.

Project Timeline and Implementation Plan:
The study outlines the projected timeline for implementation, detailing key milestones and estimating the overall duration of each phase of the project.

Conclusions and Recommendations:
Based on the findings, the report concludes with a recommendation for the most viable investment option, providing decision-makers with a comprehensive overview to support informed approval or further action.

7.1.4.Advantages and challenges of pre-feasibility studies implementation

Advantages of Feasibility studies implementation
Feasibility studies (FS) offer several important advantages including:

- Risk Mitigation: Thorough analysis at this stage helps to anticipate and reduce potential difficulties and risks during the project's subsequent implementation.
- Optimized Resource Allocation: Ensures that resources (capital, technology, labor, land) are identified and planned for efficient and effective utilization.
- Clear Financial Outlook: Offers a clear understanding of the financial implications, including capital needs, revenue generation, and overall profitability, aiding in securing funding.
- Regulatory Compliance Assurance: Facilitates early identification and planning for adherence to relevant laws, company policies including decarbonisation, and environmental regulations.

Challenges of Feasibility Studies Implementation

Despite its advantages, the implementation of Feasibility also presents several challenges that must be managed effectively:

- Information Accuracy and Completeness: Obtaining consistently accurate and complete data for market research, environmental assessments, and socio-economic conditions can be challenging.
- Uncertainty in Projections: Financial and economic forecasts (e.g., market demand, foreign exchange rates) are inherently uncertain, which can affect the reliability of the study's conclusions.
- Technology Selection Complexity: Identifying and evaluating the "most suitable" technology from various options, ensuring it is cost-effective, high-quality, and appropriate for local conditions, can be a complex process.
- Financial Mobilization and Risk Management: Successfully mobilizing the required capital and managing financial risks, including foreign exchange fluctuations and debt repayment capabilities, demands robust financial planning.
- Regulatory and Policy Dynamics: Changes in government policies, laws, and regulations, particularly concerning environmental protection or energy efficiency, can significantly impact project feasibility and introduce compliance challenges.

7.2. DE3 Guideline on Feasibility Study

7.2.1. Project scope and objectives

Define the project's scope and objectives.

Project objective

The objective of the project should be aligned with the overall strategic direction of the company. As an example, if the company has a strategic goal of reducing energy consumption by 6% over a specified period, it should be clearly stated how the project supports that goal.

The project objective should as a minimum address the following:

- Is it solely an energy efficiency project?
- Is it a replacement of worn-out equipment?
- Is it a capacity expansion project?
- Is it a simple 1:1 replacement of already existing equipment
- Or is the project an add-on to already existing equipment
- Will the project comprise other installations, building works etc.

Examples of strategic goals and supporting project objectives are listed below.

	Examples of strategic goals	Examples of project objectives
#1	Reduce unit cost [$/ton of product output] by year 20xx	The project is expected to increase automation and reduce manual labor, decreasing the company's operating expenditures.
#2	Reduce energy consumption with x% by year 20xx	The project replaces gas boilers with electric heat pumps with higher COP (coefficient of performance).
#3	Eliminate energy related carbon emissions at for all production sites by year 20xx	The project is expected to reduce carbon emission from electricity and gas by 50% in 5 years and 100% in 10 years.
#4	Increasing the capacity of the energy system by xx % by year 20xx	Securing a capacity expansion of the energy system, that supports the planned production expansion towards 2030.
#5	[…]	[…]

In the absence of guiding strategic goals, the project objective should as a minimum address energy savings, non-energy benefits and financial return expectations.

Project scope

Clearly outline the scope of the energy efficiency project, specifying the targeted areas or processes.

The project scope should be described at a high-level excluding detailed technical specification.

The project scope should as a minimum address the following

- What are the goals of the project?
- What are the deliverables?
- What tasks needs to be performed?
- What is the basis for the investment?
- What are the deadlines?
- Who should be involved?

The project scope should include a reference to the pre-feasibility study and any technical studies completed after the pre-feasibility study.

7.2.2. Technical specifications

The section should provide technical details of the proposed energy efficiency project.

7.2.2.1. Results of the Pre-feasibility Study

Description of the work done under the pre-FS and the conclusions must be developed in the FS.

If no Pre-Feasibility Study has been conducted (e.g. because the preferred solution is obvious), the work described in the separate Pre-FS guideline on the Design basis for the project, the Purpose and scope of project, and Any alternative solutions considered should be included under the FS.

7.2.2.2. Analysis and studies during the Feasibility Study

Description of any further analysis and studies done under the FS leading to the proposed project. This should include reference to any recommendations in the Pre-FS on further clarification or studies.

7.2.2.3. The proposed project

The technical specifications of an energy efficiency project provide detailed information about the technologies, systems, and processes involved in the project. The technical specifications should be based on best available technologies (BAT) available on the market.

The technical description in the feasibility study is a further development of the design basis and solution strategy described in the pre-feasibility study, to reach a basis design of the project, including additional technical details, input from manufacturers, pricing and scheduling.

The technical specifications typically covered in an energy efficiency project are listed in the table below:

The technical specifications	
System requirements and compatibility/integration with existing infrastructure and technologies	[…]
Performance criteria and capacity	[…]
Energy consumption and efficiency	[…]
Technologies required to implement the solution (e.g., heat pump, piping, electrical installations etc.)	[…]
Technology readiness assessment of key components	[…]
Market availability of key technologies and infrastructure parts	[…]
Control and monitoring systems (sensors, meters, and automation control)	[…]
Maintenance and service requirements	[…]
Regulatory compliance (involves ensuring that the technology fulfil regulatory standards and requirements with respect to e.g., environmental impact and safety).	[…]
Warranty terms and conditions	[…]
Required engineering skills and resources to develop and operate the project.	[…]
Process Flow Diagrams (PFD) and Process Instrumentation Diagrams (PID)	[…]
[…]	[…]

Table 7:1: Technical specifications for an energy efficiency project

By thoroughly examining these technical aspects, you can determine whether the energy efficiency solution is technically feasible and aligned with the goals of the organization.

7.2.2.4. Preferred suppliers

Dialogue with suppliers can be applied in some special cases, i.e. in the form of direct contracting (small scale of investment, only one supplier, supplier who has successfully implemented the similar projects, etc).

For large investment projects, FS consultants must determine accurate information based on similar projects that have been successfully implemented domestically and around the world by a number of suppliers.

For private enterprises, it is recommended to involve suppliers in the project development to an extent that a pre-liminary solution design can be presented with capacity data and drawings for all major equipment and installations.

State Owned Enterprises (SOEs) must carefully consider their ability to engage with suppliers in order not to violate the Bidding Law.

For SOEs, the parameters in the FS must be neutral so as not to exclude potential suppliers (do not present requirements/parameters where only one supplier is dominant).

In FS for SOEs, the consultant should only choose parameters publicly available on the market. For projects that require bidding, dialogue with suppliers may violate the Bidding Law. If there is only one supplier, the contractor appointment method according to the provisions of the Bidding Law shall be applied.

At this stage, potential suppliers are involved in the project development to an extent where the preferred solution can be presented. During a tendering process at a later stage the company will select the preferred supplier with the most advantageous solution.

For SOE projects subject to bidding, the participation of suppliers will violate the Bidding Law. Consulting on making FS for SOEs should therefore only refer to the Catalogues of suppliers.

7.2.2.5. Solution design

The content of the FS must comply with Article 54 of the Construction Law[6]. Article 54 of the Constriction Law states: a basic design shall be made to achieve the project's objectives, suit construction works of the project, ensure synchronism between works when they are put into exploitation and use. It follows that the basic design must include explanations and drawings expressing the contents described in the table below:

Details in a basic design description in FS according to Article 54 in the Construction Law	
a)	The construction location, direction of the line of works, list, sizes, types, and grades of works on the whole construction ground.
b)	Selected technological, technical and equipment plans (if any).
c)	Architectural solutions, ground plan, cross-sections and vertical sections of construction works and their sizes and main structures.
d)	Construction solutions, major materials to be used, estimated construction cost of every work.
dd)	Plan on connection of technical infrastructures inside and outside the works, fire and explosion prevention and fighting solutions.
e)	Applied standards and technical regulations and construction survey results for making the basic design.

Table 7:2: Required details in a basic design description in Feasibility Studies as stated in Article 54 in the Construction Law

[6] Microsoft Word - Vietnam Construction Law 2014.doc (ccoin.vn)

Drawings comprising of layout, cross-sections and vertical sections and 3D-animations should be developed to present a visual solution design for the preferred solution. The level of detail required for the drawings is scaled according to the complexity of the project.

A description of how the system is integrated and controlled must be made, making sure that the solutions can be properly integrated and that the control can interact with existing system and support the expected outcome of the project.

Usually, a preferred solution will include a main scenario with relevant sub-scenarios to consider further to choose the most suitable solution for the specific company.

The main scenario and relevant sub-scenarios should be described in terms of investment costs and operating costs so the management of the company can decide on a preferred path forward.

At this stage, potential suppliers are involved in the project development to an extent where the preferred solution can be presented. During a tendering process at a later stage the company must select the preferred supplier with the most advantageous solution.

7.2.3. Financial analysis of the project

This section shall clarify the key elements that form the foundation of the business case. This includes elements of uncertainty and sources of financial data. The project developer may use their own model or find inspiration in the “Financial Analysis Tool to Enable analysis of Financial Benefits to Enterprises of Participating in a Voluntary Agreement Scheme in Vietnam” (Output 2, November 2022). This tool can be accessed through by contacting the DEPPIII DE3 project office in Vietnam through nthngoc.depp@gmail.com.

Technology catalogues, manufacturing catalogues and existing literature are sufficient sources of information in the pre-feasibility phase. In the feasibility study data quality must be higher as the purpose of the project is to make a final investment decision (FID). To obtain higher quality data, private enterprises (but not SOEs) may engage potential supplier and contractors to get more accurate price estimates. SOEs will have to rely on public information on the parameters and costs of similar investments already made.

7.2.3.1. CAPEX

Energy efficiency projects require capital investments (CAPEX) covering different phases of the project. CAPEX can be broken down into pre-construction and construction costs. Pre-construction costs are costs occurring before the final investment decision.

- Pre-construction/Development costs (DEVEX)
  - Development and planning
  - Permitting and logistics
- Construction costs
  - Piping and other equipment costs
  - Electrical installations
  - Civil works
  - Grid connection costs
- Soft expenditures
  - Investment costs (more information is provided in section 7.2.3.7)
  - Overhead costs
- Contingency for unexpected costs

At this stage in the project a certain percentage of the budget must be allocated for unforeseen expenses, that is related to uncertainties for the individual budget elements but also including unforeseen costs that can occur in any project at this stage. The size of the unforeseen cost allocation also depends on the complexity of the project and on how many project elements are within

the control of the project. At the FS stage of the project, the unforeseen costs can account for 20-30% of the budget.
CAPEX should account for future price developments, particularly for capital-intensive components and materials.

Included in the CAPEX section is an evaluation of the robustness of the different components included in CAPEX. Typically, some expenditures are more uncertain than others. The robustness also depends on the expected time of investment and market conditions.

To gain more robust CAPEX estimates, the developer can request suppliers to provide budget quotes on some CAPEX elements, e.g., piping, and electrical installations.

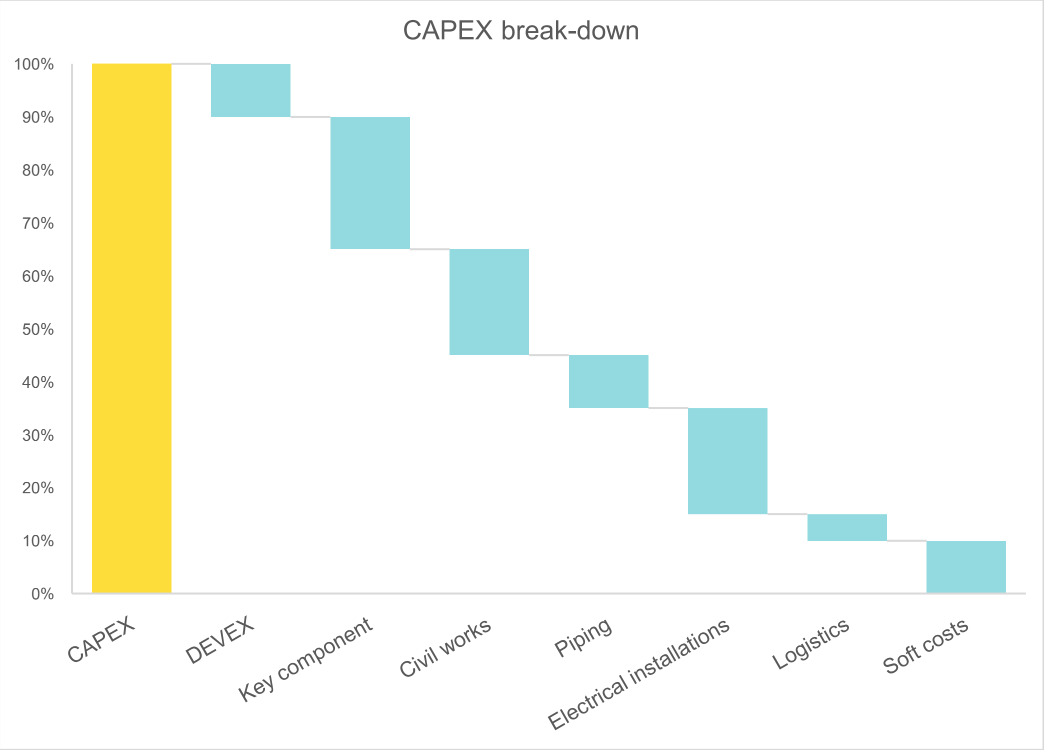


Figure 7-1: CAPEX waterfall diagram - exemplified.

7.2.3.2. OPEX

Implementation of energy efficiency projects typically results in changes in a company's operating expenditures.

Any additional operating expenses impact the financial viability of the project.

Changes in operating expenses from changes in energy expenses and other costs derived from the implementation of the project constitute OPEX in the business case. OPEX includes, for example:

- Wages and salaries for new staff within e.g., engineering
- Energy costs and other costs of operation specific consumption (e.g. oil, water etc.)
- Taxes e.g. carbon
- Maintenance
- Deferred re-investment in existing technology (if the project involves replacement of existing technology)
- Annual service agreements
- …

Energy efficiency projects are designed to generate net energy savings. Meanwhile, installation of new equipment could bring increased utility expenses in one area and energy savings in other areas.

For instance, installation of an electric heat pump with heat recovery will cause savings on the external delivery of heat while generate additional utility costs from electricity.

The impact of operating expenses on the overall financial viability of the project depends on the corresponding energy- and non-energy savings and the complexity of the project. It also depends on the level of automation of the chosen solution. Furthermore, some salary expenses are temporary and phased out over time as the company matures and gets familiar with the new solution.

There is a trade-off between wages and costs for annual service agreements. In some cases, the company has the capabilities to partly in-source service and maintenance.

Some EE providers operate with an energy-as-a-service business model, where all monitoring, servicing and maintenance is handled by the EE provider. This is sometimes the case for energy storage projects, which require more skilled competencies. If the chosen solution comes with a high degree of service, a discount on the upfront costs (CAPEX) should be expected.

7.2.3.3. Energy savings

Energy savings is a key component and should be carefully assessed in a feasibility study. Energy savings are savings in utility expenses for all energy sources used in the company.

Total energy savings over a project lifetime are derived by forecasting production volumes and the costs of energy.

Aspects to consider when forecasting annual production volumes include:

- Expected efficiencies in production,
- Expected capacity expansions
- Competition in the market and demand for products
- Historical growth in production volumes

Forecasting future annual production volumes is normally challenging. Especially in high-growth markets with considerable competition.

Elements to consider when forecasting the future energy prices include:

- Forward prices on electricity and fuels (applicable in liberalised electricity markets)
- Historic development of electricity and fuel prices
- Transportation costs
- Taxes and fees
- …

Forecasting electricity and fuel prices is subject to high uncertainty in highly liberalised markets where electricity is purchased on the spot market.

7.2.3.4. GHG savings

Energy efficiency projects will often result in reduced greenhouse gas (GHG) emissions. From a project feasibility perspective, GHG savings is important as it can tip the balance of the business case and potentially turn non-attractive projects into financially feasible projects.

The FS must calculate emission reductions from the project as pre-project emissions minus post-project emissions. For projects using electricity, the annual emission coefficient of the national power grid must be applied7. For projects using other forms of energy, non-electricity emissions factors published through MONRE's home page should be applied.8

The value of GHG emissions savings depends on the regulatory framework the company operates in.

[7] http://www.dcc.gov.vn/van-ban-phap-luat/1101/He-so-phat-thai-luoi-dien-Viet-Nam-2021.html
[8] http://www.dcc.gov.vn/van-ban-phap-luat/

In countries where an Emissions Trading System (ETS) system is operating, there is a cap on carbon emissions. Companies that are covered by the ETS system receive a fixed number of quotas that represent a company's allowance measures in carbon emissions. If a polluter emits more than its allowance, the polluter must purchase additional quotas. The cost of quotas constitutes a benchmark for potential savings arrived from GHG savings.

Similarly, companies in some countries are subject to national carbon taxes, normally expressed as a price per ton of CO2e emitted. A carbon tax is a regulatory measure to incentivise companies to reduce the carbon footprint of their operations in a given location.

There are currently no carbon taxes applicable in Vietnam, but in Vietnam, an ETS will be piloted by 2025 and fully operational in 2028 according to the Decree no. 6 of 2022.

Furthermore, the embedded CO2 content in products is increasingly becoming a competitive parameter in export markets. Many international companies are already today working to reduce the GHG emissions in their supply chain (their so-called Scope 3 emissions) under the voluntary Science Based Targets initiative (SBTi). This is reflected in requirements to producers in their supply chain to account for and gradually reduce the CO2 footprint of their products. If the enterprise operates in such markets, the potential market value of reducing CO2 emissions should be carefully assessed together with the marketing division of the enterprise (or something like that).

Finally, from 2026 some export companies will be subject to the Carbon Border Adjustment Mechanism9 (CBAM), which puts a carbon tax on certain carbon intensive goods such as cement, iron and steel, aluminium and fertilizers entering the EU.

In sum, costs savings from GHG reductions could constitute avoided carbon taxes or avoided costs associated with purchase of carbon quotas.

7.2.3.5. Corporate taxes and import duties

Tax considerations play a crucial role in assessing the financial viability of the project since it affects net profits and the financing strategy as debt is tax deductible.

The relevant corporate tax rate should therefore be identified and included in the financial analysis of the project.

Imported equipment for energy efficiency investments may in some cases be eligible for reduced import duties. It is important to reflect the actual costs incurred by the company in the financial analysis.

Similarly, the FS should identify whether there are any tax incentives for environmental projects which for which the project may be eligible.

7.2.3.6. Inflation rate

The inflation rate should be included in the business case. Inflation rate is normally forecasted by considering the historic inflation rates in a specific country and the risk of future political and economic instability.

Inflation is an important factor to consider when assessing financial viability since inflation can erode the real returns on investments. Assets that do not outpace inflation may result in a decrease in real value over time. This is particularly relevant for long-term investments.

[9] More information about the EU CBAM-mechanism can be accessed here: Carbon Border Adjustment Mechanism - European Commission (europa.eu)

7.2.3.7. Financing plan and cost of capital

The financing plan lays out the terms and conditions considering equity/loan ratios, financing cost and terms and conditions. In the feasibility phase, the considerations on financing are important since it impact total financing costs. Meanwhile, financing costs depend on available financing options and lenders' terms and conditions.

In the FS phase, developers do not have the full overview of financing costs and conditions, however the project developer can provide indications from general market conditions such as market interest rates, tenors, and preferred equity/loan ratios. The project developer may inform their assessment at the FS stage through engagement with the company's primary bank connection to obtain some preliminary indications about the costs and conditions related to external capital for the project.

The project developed should describe the following as input to the financial analysis in chapter 5:

- The Total Investment Cost
- The expected % shares of own financing (share of equity) and external financing (share of debt)
- The expected market rate for external financing (cost of debt)
- The expected tenure and collateral requirements related to the external financing
- The corporate tax rate applicable to the company[10]
- The company's required return on their own financing (cost of equity)
- The resulting Weighted Average Cost of Capital (WACC)

The cost of capital reflects the costs of financing and is essential for calculating the value of the project.

Financing typically consists of a combination of debt and equity, which is why the company specific Weighted Average Cost of Capital (WACC) should be applied in the financial analysis.

The WACC is the rate that a company is expected to pay on average to all its security holders to finance its assets.

WACC formula:

$$(Share\ of\ debt\ \times\ market\ rate) \times\ (1 -\ corporate\ tax\ rate) +\ Share\ of\ Equity \times\ Cost\ of\ equity$$

The cost of debt is adjusted for the corporate tax rate since debt is tax deductible.

For a project to be financially viable for the company, its Internal Rate of Return (IRR) must exceed the WACC.

7.2.3.8. Incentive schemes

Any available incentive schemes and public grants may be important for the financial viability of the project.

Depending on the structure of the national incentive scheme and the demand for funding, granting of incentives will be more or less likely. An assessment of how likely it is that incentive schemes will be available for the chosen project should be performed.

Name of incentive/grant	Regulation	Responsible agency	Grant size	Probability
-	§	-	(VND)	(%)
…	…	…	…	…

[10] It is noted that tax deductibility of interest on loans is capped at 30% of earnings before interest, taxes, depreciation, and amortisation (EBITDA) when a taxpayer has related-party transactions. Please refer to Vietnam - Corporate - Deductions (pwc.com)

Table 7:3: Overview of incentives

Evaluation criteria of the incentive scheme, such as net energy savings, should be included in the evaluation.

Examples of incentives are grants to reduce upfront investment costs and tax incentives tied to energy or GHG savings.

7.2.4. Assessment of the financial viability of the project

The results of the business case provide information on the financial viability and financial attractiveness of the project.

The business case returns a number of financial KPIs, which are critical information when assessing financial viability. This includes net present value (NPV), internal rate of return (IRR) and payback time (PBT).

DCF	The Discounted Cash Flow (DCF) is a valuation method used to estimate the value of an investment based on its expected future cash flows
NPV	The Net Present Value (NPV) is what a project is worth today based on Discounted Cash Flows (DCF). NPV enables comparisons of projects with different timings and cash flow distributions over the project lifetime.
PBT	The payback time (PBT) is the number of years required to recover an initial investment based on cumulative cash flows.
IRR	The Internal Rate of Return (IRR) is a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis.

Discounted Cash Flow (DCF)

The discounted cash flow (DCF) analysis is presented. The Discounted Cash Flow (DCF) is a valuation method used to estimate the value of an investment based on its expected future cash flows. DCF gives a full overview of the negative and positive cash flows in each year of the project lifetime. The DCF should inform on how the project cash flows impact the liquidity and financial position of the company including the company’s obligations concerning debt repayment.

Discounted cash flow formula:

$$DCF = \frac{CF_1}{(1+r^1)} + \frac{CF_2}{(1+r^2)} + \cdots \frac{CF_n}{(1+r^n)}$$

DCF = Discounted cash flow
CF_1 = cash flow in year 1
CF_2 = cash flow in year 2
CF_n = cash flow in additional years
r = Discount rate
n = Time period

WACC is normally used as the discount factor.

A cumulative discounted cashflow diagram is useful when you want to know how long it takes to recover the investment (pay-back time, PBT). The example in Figure 7-2 has a pay-back time of 8 years.

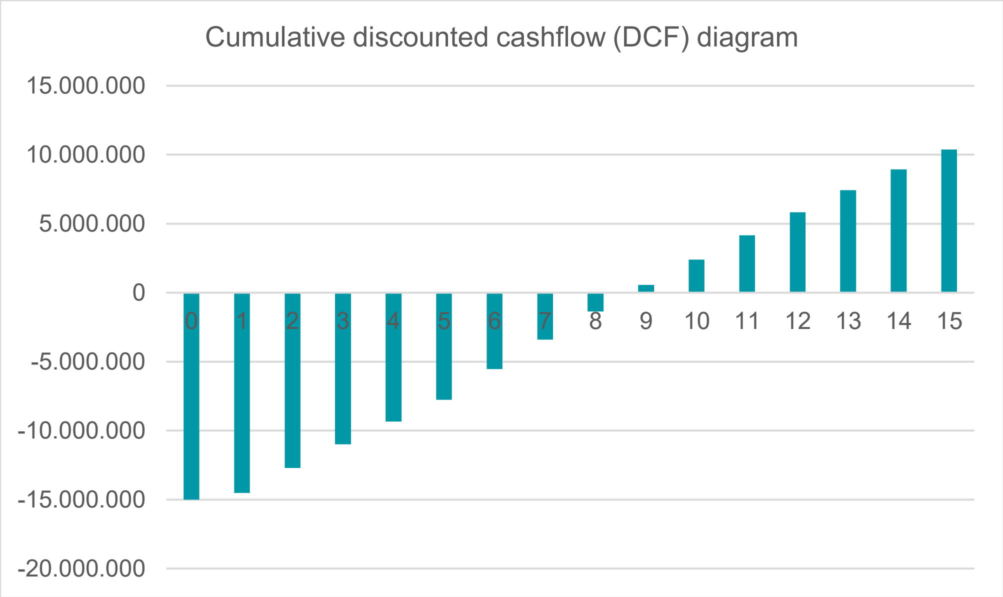


Figure 7-2: Cumulative discounted cashflow diagram, CAPEX: 15 million., discount factor: 5%, project lifetime: 15 years.

Net Present Value (NPV)

Net Present Value (NPV) is a financial metric used to assess the profitability of a project. It represents the difference between the present value of cash inflows and the present value of cash outflows over a specified period of time.

Net Present Value (NPV) is derived by deducting the initial investment from the sum of future discounted cash flows.

$$NPV = -CF_0 + \frac{CF_1}{(1+r^1)} + \frac{CF_2}{(1+r^2)} + \cdots \frac{CF_n}{(1+r^n)}$$

NPV = Net present value
CF_1 = cash flow in year 1
CF_2 = cash flow in year 2
CF_n = cash flow in additional years
r = discount rate
n = Time period

At NPV = 0, the investment 'breaks even'.

Pay-back time (PBT)

Pay-back time (PBT) is the number of years required to recover an initial investment based on cumulative cash flows.

Internal Rate of Return (IRR)

When assessing the financial viability of a project, a key criterion is whether the project Internal Rate of Return (IRR) is equal to or above the Weighted Average Cost of Capital (WACC) for the Investor.

The project IRR is the interest rate at which the initial investment is equal to the discounted value of future cash flows from the project.

Hence, when IRR=WACC, the project investment "breaks even", when IRR>WACC the project investment returns more than the average cost of capital, and if IRR<WACC the project investment is not able to pay the full financing cost.

Investors have difference risk profiles and return expectations, which will impact how attractive the project is perceived.

7.2.5. Economic Analysis of projects

For projects planning to apply for funding through a financing facility funded by an International Financial Institutions (IFI) such as the World Bank and EIB, there will be separate requirements to supplement the financial analysis (assessing viability from a financial investment point of view) with an economic analysis (assessing socio-economic viability from a society point of view). The project developer should refer to the specific guidance available for the considered financing facility as these requirements will differ between different IFIs.

In general, the approach will take its point of departure in the financial analysis and perform a number of specific corrections:

1. Restatement of all prices to be excluding any taxes, duties, and subsidies.
2. Quantify key environmental externalities - in particular reduction in GHG emissions - and if a generally accepted shadow price (published by the government or an IFI) exists, or a local/regional market price (from an existing ETS) exists, then calculate the value of the externality and include it in the economic calculation.
3. Change the WACC in the calculation (reflecting the financing cost of the enterprise) to a social discount rate for Vietnam (e.g. 6.3% based on the OECD (2021b) working paper "Assessment of a Social Discount Rate and Financial Hurdle Rates for Energy System modelling in Viet Nam" which was prepared to support the Viet Nam Energy Outlook 2021).

On the basis of these changes, the economic NPV and IRR should then be calculated and compared with the financial NPV and IRR.
It is highly recommended to align with the specific requirements of the financing facility considered as the requirements will vary between them and no uniform approach exists.

7.2.6. Non-energy benefits (NEBs)

Non-energy benefits (NEBs) are potentially significant and should therefore be carefully assessed. NEBs might be equally important – or even more important – than the benefits from improved energy efficiency.

NEBs from the chosen energy efficiency solution might comprise a wide range of areas related to product quality, capacity gains, sustainability benefits etc.

Similarly, some projects may have Non-energy Costs, e.g. in terms of additional space requirements on-site that may impact future expansion opportunities.

The value of NEBs (and costs) should be assessed (and if possible quantified) from an economic perspective. As an example, improved product quality may generate additional demand for the product and increase sales by x% (see example in Table 7:4).

Non-energy benefits and costs		
NEB	**Description**	**Valuation**
Product quality	Does the chosen solution(s) lead to improvements in the product quality? Or does the chosen solution compromise product quality?	*Increased product quality is expected to improve the company's market position and increase sales by x% compared to pre-implementation.*
Capacity gains	Does the chosen solution(s) enable the option for expanding production capacity?	The specific production costs decrease, as the plant can have a higher throughput. […]

Flexibility improvements	Does the chosen solution(s) lead to flexibility improvements?	Flexibility can be utilized to optimize the energy costs due to variable energy prices. Flexibility can also be for peak shaving which will downsize the needed equipment capacity and therefore also the related investments. Flexibility can also be in terms of ability vary the input products (e.g. types of wood) […]
Space requirements	Does the chosen solution(s) require additional – or reduced space or changed in building interior?	If additional space is needed then investments in additional buildings must be included, which can have a significant impact in the project feasibility. […]
Production efficiency	Does the chosen solution(s) improve operational up-time?	This will give a higher throughput and therefore reduce the specific production costs. […]
Future expansion opportunities	Does the project yield future expansion opportunities?	This can support the production of new products or increase the existing, which all represent at value. […]
Sustainability	Will the chosen project improve the sustainability and carbon footprint of the company? Will this address current or expected customer demands and improve competitiveness?	This will help secure or increase a marked of share the product if this is a requirement from the end customers or finally the end-user. […]

Table 7:4: Non-energy benefits (NEBs) for an energy efficiency project

Besides from the NEBs listed in Table 7:4, a more extensive list is presented in the annex. Here potentially relevant NEBs are presented, alongside an assessment of whether they might impact risks, costs, and the value proposition of the project.

Some of the questions raised in Table 7:4 are of “non-engineering” character and it is therefore important that the energy auditor and the company discuss involvement of sector- and product specialists, sales department, etc. to justify any benefit further – whether these come from the company’s own organization, a main office or external consultants.

Sustainability benefits, such as GHG savings, are important to include in the FS study, as it improves the attractiveness of the project and increases the likelihood of securing financing. This is particularly important if the company seeks financing from institutional investors like the World Bank and The European Investment Bank (EIB), as these organizations add significant weight to sustainability impacts when prioritizing investment prospects.
GHG savings occur if the project includes fuel switching whereby a more carbon intensive energy source (e.g., coal) is replaced with a less carbon intensive energy source (e.g., biomass). GHG savings may be quantified using national emission factors for the energy sources saved by the project (electricity, coal, gas, oil). For electricity the national GHG emission factors for grid-based electricity in Vietnam published by MONRE may be applied11.

In some cases, financial investors may in their Cost Benefit Assessment of a project use a shadow carbon price (which is calculated to include environmental costs which are not priced in the market) to

[11] http://www.dcc.gov.vn/van-ban-phap-luat/1101/He-so-phat-thai-luoi-dien-Viet-Nam-2021.html

assess and rank investment options. In 2020, EIB updated their shadow carbon prices to reflect best available evidence to meet the Paris Agreement12 (see Table 7:5).

EIB Shadow costs of carbon							
	2020	2025	2030	2035	2040	2045	2050
Value (Eur./tCO2e)	80	165	250	390	390	525	800

Table 7:5: EIB Shadow cost of carbon [13].

As a general principle, projects that can be achieved below EIB's shadow cost of carbon are considered more attractive and thus more likely to be considered for a loan. Meanwhile, when working outside EU countries EIB employs sensitivity analyses to account for local conditions and carbon markets.

7.2.7.Sensitivity analysis

The purpose of the sensitivity analysis is to account for how uncertainties related to, i.e. future energy prices, which could affect the overall feasibility of the project. Some risks and uncertainties cannot be quantified and should be discussed qualitatively, e.g. risks related to complexity and choice of technology.

…the sensitivity analysis should as a minimum consider the following uncertainties:

- CAPEX
- Energy prices and any applicable energy taxes
- Production volumes and production mix
- Financing costs
- Incentive schemes

The results of the sensitivity analysis are presented in a table to see the impact on key financial performance indicators (IRR, NPV and PBT).

		Scenario A	**Scenario B**	**Scenario C**
Investment	VND million	[………]	[………]	[………]
Lifetime	years	[………]	[………]	[………]
Net present value (NPV)	VND million	[………]	[………]	[………]
Internal rate of return (IRR)	%	[………]	[………]	[………]
Payback time (PBT)	Years	[………]	[………]	[………]

Table 7:6. Results from sensitivity analysis where IRR, NPV and PBT vary with CAPEX

Quantifying CAPEX uncertainties can be done by assessing uncertainties of the different components of CAPEX and assigning higher uncertainties to CAPEX elements, which are based on estimates and lower uncertainty to CAPEX elements, which are based on concrete budget codes (price lists) from suppliers. CAPEX uncertainty then becomes a weighted average as expressed in the formula below:

$$CAPEX\ uncertaintiy\ [\%] = (U_{installations} \times CAPEX_{installations}) + (U_{piping} \times CAPEX_{piping}) + \ldots\ldots$$

A similar approach can be applied to other uncertainties such as funding costs and incentive schemes.

7.2.8.Social and environmental assessment

If funding for the project is sought from financial institutions through facilities that involve international financing, there may be separate requirements for social and environmental assessment of the

[12] EIB (2023). The Economic Appraisal of Investment Projects at the EIB. 2nd edition. Report link: https://www.eib.org/en/publications/20220169-the-economic-appraisal-of-investment-projects-at-the-eib
[13]EIB (2020). EIB Group climate bank roadmap 2021-2025. Report link: https://op.europa.eu/en/publication-detail/-/publication/98cc83ef-4f06-11eb-b59f-01aa75ed71a1/language-en

project that goes beyond the national legal requirements. This will typically reflect the environmental and social procedures of the main financier and be reflected in an elaborate Environmental and Social Management Framework for the specific financing facility14.

The social and environmental assessment should account for legal and regulatory conditions impacting project implementation.

The table below should be used to describe the social and environmental implications of the project. Examples of general implications are provided. Meanwhile, in the FS study, social and environmental implications, and actions to enforce or remedy such implications should be thoroughly described.

Some implications are mostly temporary, only occurring during the construction phase while others are permanent occurring throughout the operation of the project.

Potential implications depend on the specific project, technology, and location.

Impact parameter	**Description**	**Temporary/permanent**	**Actions**
Job creation	The project has the potential to generate demand for high-skilled jobs during construction and operation phase.	Permanent	…Educating and upskilling of the local labor force
Public health	During construction, the large, concentrated workforce raises the demand for ensuring a healthy and safe working environment. After implementation the project may also result in permanent improvements in the working environment, e.g. through reduced particle emissions, noise etc.	Temporary or Permanent	…Plan work during hours where weather conditions are favorable. …install safety signs and manuals in the work environment
Labor safety	Lifting, transporting, loading, and unloading, electrical installations, hot installations can pose safety risks to workers during the construction phase. After implementation the project may also result in permanent improvements in safety, e.g. if a boiler is replaced by a heat pump.	Temporary or Permanent	…educate labor force in how to perform specific jobs in a safe manner. Introduce risk assessments procedures before any work operations are started.
Emissions of pollutants (e.g., NO_x/SO_x)	During the construction phase, exhaust gases from generators and engines release air pollutants such as NO_x, SO_x and CO_2.	Temporary or Permanent	…source engines and generators with filters to reduce release of air pollutants

[14] A good example for Vietnam is the Vietnam Scaling up Energy Efficiency Project (VSUEE), where the Environmental and Social Management Framework is available here: https://documents1.worldbank.org/curated/en/487091528452637075/pdf/Environmental-and-Social-Management-Framework.pdf

Quality of life	The project has the potential to create a more interesting working environment and it can also contribute to a feeling of being a part of contributing to the sustainability agenda.	Permanent	[…]
Education and awareness	[…]	[…]	[…]
Local industry interests	[…]	[…]	[…]
Greenhouse gas emissions	[…]	[…]	[…]
Air and water quality	[…]	[…]	[…]
Resource conservation	[…]	[…]	[…]
Waste reduction	[…]	[…]	[…]
[…]	[…]	[…]	[…]

Table 7:7: Social and environmental impact of the project during construction and operation phase

Further inspiration may be found in publicly available EIA screening checklists15 and EIA templates16.

The social and environmental assessment is part of the overall evaluation of project feasibility. It also informs project owners and prospective financiers of the general acceptance from the local community, which is critical in the implementation of the project.

In assessing the social and environmental impacts, the following stakeholders should be considered:

- Neighbours
- Staff
- Customers
- Supply chain
- Local and governmental authorities

7.2.9.Risks and mitigation strategies

A project will have several risks, which must be identified in a feasibility study. A risk log of potential risks and actions (Table 7:8) and a risk matrix (Figure 7-3), which rates risks according to impact and likelihood are necessary tools in a project.

Having a detailed risk mitigation strategy improves investor confidence as it improves the overall attractiveness of the investment. An example of a template for risk assessment is provided below.

ID	Category	Specific risk description	Impact	Likelihood	Action(s)
1	*Political risks*	1.1 Existing scheme for financial support for EE investments is discontinued	[…]	[…]	[…]
2	*Regulatory risk*	2.1 Delays in obtaining necessary permits and regulatory approval.	[…]	[…]	[…]
3	*Technical risk*	3.1. The technology does not deliver the expected	[…]	[…]	[…]

[15] https://pnea.sprep.org/sites/default/files/2022-04/SPREP%20EIA%20Screening%20Checklist.pdf
[16] https://safetyculture.com/checklists/environmental-impact-assessment-template/

		product quality or production capacity.			
4	*Risks of budget increase*	4.1 The tender outcome is higher than budget estimates.	[…]	[…]	[…]
5	*Risks of schedule delays*	5.1 The project implementation is delayed due to e.g. delayed subcontractors…	[…]	[…]	[…]
6	*Risks of reduced results*	6.1 The technology does not deliver the expected energy savings.	[…]	[…]	[…]

Table 7:8: Risk register and action log

The risk matrix is a useful tool for creating an overview of most critical risks. Risks which have high impact on project implementation and a high likelihood of realisation (placed in the red area) should be closely monitored.

Impact		*Medium*	*High*	*Very High*	*Extreme*	*Extreme*
		Medium	*Medium*	*High*	*Very High*	*Extreme*
		Low	*Medium*	*Medium*	*High*	*Very High*
		Very low	*Low*	*Medium*	*Medium*	*High*
		Very low	*Very low*	*Low*	*Medium*	*Medium*
		1	*2*	*3*	*4*	*5*
		Likelihood				

Figure 7-3: Risk matrix

The risks can be evaluated by using the following categories for each risk.

Likelihood:
1. 0-15% The likelihood is very small
2. 16-30% The likelihood is small
3. 31-45% It is likely
4. 46-60% It is quite likely
5. 61-75% It is very likely

Impact:
1. The Impact is very small. It can be handled within the plan's buffer.
2. The Impact is small. It can be handled within the project manager's tolerance.
3. The Impact is medium. This will lead to a decision presentation to the management.
4. The Impact is great. This will result in a greater delay and/or increase in the cost of the project.
5. The Impact is very great. It will close the project (showstopper).

To mitigate and handle the risk, then each risk should be addresses with the following questions:
- How can the risk be prevented?
- At what stage in the project can the risk occurs?
- Will the risk influence other project elements?
- If the risk occurs what is the consequences?
- Which actions must be taken if the risk occurs?
- When is the risk no longer present?
- If the risk is mitigated, will it then have an effect on time, content, resources etc.?
- Who is responsible for the risk?

7.2.10. Implementation plan

A high-level timeline stating the individual phases of the project and key milestones is important since it gives investors and management the confidence that the project is realistic and manageable.

Project milestones, such as budget approval or securing financing, should be included in the time schedule.

This should also include any permits needed for implementation of the project.

Month	1-3	3-5	5-7	7-9	9-11	11-13	13-15	15-17	...
Project initiation and planning	M								
Design and Engineering			M						
Financing and budget approval					M				
Permits needed					M				
Preparation of tender, Tendring, contracting and stand still						M			
Implementation								M	
Commissioning and handover									M
Monitoring and optimization									M

M = Milestone

Table 7:9: High level time schedule for project implementation

Challenges in realising the implementation plans and delays mitigation strategies should be described in chapter 7.

Challenges may for instance includes the supply chain restraints and longer environmental approval processes causing delays in project implementation.

A list of critical stakeholders and their respective roles in the different phases of the project should be described.

7.2.11. Conclusions and recommendations

In the last chapter of the feasibility study, conclusions and recommendations are made. This includes summarizing the soundness of the project, key project benefits and recommendations for implementation and further actions.

The soundness of the project

In this section, the soundness of the project is summarized. This covers the technical, financial, and practical rationale of the project.

Key project benefits

In this section, key project benefits are highlighted. Examples of project benefits include:

- Energy savings
- GHG reductions
- Cost savings
- Improved product quality

Recommendations

The last step in the FS report is recommendations for further actions and next steps required for project implementation.

This may include actions related to environmental investigations needed for detailed planning and system design, or incorporations of management techniques to complete critical steps of the project successfully. It may also include paying attention to new political winds, which could have implications for the availability of public funding of tax incentives.

The scope of this section depends on the observations made in the FS phase, the complexity of the proposed solution, and risks and dependencies identified.

Section 8: Loan Application

8.1. Introduction

This document is a guidance on the typical loan application process and related documentation requirements for Energy Efficiency (EE) investment projects in industrial enterprises (IE) in Vietnam. The guidance has been developed in the context of the Energy Partnership Programme between Vietnam and Denmark.

An energy efficiency project usually starts with an energy audit or screening of possible energy efficiency projects. The most promising solutions are assessed in a pre-feasibility study, where the options are weighed against each other. After the pre-feasibility phase, the most promising solution undergoes a more detailed assessment in a feasibility study. On this basis a Final Investment Decision is made by the enterprise management.

Before proceeding to tender and contracting, a decision is made on whether to finance the investment from own internal resources (equity) or alternatively to apply for external funding in the form of a loan from a financial institution.

External funding from a financial institution for an EE investment project may be in the form of general investment financing, typically from the enterprise's existing banking partner, or financing from a dedicated EE Financing Facility (such as the Risk Sharing Facility for Vietnam Scaling Up Energy Efficiency 'VSUEE'[17]) through a Financial Institution participating in the dedicated EE Financing Facility.

The purpose of the present Loan Application Guidance is to help enterprises preparing EE investment projects in industry in Vietnam to understand the typical loan application process and related documentation requirements they will meet if they need to access external funding for their EE investment project. This will allow enterprises to, proactively and early in the project preparation process, consider the potential sources of external funding and ensure that the necessary documentation to support a loan application will be timely available.

Separate Guidelines for Energy Audits, Pre-Feasibility Studies and Feasibility Studies for Energy Efficiency projects in industry have been developed in parallel with the present guidance and can be accessed on the VNEEP-webpage or by contacting the DEPPIII DE3 project office in Vietnam through nthngoc.depp@gmail.com.

The Loan Application Guidance includes a description of the following:

1. **Loan application process**, which describes the typical loan application process and documentation requirements for general investment financing (section 1.1) and for financing through dedicated EE Financing Facility (section 1.2).
2. **Review of loan applications by financial institutions**, which describes the typical loan appraisal process for general investment financing (section 2.1) and for financing through dedicated EE Financing Facility (section 2.2).
3. **Annex – Examples of energy efficiency projects in industry**, which provide a non-exhaustive list of examples of energy efficiency (EE) projects in industry.

Disclaimer:
The present Loan Application Guidance is for informational purposes only and does not guarantee loan approval for general investment financing or for financing through dedicated EE Financing Facility. The Loan Application Guidance is based on the general information publicly available from financial institutions in Vietnam on their loan application and appraisal process, but each financial institution will have their own specific procedures and credit review policies. Potential applicants are encouraged to consult their respective financing institutions for specific

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[17] The Risk Sharing Facility for Vietnam Scaling Up Energy Efficiency 'VSUEE' is available through https://vsuee.vn/

loan program details and requirements, early in the project development process, e.g. when it is known that external financing may be required for the project implementation.

8.2. DE3 Guideline on Loan Application

8.2.1. Introduction

8.2.1.1. Introduction

Energy efficiency (EE) is a cornerstone of Viet Nam's strategy for achieving sustainable development, energy security, and climate goals. Through policies such as the Law on Energy Efficiency and Conservation and the National Energy Efficiency Program (VNEEP), the Government has committed to ambitious targets for reducing energy intensity and greenhouse gas (GHG) emissions.

However, translating these goals into tangible investments remains challenging, particularly for industrial and commercial enterprises. One of the most persistent barriers is limited access to finance. Although a range of financing programs exists, many enterprises, especially small and medium-sized enterprises (SMEs) struggle with the complexity of financial procedures. Key obstacles include lack of awareness about financing options, unfamiliarity with loan application requirements, and limited technical capacity to develop bankable project proposals.

In this context, a loan application becomes a critical step in securing funding for EE investments. Typically, it follows a structured project development process, which includes an energy audit and a financial feasibility study. These two essential preparatory steps help establish the project's technical and economic justification and are covered in separate guideline documents.

This Loan Application Guideline has been designed to support enterprises, particularly SMEs in navigating the loan application process for energy efficiency investments. It provides clear, practical, and structured information to help bridge knowledge and capacity gaps, and to increase the bankability of EE projects.

The guideline is organized around three main components:

1. Loan application process: A step-by-step overview of how to prepare and submit an EE loan application, including required documentation.
2. Review process by financial institutions: An explanation of how financial institutions typically assess EE loan applications, including credit review and project evaluation criteria.
3. Annex: Examples of EE projects: Real-world examples of EE projects in the industrial sector to illustrate the types of investments that may qualify for financing.
4. Case studies: ….

By following this guideline, enterprises will be better equipped to prepare high-quality loan applications, thereby increasing their chances of securing financing and contributing to Viet Nam's broader energy efficiency goals.

8.2.1.2. Key related concepts

Understanding the following key concepts will help enterprises navigate the EE loan application process more effectively:

- **Loan** – A sum of money provided by a lender (e.g., a bank) to a borrower, which must be repaid with interest under agreed terms.
- **Equity** – The amount of the project's cost funded by the owner's own capital.
- **Loan Application** – A formal request submitted by a borrower to a lender, providing details about the borrower's legal status, financial condition, and intended use of funds.
- **Energy saving and efficiency:** The practice of using less energy to achieve the same level of service or output, typically through improved technology or process optimization.
- **Energy Audit:** A systematic process to assess current energy use, identify saving opportunities, and recommend measures for improvement. An energy audit provides the technical foundation for an EE project proposal.
- **Bankable Project:** A project with clear technical feasibility, proven financial viability, and acceptable risk levels, making it attractive for lenders or investors.

- **Baseline Energy Consumption:** The amount of energy used before EE measures are implemented, used as a reference to measure savings.
- **Principal** – The original amount of money borrowed, not including interest.
- **Interest Rate** – The cost of borrowing, expressed as a percentage of the loan principal per period (e.g., per year).
- **Repayment Schedule** – The agreed plan for repaying principal and interest (e.g., equal principal payments, annuity payments).
- **Collateral:** Assets pledged by the borrower to secure the loan, which the lender may claim if the borrower defaults.
- **Risk-Sharing Facility:** A financial mechanism in which a third party (e.g., donor, development bank) shares part of the credit risk with commercial lenders to encourage financing for targeted projects.
- **Net Present Value (NPV)** – The difference between the present value of cash inflows and outflows, used to assess project profitability.
- **Internal Rate of Return (IRR)** – The discount rate at which the project's NPV equals zero; a measure of investment return.
- **Payback Period** – The time it takes for the cumulative net cash flow to recover the initial investment. For case of EE project: The time required for the net savings from an EE project to recover the initial investment cost.

8.2.1.3. Loan application process

Enterprises seeking financing for energy efficiency (EE) investments typically go through a formal loan application process. This process can vary depending on whether the loan is accessed through general commercial financing or via a dedicated EE financing facility. However, both pathways require enterprises to demonstrate the technical and financial viability of their proposed EE projects and to provide comprehensive documentation.

When applying through general investment financing offered by commercial banks or other financial institutions, enterprises are required to submit a standard loan application package. The package commonly includes:

- Legal documents: Business registration certificate, enterprise charter, power of attorney (if applicable), and other documents verifying the legal status of the enterprise and authorized signatories.
- Financial documents: Audited or unaudited financial statements for the past three years (or available years), production and financial plans, debt and credit reports, and information on receivables, payables, and inventory.
- Project-related documents: An investment plan or project proposal, feasibility study or pre-feasibility report, internal approval decisions, investment registration certificate (if required), and contracts related to procurement or implementation.
-

These documents help financial institutions assess the enterprise's creditworthiness, repayment capacity, and alignment of the EE project with broader business objectives.
When applying through Dedicated EE financing programs such as the Risk Sharing Facility under the VSUEE project, there are often additional requirements tailored specifically for energy-saving investment. In addition to the standard documentation mentioned above, applicants are usually required to submit:

- *Proof of compliance with the program's technical criteria (e.g., equipment efficiency ratings, verified GHG reduction, minimum energy savings threshold, relevant certifications).*
- *An Environmental and Social Management Plan (ESMP) prepared in accordance with the donor's or program's prescribed template.*
- *Documentation to confirm eligibility for concessional terms (e.g., evidence of alignment with national EE targets or program-specific priority areas).*
- *Other documents as required by the specific financing program.*

These additional documents enable lenders to evaluate the project's impact, risks, and bankability from both technical and sustainability perspectives.

Submission and Follow-up: Once the application package is completed, it is submitted to the selected financial institution for review. Enterprises should ensure that all documents are accurate, consistent, and professionally prepared to avoid delays. During the review period, banks may request clarifications or additional information. Timely follow-up and responsiveness to lender queries can help accelerate the approval process.

8.2.1.4. Advantages and challenges in EE loan loan application preparation

Preparing for an energy efficiency (EE) loan offers several advantages for enterprises. It provides access to external capital needed to implement cost-saving EE measures and can open the door to concessional loans or risk-sharing mechanisms. EE projects often deliver reliable returns through reduced energy cost, while also enhancing a company's reputation and aligning with sustainability goals.

However, the loan preparation process also poses challenges. It often involves complex procedures and requires extensive technical and financial documentation, which many small and medium-sized enterprises (SMEs) may find difficult to prepare. Limited internal capacity, especially in developing feasibility studies, can be a significant barrier. In addition, banks may perceive EE projects as high-risk due to uncertain savings projections or lack of collateral. Awareness of available financing options remains low, and the long preparation and appraisal timelines can discourage enterprise participation.

8.2.1.5. Energy Efficiency Financing Mechanisms and Tools in Viet Nam

Energy Efficiency Financing Mechanisms and Tools in Viet Nam Various mechanisms and tools are currently in use to support EE financing, including:

- Dedicated Green Credit Lines through commercial banks, often backed by international donors (e.g., World Bank, ADB), with concessional interest rates or risk-sharing mechanisms.
- Risk-Sharing Facilities such as the World Bank’s VSUEE project, which offers partial credit guarantees to de-risk lending for EE projects.
- Vietnam Environmental Protection Fund (VEPF) and other public finance institutions that provide subsidized loans for energy-saving and environmentally friendly investments.
- ESCO (Energy Service Company) Models, where ESCOs finance and implement EE measures and are repaid through shared energy savings.
- Green Bonds and Blended Finance, which combine public and private resources and may include sovereign or sub-sovereign green bond issuances.
- International Climate Finance, such as funding from the Green Climate Fund (GCF), bilateral ODA, and donor-supported technical assistance and grants.

8.2.2. Loan application process

8.2.2.1. General investment financing

When applying for investment financing in general from a Financial Institution, the enterprises shall submit a loan application to the Financial Institution with the standard information required by the Financial Institution. This will typically include:

- Legal documents (including certificate of registration/incorporation of the enterprise)
- Financial documents (including audited/un-audited financial statements)
- Documents supporting the planned use of the investment financing.

The typical information required by the Financial Institution in Vietnam in connection with a loan application is further described in sections 8.1.1 through 8.1.3 below.

8.2.2.2. Legal documents

Enterprises applying for investment financing for an EE project can expect that the below documents will be requested by the financial institution to prove their legal eligbility.

No,	Document name	Document form	Note
I.	LEGAL DOCUMENT		
1 1.	Decision to establish a business/Certificate of business registration/Certificate of investment registration	Original/Notarized copy	Establishment decision for a one-member limited liability company in case the owner is an economic organization.
2.	Certificate of tax code registration	Original/ Notarized copy	For businesses established under the old Enterprise Law (before July 1, 2015), except for tax codes recorded on business registration.
3.	Enterprise's regulations	Original/ Notarized copy	
4.	Certificate of capital contribution/share of each member or List of capital contribution members/shareholders (contributed capital from 5% of charter capital/equity that have voting right)	Copy	Do not apply to One Member Limited Liability Company
5.	Minutes of election of company President/Chairman of the Board of Directors/ Chairman of the Board of members	Original/ Notarized copy	
6.	Document appointing Chief Accountant/Person in charge of accounting	Original/ Notarized copy	
7.	Document from the competent authority (Decision/Resolution of the Board of Members/Board of Directors/general meeting of shareholders) on: (i) decentralization and limits on capital/loan mobilization or limits on other forms of credit at the Bank; (ii) decentralize and assign authority to use assets owned by the enterprise to mortgage or pledge at the BANK for enterprise representatives to borrow bank capital and other forms of credit.	Original/ Notarized copy	If the Charter specifically stipulates and within the scope of credit authorization, this document is not needed.
8.	Decision/Decree of regular/time-to-time authorization of the Legal Representative of the enterprise for the representative to sign contracts and credit document agreements with the BANK, in accordance with the Decision/Resolution at point (15) above.	Original/ Notarized copy	Limited liability companies and joint stock companies can have one or more legal representatives. If the Charter/Document promulgated by the Board of Members/Board of Directors/General Meeting of Shareholders (Minutes/Resolution/Decision) has specific provisions and is within the scope of authorization, this document is not needed.
9.	Notify the signature sample of the legal representative/authorized representative signing with the bank	Original/ Notarized copy	

	documents/procedures related to credit granting/loan security.		
10.	Citizen identification, Identity Card, Passport, authentication documents other legal individuals.	Copy	

8.2.2.3. Financial documents

Enterprises applying for investment financing for an EE project can expect that the below documents may be requested by the financial institution to document their financial status.

No,	Document name	Document form	Note
II.	FINANCIAL DOCUMENTS		
1.	Regulations on decentralization of financial management	Original/ Notarized copy	For decentralized enterprises
2.	Tax/audit financial statements for at least the last 3 years and the most recent quarter: Balance sheet; Reporting results of production and business activities; Notes to the financial statements; Cash flow.	Original/ Notarized copy	For businesses operating less than 03 years, request to submit financial statements of previous years and the most recent quarter. For credit extensions guaranteed by 100% of the credit value by deposit at the BANK, valuable papers (except for stocks) issued by the BANK (multiplied with asset value coefficient guaranteed), it is possible Only require financial statements for the most recent year and most recent quarter. For SMEs, it is not mandatory to provide cash flow reports if SMEs do not prepare cash flow reports.
3.	Detailed list of receivables, payables, inventory, loans and financial leases, and other accounts that account for a large proportion of Assets/Capital Resources. In case the financial statements already include details of the above contents, there is no need to provide account generation details	Original/ Notarized copy	Not required for credit extension guaranteed 100% of credit value by deposit at BANK, valuable papers (except for stocks) issued by the BANK (multiplied with asset value coefficient guaranteed)
4.	Report the credit situation at domestic and foreign credit institutions (at least content on credit limits, credit types, outstanding debt, and security measures).	Original/ Notarized copy	
5.	Production and business plan, financial plan for the plan year	Original/ Notarized copy	

8.2.2.4. Documents supporting the planned use of the investment financing

Enterprises applying for investment financing for an EE project can expect that the below documents may be requested by the financial institution to document the the planned use of the investment financing.

No.	Document name	Document form	Note
III,	PROFILE OF PLANNED CAPITAL USE		

1.	Production and business plan; Loan plan/project; Document approving the loan plan/project from the competent authority: Document approving the policy/project investment permit from the competent authority of the Parent Company and/or the competent authority of the enterprise (depending on the type of enterprise); Investment policy approval document/Investment registration certificate issued by the competent authority in accordance with the provisions of law.	Original/ Notarized copy	Original/Original/Copy of CCCT Authority to approve loan plans/projects is specified in the Enterprise Charter and decentralization and authorization documents. Particularly for enterprises with State capital participation or Enterprises in which the State holds more than 50% of charter capital or total number of voting shares, approval authority must be considered in accordance with relevant legal regulations which relate to manage and use State capital invested in production and business at enterprises and exercise the rights and responsibilities of the representative of the state owner.
2.	Report on production and business situation, financial capacity, debt status from credit institutions, other organizations and individuals and income to repay debt	Original/ Notarized copy	Not required for credit extension guaranteed 100% of credit value by deposit at BANK, valuable papers (except for stocks) issued by the BANK (multiplied with asset value coefficient guaranteed)
3.	Civil, commercial output and input contracts (on goods, import-export, services)	Original/ Notarized copy	
4.	Pre-feasibility research report	Original/ Notarized copy	If available. Contents of this document Must ensure compliance with regulations specified in Article 9 of Decree No. 15/2021/ND-CP dated March 3, 2021 of the Government detailing a number of contents on construction investment project management. The company can refer to the guidance under DEPP3 project to develop the pre-FS
5.	Feasibility research report or investment report if the project only needs an investment report; Projects and investment plans...	Original/ Notarized copy	Contents of this document Must ensure compliance with regulations specified in Article 9 of Decree No. 15/2021/ND-CP dated March 3, 2021 of the Government detailing a number of contents on construction investment project management. The company can refer to the guidance under DEPP3 project to develop the FS
6.	Project approval decision of the competent authority	Original/ Notarized copy	
7.	Certificate of Investment Registration	Original/ Notarized copy	For cases subject to procedures for issuance of Investment Registration Certificate or cases which Investment Registration Certificate has been issued by the Government investment needs according to the provisions of Article 37 and Article 41 of the

			Investment Law 2020. (Including the adjusted Investment Registration Certificate when adjusting investment projects).

8.2.3. Dedicated EE financing facilities

When applying for financing from a dedicated EE Financing Facility (such as the Risk Sharing Facility for Vietnam Scaling Up Energy Efficiency 'VSUEE'), the enterprises shall submit a loan application to a Financial Institution participating in the dedicated EE Financing Facility with the standard information required by the Financial Institution, as well as the specific information required by the dedicated EE Financing Facility.

The specific information required by the dedicated EE Financing Facility will typically include:

- General description of the project scope and the enterprise
- Objective and justification for the project
- Summary of the technical assessment of the project
- Baseline energy consumption data and projected project energy savings
- Environmental and social impact assessment, and status of required government approvals
- Project investment cost and financing plan
- Financial and economic analysis of the project
- Supported by copies of:
    - Project Feasibility Study
    - Baseline energy audit report
    - Government environmental approvals (if available)
    - Government approvals for project implementation (if available)

For further guidance, please refer to the Separate Guidelines for Energy Audits, Pre-Feasibility Studies and Feasibility Studies for Energy Efficiency projects in industry which have been developed in parallel with the present guidance and can be accessed on the VNEEP-webpage or by contacting the DEPPIII DE3 project office in Vietnam through nthngoc.depp@gmail.com.

8.2.4. Review of loan applications by financial institutions

The Financial Institution will review the loan application based on the submitted information and may request clarifications from the enterprise.

8.2.4.1. General investment financing

If the application is for investment financing in general, the review of the loan application will focus on the credit review policies of the specific Financial Institution. Potential applicants are encouraged to consult their respective financing institutions for specific loan program details and requirements, early in the project development process, e.g. when it is known that external financing may be required for the project implementation.

8.2.4.2. Dedicated EE financing facilities

If the application is for financing from a dedicated EE Financing Facility, the review of the loan application by the financial institution will include both the credit review policies of the Financial Institution and a technical and economic appraisal of the EE project based on the eligibility criteria and specific requirements for the dedicated EE Financing Facility.

The first step is to confirm compliance with the general eligibility requirements under the dedicated EE Financing Facility. This includes eligibility of the applicant (the enterprise) and the proposed EE investment project in relation to the specific financing facility.

Eligibility of the applicant may include requirements for the applicant such as e.g.:

- Being registered and operating in accordance with relevant Vietnam regulations and laws;
- Providing satisfactory collateral for the loan as determined by the financial institution
- Having a satisfactory business plan and purpose for the proposed loan
- Having demonstrated financial ability to service the loan during its life
- Being current on all its existing debt obligations
- Not having committed any Sanctionable Practices (corruption, fraude, collusion, etc.)
- Not having no cross-ownership with the financial institution providing the financing.

Eligibility of the proposed EE investment project will typically be based on a list of the types of investments eligible under the financing facility, e.g., "project eligible for financing are investments into renovation and rehabilitation (adjustment, replacement) of existing physical components and systems to achieve energy efficiencies".

There may also be specific reference to a positive list of types of projects, e.g., the latest Multilateral Development Banks' Common Principles for Climate Mitigation Finance Tracking[18]:

- The entity applying shall demonstrate a substantial reduction in relative GHG emissions, carbon intensity (e.g., tCO_2e/unit of output), or energy intensity (e.g.,gigajoules/unit of output).
- Relative GHG emissions are reduced through energy savings, decreased carbon intensity, decreased use of virgin materials, or decreased waste generation.
- Potentially eligible activities include installation of more efficient equipment, changes in processes resulting in energy savings, resource-use efficiency measures, and implementation of energy-efficiency plans.

This technical and economic appraisal of the EE project will be based on the Feasibility Study and Energy Audit submitted and will typically include thorough consideration of the following aspects:

1. Project technical rationale and benefits
2. Project implementation plan
3. Project investment cost

[18] The Common Principles for Climate Mitigation Finance Tracking developed by the Joint Climate Finance Tracking Group of multilateral development banks (MDBs) consist of a set of definitions and guidelines and a list of eligible activities that allow for consistent accounting and reporting of financial flows for climate change mitigation finance. For a definition of eligible energy efficiency activities in industry, see page 25 of the December 2023 report: https://www.eib.org/attachments/documents/mdb_idfc_mitigation_common_principles_en.pdf

4. Baseline energy consumption and expected energy savings
5. Financial and economic viability of project
6. Environmental and social aspects of the project
7. Measurement and verification plan

The individual aspects of the technical and economic appraisal by the financial institution are further examplified below.

Appraisal aspects	Typical content of the appraisal
1. Project technical rationale and benefits	Assessment of the proposed technical renovation or rehabilitation, including: - evaluation and comparison of system design alternatives, key technology and process options and equipment choices; - reliability, efficiency and compatibility of the new system design, technology, process, equipment and products with existing systems; and - expected changes to technical specifications and indicators (of technology, process, equipment, system, product, production capacity) before and after the project.
2. Project implementation plan	Asessment of the schedule for project implementation and the parties who are expected to be involved in project implementation. Analysis of constraints and challenges to implementation and recommended mitigation measures.
3. Project investment cost	Analysis of various equipment, civil works and consultancy costs associated with project, and basis for the cost estimates. Evaluation of total investment cost, including interest during construction and contingency costs.
4. Baseline energy consumption and expected energy savings	Analysis of the energy use by the enterprise (or by the relevant unit, plant or area of the enterprise where the project is to be implemented) before and after the project: - The baseline energy consumption data should include data on all forms of energy consumed over an annual period, preferably for the last two years. - In addition to the quantities of energy consumed, the average expenditure during the period on each form of energy should be numerated. - Details should be provided on the expected energy consumption following project implementation and the assumptions used.
5. Financial and economic viability of project	Confirmation of economic and financial eligibility based on the criteria applicable for the specific EE financing facility. These criteria could include parameters such as: - Demonstrating a certain level of minimum energy saving (e.g. twenty percent of the energy consumption before the project)

	- Having a project payback period project within a certain maximum (e.g. a period of ten years) - Having an economic internal rate of return above a minimum threshold (e.g. at least ten percent)
6. Environmental and social aspects of the project	Review of the environment and social documents provided by the enterprise to determine compliance with all national Vietnamese environmental and social laws and regulations as well as the specific environmental and social safeguard requirements applicable to the EE Financing Facility. This may include a requirement for the enterprise to have obtained all required environmental approvals from appropriate local, provincial or state environmental authorities and having made copies of all necessary approval documents available to the financial institution.
7. Measurement and verification	Assessment of the measurement and verification plan to ensure consistency with the generally accepted M&V approach expected for the specific EE financing facility.

8.3. Annex – Examples of energy efficiency projects in industry

The following sections provide a non-exhaustive list of examples of energy efficiency (EE) projects in industry enterprises (IE) based on Annex 6. Technical Evaluation Framework for Energy Efficiency Sub-Projects of the Operations Manual for the Risk Sharing Facility for Vietnam Scaling Up Energy Efficiency (VSUEE) Project[19].

Energy efficiency and energy saving in each sector are different but potential energy saving measures include:

(a) Energy consumption systems: boiler upgrades and fuel conversion, use of cogeneration devices and electrically controlled electrical systems, including air compression systems, electric cooling system, machinery, and electric lighting;
(b) Processing technology: upgrading and replacing equipment, machinery;
(c) Waste heat and waste utilization: waste heat utilization (gases, liquids and hot/warm solids) and combustion of flammable wastes (gases, liquids, solids).
(d) Using renewable energy sources to reduce fuel and/or electricity consumption in businesses can also be considered such as installing rooftop solar systems at factories of enterprises. Investments may include (a) Cogeneration units or furnaces and (b) solar water heater for hot/warm water preparation, rooftop solar systems on factories, Lighting system using solar energy.

Figure 8-1 illustrates the energy flows and investment in typical industrial emterprise.

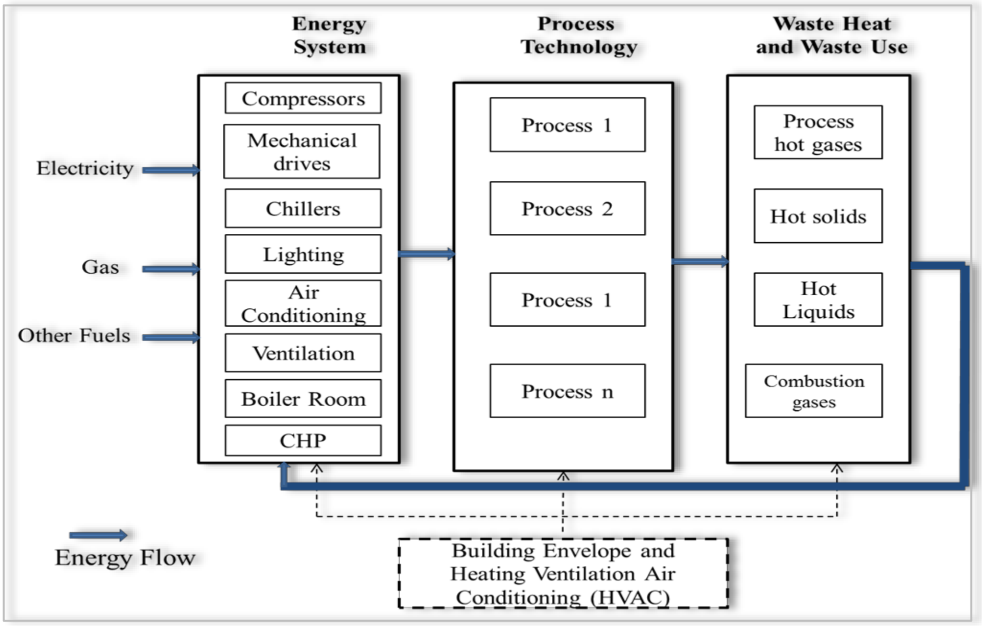

Figure 8-1: Potential EE Measures

Types of EE Investments in IEs as seen in the about figure includes three major categories: (i) energy systems; (ii) process technology; and (iii) waste heat and waste use.

- *Investments in energy systems* related to boiler upgrading and fuel switching, use of co- generation facilities, electric driven systems including compressed air systems, electric chillers, machinery and lighting; heat piping (steam, water) and associated equipment;
- *Investments in process technology* related to upgrading and replacement of equipment, machinery and facilities; and/or

[19] The Operations Manual for the Risk Sharing Facility for Vietnam Scaling Up Energy Efficiency (VSUEE) Project is accessible here: http://vneec.gov.vn/Document/Detail/118

- *Investments in waste heat and waste use* related to the utilization of waste heat (of hot/warm gases, liquids and solids) and burning of combustible waste (gases, liquids, solids) when harmful pollution can be effectively controlled.

	BOILER ROOM with associated pipe system (steam, water,	**Please**
A.1	Switching fuels from those that are expensive to ones that are less costly (including	
A.2	Replacing or adjusting fuel burners	
A.3	Improving the control & instrument system (C&I), particularly flue-gas, oxygen-	
A.4	Thermal insulation of boiler shells, distribution piping, fittings and connecting parts,	
A.5	Replacing poorly or non-functioning steam headers	
A.6	Replacing or repairing regulating and stop valves (eg. in case of leaks)	
A.7	Redesigning and removing needless pipes in the distribution system (to simplify	
A.8	Salvaging boiler flue gases heat	
A.9	Installing condensate return system	
A.10	Automatic blow down (fully automatic, timer based, etc.)	
A.11	Salvaging waste heat from boiler blowdown	
A.12	Feed water and return condensate pre-heating before entering the boiler	
A.13	Chemical treatment of feed water and condensate before entering the	
A.14	Distributed boilers instead of one centralized boiler (within distributed production	
A.15	Installing heat (hot water) accumulators to run boilers at nominal capacity as long as	
A.16	Installing steam accumulators where there is a substantial change in steam demand in short time periods (to equalize steam boiler operations regardless of	
A.17	Replacing oversized (compared to actual demand) or warn out, outdated and non-	
A.18	Replacing oversized steam piping where there is significantly reduced steam demand	
A.19	Replacing existing with new condensing boilers (reducing heat losses with flue gases due to lower flue gas temperature at the stack), particularly when	
	ELECTRIC ENERGY SYSTEMS – COMPRESSED AIR SYSTEM	
A.20	Reducing forced pressure to the minimum required	
A.21	Larger pre-cooling on inlet air	
A.22	Replacing inlet and outlet air filters	
A.23	Reducing air leaks in compressed air distribution systems	
A.24	Salvaging air heat and using it for space heating or pre-drying process,	
A.25	Separating the part of compressed air piping not in use	
A.26	Cleaning inlet air to meet required (design) cleanness and installing high	
A.27	Installing separate compressors in parts of the system with very different compressed	
A.28	Using blowers instead of compressors for providing low pressure air	
A.29	Completely replacing warn out, outdated air compressed systems, particularly air	
	COMBINED HEAT AND POWER PRODUCTION (CHP) - COGENERATION	**Please Select**
A.30	Co-generation of heat and power based on different technologies firing	
A.31	Co-generation of heat and power based on synthetic gases like biogas (digesters),	

A.32	Tri-generation when heat and cooling demand exists (eg. the beverage industry: heating demand for pasteurization, cooling/chilling of water for CO2 better absorption; electric chillers replaced with absorption	

Table 8:1: Typical Energy Efficiency Investments in Energy Systems

	DRYING FACILITIES	**Please**
B.1	Improving controls and instruments	
B.2	Improving thermal insulation of shell	
B.3	Installing synchronous burners	
B.4	Fuel switching	
B.5	Salvaging waste heat	
B.6	Refurbishing and upgrading facilities	
B.7	Improving fuel supply installations	
B.8	Installing equipment for moisture separation	
B.9	Improving air (flue gases) recirculation	
B.10	Replacing inefficient, warn out drying facilities	
	ELECTRICITY-SAVING MEASURES	
B.11	Switching to night tariffs for some parts of production facilities	
B.12	Correcting the power factor	
B.13	Reorganizing the production process to avoid peak capacity overflow	
B.14	Upgrading/replacing electricity metering devices	
B.15	Replacing electric drives with new variable speed drives (frequency regulation) or installing variable speed drives at existing rotation equipment	
B.16	Replacing inefficient electric drives with modern energy-efficient electric	
	MAIN PROCESS TECHNOLOGY	
B.17	Improving controls and instruments (C & I)	
B.18	Replacing inefficient equipment of the process technology	
B.19	Salvaging waste heat (gains from the process) to use for space heating, process	
B.20	Switching fuels (energy) (eg. coal replaced by gas in brick factories)	
B.21	Replacing main process technology	
	BUILDINGS - Improved Ventilation, Air Conditioning (HVAC), and Lighting	
B.32	Zone temperature regulations	
B.33	Waste heat recuperation systems	
B.34	Installing roof fans	
B.35	Using natural ventilation when possible	
B.36	Ventilating during the night	
B.37	Installing demand side systems in HVACs	
B.38	Applying absorption cooling methods	
B.39	Using renewable energy sources	
B.40	Installing automatic lighting system (timer operated or other)	
B.41	Installing natural light sensors for on/off switches	
B.42	Removing unnecessary lights	
B.43	Replacing incandescent bulbs with more efficient ones (flu pipes, high pressure	
B.44	Moving sensors for on/off switches (empty room, no moving, and vice	

Table 8:2: Energy Efficiency Investments in Process Technology

	WASTE HEAT AND WASTE USE	Please
C.1	Burning combustible waste (gases, liquids, solids) without harmful pollutants or where pollution can be effectively controlled (boilers, furnaces, stoves – in boilers and co-generation facilities and/or furnaces	
C.2	Salvaging waste heat using regular heat exchangers when waste gases or liquids are not abrasive or corrosive (pre-heating of condensate, feed water, combustion air, use in HVAC systems or main	
C.3	Salvaging waste heat of abrasive or corrosive fluids (gases, liquids) using ceramic or other special heat exchangers and using heat as set out	
C.4	Using latent steam heat to change pressure (in condensate return	
C.5	Collecting, separating, cleaning (if needed) condensate from steam systems and returning it to boilers or a co-generating energy system (reducing condensate losses)	

Table 8:3: Energy Efficiency Investments in Waste Heat and Waste Use

D1	To be specified by borrower	

Table 8:4: Other Energy Efficiency Investments

Case study

Loan Application for* Biomass *Boiler Investment at Hung Phat Company

Hung Phat Company operates a factory in the Thai Hoa Industrial Zone, Duc Hoa District, Long An Province. The company produces various types of paper bags for both domestic and export markets.

Currently, the factory uses an anthracite-fired boiler without any energy-efficient equipment (such as feedwater economizers, air dryers, oxygen controllers, or inverters), operating at an efficiency of about 40%. To improve efficiency and reduce costs, an energy service provider has proposed replacing the existing boiler with a new, high-efficiency biomass boiler equipped with modern energy-saving systems. Key details of the proposed investment include:

- Capacity: 5 tons of steam per hour; Fuel: Biomass
- Investment cost: VND 4,000,000,000 including the boiler, energy-efficient equipment, installation, commissioning, and design
- Environmental impact: Reduced CO_2 and CO emissions compared to the current boiler

Due to limited capital during the peak production season, the company plans to finance up to 70% of the total investment through a commercial bank loan at an annual interest rate of 12%, with equal principal repayments over 4 years. The project lifetime is estimated at 10 years. Other key financial parameters include:

- Corporate income tax: 25%
- Cost of equity: 16%
- Salvage value at project end: VND 200 million
- Monthly salary: Skilled worker – VND 10 million; Unskilled worker – VND 6 million

Requirement: Prepare the loan documents for Hung Phat Company

I. LEGAL DOCUMENTS

1. Certificate of Business Registration – Hung Phat Co., Ltd. (established 2012, Long An).
2. Certificate of Tax Code Registration.
3. Company Charter.
4. List of Capital Contribution Members: 2 members (Mr. Tran Van Nam – 70%, Ms. Le Thi Hoa – 30%).
5. Minutes of Election of Chairman of Members' Council – Mr. Tran Van Nam.
6. Appointment Decision of Chief Accountant – Ms. Le Thi Hoa.
7. Resolution of Members' Council on Loan Authorization.

8. Authorization Document for Legal Representative (loan signing).
9. Notification of Signature Specimen.
10. ID/Passport of Legal Representative.

II. FINANCIAL DOCUMENTS

1. Financial management decentralization regulations (if any).
2. Audited / Tax financial statements for the last 3 years + most recent quarter:
3. Balance Sheet (Bảng cân đối kế toán).

    - Income Statement (Báo cáo kết quả kinh doanh).
    - Notes to Financial Statements (Thuyết minh BCTC).
    - Cash Flow Statement (Báo cáo lưu chuyển tiền tệ).
    - Detailed list of receivables, payables, inventory, loans, and financial leases (if not detailed in FS).

4. Credit status report at banks/credit institutions (báo cáo tình hình tín dụng).
5. Business plan & financial plan for current year (Kế hoạch kinh doanh & tài chính năm nay).

Details are given below:

Past Financial Performance (2019–2023) (figures illustrative, VND billion)

Year	Revenue	Net Profit	Total Assets	Equity	Liabilities	Debt Ratio
2019	120	10	80	40	40	50%
2020	135	11	88	44	44	50%
2021	150	12	95	48	47	49%
2022	160	13	100	52	48	48%
2023	175	15	110	57	53	48%

Credit Status Report

- Current loans: VND 5 billion (short-term working capital with BIDV Long An).
- No overdue debts, good repayment record.
- Existing collateral: factory building and machinery (~VND 20 billion value).

Financial Plan for Current Year (2024)

- Expected revenue: VND 190 billion.
- Expected net profit: VND 16.5 billion.
- Planned investments: biomass boiler (VND 4 billion).

III. DOCUMENTS SUPPORTING PLANNED USE OF INVESTMENT FINANCING

1. Production & Business Plan + Loan Plan/Project Proposal with approval from competent authority.
2. Report on current production/business situation, financial capacity, and debt repayment ability.
3. Relevant commercial contracts (input/output, service, import-export).
4. Pre-feasibility study report (if available).
5. Feasibility Study Report (FS) or Investment Report
6. Project approval decision (if required by competent authority).
7. Investment Registration Certificate (if applicable).

Details are given below

Production and Business Plan & Loan Plan

Hung Phat Company continues to expand in the paper bag export market, targeting eco-friendly packaging. To reduce production cost and carbon footprint, the company plans to replace its inefficient anthracite boiler with a modern biomass boiler.

- **Loan requested:** VND 2.8 billion (70% of total cost).
- **Equity contribution:** VND 1.2 billion (30%).
- **Loan terms proposed:** 4 years, equal principal repayment, 12% interest.
- **Use of loan:** Equipment purchase, installation, commissioning, energy-efficient systems.

Report on Current Production & Business Situation

- Factory capacity: 120 million paper bags/year.
- Export share: 40% of sales (Japan, Korea, EU).
- Current issues: high energy cost (18% of total production cost), low boiler efficiency (~40%).
- Expected improvements: energy savings of VND 1.4 – 1.7 billion/year, CO_2 reduction.

Relevant Commercial Contracts

- Export contract with Japanese supermarket chain (annual order ~VND 30 billion).
- Domestic supply contracts with major Vietnamese retailers (Big C, Coopmart).

Pre-feasibility Study

- **Option considered:** retrofit vs. replace boiler.
- **Decision:** replacement with biomass boiler due to higher long-term efficiency.

Feasibility Study Report (FS)

a. Technical Feasibility

- Boiler capacity: 5 tons steam/hour.
- Fuel: biomass (rice husk, wood chips).
- Equipment: economizer, air dryer, oxygen controller, inverters.
- Efficiency: 75–80% vs. current 40%.
- Lifetime: 10 years.
- Environmental: reduce CO_2, SO_2, dust emissions.

b. Financial Feasibility

- **Investment cost:** VND 4.0 billion.
- **Annual savings:** VND 1.4–1.7 billion (fuel + O&M + labor).
- **Payback period:** 3.5 years.
- **NPV (12%):** VND 2.5–3.0 billion.
- **IRR:** 23–25%.
- **B/C ratio:** 1.6–1.8.
- **DSCR:** 1.3–1.6 → acceptable.

c. Environmental & Social Feasibility

- CO_2 reduction: ~2,500 tons/year.
- Compliance with Vietnamese environmental laws and World Bank standards.
- Improves working environment (lower dust, better air quality).

Project Approval Decision

Resolution by Members' Council (Jan 2024): approval of biomass boiler project investment.

Section 9: Summing up the essence of Project development

9.1. The Project Development Journey: A Strategic Roadmap to Investment

The development of an energy efficiency (EE) project is not a series of disconnected technical tasks but a single, integrated journey. This journey can be best understood as a strategic "roadmap" that guides the energy professional from an initial, broad-based energy mapping to a final, bankable investment decision. The core purpose of this structured process is to systematically transform uncertainty into confidence, thereby creating a compelling investment proposal that is attractive to both internal management and external financiers.

This entire training program, from the deep dive into energy mapping on Day 1 to the focus on feasibility studies and financing on Day 5, is designed to navigate this roadmap effectively. The process can be visualized as a **funnel of certainty**, where each successive stage narrows the focus while increasing the level of detail and confidence in the final outcome.

- **Top of the Funnel (Wide): Energy Mapping and Auditing.** At the beginning of the journey, the net is cast wide to identify all potential opportunities for energy savings. This is the phase of discovery, where Energy Mapping provides a holistic, quantitative overview of where energy is consumed, and the Energy Audit diagnoses why it is being used inefficiently. At this stage, uncertainty about the final project is high, but the cost of this initial investigation is relatively low. The goal is to generate a comprehensive list of potential EE projects.

- **Middle of the Funnel (Narrowing): Pre-Feasibility Study.** This stage acts as the critical filter. It takes the long list of opportunities generated by the audit and subjects them to a structured comparison. By evaluating alternative technical and operational options based on high-level financial and non-energy benefits, the Pre-Feasibility Study (Pre-FS) systematically eliminates projects that are not technically viable, financially attractive, or strategically aligned with the enterprise's goals. This filtering process ensures that valuable resources are not wasted on detailed studies of suboptimal solutions.

- **Bottom of the Funnel (Narrow): Feasibility Study.** Once a preferred solution has been selected through the Pre-FS, the Feasibility Study (FS) provides an intense, detailed examination of that single option. This stage transforms the chosen concept into a complete project blueprint, complete with detailed technical specifications, firm cost estimates from suppliers, a robust financial analysis, and a concrete implementation plan. Uncertainty is now low, but the resource commitment for this comprehensive study is significantly higher.

- **Spout of the Funnel (Output): Loan Application & Final Investment Decision (FID).** The final, validated project emerges from the funnel. It is now a de-risked, investment-grade proposal, supported by a comprehensive Feasibility Study that contains all the necessary documentation for a successful Loan Application and a confident Final Investment Decision by management.

This structured roadmap is, at its core, a sophisticated risk management strategy. Each stage is deliberately designed to mitigate specific types of risk before significant capital is committed. The initial Energy Mapping and Audit phase mitigates the risk of *missing high-impact opportunities* by adopting a holistic, system-wide perspective rather than focusing on isolated pieces of equipment.

The Pre-Feasibility Study explicitly mitigates
option risk (the danger of pursuing a suboptimal solution) by forcing a disciplined comparison of alternatives. Subsequently, the Feasibility Study mitigates

implementation risk by demanding detailed engineering, financial validation, and a clear execution plan, thereby minimizing the chance of project failure after the investment has been made. The entire journey is therefore not just about identifying energy savings; it is about methodically building an increasingly compelling and low-risk case for investment.

9.2. The Foundational Mindset: Applying the 'Onion' Philosophy

Underpinning the entire project development roadmap is a foundational philosophy known as the "Onion Diagram" approach. This is not merely a tool to be used during an energy audit; it is a fundamental, "inside-out" way of thinking that must be applied at every stage of analysis, from initial mapping to final design. This philosophy prioritizes challenging the core need for an energy service before attempting to optimize the systems that supply it. By focusing first on the innermost layers of energy use, the most profound and cost-effective savings can be unlocked.

The Onion Diagram methodology involves three distinct layers of analysis, which must be addressed in a specific order :

1. **Challenging the Energy Service (The Core):** This is the first and most crucial step. Before analyzing any equipment, the energy professional must question the fundamental demand for energy. The key questions are: "Is this heating, cooling, or pumping service truly necessary at its current level?" "Can the Standard Operating Procedure (SOP) be modified to reduce energy demand?" "Can a target temperature be adjusted without affecting product quality?" As illustrated by the example of challenging the milk reception temperature in a dairy, this step focuses on the process demand itself, which can sometimes yield significant savings with little to no investment.
2. **Optimizing the Process (The Middle Layer):** Only after the fundamental energy service has been validated and minimized should the focus shift to making the process itself more efficient. This layer involves applying advanced analytical techniques to the core production equipment. Methodologies such as "Level-2-mapping" are used to ensure the quality (e.g., temperature) of the energy supply is appropriately matched to the process demand, avoiding the use of high-grade energy for low-grade tasks. This is also the stage where opportunities for heat recovery are identified and Best Available Technology (BAT) is assessed for core process units.
3. **Improving the Utility (The Outer Layer):** The final step is to improve the efficiency of the utility systems that provide the energy, such as boilers, chillers, and compressed air systems. By addressing this layer last, the energy professional ensures that any new or upgraded utility equipment is sized correctly for a genuinely optimized energy demand, rather than an inflated, inefficient one. This prevents the common mistake of investing in oversized and underutilized utility systems.

This inside-out philosophy fundamentally alters the economic equation of a project. A traditional, outside-in approach might identify an inefficient boiler and immediately propose a high-efficiency replacement, with the capital cost (CAPEX) based on the current, unoptimized steam demand. The Onion approach, however, first examines the processes using that steam. By implementing heat recovery or process control improvements in the middle layer, it might reduce the total steam demand by a significant margin.

Consequently, when the analysis reaches the outer layer (the boiler), a smaller, and therefore less expensive, piece of equipment is required. The savings realized from the reduced CAPEX of the new boiler can then be used to help finance the heat recovery investment, creating a powerful synergistic effect that improves the project's overall Net Present Value (NPV) and Internal Rate of Return (IRR). This causal link—where process optimization directly reduces the investment cost of utility systems—

is a critical principle that makes complex, integrated projects more financially attractive and achievable.

9.3. From Data to Diagnosis: The Symbiotic Role of Mapping and Audits

The first active steps in the project development journey involve the distinct but inseparable functions of Energy Mapping and Energy Auditing. These two stages work in a symbiotic relationship to transform raw data into a clear diagnosis of energy inefficiency and a prioritized list of actionable projects.

1. **Energy Mapping (Section 4)** provides the holistic, quantitative "compass" for the entire investigation. It is defined as the "establishment and visual analysis of the energy flows in a system" and serves as the "first and the most important step in the energy auditing process". Through the creation of process flow diagrams and the calculation of mass and energy balances, the mapping exercise answers the fundamental questions: *What* is consuming energy, and *where* are the major consumption centers, known as "Significant Energy Users"? The map provides the data-driven foundation that directs the auditor's attention to the areas of greatest impact.

2. **The Energy Audit (Section 3)** provides the "diagnostic toolkit." Following the direction set by the energy map, the audit is a "systematic study" that investigates *why* energy is being used inefficiently in those significant areas and *how* it can be saved. This is where advanced analytical methods are deployed. Sankey diagrams are used to visualize energy losses within a specific process, BAT assessments benchmark existing equipment against the best available alternatives, and Key Performance Indicators (KPIs) are established to measure and track performance improvements.

3. A critical output of this diagnostic phase is the identification and, where possible, quantification of **Non-Energy Benefits (NEBs)**. An audit that reports only on energy and cost savings is fundamentally incomplete. In many industrial contexts, NEBs—such as increased production capacity, improved product quality, reduced maintenance costs, enhanced workplace safety, or compliance with corporate sustainability goals—are the true drivers of an investment decision. These benefits must be systematically identified and included in the project proposal to present a full and compelling business case to management.

The relationship between mapping and auditing is not a simple linear progression but an iterative loop. A high-level Energy Map initially guides the Audit's focus. However, the detailed findings of the Audit may reveal a critical data gap. For example, the initial map might identify a drying process as a Significant Energy User. The subsequent audit, using a Sankey diagram, could then pinpoint a massive energy loss in the hot exhaust air. To properly design an effective heat recovery system, the auditors would then need more detailed data on the temperature, humidity, and flow rate of this exhaust stream over a full production cycle. This new requirement would trigger a second, more focused "deep dive" mapping exercise, perhaps involving the installation of temporary instrumentation on that specific system. This demonstrates the symbiotic relationship: mapping provides the direction for the audit, and the audit refines the focus for subsequent, more detailed mapping, ensuring that analytical resources are always directed to the areas with the highest potential impact.

9.4. Building the Business Case: The Critical Function of Feasibility Studies

Once a set of technically viable energy efficiency opportunities has been identified through the mapping and audit phases, the next crucial step is to transform them into a robust, investment-grade business case. This is the primary function of the Pre-Feasibility Study (Pre-FS) and the Feasibility Study (FS), which represent the two essential stages of project validation and planning.

1. The **Pre-Feasibility Study (Section 6)** acts as the strategic **filter**. Its core purpose is to "elaborate on alternative technical and operational options" and serve as a "decision filter" before significant resources are committed to detailed engineering. The Pre-FS takes the most promising opportunities from the audit and compares them against each other. It involves a high-level technical assessment, an estimation of capital and operating expenditures (CAPEX/OPEX) with an accuracy of approximately +/- 25%, and a preliminary financial analysis. The final output is a concise report that compares the viable alternatives and provides a clear recommendation on which single option, if any, should proceed to the next stage.

2. The **Feasibility Study (Section 7)**, in contrast, is the detailed **blueprint**. It is a "full and comprehensive study" that serves as the direct "prerequisite for making investment and financing decisions". The FS focuses exclusively on the single, preferred solution selected during the Pre-FS. It develops this solution into a complete project plan, including a "basic design," detailed technical specifications, firm costings often based on supplier quotations, a full financial analysis with key indicators (NPV, IRR, Payback Time), a thorough risk assessment with mitigation strategies, and a concrete implementation plan.

The distinction between these two stages is critical: the Pre-FS is about *comparison and selection*, while the FS is about *validation and detailed planning*. A common and costly mistake in project development is to skip the Pre-FS for complex projects, which can lead to investing significant time and money in a detailed FS for what may ultimately be a suboptimal solution.

These feasibility stages facilitate a structured and essential dialogue with the enterprise's management. The Pre-FS effectively asks management: "Of these potential paths to improve our energy efficiency, which one aligns best with our current strategic goals, capital availability, and risk appetite?" For instance, an audit might propose three solutions: (A) low-cost operational changes, (B) a medium-cost heat recovery system, or (C) a high-cost full process replacement using BAT. The Pre-FS would analyze all three. Management's review of this study allows them to make a strategic choice. If capital is constrained, they might choose option A. If long-term growth and increased production capacity are priorities, they may greenlight a full FS for option C.

The Feasibility Study then answers the follow-up question: "Here is the detailed, evidence-based plan proving that your chosen path is technically sound, financially profitable, and operationally manageable." It provides the definitive evidence needed for the Final Investment Decision. This demonstrates that the feasibility stages are not merely technical exercises for engineers; they are crucial management tools for ensuring strategic alignment and making informed, data-driven investment decisions.

9.5. From Blueprint to Reality: Securing Financing for Implementation

The final, critical link in the project development roadmap is the transition from a validated blueprint to an implemented reality. This requires securing the necessary capital, which is the focus of the Loan Application stage (Section 8). A comprehensive and professionally prepared Feasibility Study is the direct and indispensable input for a successful loan application. The list of documents typically required by a financial institution—including a "Feasibility research report," detailed "Financial documents," and an "Environmental and Social Management Plan (ESMP)"—directly mirrors the outputs generated during a thorough FS.

To understand the importance of this connection, it is useful to adopt the perspective of a financial institution. Banks and other lenders do not finance vague ideas or concepts; they finance well-defined, de-risked projects. The Feasibility Study provides the concrete evidence they require to assess the key criteria for lending:

- **Technical Viability:** Is the proposed technology proven, reliable, and well-designed for the specific application? The technical specifications and basic design within the FS answer this question.
- **Financial Viability:** Are the energy savings projections realistic and well-documented? Is the project's IRR greater than the company's cost of capital? Is the payback period acceptable? The detailed financial analysis in the FS provides this proof.
- **Implementation Capability:** Are there a credible plan, timeline, and team in place to execute the project successfully? The implementation plan in the FS addresses this concern.
- **Risk Management:** Have potential technical, financial, and operational risks been identified, and are there credible mitigation strategies in place? The risk assessment log in the FS demonstrates due diligence.

The quality of the Feasibility Study does not just influence the simple approval or rejection of a loan; it can directly impact the financial terms of the loan, such as the interest rate and tenor. A lender's primary concern is managing the risk of default, and the interest rate they charge is a direct reflection of the perceived risk of a given project.

A Feasibility Study that is filled with broad assumptions, poor data, and a weak risk analysis will be viewed as a high-risk proposition. The lender may consequently reject the loan application or offer financing at a high interest rate to compensate for the uncertainty. Conversely, a Feasibility Study that presents firm supplier quotes for CAPEX, a detailed implementation schedule, a robust sensitivity analysis on key variables like energy prices, and a clear quantification of valuable NEBs presents a low-risk, high-value investment. The lender has greater confidence in the project's success and the borrower's ability to repay the loan. This confidence can translate directly into more favorable financing conditions, such as a lower interest rate. A lower cost of capital, in turn, increases the project's NPV and further improves its overall financial performance. Therefore, the diligence and rigor applied by the energy professional during the Feasibility Study phase have a direct and tangible impact on the project's cost of capital and its ultimate profitability.

9.6. The Energy Professional's Toolkit: A Synthesis of the Development Lifecycle

The journey from an initial idea to an implemented energy efficiency project is a systematic process of building knowledge, reducing risk, and creating value. Each stage in the development lifecycle serves a specific purpose, asks critical questions, and produces a distinct output that forms the foundation for the next phase. This structured approach elevates the role of the energy professional from that of a technical auditor to a strategic project developer and a trusted business advisor.

To consolidate the core learnings of this training program, the entire project development lifecycle is summarized in the table below. This tool is designed to serve as a quick-reference framework for real-world application, providing a clear guide to the "why," "what," and "how" of each critical stage.

Stage	Core Question Answered	Key Methods & Tools	Critical Output	Strategic Mindset
Section 2: The Roadmap	What is our guiding philosophy and overall plan?	The "Road Map" concept, **Onion Diagram** (Inside-Out Thinking).	A clear, structured project development methodology.	**Strategic & Holistic:** Think systems, not just components. Prioritize demand reduction over supply efficiency.

Section 4: Energy Mapping	Where does our energy go, and what are the biggest consumers?	Process flow diagrams, mass & energy balances, data collection (meters, estimates), KPI establishment.	A quantitative **Energy Map** identifying Significant Energy Users (SEUs) and major loss points.	**Investigative:** Be a detective. Follow the energy flows from source to service to uncover the full picture.
Section 3: Energy Audit	Why is energy being wasted, and what are the specific opportunities for savings?	**Onion Diagram**, Sankey diagrams, Level-2 mapping, BAT assessments, analysis of Non-Energy Benefits (NEBs).	A detailed **Energy Audit Report** with a prioritized list of technical project opportunities and their potential benefits.	**Diagnostic:** Be a doctor. Use advanced tools to diagnose the root causes of inefficiency, not just the symptoms.
Section 6: Pre-Feasibility Study (Pre-FS)	Of all the identified opportunities, which are the most viable and strategically aligned options to pursue?	High-level technical assessment, CAPEX/OPEX estimation (±25%), preliminary financial analysis (PBT), comparison of alternatives.	A concise **Pre-FS Report** comparing 1-3 solutions and recommending a preferred option for detailed study.	**Comparative & Filtering:** Be a strategist. Evaluate options against business goals and filter out weaker candidates early and cheaply.
Section 7: Feasibility Study (FS)	Is our chosen project technically sound, financially profitable, and ready for investment?	Basic design & engineering, detailed CAPEX/OPEX (from quotes), full financial analysis (NPV, IRR), risk assessment & mitigation plan, implementation schedule.	A comprehensive, investment-grade **Feasibility Study Report** that serves as the blueprint for the Final Investment Decision (FID).	**Validating & Detailing:** Be an engineer and an analyst. Build a bulletproof case with verifiable data and a concrete plan.
Section 8: Loan Application	How do we secure the necessary capital to implement our validated project?	Compilation of legal, financial, and project documents (primarily the FS Report), formal application to financial institutions.	A complete and professional **Loan Application Package** submitted to potential lenders.	**Persuasive & Diligent:** Be a project advocate. Package the evidence from the FS to persuade financiers of the project's low risk and high value.

Table 9:1: The Project Development Lifecycle: Key Stages, Questions, and Outputs

Section 10: References

As part of the Vietnam-Denmark Energy Partnership Program 2020-2025 a **Center of Excellence for Energy Efficiency** (CoE) has been established.

The CoE serves as a hub for information provision, capacity-building activities, technical support, and stakeholder connections to realize energy efficiency solutions and projects for industrial enterprises. Ans thus a lot of relevant and additional material that can be used for training and inspiration can be found on the hub.

The material has been developed as part of the Vietnam Denmark Partnership and contains among other the project development guidelines on which the training is based. Also, a number of other guidelines are available, like guidelines on energy efficiency in specific industrial sectors, or guidelines on energy efficiency processes. Also, you can find anonymous energy audits based on real energy audits conducted at at different Vietnamese enterprises. The energy audits are prepared by Vietnamese energy auditors in close cooperation with Viegand Maagoe A/S implementing the method presented in this training.

You will find the material and other information at the **Center of Excellence for Energy Efficiency**:
The Center of Excellence (CoE) for Energy Efficiency