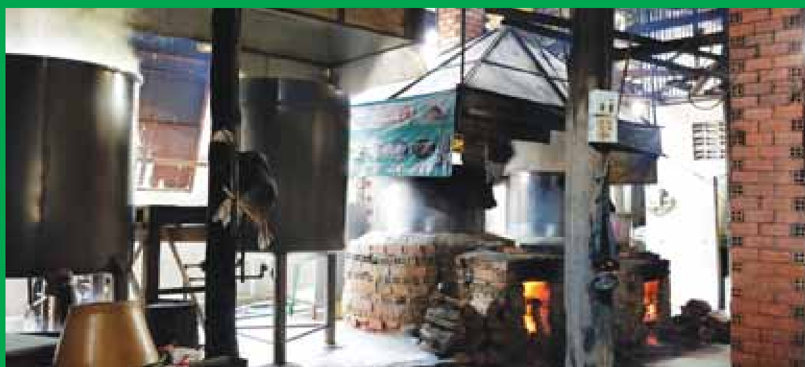
CAMBODIA CLIMATE CHANGE ALLIANCE

Implemented by: Ministry of Environment

Supported by: European Union, UNDP, SWEDEN

The Project: Demonstration of
RECP, EMS, and GHG Mitigation and
Adaptation In Industrial and Handicraft Sectors

TRAINING MANUAL FOR THE IMPLEMENTATION OF THE RESOURCE EFFICIENT AND CLEANER PRODUCTION



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List of abbreviations

BAT	Best Available Techniques
BEP	Best Environmental Practices
CCAP	Climate Change Action Plan
CCCA	Cambodia Climate Change Alliance
CCCSP	Cambodia Climate Change Strategic Plan
CCSP	Climate Change Strategic Plan
EMS	Environmental Management System
EnMS	Energy Management System
GSSD	General Secretariat of National Council for Sustainable Development
IA	Initial assessment
KPI	Key performance indicator
OPI	Operational performance indicator
TEST	Transfer of Environmentally Sound Technology
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization

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1. Introduction

General context

The Cambodia Climate Change Alliance (CCCA) is an initiative led by the Ministry of Environment and supported by the European Union, Sweden and UNDP. The overall objective of CCCA is to strengthen national systems and capacities to support the implementation and coordination of Cambodia's climate change response, contributing to a greener, low carbon, climate-resilient, equitable, sustainable and knowledge-based society and the specific objective is to contribute to the implementation of the Cambodia Climate Change Strategic Plan 2014-2023. The General Secretariat of National Council for Sustainable Development (GSSD) funded by CCCA Program has launched a new grant facility, offering support to the line ministries with approved Climate Change Action Plans (CCAP) to implement priority activities. A full project proposal submitted by the Ministry of Industry and Handicraft to GSSD for the implementation of CCAP has been endorsed as LOA No.21. The full project focuses on development of GHG's inventory in the industrial and Small Medium Enterprises and handicraft sectors, selection priority areas to demonstrate pilot project, local capacity building and identifying project sustainability as main outputs.

The project implementation will be based on a critical review of the country context, policies, strategies and instruments, as well as institutions and stakeholders' capacities, and lessons learned on implementation of past and current plans and projects/programs of the ministry of Industry and Handicraft, existing documentation and assessments of the Cambodia environment situation and climate change vulnerability and impacts.

Resource Efficient and Cleaner Production (RECP) methodology is the heart of the intervention and will be implemented in selected demo-factory.

The business case for sustainable production

Industries face a series of challenges and barriers to becoming more resource and energy efficient, non-polluting, and safe. They need to find new methods for producing products that are responsibly managed throughout their life cycle, while increasing productivity, accessing international markets with good quality products, and complying with environmental standards. The greening of industries has become a core determinant of economic competitiveness and sustainable growth.

Manufacturing industries that apply RECP could reap the following benefits:

- Increased productivity, reduced operation models, optimized investments
- minimized environmental compliance costs, reduced business risks and smaller environmental/carbon footprint;
- Compliance with international environmental standards for accessing new markets (global supply chains and export markets, new green markets, public procurement, etc.);

- secured long-term supply of production inputs: the adoption of a resource-efficiency strategy can mitigate the effects of disruptions and price volatility in the raw materials supply chain; and
- improved relationship with stakeholders (investors, banks, regulatory bodies, local communities, consumer associations, etc.).

To be effectively implemented in a company, sustainable production strategies require that the people who influence resource efficiency are committed and empowered. These people are at different levels both inside and outside an enterprise (such as customers, suppliers and authorities, as well as internal stakeholders like owners, managers and workers). Identifying and achieving the desired changes at particular levels of the management pyramid is an on-going process driven by the learning cycle. The particular steps of the learning cycle, also known as a Deming scheme are:

Plan	enterprise values, policies and strategies are used to establish objectives and targets and for planning activities to deliver results
Do	the plans are implemented
Check	the results of practical implementation are monitored and evaluated against targets and correctives action is taken
Act	the achievements are assessed, reflection on and integration of the practical experience gained is used to make leading changes to policies, strategies, concepts, or even values and guiding ideas.

The desired learning process that will lead to continuous improvement only takes place if all phases by steps of the learning cycle are completed. This process is operated again and again in learning organizations.

Figure 1: The management pyramid and the learning cycle

2. Objective of the training

The training is aimed to provide practitioners, service providers knowledge to implement the sustainable production and resource efficiency in the manufacturing industry. The training has the following specific objective:

- Introduce the concept and benefits of sustainable production concept and resource efficiency;
- Introduce and build capacity on RECP methodology;
- Challenge and solution for data collection;
- Typical RECP solutions

3. The basics and of the Resource Efficient and Cleaner Production

What is Resource Efficient and Cleaner Production?

United Nations Industrial Development Organization (UNIDO) and United Nations Environment Program (UNEP) jointly defined Resource Efficient and Cleaner Production (RECP) as the integrated and continued application of preventive environmental practices and total productivity techniques to processes, products and services, to increase efficiency and reduce risks to humans and environment. RECP is implemented by mean of types of solution, a systematic approach for their identification and evaluation, addressing existing inefficiencies and monitoring of enterprise level indicator.

RECP aims to contribute to: (1) **Resource efficiency** - through optimization of the productive use of natural resources (e.g. materials, energy, water) at all production stages; (2) **Waste Minimization** - minimization of the adverse impact of production systems on environment and nature through reduction of wastes and emissions; (3) **People's well-being** - minimization of risks to people and communities and enable their development.

RECP methodology

RECP methodology is based on:

- Understanding the issues in the company (source) by analyzing the way how resources are used, consumption data and related cost.
- Performing a systematic **root source and cause analysis** of inefficiencies (cause) by applying standard "cause categories" to explore their potential impact on process efficiency and waste generation
- Identification, evaluation and implementation of RECP options by applying "standard practices" to all waste and emissions causes and process inefficiencies.

Typical RECP options "solutions"

RECP practices provide solution categories that can be applied individually or in combination to generate options and implement RECP in enterprises. The types of options and solutions is presented in Table below.

Table 1 : Type of RECP options and typical solutions

No.	Type of options	Typical solutions
1	**Good housekeeping** - changes in operational procedures and workplace management to reduce unnecessary 'wastage''.	- Switch off what is not in use - Repair what needs reparation - Keep workplace organized and clean - Minimize and manage inventory - Keep staff motivated
2	**Input materials change** - use of alternative input materials results in lower or less problematic waste and less harmful materials are used.	- Use renewable energy - Use sustainably-sourced renewable materials - Use of secondary materials, water and energy - Use less harmful substances - Supply from local sources
3	**Better process control** - improve control over processes and equipment as to operate these continuously at highest efficiency and lowest wastage.	- Standard operating practices and process monitoring - Sub-metering water, energy and materials - Automated or otherwise improved controls, including shut off etc. - Preventive maintenance
4	**Equipment modification** - equipment modification or new technology to avoid wastage and improve efficiency.	- Insulation (pipes, equipment, walls, windows) - Proper alignment of production line - Improve process temperature, pressure, speed, mixing - Rationalize utilities and distribution systems - Combine process steps as applies
5	**Technology change** - replacement of (process) technology with more efficient and/or less wasteful technology.	- Efficient boilers, motors, fans, compressors etc. - Change of process, e.g. chemical to mechanical, multi- stage Change of process chemistry, e.g. to catalytic or solvent free - Equipment with integrated recovery loops - Advanced separation processes - Solar process cooling/heating
6	**On site reuse** – useful application of waste	- Countercurrent or cascaded use of water and energy

	(material, energy, water) within the same company for similar or alternative purpose.	- Condensate and heat recovery - Reuse of incoming packaging for outgoing products - Reuse of product waste and/or cleaning solvent in next batch of some product
7	**Production of useful by products** – convert a previously wasted materials into a substitute input material for another company.	- Provision of used cooling water for external heating or cooling purposes (buildings, fish farms etc.) - Segregate recyclables for external recycling and resource recovery - Industrial symbiosis, e.g. use of inorganics in cement making, slags in construction, etc.
8	**Production modification** - redesign product in order to reduce its environmental impact during production, use and/or disposal	- Design for optimal product lifetime - Design for minimum use of water, energy, cleaning etc. - Design for low-waste manufacturing - Design for refurbishment, recycling etc.

RECP baseline and indicators

A set of indicators are proposed to measure and monitor the companies' performances in decreasing resource use and environmental pollution, communicating success and sustaining the RECP achievements.

The RECP Indicator system comprise of:

Absolute indicators	**Relative indicators**
Resource indicators	Resource efficiency = total production / unit of resource consumption
- tons material use/year	- … total tons of material used
- m^3 fresh water /year	- … total kWh energy = energy productivity
- kWh energy/year	- …total m^3 fresh water = water productivity
Pollution indicators	Pollution intensity = total tons of waste and emissions /per unit of product
- tons of solid waste	- … total tons of waste
- m^3 wastewater	- … total CO_2 emissions
- tons of CO_2 equivalent emissions	- … total m^3 of wastewater

4. RECP methodology step by step

The RECP methodology requires multi-disciplinary teamwork and cannot be accomplished on the strengths of a single person, as might be possible with some other approaches that focus on specific sectors and/or tools. Therefore, this approach promotes opportunities for partnerships between service providers and experts in areas of sustainable production. An overview of the step-by-step method of the RECP is provided in table below.

Table 2: Overview of the RECP step-by-step

	Step	**Purpose**	**Output**
PLAN	1. Initial assessment	Initial assessment: go/no-go for decision to start TEST	Scope of work and TEST contract signed between service provider and company
	2. Policy statement	Formalize top management commitment to sustainable production and resource efficiency	Policy statement approved and communicated to internal company stakeholders
	3. Formation of RECP Team	Plan, organize and train internal company team	TEST team establish workplan developed, training and communication plan in place
	4. Identifying total cost of pollution and priority flows	Starting the diagnosis: Identify the total cost of pollution (non-product output costs) and the priority flows at company system boundary	Material/energy balance quantified at company system boundary. Priority material/energy flows selected. Baselines, objectives and targets set at company level.
	5. Setting up focal areas	Continuing the diagnosis: identify priority areas at the level of company units (cost centers) with the highest potential for improvement	NPO costs allocated to company units (cost centers). Focus areas with the highest material/energy losses and pollution generation identified. Improvement potentials estimated. Baselines, objectives and targets set up for focus area.
	6. Revealing sources and causes of inefficient material and energy use	Concluding the diagnosis: identify sources and reveal root causes of inefficiency and pollution in priority areas.	Material/energy balances in focus areas quantified. Sources and causes of inefficiencies and pollution identified. Baseline data and key performance indicators set at level of specific pollution sources
	7. Option generation	Opening the scope of possible improvement solutions	Long list of potential preventive options
	8. Feasibility analysis	Identifying a set of optimized measures	Set of technically and economically feasible measures (savings catalogue).
	9. Action Plan	Plan for implementing selected measures	Resources and top management commitment secured for implementing action plan.

	10. Information system	Plan for monitoring system to measure performance including efficiency of material and energy flows	Monitoring plan in place. Information system on priority flows and related costs established. KPIs and OPIs of improvement measure(s) defined.
DO	11. Implementation of the action plan	Implement improvement measures and increase performance in resource use.	Organizational measures, process improvements, cleaner technology, optimized end-of-pipe solutions. Supporting documentation of management systems and information system procedures
CHECK	12. Monitoring and evaluation	Measuring performance of important material and energy flows	Performance versus objectives and targets recorded. Implemented measures evaluated with respect to expected savings and performance. Improvements, corrective actions, new sources and causes of losses identified
ACT	13. Act and sustain	Reflection on experience gained and integration of TEST into business strategies and operations	Management review. Strategic reflection on how to sustain TEST, including further adoption of other sustainable production tools

3.1. Plan

3.1.1. Initial assessment

A preliminary screening is needed before starting up an RECP project in a company to determine if the introduction of resource efficiency and integrated environmental management techniques will pay back and if the company is ready to engage. The findings of the initial assessment provide a basis for deciding whether to start RECP in a specific company and highlight the potential for improvement, which can be used to leverage top management commitment to adopting an environmental policy.

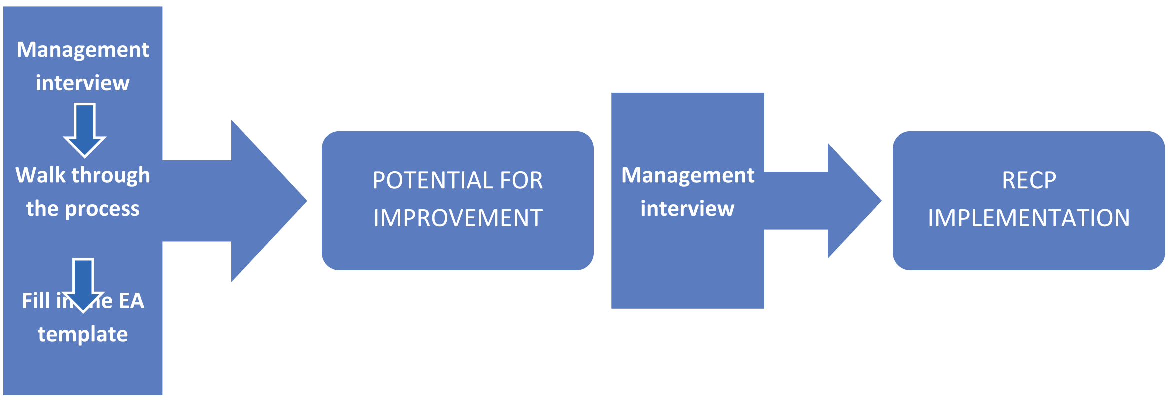


Figure 2: Workflow of initial assessment

Action

Inputs	Core activities	Outputs
Publicly available company information Company data on products, production processes, technologies, major inputs, legal compliance and pollution problems, existing management and information systems Information on existing national incentive programs for environment and energy in industry Fact sheets and case studies on resource efficiency from the company sector Benchmarking data (if available)	Management interview	Preliminary understanding of enterprise business strategy
	Walk through the production facility	Key areas of process inefficiency and immediate improvement areas for investigation Identification of major environmental problems and pollution cost (energy, waste, wastewater, and penalties/fees) Potential for starting RECP
	Fill in the IA template	
	Meeting with top management	Top management commitment Go/no-go decision for starting RECP

3.1.2. Policy statement

The strong commitment of top management is needed to initiate changes to a company's goals and guiding ideas, which will influence and determine the whole enterprise's performance.

Action

Inputs	Core activities	Outputs
Initial assessment report Legal requirements Stakeholders' expectations (stakeholder analysis if feasible at this stage) Company vision and values	Hold meeting with top management to define smart objectives, list commitments, and discuss stakeholder views	Commitment of top management
	Draft policy statement and get it signed by top management	Policy statement
	Communication policy internally (and eventually externally too)	Commitment of enterprise staff

3.1.3. Formation of RECP team

The RECP team should be formed and led by a motivated leader who can inform decision-making and should include qualified staff, comprising a mixture of knowledge and perspectives on the different business functional units. Ideally the team should be small and action driven with 3 to 5 members who could be supported by additional staff for specific activities.

The competency of the team is summary below

Core competence areas ▪ Top management representative (e.g. technical director) ▪ Knowledge of technology and materials (e.g. chief engineer) ▪ Accounting and financial expertise (e.g. chief accountant) ▪ Management systems (e.g. managers of EMS, QMS, H&S, etc.) **Supporting areas** ▪ Production planning ▪ Information systems specialist ▪ Maintenance ▪ Research and development, product design

Action

Inputs	Core activities	Outputs
Enterprise staff from different departments and knowledge areas RECP consultants & training kit	Set up RECP team, assign responsibilities, and appoint a leader	RECP team formalized
	Plan and deliver training to RECP team members on RECP approach	RECP team trained
	Plan RECP implementation in company	Workplan
	Awareness raising meetings with all company staff	Company staff ready to support RECP Team

3.1.4. Identifying of total cost of pollution and priority flows

What are the inputs/outputs associated with the highest economic losses at the company level?

This step is the starting point of the company diagnosis and the scope of the analysis is the company system boundary. The total inputs and outputs from the previous business year are collected in both volume and monetary value to complete the balance. Input losses and related costs are also estimated. The inputs are broken down into raw, auxiliary and packaging materials intended to become product and that partially end up as waste and emissions, and operating materials and energy, which by definition do not become products and thus end up in NPO. The first input-output assessment generally does not balance out to zero, but the goal is to investigate improvement options for the information system so there is better data available for the coming accounting periods. At a company level, data can be processed and information sources recorded on a regular basis (e.g. using bookkeeping/accounting references). Data should be processed and evaluated on a yearly basis in line with the existing accounting system.

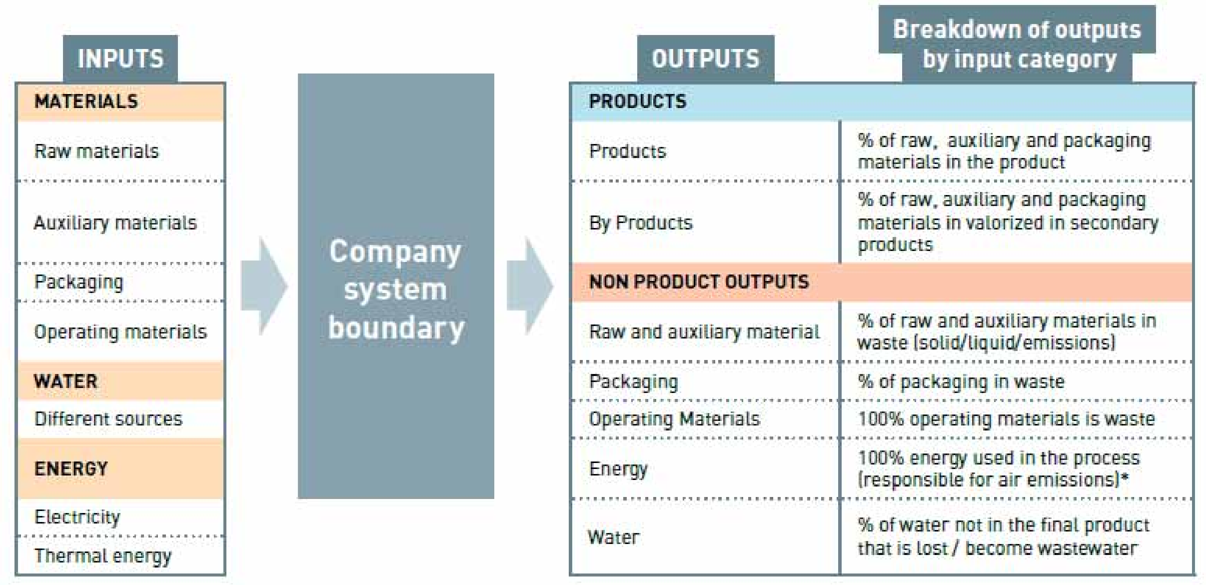


Figure 3: Input-output balance

Identifying important flows within a simplified input/output balance

In companies with very basic accounting systems and no stock management in place, it may be difficult to collect any data on inputs and outputs both in volume and in monetary value. In such cases, only the most important information for priority setting should be collected and estimates of input losses and related costs (NPOs) used, and focusing on important material and energy flows, such as:

- Expensive raw materials (reducing their loss will provide significant savings)
- Dangerous materials (toxic materials flow subject to H&S regulations or strict emission limit values)
- Bulky materials (significant in volume with specific requirements for logistics and storage)

It is best to start with the categorization shown in the Fig. 3 and identify between 10 and 20 most important inputs.

Action

Inputs	Core activities	Outputs
Policy statement IA report Data on inputs and outputs from the previous fiscal year (annual volumes and costs) Estimates of production losses (percentages) Sector benchmarks for priority flows (energy, water, major raw materials)	Fill in EMA-MFCA tool: ▪ in workshop with accounting and production departments ▪ focus on the data available and record ideas to improve the information system	Total economic losses (non-product output costs) Breakdown of NPOs by different material and energy groups at company system boundary
	Calculate total non-product output costs Identify priority flows	Inconsistencies in the company information systems and recommendations revealed for better data monitoring Priority flows (associated with major economic losses and other problems)

Significant environmental aspects of EMS (if in place)	Select KPI and establish baseline for priority flows at company level Set up objectives and targets for priority flows at company level	Saving potential for priority flows = "zero waste" savings potential KPI baseline at company level, objectives & targets for priority flows

3.1.5. Setting up focus areas

Which manufacturing processes and areas have the greatest potential for improvement?

Costs can be assigned to specific production steps or departments on the basis of the process flowchart. The scope of cost allocation is driven by the input categories identified in 3.1.4 and the structure of the process flow. Information collected at this level serves to improve the company's information system for the next business year. If there is a lack of data, allocation can be done for just the priority flows identified in step 3.1.4.

This step will highlight the areas in the company (specific departments, production units, cost centers) that generate the most significant share of non-product output costs. Operational Performance Indicators (OPIs) should be defined for these areas (e.g. energy use per unit of production at the drying stage). Benchmarking with international BAT standards or expert opinions can confirm whether a specific area with high ratio of NPOs also has significant potential for improvement and should be selected as a focus area. The latter will be further investigated in step 3.1.6 and can either be associated with the highest share of NPO costs and potential savings or be linked with significant environmental and health risks (e.g. use of toxic substances).

Action

Inputs	Core activities	Outputs
EMA-MFCA excel tool filled in for the company system boundaries from previous business year Priority flows from step 3.1.4 List of cost centers Company process flow chart Material, water, and energy balance at company level	Assign total annual material and energy volumes and costs to cost centers/ production steps for each input category (Can be based on estimates in the first try and done for the priority flows only) Use the process flow chart to define production steps as operating cost centers (if cost centers are not already defined). Supportive cost centers can be established for utilities (e. g. water treatment, steam generation, compressed air, maintenance, environmental management) Assign total annual NPOs costs (and volumes, if available) to identified cost centers/production steps and complete EMA-MFCA tool worksheet 2	Economic losses due to NPOs assigned to main production steps (cost centers) Breakdown of NPOs at different cost centers in value and volume (to the degree available) Identification of company areas with highest economic losses Inconsistencies in company information systems and recommendations revealed for better data monitoring

Objectives and KPIs defined at the company level Sector expertise International benchmarks for individual production processes in the specific industry sector (if available and applicable)	Set up OPIs for cost centers/ processes with highest NPO costs Benchmark performance of specific processes/cost centers (if international sector data are available) Walk through process for expert estimation of improvement potential of prospective focus areas	Focus areas Saving potential for focus area OPIs related to focus area for the information system
	Select focus areas	
	Calculate baselines for OPIs of selected focus areas/processes Set up objectives and targets for improvement at focus area/process level	Baseline for OPIs Objective & target for focus area

3.1.6. Revealing sources and causes of inefficient material and energy use

Where are loses and pollution generated, and what causes them?

The priority material and energy flows in the identified focus areas are now assessed in more detail so the source can be understood – physical points where a production input becomes a loss (non-product output) and the causes of these losses can be identified. Causes are analyzed in relation to the factors driving material and energy losses that can be linked to process inputs and their quality, specific process operating parameters (e.g. temperature, throughput, speed, etc.), technology features, human behavior and product design.

This is the last level of the process diagnosis as described in the box below. Performing detailed analysis only on the priority flows in the priority areas is cost-effective, as it may not be feasible to implement detailed analysis of all flows and all areas of an enterprise in the RECP cycle.

Detailed material and energy-mass balances at the selected focus area level should be completed to provide a model of how the specific process works. They help clarify and quantify the energy flows, mass flows including water, auxiliaries, operating and packaging materials, and consequently to identify factors driving their consumption and thus influencing resource efficiency.

Action

Inputs	Core activities	Outputs
Flowcharts and technology schemes of the priority areas identified in 3.1.5 EMA-MFCA excel tool data at the level of unit operations/cost centers Data from existing information systems like cost accounting, stock management, production planning and monitoring, etc. Data from physical monitoring systems of process parameters External sources of information (supplier's technical sheets, machine design nominal parameters, receipts, disposal company records etc.)	Develop material and energy balances per unit of operation for the focus areas	Quantification of material and energy flows at the level of priority areas/unit operations Suggestions for information system improvements for significant flows
	Conduct ad hoc measurements [if needed) to collect additional data for specific process/unit/machinery	
	Complete material and energy balances for relevant focus areas Data collected on energy flows can be processed with Energy Mapping excel tool	
	Interpret results and identify sources and related causes of material and energy use inefficiencies	List of priority sources of material and energy use inefficiencies and their causes (input for option generation in 3.1.7)

3.1.7. Generating options

How can the causes of material and energy inefficiencies responsible for economic losses and pollution generation be addressed?

The company diagnosis completed in 3.1.6 resulted in the inventory of priority material and energy inefficiencies/pollution sources and related causes of inefficiencies. Understanding these allows options for improvement to be generated effectively.

Broadening the scope of potential solutions for identifying an optimized set of measures can be performed with the aid of several preventive techniques that address technology, method of operation, input specifications, and product design. These should be explored according to the hierarchy shown in the Fig. 4, starting with prevention and minimization of losses (NPOs) at the source. Techniques for external recycling and valorization of by-products can be useful, though these do not reduce NPOs and can therefore be investigated at a later stage after the economically most feasible preventative solutions have been explored. Pollution treatment options (also called end-of-pipe solutions) occupy the last level of the hierarchy, as they represent additional costs and should therefore only be explored at the end, if still needed. Following this hierarchy, investments and operational costs for end-of-pipe and pollution loads can be substantially reduced, if not eliminated.

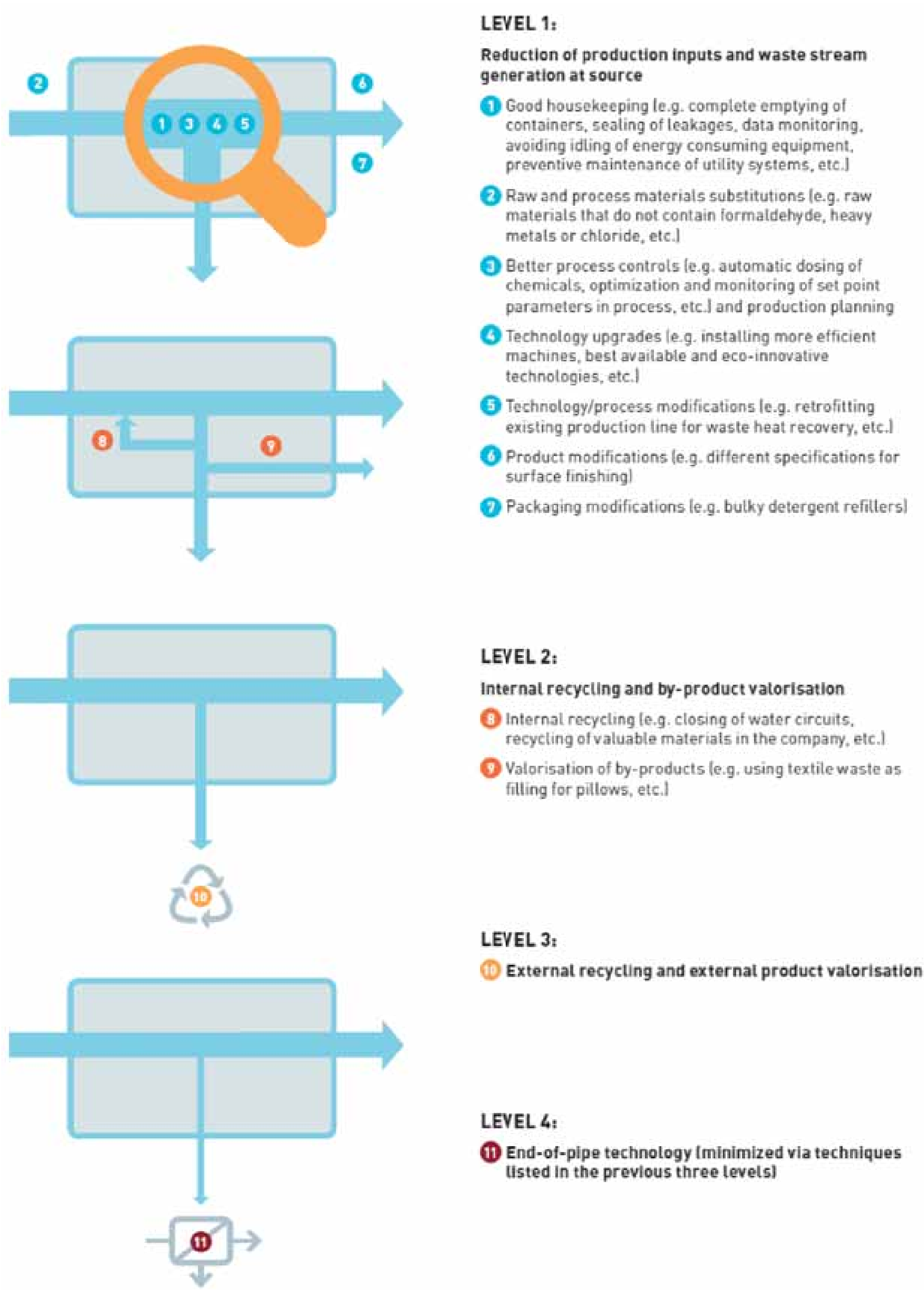


Figure 4: Hierarchy of technique for addressing causes of pollution

Action

Inputs	Core activities	Outputs
Pollution sources and related causes of pollution and findings from diagnosis List of preliminary ideas identified in previous steps (including information system improvement ideas) TEST team expertise External expertise including sector experts or sector-specific guides	Generate and record improvement options using preventive techniques: - Options should not be evaluated at this stage, but the scope of potential solutions should be as open as possible - Only clearly unfeasible options should be dismissed Collect preliminary ideas for options to improve the consistency of information system on flows	Long list of improvement options for feasibility analysis in 3.1.8 to follow

3.1.8. Feasibility analysis

Which criteria can be used to analyze the feasibility of improvement measures?

The feasibility of the options generated in 3.1.7 are now assessed using technical, environmental and economic criteria in order to define the set of optimal measures that could be implemented by the company as part of the RECP action plan.

Technical and environmental criteria can first be used to exclude options that might have an adverse impact on product quality or cause cross-media environmental side effects that could potentially offset the expected benefits. The possible impact of measures on productivity and the environmental benefits associated with the specific option should be assessed.

The cost-benefit analysis will reveal economic savings, preliminary estimates of capital and operating costs, as well as return on investment from technically viable solutions. From an economic criteria perspective, feasible solutions can be then classified into three main categories:

a) Good housekeeping measures, requiring no or low cost
b) Low-medium cost measures that can be implemented using a company's technical and economic resources
c) High investment needing solutions which necessitate a more complex technical and financial appraisal, and might require external financing

The aim of the feasibility analysis is to evaluate the preventive options for reducing material and energy flow losses at the source, starting by challenging core process needs as per the hierarchy of preventive strategies. The implementation of specific measures will change the process parameters and base lines for assessing the feasibility of other measures, as illustrated in the story below.

The outcome of the feasibility analysis is the "savings catalogue” for the top management decision-making process, which provides the technical description of and the key economic and environmental savings for a set of improvement measures.

Action

Inputs	Core activities	Outputs
Material flow and energy flow data for specific process target Technology and process operation parameters (baseline)	Evaluate each option using technical, environmental and economic criteria	Saving catalogue (set of project fiches of feasible measures)
Technology suppliers’ information and technical requirement including after-sale services RECP team and RECP consultants expert judgement	Classify measures based on economic criteria ad shortlist a set of priority solutions with highest saving potential and other benefits.	Term of reference for detailed technical and financial appraisal of high investment needing measures

3.1.9. Action plan

Which measures should be implemented given the company’s resources?

Following the presentation of the resource efficiency savings catalogue to top management, there is usually an internal discussion inside a company to review the findings of the RECP team and possible external experts and verify internal human and financial resources for developing a RECP action plan. A shortlist of feasible priority measures will then be approved for implementation. In some cases, companies reserve specific measures for further technical-financial investigation before taking a final decision on implementation. Companies should be encouraged to keep a record of feasible measures that have been rejected by top management, as they could be relevant for implementation at a later stage.

At the end of the internal review and consultation process, the company will formalize the RECP action plan, which allocates responsibilities and defines a timeline and budget for the approved measures. Access to external financing and incentive schemes may be required for high investment needing measures and should be investigated at this stage.

Action

Inputs	Core activities	Outputs
Saving catalogue (feasible measures) Financial resources Human resources Information on existing incentives schemes for resource efficiency and environmental investment	Set up action plan with timeline, budget, responsibility for implementing the set of selected measures Identify sources and modalities for accessing financing for high investment needing solutions	Management commitment to implement set of measures TEST action plan

3.1.10. Information system

How should performance monitoring of important material and energy flows be planned?

An effective monitoring system should provide information on resource efficiency through a set of indicators linked to important flows and productivity bottlenecks. These indicators are continuously developed as part of RECP and their baselines are determined in 3.1.4, 3.1.5, 3.1.6 and 3.1.8. Step 3.1.10 involves planning the information system for subsequent implementation in step 3.2 and effective monitoring in step 3.3.

The monitoring plan should be developed in parallel with the action plan: step 3.1.9 and step 3.1.10 are closely related. The monitoring system should build on existing elements already in place in a company and incorporate all relevant indicators developed in 3.1.4 – 3.1.9 into one logical system with a threefold purpose:

- control overall enterprise performance at the level of selected priority flows utilizing KPIs (for assessing performance against enterprise goals, for internal and/or external benchmarking and for internal/external reporting);
- monitor the performance at the level of key consumers (priority areas, relevant cost centers or major sources of inefficiencies and pollution) through OPIs, for:
    - measuring, recording and reporting the performance vs. baseline of the implemented resource efficiency measures included in the TEST action plan, evaluating them against specific targets to enable corrective action;
    - understanding causes of inefficiency and implementing corrective measures;
    - planning and setting up new targets;
- Make people who influence resource efficiency and pollution generation accountable at all levels.

Action

Inputs	Core activities	Outputs
Enterprise policy and goals Management commitment to monitor performance KPIs and OPIs already defined in the previous steps RECP action plan Financial resources Human resources Information and monitoring	Identify relevant KPIs/OPIs for each measure included in the action plan Identify cost-effective way to monitor both consumption and driving factors of KPI/OPI	Information system on flows People responsible for the monitoring plan appointed and trained Monitoring plan an integral part of action plan.
	Set up monitoring and evaluation plan (responsibility, frequency, procedure, budget)	
	Integrate the monitoring plan into the overall company information system Plan relevant training seminars	

3.2. Do

3.2.1. Implementation the action plan

How should internal resources be mobilized to implement measures?

The planning phase is complete and all the measures included in the action plan will now be implemented. These are just standard business improvement measures and the company should use its existing internal systems to put them into place. Internal procedures and documentation systems can be improved by establishing good practice (e.g. by implementing a monitoring system and setting up baseline before changes to production).

The action plan implementation rate varies depending on company motivation, allocated budget and staff capacity, the most important asset for this step. An action plan might be perfect, but it will not be implemented well if the people responsible are not committed or sufficiently trained to achieve desirable results. Action plan implementation is the step where all the work done thus far is appreciated and celebrated, since this is the stage where changes and improvements first become visible.

Action

Inputs	Core activities	Outputs
RECP action plan (including monitoring plan) Human resources Financial sources	Establish required documentation and information system, including installation of sub-meters (if not in place already)	Information system on flows implemented Baselines defined
	Implement action plan (supervise progress of construction and installation; verify specification of equipment, etc.)	Resource efficiency measures implemented

External experts Existing documentation of company management and information systems	Develop training plan and train company staff (e.g. in good operation of implemented measures, data collection and processing, preventive maintenance, etc.) Establish responsibilities and possibly incentives for employees implementing action plan. Internal communication of action plan	Supporting documentation and information system procedures in place (e.g. internal procedures for good housekeeping, operational work instructions to support implementation of action plan, MFCA procedures on material and energy flows) Training plan for company staff Staff informed and trained to implement and sustain action plan

3.3. Check

3.3.1. Monitoring and evaluation

How can information on the real performance of material/energy flow and of implemented measures be used?

Having a monitoring plan and a proper material and energy flow information system in place is not always an assurance that company staff complete proper monitoring and evaluation and that information is provided as feedback for actions and follow-up. Information from the monitoring system has to be systematically analyzed in order to correlate consumption with driving force (usually volume of production or degree days (DD), for example) and to calculate performance ratios against the original baseline.

Effective monitoring and evaluation of the results of the implemented measures is essential to demonstrate to the company that the expected savings have been achieved. This encourages management to invest more resources in sustaining the action plan and identifying new measures. An information system on important flows and their resource efficiency is also important for identifying new improvement options.

Implementation of the TEST action plan will modify the company's resource efficiency performance, thus establishing a new baseline for evaluating the KPIs and OPIs against targets after improvement measures are in place.

Action

Inputs	Core activities	Outputs
Monitoring plan (step 3.1.10) Indicators and performance baselines established in steps 3.1.4, 3.1.5, 3.1.6, 3.1.8 and 3.1.9	Collect data as per monitoring performance procedures and information system	Information on actual company performance related to priority flows, focus areas or specific implemented measures

and information system on flows installed in step 3.2.1 Existing procedures for data collection, documentation and reporting Enterprise staff trained in monitoring and evaluation as part of imp le mentation of information system on flows in step 3.2.1	Process collected data and calculate KPIs and OPIs set up in the monitoring plan Compare actual performance report to company goals and targets Evaluate results Take corrective action and improve measures based on understanding of actual performance and causes of possible deviations from expected values	Monitoring and evaluation as a routine part of work Effect of implemented measures optimized and sustained Continuous improvement of enterprise performance New baseline of performance indicators

3.4. Act

3.4.1. Act and sustain

The evaluation from the previous step can be used to improve company plans. However, deeper reflection on the RECP experience can result in changes to the core values, policies and strategies that drive a business. It makes sense to address this strategic level at the end of each learning cycle, since companies otherwise run the risk of continuing old patterns and repeating established routines that might be outdated.

The ultimate goal of the RECP approach is to facilitate the integration of sustainability concerns into a firm's operations in order to transform environmental (and social) challenges into business opportunities. The major drivers of this process are stakeholder expectations, both internal and external, at the base of the management pyramid. An enterprise can increase its economic value by reflecting these expectations at all levels of the management pyramid (from enterprise values, policies and goals through operational strategies and procedures to processes and products).

Action

Inputs	Core activities	Outputs
Existing enterprise values. policies and strategies Results of performance evaluation in relation to objectives and targets Scorecard with relevant indicators Information on changing business environment including values. interests and concerns of	Top management discussion on existing business strategy Link experience and results of RECP to specific values and strategic interests of company and its stakeholders Evaluate effectiveness of existing management systems in relationship to enterprise polices and goals	Integration of RECP approach into enterprise values and strategy Continuous learning leading to continuo us improvement of enterprise performance [e.g. identification of new improvement opportunities)

stakeholders including client response	Analyze and adopt possible changes to assumptions values. policies and strategies driving the business	Decision to continue RECP focused on other important material and energy flows
	Discuss possibility of repeating RECP diagnosis [steps 3.1.4 – 3.1 6) on other important flows to generate more options, a new action plan, and new objectives and targets	Inform stakeholders and improve enterprise relationship with them

5. Practical modules

5.1 Building Business Environment Profile

The main objective is to support companies to build their own environmental profile, with a particular focus on identifying resources use and environmental impacts. This step is essential for understanding how companies are performing, what their environmental and business risks are, and where to focus in order to identify the main source of losses and inefficiency. The companies' baseline profile is established in this phase through calculation of resource efficiency and pollution intensity indicators.

Building the business environmental profile

The inputs, outputs and processes and their basic interaction with the environment make up the environmental profile of a company. In order to understand the business better, the definitions of key elements are provided further:

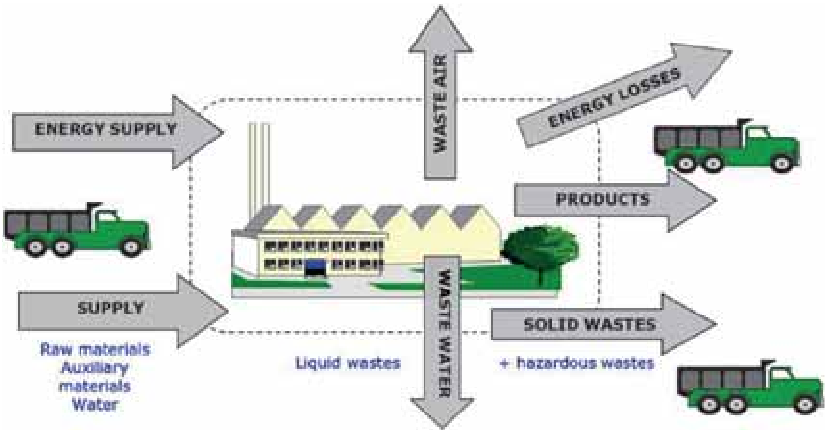


Figure 5: The main inputs and outputs of an industrial process

Inputs – are defined as everything goes into the processes: materials, water and energy used to manufacture the products

Processes – are defined as operations that are turning the inputs into products and activities needed to support production operations (e.g.: materials supply and storage, utilities provision, chemicals and waste handling, transportation)

Outputs – are defined as everything that goes out of processes, primarily products but also nonproductive outputs or waste (e.g., emissions, solid and liquid waste, waste water, lost energy, nonconforming raw materials and scrap)

Building the environmental profile requires focus on:

- Company's performance: the types, quantities and cost of materials, energy and water and the way how are they used; the types and quantities of waste, emissions and effluents, where and how are they generated; the types and quality of products;
- Management practices: management commitment and environmental policy, compliance with environmental obligations, working procedures, and practices, employees' awareness and education.
- Environmental risks derived from resource use and pollution and how the company is managing risks.

The RECP simplified assessment focus on:

Source	- Understanding the issues in the company - Data collection and evaluation
Cause	- Systematic root source and cause analysis
Option	- Identification, evaluation of RECP opportunities
Actions	- Start implementing

5.1.1 Understanding the source of issues

Understanding the source of issue require answer to a number of questions below.

What are the types, quantities and cost of resource inputs?

Companies shall identify the types, annual quantities and cost of resource inputs: raw and auxiliary materials, energy and water and their principal uses.

What are the company products?

The products and services are main outputs of company's processes and activities; the types, quantities and annual sales value are important data helping the company to understand how efficiently performs and what is their productivity.

What is the waste and emissions?

The types of waste and emissions generated during processing and other activities shall be systematically identified along with their generation sources, the annual consumption and cost. The focus should be on types and amounts of generated waste and emissions, their real cost, and practices in place to minimize them.

Where to focus?

Collecting and evaluating annual consumption data and cost of materials, energy and water, waste and emissions generation, will help the identification of:

- Particularly important mass flows in terms of quantity, economic value, toxicity, environmental impact and legal requirements.
- Particularly important waste flows in terms of quantity, cost, toxicity, environmental impact and legal requirements.

What are the risks for business and how is it managed?

The main risk for the business relates to potential difficulties of supplying quality raw materials in time and at affordable prices. Moreover, dealing with toxic materials has serious risk implications on operations, site security and employees' health and safety. In this regard the focus should be on expensive materials and toxic materials at the origin of waste and emission, and the way how they are managed.

Data collection and RECP baseline

Data collection including information on the above-mentioned categories shall be introduced in the excel file. The resource efficiency and pollution intensity indicators will be calculated using the RECP baseline profile.

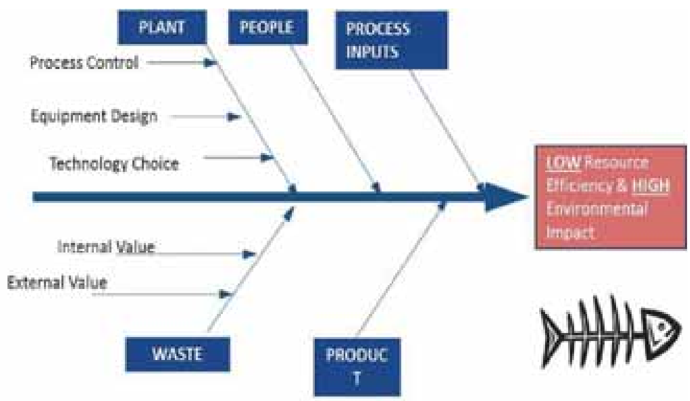
Tip! Consider:

- 3 - 5 most expensive resource inputs in your company?
- 3 - 5 most important waste streams by volume/weight?
- 3 - 5 waste streams carrying the greatest environmental risk?

5.1.2 Root cause analysis

After having identified, quantified and characterized various flows, the next step is to conduct a root cause analysis in order to find out why waste is being generated.

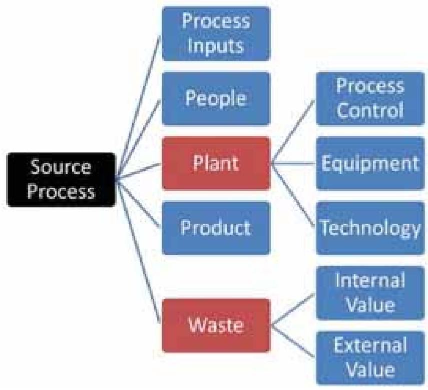
The fishbone diagram is a useful tool for conducting root source and root cause analysis in complex situations, when several factors are involved. Understanding the root cause of the problem is based on repetitive questions asking that help going beyond the surface and get to the root cause of the problem;



The following questions are asked:

What is the problem? Why the problem occurs?

Typically causes could be attribute to categories such as:



PROCESS INPUTS (choice and quality of materials,

PLANT (standard process control, operating practices selection and design of the equipment and technology)

PEOPLE (material handling, operation and maintenance procedures),
WASTE streams of internal and external value.

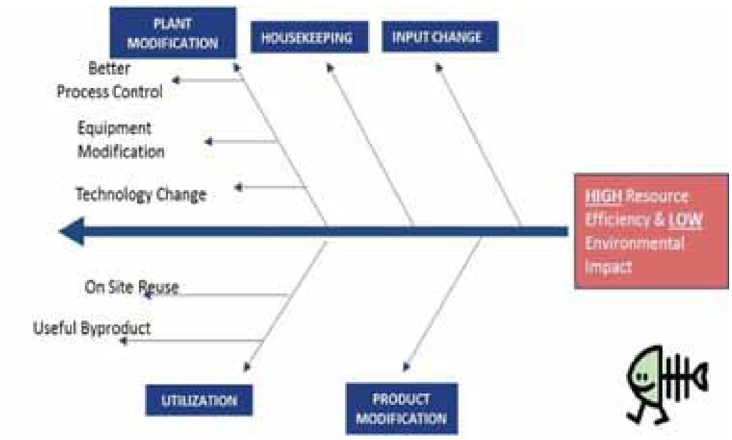
5.1.3 Generation of RECP options

Possible solutions are identified by applying the standard RECP practices to all waste and emissions causes and processes inefficiencies:

INPUT CHANGE (materials substitutions or better-quality materials)

PLANT MODIFICATION (better process control, equipment modification, technology change),

PRODUCT MODIFICATION and **INTERNAL OR EXTERNAL WASTE UTILIZATION**



The root cause analysis described above provides the starting framework for options generation, by considering the identified problems one by one and stimulating the participants to respond to the question:

HOW DO WE EFFECTIVELY SOLVE THE PROBLEM?

RECP options are generated during brainstorming sessions, a creative process that implies participation of the companies' relevant staff. During the brainstorming sessions, participants are encouraged to come up with their ideas and solutions, approach that helps creating the sense of ownership over the generated RECP options.

Screening and evaluation of RECP options

A preliminary screening of RECP options is performed to decide their priority for implementation. The exercise divides options into several categories:

- RECP Options for immediate implementation – are in general good housekeeping options or simple process optimizations and do not require further evaluation. Direct measures should be immediately implemented due to their tangible and short time benefits;
- RECP Options to be evaluated in detail – are technically and economically more complex and the decision to implement them would require performance of detailed feasibility analysis;
- RECP options postponed or rejected – usually such options are difficult to implement, have high cost or leak of available technology and shall be considered at later time.

WHAT MEASURES DO I IMPLEMENT FIRST?

The economical, technical and environmental evaluation of RECP options provides information about: the new equipment required, the changes required in the existing plant infrastructure, the cost of investment, the economic and environmental benefits such as: reduction of waste and pollutants, reductions of energy, water and materials consumption.

5.1.4 Implementation of RECP options:

Options that proves to have highest profitability are included in a detailed action plan, outlining tasks, clear responsibilities, cost and deadlines.

5.2 Energy

The main objective of this module is to guide companies to better understand the use of energy in the company, to identify the energy losses, perform a root cause analysis and generate RECP options to increase energy efficiency.

Business benefits of energy efficiency

Energy efficiency reduces the business cost and increases its profitability; experience shows that most small businesses can easily save at least 10% of their energy costs. Energy efficiency is also critical for reducing GHG emissions and their effects on climate change.

Companies reducing energy consumption benefit from direct and indirect cost savings

Energy accounts for about 5% of costs for an average manufacturing company. An energy-efficiency program can save between 10% and 30% of those energy costs within three years 3. Indirect savings from reduced maintenance, materials, waste and risk increase the benefits, combining to effectively cut direct energy costs by about half.

Energy efficiency secures businesses and reduce dependence on volatile prices

By reducing dependence on energy, the energy cost will be less reflected in the total business cost and the business will be able to better plan resources and future investments.

Energy efficiency can open new business opportunities

There is an increasing demand for industrial and consumer products that use energy efficiently. Energy efficient products are in some instance required by legislation (e.g., EU has already adopted legislation to ban the most inefficient bulbs from 2012), could offer competitive advantages and open new markets

Energy efficiency contribute to reduction of GHG and creates a culture in the company

The greatest proportion of energy used by companies comes from non-renewable resources: fuel, gas, charcoal. Those are limited and their use for generating energy produce environmental impact due to the climate change effect of greenhouse gas emissions (including carbon dioxide) released into the atmosphere.

Saving energy will impact employee's behavior, improving their motivation and enhancing innovation.

Similar approach as the above module could be used by focusing on source, cause, options and action to improve Energy Efficiency in the company.

Source	-	Where the energy used for what purpose?
Cause	-	What factors influence these energy uses?
Options	-	How to minimize these energy uses/
Actions	-	Start implementing energy efficiency option

5.2.1 Understanding the use of energy in the company

Understanding the use of energy, quantities and cost data is the first step in optimization of the overall energy consumption in the company.

What types of energy are used and for what purpose?

Types of energy in use could be: electrical energy, gas, fuel, oil, supplied by the company or even renewable energy produced at the location; the principal users shall be identified for each type of energy supplied.

What is the primary energy use, quantities and cost?

Energy could be used in production processes, utility operations and in other activities (buildings, storage, offices, etc.). There is a small chance that small companies have a physical monitoring system and are able to measure the energy consumers directly, through the existing energy counters. In the absence of such counters, the total direct energy use in production and in utility operations (steam generator, hot water system, compressor, chiller, and refrigeration) is evaluated by listing the major energy consuming processes/equipment, recording the rated energy consumption for each user/equipment, recording the annual operating hours and calculating the annual energy use in production and utility operations.

Other energy uses related to management of buildings, including process and storage areas, offices, are evaluated using the same method.

What is the indirect energy use, quantities and cost?

Indirect energy use in the utility operations is further analyzed for each utility type: production of steam, cooling water or compressed air. In order to evaluate the indirect energy use, the steam, cooling water users are listed, their operating requirements (temperature, pressure, volume), specific consumptions, annual operating hours, leading to estimation of annual consumption and of total accounted utility consumption.

What factors influence energy use?

The operating conditions, design standards, process control, operation and maintenance practices can define most of the energy consumption in a facility and therefore also influence most of the energy-saving potential. Obvious housekeeping lapses such as leaks of steam, water, condensate, compressed air or leaks from production processes could be observed during walk through the facilities.

5.2.2 Root cause analysis

After having identified, quantified and characterized various energy flows and factors influencing energy use will help understanding the causes of inefficiencies and losses. The next step is to conduct a root cause analysis by applying typical causes for inefficiency.

The case of the compressed air system is exemplified bellow:

Root Cause Category		Some examples (compressed air system)
Process inputs		• Temperature at air intake
People		• Inappropriate use e.g. for drying, cleaning. Etc.
Plant	Process control	• Operating pressure intervals
	Equipment	• Maintenance status of compressor • Design, dimensioning and layout of compressed air distribution
	Technology	• Type of compressor (compressed air supply)
Product		• Pressure at point use • Alternative power sources (compressed air uses)
Waste	Internal value	• Waste heat from compressors – replaces heating demand
	External value	• Waste heat from compressors – adds to air conditioning load

5.2.3 Generation and evaluation of energy saving options

Generation and evaluation of energy saving options is performed by applying the standard RECP practices to all causes of energy wastage and processes. In the case of compressed air system typical RECP practices that are applied to generate energy saving options and improve the system efficiency:

RECP Practices		Some examples
Input change		• Change air intake – cool and shield location
Good Housekeeping		• Avoid unnecessary use
Plant modification	Process control	• Improved controls on operating pressure
	Equipment modification	• Fix all leaks, eliminate disused parts of reticulation system, minimize pressure reduction

		• Improve maintenance on compressors
	Technology change	• Energy efficient compressor system
Product modification		• Switch to alternatives for compressed air – direct powered tools, electronic controls, etc.
reuse	On Site reuse	• Recover waste heat for building heating
	Useful by product	• Insulate to eliminate non-useful use of heat of compressor

5.2.4 Implementation of energy saving options

Preliminary evaluation of RECP options for energy conservation shall be performed and consist of:

- Evaluation of technical and organization complexity (low / medium / high)
- Estimation of energy conservation
- Estimation of investments and annual savings

Simple options shall be immediately implemented while complex options will be subject for detailed feasibility analysis. Options that proves to have highest benefits are included in a detailed action plan outlining clear responsibilities, cost and deadlines.

Typical energy efficiency options for main energy users

The section presents basic information on different energy-using systems and typical energy saving measures that could be used for identifying the focus area for RECP assessments.

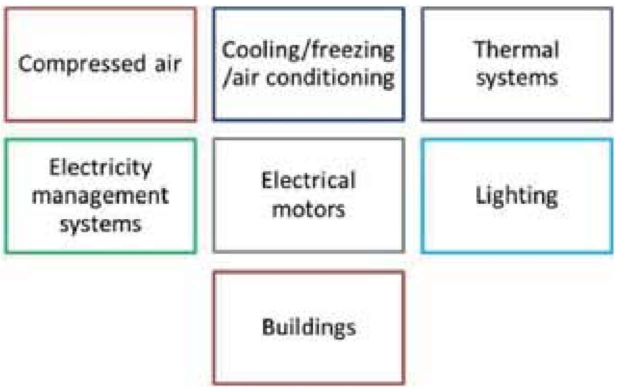


Figure 6: Typical main energy users in a factory

Typical energy saving options are listed for each system.

Compressed air: Compressed air is used in almost all types of industries and accounts for a major share of the electricity used in some plants. It is used for a variety of end-uses such as pneumatic tools and equipment, instrumentation, conveying, etc. Compressed air is probably the most expensive form of energy available in a plant, yet it is still often chosen for applications for which other energy sources would be more economical—for example, pneumatic grinders are chosen rather than electric ones.

Only 10% from energy input is converted into pressures air; 85% of energy is wasted with the cooling oil taken, 5% is lost through radiation, while significant volumes of pressures air are lost due to leaks in the system and inappropriate use. Performing a comprehensive audit of the compressed air system includes evaluations of air supply and usage, the interaction between supply and demand and the inspection of system components. During the audit, losses and poor performance due to system leaks, inappropriate use, demand events, poor system design, working pressure are evaluated and RECP measures could be established.

Typical energy savings with compressed air

- Maintaining pressure drop below 10% of compressor discharge pressure;
- Leaks detection and repair could reduce significantly the waste of energy;
- Elimination of inappropriate use
- Rationalization of compressed air by replacing with alternative systems such as blowers;
- Matching the compressor discharge pressure with the need;
- Using multiple compressors in case of demand variation; Replacing old/oversized compressors;
- Oil heat recovery through well designed systems - 50–90 per cent of the available thermal energy of the oil and could be used for heating or water.

Cooling/ freezing / air conditioning: Refrigeration is used in many industrial applications to cool the temperature or purify products, to remove heat from chemical reactions, to produce air conditioning for processes or for cooling spaces. Optimization of cooling process could be achieved by tackling three main components: optimization of demand, minimization of distribution losses and optimization of cool energy production.

Typical energy savings with cooling systems

- Well-designed system according to the demand Utilization of quality cooling machines
- Preventive maintenance and regular control of the entire system including funs and pumps
- Well-designed hydraulic system Proper insulation of the system
- Use of comfort range and rationalization Alternatively use of free cooling
- Heat recovery through effective systems

Thermal system: A boiler is defined as "a closed vessel in which water or other liquid is heated, steam or vapor is generated, or any combination thereof, by the direct application of energy from the combustion of different types of fuels. There are many types of boilers used in industry and their efficiency depends on the type of fuel used, technology, operation and maintenance.

During combustion process the input energy of fuel is transformed into various energy flows, heat and energy losses. Typical losses in a heating system are stack gas losses due to excess air stack gas temperature, losses as un-burned fuel in stack and ash, blow down losses, losses with condensate and losses by convection and radiation.

Typical energy savings with heating systems

- Replacement of old and inefficient boilers and heat exchangers
- Conducting of optimal combustion (reduce at minimum air concentration)
- Condensate recovery
- Maintaining water quality control and blowdown
- Ensuring insulation of boiler, heat exchangers and pipes
- Optimizing hydraulic pipes
- Feed water / intake air temperature Recovery of heat losses from stack

Electric motors: More than 85 per cent of electricity consumed by industry passes through electric motors. The electricity could be saved implicit by replacing old motors with new motors that are more efficient, being appreciated that at today electricity cost the running cost of motors is 8 – 10 times its investment cost.

New technologies are also available to improve motor operation and energy efficiency such as electronic soft starters and variable speed drivers.

Typical energy savings with electric motors

- Replacement of old, inefficient motors with new energy efficient motors
- Operating motor with correct balance voltage
- Avoidance of oversize motors
- Proper ventilation and heat evacuation
- Regular check on motor loading to monitor variations
- Improved maintenance Improved power input
- Adapt new technologies: variable speed drivers and electric soft starter.

Lighting: A lighting system comprise of all components needed to deliver the desired level of space or work place illumination. Several factors are influencing the lighting efficiency: the system design, the efficiency of lumps, the existence of electric control, automatic switch of when light is not needed, maintenance and cleaning of lamps and bulbs.

Typical energy saving with lighting systems

- Manual control of lighting
- Efficient bulbs and lamps
- LED lighting utilization
- Periodic maintenance and cleaning
- Automatic control
- Motion and daylight sensors

Electricity management system: The electricity cost comprises of electrical energy costs in the true sense (i.e. the cost of the kWh consumed) - that can be reduced primarily by reducing electricity consumption and the cost of power demand (i.e. the cost of the peak electrical power requirement) that can be reduced by reducing peaks of power consumption. An effective load management means control of maximum demand of the electric equipment and scheduling of its occurrence during peak/off peak periods.

Typical energy savings with load management

- Rescheduling loads - run heavy equipment according to a plan in order to reduce maximum demand and improve the load factor
- Staggering of motor loads - staggering of running is
- advisable, with a suitable time delay to minimize simultaneous maximum demand from these motors. Storage of products - for example, storing chilled water at night to provide day time air conditioning; Shedding of non-essential loads - install direct demand monitoring systems that switch off non-essential loads when a pre-set level of demand is reached.

Building: The buildings are part of the industries infrastructure and their energy efficiency is influenced by the quality of the building envelope (construction materials, walls, roof, floor, insulation), windows and doors quality, the external factors (landscaping, climate, exposure to sun and wind, etc.) playing also an important role. Making a building energy efficient could be achieved by means of reducing the need for heating and cooling.

Typical energy savings in buildings

- Building envelope insulation Double and triple glazing windows Revolving doors
- Re-organizing inside space and activities
- Reduce glass area
- Ensure shadowing during summer
- Reduce heat gain due to interior activities.

5.3 Water and used water

The main objective of this module is to guide companies to better understand the water use and waste water generation in the company, to identify the water loss, perform a root cause analysis and generate RECP options to increase the water efficiency

Benefits for companies out of water efficiency and effluent minimization

Direct and indirect cost cutting

In many company's water is taken for granted due to the small cost; the benefits of cutting the direct cost of the supplied water are not considered as paying water saving efforts. In reality, water efficiency could bring many direct and indirect benefits such us: less water distribution and treatment (lower consumption of treating chemicals, less pumping energy, lower utilization of equipment or less sewage taxes) or indirect cost from suppliers with water intensive processes and significant water impacts.

Business security

Water efficiency and water pollution control ensure compliance with applicable water regulations, securing the water license and the ability to operate and expend the business. The cost of compliance is reduced, and at the same time the risk of water contamination and environmental pollution.

Social responsibility

In many areas of the world companies are conflicting with communities in utilizing the local water resources. Another problem is the water pollution due to industrial activities that affects communities and the environment. Businesses proactive in addressing water challenges, benefit from increased reputation in the community and contribute to reduction of global and local water challenges.

Similar approach as the above module could be used by focusing on source, cause, options and action to improve Energy Efficiency in the company.

Source	-	Where is water used for what purpose?
	-	Where is wastewater generated?
Cause	-	What factors influence water uses, water losses and pollution?
Options	-	How to minimize water use, losses and pollution?
Actions	-	Start implementing water efficiency option

5.3.1 Understanding water use and waste water generation in the company

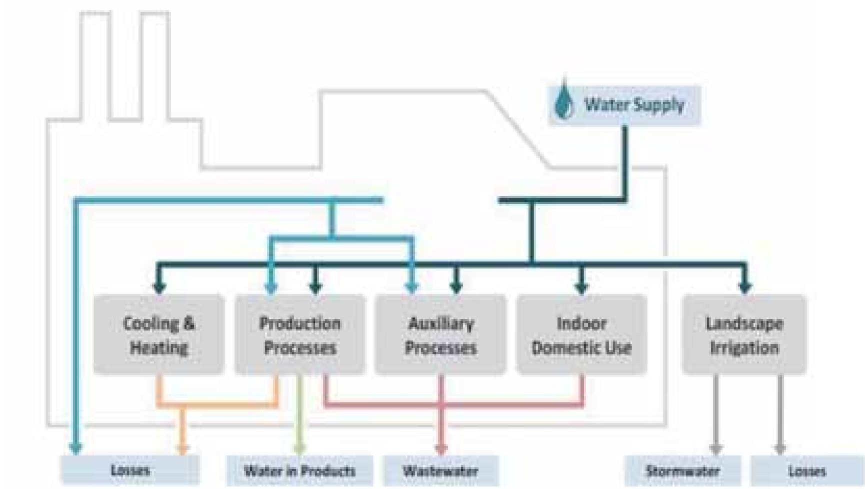


Figure 7: Typical water usage in a company

Where is water are used and for what purpose?

Building up the company's water profile implies understanding of:

- **Water supply** - water could be supplied from the local water company and/or could be extracted locally; in latter case additional water cleaning and disinfection is required, depending on the quality of the underground or surface water;

- **Water use** – water is used in production processes, in auxiliary processes, indoor activities (canteen, sanitary, garden, etc.) and in utility operations such as cooling, heating or steam production. In order to understand the water use, the water consuming processes /equipment are listed, the rated water consumption and annual operating hours are recorded and annual water consumption is estimated for each consumer.

Understanding factors that influence water consumption of a specific users and practices and techniques in place for water recovery and reuse are important indications on how water is managed in the company. The focus should be on high water consumers, at the source

Where is waste water generated? What are the water pollutants?

The **waste water streams** are identified in connection with water users, the annual waste water volumes and cost are estimated. The waste water pollutants types, quantities discharged and sources (equipment, processes, and materials) should be identified as well. The focus should be on high volume, heavy polluted waste water streams and sources.

What factors influence water use and generation of waste water?

Operating conditions, technology, design of equipment, operating practices and nature of input materials used in connection with water, the types of contaminants, how waste water is treated, etc., could have a major influence on water use, waste water generation and pollution load.

Water data collectionand monitoring

The quality of water consumption data depends on how water is monitored. Water monitoring is possible by using water meters to measure the input water source (supplied water or drilled water) and submitters to measure internal water consumers, at least for most important ones. Other techniques and methods are used to measure water flows and calculate water volumes such us portable water meters, the bucket or basin method as applicable. In many company's water is only measured by using a general water counter, in this case, the rated water consumption and annual operating hours shall be estimated for each water consuming process or equipment, in order to calculate the total annual consumption.

Collecting water data could is the first step in calculating the **real cost of water**. The real cost is usually much greater than the invoiced cost and comprise of several cost components additional to the billing cost: cost of treating chemicals, equipment, energy and labor cost, taxes for water permits and pollutants, etc.

5.3.2 Root Cause Analysis

After having identified, quantified and characterized water flows and waste water streams, the next step is to conduct a root cause analysis of identified inefficiencies by applying typical causes. The case of the bottle washing operation, an intense water consumption process in the beverage industry, is provide below:

Root Cause Category		Some examples (Bottle washing operation)
Process inputs		• Choice of cleaning agents/sanitizers
People		• Operating practices of workers • Prevailing attitudes that spills and leaks are normal
Plant	Process control	• Operating ranges for temperature and pressure
	Equipment	• Flow rate of washing nozzles
	Technology	• Wet cleaning process
Product		• Returnable bottle
Waste	Internal value	• Used wash water as substitute water for non-critical application
	External value	• Used wash water as substitute water for non-critical application

5.3.3 Generation and evaluation of options

Generation and evaluation of water saving and waste water minimization options is performed by applying the standard RECP practices to all causes of water loss, and waste water generation. In the case of bottle washing operation, typical RECP practices are applied to generate water saving and wastewater minimization options and improve the efficiency of the bottle washer:

RECP Practices		Some examples (bottle washing operation)
Input change		• More efficient cleaning agents/sanitizers • Low BOD/COD cleaning agents
Good Housekeeping		• Standard operating procedure • Improve operator awareness
Plant modification	Process control	• Improved controls of water pressure, flow and temperature
	Equipment modification	• Use low flow high pressure nozzles
	Technology change	• Dry – air cleaning of bottles
Product modification		• Change to single use packaging system
Reuse	On Site reuse	• Reuse bottle wash water for facility wash down
	Useful by product	• Reuse of bottle wash water by third parties

5.3.4 Implementation and continuation

Preliminary evaluation of RECP options for water conservation and waste water minimization is performed and consist of:

- Evaluation of technical and organizational complexity (low/medium/high)
- Estimation of energy consumption
- Estimation of investments and annual saving

Simple options shall be immediately implemented while complex options will be subject for detailed feasibility analysis. Options that proves to have highest benefits are included in a detailed action plan outlining clear responsibilities, cost and deadlines.

Typical options to improve water efficiency and minimize waste water generation

The typical strategies applied to improve water efficiency are ranging from:

- **Input changes**: using higher quality water, water less and water efficient products;
- **Housekeeping options:** adjusted water flow according to the needs, water metering and monitoring and preventive maintenance;

To more complex and difficult options such as:

- **Technology /equipment change & process control:** modification of existing equipment or install water saving devices, change to more water-efficient equipment, shift to a low-water or waterless process;
- **Internal water reuse or recycle** (treat if needed)
- **Product design** - shift to low water consumption products.

Good practices for increasing water efficiency of domestic use, cleaning processes, cooling or boiler & steam system should be also considered:

Domestic use:

- Low flush toilets/waterless urinal; Low flow valves or restrictors on taps
- Aerators on taps, showers, etc. Self-closing taps, water;
- Operate laundry, dishwashers and other equipment at full load.

Cleaning:

- Establish clear procedures; Prioritize dry clean up first;
- Replace leaking hoses and worn out nozzles;
- Use efficient spray nozzles with automatic shut off;
- Clean up with recovered (process) water.

Cooling:

- Monitor and manage blow down rates and feed water quality, possibly automate;
- Implement or improve condensate return;
- Improve external and internal feed water treatment;
- Maintain and repair steam lines, condensate traps, etc.
- Rationalize steam system over time.

Boiler & steam system:

- Monitor and manage blow down rates and feed water quality, possibly automate
- Implement or improve condensate return
- Improve external and internal feed water treatment
- Maintain and repair steam lines, condensate traps, etc.
- Rationalize steam system over time.

5.4 Materials and waste

The main objective of this module is to guide companies to better understand the material use and waste generation in the company, to identify the hot spots, perform a root cause analysis and generate RECP options to increase materials efficiency and minimizing waste.

Benefits for companies out of material efficiency and waste minimization

The benefits of more performant approaches when dealing with waste, range from direct savings out of reduced waste treatment cost to indirect benefits achieved due to reduction of input materials and to better image of the company in relation with the community and authorities.

Direct and indirect financial savings

The first and more obvious benefit is cutting direct cost with waste treatment and disposal; by increasing the recycling rate, less waste is disposed of and this is reflected in direct waste cost; a cost that could be turned into revenue paid by recycling companies. If waste is avoided or reduced, less raw materials (including toxic material) and packaging, are supplied meaning that company will spend less on input materials and will handle, store and deal with less materials and waste.

Business security

Conformance with waste obligations reduces the business risk. Dealing with toxic materials and waste is associated with risks that could be avoided by avoiding the toxic material itself. The business becomes more secure due to the decreased dependency on expensive resources and in some cases, on special toxic material.

Social responsibility

There are many ways for companies to prove on their responsibility when it comes to waste:

- Responsibility over the product that becomes a waste and in this sense is worth trying to prolong the life of the product through better quality and design;
- Responsibility regarding the waste disposed, sent to recycling or released in the environment, in the form of emissions that could affect local communities;
- Responsibility over the employees, how are they affected by waste handling activities, how are they motivated to segregate waste and follow the procedures in place;

Assuming responsibilities however, contributes to a positive perception of the company within the community, motivates the employees and improves relations with community and other relevant stakeholders including the environmental agencies.

What is waste and how to manage?

"Waste consists of costly raw materials that have not been transformed into products and for which one pays additional disposal costs". Waste is produced during production process (damaged materials, scrap, non-conform products, leakages, other losses) and support processes like: receiving and storage of input materials (packaging waste, non-conforming raw materials), maintenance (contaminated solids, oil, other hazardous and non-hazardous waste), water treatment (sludge), cleaning (packaging, chemical waste, contaminated water), and office activities (paper, plastics, cartridge).

Conventional waste management focuses mainly on the treatment of waste, an approach that intervene at the end of the production process, well known as the "end of pipe "solution, while cleaner production aims to prevent waste at the source, avoid potentially toxic processes and materials and increase efficiency of materials, favoring at the same time the economic solutions.

The major goal is to find solutions that are tackling the problems at the source, and this is also the first approach in the waste management hierarchy. If waste generation cannot be **avoided**, then they should be **reduced** to the minimum. Next option would be to **recycled** before the last option is considered, **dispose**.

Similar approach as the above module could be used by focusing on source, cause, options and action to improve Energy Efficiency in the company.

Source	-	Where are materials used? for what purpose? Where are materials lost?
Cause	-	What factors influence material consumption? What factors influence the volume and composition of waste streams?
Options	-	How to minimize material inefficiencies, losses and waste generation?
Actions	-	Start implementing RECP options to minimize the use of materials and waste generation

5.4.1 Understanding materials use and waste generation

Understanding materials use and waste generation is starting the point in optimizing materials use and minimizing waste in the company.

Where are materials used and for what purpose?

Materials are used in products, in auxiliary processes and for packaging. Listing all products and the type of materials enclosed, the rate material consumption per unit of product and the number of products, allows comparison between the theoretical material consumption versus the actual material consumption and identification of material loss.

Special attention should be paid to critical materials (materials at the origin important waste fluxes, expensive or toxic materials), processes and activities that are main sources for waste generation.

What types of waste are generated and where?

Types of waste and their source of generation are identified in connection with material use; waste streams, annual volumes and cost, destination (e.g. landfill, recycling or incineration) and main sources are listed and evaluated and proportion of waste stream from total waste is calculated. The focus should be on important waste fluxes in terms of quantity, value of the original material and toxicity.

What happens if waste is not segregated?

Waste sort - make sense when waste segregation is not performed. Since this exercise requires the team to physically sort through the trash, wearing protective gloves is a must. To conduct the inspection, a large plastic sheet is spread out and the waste sample from one day is dumped on it. The different waste categories from the waste sample are separated and weighted. Estimation of daily/monthly/annual quantities of waste streams could be performed based on the information acquired during the waste sort. This might look like a dirty exercise but in some instances is the only source of data, in particular for companies that are not performing any kind of waste sorting.

What factors influence material consumption and the volume and composition of waste streams?

Several factors are influencing material consumption and waste generation, those could relate to quality of material, product design, technology, production planning, operating processes, waste segregation practices, employees' education and behavior, logistics aspects, waste elimination solutions, etc.

Data collection

Quantities and cost are recorded for all material types and waste streams. The data could be found in the accounting documents, internal records and software, waste transfer notes, waste disposal and recycling weighting notes.

5.4.2 Root Cause Analysis

After having identified, quantified and characterized material losses, the waste streams and waste sources, the next step is to conduct a root cause analysis of inefficiencies by applying typical causes related to:

Plant: inefficient technology, inadequate automation and process control, poor production planning (frequent changeovers, cleanings, start up and shut downs), poor maintenance, malfunctions, leakages

Process Inputs: poor quality of raw and auxiliary materials, excess packaging, inefficient purchasing, poor handling, transport of goods, inadequate purchasing and warehouse management

People: lack of awareness and motivation, lack of job instruction, improper behavior, no control of cleaning company personnel

Waste: no waste segregation, poor waste logistics, no internal / external recycling solutions, no waste procedures in place;

Product: product design, low product quality, improper product dispatch

The case of product breakage in ceramics production is exemplified further;

		Some examples (product breakage in ceramics production)
Process inputs		• Quality of incoming clay
People		• Inappropriate handling of molded clay • Adherence to recipes for clay preparation
Plant	Process control	• Operating temperature control for clay firing
	Equipment	• Wear of conveyors on molded and fired product
	Technology	• Type of burners in kiln
Product		• Inherent physical strength of product designs
Waste	Internal value	• Unfired clay – can replace virgin clay
	External value	• Fired ceramics – can have value as fill material

5.4.3 Generation and evaluation RECP options

Generation and evaluation RECP options for improving material efficiency and waste minimization is performed by applying the standard RECP practices to all causes of material losses and waste generation. In the case of product breakage in ceramics production the possible options belong to typical RECP practices categories:

Root Cause Category		Some examples (product breakage in ceramics production)
Input change		• Better selection of clay with less impurities
Good housekeeping		• Standard operating procedures, appropriate implements to handle fragile items
Plant modification	Process control	• Improved control of firing temperature n the kiln
	Equipment	• Modified conveyors and handling system to reduce wear on products
	Technology	• Energy efficiency burner
Product modification		• Review/modify products forms to eliminate weak points • Dematerialize product – thinner
Reuse	Internal value	• Recover un-fire clay for internal reuse
	External value	• Offer ceramic waste as fill material - concrete, road etc.

5.4.4 Implementation and continuation

Preliminary evaluation of RECP options for increasing material efficiency and waste minimization is performed and consist of:

- Evaluation of technical and organizational complexity (low/medium/high)
- Estimation of energy conservation
- Estimation of investments and annual saving

Simple options referring to purchase improvements, waste logistics, and waste segregation and recycling should be implemented in the shortest time, while complex options will be subject for detailed feasibility analysis. Options that proves to have highest benefits are included in a detailed action plan outlining clear responsibilities, cost and deadlines.

Typical options to improve materials efficiency and minimize waste generation relate to RECP practices:

Plant modification: efficient technology /equipment, improve planning and controlling, improve automation and process control, preventive maintenance;

Input change: better selection of input materials, avoidance of toxic materials, efficient purchasing;

Good housekeeping: waste segregation procedures, systematic education, efficient waste logistics, control of cleaning personnel, stock management, waste monitoring

Waste utilization: waste segregation, internal / external reuse and recycling

Product modification: improved product design, better quality of product, optimized distribution and packaging (lightweight, squeeze, recycled, recyclable)

Good practices for increasing water efficiency of domestic use, cleaning processes, cooling or boiler & steam system should be also considered:

Incoming goods and product dispatch

- Improved inspection and strict acceptance criteria
- Minimization of inventory (Just in Time), including its diversity
- First in First Out warehouse management
- Adequate storage conditions with controlled access
- Purchase in appropriate quantity and with minimum packaging
- Production planning to follow sales/order

Production waste

- Extend product runs to minimize waste from startup/shut down
- Schedule product runs to minimize cleaning
- Recover cleared out product for reuse in next batch
- Reduce stress from equipment on products
- Maintain even process conditions (better mixing, heating, cooling)

Auxiliary processes

- Purpose to extend use and minimize consumption and waste diversity, where possible systems, where appropriate lubricants, cleaning agents etc.

Office and canteen

- Go paperless;
- Use recycled paper
- Select reusable/refillable products
- Use recycled paper and office products

- Waste segregation
- Staff motivation
- Reusable cups & cutlery;
- Buy local;
- Avoid single dose packing

6. Training approach

The capacity building training is more of a hand-on “practitioner-oriented” approach. A participative approach, where participants are encouraged to share their experiences, engaged in constructive dialog, would be employed. The needs and desires of the participants will be considered and should drive the style of the training.

The following training/capacity-building approaches would be employed individually, or in some combination, to achieve learning needs with respect to the traditional learning styles and the current needs of the participants:

- Lectures through presentation (concept and benefit of sustainable production and resource efficiency, RECP step by step, and practical modules);
- Individual or group works (capacity assessment);
- Role playing exercises; and
- Field visits to sites (if any).

7. Expected outcome

The following outcomes are expected from the training:

- The trainees learned the basic principle and benefit of the sustainable production and resource efficient
- The trainees understood the step by step approach of RECP
- Improved and built coordinating mechanism among relevant stakeholders for future cooperation on the implementation of RECP in the demo factory.

8. Training process

Three capacity building training will be organized:

- First training: the first training will introduce general concept and benefit of the sustainable production and RECP; step by step approach of the RECP and its relationship with the learning cycle Plan-Do-Check-Act; data requirement; and indicators.
- The second training will introduce the two practical modules namely: building an environmental profile and energy. Introducing the main and indirect use of energy, identifying main energy users, providing the typical energy efficiency options.

- The third training will introduce the remaining two practical modules listed in the RECP guide namely: Water and Materials and Wastes. Understanding water and materials use and waste /wastewater generation; typical options to improve water and materials efficiency and minimizing the generation of wastes.

9. Trainees

The training is designed mainly for staffs of the Ministry of Industry and Handicraft with mandate to promote sustainable production and resource efficient in manufacturing industry sector and manufacturing industry such as garment, food and beverage company… The training manual is also suitable for service providers, and relevant line ministries, CSOs who are intent to promote resource efficiency and reduction of environmental footprint from industrial activities.

10. Evaluation

A post test will be conducted to assess the understanding of the participants at the end of each training as well as to evaluate the effectiveness of the training. The feedback, test results will be analyzed and will be used to further improve the efficiency and effectiveness of the future training.