
**Regional Resource Efficient and Cleaner Production (RECP) Demonstration Programme for Eastern Partnership Countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine) ([1])**

**Scaling Up Resource Efficient and Cleaner Production in Small Businesses**

# RECP Clubs for Small Enterprises

# RECP Manual for Enterprises

[1] The regional RECP demonstration project is implemented by UNIDO within the framework of the EaP GREEN programme which is funded by the European Union and with additional financial support for the RECP component from the Government of Slovenia, the Development Bank of Austria and UNIDO.

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## BACKGROUND

The Partnership for Environment and Growth (EaP GREEN) supports the governments of Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine to start the transformation to a green economy and thereby decouple economic growth from resource depletion and environmental degradation. EaP GREEN is implemented by a consortium of international organizations, under the leadership of OECD and with contributions from UNECE, UNEP and UNIDO (www.eap-green.org). Under EaP GREEN UNIDO works to demonstrate the opportunities for manufacturing enterprises, in particular from food processing, construction materials and chemicals and allied sectors, to put green economy in practice.

UNIDO therefore designed and implements a regional Resource Efficient and Cleaner Production (RECP) demonstration programme covering all six countries. RECP concerns 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. Doing so contributes to efficient use of materials, water and energy, reduction of waste, effluent and emissions and improving human health and well-being (www.unido.org/cp).

The RECP Club is a supporting model developed for scaling up and mainstreaming RECP in enterprises, in particular smaller businesses. This Club approach is based on 20+ years of international experiences, including, under different names, for example in India, Austria, United Kingdom or South Africa.

Within the EaP region, the first RECP Clubs were developed by UNIDO in Moldova, during 2014, as a component of the National Cleaner Production Programme (www.ncpp.md) (supported by the Government of Austria). Three parallel RECP Clubs were run in three different regions and resulted in the uptake of RECP concept in 25 companies, identification of 160 RECP measures with significant environmental and economic benefits. The Clubs were hosted by local governments (represented through the Mayors' offices) and thereby in turn contributed to strengthened regional cooperation.

## RECP CLUB AIM AND OBJECTIVES

The aim of the RECP Clubs is to support small businesses to identify viable economic and environmental solutions for their business.

The principal idea of a RECP Club is to bring together up to 10 small businesses from the same region and take them jointly through an intensive training and coaching programme over a period of about 4 months, leading to a customized RECP action plan for all member companies on completion of the Club. Upon completion of the Club programme, each member enterprise shall have developed an actionable RECP plan and have started with its implementation. The 'hosting' organization (municipality or other regional or local authority) is awarding successful enterprises by providing a certificate of completion, which could also be renewed annually if enterprises continue to improve their environmental initiatives.

A total of six modules is foreseen, organized by thematic area, in the following sequence:


**Figure 1 Modules of RECP Club**

1. Business Profile: profiling of the enterprise with a particular focus on identifying resource uses and environmental impacts;

2. Energy: understanding energy use in company and developing energy efficiency options for processes, utility systems and buildings management;

3. Materials and Waste: understanding main material flows in enterprise and associated waste streams, and developing materials efficiency and waste reduction options;

4. Water and Waste Water: understanding main water flows in enterprise and associated waste water streams and developing water efficiency and effluent reduction options;

5. Chemicals, Hazardous Waste and Emissions: understanding chemicals use and associated hazards and emissions, and developing options for sound and responsible chemicals use; and

6. Action Planning: bringing together options from different topics into an integrated approach for enterprise with short, medium and longer term goals and actions.

Each thematic modules describes:


The WHAT – the global and national concerns as well as concerns at the business level related to resource consumption (materials, water and energy) and generation of waste and emissions;

The WHY – the challenges for businesses in terms of cost, risks and impact on the environment, the benefits out of RECP implementation and local business examples;

The HOW – the RECP method applied for understanding the issues in the company, performing a systematic root source and root cause analysis and identifying, evaluating and implementing RECP options for each thematic area.

## BENEFITS FOR RECP CLUB MEMBERS

The member enterprises have the chance to actually implement the RECP approach and to reduce the environmental impact of their activities and realise economic benefits at the same time. The improvements in enterprises will contribute to the general improvement of the local business environment and in the end to increase competitiveness of local economy and the quality of the environment, reducing in this way the negative impact on the local population and community. By actively participating in the Clubs' activities the member enterprises will have financial, business and environmental benefits and will be able to:


- Reduce cost through improved efficiency and productivity
- Reduce environmental impact of their operations
- Increase knowledge on resource efficiency techniques and practices
- Access essential information referring to best practices and using innovative tools and approaches
- Promote their organization and services through clubs events, publications and media
- Get awarded by the local authority
- Connect with other fellow professionals, exchange ideas and opportunities
- Add their own case studies and success stories
- Be part of a community of innovation.

## THE BASICS AND THE APPROACH OF RESOURCE EFFICIENCY AND CLEANER PRODUCTION (RECP)

*Resource Efficient and Cleaner Production* has been defined 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 (*UNIDO&UNEP*)

The basic idea of RECP is:

*"An ounce of prevention is worth more than a pound of cure"*

RECP is put in practices by means of types of solutions (RECP practices), a systematic approach for their identification and evaluation (RECP method), addressing existing inefficiencies (RECP issues) and monitoring of enterprise level results (RECP indicators).


**Figure 2 The aims, issues, method and practices of RECP**

**RECP Aims -** RECP aims to contribute to:


**Resource efficiency** - trough optimization of the productive use of natural resources (materials, energy, water) at all production stages;

**Waste Minimization** - minimization of the adverse impact of production systems on environment and nature through reduction of wastes and emissions;

**People's well-being** - minimization of risks to people and communities and enable their development

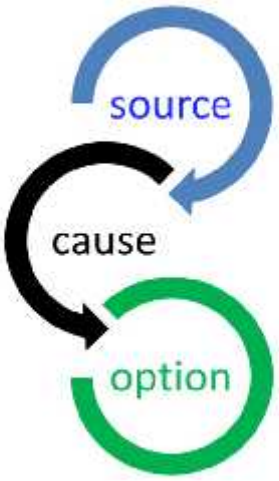
**The type of issues addressed by RECP** refers to resource use and generation of waste and emissions, meaning:

| | | | |
|---|---|---|---|
| | Selection and efficient use of **materials** | | Reduction and safe disposal of **waste** |
| | Sourcing and efficient use of **water** | | Reduction and treatment of **waste water** |
| | Selection and efficient use of **energy** | | Reduction and control of **air emissions** |

**Figure 3 RECP issues**

**RECP Method 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 opportunities** (option) by applying "standard practices" to all waste and emissions causes and process inefficiencies.

**RECP Practices**

RECP practices provide solution categories that can be applied individually or in combination to generate options and implement RECP in enterprises. The types of solutions that could be applied for increasing efficiency are named RECP practices and refers to:

**Figure 4 RECP Practices**

1. **Good housekeeping - changes in operational procedures and workplace management to reduce unnecessary 'wastage''**
   The typical solutions could refer to:
   - 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.**
   **The typical solutions are:**
   - 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.**

   Referring to this RECP practice the typical solutions could be:

   - 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**
   Typical solutions for equipment modification are:
   - 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**
   Typical solutions refers to:
   - 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 (material, energy, water) within the same company for similar or alternative purpose**
   **Typical solutions refers to:**
   - Countercurrent or cascaded use of water and energy
   - 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**
   Typical solutions refers to:
   - 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**
   Typical solution refers to:
   - 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 data 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**:

- Resource use indicators – tons material use /year

  - $m^3$ fresh water/year
  - kWh energy/year
- Pollution indicators
  - tons of CO2 equivalent emissions
  - $m^3$ waste water
  - tons of solid waste

**Relative indicators**

- Resource Efficiency = total production output / unit of resource consumption…
  - ….. total tons of material used
  - ..... total kWh energy = energy productivity
  - .... total $m^3$ fresh water = water productivity
- Pollution intensity = total tons of waste and emissions… / per unit of product
  - ….total $m^3$ waste
  - ….total $CO_2$ emissions
  - ….total $m^3$ of waste water

## HOW TO APPLY RECP IN YOUR COMPANY

**The application of RECP** is based on the self-assessment of companies' performance with a focus on resources use, waste and emissions generation, identification and quantification of losses and their impact in the productivity and financial performance.

The basic idea is to help companies to help themselves!

For this purpose the companies you will be benefit from thematic training, coaching and continuous guidance as well as individual support during workshops, technical visits and distance interaction.

A set of tools and worksheets have been elaborated to support the self-assessment and help you to **understand the issues** in the company by analysing the way how resources are used, resource consumption and waste generation data and their related cost; **to perform a systematic root source and root cause analysis** of the identified inefficiencies by applying standard "cause categories", to explore their potential impact on process efficiency and waste generation and **to identify RECP opportunities** by applying "standard practices", evaluate and implement RECP options.

The tools and worksheets are described in the following:

## The Self-Assessment Tool

The Self-Assessment Tool is meant to be used by your company under direct guidance and supervision of the RECP Facilitator. One worksheet per topic has been designed for building up the environmental profile, assessing resource use, quantities and cost (energy, water & waste water, materials & waste, chemicals & hazardous waste) and elaboration of the RECP Action Plan.

Each thematic worksheet results into a thematic option list including sections for their evaluation. In the last worksheet, the action plan is developed by bringing together all RECP options that have emerged from detailed analysis, screening them and defining the tasks needed for their implementation.

The tool comprises of seven parts as follows:

- **Introductive Part** : "General information"
- **Part 1 "Profile"**: This section offers a framework for data collection and for the establishment of the company's baseline profile. Based on the primary analysis of the mass flows quantities, economic value, and environmental impact, main environmental priorities are identified. Data collection (quantities and cost) in this phase is critical and will be used for continuation of the self assessment on energy, water & waste water, materials & waste and chemicals & hazardous waste. Total resource use (input) and total waste and emissions generation (non-productive output) data is transferred from Part 1 "Environmental profile" (type, physical unit,

annual physical use, annual cost, principal uses and main sources for waste and emissions generation) to the next thematic sections.

- **Part 2 "Energy", Part 2 "Water", Part 4 "Waste" and Part 5 "Chemicals"** are designed to provide a framework for:
    - Mapping and quantification of resources: types, the purpose of use, their actual use versus tehoretical use, operating conditions and factors influencing them
    - Mapping and quantification of effluents, waste and emissions: types, source and factors that influence their generation
    - Identifying causes of inefficiency and loss for each type of resources, waste and emission, as a starting point for RECP options generation, that contribute to resource conservation and waste and emission minimization.
- **Part 6"Action Plan"**: outlines the **RECP options catalogue** and categories of tasks associated to each RECP option, as well as their economic and environmental benefits, deadlines for implementation and responsible persons.

Attention!
Never try to fill in the yellow columns, they are pre-set to calculate automatically.

## The Self-Assessment Worksheets

Five Self-Assessment Worksheets were created to be used by your company under direct supervision of the Facilitator. The worksheets comprise of two main parts:

**Initial stock take** – a section to be used during the workshops, while you will be asked to "take your company pulse" by performing the initial evaluation in your company referring to resource use, cost and sources of losses, generation of waste, effluents and emissions; measures taken so far to improve the situation. After completing the initial evaluation you will be invited to explain your choices during the plenary sessions.

**Self-assessment** - a section meant to introduce the relevant part of the Self-Assessment Tool and to provide detailed instructions on type of information and data to be provided and how to fill in the relevant section of the tool, along with guided questions for identification of inefficiencies and losses. You will be asked to reflect on the questions and prepare for reporting on your achievements on the topic, during the next workshop.

## The Enterprise Report template

Essential information regarding the RECP self-assessment and the achievements of your company should be gathered in a single document used as an instrument for internal and external communication. The report template is designed in the form of an extended action plan and contains four sections:

(1) Background and introduction: describes what RECP is and what has been done;
(2) The action plan;
(3) Implementation (summary of tasks for the options);
(4) Suggestions for management (suggested cross cutting improvements)

## MODULE 1: BUSINESS' ENVIRONMENTAL PROFILE

The main objective of Module 1 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.

**Key elements**

**What? Global, national and business concerns**

**Why? Benefits for businesses**

**How? Building the environmental profile**

**Expected results**

**Environmental profie**

**Baseline data for materials, water , energy and waste**

**Baseline profile - indicators for resource efficiency and pollution intensity**

### Global environmental concerns

Rapid increases in materials consumption and waste generation are global concerns given environmental impacts along the entire life cycle: extraction, processing, use and disposal of materials. The intense use of materials, energy and water has serious implication on the extraction rates and scarcity of natural resources, environmental pollution (air, water, and soil), ecosystems services and human health. International trading and prices on the market of raw materials and other goods are more consequences that are affecting directly the business' competitiveness and productivity.

In this regard, promoting resource efficiency has become an economic imperative for any business to survive. Every industry has the possibility for improving its production efficiency through systematic interventions. The first step towards resource efficiency is to recognize that there is a room for improvement, assess the financial implications of resource use and waste, ensure commitment and leadership from management, motivate and engage the employees in a creative thinking process.

National concerns….

## Business concerns

Cost to business - access to and costs of materials and waste management are becoming business priorities. Growing prices of raw materials and energy as well as inefficient use of resources is strongly reflected in the financial performance of the businesses and its competitiveness.

Risk to business primarily relates to the difficulty of supplying good quality raw materials at fair price. Due to their extensive consumption, some materials are becoming scarce and their price is fluctuant on the market. On the other hand, the environmental legislation in transition and developing countries is under continuing change; confusing amendment of the existing legislation or frequent release of new regulations is difficult for businesses to understand, follow and adopt measures to comply with. Consequently the SME's are many times not aware of applicable requirements neither of their environmental impact, a situation that could lead to suspension of their license. Problems may occur due to illegal waste disposal, the risk of chemical accidents and their possible impact on employees' health and communities, representing additional risks for businesses.

Impact on the environment – the SME's account for a large part of the world's resource consumption and waste and emissions generation. While pollution created by individual companies is low, the overall impact of SME's is high due to their large number. The existing data shows that SME's have the tendency of underestimating their environmental impact, do not associate the environmental impact with production inefficiency, and the saying "what is not measured cannot be managed" is particularly true in case of SME's. Amongst the sectors identified as having particularly significant impact on the environment are: agriculture, particularly livestock farming, constructions, food sector, metal products, textile and leather, manufacturing, timber and wood industry.

## Business benefits of environmentally responsible behaviour

There are at least three types of business benefits that could results from a responsible environmentally behavior:

**Improved business performance**

Better business performance could be achieved by increasing resource efficiency, improvement that has a positive impact on cost reduction, reduction of toxic materials consumption and waste and emissions generation. Improved products from better controlled processes could better meet customers' expectations, contribute to better positioning of the business on the market and increase of sales.

**Business security**

Investing more in environmental compliance and reducing waste and pollution eliminates risks for businesses and enable them to operate and act in time in order to adapt to more demanding environmental

legislation. A secure business will be more reliable in front of partners and will have better access to grants and loans, gaining a strategic foresight by anticipating how business can innovate and add more value.

Relation with stakeholders

Environmental responsibility helps businesses to enhance their reputation by setting up a positive example, fact reflected in people retention and motivation and in better relationships with community and other relevant stakeholders.

Taking environmental responsibility requires time, efforts and resources for a company but could lead to process, products and services improvements and less impact on the environment. SME's are small businesses and have more difficulties in accounting environmental responsibility, they are often confronted with **challenges** such as:

Lack of awareness - SME's are small organizations with a limited number of employees, often multitasking and less prepared to cover the entire range of technical and legal problems. This situation conducts to a sceptical attitude and the failure of associating the potential benefits, cost savings and customer rewards with environmental improvements.

Lack of knowledge – the limited resources are also reflected in the low technical expertise of the SME's personnel, inability of hiring higher personnel or offering systematically educational programs. Keeping up with environmental legislations under continuous change is another challenge, consequently SME's are many times not aware of applicable requirements neither of their environmental impact or associated production inefficiencies, a situation that makes difficult the improvement of their performances.

Lack of infrastructure **-** SME's have limited financial resources, access to capital and consequently, limited access to new technology and equipment, one of the main causes for low productivity and inefficient use of resources. Besides this SME's, in developing countries, do not have access to decent environmental infrastructure because this infrastructure is either very poor, or in some regions, is totally missing (recycling technologies, waste/water treatment technologies, etc.).

## 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:

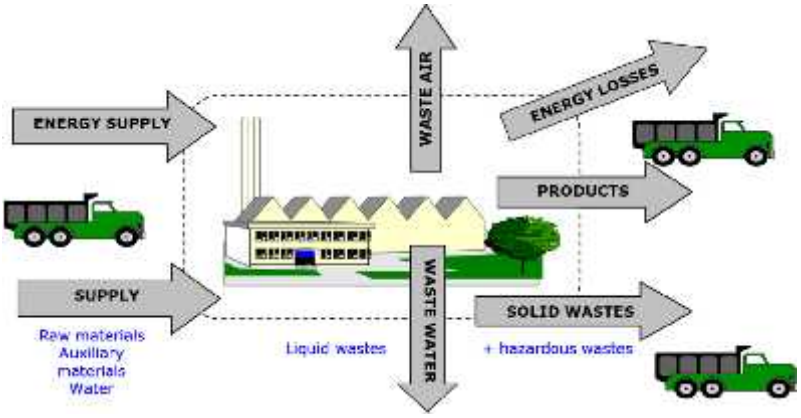



**Figure 5: The main inputs and outputs of an industrial process**

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 focuses 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

Action

- Start implementing


Understanding the issues in the company would require response to a number of questions:

| | |
|---|---|
| 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's 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.

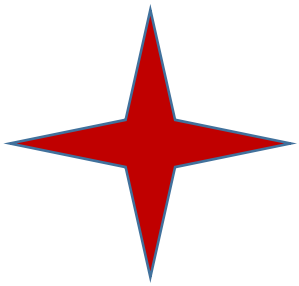
What are the risks for business and how is managed?

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 Self-Assessment Tool, Part 1 – "Profile" – resource efficiency and pollution intensity indicators are automatically calculated and form 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?


Root cause analysis **-** 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.

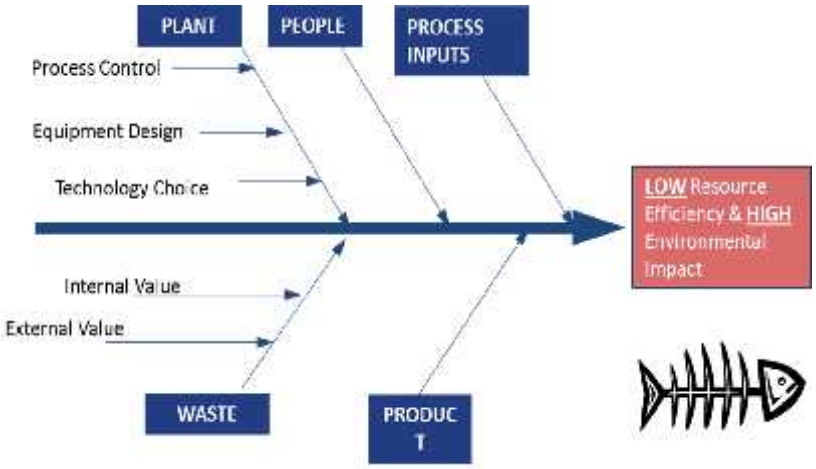



**Figure 6 Root cause analysis using fishbone**

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.

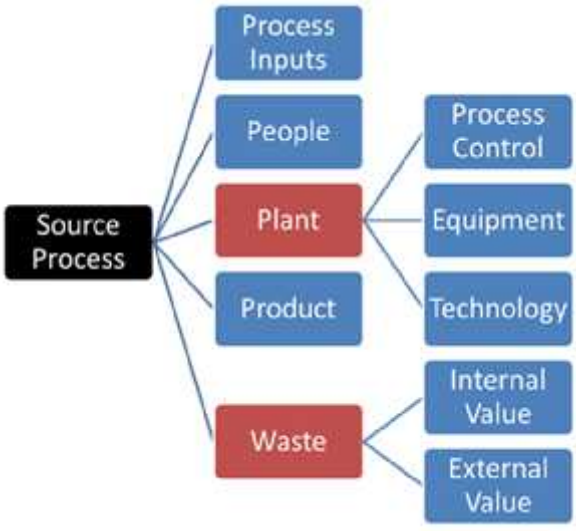
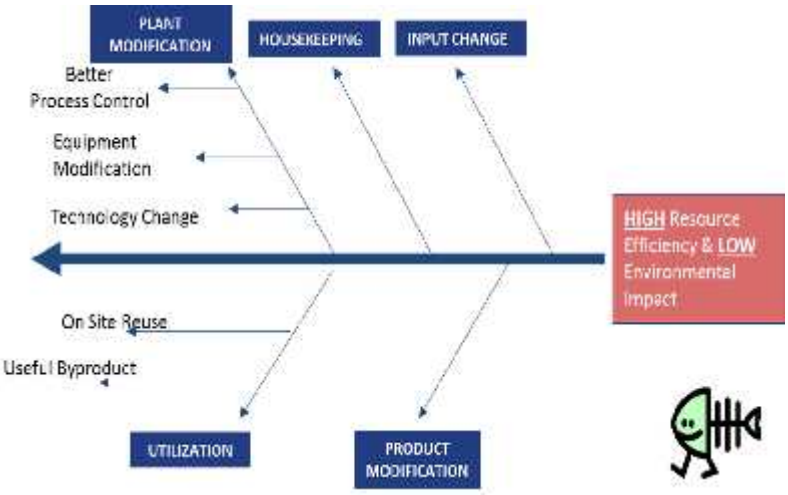



**Figure 7 Typical causes categories**


## 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**

**Figure 8 Options generation using reverse fishbone**

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?**

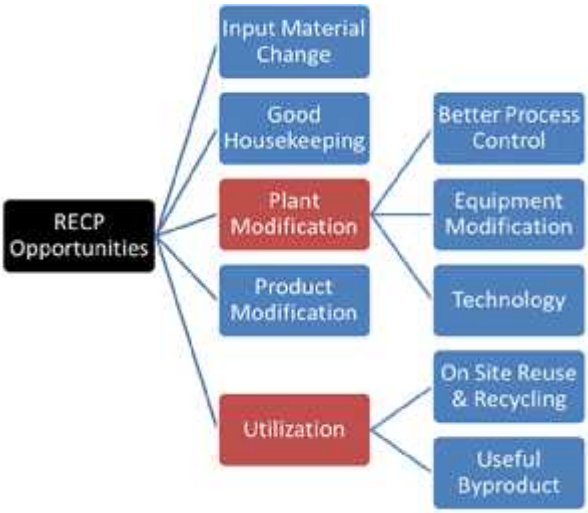



**Figure 8 Typical RECP Practices**

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

The main question is:

**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.


### 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. Module 6 is dedicated to implementation of RECP, explains further how to select and evaluate the RECP options and how to build up an RECP Action Plan.

## MODULE 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.

**Key elements**

**Expected results**

**What ? Global, national and business concerns**

**Why? Benefits for businesses**

**How? RECP for energy efficiency**

**Energy profile:**

**- Energy use, quantities and cost**

**RECP Options to increase energy efficiency**

## Global concerns

Worldwide, the continued rise in primary energy consumption has been increased by 38% since 2000 while energy use causes 69% of global greenhouse gas emissions. Energy use is associated with other environmental impacts such as depletion of natural resources, land use, air and water emissions and waste generation.

## National concerns

## Business concerns

Worldwide manufacturing companies account for nearly a third of the global energy consumption. The US Energy Information Administration (EIA) expects the price of WTI crude oil to grow year-over-year by 2.5 to 3% until 2030[2]. The volatile price of energy affects in particular small companies that are having difficulties in planning their business and resources: when the energy prices increases the transportation, the supplied goods and their own operations cost more. In many regions companies are experiencing frequent disruption of energy supply which is perceived as having a dramatic impact on the production process. The great existing potential to reduce energy use in companies, on the supply chain or to increasing energy performance of products is not yet exploited in spite of possible financial and market benefits.

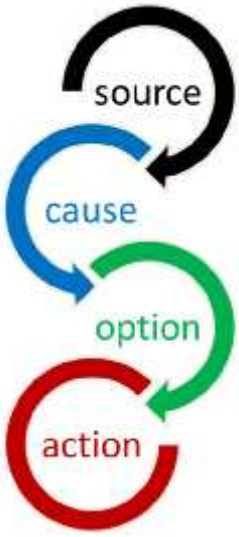
## Business benefits of energy efficiency

[2] EIA International, International Energy Price Information, 2008

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

[3] Bain&Co,, internet source




Improving Energy Efficiency in the company requires focus on:

Source:

– Where is energy used for what purpose?

Cause:

– What factors influence these energy uses?

Option:

– How to minimize these energy uses?

Action

– Start implementing energy efficiency options


## 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.


### Root cause analysis

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<br>• Design, dimensioning and lay out of compressed air distribution |
| | Technology | • Type of compressors (compressed air supply) |
| Product | | • Pressure at point of use<br>• 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 |

**Figure 9 Root cause analysis in case of compressed air system**


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 shielded 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<br>• Improve maintenance on compressors |
| | Technology Change | • Energy efficient compressor systems |
| 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 |

**Figure 10 –Generation of RECP energy conservation measures for compressed air system**


## Implementation of energy saving options

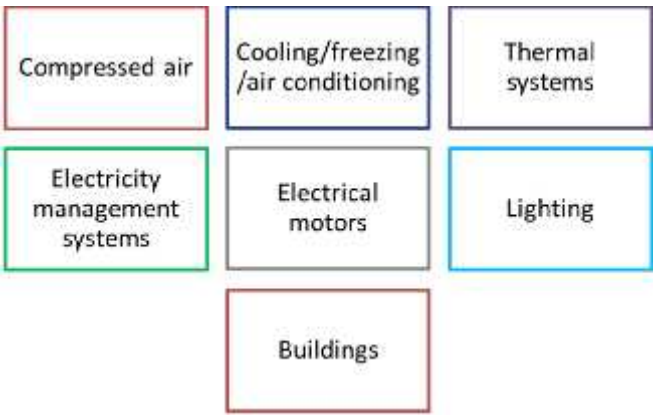
Preliminary evaluation of RECP options for energy conservation shall be performed and consist of:

- Evaluation of technical and organizational complexity (low/medium/high)
- Estimations 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

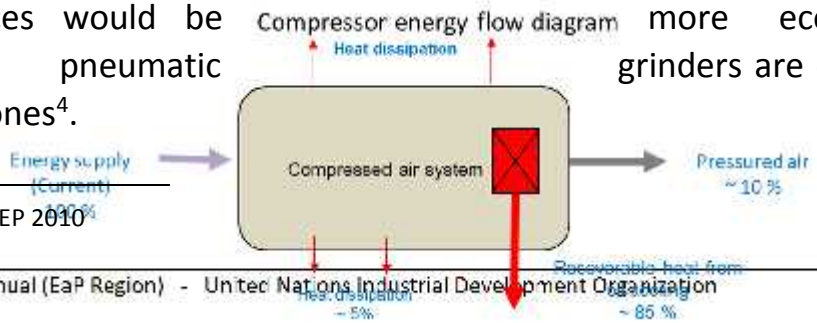
The section presents basic information on different energy-using systems and typical energy saving measures that could be used for identifying the focus area for RECP assessments.




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[4].




[4] CP-EE Manual, UNEP 2010

**Figure 11 Compressor energy flow diagram**

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.

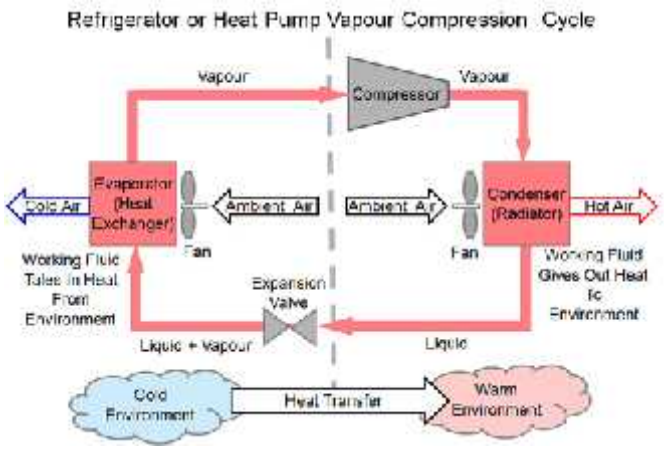



**Figure 12 Refrigeration or Heat Pump Vapour Compression Cycle**

## 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 systems

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.

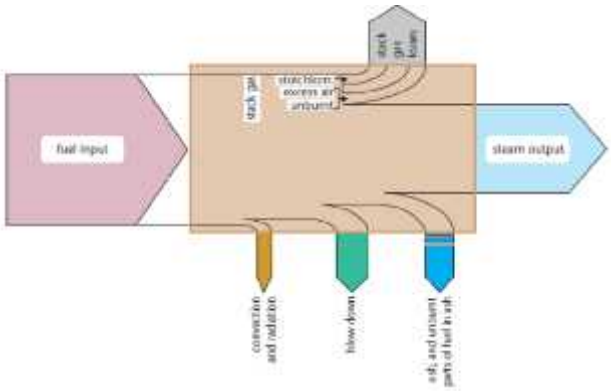



**Figure 13 Boiler's energy balance**

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<br>Conducting of optimal combustion (reduce at minimum air concentration)<br>Condensate recovery<br>Maintaining water quality control and blowdown<br>Ensuring insulation of boiler, heat exchangers and pipes<br>Optimizing hydraulic pipes<br>Feed water / intake air temperature<br>Recovery of heat losses from stack gas |

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[5].

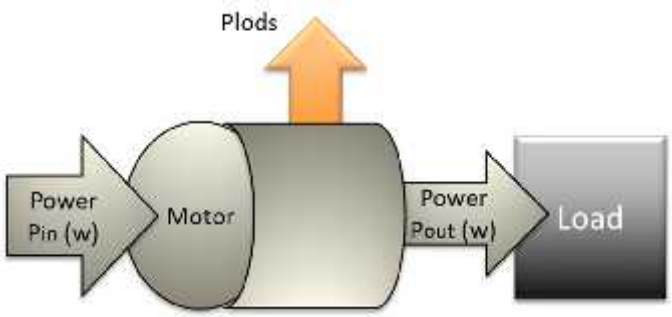



**Figure 14 Pumps' energy balance**

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<br>Operating motor with correct balance voltage<br>Avoidance of oversize motors<br>Proper ventilation and heat evacuation<br>Regular check on motor loading to monitor variations<br>Improved maintenance<br>Improved power input |

[5] CP-EE Manual, UNEP 2010

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.

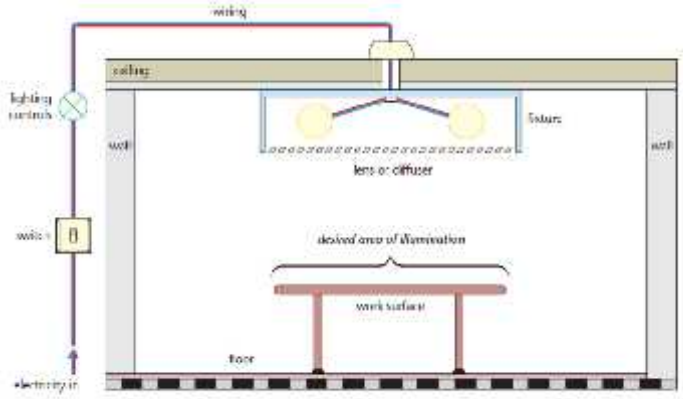



**Figure 15 Example of lighting control**

Typical energy savings 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 systems

The electricity cost comprise 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.

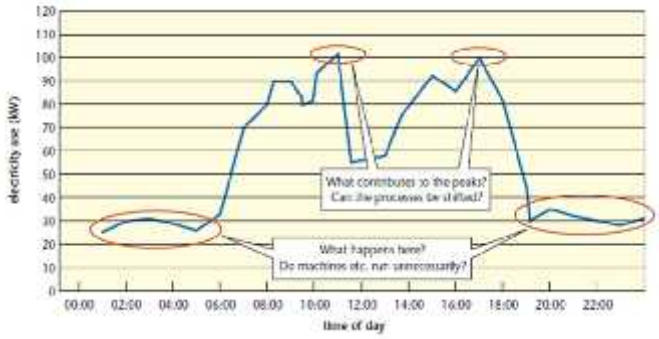


**Figure 16 Measuring electric load**

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.

Buildings

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.

## MODULE 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.

**Key elements**

**What ? Global, national and business concerns**

**Why? Benefits for businesses**

**How? RECP for water efficiency and waste water and pollutants minimization**

**Expected results**

**Water profile**

**- Water use, consumption and cost**

**- Waste water generation and sources for water pollution**

**RECP Options to increase water efficiency and minimize waste water and pollutants**

### Global concerns

Water use as well as water pollution have been intensified dramatically in the last century. The population growth, urbanization, migration and industrialization and increase in production and consumption have tripled freshwater withdrawals over the last 50 years, and continuing its increasing trend by 64 billion cubic meters a year[6]. Worldwide, the agriculture sector is already the largest user of water resources, accounting for roughly 70% of all freshwater withdrawals globally, compared to 20% for industry and 10% for domestic use.

National concerns ….

### Business concerns

[6] Water for Sustainable World, World Water Development Report, 2015

Only 20% of the total water consumption worldwide is by industry, although businesses can't function without water. The access to quality water sources is essential for a range of industrial processes, support functions and as an ingredient in many products, consequently, the availability of clean water is a precondition for many businesses. Interrupted supply, water contamination, pressure to change water allocation, public and community perception on how companies respond to local water challenges, or the increasing demand of legislation are major business risks impacting their productivity, ability to operate and sometimes critical business decisions.

## Benefits for companies out of water efficiency and effluent minimization

### Direct and indirect cost cutting

In many companies 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.

## Improving Water Efficiency and Mimimizing Waste Water and Pollutanst


Source:

– Where is water used for what purpose?

– Where is waste water generated?

Cause:

– What factors influence water uses, water losses and pollution?

Option:

– How to minimize water use, losses and pollution?

Action:

– Start implementing water efficiency options


## Understanding water use and waste water generation in the company

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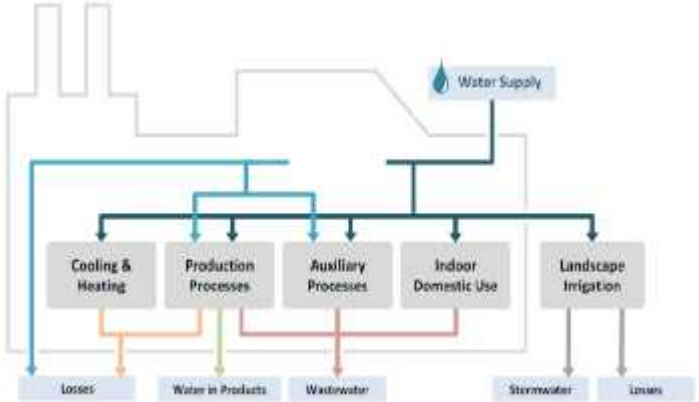



**Figure 17 Water use in an industrial company**

### Where is water used in the company and for

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

- **Water supply** - water could be supplied from the

[7] Water Toolkit, EPA

what purpose?

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 collection and 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 companies 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.


## Root Cause Analysis

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 provided bellow:

| Root Cause Category | | Some examples (bottle washing operation) |
|---|---|---|
| Process Inputs | | • Choice of cleaning agents/sanitizers |
| People | | • Operating practices of workers<br>• Prevailing attitudes that spills and leaks are normal |
| Plant | Process Control | • Operating ranges for temperate and pressure |
| | Equipment | • Flow rates of washing nozzles |
| | Technology | • Wet cleaning process |
| Product | | • Returnable bottle |
| Waste | Internal Value | • Used wash water as substitute water for non critical applications |
| | External Value | • Used wash water as substitute water for non-critical applications |

**Figure 18 – Root cause analysis in case of bottle washer operation**

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 the bottle washing operation typical RECP practices are applied to generate water savings and waste water minimization options and improve the efficiency of the bottle washer:

| RECP Practices | | Some examples (bottle washing operation) |
|---|---|---|
| Input Change | | • More efficient cleaning agents/sanitizer<br>• Low BOD/COD cleaning agents |
| Good Housekeeping | | • Standard operating procedure<br>• Improved operator awareness |
| Plant Modification | Process Control | • Improved control of water pressure, flow and temperature |
| | Equipment Modification | • Use low flow high pressure wash 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 |

**Figure 19 –Generation of RECP options to improve the bottle washer operation**


### 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)
- Estimations 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 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;<br>Low flow valves or restrictors on taps;<br>Aerators on taps, showers, etc.<br>Self-closing taps, water;<br>Operate laundry, dishwashers and other equipment at full load. |
| Cleaning | Establish clear procedures;<br>Prioritize dry clean up first;<br>Replace leaking hoses and worn out nozzles;<br>Use efficient spray nozzles with automatic shut off;<br>Clean up with recovered (process) water. |
| Cooling | Monitor and manage blow down rates and feed water quality, possibly automate;<br>Implement or improve condensate return;<br>Improve external and internal feed water treatment;<br>Maintain and repair steam lines, condensate traps, etc.<br>Rationalize steam system over time. |
| Boiler & Steam system | Monitor and manage blow down rates and feed water quality, possibly automate<br>Implement or improve condensate return<br>Improve external and internal feed water treatment<br>Maintain and repair steam lines, condensate traps, etc.<br>Rationalize steam system over time. |

## MODULE 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 minimize waste.

**Key elements**

**What ? Global, national and business concerns**

**Why? Benefits for businesses**

**How? RECP for materials efficiency and waste minimization**

**Expected results**

**Waste profie**

**- Material use, consumption and cost**

**- Types of waste, volumes and sources**

**RECP Options to increase materials efficiency and minimize waste**

### Global concerns

The global materials consumption rose by 80% between 1990 and 2008 and continues its ascendant trends; according to UNIDO this will triple by 2050, assuming that all countries catch up to OECD levels from 2030 onward. The intense use of materials is associated with increasing extraction rates and lead to depletion of natural resource stocks and scarcity of indispensable materials, such as rare metals. The extraction, processing, transport, use and disposal of materials (e.g. pollution, waste, and habitat disruption) exert environmental pressure and have dramatic effects on environmental quality (e.g. air, climate, water, soil, biodiversity, and landscape), ecosystems and human health.

## National concerns

### Business concerns

The companies are dependent on raw materials in order to produce their goods. The increasing use of materials raise the demand on the market and influences the international trade and market prices of raw materials. Due to small conversion rates of input material into finished goods, high quantities of raw materials are wasted. The access to quality and affordable raw materials and the ability to maximize their conversion into products influence the productivity and competitiveness of the companies. Interrupted supply of materials or lacking access to waste infrastructure induce loss of production while poor waste management and illegal dumping could lead to suspension of operating license

### 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;

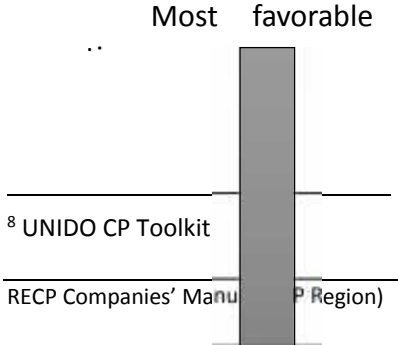
Assuming responsibilities however, contributes to a positive perception of the company within the community, motivates the employees and improves relations with community and other relevant stakeholders including the environmental agencies.

## 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"[8]. 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.

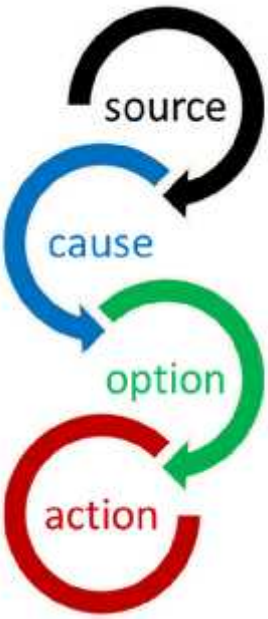
The major goal is to find solutions that are tackling the problems at the source, and this is also the first approach in the waste management hierarchy.




[8] UNIDO CP Toolkit


**Figure 20 Waste hierarchy**

## Improving materials use and minimizing waste by applying RECP




Source: Where is materials used water used for what purpose and with what material losses?

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

Option: How to minimize material inefficienices, losses and waste generation ?

Action: Start implementing RECP options to minimise the use of materials 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.<br>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. |


Root Cause Analysis - 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;

| Root Cause Category | | Some examples (product breakage in ceramics production) |
|---|---|---|
| Process Inputs | | • Quality of incoming clay |
| People | | • Inappropriate handling of molded clay<br>• 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 |

**Figure 21 Root cause analysis for product breakage in ceramics production**


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 belongs to typical RECP practices categories:

| RECP Practices | | 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 in the kiln |
| | Equipment Modification | • Modify conveyers and handling system to reduce wear on products |
| | Technology Change | • Energy efficient burners |
| Product Modification | | • Review/modify product forms to eliminate weak points<br>• Dematerialize product - thinner |
| Reuse | On Site Reuse | • Recover un-fired clay for internal reuse |
| | Useful By Product | • Offer ceramic waste as fill material – concrete, road etc. |

**Figure 22 Generation of RECP options for minimization of product breakage in ceramics production**


## 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)
- Estimations of energy conservation
- Estimation of investments and annual savings

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 & product dispatch | Improved inspection and strict acceptance criteria<br>Minimization of inventory (Just in Time), including its diversity<br>First In First Out warehouse management<br>Adequate storage conditions with controlled access<br>Purchase in appropriate quantity and with minimum packaging<br>Production planning to follow sales/order |
| Production waste | Extend product runs to minimize waste from start up/shut down<br>Schedule product runs to minimize cleaning<br>Recover cleared out product for reuse in next batch<br>Reduce stress from equipment on products<br>Maintain even process conditions (better mixing, heating, cooling) |
| Fit for<br><br>Minimize<br>Use dosing<br>Coolants, | Auxiliary processes | Purpose to extend use and minimize<br>consumption and waste<br>diversity, where possible<br>systems, where appropriate<br>lubricants, cleaning agents, etc. |
| Office & canteen | Go paperless;<br>Use recycled paper<br>Select reusable/refillable products<br>Use recycled paper and office products<br>Waste segregation<br>Staff motivation<br>Reusable cups & cutlery;<br>Buy local;<br>Avoid single dose packing |

## MODULE 5 – CHEMICALS, HAZARDOUS WASTE AND EMISSIONS

This module's main purpose is to guide companies to better understand the chemicals use, chemical risk and types of hazardous waste and emission, understand the factors influencing them, perform a root cause analysis of the inefficiencies and generate RECP options to improve chemical use and minimize hazardous waste and emissions.

**Key elements**

**What ? Global, national and business concerns**

**Why? Benefits for businesses**

**How? RECP for chemicals efficiency and hazardous waste and emissions minimizations**

**Expected results**

**Chemical profie**

**- Chemical use, consumption and cost**

**- Chemical risk**

**- Types of hazardous waste and emission, volumes and sources generated**

**RECP Options to increase chemicals efficiency and minimize hazardous waste and emissions**

## Global concerns

Chemicals are part of our daily life. Chemicals are intensively used in industries and the growth trends and the changes in global production will increase even more the use of chemicals. Presently, more than 80,000 chemicals are used in production processes and operations, a multitude thereof can possibly be created and released in routine operations or during accidents. These trends affect all countries and require responsible use and management of chemicals, as part of necessary solutions to control risks and the generation of hazardous waste and emissions.

Chemicals and chemical waste are at the origin of air, water and soil pollution and are a major factor wildlife loss. Chemicals released into the air can act as pollutants, greenhouse gas emissions and ozone depleters and contribute to acid rain formation. Chemicals contaminate the water resources through direct discharges to the water bodies or indirect contributions of air pollutants and have adverse effects on water quality and aquatic organisms.

## National concerns

## Business concerns

Chemicals are typically expensive materials as well as cost associated with elimination of hazardous waste generated. The cost paid by businesses is often influenced by inefficient supply, improper use of chemicals or poor chemicals management. Besides cost, there are serious risks implications out of unsafe use that could affect the business operations and facilities, the workers' health and the environment. Using hazardous chemicals in high amounts could have additional legal implications, increase the risk and the need for pollution control, monitoring and reporting. Dumping of hazardous waste, emissions released into the air, water or soil have adverse effects on air, water and soil.

## Business benefits

Businesses could benefit out of efficient and responsible use of chemicals by cutting cost, improving business security and increasing the social responsibility of the company.

| | |
|---|---|
| Direct and indirect savings | Reducing chemicals input results in direct cost cut with supplied chemicals or indirect cost cut with hazardous waste disposal and reduction of risk and pollution control. |

| | |
|---|---|
| Business security | Identifying and understanding the risks out of chemical use and hazardous waste handling ensures better risk control, safer operation, and compliance with applicable legal requirements. |
| Social responsibility | Engaging with business partners to improve chemicals safety and keeping the workers updated on chemicals hazards and handling procedures, contribute to positive impact on workers' health and safety, enhance risk awareness and emergency preparedness and improve relations with community. |

## What are chemicals and how are they classified?

A chemical could be:

**A Substance**: chemical elements and their compounds in the natural state or obtained by any production process;

**A Mixture**: mixtures or solutions compose of two or more substances in which they do not react;

**An Alloy**: metallic material consisting of two or more elements so combined that they cannot be readily separated by mechanical means.

After type of use in industry chemicals could be divided in the following categories:

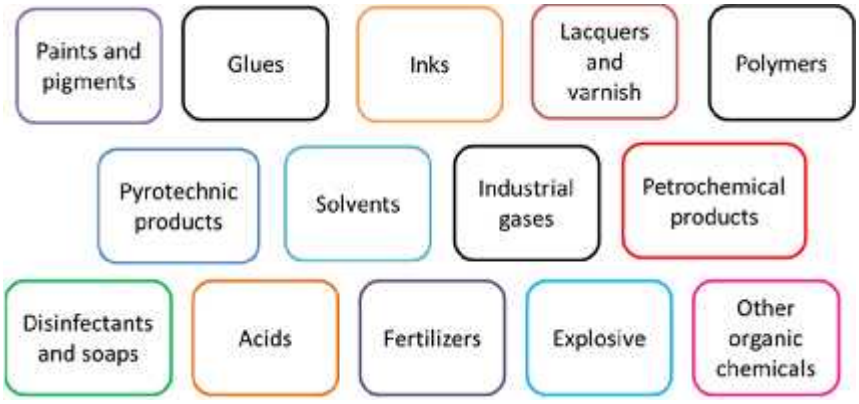



**Figure 23 Types of chemicals used in industry**

The chemicals are subject to many international and European regulations, conventions and treaties translated in many countries into the national legislations. The UN Globally Harmonised System of Classification and Labelling of Chemicals is an international non-binding treaty that harmonise criteria for classification of substances and mixtures, and hazards communication elements. The hazard classification and labelling systems addresses potential exposures to

all potentially hazardous chemicals, in all types of use situations, including production, storage, transport, workplace use, consumer use, and presence in the environment, and are intended to protect people, facilities, and the environment.

The GHS classification system is based on chemicals intrinsic properties; chemicals are classified according to their physical, health and environmental hazards. The hazards are communicated through:

**a) Labelling:**

- ✓ **Chemical identity** (UN number, CAS number)
- ✓ **Pictograms** – graphical composition that includes a symbol
- ✓ **Signal words** - word used to indicate the relative level of severity of hazard and alert the reader to a potential hazard on the label, e.g., DANGER


**Figure 24 Chemical hazards pictograms**

- ✓ **Hazard statements** – a phrase assigned to a hazard class and category that describes the nature of the hazards of a hazardous product, including, where appropriate, the degree of hazard, e.g.: harmful to aquatic life H402
- ✓ **Precautionary statements** - phrases (and/or pictograms) that describe recommended measures that should be taken to minimise or prevent adverse effects resulting from exposure to a hazardous product, or improper storage or handling of a hazardous product, e.g.: Prevention, codes P2xx[9]

**Figure 25 Precautionary pictogram**

- ✓ **Supplier information**
- ✓ **Shipping information**

**b) Safety data sheets**

[9] Definitions by GHG, UN 2013

Safety data sheets (SDS) are the main tool for ensuring that PRODUCERS and SUPPLIERS of chemicals communicate enough information along the supply chain to allow safe use of their substances and mixtures. It provides information regarding the safe use of chemicals at the work place enabling the employer to develop protection measures at the work place and to consider measures for protecting the environment.

**Chemical waste or hazardous waste** is defined as any unnecessary or excess use of chemicals that could be harmful for human health or the environment and/or compound or materials containing chemicals that requires safely disposal. Chemical waste streams include all chemical losses due to chemicals input materials (oversupply or wrong supply, expired and unlabelled chemicals), processes (by products, used chemicals and pollutants released) and materials contaminated with chemicals.

## What is chemical risk and how to evaluate?

Small companies have the tendency to undermine the risks resulted from chemicals use often due to lack of information and education. The use of chemicals and hazardous waste handling implies accident, health and safety and environmental risks. The risk is given by the intrinsic hazards of chemical agents in use, frequency/duration of exposure, quantity of chemical agents used and or present in the facility, method of use and/or storage.

In order to assess the **risks potential**, all possible accident scenarios should be identified, possible **occurrence** and **severity** of their impact on workers' health, communities, environment and economics:

**Risk = Frequency x Severity**

**10**


**Figure 26 Example of risk rating**

[10] Promoting Resource Efficiency in Small & Medium Enterprises: industrial training handbook, UNEP. 2010

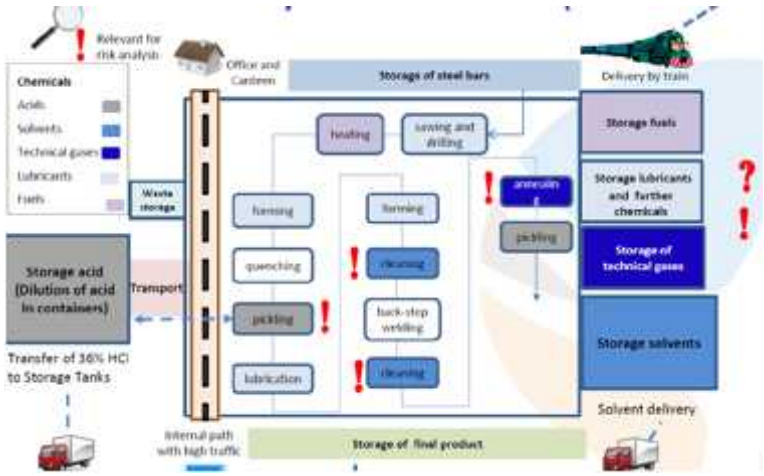
The acceptability of risk is decided on basis of multiplication of frequency and severity. In the above example a total score for risk between 10 and 14 need high level of control while a risks with total score > 14 are is considered inacceptable.

Risk assessment is performed in steps according to following methodology[11]:

- Identify the chemicals, their quantities and the hazards involved
- Identify hazard hot-spots paying particular attention to the use, storage and handling of large volumes and/or hazardous chemicals
- Identify risk prone and vulnerable groups, areas and assets in case of an accident
- Identify potential accident scenarios related to each hazard hotspot
- Identify the severity of related health, environment, social and economic impacts in an accident situation
- Estimate the likelihood of the identified accident taking place
- Assign a risk factor to each hazard hotspot
- Priorities the hazard spots
- Map hazards spots
- Provide an emergency plan to respond to incident and accidents might occur

In order to identify the chemical use and the associated risks the processes and activities using chemicals are scanned and listed. For more detailed evaluation, simple process flowcharts could be drawn and chemicals uses identified from the first activity to the last; chemicals quantities and hazards associated to each activity or process step are marked on the flowchart. The information could be transposed at the company scale by transferring the identified hazard spots to the floor plan. The results out of this exercise is the hazards' hotspot map that clearly shows the chemical use in different stages of the processes, the quantities and the specific hazards

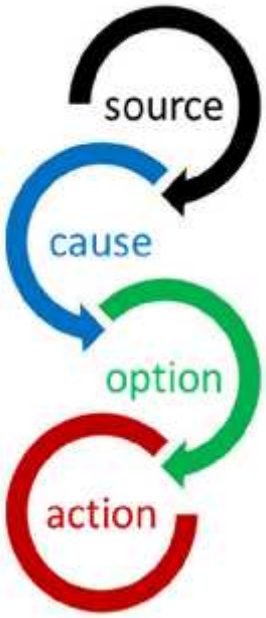
12




[11] Promoting Resource Efficiency in Small & Medium Enterprises: industrial training handbook, UNEP. 2010
[12] Sonya Bauer, 2015 - Hazard Management

Figure 1 Hazards hotspot map

## Improving chemical efficiency and minimizing hazardous waste by applying RECP




Source: Where are chemicals used for what purpose and what is their fate (product, conversion, waste)?

Cause: What factors influence the use and fate of chemicals?

Option: How to minimize the causes of high usage of chemicals and their undesired fate, including possible release into environment?

Action: Start implementing chemicals efficient and responsible use options.


### Understanding the use of chemicals and chemical waste generation

Getting better information about the chemicals supplied, the chemicals use, and internal procedures for handling chemicals and storage, all potential sources of chemical waste are the first steps in the optimization of chemical use and minimization of hazardous waste.

#### Where are chemicals used for what purpose and what is their fate

Chemicals could be used in production /products and in auxiliary processes; In order to identify the chemical use and the associated risks, the processes and activities using chemicals are scanned and listed along with quantities, cost and classification according to GHS.

- Chemicals used in production – all chemicals used in products/production are recorded, their place of use and purpose in product(ion), the theoretical chemical requirement per unit of product(ion) and the actual consumption, given this way the possibility to evaluate the chemicals losses as a percentage % of theoretical chemicals requirement.
- The chemicals use in auxiliary processes are separately listed, the place and purpose of use, quantities and final destiny (where does the chemical ends up?)


What are the types and quantities of hazardous waste and emissions? Where are they generated?

The chemicals in use are at the origin of hazardous waste. Hazardous waste includes all chemical losses due to: chemicals input materials (oversupply or wrong supply, expired and un-labelled chemicals), processes (by products, used chemicals and pollutants released) and output materials (materials contaminated with chemicals, any chemical waste stream). Hazardous waste streams should be characterized and quantified: annual quantities, elimination cost and destination are recorded in relation with their source of generation. The types and quantities of emissions generated (air, water) are recorded and main source of generation are identified.

Data collection - Chemicals inventory and hazard classification

Building up and updating the chemicals inventory helps the systematic identification of chemicals that are stored, handled and used in the company. Such inventory is gathering information related to: types of chemical and their composition, monthly and annual consumptions, expiration date, types of hazards, types of storage, chemicals cost. The sources of information are data from suppliers, in particular the chemicals' safety data sheets, supply notes, internal storage records, or accounting documents.

Root Cause Analysis – the main question is how to minimize the high usage of chemicals and their undesired destiny, including possible release into environment. Having identified, quantified and characterized chemical uses, the hazardous waste streams and sources, and the factors influencing them, the next step is to conduct a root cause analysis by applying typical causes related to:

**Plant**: old technology, process design, process control, improper maintenance

**Process inputs**: choice and quality of chemicals, various types of hazardous chemicals in use, supplying process, poor handling and storage;

**People**: mishandling, behavior and attitude, lack of knowledge about risks for humans and the environment

**Product**: product design, customer specifications, quality requirements

**Waste** of internal and external use

Exemplification of root cause categories for textile dyestuff is provided bellow:

| Root Cause Category | | Some examples (textile dyestuffs) |
|---|---|---|
| Process Inputs | | • Choice of dyestuffs and auxiliary textile chemicals<br>• Quality of yarn/fabric to be dyed |
| People | | • Operating practices of workers<br>• Prevailing attitudes that spills and leaks are normal |
| Plant | Process Control | • Operating ranges for temperate, pressure and time of dyeing |
| | Equipment | • Liquor ratios of dyeing equipment and exhaustion levels achieved |
| | Technology | • Use of exhaust dyestuffs |
| Product | | • Customer specification of color and dyed cloth features |
| Waste | Internal Value | • Drained dye liquors still contain un-exhausted dyestuff |
| | External Value | • Drained dye liquors and subsequent wash waters might still be useable in uncritical applications outside company |

**Figure 27 Root cause analysis in the case of textile dyestuff**

Generation and evaluation of chemical efficiency and hazardous waste an emissions minimization options is performed by applying the standard RECP practices to all causes of inefficient use of chemicals and hazardous waste and emission generation.

In the example of textile dyestuff, the generated options are part of the typical RECP practices

| RECP Practices | | Some examples (textile dyestuffs) |
|---|---|---|
| Input Change | | • Advance generation dyestuffs with higher exhaustions<br>• Low BOD/COD and or biodegradable textile chemicals |
| Good Housekeeping | | • Standard operating procedure<br>• Improved operator awareness |
| Plant Modification | Process Control | • Improved control of operating pressure, flow, temperature and time in dyeing equipment |
| | Equipment Modification | • Reduce liquor ratio of dyeing equipment<br>• Improve mixing in dyeing equipment |
| | Technology Change | • Change from wet dyeing to chemically dyed synthetic blends |
| Product Modification | | • Extend production runs, lax color specifications |
| Reuse | On Site Reuse | • Dyes not recoverable, water reusable, including for heat recovery |
| | Useful By Product | • Dyes not recoverable, water reusable, including for heat recovery |

**Figure 28 RECP options for chemical efficiency and hazardous waste and emissions minimization in case of textile dyestuff**


### Implementation and continuation

Preliminary evaluation of RECP options for efficient use of chemicals and hazardous waste and emissions minimization is performed and consist of:

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

Simple options referring to possible improvements of the chemicals purchasing, handling and storage, recording and risk evaluation, chemical waste segregation and safe disposal should be implemented in the shortest time while more 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 chemical efficiency and minimize chemical waste generation:

Three types of options are interesting when dealing with chemicals:

- Options to reduce chemical risk
- Options to reduce chemical input
- Option to reduce chemical waste

These could be assigned to typical RECP practices, ranging from:

**Good housekeeping**: in time delivery, avoidance of unnecessary supply, right size containers, chemicals inventory and labeling, correct collection, storage and labelling of hazardous waste

**Utilization**: good knowledge and application of applicable legal requirements, internal procedures for supplying, storing, handling and disposal of chemicals, employee's education information, technical and organizational measures to protect the employees' health

To more complex and higher impact options:

**Input change**: substitute chemicals, eliminate the use of toxic chemicals when possible, reduction of the overall amount of chemicals used in the processes, reduction of the chemicals numbers in use

**Plant modification**:

- Process control: Shift to less harmful chemicals or “chemical less” processes, reduction of the overall amount of chemicals used in the processes
- Technology change

**Product modification: r**eplacement of harmful chemicals from product design phase

**Waste** on site and external reuse and recycling

## MODULE 6 – IMPLEMENTATION AND ACTION PLANNING

The main aim of the final module is to provide the method and the framework that support implementation of the RECP options that have emerged from the detailed analysis of:

Energy, Water and Waste Water, Materials and Waste, Chemicals, Hazardous Waste and Emissions.

### How to develop an Action Plan?

The RECP Action Plan main objective is to facilitate implementation of RECP options that have proved to be profitable and due to their tangible benefits are approved by the management.

Performing the detailed evaluation of resource use, effluent, waste and emissions generation, identifying the causes for inefficiency and generating RECP opportunities will bring the company to the status of having identified the RECP opportunities for each thematic area and preliminary evaluations performed.

The Action Plan starts to be developed over the course of the program; RECEP opportunities generated for each thematic area are listed in the part 2 – 5 of the Self-Assessment tool and their preliminary evaluation is performed by estimating:

- Technical and organizational complexity (low/medium/high)
- Resource conservation reduction
- Waste and emissions minimizations
- Investments and annual savings

From this point onward, the next steps shall be taken to develop the Action Plan:


**Figure 29 Main steps for developing the RECP Action Plan**

Elaboration of the consolidated list of options

RECP options generated during the assessment of thematic areas and listed together and organized per unit of operations. Mutual interferences and exclusions or possibilities to combine are considered in this step; the results of this exercise is the consolidated list of optons.

Screen RECP options

RECP options from the consolidated list are sorted, assigned to one of the following categories and discussed with the management.

- RECP options for immediate implementation
- RECP options to be evaluated in detail
- RECP options rejected

Define the Catalogue of agreed RECP options

The resulted **Catalogue of RECP Options** is the starting point in elaboration of the RECP Action Plan. Options for immediate implementation should be considered first and proceed with their application. Complex options require detailed analysis and for this purpose

feasibility studies are performed to assess related technical, economic and environmental aspects. (main steps described in the following section).

### Decide on next tasks

The tasks required to support the RECP options implementation are defined based on the type of option. Those could belong of one of the following groups :

- **Implement** - do what is useful to implement the option
- **Measure** - collect additional information on process inputs and outputs;
- **Refine** - work out technical details how to implement option;
- **Evaluate** - detailed technical and economic feasibility analysis for complex options

### Decide on cross cutting improvements

Sustaining RECP activities requires additional management tasks that are not linked to just one option but contribute to cross cutting improvements; those could relate to improved management leadership and commitment, establishing a business strategy that enclose short, medium and long term objectives, addressing environmental and resource efficiency issues in a systematic manner, motivate employees and involve them in the innovation process. Examples of such tasks could be :

- Monthly reporting of water and energy use
- Install environmental benchmarking system
- Implement environmental management system
- Implement environmental accounting system
- Develop an environmental statement of the manager
- Establish the RECP achievements communication day
- Increase knowledge of staff through technical training
- Environmental suggestion box
- Employees awarding

## Evaluation of complex RECP options

Feasibility studies are performed to assess technical, economic and environmental aspects of complex RECP options. The feasibility study it's a detailed analysis of those measures that are technically and/or economically more complex and often require financial investments. The approval of their implementation is a business decision that should be well documented in terms of technical and operational feasibility, economic feasibility and environmental feasibility. The feasibility studies integrate results of technical, economic and environmental evaluation:

Technical evaluation and organizational evaluation - consist of identification and evaluation of required new equipment and necessary changes in existing plant infrastructure and assessment of the impact of the respective option. The main questions to be asked are:

- Will it work?
- What do we have to do to make it work?
- What will we gain?

Economic evaluation is intended to estimate the economic benefits of all above described reductions plus less obvious financial benefits out of reduced sick days, reduced liabilities, potential profits from sale of waste or by products, etc. Estimations of the economic cost of each option will require calculations of investments and depreciation cost of new technology, training and personnel cost, outside service cost, etc.

Environmental evaluation is intended to analyze what are the benefits for the environment out of options implementation; benefits are measured in pollutants and waste reduction, toxicity of emissions reductions, decrease of energy, water and material consumption, hazardous waste and toxic chemicals reductions, decrease of noise level or risks for the environment and workers.

Results of technical, economic and environmental evaluation are integrated and the options with highest profitability are selected and have first priority for implementation.

## Monitoring RECP Benefits

The main question is: "How do I measure the performance?"

In order to track performance out of RECP options implementation and the success of the project, a new set of RECP indicators should be calculated and compared with baseline. The baseline data established at the beginning of the project (annual consumptions of materials, water, energy, waste, pollutants and initial RECP indicators) is examined. Similar data is gathered after one year implementation and total benefits achieved (total investment, annual saving and annual environmental benefits) are documented and a new set of RECP indicators are calculated;

The progress is tracked by comparing the initial RECP indicators with the one/two/… years post implementation RECP indicators; an example is offered in the following:

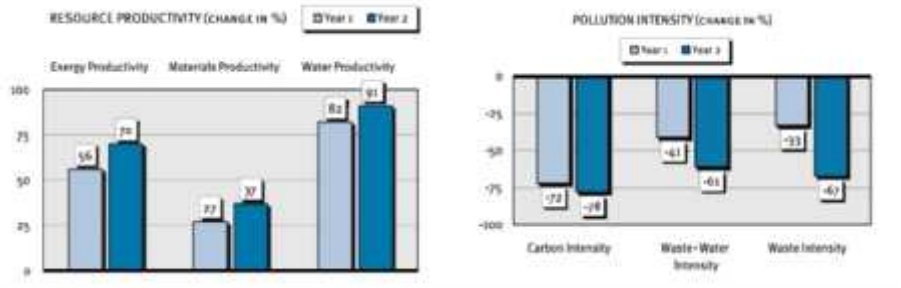



**Figure 30 Evolution of RECP indicators (Enterprise-Level Indicators for Resource Productivity and Pollution Intensity)**

In the above example, RECP has been implemented throughout two consecutive periods, and in addition to the baseline, two follow-up measurements have been made. For energy productivity, the first follow-up measurement showed a 56% increase in productivity, i.e., the company was producing 56% more product output per energy unit.

The second follow-up measurement showed a 70% increase in productivity, again compared to the baseline. This means that the company had increased its productivity by 14% during the period between the first follow-up measurement and the second follow-up measurement[13].

## Sustaining RECP

RECP is not a singular approach but rather a continuous improvement process; if applied consistently and continuously brings important environmental and economic benefits to the company.


[13] UNIDO RECP Indicator Primer, 2010

**Figure 31 – Important elements for mainstreaming RECP**

Success out of RECP application requires mainstreaming RECP in company's management and operations. The management shall have a clear understanding of losses and associated cost, be informed of RECP achievements and their impacts on companies' operation and profitability, enable creativity and motivate employees to get involved in the innovation process and anchor RECP in the existing management systems and business strategy of the company.