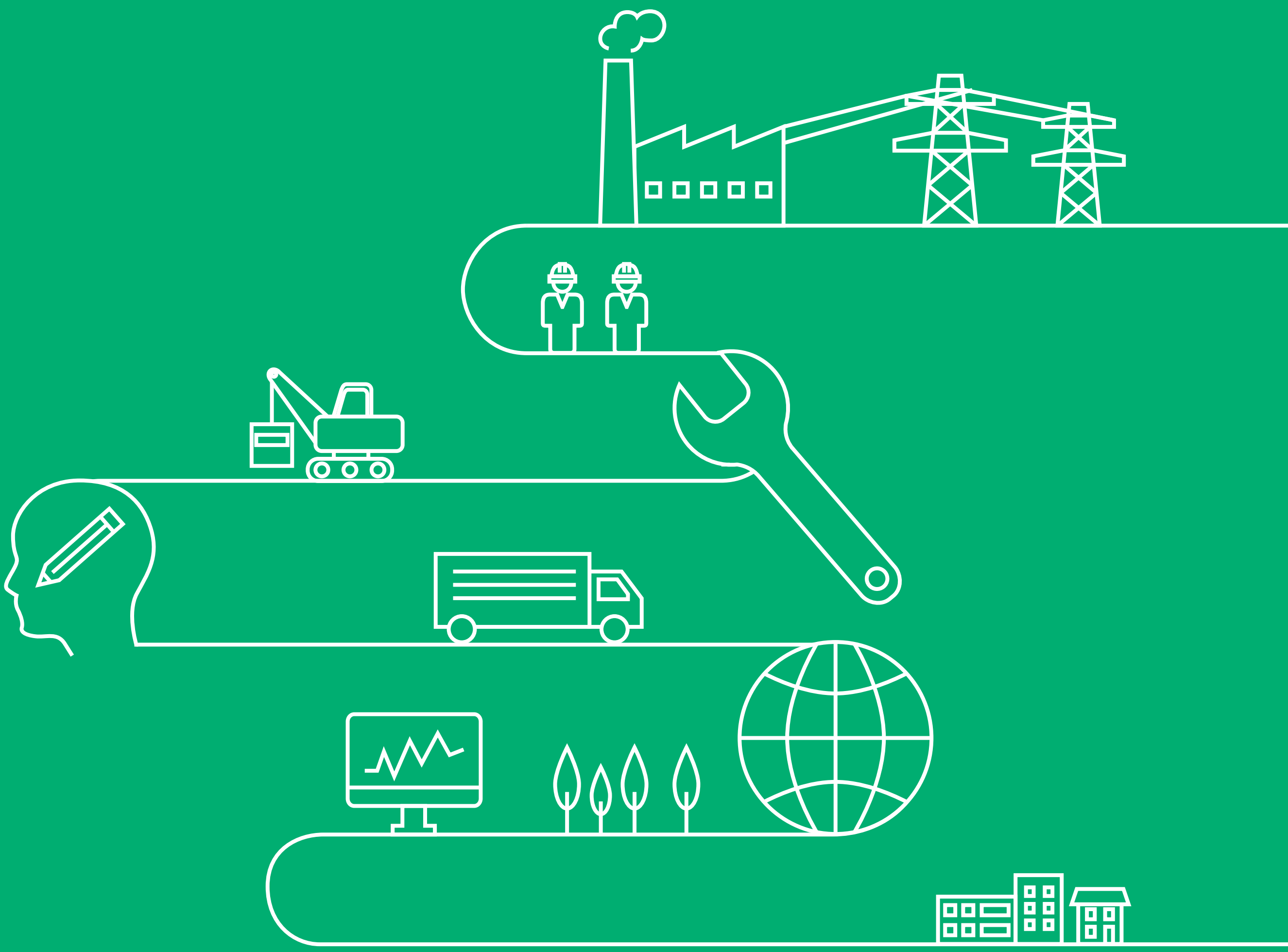
TEST GUIDELINES

# AN INTEGRATED APPROACH FOR SUSTAINABLE PRODUCTION IN THE MANUFACTURING SECTOR



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**For more information, please contact:**

Ms. Carolina Gonzalez Mueller
Department of Environment
Tel: (+431) 26026 3814
United Nations Industrial Development Organization
Vienna International Centre
PO Box 300, A-1400 Vienna, Austria
c.gonzalez-mueller@unido.org
www.unido.org

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AA1000 | Assurance accountability standard for corporate social responsibility |
| BAT | Best Available Technique |
| BREFs | BAT reference documents (also EU BREFs) |
| BOD | Biological Oxygen Demand (which can be specified further as BOD5 measured after 5 days of incubation) |
| CIP | Clean in Place or Cleaning in Place |
| $CO_2$ | Carbon dioxide |
| COP | Coefficient of performance |
| COD | Chemical Oxygen Demand |
| COMFAR | Computer Model for Feasibility Analysis and Reporting (UNIDO Software for evaluation of investments) |
| CSR | Corporate Social Responsibility |
| EM | Environmental Management |
| EMA | Environmental Management Accounting |
| EMS | Environmental Management System |
| EnMS | Energy Management System |
| ERP | Enterprise Resource Planning |
| EU | European Union |
| EUR | Euro |
| GRI | Global Reporting Initiative |
| G4 | GRI's fourth generation of Sustainability Reporting Guidelines |
| HACCP | Hazard Analysis and Critical Control |
| H&S | Health and Safety |
| IR | Initial Review (within ISO14001 standard) |
| IRR | Internal Rate of Return |
| ISO | International Organisation for Standardisation |
| ISO 9001 | Quality management systems: requirements |
| ISO 14001 | Environmental management systems: requirements with guidance for use |
| ISO 14004 | Environmental management systems: general guidelines on principles, systems, and supporting techniques |
| ISO 14006 | Environmental management systems: guidelines for incorporating Ecodesign |
| ISO 14021 | Environmental management: life cycle assessment; principles and framework |
| ISO 14044 | Life cycle assessment: requirements and guidelines |
| ISO 14046 | Environmental management: water footprint; principles, requirements and guide-lines |
| ISO 14064-1 | Greenhouse gases - part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals |

| | |
|---|---|
| ISO 14067 | Greenhouse gases - carbon footprint of products: requirements and guidelines for quantification and communication |
| ISO 14051 | Environmental management: Material Flow Cost Accounting standards (MFCA) |
| ISO 22000 | Food safety management systems: requirements for organization in the food value chain |
| ISO 26000 | Guidance on social responsibility |
| ISO 45 001 | Occupational health and safety management systems – Requirements with guidelines for use |
| ISO 50001 | Energy management systems: requirements with guidance for use |
| kg | Kilogram |
| KPI | Key Performance Indicator |
| kWh | Kilowatt hour |
| l | Litre |
| LCA | Life Cycle Assessment |
| LCCA | Life Cycle Cost Analysis |
| $m^3$ | Cubic meter |
| MFCA | Material Flow Cost Accounting |
| M&T | Monitoring and Targeting |
| NPO | Non-product Output |
| OPI | Operational Performance Indicator |
| PBP | Pay-back Period |
| PLC | Programmable Logic Controller |
| PPS | Production Planning System |
| QMS | Quality Management System |
| RECP | Resource Efficient and Cleaner Production |
| RECPA | Resource Efficient and Cleaner Production Audit |
| RE | Resource Efficiency |
| ROI | Return on Investment |
| SA 8000 | Social Accountability Standard |
| SCP | Sustainable Production and Consumption |
| SETAC | Society of Environmental Toxicology and Chemistry |
| SEUs | Significant Energy Uses |
| t | Tonne |
| TBD | To be defined |
| TEST | Transfer of Environmentally Sound Technology |
| UN Environment | United Nations Environment Programme |
| UNIDO | United Nations Industrial Development Organisation |
| WWTP | Wastewater Treatment Plant |
| y | Year |

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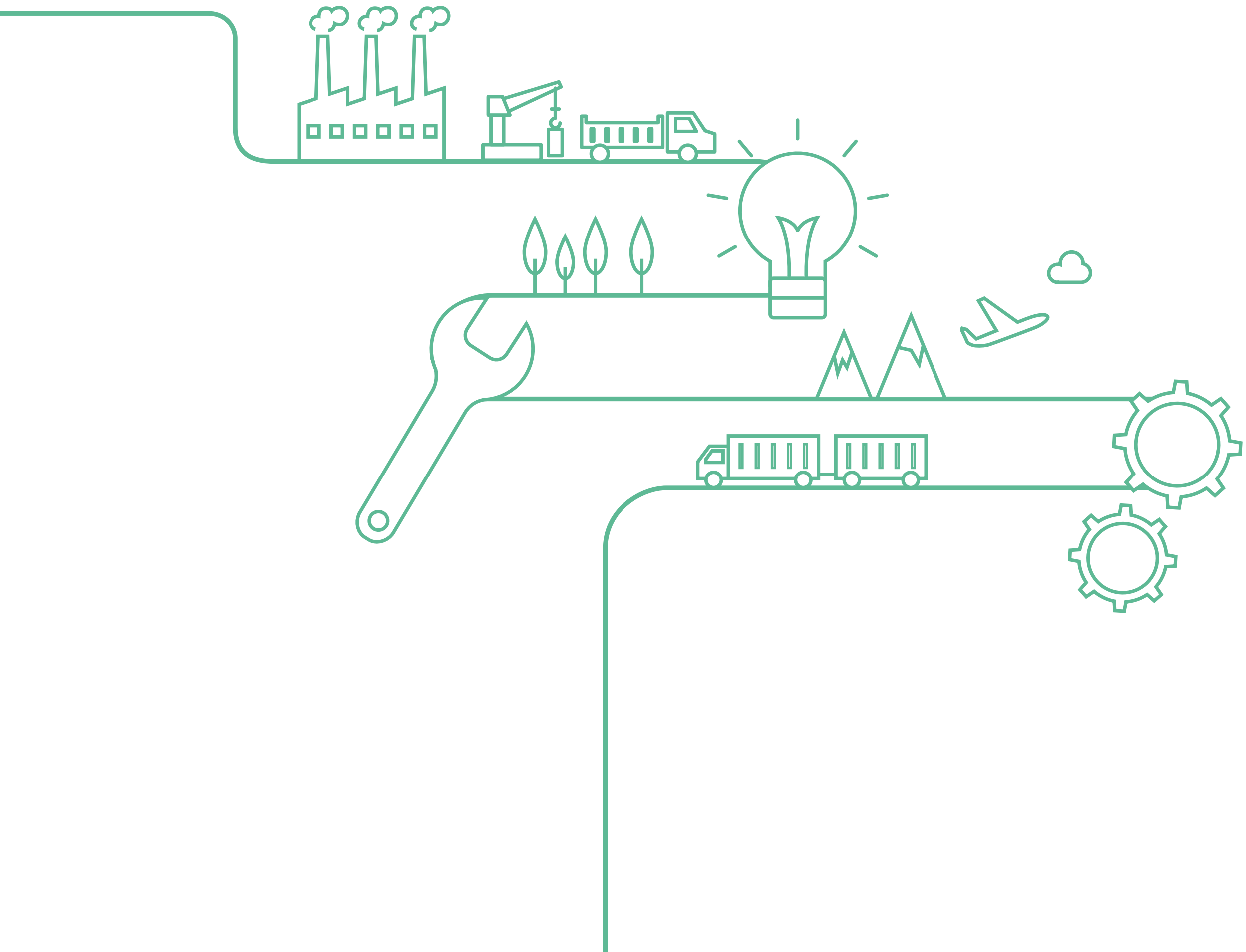

# INTRODUCTION

These guidelines were prepared by the United Nations Industrial Development Organization (UNIDO), Industrial Resource Efficiency Division of the Department of Environment, within the framework of the MED TEST II component of the EU funded SWITCH-Med initiative. This regional initiative aims at promoting the shift toward sustainable consumption and production (SCP) patterns in eight countries of the South European Neighbourhood (Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestine and Tunisia).

The intended users of these guidelines are service providers and practitioners in companies. The purpose of this document is to assist them in supporting companies wanting to shift towards sustainable production models, through the implementation of TEST projects. A secondary purpose of these guidelines is to assist development agencies and national authorities in designing and delivering technical assistance programmes to improve resource efficiency in the industrial sector.

The guidelines provide descriptions of the overall logic of the methodology and then of each step, giving links to tools to support implementation. The guidelines are part of the TEST training toolkit that incorporates other supporting materials (worksheets, exercises, presentations, case studies, etc.).

The primary sector which is aimed at in these guidelines is the manufacturing sector, although with appropriate modifications they could be used for any sector. In particular, the guidelines are aimed at supporting companies in the manufacturing sector with about 50 employees and over. [1]

The document is comprised of five chapters: this introductory chapter, which gives an overall description of the TEST approach, followed by four operational chapters describing each of the four phases of a complete TEST cycle. These four phases align to the Deming cycle: planning, support and operation, performance and evaluation, and improvement. As the main client for these guidelines are practitioners and service providers, the chapter on planning is the longest and most detailed since this is where they will be most involved in supporting companies. This chapter is therefore organized into 8 steps to guide the practical implementation of this very critical phase. The other three operational chapters are also described, because even in these phases companies can request support from practitioners and service providers.

Each chapter is described within a common structure:

- A rationale, which provides the overall justification for a particular step and its overriding logic;
- An action table, which summarizes the key activities to be undertaken, the required inputs, and expected outputs of that particular step;
- One or more case studies on the implementation of this step, which have been taken from enterprises that have implemented a TEST project in the Mediterranean context[2]; additional reference case studies are presented in appendix A to the guidelines including a full case illustrating implementation of TEST step by step in a company
- Tips, which lists a set of key recommendations and tips for implementing the step; in some chapters insights are highlighted in separate coloured boxes
- Finally, a table which provides links to the core elements for integration of RECP into management systems. Management systems (particularly EMS and EnMS) are the backbone for sustaining RECP in a company, and this section shows how each TEST step can support the creation of core management system elements where these are not in place, or how existing management system elements in a company can be upgraded to embed resource efficiency.
- It is recommended to follow the TEST steps as they are described in these guidelines so as to avoid suboptimal results. Nevertheless, since the implementation of the TEST approach is needs driven, some steps can be implemented at different degrees of complexity and depth, depending on a company's initial situation.

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[1] UNIDO has other tools, such as RECP clubs, which are more appropriate for small companies.

[2] The majority of the case studies have been developed within MED TEST II (SwitchMed initiative) and the remaining ones are from Med TEST I (Med Partnership initiative).

# SCOPE OF TEST GUIDELINES

## BACKGROUND

Over the past three decades, a range of concepts and tools have been developed to help industry to be more sustainable in its production and more efficient in its use of resources. These include pollution prevention, waste minimization, cleaner production, eco-efficiency, and eco-innovation, with a specific focus on waste, energy, and materials. These concepts and tools have the common objective of bringing two seemingly conflicting goals together, financial gain and environmental improvement. The term Resource Efficient and Cleaner Production (RECP), used throughout these Guidelines, refers to the adoption of cleaner production techniques to accelerate the application of preventive environmental strategies to processes, products and services, with the aim of increasing material and energy efficiency and reducing risks to humans and the environment. Throughout these Guidelines the term »resource efficiency« refers to both material and energy efficiency. Resource efficiency approaches are sought as building blocks of the Circular Economy.

The approach proposed in these guidelines, which it is called the TEST[3] approach, builds on all the concepts and tools mentioned above. However, it also includes some further specific features of its own.

Firstly, the TEST approach goes beyond the traditional »one-stop improvement« or »audit-like« approaches to resource efficiency in the system approach, driving continuous learning and improvement. It builds on:

i. the Resource Efficient and Cleaner Production Assessment (RECPA) methodology, which includes adoption of new eco-efficient technologies;

ii. an effective and supportive information system for material and energy flows and related costs based on Material Flow Cost Accounting (MFCA) principles;

iii. the core elements of an Environmental Management System (EMS) and an Energy Management System (EnMS) to sustain performance.

Secondly, TEST addresses all the levels of a business (operational, managerial, strategic), identifying the most important leverage points for improvement and the most appropriate tools for intervention. A company's success in increasing its resource efficiency is influenced not only by the management of material and energy flows at the process or product level, but also by the existing monitoring systems of these flows, by enterprise strategies and policies and, last but not least, by stakeholder values and the relationship which the enterprise has to them. Ultimately, with its systematic approach TEST helps companies build the environmental pillar of their Corporate Social Responsibility (CSR) strategy, paving the way towards the adoption of eco-innovation, eco-design and more circular business models.

Thirdly, TEST facilitates effective engagement of employees in a company who normally do not get involved in resource efficiency efforts and yet have a role in it, and by promoting teamwork it supports the collaboration of all these employees, with different responsibilities in the company and from different operational levels and who therefore usually have different views and priorities. Most importantly, TEST enables technical staff from the operational side of the business and managers/accountants from the financial side to understand each other and to work towards the same goal of turning waste and financial losses these represent into profits.

Finally, all the tools which are part of the TEST approach are customized in a way that matches the needs of an enterprise within its operating framework conditions and enhances organizational learning. This brings the desired level of flexibility, aligning expectations and capacities with achievable benefits within a manageable project cycle. This is particularly relevant for SMEs, which have limited internal capacities to undertake resource efficiency assessment.

As its name proclaims, TEST embeds in it the concept of »environmentally sound technology«. At one level, this concept includes those techniques, technologies, processes, materials and procedures which increase resource efficiency and reduce environmental damage by preventing pollution at the source, by recycling production residues or by valorizing them. At another level, it includes end-of-pipe technologies, since it is recognized that they are often needed at the end to meet emission limit values. End-of-pipe technologies can be very useful in treating pollution flows that cannot be prevented. However, they shift pollution from one environmental media to another and entail significant investment and operational costs. The TEST approach does not focus on end-of-pipe technology, instead its implementation results in minimized pollution control costs through the systemic exploration and adoption of effective preventive strategies.

## THE BUSINESS CASE FOR SUSTAINABLE PRODUCTION

The greening of industries has become a core determinant of economic competitiveness and sustainable growth within the paradigm shift toward a circular economy model. This means that industry should continue to produce, albeit in a sustainable way by decoupling growth and revenue from excessive and increasing resource use and pollution. Manufacturing companies in particular face a series of challenges and barriers to increasing the productivity of their operational process and making them more resource efficient (which includes being more energy efficient), less polluting, and safer. Companies also need new methods and business models to make products that are responsibly managed throughout their life cycle, while continuing to be able to access international markets with good quality products and complying with environmental standards.

Adopting the TEST approach allows enterprises to apply sustainable production models, resulting in the gain of the following benefits:

- increased productivity, reduced operational costs, improved product quality, optimized investments;
- minimized environmental compliance costs, reduced environmental /carbon footprint;
- new business opportunities in accessing new market segments (global supply chains, new green markets, green public procurement, etc.);
- mitigation of business risks due to disruption, shortage and price volatility in raw material supply chains;
- improved relationship with their stakeholders (investors, banks, regulatory bodies, local communities, consumer associations, etc.).

Experience has shown that the economic benefits that a company can enjoy from implementing sustainable production measures are often better than they expected, as resource efficient solutions can be highly effective in generating short-term returns on investment.

[3] Transfer of Environmentally Sound Technology

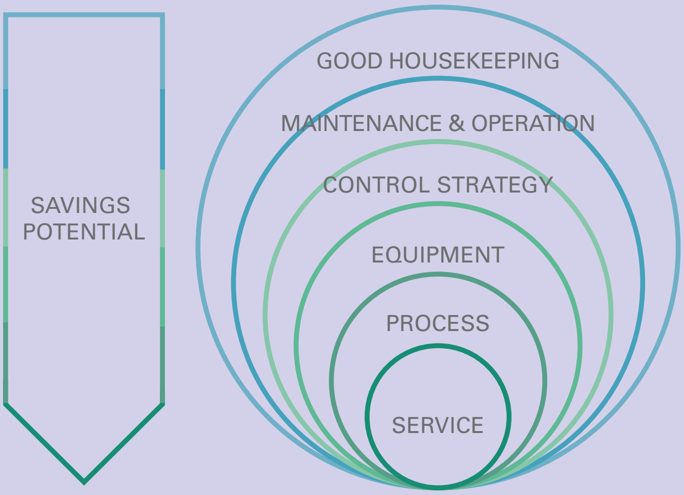
## RATIONALE FOR ADOPTING A TEST APPROACH

The core of the TEST approach is that it allows the companies which apply it to identify and implement the full potential of the environmental improvements hidden in their operations but also, and equally importantly, to exploit to the full the financial benefits arising from these improvements. The potential to enjoy financial benefits is essential for convincing companies to pursue sustainable production beyond the life of a project. Convincing them of this can be achieved by:

- Revealing the actual costs of resource use inefficiencies in their production processes along with the associated pollution, by quantifying the costs of all materials that have not left the manufacturing site as a product, but have become so-called non product outputs (NPOs). The purchase costs of all NPOs are typically at least one order of magnitude higher than the average expenses for waste disposal and emissions treatment. However, the latter costs are more visible in a company‘s accounting system, while material losses are often not recorded in its information systems. The concept and the methodology to calculate NPO costs builds on the ISO standard 14051 on Material Flow Cost Accounting (MFCA);

- Setting priorities by linking company goals in area of productivity and environmental management with the use of raw materials, water, energy and the generation of major losses (waste and emissions) - and benchmarking a company‘s performance with international best practices for the industry sector (when available, benchmarks can often provide a preliminary indication of achievable improvements);

- Identifying and investigating in detail the leverage points (sources and causes of major losses and pollution) to gain an in-depth understanding of the factors influencing key resource/energy consumers within a process, thus focusing on the core problems;




- Leak inspection programmes
- Performance monitoring (OPIs, pressure losses, energy use, etc.)
- PLC (programmable logic controller) for carbonation process
- Install $CO_2$ recovery plant to recycle $CO_2$ from bottle drying operations
- Replace liquid $CO_2$ with on-site $CO_2$ production from boiler flue gas
- Substitute $CO_2$ with filtered compressed air for drying bottles

FIGURE 1: Onion diagram for preventive strategies and resource efficiency measures in a beverage company ($CO_2$ material flow)

This chart illustrates different types of resource efficiency measures from good housekeeping to service that deal with the specific process needs for a defined material or energy flow. In this example, the selected material flow is carbon dioxide ($CO_2$), which is used in the product (carbonated soft drinks) and for drying bottles before product filling. Reducing the core process needs for $CO_2$ (e.g. by replacing $CO_2$ with filtered air for bottle drying operations) is the measure with the highest savings potential: implementing other resource efficiency measures before this one will lead to sub-optimal solutions.

- Using preventive techniques by challenging assumptions about the core process input needs when generating options for resource productivity and energy efficiency. This approach leads to the identification of an optimal set of measures with the least effort and highest benefits (see example in figure 1). The feasibility analysis of identified resource efficiency measures will incorporate economic savings associated with reducing the non-product output costs;

- Improving the information system on material and energy flows step-by-step, to allow regular monitoring of a company's performance through a set of indicators for important material and energy flows and productivity bottlenecks, enabling continuous generation of new resource efficiency opportunities.

The adoption of sustainable production strategies by companies needs the commitment and engagement of the different people who influence resource efficiency, not only inside an enterprise but also outside it (customers, suppliers, production managers, workers, etc.). Acknowledging this, the implementation of TEST has been structured into the four phases aligned to the learning cycle, also known as Deming cycle, used in the ISO standards. A company going through all the phases of the TEST cycle can initiate the required changes at each level of the management pyramid (fig. 2) to drive the process of continuous improvement of resource productivity patterns.

PLANNING
Pushed forward by management leadership, enterprise values, policies and strategies are used to establish smart objectives, planning, and step-by-step assessment;

SUPPORT and OPERATION
The necessary resources are provided and the actions are implemented;

PERFORMANCE EVALUATION
The results of implementation are monitored and evaluated against smart objectives and indicators while performance is reviewed by the top management;

IMPROVEMENT
Reflection on the experience gained at management level is used to update policies, strategies, or even business values - providing the basis for new planning and continuous improvement.

## THE MANAGEMENT PYRAMID

TEST is about change at the mind-set, policy, strategy, management system, process and in some cases even product level. Changes are effective and sustainable only if consistent throughout all levels of the management pyramid. The lower a level is on the management pyramid (closer to the strategic levels and interests of stakeholders), the more powerful it is for initiating and maintaining desirable changes. At the same time, these lower levels have a higher degree of resistance to change. It is, after all, easier to change technologies than the way people think (more information on related management of change can be found for example in Meadows 1997, De Palma 2010 or Dobes 2013).

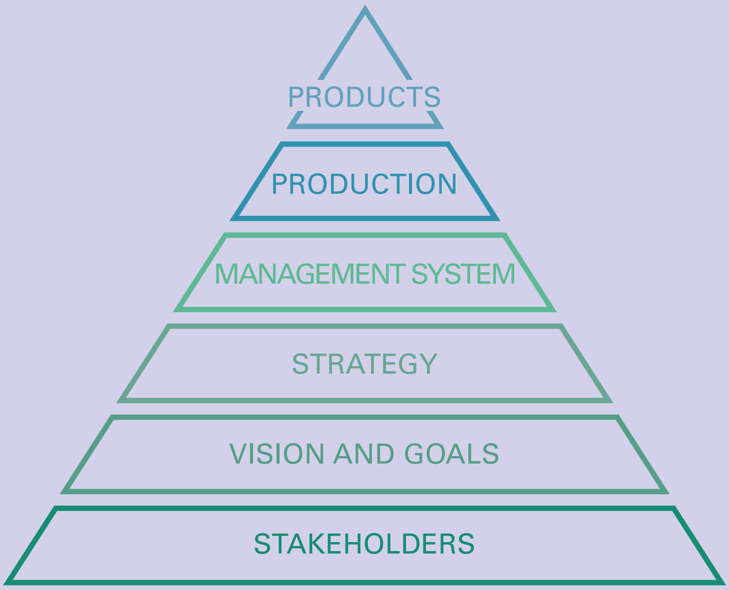



**Figure 2:** The management pyramid

The management pyramid is a way to systematically visualize the relationships among the key components of a business. The base of the pyramid represents the values of stakeholders and the relationship a business has with them. The second and the third levels of the pyramid respectively represent the vision/mission/core principles and goals, and the strategies for achieving them. The management systems provide the necessary links between the strategic and the operational levels of the business. The latter includes the company's operations, its means, and performance. The top of the management pyramid represents the desired outputs, products and/or services, which are directly connected to stakeholders' expectations.

## TOOLS FOR SUSTAINABLE PRODUCTION

There are several tools for supporting companies in integrating sustainable production into their operations and each tool does it from different perspective. Table 1 below summarizes the main characteristics of the most commonly tools used in the area of sustainable production, while figure 3 illustrates the level of the management pyramid upon which each of these tools primarily acts.

| TOOL | OBJECTIVE | FOCUS | LIMITATIONS |
|---|---|---|---|
| **Resource Efficient and Cleaner Production Assessment (RECPA)** | To improve resource productivity and environmental performance by feasible measures that also bring economic benefits to a company | Analysis of the root causes of important losses and use of different preventive techniques for generating solutions. | Lacks the information and management system for monitoring the efficiency of material/energy flows and for continuous improvement. |
| **Material Flow Cost Accounting (MFCA)** | To monitor material and energy flows and their related costs through setting up of an appropriate information system. | Tracking and monitoring the non-product outputs in both physical and monetary units (e.g. volume and money) by linking accounting and production data.<br><br>Reveals the actual costs of production inefficiencies and losses, including hidden environmental costs. | Focuses on annual or process-specific cost indicators and does not consider the dynamic baseline of industrial processes.<br><br>Does not address measures to improve physical performance and cannot bring the desired organizational learning on its own. |
| **Monitoring and Targeting (M&T)** | To control actual resource efficiency performance by setting up an information system correlating energy, water or material consumption data to relevant driving factors | Monitoring resource efficiency at the level of the whole company, specific cost centres or sources of losses.<br>It enables accountability for resource efficiency. | Difficult to implement in situations where driving factors cannot be easily defined.<br><br>Requires tools for identification of measures like RECPA. |
| **Environmental and Energy Management System (EMS & EnMS)** | To implement a company‘s environmental and/or energy policy in line with international standards based on a systems approach | Provides the backbone for linking all levels of a business and for managing its environmental/energy aspects for continuous improvement. | Does not provide a practical tool to identify measures to improve environmental performance. |
| **Corporate Social Responsibility (CSR)** | To integrate all sustainability aspects related to social, environmental, and economic dimensions into business strategy and operations. | Overall umbrella and approach for sustainable production tools, to manage business risks and opportunities, including the values of stakeholders. | Risk of it being only formally implemented as it requires changes on the most »difficult« level of the management pyramid that deals with enterprise values and strategies. |
| **Life Cycle Assessment (LCA)**<br><br>**Eco-design** | To analyse (LCA) and reduce (Ecodesign) environmental footprint of products and services along their life cycles, both upstream and downstream. | Addresses key environmental impacts of a product or service beyond manufacturing and stimulates the design of sustainable goods and services for a circular economy. | Requires additional tools to incorporate social and financial aspects.<br><br>Complexity and cost can be high, depending on the scope and type of product/service. |
| **Eco-innovation** | To stimulate incremental or radical changes in how products and services are delivered to minimize resource use and environmental impacts. | Targets products, processes, marketing methods, organizations and institutions to create new business models based on stakeholder’s expectations in the area of sustainability. | A complex process requiring significant organizational resources, proper policy incentives, and an enabling business environment. |

TABLE 1: Characteristics of sustainable production tools

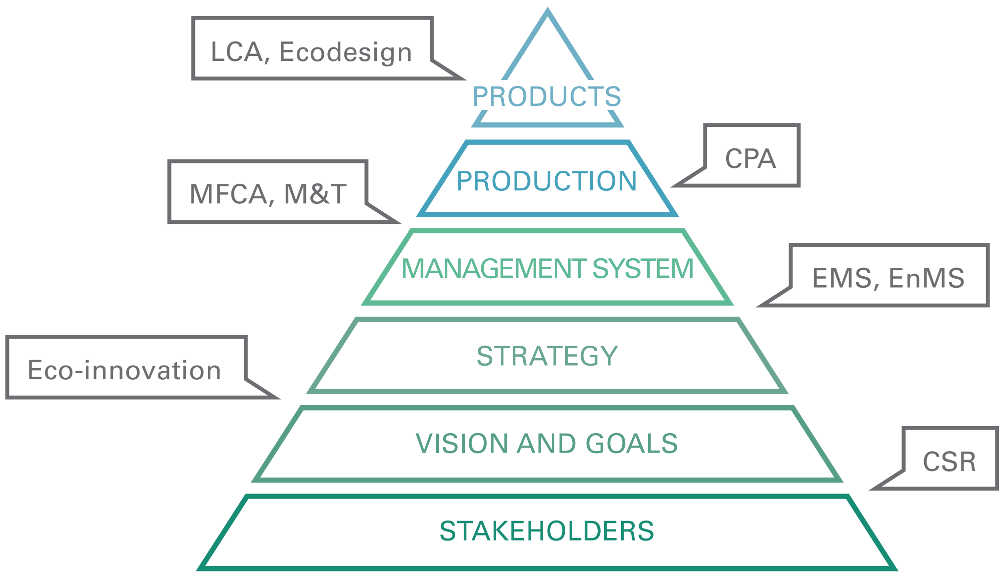



FIGURE 3: Principal focus of sustainable production tools in the management pyramid

The implementation of any individual sustainable production tool, although effective in identifying particular improvements, can easily lead to sub-optimal solutions. As a result, the company may have difficulties in initiating and maintaining the desired changes in the guiding ideas, strategies or systems and their alignment with sustainable production principles. Combined use of selected tools and their core elements can effectively accelerate organizational changes in the direction of sustainability, taking advantage of the complementarity and synergies of specific tools.

## OVERVIEW OF THE TEST APPROACH

The TEST approach is a systematic way of identifying and exploring the most feasible potentials for resource efficiency and continuous improvement of the use of materials, water and energy within a company, building on its specific needs and internal capacities.

It combines the essential elements of a set of tools for sustainable production, namely Resource Efficient and Cleaner Production Assessment (RECPA), Material Flow Cost Accounting (MFCA) and environmental and energy management systems (EMS/EnMS) within the framework of the learning cycle (Plan, Do, Check, Act). As a result of the customized integration and implementation of these tools and their elements, best practices, new skills and a new management culture are adopted, enabling the company to move forward toward more sustainable production business models.

At the centre of the TEST approach is the Resource Efficient and Cleaner Production Assessment (RECPA) tool, a step-by-step assessment of financially feasible options for improving the resource efficiency and environmental performance improvements of production systems. The core output of this tool is a portfolio of financially feasible solutions, including good housekeeping, operational control improvement, process and product modifications, eco-innovative technologies.

Elements of Material Flow Cost Accounting (MFCA) are built into particular steps of RECPA to strengthen priority-setting based on non-product output costs and to put in place ad hoc information- and monitoring systems for the important material and energy flows as well as for key areas/processes where major losses and consumption are occurring. An MFCA-based information system is necessary for monitoring the performance of implemented measures and programs to demonstrate their real impact on medium to long-term decisions. It also enables accountability of enterprise staff, as well as monitoring and reporting actual company performance against baselines and targets set up within smart objectives and key indicators. An effective information system enables control of resource efficiency by linking consumption of priority flows (recorded within MFCA) to specific driving factors (for example volume of production which has to be monitored separately). One of the best practices in this area is Monitoring and Targeting (M&T).

Core elements of Environmental Management System (EMS) and Energy Management System (EnMS) are used in TEST to integrate resource efficiency into the company's overall management systems, providing operating criteria and internal resources for ensuring that the outputs of improvement programs are implemented, sustained and further developed. EMS and EnMS which are designed in synergy with the implementation of RECPA and MFCA tools have a solid foundation for leading companies toward continuous improvements in their production patterns.

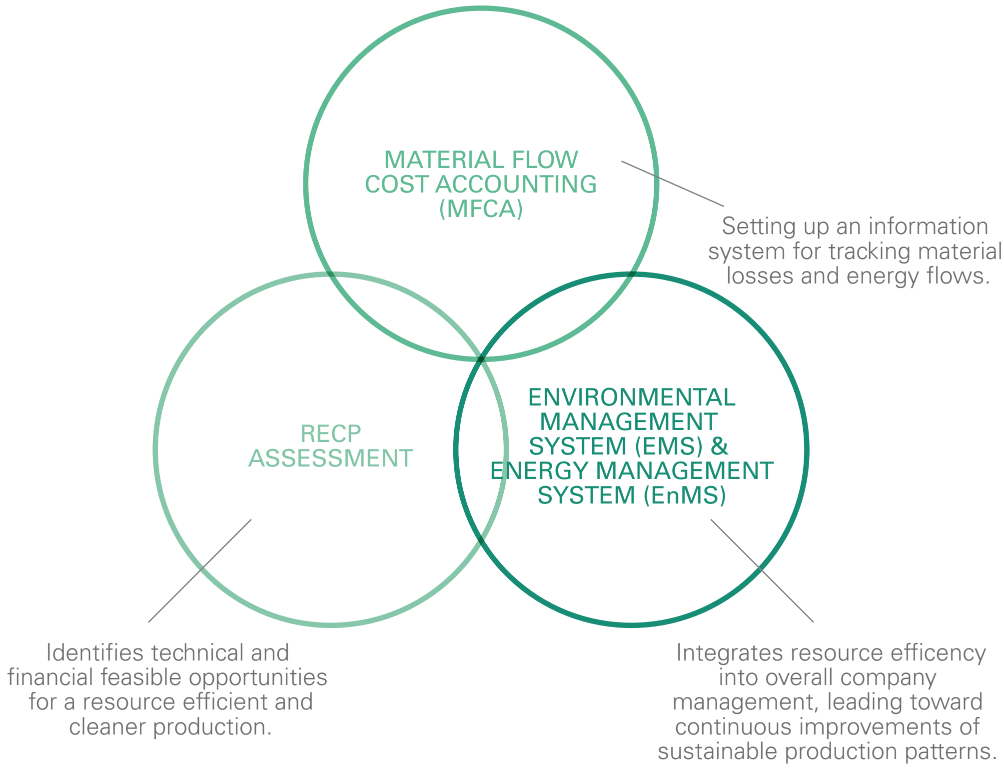



FIGURE 4: Tools used within TEST

The TEST approach does not promote the implementation of full-scale MFCA and/or an EMS/EnMS unless a company has the resources, the immediate need and the commitment to pursue ISO certification. Depending on the starting situation in a company, the core elements of MFCA and EMS/EnMS may be sufficient to integrate and sustain resource efficiency strategies. Nevertheless, experience has shown that the successful completion of a TEST cycle usually results in a company's commitment to follow up with the implementation of other sustainable production tools, including completing EMS/EnMS to acquire ISO certification.

The completion of the TEST cycle lays the foundation for implementing Corporate Social Responsibility (CSR), which addresses all three sustainability dimensions (environmental, social, and economic) and provides a strategic basis for all other sustainable production tools as shown in the management pyramid (Figure 3). In particular, TEST envisages a simplified stakeholder mapping and analysis tool for kicking off a reflection on the expectations and values relevant for long-term business sustainability. While TEST creates a solid basis for addressing the environmental and economic dimensions of CSR, the social dimension can be strengthened as part of the follow-up activities, depending on a company's specific needs.

Despite the fact that the TEST approach focuses on manufacturing processes, it includes a simplified life cycle check list that can assist a company in identifying opportunities to expand the scope of the analysis of improvement measures along its supply chain outside of the boundaries of the manufacturing sector proper. These opportunities can be explored in more depth using standard Life Cycle Assessment (LCA) or Eco-design tools, as part of or as a follow-up to the TEST project's cycle. In order to explore life cycle opportunities, we recommend using the concept of Circular Economy which is based on extending resource efficiency strategies to the whole value chain.

The TEST approach requires multi-disciplinary teamwork, both within the company and with external expertise. This promotes opportunities for partnerships between service providers and experts in areas of sustainable production tools.  A summary of the steps used within the TEST approach is provided in table 2.

| STEP | PURPOSE | OUTPUT |
|---|---|---|
| 1. PLANNING | | |
| 1.1 Initial screening | Initial review of company, go/no-go decision to start TEST. | TEST contract signed between service provider and company. |
| 1.2 Scoping and policy | Formalize top management commitment to RECP and scope of the work | Policy statement drafted and communicated to internal (and eventually also external) stakeholders. |
| 1.3 TEST team | Plan, organize and train internal company team (as well as external team, if created). | TEST team established, workplan developed, training and communication plan in place. |
| 1.4 Identifying total cost of NPO and priority flows | Starting the diagnosis: Identify the non-product output (NPO) costs and volumes and the priority flows at company system boundary. | Material/energy balance quantified at company system boundary and links with company accounting procedures established. Benchmarking, priority material/energy flows selected and for these objectives, indicators (KPI) and baselines are set. |

| STEP | PURPOSE | OUTPUT |
|---|---|---|
| 1.5 Setting up focus areas | Continuing the diagnosis: identify focus areas at the level of production steps (e.g. cost centres) with the highest potential for improvement. | NPO costs allocated to production steps (cost centres). Material/energy balances of the priority flows. Focus areas with the highest material/energy losses and pollution generation are selected. Accounting procedures linking priority flows within focus areas established: setting indicators (OPI) and baselines. |
| 1.6 Revealing sources and causes of inefficiency | Concluding the diagnosis: identify sources and reveal root causes of inefficiency and pollution within focus areas. | Material/energy balances of the focus areas, if relevant, completed. Sources and causes of inefficiencies and pollution are investigated. Performance indicators and baselines set at the level of specific pollution sources |
| 1.7 Option generation and feasibility analysis | Broadening the scope of possible improvement solutions and techno-economic analysis of a set of optimized | Long list of potential preventive options. Saving catalogue comprising feasible measures for improving resource efficiency in the company. |
| 1.8 Action plan | Plan of actions for implementing and monitoring validated measures. | Resources and top management commitment secured for implementing TEST action plan including operation control |
| 2. SUPPORT AND OPERATION | Implementation of the TEST action plan including improvement measures and monitoring to increase performance in resource use. | Organizational measures, process improvements, cleaner technology implemented. Supporting documentation of management systems and information system procedures for monitoring resource efficiency in place. |
| 3. PERFORMANCE EVALUATION | Measuring and evaluating performance of important material and energy flows. | Resource efficiency performance measured and evaluated versus smart objectives. Management review for performance evaluation, communication. |
| 4. IMPROVEMENT | Reflection on experience gained and integration of TEST into business strategies and operations. | Corrective actions are taken to ensure continuous improvement. Strategic reflection on how to sustain and expand RECP, including further adoption of other sustainable production tools and exploration of possible links to Circular Economy. |

TABLE 2: Overview of the TEST approach and its steps

# UNIDO MED TEST PROGRAMME

The TEST approach was developed by UNIDO in 2000 and first piloted in the industrial hot spots of the Danube River Basin. Since then, TEST has been replicated in several regions worldwide in industrial hot spots.

UNIDO launched the MED TEST programme in the North African and Middle East region with a first pilot phase, which lasted from 2009 to 2012 (Med TEST I). This phase targeted three countries, namely Egypt, Morocco and Tunisia. The objective of the programme was to strengthen national capacities in the use of integrated resource efficiency tools while demonstrating the business case for sustainable production in the manufacturing sector. During the first pilot phase, a pool of 43 companies introduced the TEST approach at their facilities, identifying a portfolio of RECP measures worth approximately € 17 million of private sector investments leading to significant savings in energy, water and raw materials.

The second phase of the TEST programme (MED TEST II) was kicked off in 2014 within the framework of the EU-funded SwitchMed initiative led by UNIDO. During this second phase, which aimed at scaling up the results of the pilot phase to all the countries of the MENA region, more than 125 companies were engaged to demonstrate at larger scale how resource efficiency can be an effective strategy for helping businesses accommodate constraints on natural resources efficiency in their management systems (e.g. ISO14001 or ISO50001), improve their image and brand value, and strengthen their relationships with their stakeholders. The total private sector envelope that was leveraged for financing RECP projects during Med TEST II was significantly higher compared to the first phase, with more than € 87 million worth of investments, which corresponds to an average 75% increase per company. These RECP investments were financed by a mix of private equity, direct loans and blending financing instruments (grants plus loans provided by national financing schemes[4]).

The two charts below in figure 5 illustrate the distribution of payback periods (PBPs) of the identified RECP measures in MED TEST I and MED TEST II projects respectively, which confirmed the highly profitable business case for resource efficiency. Recorded resource savings per company compared to baseline were shown to be in the range of 24% for energy, 20% for water and 5% for raw materials.

While the profitability of the RECP business case remained mostly unchanged between phase I and II, it was observed that there was a much higher uptake of RECP investments by companies during the second phase of the programme. This was essentially due to changes which occurred in the business environment, such as: availability of a wider range of financing instruments for energy and resource efficiency; increased costs for energy due to removal of subsidies; higher material costs, especially for imported items; increased interest on the part of SMEs from the MENA region to access EU markets where green criteria are more common; stronger focus of companies on production cost reduction strategies to boost competitiveness; greater awareness of companies regarding water scarcity, at least in some water intensive sectors (e.g. the textile and chemical sectors); progressive improvement of environmental compliance regimes in some countries.

Impact results publications and industry case studies from the MED TEST programme can be downloaded www.switchmed.eu.

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[4] Within the framework of Med TEST II, UNIDO established a cooperation agreement with some national financing schemes, some of which were managed by EBRD (GEFF and MORSEFF facilities). This was an effective approach to complementing technical assistance with financing incentives.

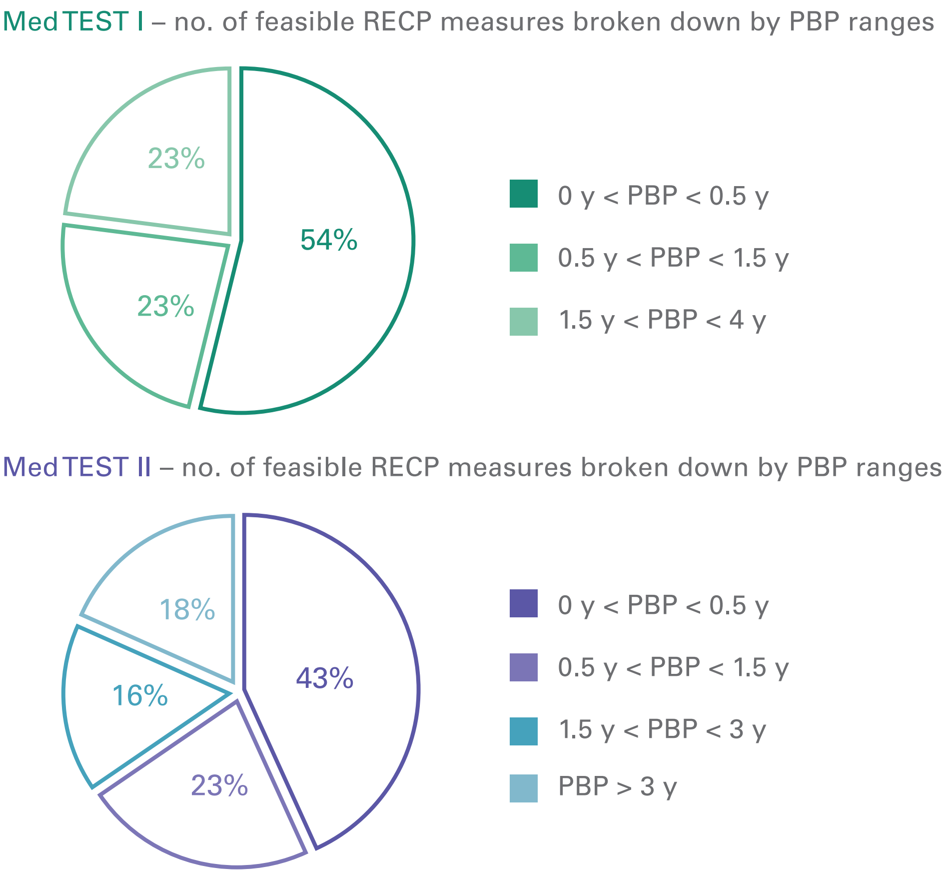
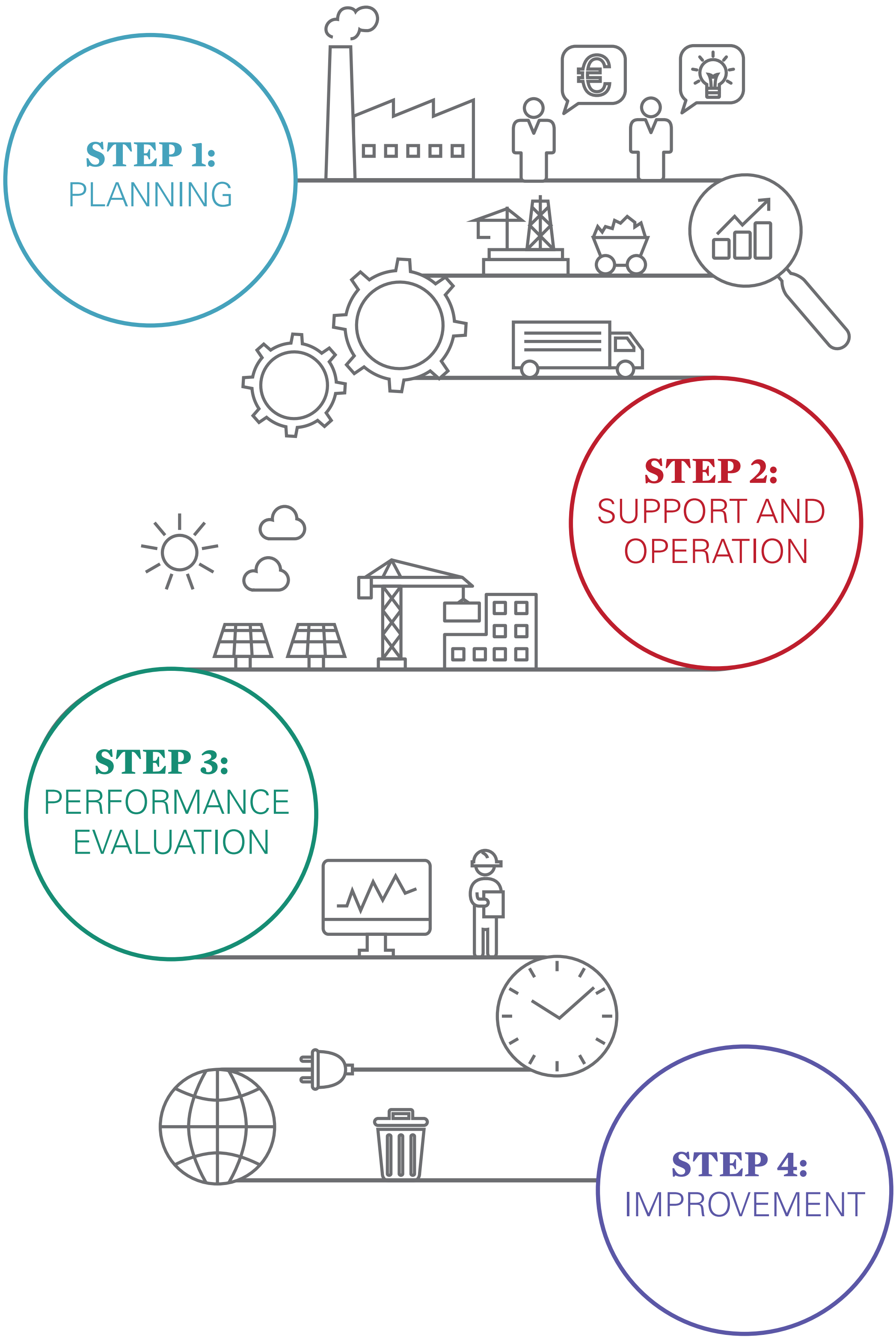



FIGURE 5: Distribution of payback periods (PBPs) of the identified RECP measures in MED TEST I and MED TEST II projects

# TEST STEP BY STEP



# STEP 1: PLANNING

| | |
|---|---|
| Step 1.1 | Initial Screening |
| Step 1.2 | Scoping and policy |
| Step 1.3 | TEST team |
| Step 1.4 | Identifying NPOs costs and the priority flows |
| Step 1.5 | Setting up focus areas |
| Step 1.6 | Revealing sources and causes of inefficiency |
| Step 1.7 | Options generation and feasibility analysis |
| Step 1.8 | Action plan |

# STEP 1.1 INITIAL SCREENING

Is there a potential for resource efficiency in the company?

## RATIONALE

A preliminary screening is needed before starting up a TEST project in a company, to determine if the introduction of resource efficiency and integrated environmental management techniques will pay back (the business case) and if the company is ready to engage. The findings of the Initial Screening provide a basis for deciding whether to start TEST in a specific company. They highlight the potential for improving resource and energy use, which can be used to persuade top management to adopt an environmental policy (step 1.2). Since the Initial Screening can be used by service providers as a »marketing« tool to acquire new clients, it can be offered free of charge. The workflow of an Initial Screening is outlined in figure 6.

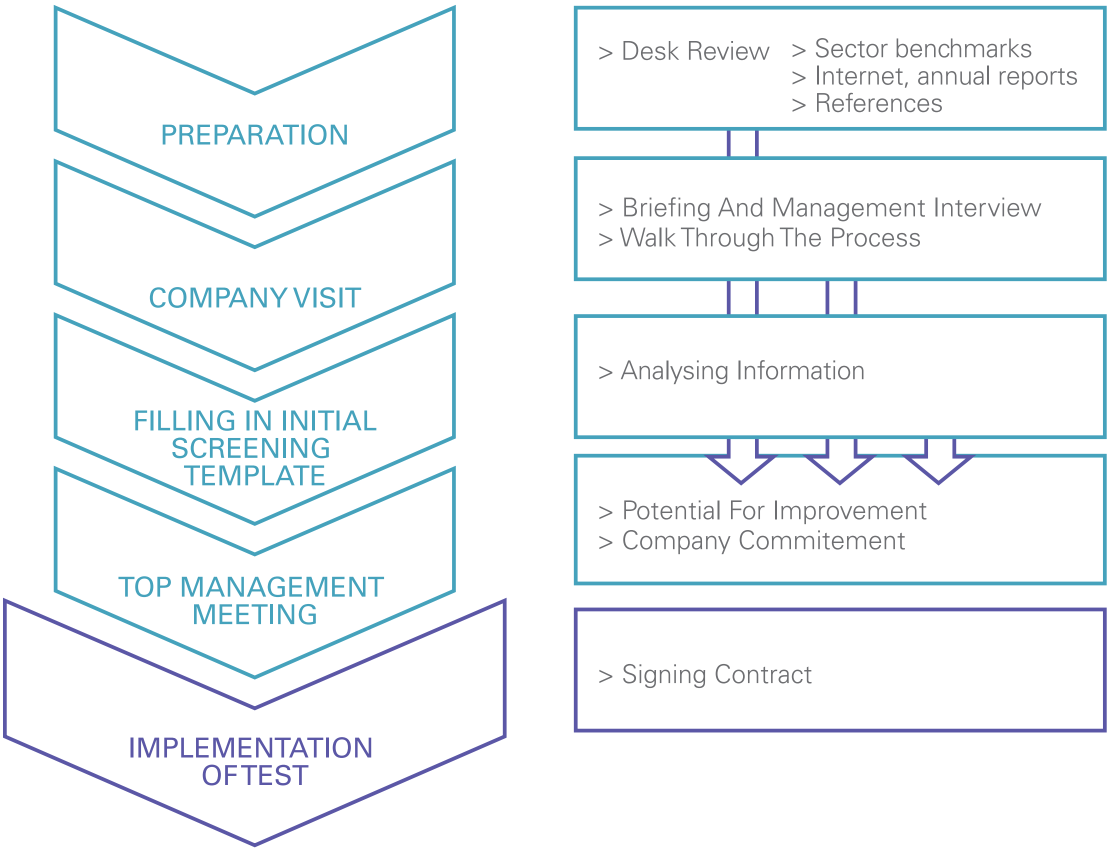



FIGURE 6: Workflow of an Initial Screening

## ACTION TABLE

<table>
<tr><th>INPUTS</th><th>CORE ACTIVITIES</th><th>OUTPUTS</th></tr>
<tr><td rowspan="5">Publicly available company information<br><br>Company data on products, production processes, major inputs, pollution problems and systems<br><br>Industry sector benchmarks</td><td>Introductory desk survey<br>Management interview</td><td>Top management priorities</td></tr>
<tr><td>Walk through the production facility</td><td rowspan="2">Key process inefficiencies and immediate areas of high potential for resource efficiency</td></tr>
<tr><td>Fill in the Initial Screening template</td></tr>
<tr><td rowspan="2">Meeting with top management</td><td>Top management commitment<br>Go/no-go decision for starting</td></tr>
<tr><td>TEST<br>Service agreement signed</td></tr>
<tr><td>Tools</td><td colspan="2">Initial Screening template</td></tr>
</table>

## BENCHMARKING

Benchmarking enterprise performance metrics with industry standards or best practices from peer companies is a useful tool. When information is available for a specific sector or type of technology, benchmarks can be used to estimate potential for improvement from adopting best available techniques (BATs).

Benchmarks, if available, can be used in different steps of TEST, including the Initial Screening. Indeed, although the Initial Screening is mostly a qualitative assessment, benchmarking can be quite useful for obtaining commitment from a company's top management to start a TEST project in order to increase productivity.

The most commonly available benchmarks are based on international state-of-the-art BATs. These do not necessarily take into account the features of national technology and production systems that may influence their applicability in a given context. Some national or regional benchmarks can also be found in reference publications or studies. Examples of sources of data for benchmarking are listed below:

- EU BREFs - Best Available Techniques Reference Documents [5]
- IFC Industry Sector Guidelines [6]
- Sector specific industry manuals
- MED TEST country best practices

[5] http://eippcb.jrc.ec.europa.eu/reference/

[6] http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/our+approach/risk+management/ehsguidelines

## CASE STUDY: INITIAL SCREENING

During the initial contact with a textile company, the management expressed its scepticism about what concrete benefits they could gain from participating in the TEST project. Their past experience in a similar project had not been positive. The TEST expert, who was well-prepared for the visit, provided some figures on resource efficiency economic savings that were achieved by similar textile companies, using information from the MED TEST I factsheets. The company was convinced to start with the IS.

***»Their constraints clearly pointed to the need to reduce energy costs and improve chemical management.«***

Before conducting a walk-through of the site, the expert listened to company management's expectations but also to their constraints, which clearly pointed to the need to reduce energy costs and improve chemical management.

Consequently, during the walk-through of the production line, the expert focused on highlighting concrete examples on how to address these two major areas of concern:

- Proper insulation of the boilers and steam piping, recovery of steam condensate running to the sewer system
- Separation of the chemical storage area from the room where well water was also stored, to prevent that the ongoing water leakage from pumps and transfer pipes would damage the chemical storage area and generate chemical spills into the sewer system.

Understanding the company's concerns and priorities proved to be very useful prior to formulating and presenting the key observations from the site visit to management. Some recommendations were made right after the site visit, demonstrating valuable expertise which prompted the company to change its attitude and decide to engage in the project.

## TIPS

- A company's readiness to engage in a TEST project is often demonstrated by its willingness to share data on processes already at the stage of an Initial Screening.
- If a company's involvement in the TEST project is partly or fully subsidized by a national/international program, exploring the creditworthiness of the company will increase the chances of engaging with companies that are able to effectively implement and invest in environmentally sound technology.
- Information on existing grants and funding programmes for resource efficiency investments and environmental compliance are leverage points for top management commitment, and can be presented during the Initial Screening.
- Convincing a company to start a TEST project, whether as a subsidized or fully commercial application, relies on the consultant's ability, at this early stage, to pitch the business case of resource efficiency to top management, showing the added value to the company with an indication of potential economic benefits and practical examples of improvement options, in line with the initial expectations of the company.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| An IS provides information for understanding the context in which the company is operating including important issue related to resource efficiency. This contributes to the identification of environmental and energy aspects. | An IS provides additional information related to the resource efficiency of the production system, revealing new resource/energy efficiency priorities which can be integrated into an existing environmental or energy management system. |

# STEP 1.2 SCOPING AND POLICY

How to define and communicate a company's commitments to resource efficiency?

## RATIONALE

The commitment of top management to resource efficiency is essential to initiate changes to the company's goals and vision, to influence and define its overall performance. This commitment should be communicated to the company staff at the beginning of the TEST project (and possibly to its external stakeholders as well).

If the company already has a formalized policy document, the latter can be amended to integrate specific resource efficiency objectives. If there is no such policy document yet, it is recommended that top management adopts at least a brief policy statement at this stage to let company staff know about top management's commitment to resource efficiency. Sources recommended for development of a policy statement are highlighted in figure 7.

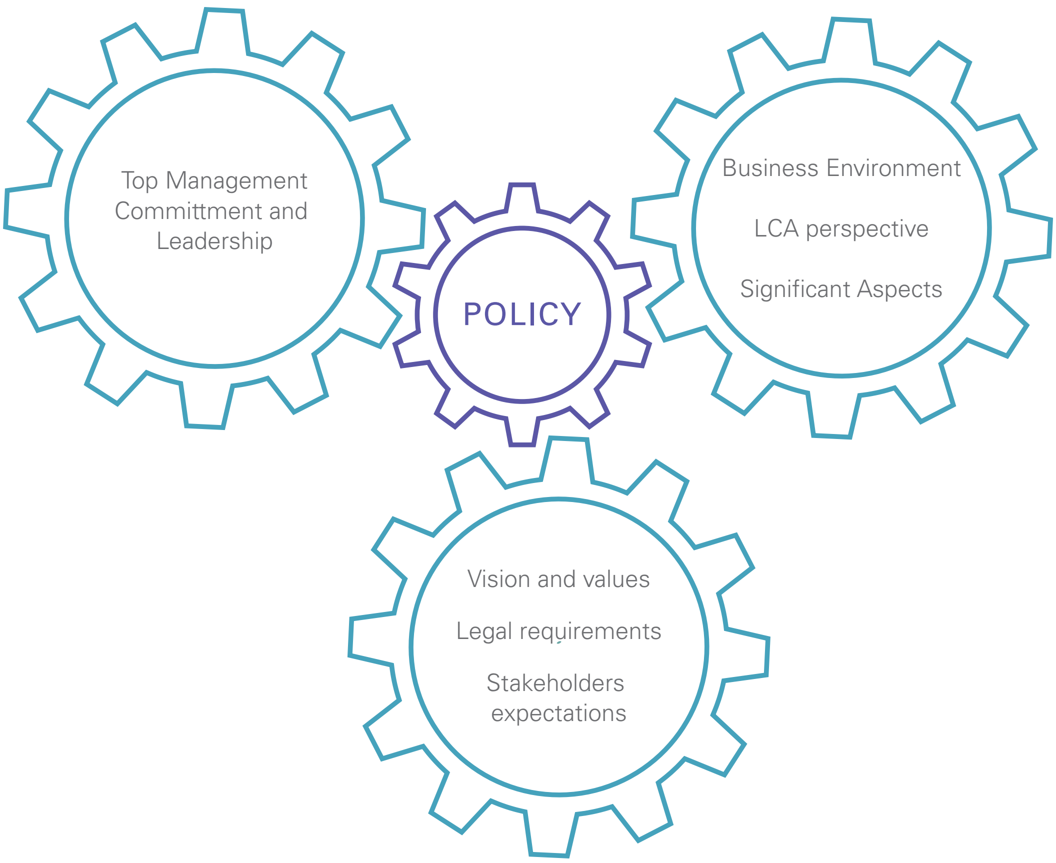



FIGURE 7: Development of policy statement

## ACTION TABLE

| INPUTS | PROCESS | OUTPUTS |
|---|---|---|
| Initial Screening report<br><br>Legal requirements<br><br>Stakeholders' expectations<br><br>Company strategy<br><br>Life Cycle / Circular Economy Perspectives | Meeting with top management to define objectives, list commitments and review life cycle / circular economy perspectives.<br><br>Interviews with stakeholders (internal/external) | Commitment of top management |
| | Drafting policy statement | Policy statement |
| | Communicating policy internally (and eventually externally) | Enterprise staff informed |
| Tools | Stakeholder Analysis<br>Policy checklist<br>Life Cycle Perspective checklist | |

## CASE STUDY: RELEVANCE OF THE POLICY STATEMENT

At the beginning of a TEST project in an Egyptian company already certified ISO 14001, top management did not deem it necessary to review and update the environmental policy to include a clear commitment to resource efficiency. They claimed »We are committed and we need the TEST project, we want to know our benchmarks and explore resource efficiency potential«. As a result, the importance of resource efficiency and the scope of the intervention was not properly communicated and clearly understood by company staff. Moreover, the person responsible for EMS was appointed as the company's team leader of the TEST project, which meant that activities initially focused on more procedural aspects, rather than on core resource efficiency improvements.

When the company's TEST team realized the level of detail and amount of data required on raw material use at production levels, they were not motivated to provide accurate data. As a result, the consultants were not able to identify the priority areas for intervention and develop the project's baseline, resulting in the project being delayed.

*»The company's TEST team was strengthened and all company staff was informed«*

A meeting with top management seemed necessary to illustrate with concrete examples how resource efficiency links to the core of any business strategy. This triggered a management decision to review the environmental policy and integrate resource efficiency objectives. The company's TEST team was strengthened and all company staff was informed.

The review of the company's existing environmental policy gave new impetus and was of paramount importance to ensuring that all staff knew why the company was engaging in the TEST project, and what the economic benefits over the short and the long-term would be compared to the negative consequences of wasted production inputs. This strategic change in policy and the clear support of top management to it put project implementation back on track, and time and effort were focused on achieving concrete results.

## TIPS

- Sometimes it can be difficult to convince top management to formally introduce RECP into the company's policy at this early stage. In these cases, it can be more effective to do so by the end of the TEST planning phase, once the resource efficiency measures are identified.
- To be effective, a policy statement should clearly reference resource efficiency, cleaner production, and energy efficiency objectives, as well as significant environmental aspects and significant energy uses. A stakeholder analysis or a Life cycle indicative review can help in deciding if significant environmental aspects within the life cycle should be considered as well.
- The integration of the social values and expectations of external stakeholders in the policy development process requires a consultation process (interviews) that could be challenging at this early stage. If this is the case, it can be postponed to the end of the TEST project. The same is valid for the integration of Life Cycle / Circular Economy perspectives.
- Whether in the form of a new or modified policy statement or in some other way, communicating top management's commitment to resource efficiency generally and the TEST project in particular to all employees is essential to the success of the project.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| The RECP policy statement shall be drafted in line with the environmental/energy policy requirements of the ISO standards. | Existing management system policies can be updated to include a clear commitment to resource efficiency and energy performance objectives to enhance the company's environmental performance. |

# STEP 1.3 TEST TEAM

How to mobilize the internal skills of a company and plan for implementing TEST?

## RATIONALE

The implementation of an integrated resource efficiency initiative like TEST requires the full engagement of a company's internal team – the TEST team. This team will be a resource pool that will drive the process and interface with external consultants and service providers.

The TEST team should be led by a motivated leader who can inform decision-making, and should include key staff with relevant knowledge and perspectives on the different business functional units. The box below shows examples of suitable TEST team members. In medium-sized companies, the team may be formed for example by 2-3 members who could be supported by additional staff for specific activities. The TEST team will be responsible for compiling process data, as well as for developing, implementing and evaluating the TEST action plan. The motivation of the TEST team is crucial: experience shows that better results can be achieved when top management sets up an internal incentive scheme to reward staff for playing an active role in TEST implementation.

The training of the TEST team and a broader awareness program targeting workers and employees can be planned in several short sessions as illustrated Figure 8. Each session is interspersed with practical work in company, for data collection and analysis. Training of internal teams is important to strengthen capacity and upgrade a company's skills in the fields of resource efficiency and integrated environmental management for continuous improvement. After a project has started, proper planning and delivery of company training activities is essential for a project's success.

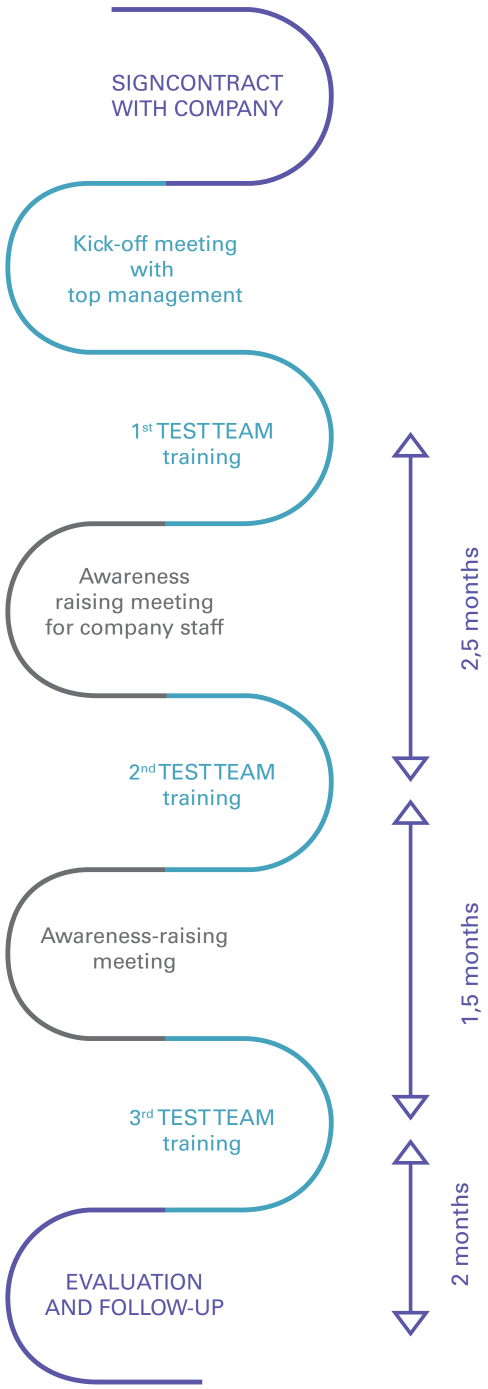



FIGURE 8: Example of planning company training activities

| KNOWLEDGE AREAS OF TEST TEAM MEMBERS | |
|---|---|
| **Core competences**<br><br>• Top management representative (e.g. technical director)<br>• Process and technology (e.g. chief engineer, production manager)<br>• Accounting and financial expertise (e.g. chief accountant)<br>• Management systems (e.g. managers of EMS, QMS, H&S, etc.) | **Supporting areas**<br><br>• Production planning<br>• Information systems specialist<br>• Maintenance<br>• Research and development, product design |

## ACTION TABLE

| INPUTS | PROCESS | OUTPUTS |
|---|---|---|
| Company policy and commitment<br><br>Different profiles of enterprise staff members<br><br>External consultants and service providers | Set up TEST team, assign responsibilities, and appoint a leader | TEST team formalized |
| | Plan and deliver training to TEST team members | TEST team trained |
| | Plan TEST implementation in company | Workplan |
| | Awareness raising meetings with all company staff | Company staff engaged |
| Tools | TEST training and awareness raising plan | |

## CASE STUDY: BUILDING INTERNAL CAPACITIES

A new family business in Palestine producing a variety of chocolate and confectionery products decided to implement a TEST project. At the start of the project, it already had an advanced company culture. For instance, an informal social corporate responsibility practice was in place, while the employees showed ownership of the company's performance and were strongly committed to the company's goal of continuous improvement. The owners of the company were keen to use the TEST project to train company staff members and to integrate RECP into company operations.

After integrating RECP into its policy statement, the company established a very strong internal TEST Team. It was composed of the company owner and General Manager as the team leader, the Production Manager, and the Quality Manager. They were trained in the TEST approach by international trainers. As a follow up, they organized a set of trainings for all company staff that could influence resource efficiency in the production lines, storage, maintenance, utilities and company management. Consequently all company staff was trained and involved in implementation of TEST in the company. The owner even introduced a financial premium for those employees who identified resource efficiency options.

All this resulted in a set of more than 30 feasible RECP measures corresponding to total annual savings of € 92,370 on the costs of energy, water and raw materials. With an estimated investment of € 73,400, this resulted in an average payback period of less than one year.

The company integrated RECP into its culture for continuous improvement, extending the skills and experience gained to the new production lines and premises of their expansion project.

## TIPS

- Properly selected company employees can grasp the resource efficiency approach very quickly during the initial training activities, becoming the creative engine for identifying improvement solutions – they know their processes better than any external consultant.
- The TEST team should be encouraged to establish internal communication routines. Regular company internal meetings could serve as an opportunity to share progress and enhance the visibility of TEST activities in the company.
- A close coordination between the external TEST consultants and the company TEST team will prevent internal resistance and miscommunication that can block project progress.
- Building resource efficiency skills within the company not only boosts the knowledge but also the motivation of the company team to continue beyond the TEST project's lifetime, strengthening teamwork and relationships and paving the way for shared responsibility for company performance.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| The management should formally assign roles and responsibilities to the team members and ensure that training and internal communication plans are defined at this stage. | The TEST team should include key staff responsible for the existing EMS/EnMS in addition to resources with in-depth knowledge of production processes and resource efficiency. |

# STEP 1.4 IDENTIFYING NPOs COSTS AND THE PRIORITY FLOWS

What are the material and energy inputs/outputs associated with the highest economic losses and/or to the most significant environmental impacts?

## RATIONALE

The starting point of the TEST diagnosis focuses on the company system boundary (the boundary through which flows of materials, water and energy enter and/or leave a production system). Its aim is to identify the material and energy flows with the highest potential for resource efficiency improvement. These can then be selected as priority flows and analyzed in more detail in steps 1.5 and 1.6.

Companies often do not realize that the actual costs to them of the waste and pollution which they generate are not just comprised of disposal fees, treatment and equipment costs, but that they also include the costs of purchasing materials that are turned into waste or excess energy. These costs are called »non-product output« costs (NPO costs) and are on average one order of magnitude higher than the costs for waste disposal and emissions treatment. Managers do not realize this because actual NPO costs are rarely tracked by companies' accounting systems. However, they can be calculated or estimated by accounting and production managers.

NPO costs and quantities provide an initial indication of the efficiency with which a company is using its resources, thus representing what could be saved in physical and monetary terms if all production inputs were entirely converted into the final product (»zero waste scenario«). However, this is a theoretical scenario that may not be realistically achievable on the basis of state-of-the-art technology. Therefore, benchmarking with international standards and best available techniques (BATs) should also be performed in order to estimate the magnitude of the realistically potential savings for specific flows (e.g. energy, water, main raw materials). The potential economic saving in relation to BAT standards is one of the key criteria for selecting a priority flow that will be subjected to further detailed analysis during the TEST project.

The calculation of NPO costs and quantities is normally based on data from material balances and the list of accounts, as many companies do not have more detailed information systems. The total inputs and outputs from the previous business year are collected in both volume and monetary value to complete the balance. Losses of inputs (materials, water and energy) and related costs are estimated. The material inputs are broken down into raw, auxiliary and packaging materials, which end up as products, waste or emissions (see input/output categories in figure 9). Operating materials and energy, which by definition do not become (part of) products, are considered 100% NPO. The first input-output assessment generally does not balance out to zero, but the goal is to define the baseline of the total NPO costs and to record improvement options for the information system so that there is better data available for the coming accounting periods.

Priority flows are selected based on the following criteria:

a. Total economic loss due to the inefficient use of specific material, water or energy flows (NPO costs) vs. benchmarks
b. Potential for monetary and physical savings of material, water or energy
c. The company's own environmental concerns (legal requirements, scarcity of production inputs, health and safety issues, etc.)

Material Flow Cost Accounting (MFCA) principles have been used to develop an excel tool (MFCA tool), which is part of the TEST toolkit. This tool enables the company to record: inputs and outputs in physical and monetary terms; consistency checks; recommendations for the improvement of the company's information systems; the breakdown of NPOs to specific production areas (STEP 1.5 of TEST); and the calculation of the total NPO costs, linking the knowledge of accountants and engineers. Data are to be processed and evaluated on a yearly basis, and the existing accounting system (mainly financial accounting, stock management, cost accounting and eventually production planning) is progressively improved upon implementation of the recommended improvements.

As part of this step, the TEST Team can initiate the information system for resource efficiency for the selected priority flows, by:

- Setting up key performance indicators (KPIs) for each priority flow (for example, if water was identified as a priority flow the KPI can be the annual amount of water used per unit of production ($m^3/t$)
- Calculating the baseline for the KPI (usually based on data from the previous year – e.g., the amount of water used per ton of production in the previous fiscal year)
- Formulating an objective for each priority flow (for example, increased water conservation) and setting up a specific target (e.g., % of increased water efficiency within a defined period)

Usually, the above elements of the information system do not require the installation of metering equipment as the company can use information available within its accounts and stock management system and/or data from billing meters. However, measuring inputs on stock and in production, as well as scrap and waste is a prerequisite.

Also, it should be stressed that as soon as a flow is recognized as a priority flow, its resource efficiency performance should be regularly monitored, if this is not yet being done.

## IMPORTANCE OF BASELINES

At the beginning of this step it is crucial for the TEST Team to record the **baseline** for any priority flow – initial efficiency performance for a material/energy input using a relative indicator (e.g. annual electricity use in kWh / unit of production). Setting up this reference value is an important precondition for monitoring performance.

## IMPORTANCE OF PERFORMANCE INDICATORS

Performance indicators link objectives with performance:

OBJECTIVE – INDICATOR – PERFORMANCE

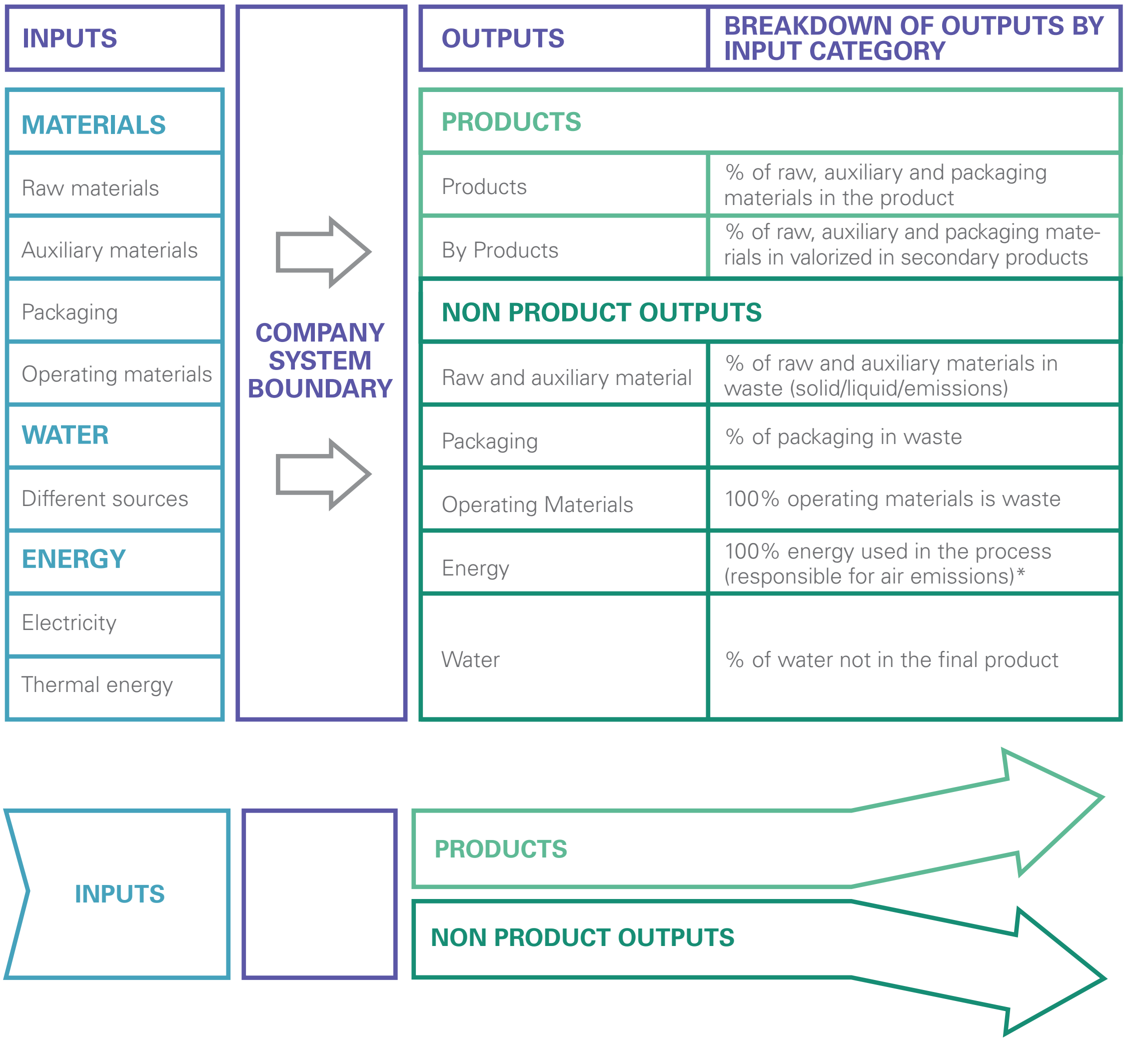



**FIGURE 9:** Input/output balance and non-product output (NPO) categories

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| Initial Screening report, flow charts, production inputs and outputs of the previous fiscal year (annual volumes and costs) and estimates of losses (percentages)<br><br>Sector benchmarks (energy, water, raw materials), if available<br><br>List of the company's significant environmental aspects and impacts | Collect or estimate data on major inputs and outputs at company system boundary using the MFCA excel Tool (e.g., workshop with accounting and production departments) | Total NPO costs of previous fiscal year<br><br>Breakdown of NPOs by raw material and energy categories at company system boundary |
| | Identify priority flows using the following criteria:<br>a. High NPOs compared to benchmarks with significant associated costs (potential for RECP improvements)<br>b. Major environmental aspects/impacts (e.g., water scarcity) | Choice of priority flows for further investigation<br><br>Recommendations for improving the information system on priority flows |
| | Set up resource efficiency objectives for priority flows at company level, define KPIs and calculate baselines for priority flows at company system boundary | Objectives, KPIs and baselines for priority flows at company system boundary (information system) |
| Tools | MFCA manual<br>MFCA excel tool | |

## HOW TO USE THE MFCA EXCEL TOOL TO IMPROVE THE INFORMATION SYSTEM ON RESOURCE EFFICIENCY

In most companies the exercise of calculating the mass balance for a fiscal year can be completed consistently enough during a one-day workshop. The objective is not to have a perfect balance, but to check the consistency of inputs to outputs, to record data inconsistencies, and to identify options for the improvement of existing information systems. The MFCA excel tool can be used even if estimates rather than actual data are available. It provides a structured approach that allows for gradual refinement.

The only necessity is that someone who knows the company information systems works together with someone from the production department (and environmental department, if it exists), preferably with direct access to the financial accounting and stock management system. Whenever data is not available, an estimate is made, and a record on how the estimate was calculated is entered into the excel tool, along with a recommendation on how to improve the data/information system.

In companies with very basic accounting systems and no stock management in place, it may be difficult to collect any data on inputs and outputs both in volume and in monetary value. In such cases, estimates of input/output and loss-related costs (NPO costs) can be used for the important flows. For instance, using the categorization shown in fig. 9, around 10-20 of the most important inputs in volume and costs can be selected for filling in the MFCA excel tool. This approach is used in a traditional Resource Efficient and Cleaner Production Assessment and is known as »TOP 20«. It is recommended to also use the MFCA tool when working primarily with estimates, as this enables setting up an information system on resource efficiency in an effective way, integrating technical and accounting information.

The most valuable result of the first MFCA assessment which a company does is not necessarily a complete mass balance, but a list of recommendations for improving data management, the understanding of the consistency of material flows and a baseline for the NPO costs of the previous year, as data on money is frequently more available compared to data on volumes. The MFCA manual contains a checklist for recommendations typically listed during an NPO data assessment workshop.

**Typical recommendations for better and consistent data monitoring systems for resource efficiency from an MFCA perspective include:**

- Data recording of material purchases in financial accounting by material groups
- Separate accounts for different material groups
- Separate posting of materials and services (e.g., the account for maintenance often includes both)
- Posting of inventory losses by different materials, not just in one line
- Recording of material numbers in production planning systems and stock management
- Estimation and recalculation of scrap percentages
- New accounts for better data monitoring, e.g. for energy consumption
- Establishing balances for energy, water and mass flow in order to verify the distribution to production steps
- Reworking the structure of cost centres and making them consistent with technical data monitoring interfaces, so that regular performance measurement is possible

These recommendations for data monitoring, as well as other aspects of MFCA implementation, are further explained in the MFCA Manual.

## EXPERIENCE WITH INTRODUCING MFCA IN 50 COMPANIES IN THE SOUTHERN MEDITERRANEAN REGION

Within the framework of the MED TEST II project, about 50 MFCA assessments were performed in Morocco, Tunisia, Jordan and Lebanon, mostly in the food sector. The distribution of NPO costs in these companies is presented in table 3. On average, total costs for materials and energy constituted 60-70% of all expenses in the profit and loss accounts. Labour costs were typically lower in these countries compared to Europe, while costs for environmental protection hardly existed.

At the beginning of the TEST project, most companies had no records on their environmental costs, not even their energy costs, and were not familiar with the concept of NPOs. For the most part, the MFCA assessments were based on preliminary estimates using data from financial accounting, stock management and production to the degree available. After the MFCA assessments, the companies realized that their total NPO costs ranged between 8 and 16 % of their total expenses. Experience from the TEST projects in the companies, shows that NPO costs can be reduced within a range of 20-50-%. Thus, a resource efficiency programme can help companies to cut down by at least 2- 5% their expenses.

Only a few companies had a high ratio of total raw material input ending up in the final product output (up to 94%), showing good material efficiency ratio. On average, companies only converted 65-75% of their physical raw material inputs into product outputs, with the rest being »lost« as waste and emissions.

| | LOWEST DATA | AVERAGE DATA | HIGHEST DATA |
|---|---|---|---|
| **Costs of Material and Energy Input as % of total Expenditures (Profit & LossAccounts)** | 37% | 60-70% | 79% |
| **Total Raw Material in the Product in % of Total Raw Materials Input** | 40% | 65-75% | 94% |
| **Total NPO Costs in % of Total Expenditures** | 3% | 8-16% | 21% |
| **Total NPO Costs (in EUR)** | 160,000 | 1-2 M | 16 M |

TABLE 3: Distribution of NPO costs in 50 companies

The range of distribution of NPO costs across the different cost categories was widespread, depending on the specific industry sector, production processes and the status of monitoring of material and energy flows, as illustrated in the table 4.

Nearly all companies participating in Med TEST II initially wanted to focus only on energy, as they considered this to be their main priority. Yet after the MFCA assessment companies realized that raw material losses also constituted a significant loss in monetary value, corresponding to 40-80% of NPOs.

Table 4 gives typical examples of the breakdown of NPOs costs by cost category for selected companies. The results illustrate the significant variance that can be found even within companies of the same industrial branch. Only a few companies paid some costs for external services for waste management, while a few others were also able to sell some of their waste for recycling as shown in the column EoP costs and earnings. These costs are normally the only ones related to environmental management that are visible in the accounting system of a company. Yet these costs are extremely small compared to all the other NPO costs, showing that the companies' accounting systems are failing to show the true costs of resource and energy inefficiency.

| NPO Raw materials | NPO Packaging | NPO Operating materials | NPO Water | NPO Energy | EoP costs and earnings | Total NPO % |
|---|---|---|---|---|---|---|
| 10% | 4% | 30% | 5% | 50% | 1% | 100% |
| 26% | 4% | 14% | 1% | 55% | 0% | 100% |
| 47% | 12% | 22% | 2% | 15% | 4% | 100% |
| 72% | 6% | 6% | 0% | 16% | 0% | 100% |
| 80% | 2% | 3% | 1% | 12% | 2% | 100% |

TABLE 4: Typical ranges of NPO costs distribution by input categories

KPIs and related baselines were identified for all flows with significant NPO costs. Benchmarking and estimation of potential for savings showed that there was reasonable potential for improvement. Based on high NPO costs and potentials for savings and improvements in most companies, energy consumption and raw materials were defined as priority flows selected for detailed analysis. In some cases, operating materials were also chosen as priority flows. The companies implemented a monitoring system consisting of several weighing scales in the incoming store and the production lines.

The NPO losses of raw materials and energy consumption were subsequently broken down by production steps and gradually measured. For further details on the MFCA case studies, please see Appendix A and the MFCA manual.

## TIPS

- Time management for this step is crucial. On average, it should require 5 person days of the TEST Team. If specific data are not available in the accounting system, rough estimates can be used for the priority setting. Real data may be collected for priority flows in next steps of the analysis and the MFCA excel tool recalculated.
- Engineers know their technologies very well, but lack information on amounts and prices of inputs/outputs, while this information is available in the accounting department. On the other hand, accountants have little understanding of the production processes and ignore NPO costs due to accounting practices. Organizing a one- or two-day workshop with the accountant, production manager and environmental manager is recommended to streamline the process.
- The only information system available in all companies is the financial accounting system. It is thus the starting point for the NPO assessment, using the list of accounts of the previous business year. However, it may not be of good quality and inconsistent. If a stock management system is in place, this would be a useful source of recordings of the volumes of materials purchased and used for production. Stock management is often not installed consistently and e.g. does not provide actual aggregated amounts in volumes by raw material categories or does not trace operating materials. In cases where cost accounting and production planning are established (mostly larger companies), these are valuable sources of information and should be used to check consistency of material flows recorded for the fiscal year.
- The »zero waste« savings potential corresponding to the total value of NPOs costs, although it may not be achievable with existing BATs, can motivate a company to commit to resource efficiency. In most cases, international benchmarks for resource use can be difficult to find. Even if they exist, their use can still be challenging and not fully accurate since products and production processes varies to a great extent. That being said, international benchmarking can indicate trends in resource-use performance and provide essential information to convince companies to focus on specific priority flows.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| The MFCA tool can be used for identifying the environmental aspects of an organization. The priority material, water, and energy flows identified at this step are related to environmental and energy aspects of the company as defined by ISO standards. Indeed, the evaluation process for identifying and prioritizing significant aspects may include eco-efficiency criteria (e.g., cost of material/energy losses) in line with the MFCA principles and tools. | Data on waste and emissions is typically better recorded if an EMS is in place and thus calculation of the mass balance is supported. The MFCA tool can be used by the company to collect data for the identification of environmental aspects related to priority flows. Eco-efficient criteria (e.g. cost of material/energy losses) used within the MFCA analysis can be integrated into existing evaluation process for prioritizing significant environmental aspects. |

# STEP 1.5 SETTING UP FOCUS AREAS

Which manufacturing processes and areas have the most significant share of NPO costs and the greatest potential for improving resource efficiency?

## RATIONALE

Understanding which areas of a production system have the greatest potential for improving resource efficiency requires the distribution of the NPO data from the company system boundary to individual resource/energy users. The latter may be identified as cost centres and/or production lines or steps, depending on the complexity of the company. This process will lead to the identification of the focus areas for each of the priority flows identified in step 1.4, and to the further improvement of the company's information system for the next business year. A reference case study illustrating how to use MFCA tool to select focus areas is provided in appendix A to these guidelines.

For energy flows, the cost allocation process can be based on three different levels of accuracy depending on the existing information system: i) energy consumption estimates based on nominal plate value of machines; ii) data collected during spot measurement campaigns; iii) real time energy consumptions from metering systems in place. Water consumption at specific processes can similarly be estimated or measured. As for the allocation of material losses, this can be more challenging considering that even companies with a cost accounting and production planning systems in place may not have this kind of information in place for most material flows. Therefore, material losses at specific process are often estimated in the first place, and can be updated later on if measurement campaigns are conducted (such as, for example, weighing material losses at production line for a batch over a period of time).

This step will highlight the areas in the company (specific departments, production units, cost centres) that generate the most significant share of the total NPO costs. Benchmarking with international BAT standards or expert opinions can confirm whether specific areas with high ratio of NPO costs also have significant potential for improvement and should be selected as focus areas. (Note that another, or additional, reason for deciding on a focus area is that it is a source of significant environmental and health risks - e.g. use of toxic substances). The chosen focus areas will be further analyzed in step 1.6.

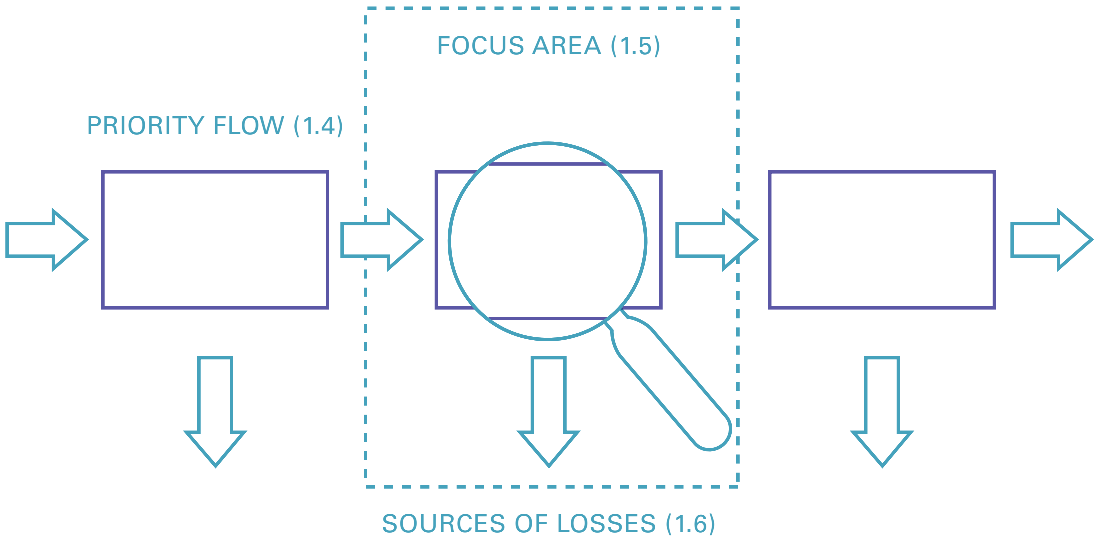



**FIGURE 10:** priority flows, focus areas and sources of losses

The TEST Team should define Operational Performance Indicators (OPIs) for the selected focus areas (e.g. energy use per unit of production at the drying stage). These OPIs are to be included in the information system on flows (a monitoring system for regular data measurement and survey of process resource efficiency described in chapter 3). Calculating and recording the baseline for OPIs at this stage enable future monitoring of performance, and validation of RECP improvements at company site. Note that the KPIs set at the company boundary level for priority flows cannot be used for monitoring real savings associated with a RECP measure, as several measures may have contributed to the improvements in the use of a specific material or energy flow.

## MONITORING FINANCIAL AND PHYSICAL FLOWS USING THE MFCA TOOL

All companies will have financial information systems, monitoring the company's financial flows. These can include financial accounting, stock management, production planning and cost accounting. However, their information systems often do not include sufficient information on the material and energy flows in volumetric terms to allow them to establish a mass balance on a regular basis to monitor their consumption of materials and energy in physical terms. This is particularly true of SMEs. In such cases, the MFCA tool can be used to complement a company's financial information system for an effective monitoring of material and energy flows.

Building the MFCA information system starts from the top down, from the company system boundary. The input-output balance at the corporate level should be calculated annually using the MFCA tool and be linked to the bookkeeping, cost accounting, storage and purchase as well as production planning systems. The values and volumes in tons or kilograms of all material flows should be listed when the related invoices are recorded. Reclassifying accounting data after the initial entry is often impossible and always time-consuming and costly, as it requires going back to the original invoices. Hence the best practice is to capture any information necessary for subsequent analyses when the data is first entered into the information system. Modifying existing systems can be a costly practice, but environmental and mass balance considerations can often be incorporated when the financial information system is adjusted for other reasons.

Raw and auxiliary materials as well as packaging are typically recorded in stock management and production planning systems (PPS), but not on cost centres. This is the main hindrance to applying MFCA as described in ISO 14051. Typically, operating materials as well as water and energy consumption are recorded on cost centres, but seldom monitored in stock management. Only financial accounting records all the data on material inputs, though most often only in monetary terms and with no clear disaggregation rules or consistency checks with other information systems.

In larger organizations, if monitoring of monthly data on volumes of production inputs is in place, the existing information systems can provide consistent data once the recommendations recorded in the MFCA tool are fully implemented. This is for instance the case in companies that are running Integrated ERP system. The MFCA is compatible for integration with their ERP tool, and its use will mainly focus on recording consistent data on volumes for proper aggregation.

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| MFCA excel tool filled in at the company system boundary (worksheet 1) for the previous fiscal year<br><br>Priority flows selected in step 1.4<br><br>Company process flow chart, list of cost centers<br><br>Material, water and energy balances at company level | Define production steps as operating cost centres (if cost centres are not already defined). | NPOs in money and, if available in volume, terms assigned to main production steps<br>(cost centres)<br><br>Inconsistencies identified in company information systems, and recommendations elaborated for better data monitoring |
| | Assign annual NPO costs (and volumes, if available) to identified cost centres/ production steps and complete MFCA tool worksheet 2.<br><br>For energy flows, the energy mapping tool can be used. | |
| Objectives and KPIs defined at the company level<br><br>International benchmarks for individual production processes in the specific industry sector (if available and applicable) | Set up OPIs for cost centres/ processes with highest NPO costs<br><br>Benchmark performance of specific processes/cost centres (use benchmarking data if available, otherwise use expert judgment) | Savings potential developed for areas with high NPO costs<br><br>Focus areas selected and related to priority flows<br><br>OPIs related to focus areas |
| | Select focus areas | |
| | Calculate baselines for OPIs of selected focus areas<br>Set up objectives for improvement at focus area level | Baselines for OPIs and reference to international best practices and benchmarks |
| Tools | MFCA excel tool<br>MFCA manual<br>Energy Mapping excel tool<br>Monitoring and Targeting tool[7] | |

[7] This tool has been developed by UN Environment

## HOW TO IDENTIFY FOCUS AREAS (KEY ENERGY CONSUMERS) FOR ENERGY FLOWS

The identification of focus areas for energy flows, also defined as key energy consumers in the ISO5001 standard, consists of making a balance of both electrical and thermal energy. The Energy Mapping Tool can be used when registering the monthly consumption for each energy source, and provides the breakdown in terms of both consumption and cost. The tool has one input tab for each energy source.

The energy mapping tool has specific worksheets to record estimated consumption data based on name plate power consumption, operating hours, load factor, and duty cycle of energy users. Generally, the energy balance is broken down by utilities, for instance boilers, compressors, chillers, and other service units that are energy demanding. These utilities are usually located within a dedicated plant supplying the entire company with the relevant energy service. Often, companies do not monitor the energy consumption of each machine or department. Therefore it is more difficult, but preferable, to apportion electrical and thermal energy (e.g. compressed air, cooling water, chilling water, and steam requirements) by process steps, as this will make more visible the energy demand of individual processes and make further analysis easier. This methodology provides better insight as to where the energy is being consumed in the production line. This is where the optimization efforts should start, by reducing »end use«, by challenging energy operating parameters in processes (temperature of pasteurizers, compressed air pressure at specific users, etc.) as well as by eliminating leaks and insulating pipes (good housekeeping) and training machine operators who are often not aware of how expensive it is to produce compressed air, for instance.

While a focus on end-use and distribution is important, there is also a potential for energy efficiency in energy supply systems such as those producing chilled water, refrigeration, compressed air, vacuum, steam, electricity, ventilation. These often make up a significant part of the total energy losses of the company. These utilities should be subject to »system optimization«, as there are often considerable savings in optimizing the way you operate your boilers, compressors, fans, pumps etc. and still supplying the same energy service (power, pressure, temperature etc.).

Once the energy key consumers are identified, performance indicators can be selected as a basis for energy management to monitor and measure energy-related performance. The energy performance indicators must be checked regularly and compared to the initial energy baseline.

### REGRESSION ANALYSIS

The means to establish baseline in the dynamic industrial settings and to monitor the real resource efficiency is regression analysis. Used in statistical modelling the regression analysis describes the relationships among variables. And we want to monitor resource efficiency in situation of changing variables (factors influencing for example energy consumption like volume of production or ambient temperature). If we want to monitor for example energy efficiency it is not sufficient to record just absolute numbers of energy use, we have to identify factor(s) driving this consumption and monitor also them. Regression analysis consists of comparing the company's historical energy data with the factors driving consumption, usually the production volumes (cooling degree days could be another example of a driver in case of cooling loads). For continuous production systems, the main driver is generally production volumes, with these expected to show good correlation with energy consumption. If the correlation exceeds 0.75 ($R^2 > 0.75$) with one driver, the regression equation, which is usually a straight line equation, provides values for the equation constant and the straight line slope. If the correlation is below 0.75 ($R^2 < 0.75$), the regression analysis should take into account multiple drivers. (Note: an $R^2$=1 implies perfect correlation)

A sample regression analysis data is illustrated in figure 11. The intercept represents the baseload, which is the consumption level when there is no production. In other words, the baseload reflects those energy consumers that are not affected by the production level; in figure 11, the baseload consumption is 209.62 kWh. If the baseload is relatively high, it indicates that either equipment control is not functioning or the company has many pieces of equipment running idle for long periods of time. There can be good reasons for a high baseload consumption, for example, a frozen food business operating on one shift which uses a significant proportion of its total energy in refrigerating cold stores that are always in operation.

The slope of the regression line indicates the rate at which energy consumption changes per unit of production volume. Again referring to the example in figure 11, the slope is 0.2665. This indicates that each additional ton of production results in a 0.2665 kWh increase in energy consumption. With low baseload, this slope is comparable to the specific consumption figures, and can be benchmarked against the BREF figures. The regression analysis can be done with the Energy Mapping Tool after filling the KPI worksheet with the data of the main driver for each energy source.

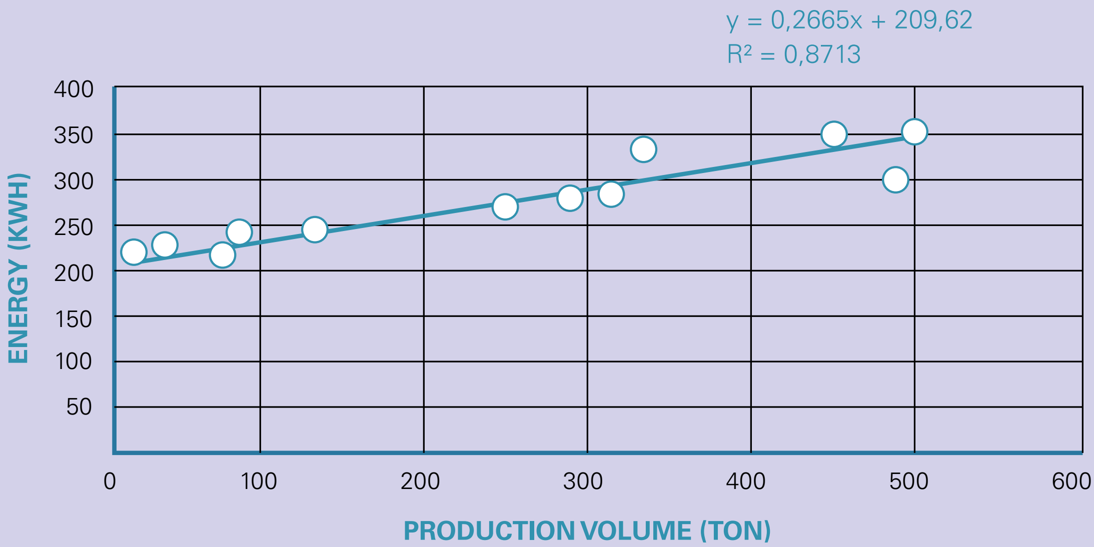



FIGURE 11: Example of regression analysis based on one driving factor: production volume

## CASE STUDY: ANALYSIS OF PRIORITY FLOWS

In an Egyptian potato processing company, raw material and energy were identified as priority flows. The TEST team prepared mass and energy balances to identify the focus areas. The mass balance revealed that 80% of the raw material weight was lost in the fryer section. The energy balance identified thermal energy as the priority energy flow, and a Sankey diagram was prepared to illustrate the breakdown of thermal energy by key users. The diagram revealed that most of the thermal energy was consumed to evaporate moisture from the potatoes at the fryer, followed by the thermal energy used at the blancher. Both the mass balance sheet and Sankey diagram are presented in figure 12.

At the project's start, it was a challenge to detect raw material losses, as no significant waste was noted along the production line during the walk-through (step 1.1). All the losses appeared to be already minimized and

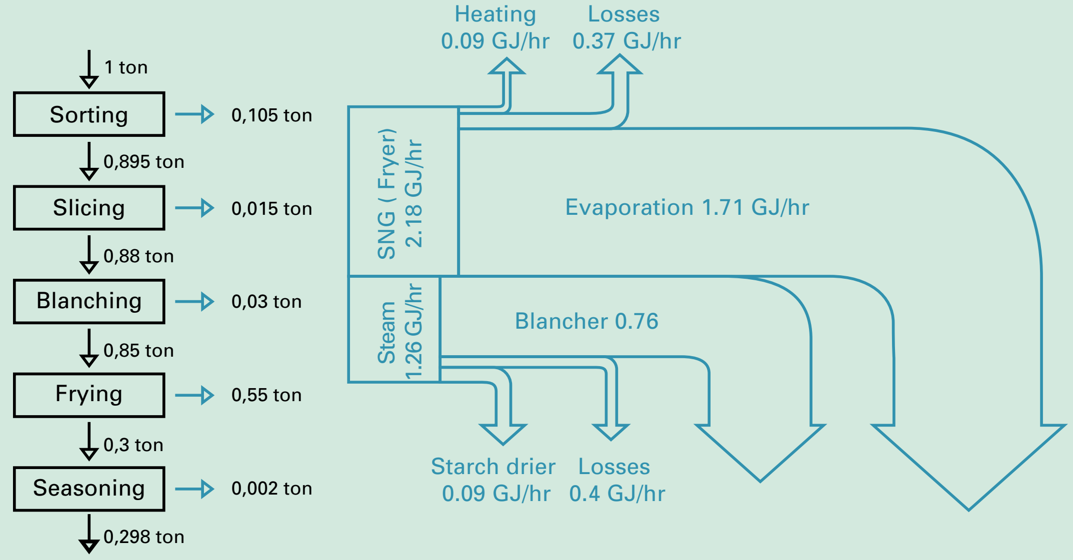



FIGURE 12: Raw material (potato) mass balance and thermal energy balances (Sankey diagram) of key energy users (fryer and blancher)

the production hall was perfectly clean. As for energy, the initial audit of the utilities focused on the boiler in terms of insulation and condensate recovery. Thanks to the mass balance implemented in Step 1.5, the team gained better insights leading to the identification of the frying section as the priority area for material losses. The Sankey diagram revealed that significant energy users are the fryer and the blancher. The energy used by these two processes was 8 times higher than the energy losses of the boiler and steam pipelines together.

*»...this solution led to the environmental benefit of decreasing the $CO_2$ emissions as well as air pollution...«*

When the TEST team was informed about the key findings (in Step 1.6), they underlined that the losses in the fryer are »natural loss«, due to the high water content (generally around 80% in weight) in the raw potatoes. The energy used for evaporation of potato water content is lost in the form of latent heat and released to the environment through the fryer chimney. The calculation of the energy content in the vapour revealed the largest energy carrier within the company boundary.

Following in-depth investigations and several unsuccessful discussions to tackle the first and second tiers of options (eliminate the source of loss, reduce the source of loss) or to find alternatives for reducing the losses of raw material, the team investigated the third tier for options generation (recycle/reuse). The availability of latent heat in the fryer emissions, which is almost 2.5 times the energy needed by the blancher, highlighted the possibility of recovering energy from the fryer and using it in the blancher. It was found to be feasible to send the vapor from the fryer chimney through a heat exchanger and use the recovered heat in the blanching process.

This measure reduced the company's energy consumption by cutting the steam demand from the blancher. In addition, half the energy losses of the steam generation and distribution system were reduced. It also decreased the demand for boiler feed water, with all its associated softening chemicals, and feed-pump electricity consumption. Further to the economic savings, this solution led to the environmental benefit of decreasing the $CO_2$ emissions as well as air pollution in the form of odours released through the chimney.

## TIPS

- Cost centres are well defined and used for allocating production costs in those companies that have a cost or management accounting system in place (specific departments, process units, or even machines). Often, different managers are responsible for different cost centres, and this requires facilitating teamwork during the MFCA data collection process.
- If a company does not have a cost accounting system in place, costs can be assigned to specific production steps or departments on the basis of the process flowchart. The ISO 14051 MFCA standard uses the term »quantity centre«, which can also be related to cost centres or production steps.
- Supportive cost centres can be established for utilities (e.g., water treatment, steam generation, compressed air, maintenance, environmental management). When cost accounting is in place it is possible to apportion the different utility costs to the production cost centres (end users).
- If data are missing, the best possible estimation should be made in addition to planning how to improve the data collection systems. Companies are recommended to invest in installation of sub-meters for energy and water at the priority areas/key consumers.
- If different people provide different figures during the analysis, the revealed data inconsistency can be presented as a learning opportunity for the company team. This fosters the need for understanding the real sources and causes of inefficiencies within the process.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| This step provides a sound basis for setting up the Register of Significant Environmental Aspects and for determining significant energy uses (SEUs). Information supports the defining of objectives for the Environmental and Energy Management actions. | The significant environmental and energy aspects can be reviewed, taking into consideration the new areas of significant NPO losses, costs and energy consumption and uses identified. On this basis, existing objectives can be reviewed within the Environmental / Energy Management action plans. |

# STEP 1.6 REVEALING SOURCES AND CAUSES OF INEFFICIENCY

How to analyse the root causes of significant material and energy losses and pollution generation?

## RATIONALE

This is the last level of the TEST diagnosis. Focusing on selected priority flows and focus areas is a cost-effective approach, as it may not be either feasible or worth to analyse in details all material and energy flows and production areas of a company.

The priority flows within identified focus areas are analysed in more detail in order to detect the sources of inefficiency – the physical points where a production input becomes a loss (non-product output) – and understand the causes. These usually relate to several factors that drive material and energy use, including process inputs quality, specific process operating parameters (e.g. temperature, throughput, speed, etc.), features of the process technology, human behaviour, and product design. Several widely used tools can be used for cause analysis, such as the fishbone (or Ishikawa) diagram, the 5 Ms; 5 Why's, Six Sigma etc.

Depending on the complexity of the selected focus areas, detailed material and energy-mass balances can be required to model specific sub-processes, mapping all inputs (energy, water, auxiliaries, operating and packaging materials) and outputs of the focus area to understand all the causes of the losses.

Implementing this step of detailed analysis may require both expert judgment and data measurements to understand what is actually happening within a specific part of the process: one round of data collection through ad hoc measurement is usually sufficient for the purpose. Data measurements are also useful for setting up the baseline and the Operational Performance Indicators (OPIs) at the level of specific processes, and these can be used for more accurate feasibility analysis of improvement options and/or for calculating real savings and performance improvements. It is recommended to install a permanent monitoring system for systematic monitoring of the resource efficiency performance of important sources of losses. For more information on this, see chapter 3.

## ACTION TABLE

<table>
<tr><th>INPUTS</th><th>CORE ACTIVITIES</th><th>OUTPUTS</th></tr>
<tr><td rowspan="4">Flow charts and technology schemes (including Sankey charts) of identified focus areas<br><br>MFCA excel tool (worksheets 1 and 2 filled in)<br><br>Data from existing information systems like cost accounting, stock management, production planning and monitoring, etc.<br><br>Supplier’s technical sheets, machine nominal parameters, company records on waste disposal, etc.</td><td>Finalize material and energy balances for priority flows in the focus areas (if the sources and causes of losses are not evident)</td><td rowspan="3">Quantification of material and energy flows at the level of focus areas/unit operations<br><br>Recommendations for improving the RECP information system for significant flows within priority areas</td></tr>
<tr><td>Conduct ad hoc measurements (if needed) to collect additional data for specific processes/ units/machinery</td></tr>
<tr><td>Process data on energy flows with the Energy Mapping tool</td></tr>
<tr><td>Interpret results, identify sources and related causes of material and energy use inefficiencies</td><td>List of causes of inefficiencies in material and energy use, by source</td></tr>
<tr><td>Tools</td><td colspan="2">Energy Mapping excel tool<br>Fishbone diagram</td></tr>
</table>

## ANALYSIS OF INEFFICIENCY SOURCES FOR ENERGY FLOWS

Energy auditors tend to rely on standard checklists when analysing the efficiency of key energy consumers. There are a variety of readily available checklists for each category of energy consumer, and they are accessible on the internet. These include checklists for boilers, compressors, cooling towers, pumps, fans, etc. These checklists will provide quick identification of items which are not optimized.

In order to fill in the checklists, energy measurements for both electric and thermal users are needed to get a better understanding of the performance of specific equipment. Depending on the parameters that need to be measured, it is recommended to set up a measurement plan prior to starting the measurement exercise, to identify the measurement locations, and the needed measuring equipment.

Benchmarking analysis is occasionally used at the level of energy key consumers to reveal the potential for improvement. Some independent testing agencies publish equipment-specific benchmarks for performance (CAGI sheets are an example for compressors benchmarks).

Regression analysis at the level of energy consumers can also be used to reveal the performance of specific areas, especially when regression analysis at company level does not show good correlation. In these cases, experience has shown that a regression at the level of specific energy consumers might provide better correlation, since the (main) driver for energy consumption can be more easily identified. If the regression at the level of a focus area doesn’t provide good correlation with the driver, then it is probable that the equipment runs idle for significant periods of time, or that the equipment is poorly controlled, or that there is another hidden driver of energy use to identify (this can be done by using multiple regression).

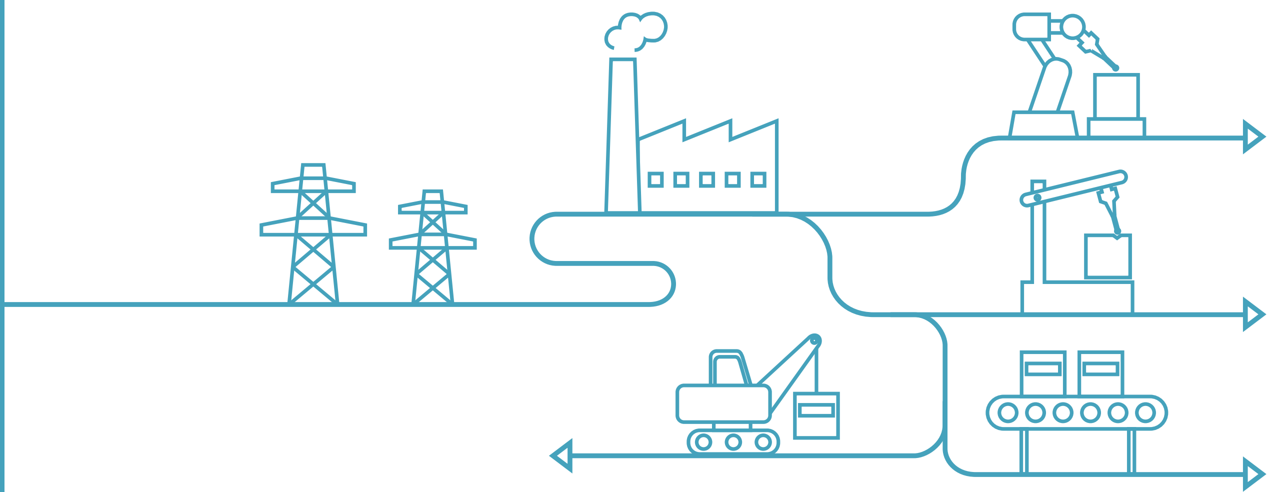
The Energy Mapping excel tool can be used for logging/recording the energy consumption and different driver(s) values (see the tab Details). Those consumption and driver(s) values are automatically transferred into other tabs of the tool to calculate the OPIs or to input the regression analysis.

In appendix A to these guidelines it is illustrated a reference case study on implementing TEST in a company with a focus on energy flows.

## PARALLELS WITH THE ISO 50001 MANAGEMENT SYSTEM STANDARD

An efficient use of a company's human and economic resources is at the core of TEST approach, by focusing the detailed analysis of inefficiencies only on those areas with the most promising potential for improvement. A similar prioritization approach is also adopted for energy management in accordance with ISO 50001 for continuous energy performance improvement. The following table provides a summary of the energy assessments required by EnMS and the equivalent step of TEST approach.

| EnMS – ISO 50001 REQUIREMENT | TEST APPROACH |
|---|---|
| Analysis of energy use and consumption in the company, based on measurements and other data (e.g. company energy bills). | Step 1.4 of TEST- setting the energy baseline at the company system boundary. |
| Identification of the areas with relevant energy use (significant energy uses), such as specific equipment, utility systems, but also an assessment of trends and key influencing factors for energy use | Steps 1.5 and 1.6 of TEST – identifying priority areas for energy flows and cause analysis. |
| Identification of the potential for energy performance improvement, energy assessment is updated on regular intervals. It must also be updated if significant changes are introduced in the company operation. | Steps 1.5 and 1.6 (and step 3 for regular monitoring of energy performance) using KPIs/OPIs and benchmarks, as well as regression analysis to monitor actual resource efficiency |



## CASE STUDY: INPUT-OUTPUT IMBALANCES

During step 1.4, an SME manufacturing ball bearings had identified cutting oils as one of the priority flows due to the associated high annual financial loss. During step 1.5 the turning shop had been identified as the cost centre with the highest NPO costs, and it was selected as a focus area. In step 1.6, the material flow balance for cutting oil was completed for the turning shop, using both measured and estimated data. The mass balance could not be closed as a significant amount of cutting oil, corresponding to approximately 30% of the total input, appeared to be lost »somewhere« in the company, as illustrated in the figure 13.

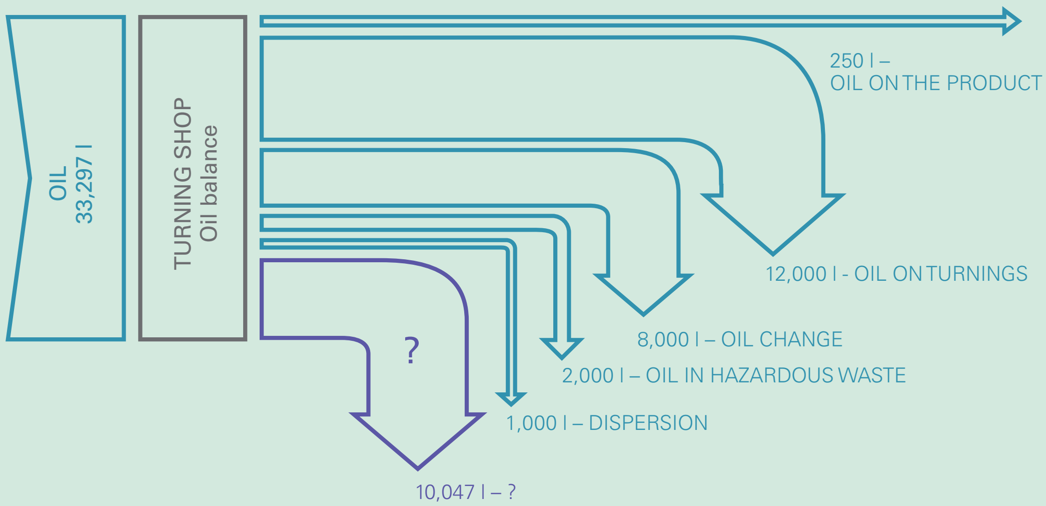



FIGURE 13: Initial balance of turning oil in manufacturer of ball bearings

An on-site visit was implemented during the first working shift with the purpose of identifying the lost cutting oil flows. During the material analysis another material flow (wood chips), hitherto unrecorded, was identified. There was neither any record of the total amount of wood chips used in the turning shop, nor any data on the amount of wood chips in waste flows. Wooden chips were simply available in the turning shop for cleaning the floors with no record of use. However, its volume was estimated to be relatively low, which turned to be a mistake as showed later.

*»The detailed analysis at this step enabled the TEST Team to identify a set of resource efficiency measures.«*

After repeated discussions with employees, it appeared that the lost oil flow was generated during the second working shift. It turned out that, due to a lack of regular supervision during the second shift, workers were keeping the covers of the turning machines open. A large amount of cutting oil was consequently spilling out onto the floor and employees were using wood chips to clean it up. They were then disposing the large amount of oily wood chips by mixing them with non-hazardous waste disposed of in plastic bags, and were apparently not aware of potential sanctions the company could be incurring for creating an environmental risk of this type. Particular turning machines were identified as the main source of the oil spillage (and the causes identified included not just the mode of operation but also the machine's design that allowed such wasteful operation). The method employed to handle the waste generated represented additional risks.

The detailed analysis at this step enabled the TEST Team to identify a set of resource efficiency measures. In addition to the obvious good housekeeping measures, new cleaning methods and procedures for recovering used oil from the turnings were also defined. Figure 14 shows the new complete balance.

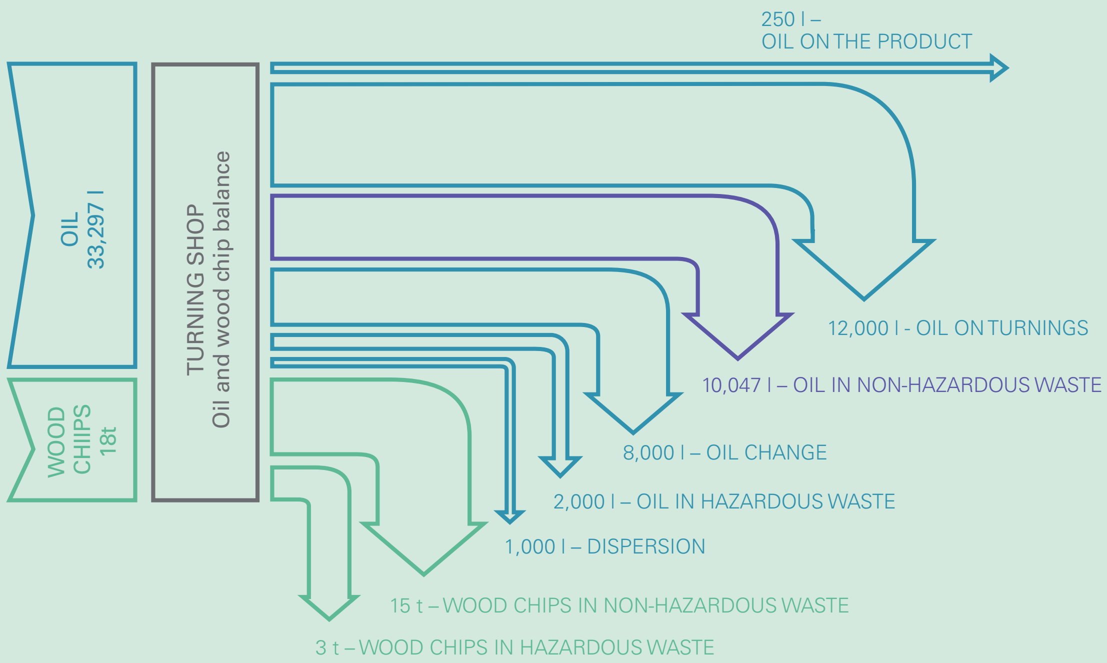



**FIGURE 14:** Complete balance of turning oil and wood chips in manufacturer of ball bearings

## CASE STUDY: DETAILED ANALYSIS OF ENERGY FLOWS

A small-sized dairy company in Lebanon had already explored some improvement measures to save water and energy before it started the TEST project. What tipped the balance in the decision of the MED TEST II project management team to include the company was the unbounded enthusiasm and motivation of the owner to implement RECP measures in his company. This commitment is at the root of this success story.

Energy was found to be the second priority flow after raw materials due to its significant NPO costs and potential for increasing the company's energy efficiency: the specific energy consumption of the plant was 0.45 KWh/kg milk, whereas the international benchmark for best practice in dairy sector is 0.3 KWh/kg milk.

At the beginning of the project, the company was convinced to install an information system: overall, 36 meters were installed in the company, mainly for monitoring energy and water use. Readings from the meters were recorded every day at the end of each shift together with the daily production quantities expressed as weight of milk processed and type of product made. The decision to install the information system at the project's start was crucial, as there was no history for the plant's energy use other than the electricity and fuel bills, and these were not enough to establish reliable baselines at the level of the chosen focus areas. This decision was adopted for several reasons: the most important being that *»taking daily readings is like taking the pulse of the plant«* said the plant manager. It also turned out to be a very effective way to engage both management and operators in improving resource efficiency (this phenomenon was observed not only in this company but also in other companies where monitoring systems were installed at the start of the TEST project).

The daily readings of critical operating parameters enabled the data analysis of specific energy consumers. From this, two significant energy consumers were identified: the steam and the chilled water systems. During step 1.5, the energy baselines had been calculated for monitoring the energy efficiency of these two focus areas.

The collected data also enabled a regression analysis to be carried out during step 1.5 at the level of the two focus areas, based on real data, which was used to set not only the baselines for the boilers and chillers but also to analyze their energy performance. For boilers, the regression between energy consumption and processed milk quantities resulted in a poor correlation coefficient ($R^2$=0.6). At the same time, single regression made between boiler energy consumption and ambient temperature also showed a poor correlation coefficient ($R^2$=0. 3). The consultants then conducted a multi-regression analysis, where energy consumption was thought to be affected by the ambient temperature besides the production level. The multi-regression showed improved correlation ($R^2$=0.77). The resulting regression equation was Eb = 0.36*P – 425*T – 9141 (where Eb is the energy consumed by the boiler in KWh, P is the quantity of milk processed in kg and T is ambient temperature in °C).

The regression analysis for the chillers showed better results. The correlation between chiller energy consumption and quantities of processed milk gave an $R^2$=0.75. The correlation coefficient increased to $R^2$=0.997 when ambient temperature was taken into consideration. The regression equation obtained was Ec = 0.077*P – 138*T + 3870 and it is used as baseline for the chilled water system (where Ec is the energy consumed by the chiller in KWh and the other symbols are as above).

The results of the regression analysis led to more investigations to understand the inefficiencies within each of these two energy users. The specific energy consumption of both the chilled water and the steam systems were analyzed thanks to the collected data (fuel consumption and steam output for boiler, electricity consumption and cooling effect for chillers). Boiler efficiency was around 70% while the chiller system's Coefficient of Performance was nearly 1.3, both values being indicative of low efficiency. Further investigations went on to determine the root causes of these inefficiencies, the core activity of Step 1.6. The following deficiencies were identified:

- The boiler internals were not being cleaned periodically
- The boiler burner was out of tune leading to a less than optimal air-fuel mix ratio
- Two boilers were being used while one alone could do the job (poor load matching)
- The condenser fins of the chiller were clogged and bent
- The configuration of the refrigerant piping in the chiller ice bank tank was not conducive for good heat transfer
- In many places, insulation of the chiller and steam systems (pipes and equipment) was in poor condition.

*This story continues in chapter 3 - page 82.*

## TIPS

- During this step there is often the tendency to replace detailed analysis and balances by an expert judgement. This can be the right approach in some simple cases of standard technologies (where steps 1.5 and 1.6 can be conducted as a single step). However, especially in cases related to material and water flows, it is necessary to understand the real performance of a process and this often requires measuring specific flows and completing a mass balance of the focus areas.
- Analysis of flows is often viewed from different perspectives within a company. The engineers take a bottom-up approach, starting from specific processes using process flow diagrams and balances. Accountants have a top-down approach, using information from the accounting system, stock management and production planning systems in addition to profit and loss accounts. An efficient and effective data collection process depends on defining priorities and interfaces between different perspectives and information systems that may exist in a company in order to generate consistent information on a regular basis. This enables priority setting and good diagnoses of causes of inefficiencies for important sources of losses.
- Developing mass balances requires data on inputs and outputs that may be missing due to insufficient monitoring of material and energy flows. As a first step, data can be estimated or calculated as in the previous steps (estimating water consumption, for example, can be very simple using just a bucket and a stopwatch).
- Depending on data availability, mass balances can be created using data from a time period shorter than a year, such as a month or a production shift. In this case, it is essential to verify that the annual data are consistent with the data for shorter periods.
- Discrepancies in collected data can lead to the recognition of hidden pollution flows and sources as shown in the case history in this chapter.
- Repeatedly asking »why« can be an effective technique for understanding the causes of pollution generation. It can really pay back allocating sufficient time to reach a good understanding of these causes.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| Like in the previous step 1.5, this step provides an additional level of detailed information for setting up the Register of Significant Environmental Aspects and for identifying areas of significant energy consumption and uses. On this basis new RECP objectives and actions can be planned. | The significant environmental and energy aspects can be reviewed, taking the identified new areas of significant material and energy consumption into consideration. On this basis, existing company objectives can be reviewed and RECP actions planned. |

## OVERVIEW OF THE PRIORITY SETTING PROCESS AND DIAGNOSIS FOR UNDERSTANDING CAUSES OF IMPORTANT MATERIAL AND ENERGY LOSSES (STEPS 1.4, 1.5 AND 1.6)

| LEVEL OF ENTERPRISE DIAGNOSIS | SYSTEM BOUNDARY | OUTPUT OF THE ANALYSIS | INDICATORS | SOURCE OF DATA |
|---|---|---|---|---|
| **1.4 Identifying priority flows -** bird's-eye view | Company system boundary | Priority flows (specific material/energy flows) | KPIs | Existing accounting and production data, estimates |
| **1.5 Setting up focus areas -** medium-level view | Priority flow | Focus areas (specific departments, production units, cost centres) | OPIs | Estimates and measurements |
| **1.6 Revealing sources and causes** of inefficient material and energy use - detailed assessment | Focus area | Sources of pollution Causes of pollution for each source | OPIs | Measurements and estimates |

## CASE STUDY: DETAILED ANALYSIS IN A MECHANICAL COMPANY

The company, based in Tunisia, is a large producer of shock absorbers for automobiles and heavy trucks, exporting its products to Europe, Africa and Middle East.

Resource efficiency is pivotal for the company's strategy currently focused on competitiveness and continuous improvement. The TEST project provided the company with the required tools for reducing the overall costs of production, by reducing the consumption of inputs – such as raw materials, chemicals, spare parts and energy - but also the cost of environmental compliance.

The project was implemented over a two-year period (2015 – 2016) and the story assesses the analysis process and the progress achieved through the implementation of the MFCA approach and adoption of Resource Efficiency measures. The project team was led by the company's quality manager. It included some internal staff from production and accounting, and was supported by an external MFCA consultant.

### STEP 1.4: IDENTIFICATION OF PRIORITY FLOWS

Before the implementation of the MFCA tool, the company had no precise idea about the NPO costs. The only available figures were about some NPO quantities and costs at the company boundary for wastewater and solid waste management.

There was no data on the NPO value of inputs and especially no data on how NPO costs were distributed along the production process in term of quantities and value.

At this stage, the MFCA tool allowed the TEST Team to:

- map all inputs and outputs at the company boundary level
- have a quantitative and financial estimate of all the NPOs

The first MFCA-based analysis revealed some unexpected results which surprised the company's top management as they did not expected company losses to be so high:

- Total NPOs costs represent approximately 13% of total production costs in 2015
- Environmental costs: 36,600 €/year – this turned out to be 4% of total NPO costs;
- Losses of raw materials: 150,000 €/year – this amounted to 16.3% of the total NPO costs and 2.7% of the overall production costs;
- Operating materials: 550,000 €/year – this was 59.3% of the NPO costs or 9.81% of the overall production costs;
- Energy consumption: 180,000 €/year – this represented 19% of the total NPO costs or 3.15% of the total production costs

The overall breakdown of the NPO costs is given in figure 15.

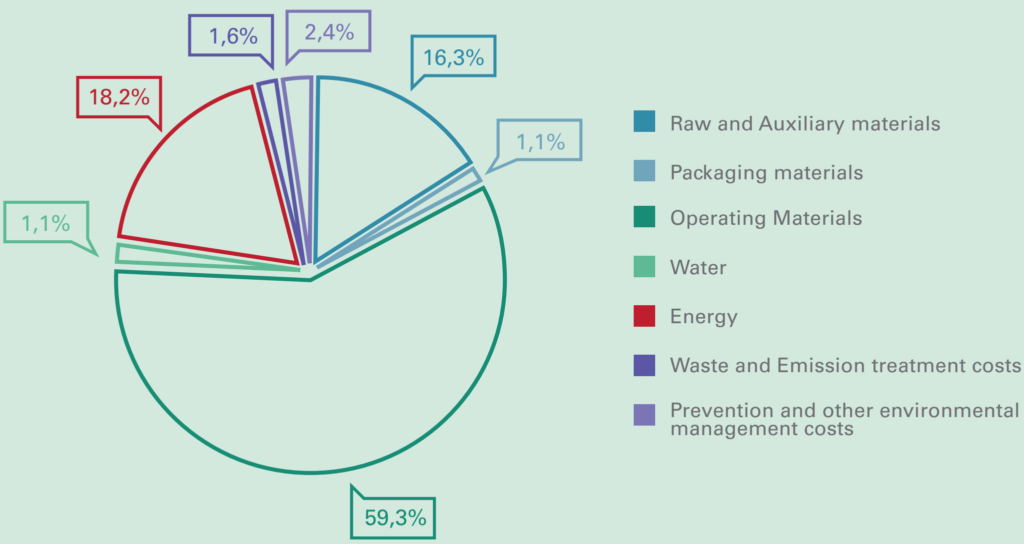



**FIGURE 15:** Breakdown of NPO costs in a company of the automotive sector

The MFCA indicated three main areas of intervention to the TEST Team, taking into consideration both the environmental impact and the potential for further improvements:

- Raw & Auxiliary materials (in particular, steel tubes and rods)
- Operating Materials (in particular lubricants)
- Energy

These choices were approved by the top management.

**Improving information system on resource efficiency**

Due to the high level of NPO costs the top management also decided to improve the company's information system, asking the TEST Team to work on the company's databases and to equip the production staff with the necessary measurement tools and procedures. The objective was to produce detailed information on:

1. The volume of material flows
2. The energy used at specific production steps
3. Related NPO quantities and costs

The TEST team was asked to work on the company's accountancy and other databases to obtain estimates of specific values. Guided by the TEST Team, the company took the following actions:

- It put in place a weighing system at different stages of the production process to calculate the losses of those raw and operational materials which had been identified as priority flows;
- It classified raw materials, articles and components by family and created one specific code in the information systems for each significant raw material;
- It weighed the different components to determine the average mass by family
- It set up different meters to measure energy consumption by production process and by energy-consuming equipment;
- It decided to implement an energy management system based on ISO 50001

The TEST Team has also searched the data sources to be recorded in the MFCA tool to enable future follow up initiatives. Although more work on the information system is required to get more detailed and relevant data, the company has made substantial progress in upgrading its information system.

### STEP 1.5: IDENTIFICATION OF FOCUS AREAS

The second phase of the MFCA analysis during step 1.5 consisted in determining the allocation of the NPOs along the production process to identify the areas requiring a more detailed analysis. This distribution the NPO costs (in EURO) per process is presented in table 5. Note that the company could sometimes only estimate the NPOs since the existing information system was not capable of providing such data.

| PRIORITY FLOW | TOTAL, EURO | PROCESS / WORKSHOP | | | | | OTHERS |
|---|---|---|---|---|---|---|---|
| | | WELDING | MACHINING | MOUNTING | CHROMING & PAINTING | PACKAGING | |
| Raw & Auxiliary materials | € 141,421 | € 49,615 | € 43,725 | € 25,380 | € 18,148 | | € 4,551 |
| Packaging materials | € 8,950 | | | | | € 8,950 | € 0 |
| Operating materials | € 385,229 | € 111,379 | € 107,442 | € 94,778 | € 51,625 | € 14,574 | € 5,427 |
| Water | € 6,512 | | | | | | € 6,512 |
| Energy | € 201,435 | € 19,443 | € 121,837 | € 11,471 | € 28,539 | | € 20,143 |
| **TOTALS** | **€ 743,572** | **€ 180,439** | **€ 273,006** | **€ 131,630** | **€ 98,313** | **€ 23,524** | **€ 36,634** |

TABLE 5: Distribution of the NPO costs per specific processes

Based on this analysis, the company selected the following focus areas related to the processes of:

- Machining
- Chroming and Painting
- Welding

Chroming and plating were selected over mounting because of high identified potential for improvement compared to the mounting process, as per expert judgement.
The result of the MFCA analysis convinced the top management to give its full support to the TEST project going on to identify sources and causes of losses and to develop and implement RECP measures.

### STEP 1.6: IDENTIFICATION OF SOURCES AND CAUSES OF LOSSES

The TEST Team, with the support of an external metal sector and resource efficiency expert, consequently undertook a detailed analysis to identify the major sources and causes of material and energy losses in all the focus areas.

The analysis focused on assessing the technology used and on observing the operating and good housekeeping practices. The TEST team held brainstorming sessions dedicated to analyzing the causes related to losses in the key flows in each focus area. Each potential cause they identified was traced back to its root cause. The Team used the fishbone diagram method to assist them in this analysis. Figure 16 shows the result for the Team's analysis of the chromium plating process.

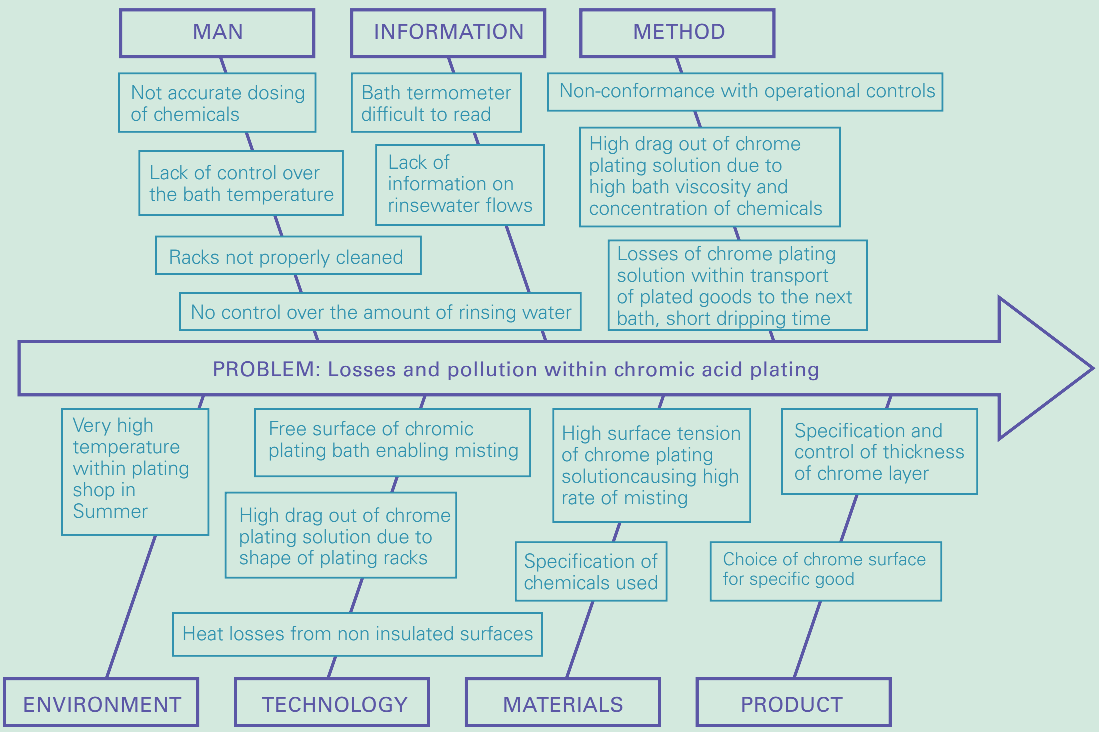



**FIGURE 16:** Fishbone diagram for chrome plating process

The project team prioritized the following causes of inefficiencies and waste generation:

- Non-conformance with operational controls in the chroming process, leading to wasted chromium (30kg/per week) and irregular surface treatment which was causing partial oxidation of the coated metal rods.
- The machining process and cleaning procedures resulting in fluids contaminated with lubricants that are a hazardous waste with no possibility for reuse and recycling.
- Non-compliance with operating welding parameters and standards, generating steel scrap from the welding process.
- Poor conditions and maintenance of certain welding stations, generating steel scrap.
- Excessive overspray in the paint workshop, resulting in high losses of paint (30-40% of input) with high emissions of solvents and generation of hazardous sludge.
- Storing wastewater on-site instead of sending it to the industrial water treatment plant, causing high costs of wastewater management

In parallel, an external local expert conducted an energy diagnosis to identify areas of excessive consumption and possible improvement options. Inefficiencies were found in equipment, the lighting system, the compressed air and steam networks, and utility equipment (compressors and boilers). These were considered as the areas where the highest savings could be reached.

The implementation of this step highlighted the importance of teamwork and especially the involvement of the company workers on the shop floor who provided significant inputs for analyzing the causes of inefficiency.

The experience of the external experts was also a good asset for building confidence in the analysis process as well as providing information on the knowledge on the latest developments and best available techniques.

## CONCLUSIONS

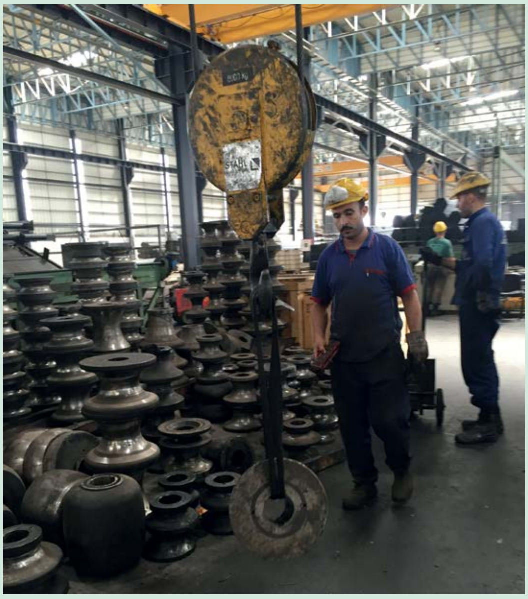
The company implemented a series of actions to reduce raw material and energy consumption such as:

- Installing a centrifugal separation system, to reduce the consumption of cutting oil in the machining process by 75%, and to also make it recyclable;
- Switching from liquid to a more efficient powder painting process, to reduce losses from 30% to 8%, and to not generate a sludge requiring treatment;
- Implementing energy efficiency measures, to reduce by 12% the energy consumption (preventive maintenance of the compressed air system, thermal insulation of the refrigeration system, and putting in place an energy management system).
- Designing training programs on RECP for employees, to increase competencies but to also increase their awareness of the importance of resource efficiency in production.

In summary, the implementation of the MFCA tool allowed the company to become properly aware of its NPOs, which in turn allowed it to implement the most promising actions to achieve resource efficiency targets based on best practices in the industry.

The MFCA tool proved to be efficient in monitoring and analysing the real costs of NPOs and in cost allocation, thus providing a sound basis for motivating the company to assess the root causes of losses and the feasible improvements through the application of resource efficiency measures based on best available techniques.

The company is already reaping the benefits of RECP with positive impact on its bottom line. This has motivated the company to further improve its information system by establishing analytical accounting system and to systematize the monitoring of raw materials consumption in quantity and in price on the ERP system.



# STEP 1.7 OPTIONS GENERATION AND FEASIBILITY ANALYSIS

Which techniques can be utilized to generate a set of resource efficiency measures?

## RATIONALE

This step builds on the root causes of significant material and energy losses identified in the previous step. It starts by broadening the scope of potential solutions by generating a broad menu of possible options and then narrowing the menu down to an optimal set of feasible measures to be subjected to feasibility studies, as illustrated in figure 17.

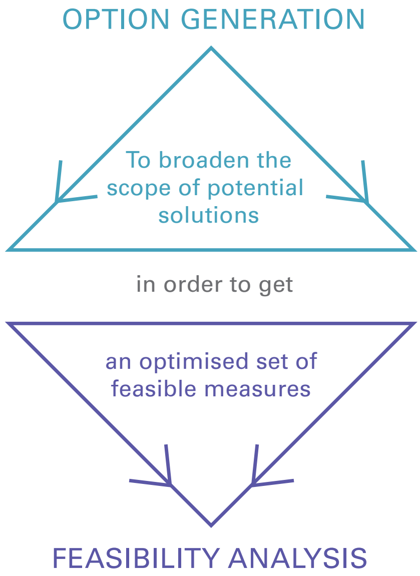


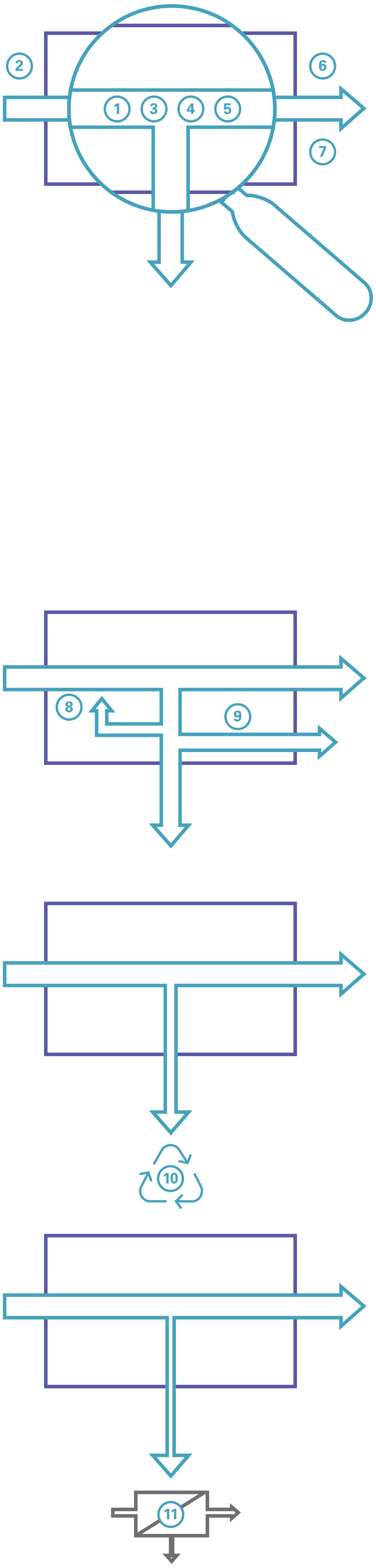

FIGURE 17: Developing improvement measures

## OPTIONS GENERATION

Once the company diagnosis in step 1.6 has been completed, possible options for improvement can be generated effectively. A brainstorming approach should be used, where the participants should be encouraged to think as far as possible »outside the box«, and where the proposing of even radical options should be encouraged. Options can be explored according to the hierarchy shown in the figure 18.

The TEST Team should first focus on identifying options which prevent NPOs from being generated in the first place or, failing that, which minimize them (so-called reduction at source). Such options fall into the categories of good housekeeping, changing input specifications, improving process control, modifying equipment, changing technologies, and modifying products, turning wastes into by-products, and on-site reuse and recycling of wastes. Techniques for internal recycling and valorization of by-products can be considered next. While external recycling leads to a reuse of a waste and thus a reduction in environmental impacts it does not reduce NPO and it entail risks to the environment in its transport off the site to its new site of use as well as in its processing to make it reusable. This is why these techniques should be investigated at a later stage after the economically most feasible preventive solutions have been explored.

Pollution and waste treatment options (also called end-of-pipe solutions) should be investigated at the very end. While these kinds of solutions are often required to comply with emission limit values and waste management requirements, even after preventive solutions have been adopted, they require high capital expenditures, have continuing operational costs, and show no return on the investment. By following this hierarchy, the TEST Team can substantially reduce, and in some cases eliminate, the investments and operational costs for end-of-pipe solutions.




LEVEL 1:
Reduction of production inputs and waste stream generation at source

1. Good housekeeping (e.g. complete emptying of containers, sealing of leakages, data monitoring, avoiding idling of energy consuming equipment,preventive maintenance of utility systems, etc.)
2. Raw and process materials substitutions (e.g. raw materials that do not contain formaldehyde, heavy metals or chloride, etc.)
3. Better process controls (e.g. automatic dosing of chemicals, optimization and monitoring of set point parameters in process, etc.) and production planning
4. Technology upgrades (e.g. installing more efficient machines, best available and eco-innovative technologies, etc.)
5. Technology/process modifications (e.g. retrofitting existing production line for waste heat recovery, etc.)
6. Product modifications (e.g. different specifications for surface finishing)
7. Packaging modifications (e.g. bulky detergent refillers)

LEVEL 2:
Internal recycling and by-product valorisation

8. Internal recycling (e.g. closing of water circuits, recycling of valuable materials in the company, etc.)
9. Valorisation of by-products (e.g. using textile waste as filling for pillows, etc.

LEVEL 3:

10. External recycling and external product valorisation

LEVEL 4:

11. End-of-pipe technology (minimized via techniques listed in the previous three levels)

**FIGURE 18:** Hierarchy of techniques for addressing causes of resource inefficiency

## FEASIBILITY ANALYSIS

The TEST Team can now assess the feasibility of the options which they have identified. To do so, they will use technical, environmental and economic criteria in order to decide on the optimal set of options for the company to implement as part of its TEST action plan. The TEST Team should bring in the perspectives of different internal stakeholders, as highlighted in figure 19.

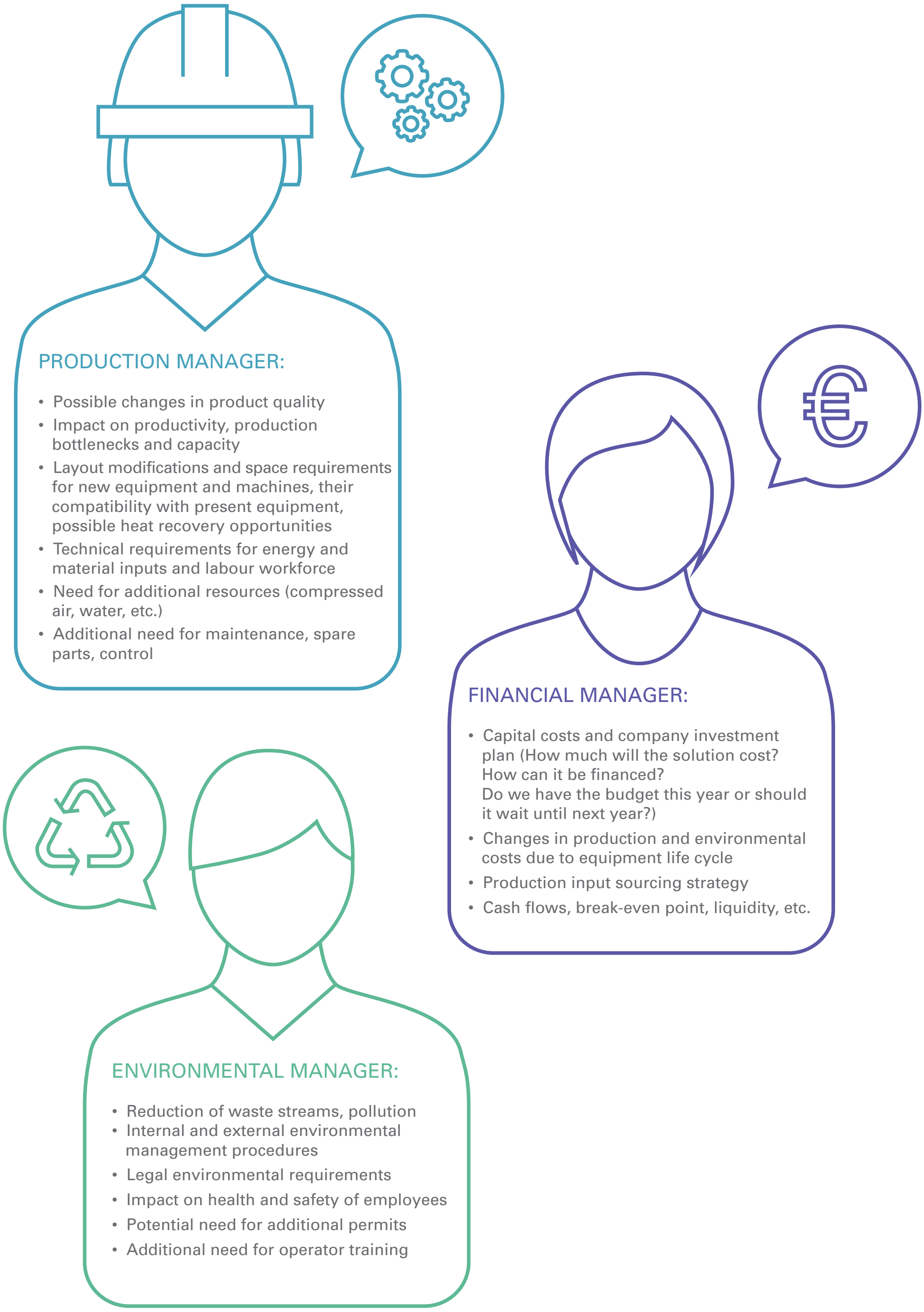



FIGURE 19: Basic requirements for a new technology investment based on different internal stakeholders perspectives

The TEST Team will first use technical and environmental criteria to exclude options that might have an adverse impact on product quality or might cause cross-media environmental side effects that could potentially offset the expected environmental benefits.

For those options surviving the technical and environmental assessment, the TEST Team will carry out a cost-benefit analysis. This analysis will quantify the economic savings from implementing each option, the capital expenditures required to implement the option, the change in operating costs brought about by implementing the option, and finally the return on the investment. With respect to the economic assessment, options can be classified into three main categories:

a. Good housekeeping measures, requiring no or little cost to implement;

b. Low-medium cost measures, which can be implemented using the company's own technical and financial resources

c. High cost measures that might require external financing. These measures normally entail an initial prefeasibility study and a subsequent more complex technical and financial appraisal that is often carried out by the company.

Resource efficiency criteria can assist companies in optimizing basic technological parameters and identifying the most appropriate technology providers from a range of suppliers on the market.

The outcome of the feasibility analysis is the »savings catalogue«, which the TEST Team will submit to top management for their review and approval. This provides the technical description and the key economic and environmental indicators for the set of feasible improvement measures which the TEST Team recommends be implemented. This set of measures is usually mix of good housekeeping measures, measures to improve operational control, modifications of the existing technology, as well as investment in new equipment.

## FEASIBILITY ANALYSIS BASED ON LIFE CYCLE COST ANALYSIS (LCCA)

The evaluation of new equipment should be based on techniques that consider not only the initial capital investment and layout, but also all the operating costs during its expected life time (i.e. raw and operating materials used, running air compressors, pumps, maintenance, treating pollution, end-of-life disposal, etc.). The operating cost for material and energy inputs and maintenance can easily amount to 80-90% of the total life cycle cost and should therefore also be considered.

To do this, the TEST Team can use a technique called Life Cycle Cost Analysis (LCCA). It can be used to generate data for a cash flow analysis of an investment project. The MFCA approach can be used as a supporting tool to identify all the relevant costs. Some »cheap investments« can turn out to be very expensive at the end of the technology's life cycle compared with more resource efficient equipment!

Payback period is an economic indicator that can be effectively used to evaluate low investment measures, but for assessing solutions needing significant levels of investment it is more appropriate to use indicators such as return on investment (ROI) or internal rate of return (IRR). Overall, measures needing high investments require detailed technical and financial appraisal before they are submitted to top management for their approval.

## SUSTAINABLE DESIGN

This is another technique that can be employed for analyzing large investments in new production lines and green-field projects. This technique is carried out in parallel to the traditional engineering design process, and systemically applies resource efficiency to virtual material and energy flows.

A detailed analysis of the initial engineering design parameters is conducted to generate optimized solutions in terms of selected technology, operating set points, and plant layout. Accordingly, the engineering company integrates resource efficiency principles into the design of the new investment, which is more cost effective than retrofitting or modifying existing processes after the initial investment has been made.

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| | OPTIONS GENERATION | |
| Inventory of pollution sources and related causes<br><br>List of preliminary ideas identified in previous steps (including recommendations for improving the information system)<br><br>External expertise including sector experts or sector-specific guides | Generate improvement options, giving priority to using preventive techniques:<br>• options should not be evaluated at this stage,<br>• only clearly unfeasible options should | **Long list of improvement** options ready for the feasibility analysis |
| | FEASIBILITY ANALYSIS | |
| The long list of improvement options<br><br>Material and energy flow data for specific process steps<br><br>Technology and process operational parameters (baseline)<br><br>Technology suppliers' information and technical requirements, including after-sales services | Evaluate each option using technical, environmental and economic criteria<br><br>Classify measures based on economic criteria<br><br>Prepare summary report/ presentation to inform top management and support its decision-making process | **Savings catalogue** (set of project fiches with pre-feasibility data and key indicators)<br>Terms of reference for detailed technical and financial appraisal of measures needing high investments |
| Tools | Sector specific manuals and BREFs<br>Financial Metrics Light [8]<br>Template for reporting results of feasibility analysis | |

[8] Copyright © 2008 Solution Matrix, free download from the web

## CASE STUDIES FROM THE DAIRY SECTOR

### A) FROM CAUSE ANALYSIS TO OPTIONS GENERATION

At the start of the TEST project, a Moroccan food company producing cheese was disposing high volumes of organic waste to landfill. This practice had some risks related to counterfeiting, product re-use or black market sales, which could have negatively impacted the company's brand. The company was therefore considering incineration as an alternative solution, although management was concerned about the costly investment required.

*»The implementation of these measures reduced returns from clients and finished product losses by 50%.«*

The detailed analysis which the TEST Team implemented in step 1.6 highlighted two priority raw material flows associated with high NPOs: butter and milk powder. These corresponded to 22% of total NPO costs. Several sources in the production process were identified as causing these material losses: tri-blender, cutter, paste transfer storage tank, Filling & Packing Department. However, a more detailed analysis showed that the losses generated during the production process accounted for only a fraction of total losses, since only 10% of the total organic waste originated from the production process. The remaining 90% was made up of returns of expired and damaged products from clients, as the company was responsible for their collection and final disposal. As a result, options generation shifted to focus on the supply chain, and the following main causes were identified:

- temperature fluctuations during transportation of the final product;
- improper refrigeration during intermediate storage by wholesalers and by retailers;
- poor product shelf-life management; and
- inefficient handling of the final product inside the factory and during truck loading.

Once the above root causes were identified, the TEST team started a brainstorming process for generating ideas leading to the identification of possible options for reducing NPOs along the supply chain, such as:

- preparing work instructions for handling the final products during loading and unloading at the intermediate storage facilities;
- replacing the secondary packaging material with another type of higher strength to reduce breakages during loading/unloading of trucks;
- training truck drivers to minimize door openings during transportation and monitor the temperature control systems;
- preparing work instructions to improve in-company storage of the product on palettes and on racks;
- using a racking facility in the wholesalers' stores; and
- setting up a protocol to control the product shelf-life at retailers.

The implementation of these measures reduced returns from clients and finished product losses by 50%. Since the total volume of organic waste had been significantly reduced at the source, the company decided to rethink the initial idea of waste incineration (which was no longer economically feasible) and instead valorize the damaged product as animal feed.

### B) FROM OPTIONS GENERATION TO FEASIBILITY ANALYSIS

The detailed analysis at a dairy company in Tunisia, highlighted water as one of its priority flows. The water balance showed that after the cleaning-in-place operation, the second largest source of water consumption was the milk cooling stage after homogenization (operating separately from pasteurization). It was responsible for approximately 22% of total water use. The specific technology used at this stage was once-through cooling, consuming approximately 120,000 $m^3$/yr, that were discharged into the sewage system, generating a high volumetric load for the WWTP.

The TEST team's immediate reaction was to investigate possible solutions for eliminating once-through cooling by closing the loop with either a cooling tower circuit or a chilled water circuit. The latter appeared to be the most feasible due to the low temperature set point required after the homogenizing process. However, this solution would entail significant investment to increase the company's chiller capacity.

Before further investigating the economic and technical feasibility of purchasing additional chiller units, an external expert suggested to the TEST Team to consider another option in more detail, »partial milk homogenization«, which could reduce water use and cooling demand at the source (BAT in the EU BREF for Food, Drink and Milk Industries). This option recommends homogenizing cream with a small quantity of skimmed milk as an alternative to the current process design, which sends the total milk volume through the homogenizer. The economic feasibility analysis showed that a 65% reduction in operating costs (both electricity and water intake used for direct product cooling) could be achieved simply by reducing the number of existing homogenizers in operation without major technology modifications or investments (except for some piping and control system changes).

Implementing partial milk homogenization would dramatically reduce cooling demand, and direct cooling could be eliminated by linking to the existing chiller unit capacity. Consequently, the investment cost for eliminating direct cooling would be significantly reduced (only piping, valves and heat exchangers), and the payback period would be shortened by more than half. Table 6 illustrates how the parameters and baseline for calculating the economic savings of eliminating direct cooling changed through the implementation of partial milk homogenization.

| PROCESS NEEDS (homogenizer) Water for direct cooling: | ELIMINATION OF DIRECT COOLING (closing the cooling water loop at homogenizer with chilled water circuit) | |
|---|---|---|
| | Without partial milk homogenization | In combination with partial milk homogenization |
| Volume ($m^3$/y) | 120,299 | 42,105 |
| Cost (EUR/y) | 86,480 | 30,270 |
| Cooling demand (chilled water): | | |
| kWh/y | 1,117,440 | 391,107 |
| Cost (EUR/y) | 21,140 | 7,400 |
| **Payback period (PBP)** | **>5 y** | **2.5 y** |
| Process water (= 90 %) | 0.72 | EUR/$m^3$ |
| Chilled water 3°C (R717, COP = 3.2) | 0.019 | EUR/kWh |
| Cooling tower water | 0.0017 | EUR/kWh |

TABLE 6: Feasibility analysis of eliminating direct cooling at homogenizer with and without partial milk homogenization

Table 7 summarises the overall results of the feasibility analysis at the company and provides key economic and environmental figures for the 10 feasible measures identified. The external expert recommended that the company start by implementing measures with the highest cost saving potential and increased productivity (reducing the process needs first) such as:

- reduction of product losses in processing and client returns;
- partial homogenization of milk; and
- management of ammonia chiller performance.

| | MEASURE | Cost savings [EUR/y] | Investment [EUR] | Payback [y] | Reduced $CO_2$ emissions [t/y] | Reduced water consumption [$m^3$/y] | Reduced $BOD_5$ [kg/y] | Reduced COD [kg/y] | Reduced solid waste |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Optimisation of cream separator and centrifuges | 16,200 | 2,800 | <1 | 92 | 3,709 | 57,456 | 92,232 | - |
| 2 | Recovery of milk and fermented products sent to WWTP | 27,060 | - | immediate | 165 | - | 104,241 | 167,334 | - |
| 3 | Reduced product losses from product transfer | 311,860 | 50,000 | <1 | 151 | - | 94,392 | 151,524 | - |
| 4 | Pasteurisation - heat recovery | 92,588 | TBD | TBD | 3,506 | 19,165 | - | - | - |
| 5 | Partial homogenization of milk | 99,921 | 68,800 | <1 | 385 | 78,194 | - | - | - |
| 6 | Optimization of cleaning-in-place (CIP) | 50,580 | 58,000 | 1 | 468 | 66,528 | - | - | - |
| 7 | Cleaning of crates | 43,494 | 6,000 | <1 | 338 | 28,843 | - | - | - |
| 8 | Optimisation of chilled water production | 61,103 | 28,000 | <1 | 538 | 1,740 | - | - | - |
| 9 | Leak detection inspection programme | 7,366 | - | Immediate | 39 | - | - | - | - |
| 10 | Elimination of direct cooling (after implementation of option 5 above) | 22,871 | 57,600 | 2.5 | 65 | 42,105 | - | - | - |

**Table 7:** Summary of feasibility analysis results for a dairy company

## TIPS

- The focus of options generation should be on generating as many options as possible, including any ideas that have been already generated in the previous TEST steps
- It is a good practice to also keep a record of rejected options for possible future use and/or for inspiration during the next round of innovation efforts.
- Brainstorming is an effective and recommended technique for options generation, as it leverages the variety of expertise in a team and overcomes barriers to the open sharing of ideas and mutual inspiration. If people are hesitant to express their ideas during a shared session, ideas could be individually recorded from different team members. A brainstorming workshop involving not only the TEST team, but also for example, an external expert can be useful to generate options for complex focus areas.
- Emission and pollution reductions for specific measures can be difficult to estimate for an accurate estimation of savings. Pollution intensity benchmarks are available in the literature (e.g. EU BREFs) for some products (e.g. $BOD_5$ per $m^3$ of milk).
- MFCA data can be used during the economic feasibility assessment. Moreover, a sensitivity analysis could be performed if relevant changes in the business environment are expected in the short to medium term (increasing environmental management costs due to enforcement of new legislation, removal of subsidies on energy/water prices, increase in the price of important raw materials, etc.).
- Detailed technical studies for investigating the feasibility of complex options and/or those requiring high investment can be listed and budgeted at this stage already – and integrated into the TEST action plan.
- The savings catalogue of feasible measures should also include measures for improving the information systems on material and energy flows in the company.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| Integrating preventive techniques into the company's operational decision-making processes can lead to better performance.<br><br>The output of this TEST step provides a sound basis for developing a company's Environmental/Energy Management action plans. | The options generation and feasibility analysis methodology could be used as a tool in operational planning and controls for improving operational processes' effectiveness, based on the hierarchy of preventive techniques.<br><br>Existing EMS/EnMS action plans can be reviewed and updated to include newly identified feasible resource efficiency measures. |

# STEP 1.8 ACTION PLAN

What measures to implement and monitor for improving company performance?

## RATIONALE

The TEST Team presents the savings catalogue to top management and discuss it with them. This is the moment when the company decides which of the proposed actions are to be implemented, based on internal priorities and resources. In some cases, top management requests that certain measures be subjected to further study of their technical-financial aspects before they take a final decision. The TEST Team is encouraged to record all the feasible measures in the savings catalogue, including those that have been rejected by top management, as they could be relevant for implementation at a later stage.

At the end of the internal review and consultation process, the TEST Team will formalize the TEST action plan. This will allocate responsibilities, and define time lines and budgets for the approved measures. External financing and the possibility to access incentive schemes for measures requiring high investment may be investigated at this stage.

As part of the TEST action plan, the TEST Team establishes an operational control plan so that the real savings from implementation can be properly measured. For instance, for each RECP measure in the action plan, the TEST Team should define indicators and should set up a cost effective monitoring system for both consumption and driving factors. This is the last element of the overall information system for resource efficiency, which is being built up step by step throughout the TEST methodology.

### RECP INFORMATION SYSTEM

Many companies only have the mandatory minimum financial accounting system. For better data monitoring, a stock management system and eventually a cost accounting and production planning system may be needed. Companies set up their information systems to monitor resource efficiency and environmental performance in many different ways. At the beginning some only have information on key consumers at the process level. Some companies have energy sub-meters to monitor consumption by key consumers, which register consumption data at regular intervals. Few companies analyze data on energy and raw material consumption and correlate them with the relevant consumption-driving factors to calculate relative indicators in order to measure resource efficiency.

However, a proper information system for RECP is essential and can provide the following benefits:

- It can control the enterprise's performance at the level of selected priority flows using KPIs (for assessing performance against enterprise goals, for internal and/or external benchmarking and for internal/external reporting).

- It can monitor performance at the level of the focus areas and sources of losses through OPIs, for:
    - Measuring, recording and reporting performance vs. baseline for the implemented resource efficiency measures included in the TEST action plan, evaluating them against specific objectives and targets to enable corrective action
    - Understanding causes of inefficiency and implementing corrective measures and generating new options;
    - Setting performance improvement objectives;
- It can measure improvements of performance resulting from implementation of RECP actions (e.g. TEST action plan)
- It can make people who influence use of resources accountable for resource efficiency at all levels.

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| Savings catalogue (feasible measures)<br><br>KPIs and OPIs already defined in the previous steps<br><br>Elements of existing information on resource efficiency<br><br>Information on existing incentives schemes for resource efficiency and environmental investments | Draft an action plan reflecting top management's decisions. The plan includes timeline, budget, responsibilities for implementing a set of RECP measures<br><br>Select indicators for each measure in the TEST action plan and set up a cost effective way to monitor both consumption and driving factors of KPI/OPI.<br><br>Finalize the overall monitoring plan for resource efficiency (responsibility, frequency, procedure, budget) as part of operation control<br><br>Identify modalities for accessing financing for high investment needing solutions | Management commitment to implement selected measures and the information system on resource efficiency<br><br>TEST Action Plan and Monitoring Plan |
| Tools | Action Plan template<br>Monitoring Plan template<br>Monitoring and Targeting Tool<br>Energy Audit checklist<br>Sustainable Design for new equipment | |

## CASE STUDY: SETTING UP AN ACTION PLAN FOR RESOURCE EFFICIENCY IN A PLASTIC RECYCLING COMPANY

An Egyptian plastics recycling company decided to implement a TEST project with the aim of reducing its production costs using Resource Efficient and Cleaner Production techniques. At the project's start, the company was mainly focused on water and energy savings, since management knew that its consumption of these was above the industrial sector average. However, after the TEST »Priority Flow analysis« using the MFCA tool the TEST Team obtained an indication of the NPO costs and management realized that most of their losses came from a low yield in material processing. Because of this thorough analysis, the focus shifted to reducing losses of raw materials.

Once the savings catalogue was finalized, the TEST Team and its consultants organized a meeting with the company's Board of Managers to present the result of the analysis and a draft of the action plan to implement their recommended measures. The board of managers quickly approved the implementation of easy-to-implement, no/low cost measures, which included changing the size of the mesh in the sieve screens to reduce the possibility of rejecting properly sized flakes, shifting the supply of raw material to a higher grade, and reducing the percentage of rejected material.

One of the suggested measures consisted in reducing the operating temperature of the polymerization stage. The TEST Team estimated that the savings from this would be consistent. The management decided to further analyze this option by consulting with the technology supplier to jointly verify whether a lower temperature could affect the polymerization process or not.

Another measure addressed installing an automatic sorting machine to return the good bottles from the rejected stream back to the production. Whilst the company decided to accept the concept behind the measure, it decided to hire manual sorters instead of buying an automatic sorting machine that would entail high investment.

On the other hand, the company challenged the Team's recommendation to add a vacuum filter to the line processing the high grade raw material. Based on the consultants' analysis, the Team said that this measure would have reduced water consumption, whilst the board of managers believed that it would only enhance the quality in production. The Team argued that the filter would remove contaminants from the wash water. Thus, the cleaned water could be reused in the washing process, with a clear saving in water consumption. This measure was retained for further study.

Two measures listed in the savings catalogue were eventually discarded for technical reasons. The first discarded solution required the company to work with the suppliers of plastic waste bales, to receive better sorted material with lower percentages of reject materials such as cardboard and paper; unfortunately, the suppliers could not fulfil the request. The second discarded solution aimed at increasing the quality of sorting to reduce the quantity of recyclable flakes ending up in the rejects. This option could not be implemented due to the type the existing filters.

At the end of the meeting, the board of managers approved the action plan as illustrated in the table 8.

| No | Objective | Title of the Action | Responsible[9] | Budget (EUR) | Category | Target / indicator | Ac-cepted | Dis-carded | Re-tained for study |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Secondary raw material supply | Import better quality PET bottles bales from Europe | Procure-ment & Quality | 0 | No cost | To increase ratio of good quality PET bottles to 50% | x | | |
| 2 | Optimization of PET wash-ing line bottle pre-treatmen | Check efficiency of de-labeler/ labels separator | Production | 100,000 | Invest-ment | Reduce the loss of material after bottle sorting by 1% | x | | |
| 3 | | Reset the bottle sorters and set up new process parameters | Production | 5,000 | Medium cost | Reduce the loss of input material by 0.7% | x | | |
| 4 | | Install an auto-matic third bottle sorting machine | Manage-ment, Operations & Technical office teams | 80,000 | Invest-ment | Save 1% of the input material | | | x |
| 5 | | Contact with bales supplier to elim-inate cardboard sheet | Procure-ment | 0 | No cost | Eliminate cardboard waste | | | |
| 6 | Optimization of PET wash-ing line flakes production | Restart the vacuum filter when processing European bales of bottles | Mainten-ance | 0 | No cost | Reduce water consumption by 1 $m^3$/ton product | | | x |
| 7 | | Adjust air flow of vertical air stream separator | Production | 0 | No cost | Reduce loss of good flakes from the air stream separ-ator by 0.5% | x | | |
| 8 | | Check the size of the mesh of the sieve screen | Production | 3,000 | Medium cost | Reduce loss of good quality material from the sieving table by 0.5% | x | | |
| 9 | | Install a re-sort channel on the Sortex flakes sorter | Operations & Technical office teams | 20,000 | Medium cost | Reduce loss of good quality material from the sorter by 1% | | x | |
| 10 | | Improve the sep-aration of oil from the process water | Technical office team | 150,000 | Invest-ment | Water savings by 2.5$m^3$/ton product<br>Energy savings by 7% | | x | |
| 11 | Adjusting the set points of the Solid State Polyconden-sation production line | Adjust the Polyconden-sation process temperature at recommended values. Combined with putting the vacuum pump of the degassing in function. | Mainten-ance | 0 | No cost | | x | | |

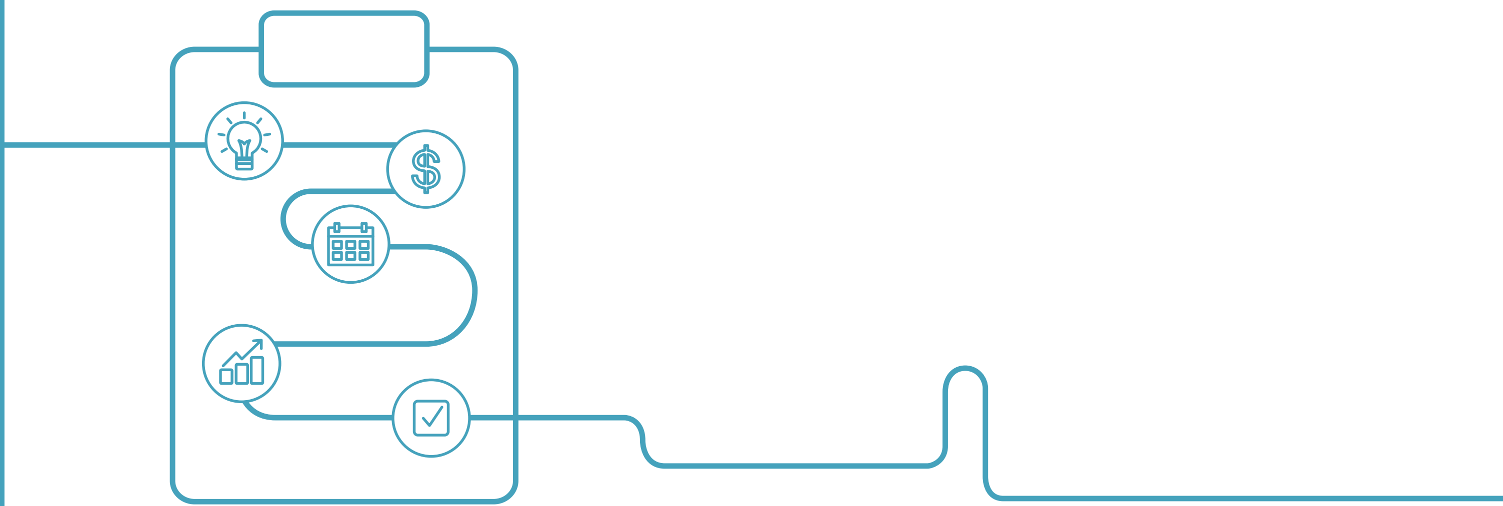
**TABLE 8:** TEST Action Plan for a plastic company

## TIPS

- The review of existing, or preparation of new, specific internal operational criteria and working instructions related to good housekeeping measures or to monitoring material and energy flow data and environmental performance should be included in the action plan.
- Training of enterprise staff is an integral part of the action plan to ensure that people involved in the implementation of the action plan are capacitated and motivated not only to implement particular measures and monitoring, but also to sustain their effects.
- An effective information system on flows should be finalized at this last stage of the planning, otherwise monitoring and evaluation may be forgotten later when measures have been implemented and no baseline is available.
- If relevant, a budget should be allocated for additional monitoring and measurements (e.g. installation of sub-meters, software, external services for sampling wastewater pollution loads, human resources, etc.).
- OPIs should be defined in such a way that they enable feasible measurements of both absolute consumption and associated driving factors for meaningful correlation, leading to monitoring of real performance in resource efficiency.
- A solution for real-time monitoring should be considered only if needed to manage important flows (and if it pays back). Monitoring selected OPIs once a week can be sufficient to enable the implementation of any necessary corrective actions or the identification of possible improvement options.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| This step facilitates the development of operational controls for effective implementation of a resource efficiency action plan | Existing EMS/EnMS documents can be reviewed to identify gaps and plan add-ons related to operational controls, including training and communication plans. |



# STEP 2: SUPPORT AND OPERATION

# STEP 2 SUPPORT & OPERATION (IMPLEMENTATION)

How to support a company in implementing the TEST action plan?

## RATIONALE

At this stage, the results of the work done in Step 1 start to become visible as the recommended improvements are brought on line.

Support and operation is all about the execution of the action plan that will enable the company to achieve resource efficiency and pollution prevention objectives. For this purpose the company allocates the human, financial, and material resources necessary to implement the action plan.

In this respect, the company ensures that competent staff is available based on appropriate education, training and experience. Accordingly, operational controls are established for internal as well as outsourced processes. These operational controls include technical controls related to the areas of engineering, maintenance, quality and safety. They also include administrative controls consisting of providing information on resource efficiency including significant energy uses to personnel working for or on behalf of the company.

The speed with which the action plan is implemented varies, depending on the company's motivation, the allocated budget, and the staff capacity. An action plan might be perfect, but it will not be implemented well if the people responsible for its implementation are not committed or sufficiently trained to achieve the desired results.

External TEST consultants may still play a role in supporting companies during the implementation of their action plan. For instance, they can play a role in the implementation of good housekeeping measures (regulation of boilers and utility systems in general, development of the information system, training, etc.) or in the identification, selection and supervision of external service providers and technology suppliers to ensure that quality and sustainability criteria are properly taken into consideration.

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| TEST action plan<br><br>Human and financial re-sources<br><br>External experts/service providers/suppliers<br><br>Existing documentation of management and informa-tion system | Finalize documentation and information system, including purchase and installation of sub-meters (if required) | Information system for RECP implemented (including rou-tines for NPO assessments for priority flows) |
| | Implement measures in the TEST action plan (specifica-tions, procurement, installa-tion, etc.)<br><br>Train company staff (in, e.g., preventive maintenance, measurement of performance, production operations, etc.)<br><br>Establish and communicate responsibilities and set up incentives for employees responsible for implementing the action plan. | Resource efficiency measures implemented<br><br>Supporting documentation in place (e.g. internal proced-ures for good housekeeping, operational work instructions to support implementation of the cation plan)<br><br>Training plan for employees to sustain RECP in the com-pany<br><br>TEST Action plan communi-cated internally |
| Tools | Action Plan | |

## CASE STUDY: OVERCOMING BARRIERS DURING THE IMPLEMENTATION OF A TEST ACTION PLAN

At the start of the project, a beverage company in Tunisia was planning to build a wastewater treatment plant (WWTP). The company's main motivation to implement this action was a requirement of its major client, which had stated that it might consider voiding the supply contract if this request was not met.

The TEST Team had to seek management sup-port and work on improving internal communi-cation in order to ensure that everyone received the right message about TEST as a win-win strategy and that implementation of the action plan would lead to improvements in the pro-duction process and contribute to increasing the efficiency of the WWTP under construction.

The TEST team integrated the TEST action plan into the company's ISO 14001 Environmental Management System, which was in the prepara-tion stages. The result was a strengthened EMS program with a strong focus on resource effi-cient and cleaner production. Other procedures were also developed to support good housekeep-ing and process optimization measures.

The approved TEST action plan included a number of good housekeeping measures designed to reduce by one third the organic pollution and the volumetric load going to the drain and on to the WWTP. For instance, the implementation of a management system for on-time sorting of returned goods (soft drink bottles) from clients would contribute to product recovery of 0.4% and reduce the volume of non-conforming products sent to drain by 95%. A procedure for on-site segregation and a storage system were also included in the EMS to valorise expired/damaged products as animal feed. As a result, COD and BOD5 loads to the WWTP were reduced by 27 t/y and 21 t/y respectively.

*»The tendency to view good housekeeping as 'soft' measures rather than 'real' measures to be prioritized.«*

When the TEST team started its work on implementation of the action plan, it highly recommended that these good housekeeping and low cost measures be implemented before designing the WWTP as it would reduce size of the WWTP and therefore the needed investment and operational costs. However, the Team did not receive enough support from the production manager, who was reluctant to change routine procedures as the company was certified for quality and food security (ISO 9001 and ISO 22000). The mind-set of the production manager clearly highlighted a typical barrier: the tendency to view good housekeeping as 'soft' measures rather than 'real' measures to be prioritized.

Although the WWTP was finally commissioned without taking into account the expected load reduction derived from the implemented measures, it was verified that once installed the WWTP could operate with one-third less electricity for the aeration system compared to the design parameters. This drop was due to organic load reduction of the RECP measures. Initial financial and environmental benefits were achieved, creating confidence and motivation among the rest of the staff. This paved the way for the generation of new options and the subsequent implementation of the more costly measures in the action plan. The company also received ISO 14001 certification in 2012.

Top management appreciated and supported the TEST team, which was also manifested in rewards. The internal TEST team received a promotion, and were allowed to participate in other training seminars, and given responsibility for sharing the results with other production sites in the group, with the objective of replicating the experience. The company now enjoys the best resource consumption rates in the group and the project team provides regular technical assistance to increase resource productivity to all other production sites of the group.

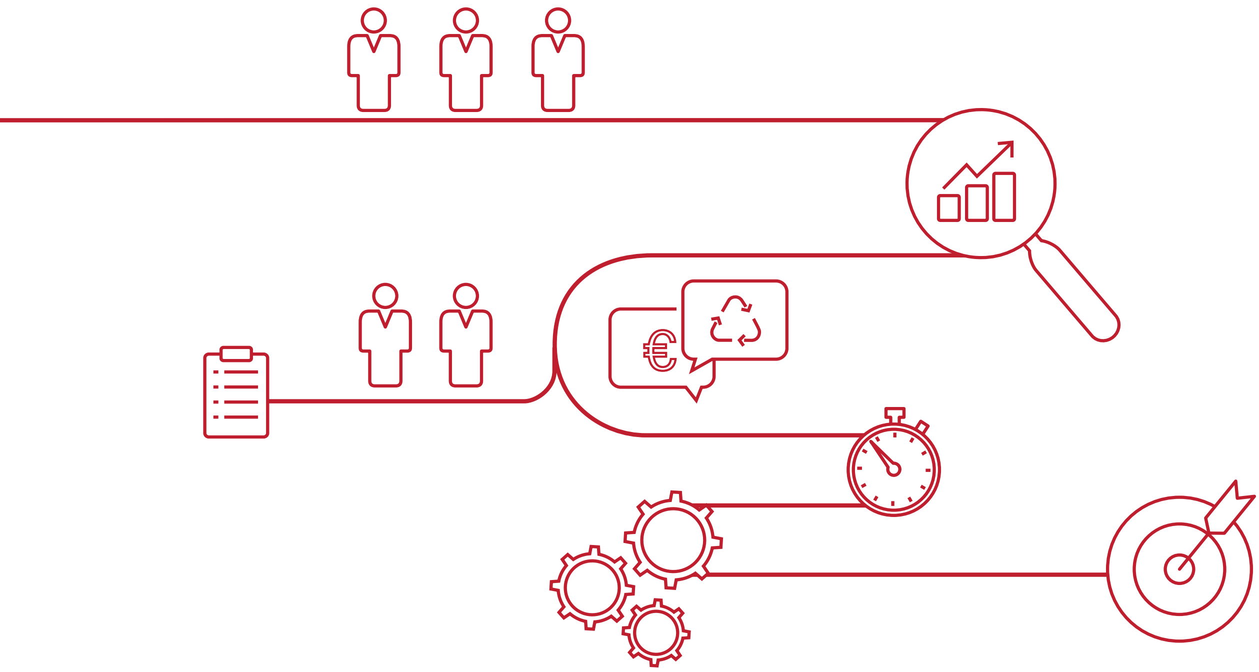
## TIPS

- Operating criteria and controls of the processes related to resource efficiency should be implemented to make sure that they are effective and achieve the desired results. This includes work instructions for implementation of operating criteria related to resource and energy efficiency as well as preventive maintenance.
- Company purchasing processes may also be consolidated by integrating new criteria and procedures for a life cycle perspective of products and services.
- The communication of work instructions and operational criteria internally as well as to suppliers of products and services is essential to strengthen motivation of the staff to cooperate in to implement the TEST Action plan.
- Additional resource efficiency training may be required for the staff in charge of the action plan's implementation

- External experts can play a role in linking the company to existing financing organization that provide grants or blended financial instruments for investments in resource and energy efficiency, clean and end-of-pipe technologies.
- Good housekeeping measures should be implemented first, as they bring benefits at no cost to the company. They deserve as much attention as traditional equipment upgrades. The effects of good housekeeping measures can be sustained by making the people who influence operations accountable.
- The information system on data collection and processing is an integral part of the action plan's implementation.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| Resource efficiency management system documents can be developed at this stage.<br>If a company does not intend to pursue EMS/ EnMS certification, only the documented information related to operational controls may be put in place, e.g. those related to implementing good housekeeping measures and to the effective monitoring and evaluation of specific measures in the TEST action plan. | Existing management system documents including work instructions should be reviewed and upgraded as necessary to sustain resource efficiency measures (good housekeeping, operational procedures) and the monitoring and evaluation of implemented measures.<br>The newly established information system on priority flows and resource efficiency should be integrated in the existing management system, linking the managerial and operational levels of an enterprise. |



# STEP 3:
# PERFORMANCE EVALUATION

# STEP 3 PERFORMANCE EVALUATION (MONITORING)

How to use the established information system on resource efficiency to monitor, analyze and evaluate performance for continuous improvement?

## RATIONALE

During the planning phase of TEST methodology (Step 1), the company will have designed an information system for resource efficiency that will allow controlling the most significant inefficiencies related to resource productivity. This information system is essential for continuous improvement of the company's performance against objectives and targets defined in the RECP policy.

The information system is constituted of several elements, such as: a set of resource efficiency indicators linked to important flows at the level of the whole company as well as to productivity bottlenecks at operational level that are set at the end of step 1.6; routine procedures for measuring, recording and analysing specific data in the production and accounting departments; installed measurement devices (both hardware and software); a well-defined monitoring plan with frequency and responsibilities for monitoring, which has been designed in step 1.8 and implemented in step 2.

In step 3, the already established information system is utilized to measure real performance and improvements resulting from the implementation of RECP options, and is compared with the initial baselines quantified during the planning step 1. Results of this analysis are then shared with the management team to allow them to carry out review internal processes as part of the company's decision making processes.

Monitoring requires internal human resources who should be trained on how to operate the information system, in close cooperation between engineers and accountants.

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| Baselines calculated in steps 1.4, 1.5, 1.6 and 1.8<br><br>Information system on flows installed in step 2.<br><br>Existing procedures for data collection, documentation and reporting<br><br>Enterprise staff trained in monitoring and evaluation as part of implementation of information system on flows in step 2. | Compile data as per monitoring performance procedures set in the information system<br><br>Analyse data and calculate KPIs and OPIs set up in the planning phase<br><br>Compare actual performance report to the company's smart objectives<br><br>Evaluate results<br><br>Conduct management review for performance evaluation<br><br>Establish new baselines of performance indicators | Routine monitoring in place (following operation control)<br><br>Values of KPIs and OPIs for actual company performance<br><br>Trends in resource efficiency performance<br><br>Management review for performance evaluation<br><br>New baseline of performance indicators (KPIs and OPIs)<br><br>Reporting monitoring results to stakeholders. |
| Tools | MFCA excel tool<br>Energy Mapping excel tool<br>Monitoring and Targeting tool<br>Monitoring Plan | |

## CASE STUDY: OPERATING AN INFORMATION SYSTEM ON RESOURCE EFFICIENCY

We continue here the case study of the dairy company presented in step 1.6 about introducing the results of an information system on resource efficiency. As already described there, the company's information system had helped the TEST Team to identify sources and causes of losses Here, we will show how the information system can be used to continuously manage priority flows and, simultaneously, monitor the benefits of the measures which have already been implemented.

28 measuring points were established in the information system for the monitoring energy efficiency in the steam and chilled water systems. Data from these monitoring devices started to be collected on daily basis as of July 4 2016, early on in the TEST project. Data was also gathered on daily production levels, expressed as weight of milk processed, and a record kept of the type of products made.

In April-May 2017, the company implemented a set of measures to increase the efficiency of the steam system, such as upgrading the piping and insulation and improving load matching. The company also refurbished the chilled water system, replacing all piping insulation, brushing and cleaning the condenser fins, insulating the ice bank tank and, in order to improve heat transfer, changing the configuration of the chilled water piping inside the ice tank.

As the steam system represented about 70% of the company's energy demand, significant savings were brought about after the implementation of the above-mentioned measures. For instance, the specific energy consumption of the plant dropped from 0.45 KWh/kg of milk processed in February 2017 to 0.36 KWh/kg milk a year later, representing a 20% improvement in one year. These improvements could be measured thanks to existence of the information system, the baselines calculated in step 1.6, the monitoring plan designed in step 1.8 and step 2, as well as to the monitoring done during step 3.

Figure 20 below shows the actual vs predicted energy demand for the steam boilers from July 2016 to February 2018.

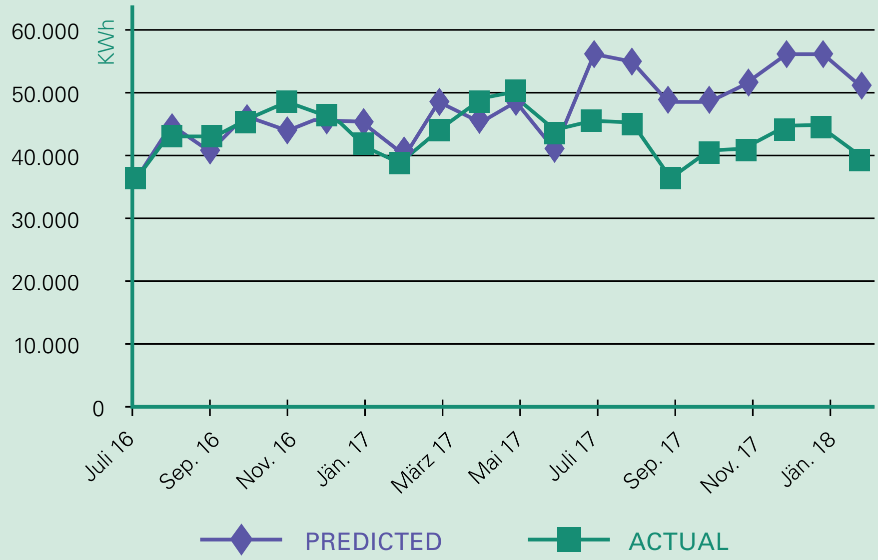



**FIGURE 20:** Predicted versus actual energy consumption within the steam system

The blue line represents the baseline generated using the initial set of data and the consequent initial regression analysis (theoretical consumption calculated utilizing the baseline). In other words, it represents the consumption the company would have had if the TEST project had not been introduced. The red line, on the other hand, represents the actual readings of energy consumption. Until June 2017 the two lines are well synchronized, showing that the baseline for original performance was well set up before improvement measures began to be implemented. However, after June 2017 a visible variation appears between the predicted consumption (calculated based on the original baseline) and actual consumption based on monitoring of actual performance; the difference represents the savings achieved as a consequence of the measures implemented in the steam system.

Figure 21 shows the cumulative savings over the 8 months which followed the implementation of the improvement measures.

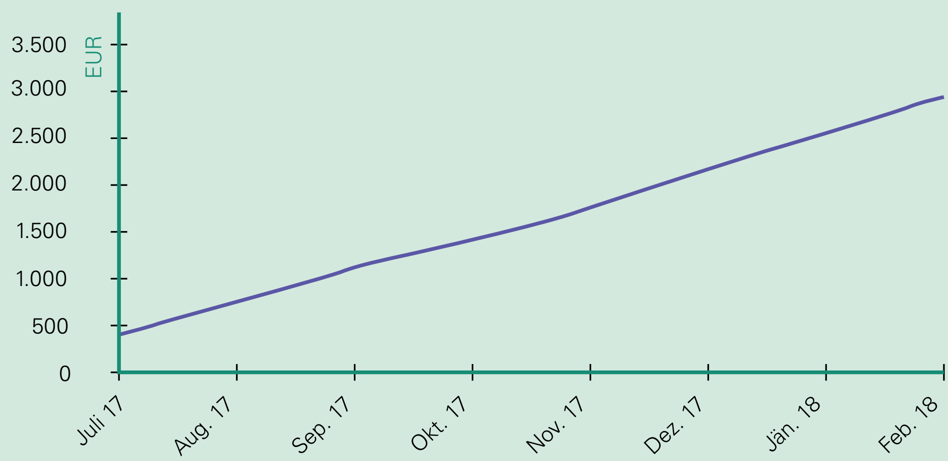



**FIGURE 21:** Cumulative money savings for steam system

The savings amounted to 7 tons of diesel fuel with a value of around € 3,000 (the margin of error in these estimates is ± 15% considering the magnitude of the correlation coefficient); the actual payback period for improving the steam system turned out to be around 1.3 years compared to the initial estimate of 2 years (in other words, real energy savings were higher than had been predicted).

The programme of regular monitoring based on the established RECP information system also quickly revealed a hidden leakage of cooling water, as it highlighted a sudden and significant decrease of energy efficiency in the chilled water system. The company, thanks to monitoring, was then able to fix the leak immediately.

Today the board of managers appreciates its new RECP information system as an essential tool for running its operations.

## TIPS

- Results of monitoring indicate the real savings, which quite often exceed the preliminary estimates. These savings can also justify financing for additional resource efficiency measures by the company.
- Quantification of real savings from implementation of RECP is essential to ensure management support for continuous improvement. Relative indicators (KPIs/OPIs), baselines, a monitoring plan based on an established information system enable correct monitoring of not only the consumption of relevant material and energy flows but also of the driving factors responsible for this consumption.
- As a result of the systematic monitoring of its resource efficiency performance, the company can set itself a new baseline, which is then the basis for setting new objectives and targets.
- Monitoring and evaluation can be labour intensive and require dedicated and skilled resources. Employees have to be properly trained to perform monitoring to understand its added value. Monitoring should be part of employees' normal routines and job descriptions.
- The results of monitoring and evaluation, when discussed inside the company, offer opportunities for organizational learning and continuous improvement.
- OPIs and KPIs should be an integral part of operational reporting and management board review meetings.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| Documented information such as work instructions could be developed for the collection, processing, recording, evaluation and reporting of monitoring data, but also for documenting and recording any corrective actions to the internal management system with respect to monitoring. These could be part of a future EMS/EnMS.<br><br>Results from monitoring after implementation of RECP (real vs. expected) should be presented during internal management review meetings. | The information system on resource efficiency and the indicators should be integrated into the existing management information system and related documented information.<br><br>Monitoring data can be used to evaluate conformance to environmental objectives and to set up new management system baselines.<br><br>Information on monitoring results should be included for consideration in the EMS/EnMS management system review. |

# STEP 4: IMPROVEMENT

# STEP 4 IMPROVEMENT

How can the can the company reflect the experience gained with TEST in its business strategies and day-to-day operations?

## RATIONALE

This chapter outlines actions which a company can take to continually improve its performance through RECP and to expand the scope of TEST with follow-up activities focused on eco-innovation and sustainable development.

With the concept of PDCA as its foundation, the TEST approach provides an iterative process to achieve continuous improvement. The completion of all TEST steps closes the learning cycle, securing long-term benefits for the organization in terms of resource efficiency and integrated environmental performance management.

When company management, through the management review process, reviews the results from the previous step of performance evaluation, it can take decisions to consolidate and sustain the TEST experience. This is likely to impact its business model, leading to changes in its core values and strategies regarding sustainable development. This is the ultimate goal of TEST approach.

The major drivers of this process are stakeholder expectations, both internal and external, at the base of the management pyramid. An enterprise can increase its economic value by reflecting these expectations at all levels of the management pyramid (from enterprise values, policies and goals, through operational strategies and procedures, to processes and products).

Opportunities for developing partnerships with stakeholders along the supply chain, rethinking the business model toward a more circular one, for implementing a full-scale EMS/EnMS and having it certified, and improving the product life cycle are all actions which a company could pursue within the framework of continual improvement.

While many opportunities for green and circular business models link product design and manufacturing to value chain management (see fig. 22), companies (in particular SMEs) may more quickly be able to introduce improvements into their internal production processes first rather than at value chain level. The latter would require more complex analysis and greater capacity to cooperate with other organizations in the value chain. This is the main reason why it is good to start first with the TEST approach focusing on production processes. This brings the company not only direct environmental benefits and increased income but also, after completion of the TEST project, new skills as well as new reasons and arguments to use in the framing of cooperation with stakeholders along the value chain.

Every company is connected to the other entities in the value chains through flows of materials, energy and water, which are turned into product and non-product outputs. These are the focus of the TEST approach detailed analysis. Companies can then use the information they have gathered on these flows to calculate the environmental footprint of their products and undergo a simple life cycle analysis (see step 1.2 of TEST). Companies are usually very surprised by how much information they have gathered by end of the first TEST cycle on the impacts of their products over the whole of their life cycle as well as on the and opportunities for improving these impacts.

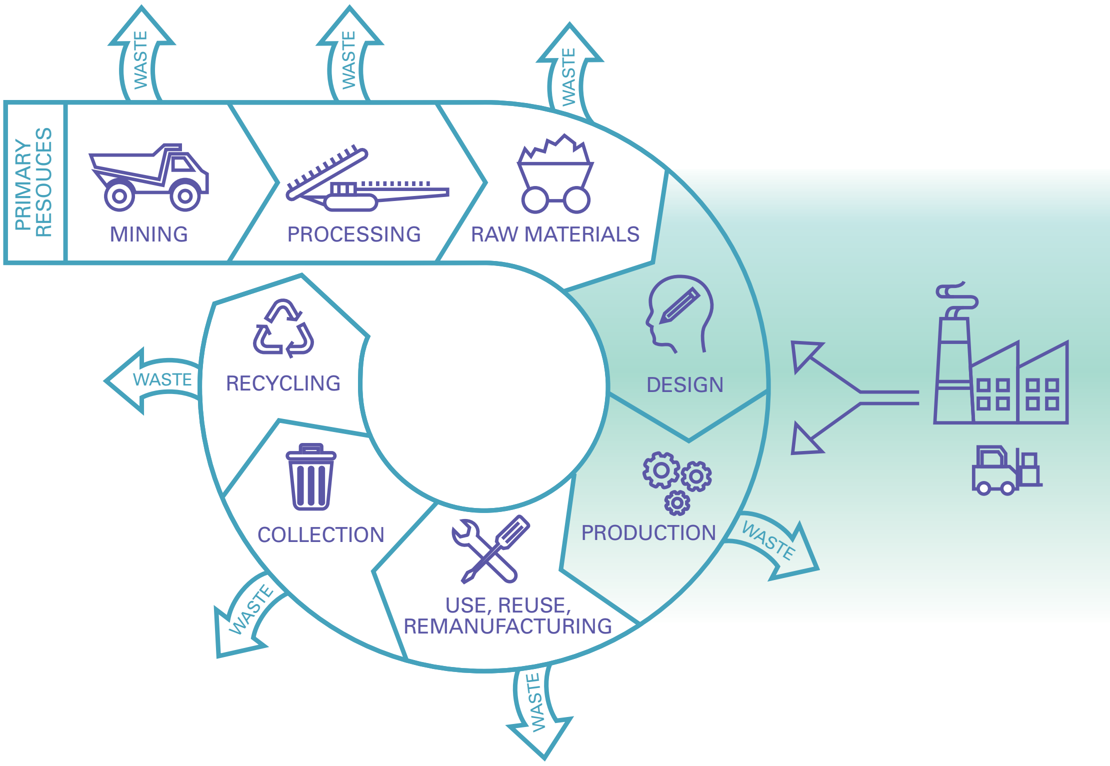



**FIGURE 22:** Linkages between product design and manufacturing to value chain management within the circular economy business model

## ACTION TABLE

| INPUTS | CORE ACTIVITIES | OUTPUTS |
|---|---|---|
| Company vision, strategy and management systems | Top management reviews the company's business vision, strategy and management systems, linking them to the results of the TEST experience, aligning to sustainable development goals and new Eco innovative business models | Integration of TEST approach into the enterprise's strategy, operations and management systems, as well as adoption of new eco innovative models responding to emerging needs in the business environment. |
| Management review | Analyze and adopt possible changes to assumptions, values, policies and strategies driving the business<br><br>Take corrective actions to ensure improvement of performance | Corrective actions are taken for ensuring improvements<br><br>Continuous learning leading to continuous improvement of enterprise performance (e.g. identification of new improvement opportunities) |
| Stakeholders expectations | Discuss possibility of launching a second cycle of TEST by repeating the application on other business units, material/energy flows, setting up new smart objectives, and generating more RECP options and new action plan (steps 1.4 – 1.8)<br><br>Complete stakeholders mapping and material analysis Initiate dialogue with stakeholders for building partnerships for new circular models | Replication of TEST is started in other areas of the company.<br>The design of fully-fledged EMS/EnMS systems for possible certification is completed, building on the core elements already in place<br><br>Kick-off of new projects related to LCA and/or product design<br><br>Introduction of CSR guidelines from ISO 26000 in support of the adoption of sustainable development codes of conduct. |
| Tools | Life Cycle Perspective checklist<br>Policy checklist<br>Stakeholder Analysis | |

In addition to the relevant TEST tools cited in the table (also referenced in the policy step 1.2), the following existing tools and standards could be useful here: Eco-Innovation Manual (UN Environment, 2014), Business Model Canvas (Osterwalder, 2009), Life Cycle Assessment / ISO 14040 and Corporate Social responsibility/ ISO 26000 and AA1000.

## CASE STUDY: PRODUCT ENVIRONMENTAL FOOTPRINT (PEF)

A Tunisian company operating in the agro-food sector successfully completed the first TEST cycle. After that, it decided to keep on implementing RECP options in its processes. At the same time, it wished to extend the scope to the whole life-cycle of its production of pasta.

This decision was due to the company's increased awareness that a more environmentally friendly product would be more competitive, becoming also more attractive for the European markets where the company is exporting.

After attending an EU seminar on the Product Environmental Footprint (PEF) initiative which was organized by UNIDO under the SiwtchMed initiative, the company decided to perform an LCA analysis of its products using the PEF method, seeing this as an opportunity to measure and if possible improve environmental performance of its pasta product throughout its life cycle and to communicate about it with its stakeholders.

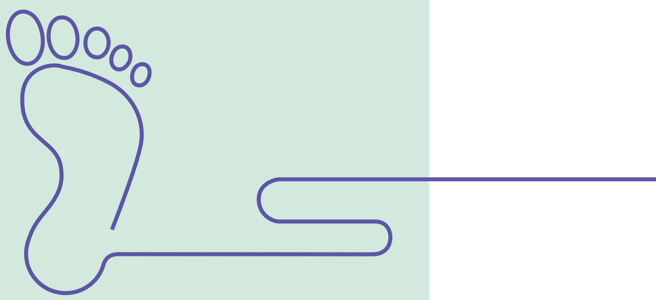
The company received external assistance in applying the PEF category rules and guidelines developed by the EC for Life Cycle Assessment (LCA) based product claim standards. LCA is a well-known and widely used method for assessing the potential environmental impacts and resources used throughout the entire life cycle of a product or process, including raw material acquisition, production, use, and end-of-life phases as defined by SETAC and codified within ISO 14040-44 standards.

For the PEF project, the company selected »Spaghetti II«, its best-selling product made from durum wheat semolina and packed in 1 kg packs. The main objective of this assessment was to evaluate the overall environmental burden of the company's Spaghetti II production system and to identify the environmental hot spots within the product's entire life-cycle (i.e., the places in the life-cycle that make a significant contribution to the overall environmental burden).

The study was undertaken by local expert from a Tunisian organization with the technical support of a UNIDO international expert.
The PEF analysis applied the LCA methodology and the PEF category rules including the circular economy formula for waste management. The functional unit to be analyzed was defined as the production of 1 kg of Spaghetti II. The data collection phase built on much information already available from TEST implementation.

***»The PEF study has also helped the company respond to the needs of the European single green market and it will prevent company falling behind the competition.«***

The LCA assessment boundary was established for the Spaghetti II production system and was divided in six sub-systems covering particular stages of the product life cycle including wheat production and import, pasta production process and packaging, distribution, cooking and end of life. Four of these were considered to be significant and were the subject of further analysis. A generic model for the life cycle of pasta is presented in figure 23.



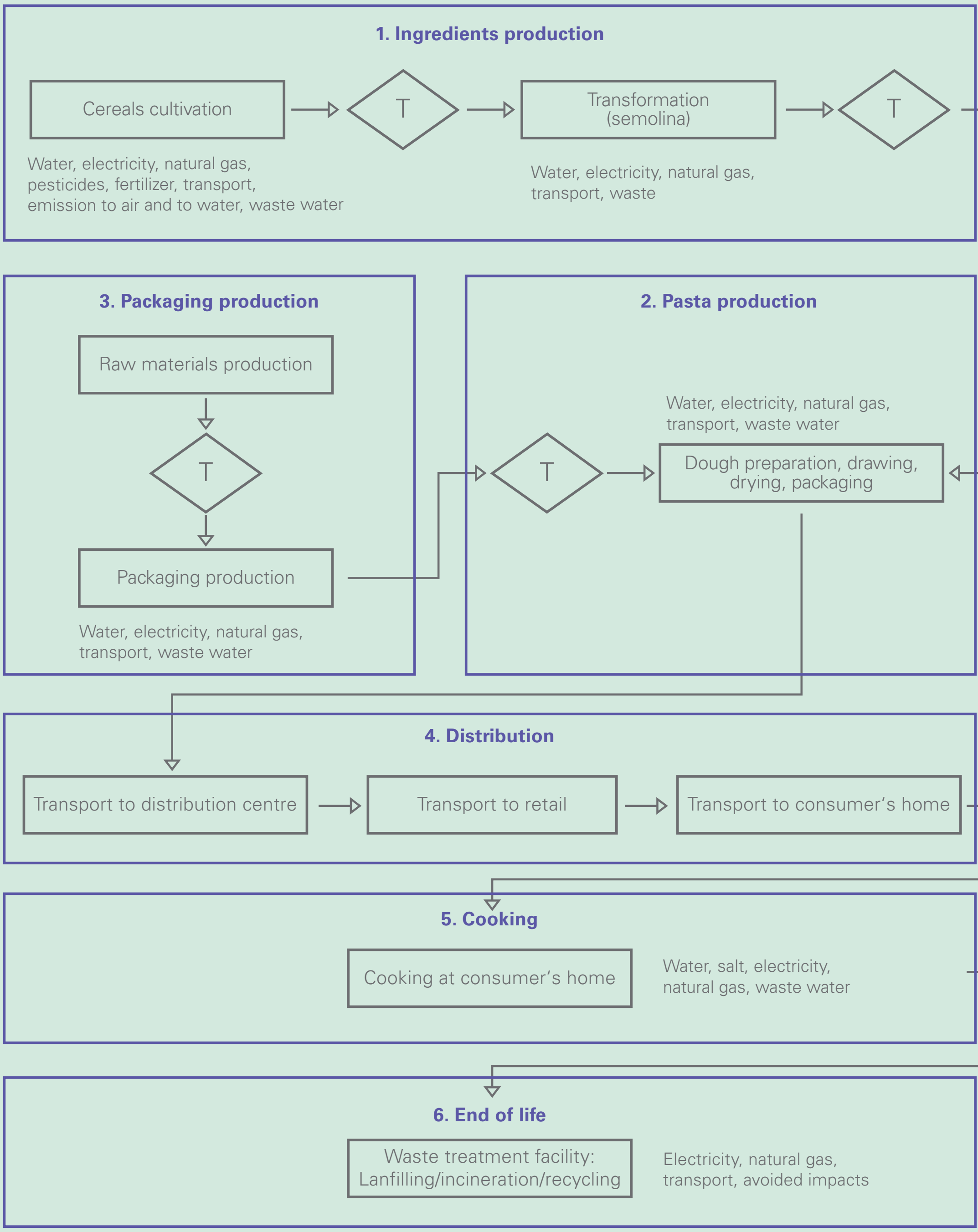



FIGURE 23: Generic life cycle model for pasta

The study identified the wheat and pasta production process subsystems as being the major contributors to the overall environmental burden of the entire Spaghetti II system (they were responsible for the highest impact in fourteen out of the 16 predefined impact categories). The relative contribution of each subsystem to the environmental impacts of Spaghetti II is shown in figure 24.

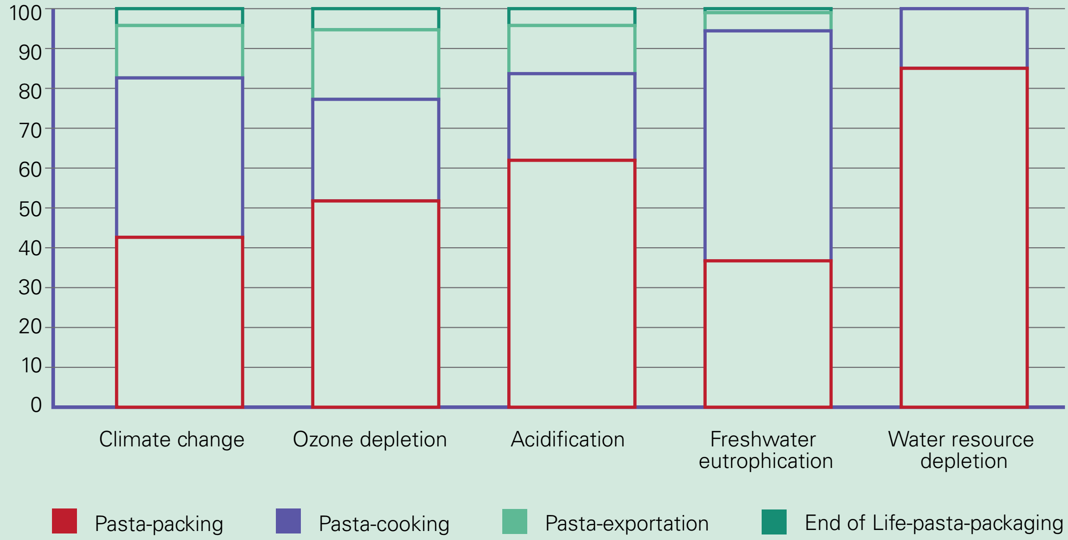



FIGURE 24: Relative contribution of four basic subsystems of the life cycle of Spaghetti II to the predefined environmental impact categories

The analysis was further refined by breaking down the wheat production sub-system to define the most relevant elements for the environmental categories. The result clearly identifies the pasta production including wheat grain production and its import as being the greatest contributors to the environmental impact of the pasta production process.

More specifically, the total GHG emissions of the Spaghetti II system are estimated to be approximately 1.2 kg $CO_2$ per kg of Spaghetti II. Approximately 30% of these emissions are attributable to the production and import of wheat, especially due to the emission of NOx associated with the use of fertilizers during wheat production as well as to the emissions of $CO_2$ by sea transport freight during the wheat's import.

The water resource depletion (WRD) of the system is estimated to be approximately 12.4 liters per kg of Spaghetti II produced. The subsystem that contributes the most in the WRD impact category is wheat production (~86%).

After completing the pilot PEF project, company management held a strategic discussion on the PEF results drawing the following lessons:

- Efforts at environmental improvements of the whole pasta process should focus on shifting to the use of locally produced eco-friendly wheat;
- The PEF exercise provided a sound methodology for measuring environmental performance, and it is a useful communication tool to provide reliable and transparent information on the company's environmental performance to its stakeholders;
- The PEF results brought about an understanding of the product's environmental hotspots and about the potential to reduce its environmental impacts;
- Outputs of the PEF study supported decision making based on LCA thinking, thus enabling the exploration of eco-design strategies. In this respect, the company is also planning to switch to the use of biodegradable packaging.

The company believes that the PEF could be considered as part of a circular economy. The PEF study has also helped the company respond to the needs of the European single green market and it will prevent company falling behind the competition.

## TIPS

- Top management and middle management engagement are required to effectively complete this step of TEST. They are necessary for a correct evaluation, reflection and decision making on new actions for continual improvement.
- Top management normally takes decisions at the end of this step on follow-up opportunities for continuing with the full implementation and certification of a management system (the groundwork was laid during the first TEST cycle) and/or the use of other tools for sustainable production.
- The importance of internal and external stakeholders in determining the success of a company in today's business environment is growing. Analyzing the materiality aspects from both a company management and a stakeholder perspective (materiality analysis) can reveal important gaps and opportunities for expanding TEST to CSR and circular business opportunities.
- Implementing new, advanced sustainable production tools requires professional skills that are usually not available in a company. Specialized external assistance can guide the company through the implementation process smoothly and ultimately make the whole process cost effective.

## MANAGEMENT SYSTEM INTEGRATION

| EMS / EnMS NOT IN PLACE | EMS / EnMS IN PLACE |
|---|---|
| Improvement actions are defined at this stage, including corrective actions, continual improvement initiatives, breakthrough change, innovation and reorganization. | Integration of RECP into the core value proposition of a company's strategy and operations is the expected result of the successful implementation of TEST project.<br><br>A formal commitment for sustainable development in the environmental policy can be obtained by the end of this step. |

# APENDIX A: REFERENCE CASE STUDIES

## CASE STUDY: PRIORITY SETTING WITH THE MFCA TOOL

A Moroccan company active in the food industry, produces biscuits. The main processes are: mixing, kneading, baking, shaping, cooling, and packaging. At the beginning of the project, the company had little understanding of its total environmental costs. It had initially wanted to focus its TEST project only on energy, as it considered this to be the main priority. Yet, after the MFCA assessment undertaken in step 1.4 of TEST, based on preliminary estimates and production and accounting data from the previous business year, the company's management realized that raw material losses also represented a significant cost. The total NPO costs were estimated at 4,450,000 EUR, which represented 15.6% of total production costs. 31% of total NPO costs were due to raw material losses. To put in another way, 10.3% of the company's total sales were lost (not converted into the final product). The breakdown of NPO costs is shown in table 9 (as there was no environmental management system or formal waste management in place, there were no waste management, end-of-pipe, or MFCA system costs):

| NON-PRODUCT OUTPUTS (NPO) | PERCENTAGE DISTRIBUTION % |
|---|---|
| **1. Costs of Material and Energy Inputs** | **100%** |
| 1.1. Raw and Auxiliary Materials | 31% |
| 1.2. Packaging Materials | 4% |
| 1.3. Operating Materials | 8% |
| 1.4. Water | 3% |
| 1.5. Energy | 54% |
| **2. Waste Management/End of Pipe Costs** | **0,0%** |
| 2.1. Equipment Depreciation of End of Pipe Equipment | |
| 2.2. Internal Personnel | |
| 2.3. External Services | |
| 2.4. Fees, Taxes and Permits | |
| 2.5. Fines, Remediation and Compensation | |
| **3. MFCA SYSTEM COSTS** | **0,0%** |
| 3.1. Equipment Depreciation | |
| 3.2. Internal Personnel | |
| 3.3. External Services | |
| 3.4. Other costs | |
| **TOTAL COSTS (1. + 2. + 3.)** | **100.0%** |
| **4. ENVIRONMENT-RELATED EARNINGS** | **0.0%** |
| 4.1. Other Earnings | |
| 4.2. Subsidies | |
| **TOTAL ENVIRONMENT-RELATED EARNINGS** | **0,0%** |
| **TOTAL NPO COSTS** | **100.0%** |

TABLE 9: NPO breakdown at a biscuit factory

Next, the team identified KPIs and related baselines for all flows with significant NPO costs. Based on high NPO costs and potential for savings / improvement, energy and raw materials were selected as priority flows for detailed analysis. This successfully concluded step 1.4.

Moving on to step 1.5 of TEST, the team first distributed the total NPO costs to cost centers. This allowed the company to start identifying its focus areas.

| COST CENTERS | % OF TOTAL NPO |
|---|---|
| Reception-Storage Raw Materials / Finished Products | 0.21% |
| Biscuit B1 | 9.53% |
| Biscuit B2 | 9.53% |
| Biscuit B3-1 | 9.53% |
| **Biscuit B3-2 – Momo & EYO'O** | **32.00%** |
| Biscuit B3-2 – Cracks | 11.37% |
| Wafer FM B1 | 5.40% |
| Wafer FM B2 | 5.49% |
| Wafer HAAS B1 | 5.40% |
| Wafer HAAS B2 | 5.48% |
| Sponge Cake »Génoise« | 5,72% |
| Administration | 5,72% |

TABLE 10: Breakdown of NPO by cost centers for biscuits producers

Because the production line B3-2 alone was responsible for 32% of losses as shown in table 10, the team chose this as the focus area. An in-depth follow-up on this production line showed several critical points in which materials were being lost mainly because of the equipment's inefficiency. The TEST Team generated several recommendations for improvement. These were implemented in the follow up TEST steps. Operational Performance Indicators (OPIs) were identified, and monitoring was also installed at the level of focus areas. After having enough data on performance of specific OPIs the baselines were established.

The implementation of good housekeeping measures alone is expected to save 665,514 € per year with a payback equal to 0.7 years. The overall investments made by the company have been estimated at 1,842,282 €. These investments will lead to savings of around 780,677 € per year. The investments and good housekeeping measures will reduce the consumption of water by 812 $m^3$/year, of energy by 3,981 MWh/year, including the equivalent of 155 t/year of propane, and of raw materials by 233 t/year. The emissions of $CO_2$, $BOD_5$ and COD will be reduced by 1,933 t/year. These convincing results were based on the solid results of a well done analysis, starting with the identification of priority flows in step 1.4.

## CASE STUDY: USING TEST TO OPTIMIZE ENERGY FLOWS IN A TEXTILE COMPANY

The experience of optimizing energy use in TEST is illustrated here with a textile company (denim washing) operating in Tunisia. The company has a production regime based on three shifts (3x8h) for 6/7 days (under normal production conditions), with an annual hourly production rate of 6,912 hours.

### STEP 1.4: ENERGY AS PRIORITY FLOW

Following the MFCA analysis that identified energy as the most important priority flow, an energy audit was performed.

The energy audit was conducted by the national energy expert in close collaboration with the company team. This resulted in a transfer of knowledge which strengthened the company's internal capacities. Among other tools, the expert used the Energy Mapping tool provided in the TEST toolkit, which has been adapted to the Tunisian energy context. Data from the company energy bills from the year 2014 were recorded as shown in table 11.

| ENERGY SOURCE | TOTAL CONSUMPTION | TOTAL COST IN EUR | AVERAGE ELECTRICITY TARIF | POWER FACTOR COS (PHI) | KPI FOR ENERGY EFFICIENCY | $CO_2$ EMISSIONS /YEAR |
|---|---|---|---|---|---|---|
| Electricity | 2,156,984 kWh | 139,587 | 0.07 EUR / kWh | 0,92 | 1.00 kWh/pair of jeans produced | 1,404 tonnes |
| Gas | 14,644,463 $kWh_{th}$ | 242,629 | 0.01 EUR / kWh | | 6.62 $kWh_{th}$ / pair of jeans produced | 3,992 tonnes |

TABLE 11: company data (energy bills) and baselines of company performance, at project's start

The total annual energy (electricity and gas) consumed by the company in 2014 was around 16.8 GWh for a production of 2,234,823 pair of jeans, i.e., with an energy consumption indicator of 7.62 kWh/pair of jeans produced. The distribution of the energy consumption between gas and electricity was 74% and 26%, respectively.

### STEP 1.5: IDENTIFICATION OF FOCUS AREAS / SIGNIFICANT ENERGY USERS

After analysing the company's overall energy consumption, the project team proceeded with the identification of the sources of energy consumption for priority energy flows, and the distribution of consumption to the main cost centres and significant energy uses as illustrated in figure 25. For this purpose, measuring instruments including an infrared thermography control camera, power system analyzers, a combustion analyzer, a lux meter, and electrical and thermal measurement equipment were used.

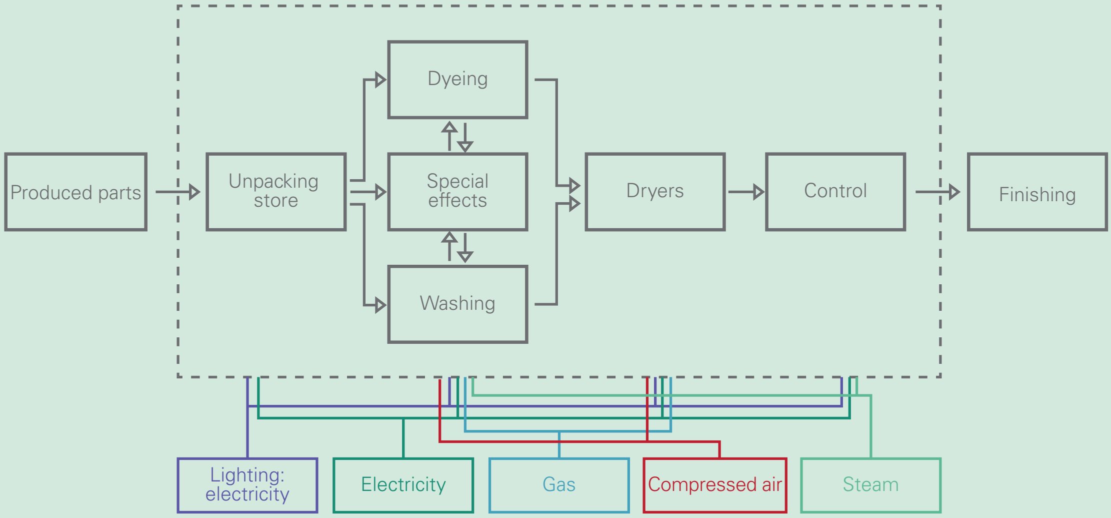
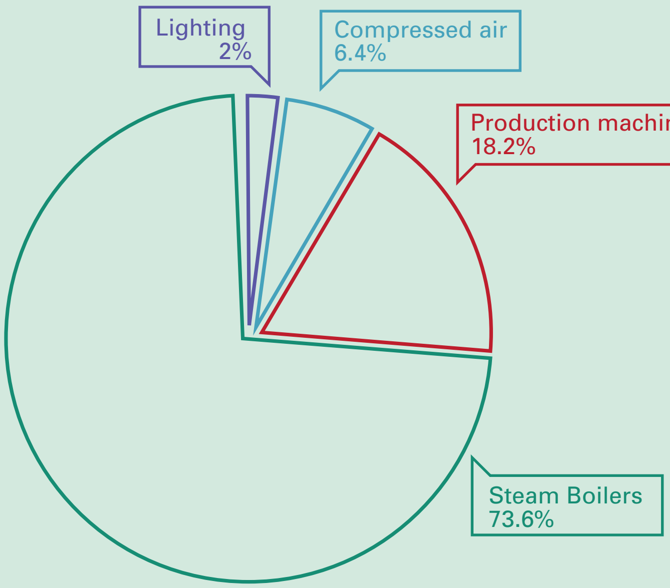



FIGURE 25: Process flow chart and energy flows in a Denim washing plant

Significant energy uses (as defined by the ISO 50001 standard) are those uses that represent a significant consumption in relation to the total consumption and/or represent a significant energy savings potential in line with the criteria for selection of focus area in the TEST approach and methodology.

The energy balance and the identified focus areas / significant energy uses, subject to an in-depth diagnosis and energy measurement, are listed in the figure 26.




Electricity:

- Production equipment
- Air compressors and equipment consuming compressed air
- Lighting

Thermal energy:

- Boilers
- Equipment consuming steam

Distribution of total annual consumption in 2014

FIGURE 26: Energy balance and identified focus areas.
Energy consuming equipment has been considered a high priority, with special focus on consumption of steam. Lighting was also included as a focus area due to an obvious potential for improvement.

### STEP 1.6: ANALYSIS OF THE CAUSES OF ENERGY INEFFICIENCY

The following causes of inefficiency were detected:

- The analysis of the maximum power demand during 2014, as indicated on the invoices, revealed that the standard model contract with the electricity company is not suitable for the production regime and results in an additional cost on the order of 6.4%.
- The steam distribution circuit is not subject to preventive maintenance, resulting in leaks in the thermal insulation of auxiliary connections (valves and flanges).
- The analysis of the electrical measurements on the different equipment with variable speed drives revealed a very high overall rate of the current harmonics (205% higher than the 10% threshold), resulting in the creation of a harmonic pollution at the electrical network level. This situation has led to breakdowns and damage to the electronic cards of these pieces of equipment, and losses in material and energy.
- Energy losses due to leaks on the network and on the machines consuming compressed air were identified during the plant's annual suspension period. These losses are estimated at 376,659 kWh/year and a value of 27,119 €/year.
- During the inspection of the lighting system, it was found that the ferromagnetic ballasts of the old T8 neon tubes were still connected and that they were double feeding the new T5 tubes. This configuration generates an additional consumption of 10 W per neon tube.
- During the detailed analysis, it was noticed that the idle running of some production equipment resulted in an unjustified waste of energy.

### STEP 1.7: IDENTIFICATION OF THE ENERGY SAVING MEASURES

Addressing identified causes of inefficiency, a menu of energy saving options was developed, assessed and validated by the company, as follows:

- Change of contract type with the electricity company and change to an hourly scheduling contract with the following subscribed power levels:

| PRIME (EUR) | REDUCED (KW) | WINTER PEAK (KW) | EVENING (KW) | SUMMER PEAK (KW) | DAY (KW) |
|---|---|---|---|---|---|
| 2,400 | 700 | 600 | 600 | 800 | 800 |

  This action generates monetary gains on the order of 6.4% on the electricity bill.
- Lighting system repair by the elimination of the ferromagnetic ballasts of the old T8 neon tubes. The energy gains that are guaranteed by this action are 25,790 kWh, and around 16.9 t of $CO_2$ emissions are avoided.
- Repair of the compressed air leaks should generate estimated annual energy gains of around 323,269 kWh (i.e., around 23,277 €) and around 210 t of $CO_2$ emissions are avoided.
- Thermal insulation of the valves and flanges of the steam circuit. The annual energy gains of this measure were estimated at around 86,205 kWh, and 57.4 t of $CO_2$ emissions was estimated to be avoided.
- Boiler combustion control to eliminate the incorrect setting of excess air. This action generates annual savings of around 170,997 kWh and reduces $CO_2$ emissions by around 11.4 t.

- Treatment of the electrical harmonics by the acquisition and installation of passive harmonic filters on each variable speed drive of the production machines. In addition to the protection of electrical equipment against the harmful effects of harmonic currents, this measure generates annual savings of around 12,365 kWh, a reduced amount of $CO_2$ emissions in the range of 8 t, and a reduction in annual maintenance costs of around 23,078 €.
- Finally, it was recommended to improve the energy performance of the production equipment by strengthening preventive maintenance procedures as well as production procedures, and through technical assistance to improve productivity in the various workshops and on the workstations.

## CONCLUSION

All the identified and validated measures were included in the TEST action plan. Expected gains due to the implementation of improvement measures in terms of energy savings were estimated at 618,628 kWh/year equivalent to a reduction of 304.1 t $CO_2$/year. Moreover, a financial gain of 66,686 €/year is expected to be achieved against an investment of about 50,000 €, resulting in a payback period of nine months.

The good project results that led to substantial gains in terms of energy efficiency, have motivated the company management to consider establishing an energy management system according to ISO 50001. With the application of the Energy Mapping tool and the diagnosis performed with it, several elements of an energy management system are already in place, including the analysis of energy consumption (overall and of the different end uses), the identification of significant energy uses, and the potential for improving the energy performance.

## CASE STUDY: STEP BY STEP IMPLEMENTATION OF TEST IN A BEVERAGE COMPANY

The experience of implementing the complete TEST methodology in a medium-sized food enterprise is illustrated here.

The company in question is located in the Middle East and is producing carbonated soft drinks for the local and regional markets.

The company was assisted by external consultants (service providers) during its first application of TEST. Based on the successes of that first application, it has decided to continue using the tools and the methodology, using the internal capacity that was built during the TEST project.

The costs for the company's materials, water and energy inputs are about 66% of total expenditures. Any improvement of resource efficiency will thus also significantly improve overall economic performance.

### STEP 1.1 - SITUATION AT THE START OF TEST PROJECT

The initial screening of the company did not highlight any immediate potential for RECP improvement, as the company already:

- had state-of-the-art and well operated technology in line with international standards in place, as well as an environmental management system certified against ISO 1400;
- had engaged with CSR for a decade, with an annual sustainability report published and audited regularly;
- had its $CO_2$ emissions verified according to ISO 14064-1 by SGS.

The company had also introduced a sophisticated information system for resource management and planning. Thus, the company's only driver to join the MED TEST II project in 2016 was the top management's strong commitment towards continuous improvement and search for new approaches on how to achieve it.

### STEP 1.2 - DRAFTING THE RECP POLICY STATEMENT

The company already had in place an environmental policy adopted in the framework of the ISO 14001 system, which included a clear commitment to continuous improvement of the company's environmental performance. Nevertheless, the company decided to use the TEST project to upgrade its system to the levels required by the latest version of ISO 14001, ISO 14001:2015. A new policy statement was therefore elaborated, focusing on incorporating resource efficiency.

The top management signed the new policy and distributed it to all departments of the plant, from administration to production.

### STEP 1.3 - SETTING UP THE TEST TEAM

A company TEST team was established in the company. It was led by the production and maintenance manager and included the quality manager, the HSE manager, and some technicians; an important member of the team was also the Acting Financial Controller, who represented the company's financial department.

An external TEST team of service providers was also formed, including national RECP and energy efficiency experts and an expert on management systems, all under the coaching of international experts. The company TEST team was trained during the project, both as part of common training sessions with other companies as well as by in-company specific workshops, such as one on MFCA.

## STEP 1.4 - IDENTIFYING THE PRIORITY FLOWS AND LAYING DOWN THE FOUNDATION OF THE RECP INFORMATION SYSTEM

The initial input-output analysis at the company boundary was completed through a data collection process, which set up the basis for a good cooperation between the internal and external TEST teams. Company members were very cooperative, providing needed data based on mutual trust.

The company has very good information systems in place. It applies a financial and cost accounting system and records all material inputs via stock management in addition to using a Production Planning and Enterprise Monitoring System. However, most material inputs are recorded only in units in the stock management. It was recommended to consistently record raw materials, packaging materials, and operating materials in kg in order to be able to aggregate. The company recalculated the units into volumes and within a couple of days a quite consistent material and energy balance was available.

The concept of non-product output (NPO) was new to the staff. The assessment was done based on the list of accounts for the financial year 2015. The MFCA analysis highlighted that approximately 7% of the value of purchased inputs was lost as NPO costs. Their distribution is shown in figure 27.

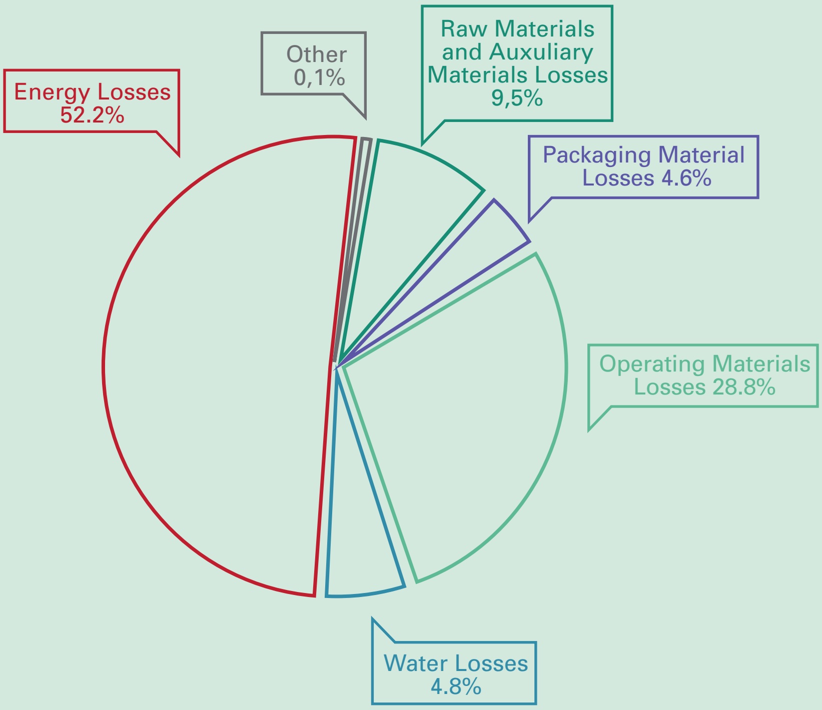



FIGURE 27: Distribution of NPO costs in producer of soft drinks

Energy was identified as the main priority, representing more than half the total NPOs. Since operating materials were responsible for 28% of NPO costs, it was recommended to improve stock management and cost accounting for this material group. End-of-Pipe treatment and disposal costs were only responsible for 0.1% of NPO costs.

A more detailed analysis of material NPOs highlighted the negative financial consequences of the loss of material deriving from products returned by customers and the important financial losses of operating materials such as chemicals used for cleaning operations. In general, the MFCA tool was essential to define the NPOs, leading the TEST Team to identify the following priority flows: Energy (electricity and thermal); Water; Chemicals; Packaging materials (Cans & Preform); Sugar; Concentrate.

## STEP 1.5 - IDENTIFYING THE FOCUS AREAS

The NPO costs associated to the selected priority flows were distributed among the main company cost centres using the MFCA tool; an overview of the result is presented in figure 28. The figure supports the conclusion reached by the TEST Team that further detailed analysis for material and water flows should focus mainly on production lines (including syrup preparation), but also the store for chemicals used in cleaning operations, which represent 48% of the total NPOs from the HSEQ department. Energy measurements conducted in the production lines showed that there was limited potential to save energy there, as the production lines were already meeting very high energy efficiency standards. For this reason, production lines were not identified as a focus area for energy and detailed analysis focused on utilities (whose NPO costs are distributed to specific production lines in figure 28).

For each priority flow the identified focus areas are provided in Table 12.

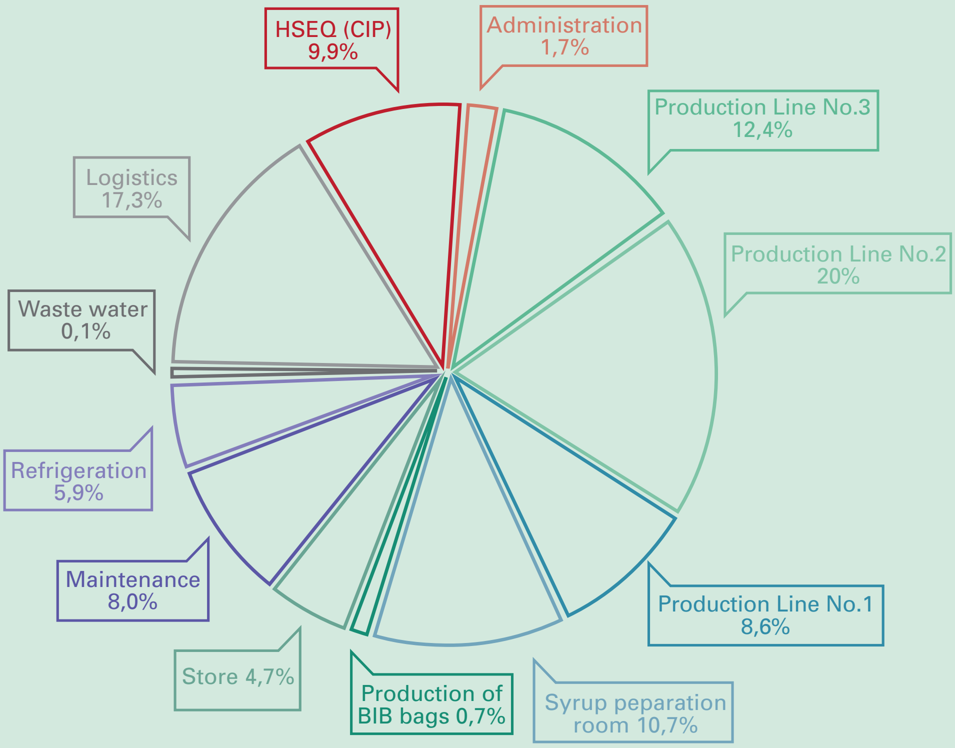



**FIGURE 28:** Distribution of NPO costs per company cost centres

| PRIORITY FLOW | FOCUS AREAS |
|---|---|
| Energy | Utilities (energy measurements showed low potential for improvement within the production lines) |
| Water | Production lines (CIP, washing of cans and bottles)<br>Refrigeration (Cooling towers) |
| Sugar | Syrup preparation room (sugar bags handling and loading process) |
| Chemicals | HSEQ and maintenance (Stock management) of chemicals used in CIP (cleaning operations) |
| Cans | Store (damaged products caused by handling) Production lines |
| Concentrates | Production lines (Filling operations) |

**TABLE 12:** Identification of focus areas for specific priority flows

The distribution of NPO costs to the main cost centres of the company was first estimated and then gradually refined. It showed that one production line in particular had a significantly high share of total NPO costs. This outcome encouraged the company to reduce the operating hours of this line by 50% in 2017, leading to significant savings as further described in step 1.7.

### STEP 1.6 - IDENTIFICATION OF SOURCES AND CAUSES OF LOSSES

To identify specific sources and root causes of losses, the TEST Teams used detailed diagrams of the processes as well as observations of the use of the priority flows and balances. Additional data from the monitoring of specific energy and water flows and expert estimates were also used. Examples of identified causes of inefficiency for one focus area (CIP) are provided in the left-hand column of table 13.

### STEP 1.7 - OPTIONS GENERATION & PREFEASIBILITY ANALYSIS

The TEST Teams conducted brainstorming sessions to generate RECP options, focusing on the most important sources of losses. Service providers brought in their expertise, and the company TEST team cooperated not only in discussing the proposed options but also in sharing their own ideas. These meetings were opened up to other members of the company staff. The right-hand column of table 13 provides an example of the results of such sessions for the improvement of water efficiency during the Clean-In-Place (CIP) step.

| FOCUS AREA/ROOT CAUSES | POTENTIAL OPTIONS TO THINK ABOUT |
|---|---|
| Clean In-Place (CIP):<br><br>Manpower: Manual control is poor (including the rinsing time or dosing of caustic solution).<br><br>Management: Design of production plan, marketing strategy is causing the need for frequent cleaning.<br><br>Technology: No recycling of the rinse water.<br><br>Input materials: Using caustic solution that needs large amounts of water afterwards for rinsing.<br><br>Product: Drinks flavours are changed 3-4 times a day, which affects water usage due to changes from one flavour to the other. | • Last rinse can be saved and used for another rinse. Use the existing pre-rinse tank which currently is not functional.<br><br>• Ensure proper dosing of chemicals, use an automatic dosing system.<br><br>• Optimise operation parameters of the existing CIP system.<br><br>• Better scheduling product changeovers; try to change to 2 flavours per day instead of 3 or 4.<br><br>• Introduce a ‘pigging’ system to push out product from the pipelines before washing them.<br><br>• Investigate the use of activated oxygen cleaning (ozone cleaning) or Electro Chemical Activation (ECA).<br><br>• Use transmitters (pH or conductivity meters) to determine if content of tanks or pipes is product or not.<br><br>• Recycle the hot water (80-95oC) for cans and some other lines. |

TABLE 13: Identified causes of losses and options generated for CIP focus area

The feasibility analysis was conducted for the identified options. For example, for the option already mentioned in the step 1.5, the feasibility study can be summarized as follows. The idea was very simple - to cut down the operating hours of line No. 2 which generated high NPO costs. It was found to be technically feasible to operate line No. 2 for 78 days per year in 2017 instead of 3 days a week (this represents 50 % reduction ((3*52-78)/(3*52) = 0.5). As shown by the MFCA tool, shifting production from line No. 2 to another line will reduce overall NPO costs by 4.25%, which represents savings of 125,000 €/year. Difference in pollution generation can be calculated based on difference of losses and pollution produced by the two relevant lines. These are, for example, 74.4 $m^3$/d of water use or 833 kWh/d of energy use. Multiplying these savings by 78 days provides environmental benefits of this no-investment measure (in our example water use will be reduced by 5,800 $m^3$/year and energy consumption by 965,000 kWh/year, leading to , among other things, reduction of $CO_2$ emissions by 270 t/year).

## STEP 1.9 & STEP 2 – ACTION PLAN, IMPLEMENTATION AND MANAGEMENT SYSTEM INTEGRATION

A total of 25 feasible RECP measures were identified. These were inserted into the savings catalogue and presented to the top management for its approval. The top management approved 21 of these measures and these were included in the TEST Action Plan. By the end of the first TEST cycle, 16 measures were already implemented, 2 were being subjected to more detailed feasibility studies, and 3 were planned for implementation.

New resource efficiency procedures were integrated into the company's EMS adding new aspects, objectives, measures and action plans. For example, in line with the objective of reducing water consumption, several new water meters were planned for installation in addition to the existing ones to provide data for calculating the OPIs and KPIs at the level of the company. Where and how to collect and process these data is specified in a new water conservation procedure, with guidelines describing, among other things, how to process and document information, and what employees must do to develop, implement and maintain water conservation measures including, for example, development of a leak prevention program. The latter specify to whom and how to provide needed training and information, what is the division of responsibilities and how performance and achievement of particular targets, etc., is controlled.

An EMS upgrade guide was prepared as part of the TEST project; it describes, for example, the steps that the company should take to use the technical TEST report or how the company can use TEST for an upgrade of its EMS to the levels required by ISO 14001:2015. And as mentioned above, new aspects; water consumption and energy consumption, were added to the company's EMS.

## STEP 3 - PERFORMANCE EVALUATION

At the start of the TEST project, the company had the billing meters for energy and water as well as some sub-meters for electricity and water consumption with manual reading.

After completion of the MFCA analysis, a new approach to the management of resource efficiency was integrated into the existing company-wide information system, linking the monetary information system with the monitoring of priority flows. New objectives, KPIs and targets for improvement were set up for the priority flows for the duration of the first TEST cycle as shown with some examples in table 14. For each objective, three KPI values are provided: a baseline (original performance based on data from fiscal year 2015), a target for 2017, and the actual performance in 2017 as monitored in the information system.

| PRIORITY FLOW | TARGET | KPI | MON-ITORING PERIOD | EVALUA-TION | BASE-LINE 2015 | TARGET 2017 | PERFORM-ANCE 2017 |
|---|---|---|---|---|---|---|---|
| Electricity | Increase energy efficiency | kWh / hl of beverage produced | Per day | Weekly technical meetings Quarterly top management meetings | 8.2 | 7.8 | 6.4 |
| Water | Increase water efficiency | l of water / l of beverage produced | Per day | Weekly technical meetings Quarterly top management meetings | 2.2 | 1.9 | 1.6 |

TABLE 14: Example of objectives for continuous improvement and related key performance indicators (KPIs)

Company performance measured through KPIs in 2017 (in comparison to the baseline year 2015) shows that the implementation of the RECP measures led to greater reductions in the use of resource than what was originally planned and targeted.

The TEST project identified total annual savings amounting to 652,800 €. This result was obtained through an estimated investment of 152,000 €, giving an average payback period of 0.2 years.

## STEP 4 - IMPROVEMENT

The TEST project and its results were presented in a meeting organised by the holding company. Company members were very proud of the results achieved. For its part, the holding company decided to spread the good practice of TEST to its other companies in the Middle East.

Existing resource efficiency objectives were reconfirmed and more ambitious targets were set for the longer term. The company's TEST team will continue to perform in-depth analysis of those focus areas which could not be assessed during the first TEST cycle. Regular meetings with top management will also continue, to discuss progresses and new priorities.

It was also decided to install additional water meters, create a permanent monitoring program and use new data for further expansion of the water balance.

MFCA analysis was crucial for quantifying the NPO costs and for pointing out the right priorities at the beginning. However the top management decided to restrict the use of the defined MFCA accounts (and repetition of the detailed MFCA analysis every year) due to the perceived high labour intensity of this work.

The company information system is based on work with priority flows, KPIs, OPIs and specific targets to guide and monitor achievements of continuous improvement. The company will continue to monitor selected NPO costs also within the next TEST cycles.

The company also decided to share its experience with the systematic application of RECP with its stakeholders; in addition to harvesting the economic and environmental benefits of RECP, this decision led to increasing the company's broader social capital.

# APPENDIX B: GLOSSARY

| TERM | EXPLANATION |
|---|---|
| Action Plan | Plan for implementing improvement measures. |
| Balance (material, water, or energy), also mass balance | Statements on the conservation of mass and energy within processing operations. By accounting for materials, water or energy entering and leaving a system, all flows can be quantified (including those which are difficult to measure) and even previously unknown flows can be identified. |
| Carbon footprint | Total set of greenhouse gas emissions caused by an enterprise. |
| Cause of pollution | Factor driving material and energy losses and causing NPO generation. |
| Circular Economy | Economy using natural resources in a resource-efficient and ultimately regenerative way. Approaches applied to achieve circular economy include sustainable (circular) design and RECP, new business models, skills in building cascades and reverse cycles, and cross-cycle/cross-sector collaboration. |
| Cost centre | Specific department, process unit, or even machine to which costs are allocated in a company. |
| Deming Scheme | The learning cycle Plan-Do-Check-Act (PDCA) used in, among other things, international business standards (e.g., ISO). |
| Eco-design | The design or redesign of products, services, processes or systems to reduce damage to the environment, society, and the economy, through resource efficiency and through reductions of the impacts on the environment and society |
| Eco-innovation | Development and application of a business model, inspired by a new business strategy, that will lead to a company's enhanced sustainability performance through a combination of significantly improved or new products (goods/services), processes, market approaches and organisation structures [UN Environment, 2014]. |
| EMA Environmental Management Accounting | Identification, collection, analysis and use of two types of information for internal decision-making: a) physical information on the use, flows and destinies of energy, water and materials (including wastes) and b) monetary information on environment-related costs, earnings and savings [UN DSD, 2001] . |
| End-of-pipe technology | Technique for pollution control and abatement before release into the environment (e.g. wastewater treatment plants, air protection filters or landfills). |
| Environmentally sound technology | Techniques and technologies for preventing and reducing environmental damage. |
| Expenses | The economic costs a business incurs through its operations to earn revenue. |
| Focus area | Cost centre, specific processes and/or equipment associated with significant losses of material and energy production inputs and/or generation of major harmful outputs. |

| | |
|---|---|
| Information system for resource efficiency | In TEST, this means integration of significant resource efficiency concerns into the information systems already existing within a company (like for example accounting or SAP) resulting in need driven improvement of these systems. |
| Key performance indicators (KPIs) | Key indicators based on financial or non-financial metrics used to reflect the critical success factors of an organization and measure progress towards its goals (in TEST, KPIs are set up in step 1.4). |
| Life cycle costs | Costs of an investment project including not only initial investment costs but also all the operating costs during its expected life time. |
| Management pyramid | Scheme of key components in a business from a systems perspective, laid out in pyramid form. |
| Materiality analysis | Analysis of the important environmental, economic and social issues that affect a business from the stakeholders' perspective (both internal and external). |
| MED TEST I | Pilot implementation of TEST approach in the Mediterranean region between 2009 and 2012 (www.unido.org/medtest). |
| MED TEST II | Upscaling of TEST project in the Mediterranean region as part of the SWITCH MED Program (http://www.switchmed.eu). |
| Material Flow Cost Accounting (MFCA) | Tool for quantifying the flows and stocks of materials in processes or production lines in both physical and monetary units. Described in ISO 14051. |
| Monitoring & Targeting (M&T) | Method determining the relationship between energy consumption and relevant driving factors at the level of specific cost centres to enable resource efficiency control. |
| Non-product Output (NPO) | All material outputs other than intended products generated in the mass balance for a defined system boundary.<br><br>NPOs include air emissions, wastewater and solid waste, even if these material outputs can be reworked, recycled or reused internally, or have market value.<br><br>By-products can be considered as either NPOs or products, at the discretion of the company.<br><br>(Similar to »material loss« in ISO 14051) |
| Objective | Result to be achieved, which can be expressed in different ways, e.g. as an intended outcome, a purpose, an operational criterion, as an environmental objective. Other words with similar meanings (e.g. aim, goal, or target) can be used. |
| Operation control | Authority over normal business operations at the operational level. Operational control includes control over how normal business processes are executed. |
| Operational performance indicators (OPIs) | Indicators to measure a system's internal performance in supporting company-wide KPI and enabling an understanding of performance of specific company areas or units (OPIs are within TEST set up at the level of steps 1.5, 1.6 and 1.8). |
| Policy statement | Statement from top management to communicate a company's commitment to resource efficiency. |
| Pollution intensity | Pollution generated per unit of production (usually volume of production). |

| | |
|---|---|
| Priority flows | Material and energy flows that are important from a company perspective - usually flows that are expensive, are related to significant environmental, health and safety risks (regulated by legislation), or have high volumes. |
| Relative indicators | (Also »normalized indicators«) are indicators linking the absolute metrics to reference data; they are most effective for monitoring resource efficiency. |
| Sankey diagram | Also Sankey chart: specific type of flow diagram, in which the width of the arrows is proportional to flow quantity. |
| Six Sigma | Practical approach for quality improvement in production processes. |
| Source of pollution | Point at which losses of material/energy occur and an NPO is generated. |
| Stakeholder | An organisation, group or individual which affects or can be affected by a company's actions (these can be both internal and external to the company). |
| Sustainable development | Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs; development that sustains a quality of life within the limits of the Earth and its ecosystems. |
| Sustainable design | Systemic consideration of resource efficiency and other sustainability criteria at the design stage for new production processes or facilities. |
| Sustainable production | The creation of goods and services which are non-polluting; conserve energy and natural resources; are safe and healthful for consumers, and whose production uses processes and systems which are non-polluting, conserve energy and natural resources, are financially viable, are safe and healthful for workers and communities. |
| Sub-meter | A meter downstream of another (usually billing) meter at company border to sub-divide the usage of material, energy or water among two or more users (cost centres). |
| SWITCH MED | EU-funded program that includes a component for upscaling TEST in the Mediterranean Region (MED TEST II). |
| TEST | UNIDO's Transfer of Environmentally Sound Technology approach. |
| TEST cycle | Four steps for implementing the TEST approach in a company following the PDCA from the Deming scheme. |
| TEST program | Program for implementation of TEST approach in an enterprise or a pool of demonstration companies. |
| TEST project | Implementation of the first cycle of TEST approach in a company, usually with the assistance of external service providers |
| TOP 20 | Tool used in RECPA to record NPO costs for up to 20 of the most important material and energy inputs. |
| TEST Training Kit | Set of more detailed information, training materials etc. for implementing the TEST approach. Annotations for TEST tools are provided in Appendix C. |
| UN Global Compact | United Nations initiative to encourage businesses worldwide to adopt sustainable and socially responsible policies, and to report on their implementation. |
| Zero waste | Strategy to continuously reduce the amount and dangerous features of waste, with the long-term vision of zero pollution. |

# APPENDIX C: ANNOTATIONS OF TEST TOOLS

| TOOL | ANNOTATION |
|---|---|
| Action Plan template | Template table for developing an Action Plan |
| Energy mapping excel tool | Excel-based tool for basic energy auditing and management. Among other things, it enables the mapping of annual energy consumption, the setting up and control of Key Performance Indicators and the performance of regression analyses. |
| Financial Metrics Ligth (Copyright © 2008 Solution Matrix) | This excel based tool provides calculators for the most common criteria for evaluation of economic feasibility of RECP options (projects), namely project cash flow, cumulative cash flow, payback, return on investment (ROI), internal rate of return (IRR) and net present value (NPV).<br><br>The tool can be downloaded free of charge after leaving a contact here: http://www.solutionmatrix.de/download-center.html |
| Fishbone diagram | Also called Ishikawa diagram. Is a causal diagram created by Kaoru Ishikawa structuring the analysis of the causes of a specific problem. This diagram was amended in TEST to allow it to be used to analyse the causes of losses of specific material, energy or water flows. |
| Initial Screening template | Template with questions to be asked in the Initial Screening. |
| Life Cycle Perspective checklist | Checklist for a simple introductory evaluation of a given product with the purpose of providing an indicative list of areas in the product's life cycle where potential improvements could be further explored. In the second part of the checklist, an overview is provided of eco-design strategies which could be used to address identified opportunities for improvement. |
| MFCA excel tool | Excel-based tool for drafting mass balances and calculating NPO costs based on MFCA principles. The MFCA excel tool is one of the core tools used in TEST. It enables effective communication between financial and technical staff on the identification of priority flows and focus areas, and allows for the establishment of indicators and taking control over resource efficiency. |
| MFCA manual | Guide for implementing MFCA in SMEs. It includes step by step guidance on how to work with the MFCA excel tool. |
| Monitoring and Targeting tool (UN Environment) | Excel-based tool designed mainly for training purposes for applying M&T principles and for pilot implementation of regression analysis in two cost centres. This M&T calculator can also be used to estimate savings for good housekeeping potential based on historical data. |
| Monitoring Plan template | Template table for developing a Monitoring Plan for RECP measures to be implemented. |
| Policy checklist | Contains guiding questions for drafting a RECP policy statement or upgrading an existing policy document to include resource efficiency objectives in a company. |

| | |
|---|---|
| Savings catalogue | Set of project fiches for RECP improvements that are feasible from a technical, environmental and financial point of view and can be included in the Action Plan when approved by top management. |
| Sector specific manuals and BREFs | These documents contain benchmarking information for specific processes and solutions and description of specific problems faced. They also include references on Best Available Techniques and their performance. |
| Stakeholder Analysis | Contains a simple checklist for stakeholder identification, analysis, engagement and communication. |
| Template for reporting results of feasibility analysis | Template table for developing a feasibility study and for presenting its results. |
| TEST training and awareness raising plan | Provides guidance on the development of training and awareness raising plans including examples of content of two types of trainings:<br>a) cumulative trainings for group of 8-10 companies<br>b) in-company trainings |

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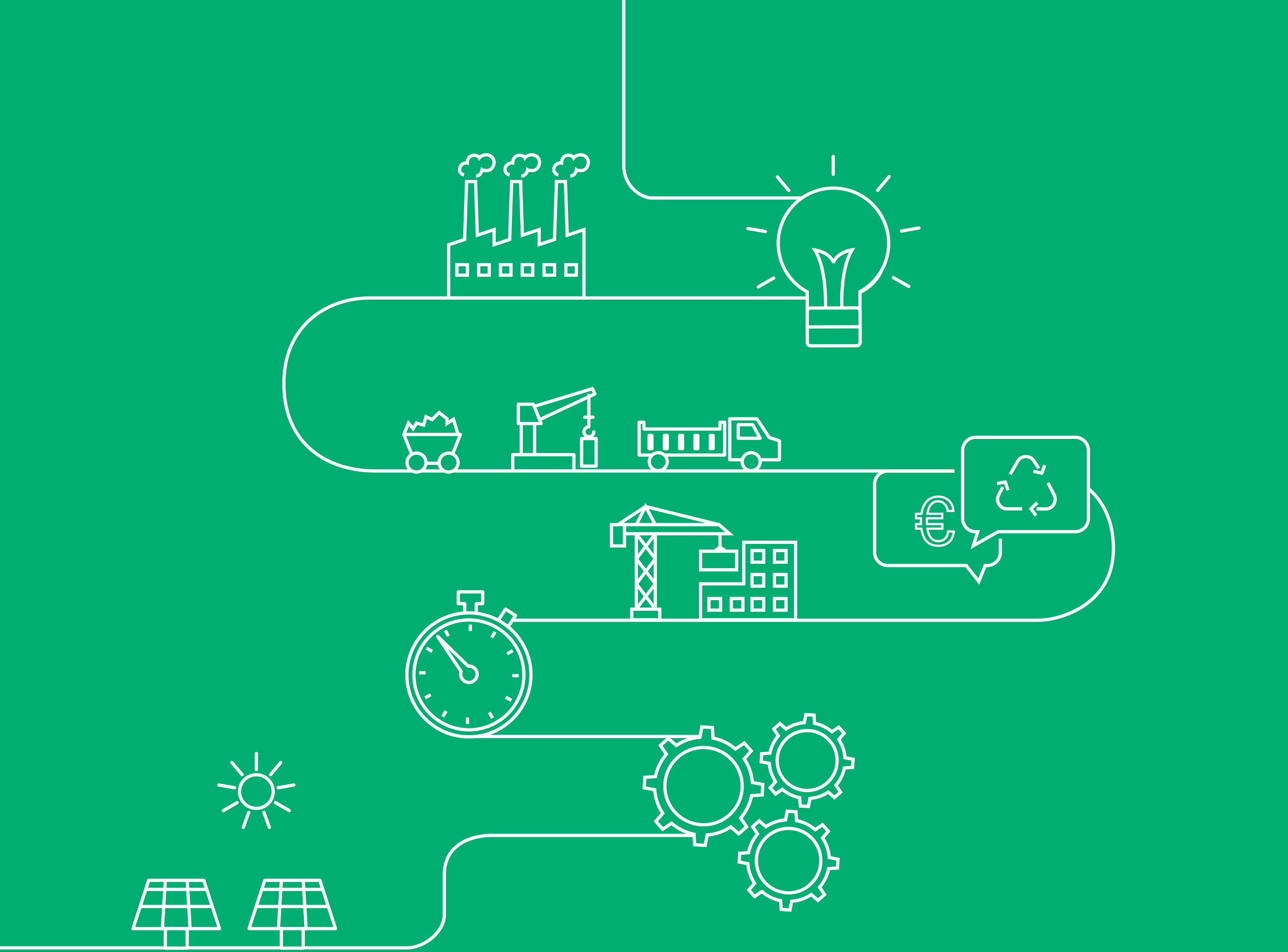

Supporting the Development of Green Industry and Sustainable Production in the Southern Mediterranean.

The UNIDO Transfer of Environmentally Sound Technology Programme (TEST) to harness the full potential of industry's contribution to Inclusive and Sustainable Industrial Development.

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