TEST Step by Step - PLAN

	Step	Purpose
PLAN	1.1. Initial screening	Initial screening: go/no-go for TEST
	1.2 Scoping and Policy	Top management commitment to RECP and scope of the work
	1.3 TEST team	Plan, organize and train internal company team (as well as external team, if created).
	1.4 Identifying total cost of NPO and priority flows	Starting the diagnosis: Identify the non-product output (NPO) costs and volumes at company system boundary.
	1.5 Setting up focus areas	Continuing the diagnosis: identify focus areas at the level of production steps (e.g. cost centres).
	1.6 Revealing sources and causes of inefficiency	**Concluding the diagnosis: identify sources and reveal root causes of inefficiency and pollution within focus areas.**
	1.7 Option generation and feasibility analysis	Broadening the scope of possible improvement solutions and techno-economic analysis of a set of optimized feasible measures
	1.8 Action plan	Plan of actions for implementing and monitoring validated measures.

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P 1.6 – Revealing sources and causes of inefficient material and energy use

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

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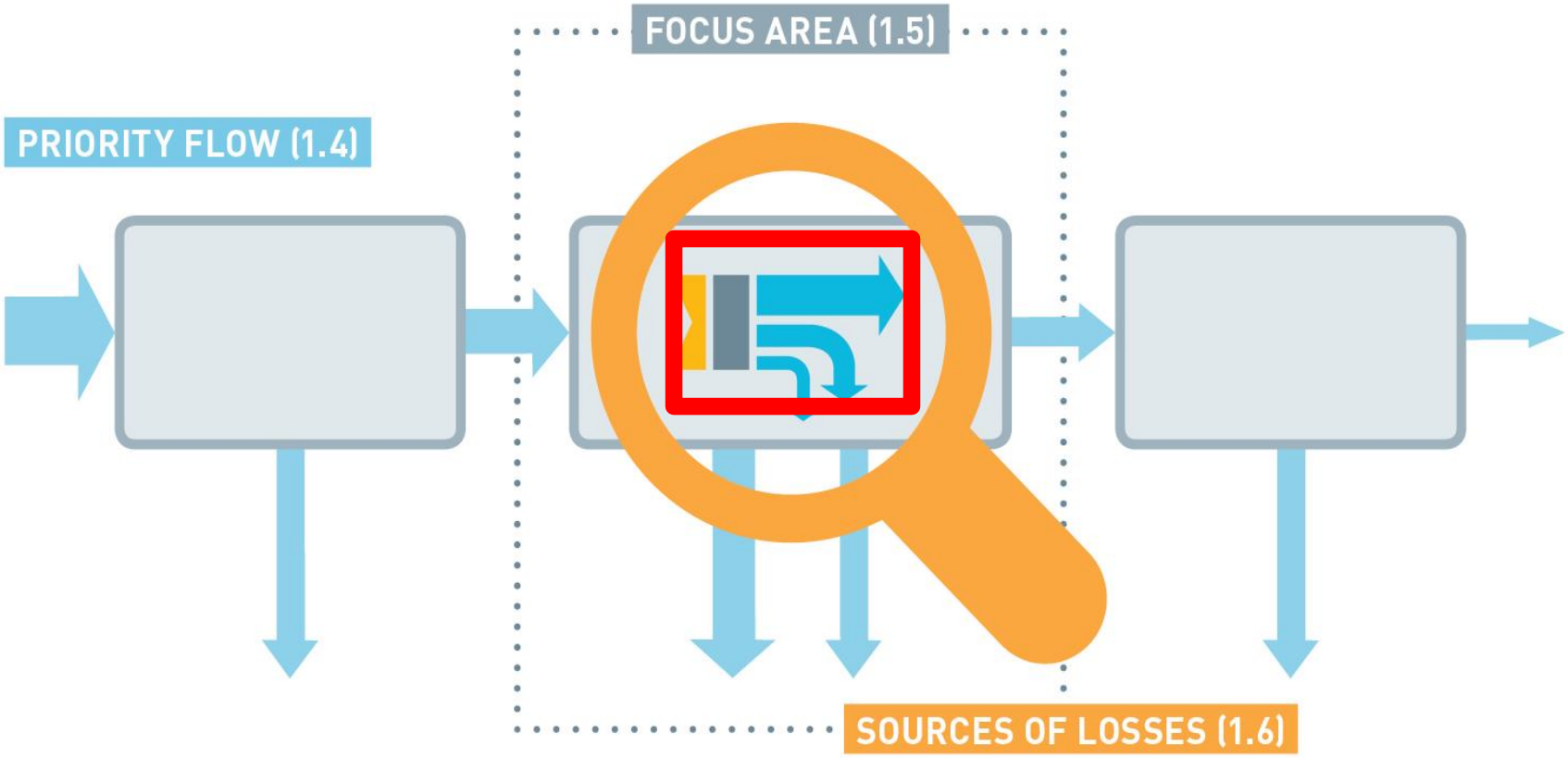
OVERVIEW OF THE PRIORITY SETTING PROCESS AND DIAGNOSIS FOR UNDERSTANDING CAUSES OF IMPORTANT MATERIAL AND ENERGY LOSSES (STEPS 1.4, 1.5 AND 1.6)

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
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

Moving from focus area level to sources of losses



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Going in deeper detail within a focus area

Step 1.6 utilises for detailed analysis the same basic approach as step 1.5:

- Qualitative balance
- Quantitative balance
- Indicators

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Overview of Step 1.6

Inputs	Activities	Outputs
Flow charts for identified focus areas MFCA excel tool (worksheets 1 and 2 filled in) Data from existing information systems like cost accounting, stock management, production planning and monitoring,etc. Supplier's technical sheets, machine nominal parameters, company records on waste disposal, etc.	Finalize material and energy balances for priority flows in the focus areas Conduct ad hoc measurements (if needed) to collect additional data for specific processes/ units/machinery Process data on energy flows with the Energy Mapping tool Interpret results, identify sources and related causes of material and energy use inefficiencies	Quantification of material and energy flows at the level of focus areas/unit operations Recommendations for improving the RECP information system for significant flows within priority areas List of causes of inefficiencies in material and energy use, by source

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Steam leakage

Source of losses

Cause of losses

... in most cases it is not so obvious and we need a systemic approach to identify sources and causes

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Techniques to reveal sources and causes of *inefficient resource use*

REVEALING SOURCES THROUGH DETAILED MATERIAL BALANCE

- Define the objectives and parameters to be monitored (within priority area selected in step 1.5)
- Define the balance (scope, period, detailed process steps)
- Draw the flowchart: material flows – quality
- Draw up the balances: material flows – quantity
- Identify important sources of pollution

REVEALING CAUSES THROUGH CAUSE – EFFECT ANALYSIS

- Interpret the results of detailed material balance
- Identify causes of pollution (utilising Cause – Effect Analysis)

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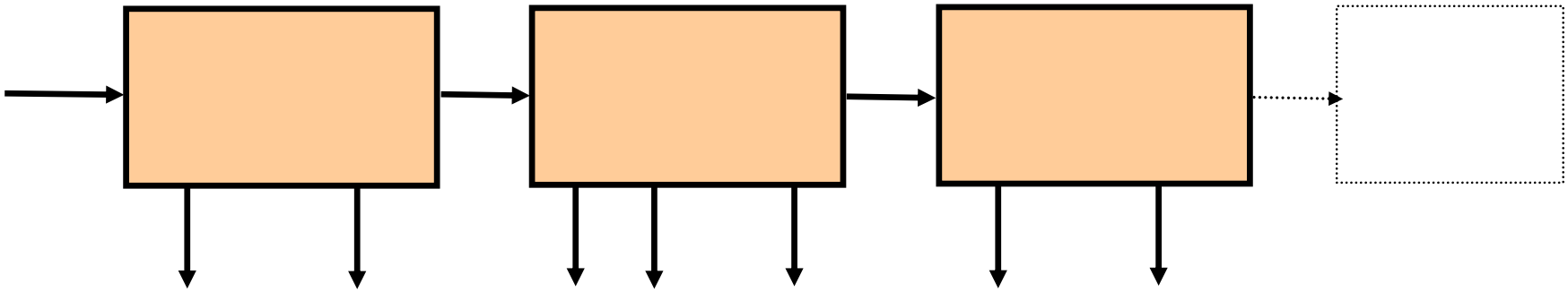
Draw up the balance: material flows – quality



Assign qualitative flows

to specific process steps

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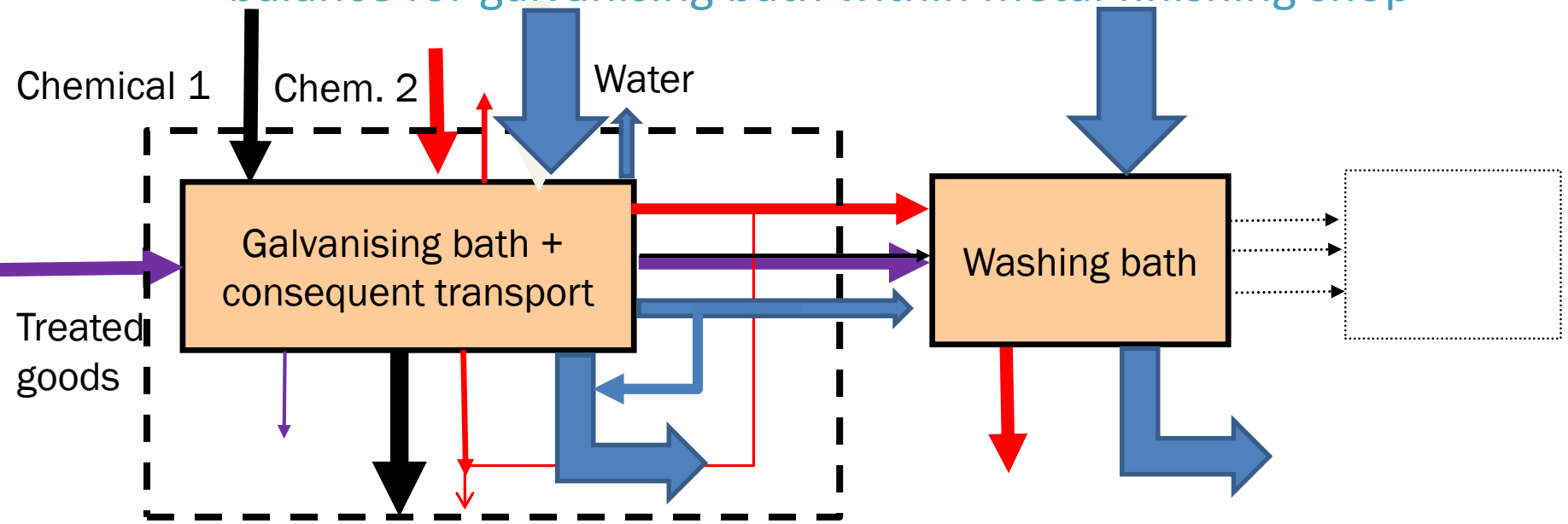
EXAMPLE: Qualitative specification for detailed water and material balance for galvanising bath within metal finishing shop



Detailed balance for galvanising bath and transport to the next bath: (balance borders are highlighted by dashed line; all flows should be quantified within the next step)

- Treated goods in = rejects + goods out
- Chemical 1 (electrode from plating metal) in = chemical 1 out in waste water + chemical 1 out as waste + chemical 1 on surface of goods
- Chemical 2 (liquid) in = chemical 2 out in waste water + chemical 2 out in drag out to the next bath + chemical 2 in drag out droping to floor and going to waste water + chemical out to air (for example dangerous vapors of an acid)
- Water in = water out as waste water from replacing the bath + water out as drag out going to next bath + water out as drag out going to floor (waste water) + out to air (vapors)

Draw up the balance: material flows – quantity

- Through quantification of flows can be assigned costs and risks to specific flows

- Collecting quantifiable data
  - **top – down** utilising data from step 1.5
  - **bottom - up** utilising data collected at the process level (examples of data sources are provided within step 1.10)
  - Use theoretical data (e.g. chemical formula)

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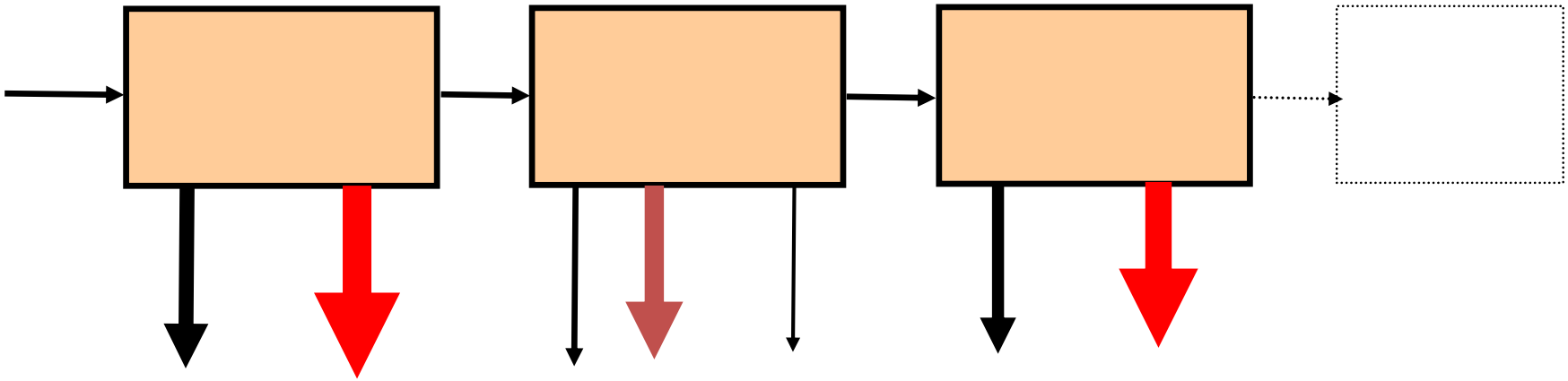
Identification of significant pollution sources



(sources of losses)

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EXAMPLE: Implementing material balance within a painting shop

Basic Process steps:

- Pre-treatment
- Priming, painting
- Drying

Other steps:

- Steam generator
- Exhaust air filter
- Cleaning of spray gun and container

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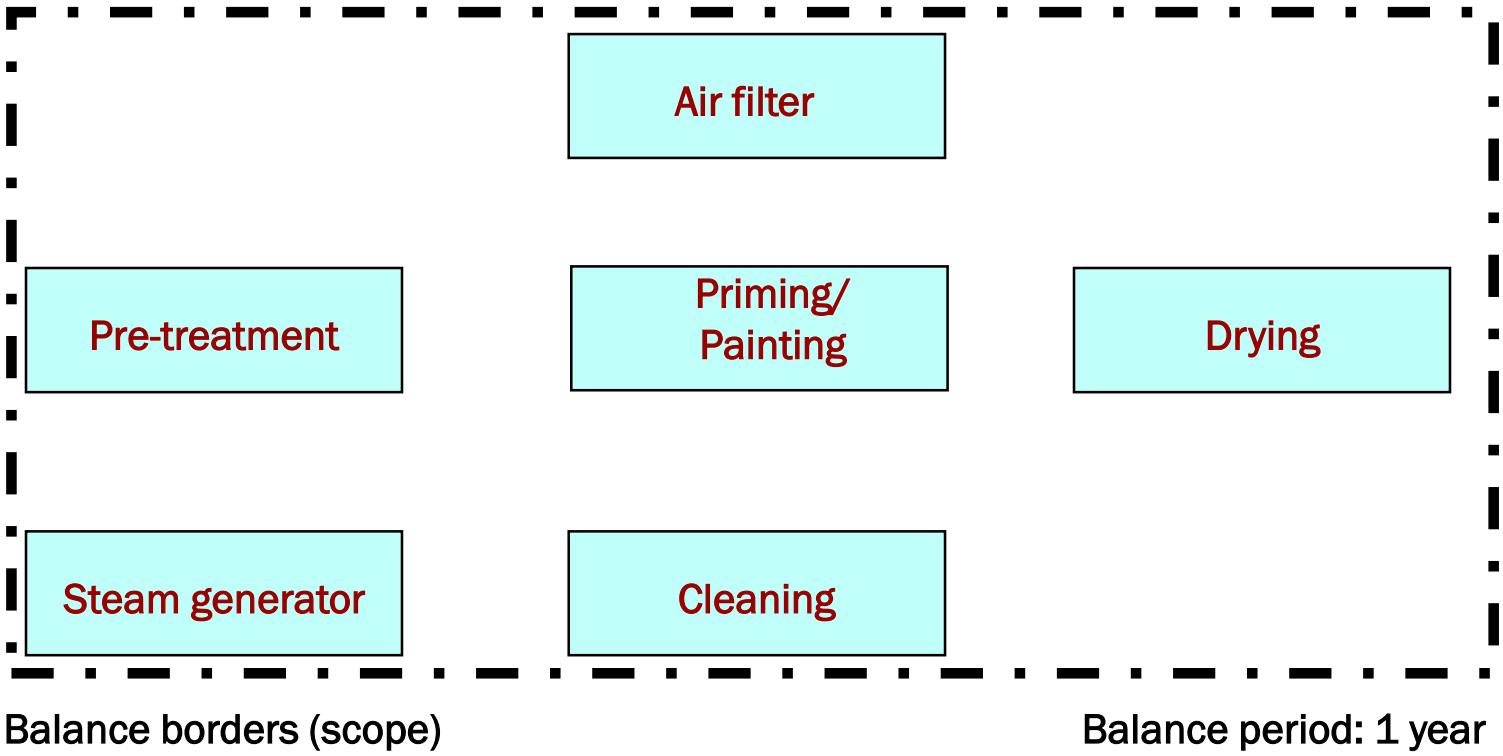
EXAMPLE: Processes within painting shop

Task: **Assign total annual material and energy volumes and costs to cost centres/production steps for priority flows** (paints, solvents - into the balance are added also process materials as they are related to these priority flows)



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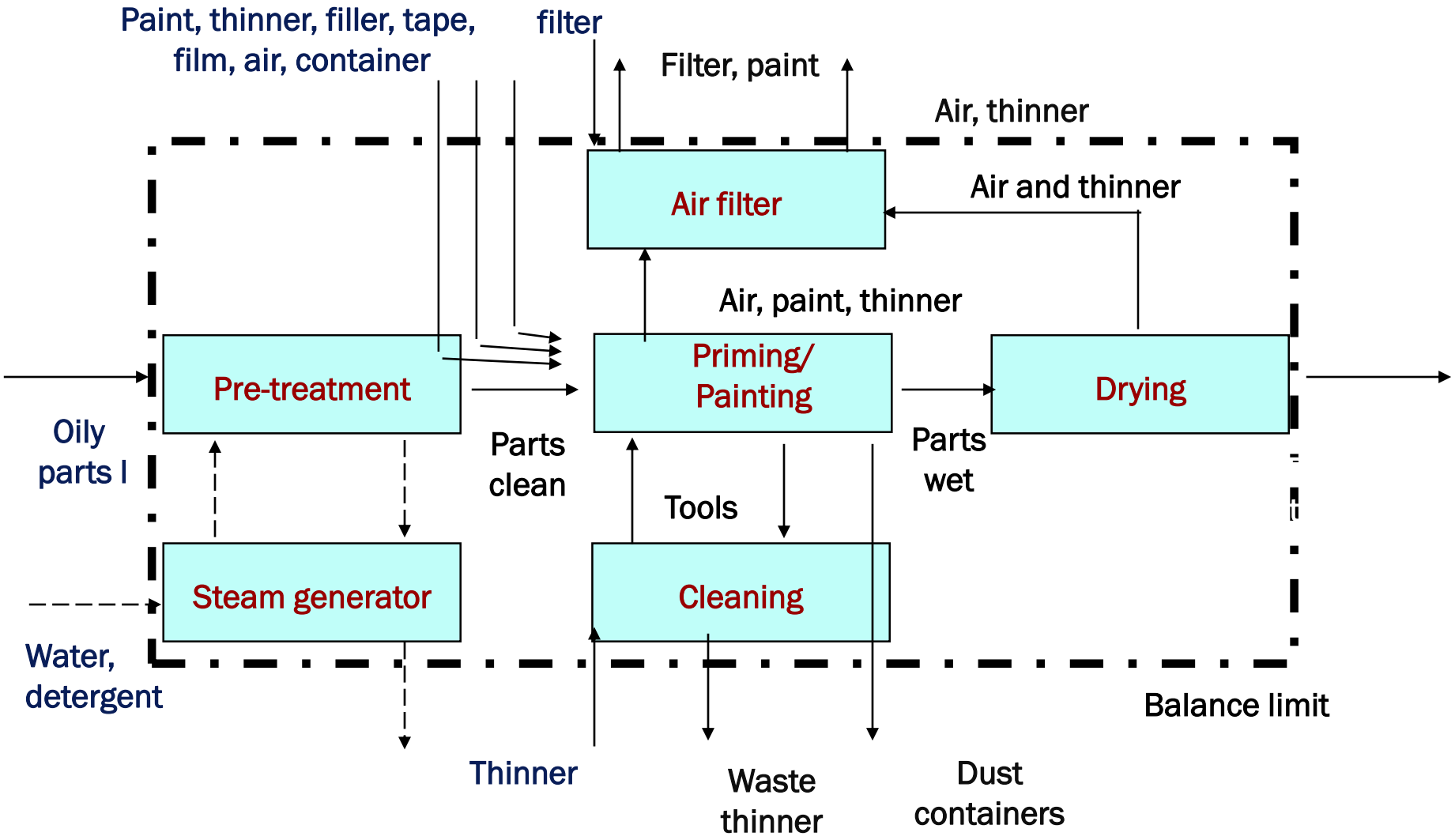
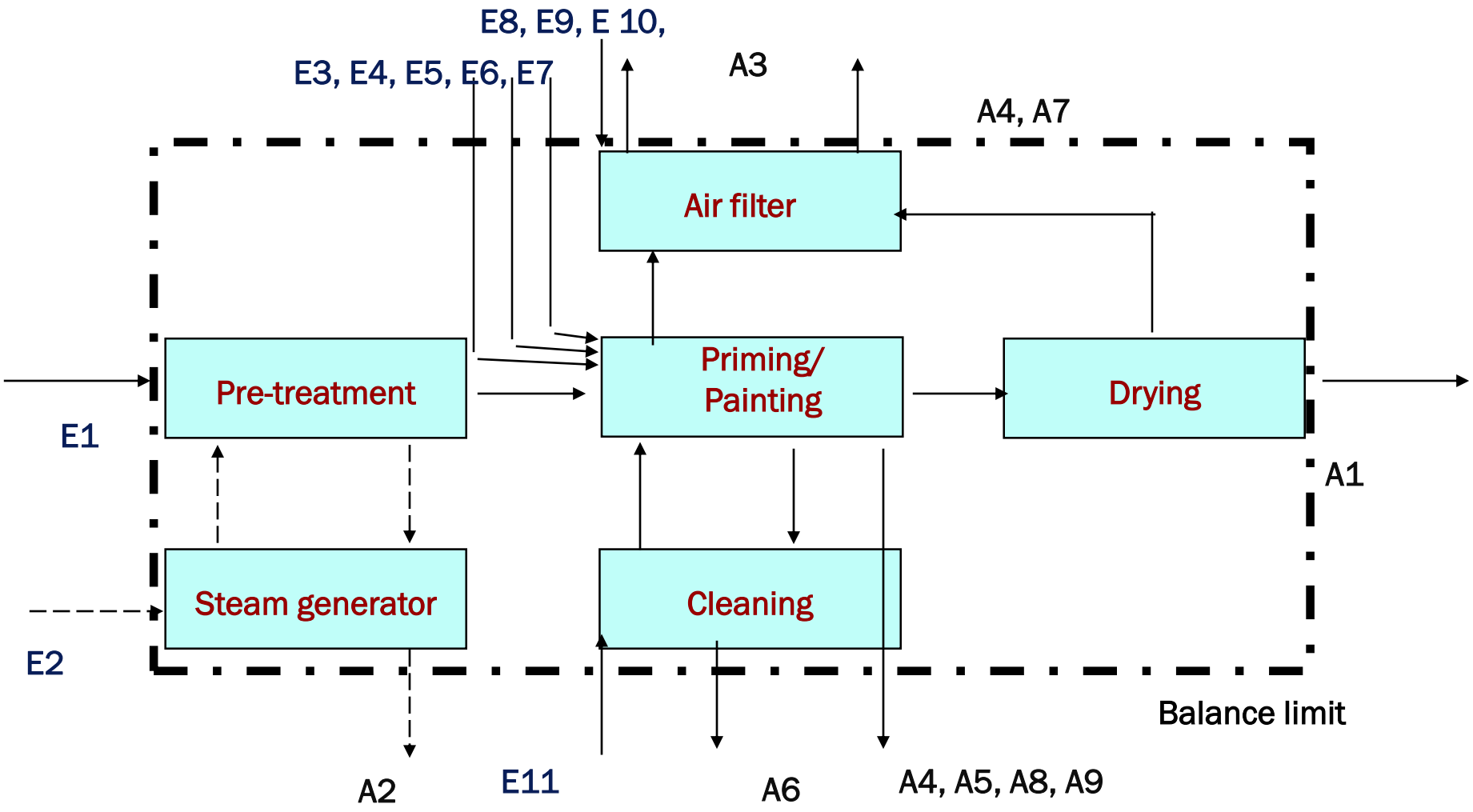
EXAMPLE: **Flowchart** for painting shop



EXAMPLE: I-O balance for the painting shop



EXAMPLE: Calculating I-O balance

Material flow analysis – flow data

Stream		Quantity	Unit	Stream		Quantity	Unit
E1	Oily workpiece	20400	kg	A1	Workpiece With paint	20000 800	Kg Kg
E2	Steam, water	9500	M^3	A2	Waste water With oil, sludge	50000 400	Kg Kg
E3	Detergent	60	L	A3	Air solvent	101 mi. 3600	M^3 Kg
E4	Filler	120	Kg	A4	Dust	100	Kg
E5	Hardening agent	24	Kg	A5	Container	n. q.	
E6	Films	150	M^2	A6	Spent solvent	1400	kg
E7	Tape	450	Roll	A7	Spent filter	2700	kg
E8	Pressurized air	39000	M^3	A8	Sludge	393	Kg
E9	Air	59 million	M^3	A9	Covering material	n. q.	
E10	Paint Solvent	4000 2000	Kg kg				
E11	Solvent	3000	Kg				
E12	Air	42 million	M^3				
E13	Filter	100	kg				

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Quantitative material flow analysis

Balance for solvents

Input			
E10	Solvent in paint	2000	Kg
E11	Solvent	3000	Kg
Total		5000	kg

Output			
A2	Solvent in exhaust air	2700	Kg ???
A6	Spent cleaning solvent	1400	Kg
A8	Paint sludge	393	kg
	Losses	*507*	*kg ???*
Total		5000	kg

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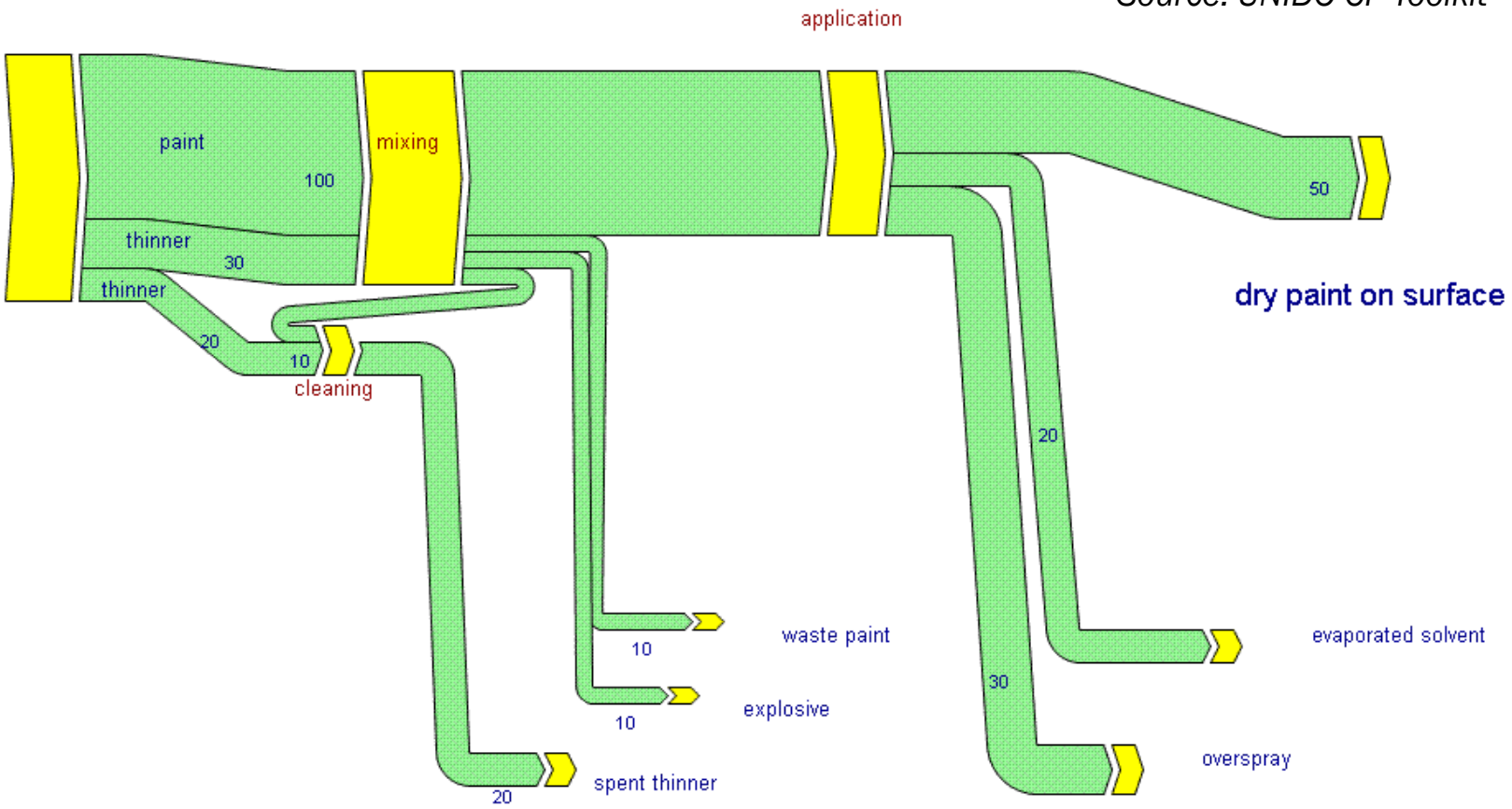
Example of background presentation for interpreting results – Sankey diagram from painting shop

Source: UNIDO CP Toolkit



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Example – turning shop

Interpret results of oil balance implemented within company producing ball bearings. Balance of cutting oil was implemented for previous fiscal year within the turning shop.

Oil input in the turning shop in litres per fiscal year

TOTAL	33,297

Oil output in the turning shop in litres per previous fiscal year

- On the turnings (estimation based on benchmarking data)	12,000
- Oil exchange during cleaning of machines (measured)	8,000
- in hazardous waste (measured)	2,000
- loss by dispersion and evaporation (expert estimation)	1,000
- on the product (estimation based on benchmark data)	250
TOTAL	23,250

Imbalance	*10,047 l/y*

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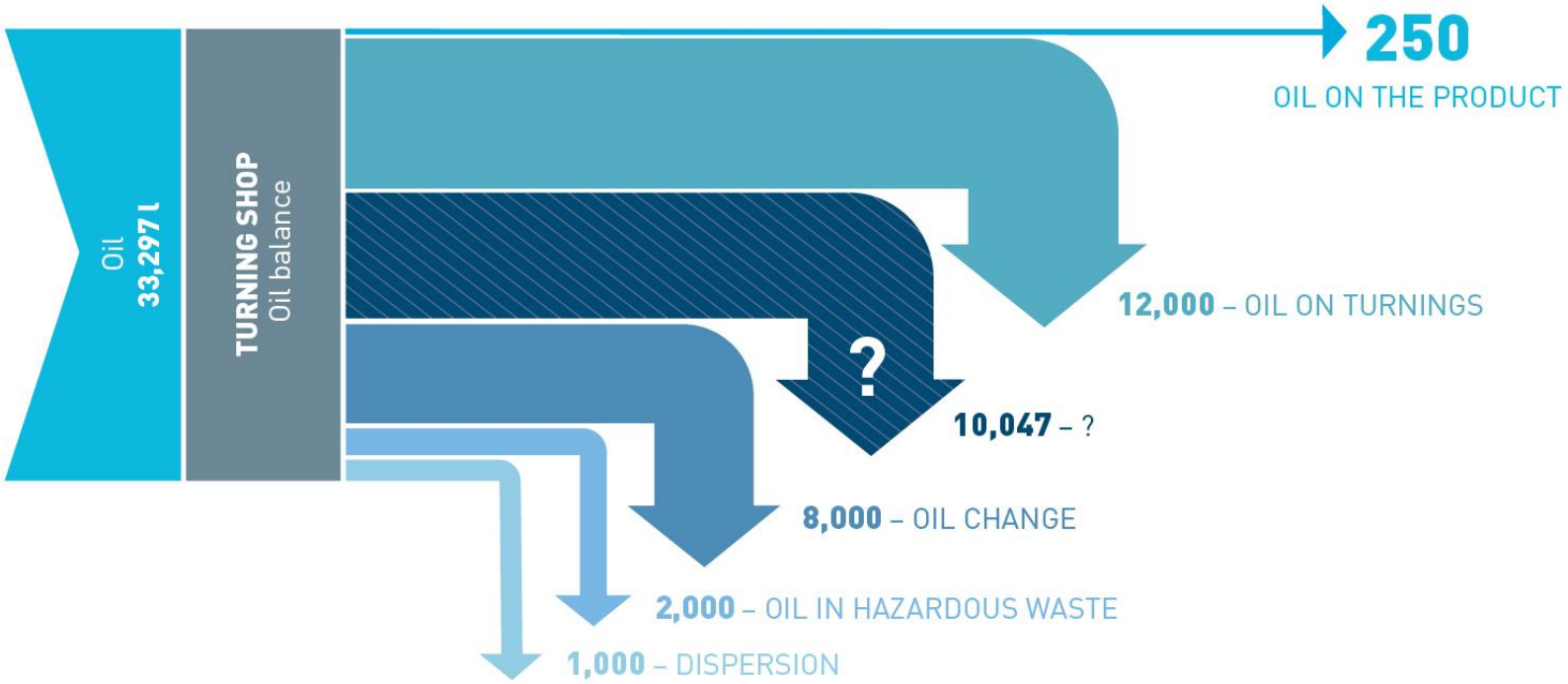
Example – turning shop:
Oil imbalance of 10,046 l/y in Sankey diagram



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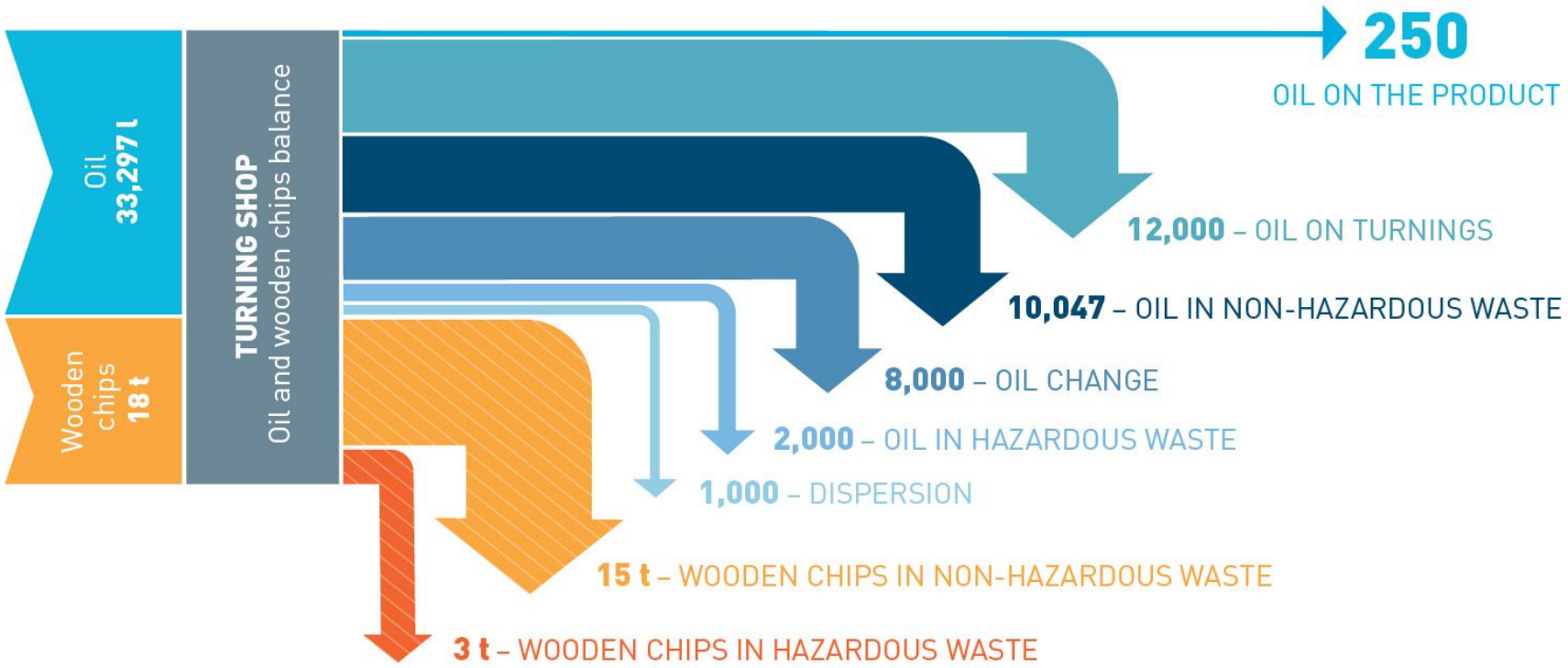
Example – turning shop:
Complete Sankey diagram



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Revealing causes of pollution

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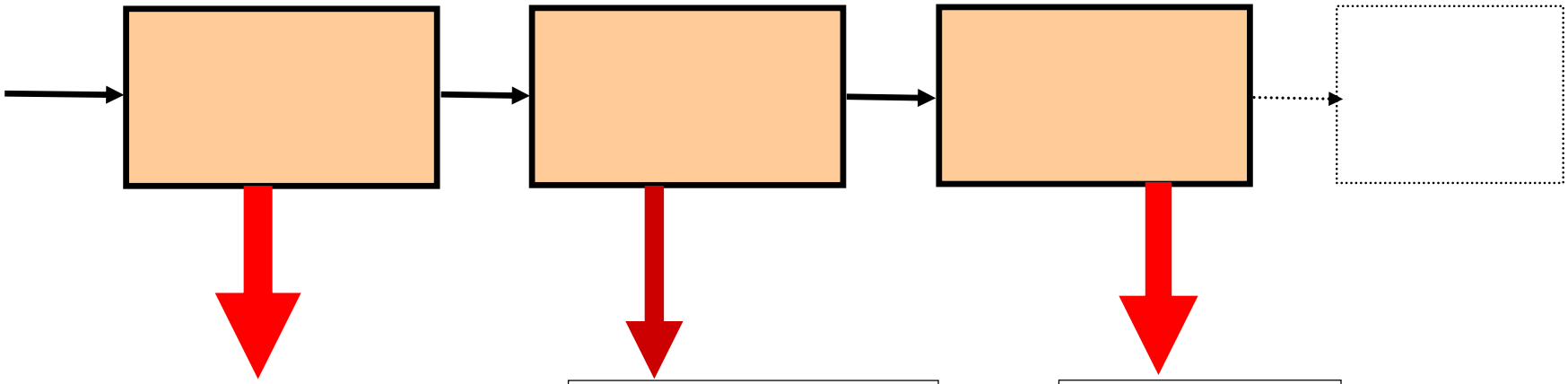
Identification of **c a u s e s** of losses and pollution



Losses & Pollution causes :

SOURCE 1
- Material
- Technology

SOURCE 2
- Method
- Man
- Technology

SOURCE 3
- Man
- Product design

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Spent sufficient effort with cause identification

!

It is crucial to discover the root causes of a problem in a systemic way (to avoid addresing just the ones that are most obvious – this leads to suboptimised solutions)

Revealing cause – effect relationship:

Asking question WHY? repeatedly

For the Cause – Effect Analysis can be utilised the Fish Bone Diagram

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Question all possible factors influencing losses (pollution generation)

Basic factors influencing losses / pollution generation:

- Product design
- Choice of input materials and their quality
- Choice of technology and quality of specific equipment
- Method (way of operating technology)
- Information flows (incl. measurement and communication)
- Man (mindset, knowledge, skills and motivation of people)
- Environment (natural conditions, working environment)

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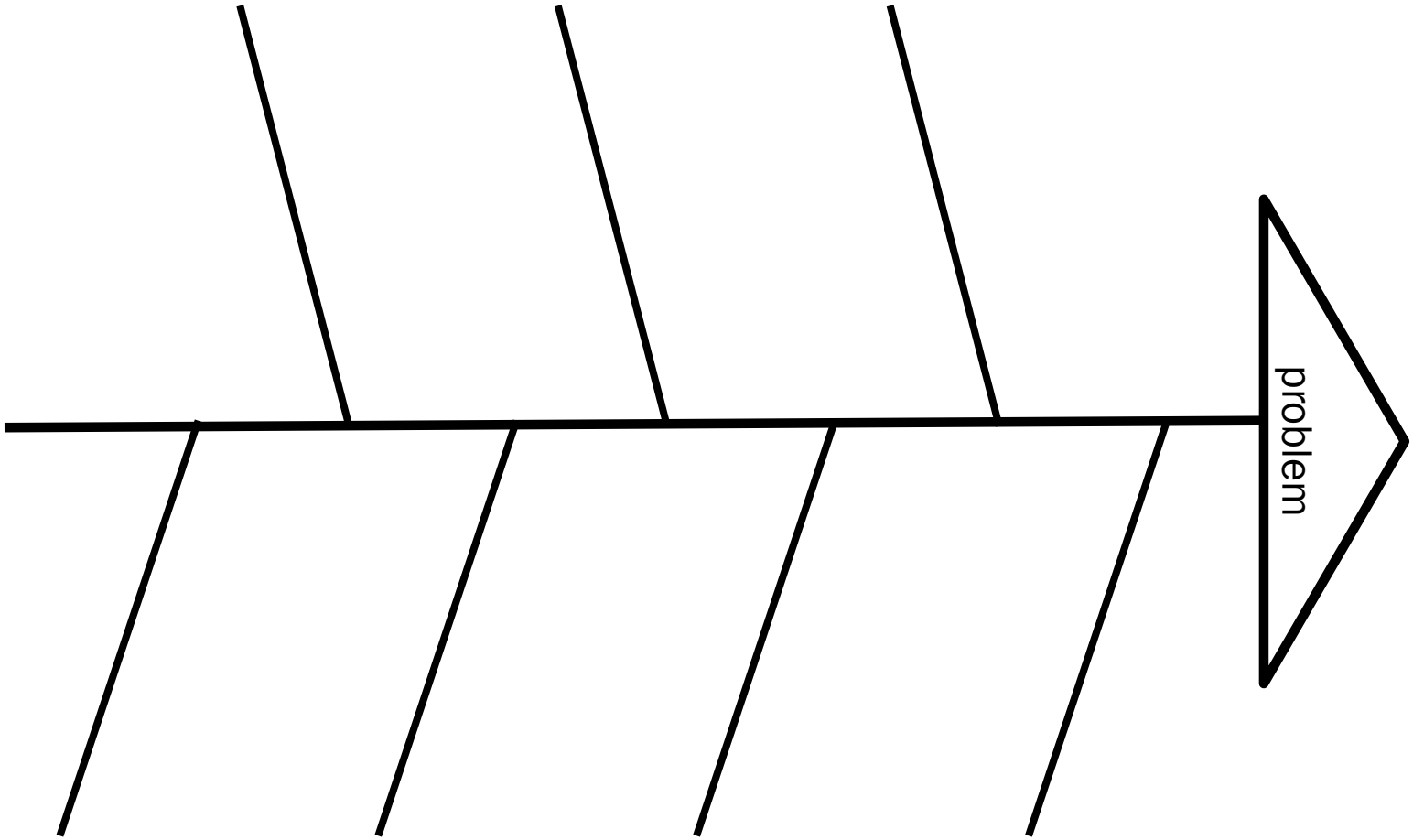
Cause and Effect Analysis based on Fishbone Diagram



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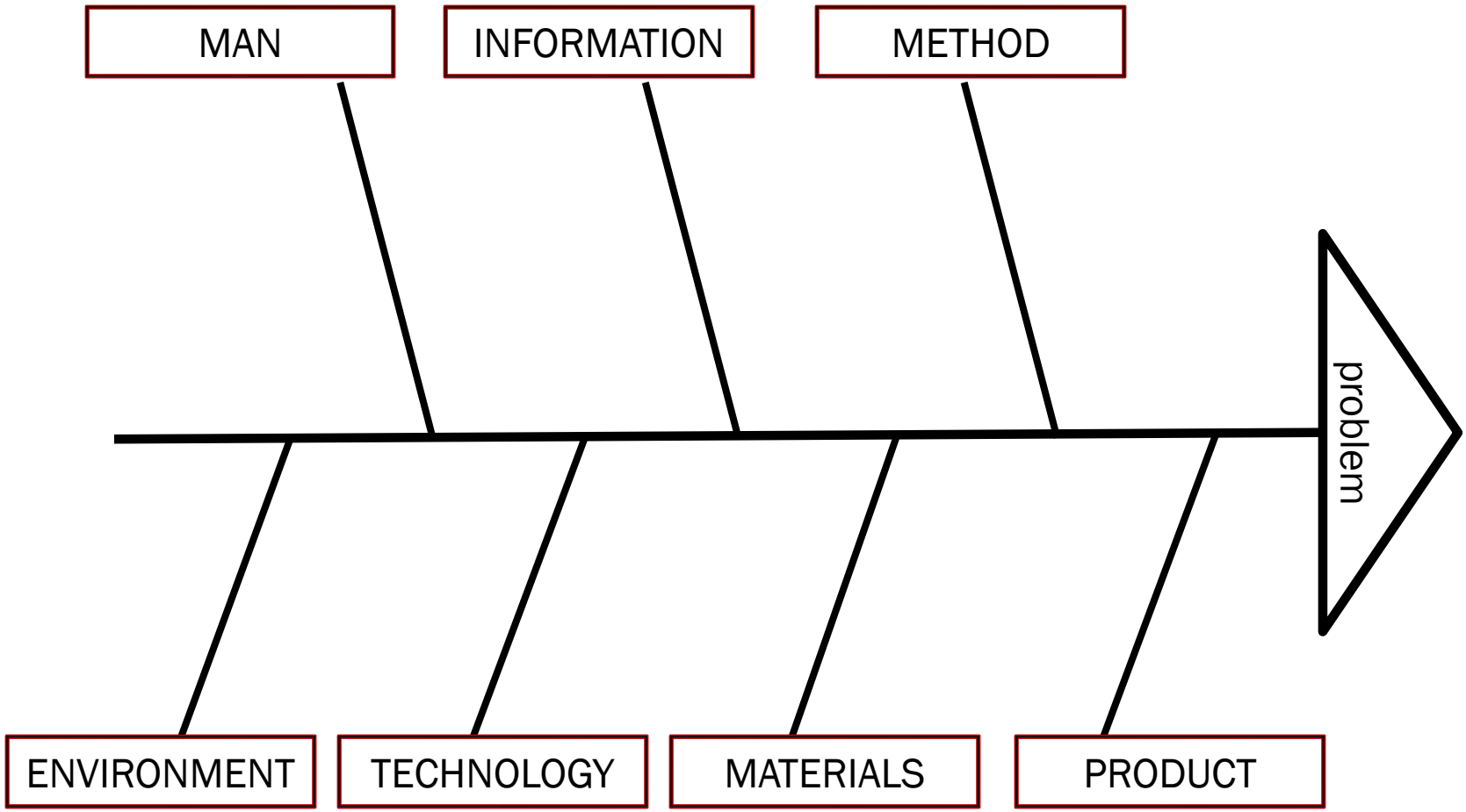
Cause and Effect Analysis in Resource Efficiency



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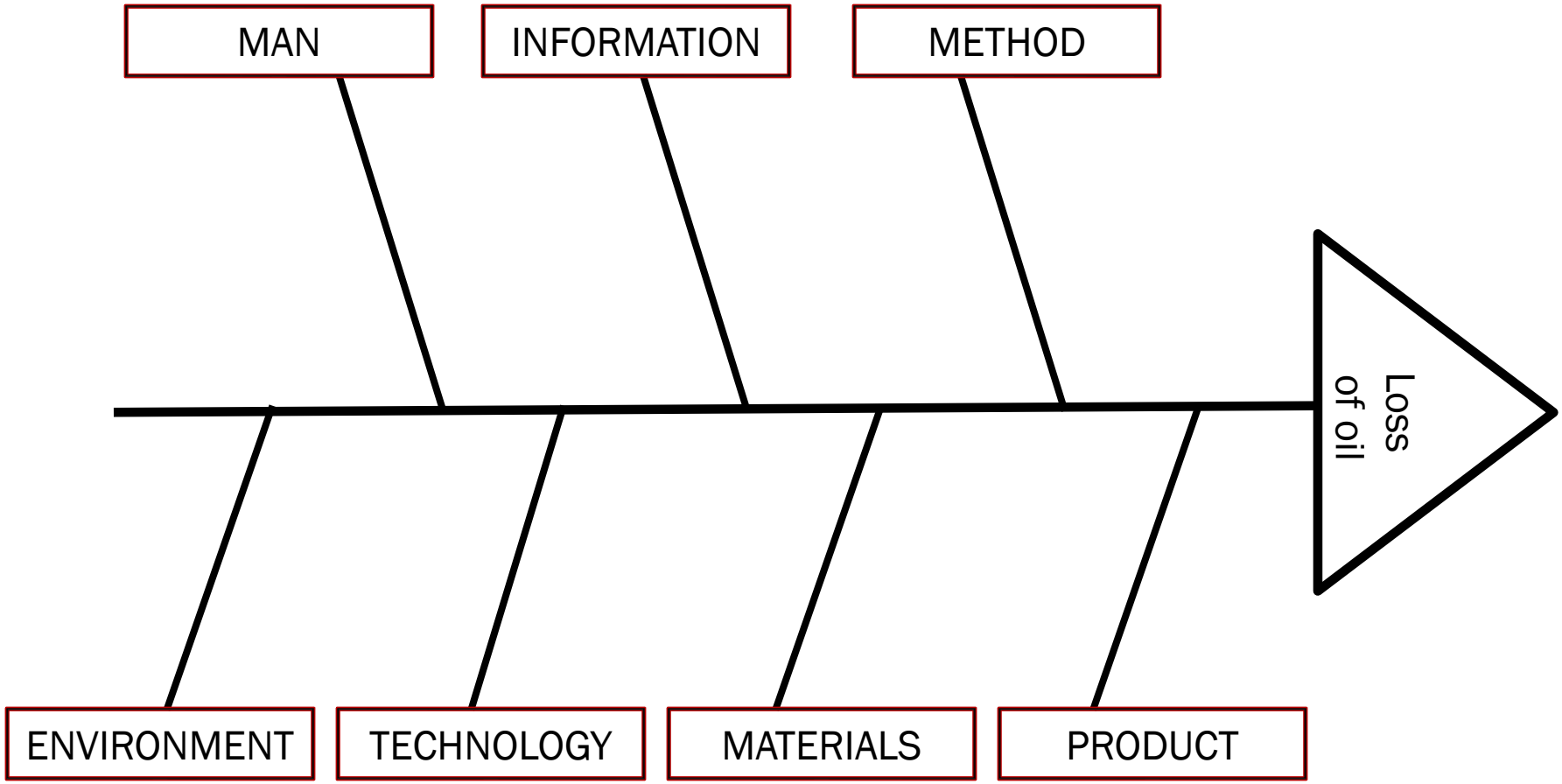
EXERCISE: Cause and Effect Analysis within the TURNING SHOP



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Overview of major outputs of detailed balance

- **Identification of sources of losses** (waste and emissions are traced to their source – point/area where they are generated)
- Quantification of flows and related losses and problems and their prioritisation
- Data for establishing a baseline for controling performance of important sources of losses (pollution)

- **Understanding of causes of losses / pollution generation** (which enables generation of an efective set of improvement solutions within the next step)

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Highlights

- An estimate is better than doing nothing at all (it is better to be „approximatelly right then accurately wrong“); 80 – 90% accuracy of estimtes is usualy sufficient
- 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.
- Use simple measuring instruments, if necessary, contact the supplier for data
- Discrepancies in collected data can lead to the recognition of hidden pollution flows and sources as shown in the case history in this chapter.
- It can really pay back allocating sufficient time to reach a good understanding of these causes.

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Case study

Revealing causes of LOSSES and POLLUTION

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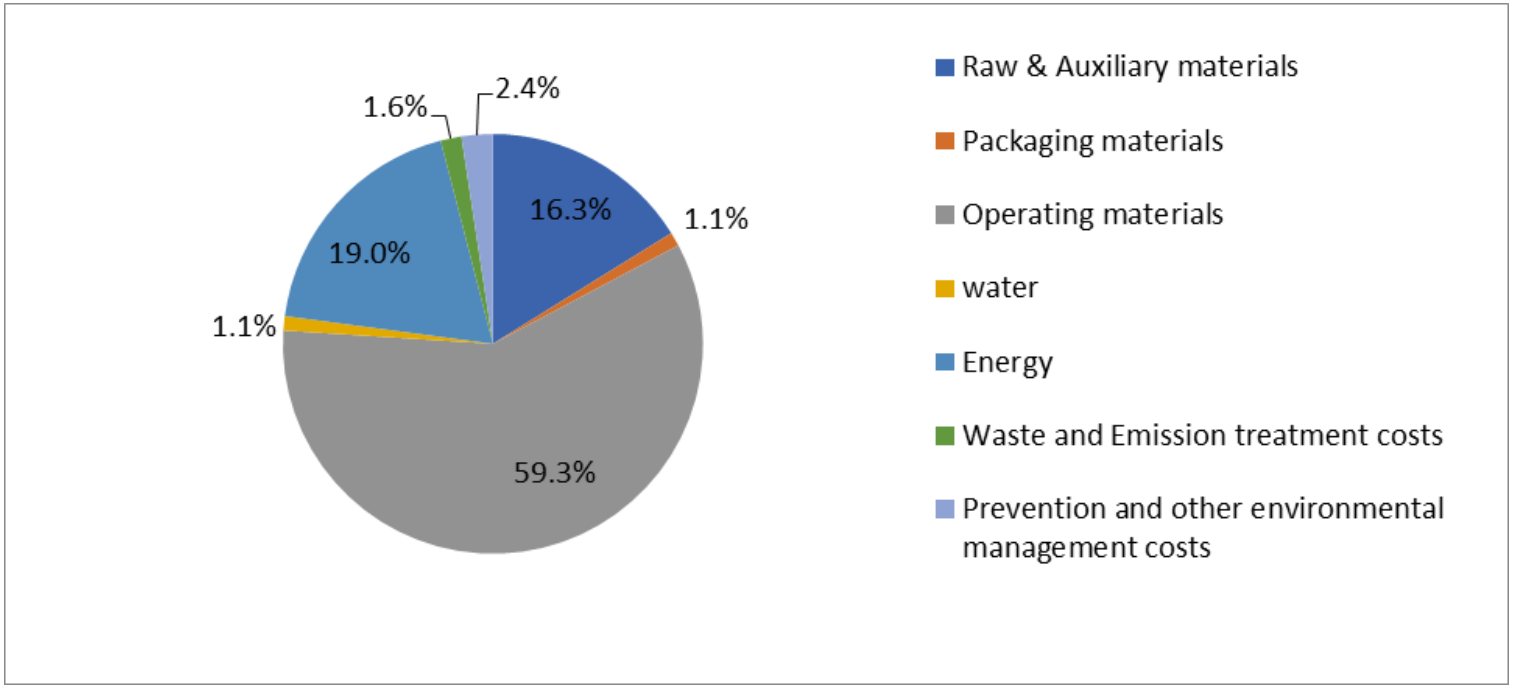
Priority Flows: step 1.4

- **Company sector :** Manufacturer of shock absorbers for cars and lorries



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Focus areas: step 1.5

Priority flow	Total in Euro	Process/workshop					
		Welding	Machining	Mounting	Chroming & Painting	Packaging	others
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

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Identification of sources and causes of losses

- **Focus area** : the chromium plating process

- **Causes analysis method**: fishbone diagram
  - assessment of the technology used
  - Observation of operating and good housekeeping practices.

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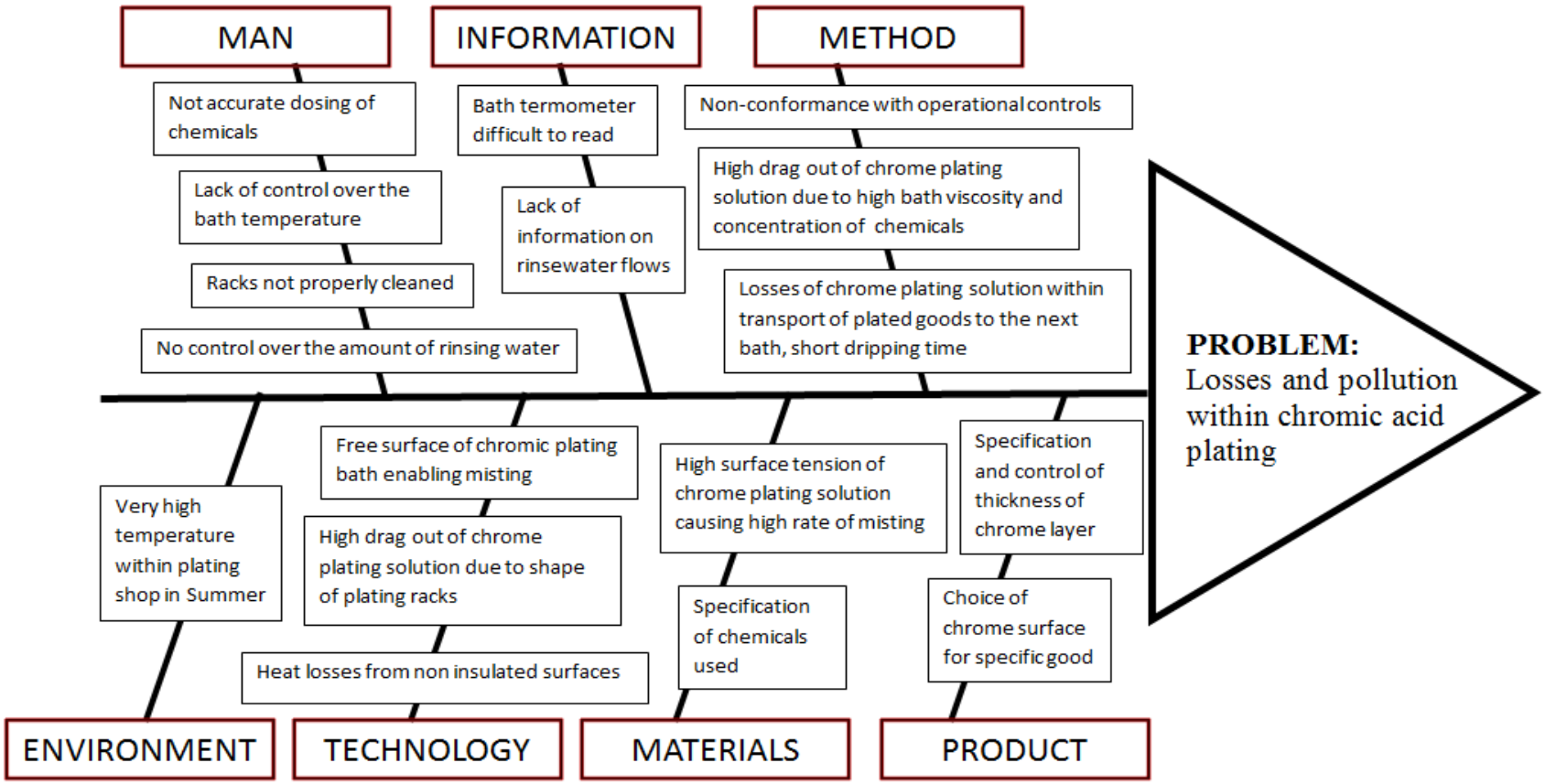
Fishbone diagram for chrome plating process



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Prioritization of 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

This step highlighted the importance of teamwork and especially the involvement of the company workers on the shop floor who provided significant inputs for analysing the causes of inefficiency.

Linkages with EMS

EMS Not 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.

EMS In place

- 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.

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