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European Union for Environment Regional Programme "Resource Efficient and Cleaner Production (RECP) Project

RECP Coaching Program in Armenia
Second day

Nune Harutyunyan

Dshkhuhi Sahakyan

Tigran Sekoyan

Yerevan 2020

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Continuing with the RECP method

Tools: Material and energy flows analysis

> Obtain management commitment
> Organise project team
> Identify barriers & solutions
> Set objectives
> Pre-assess

> Identify sources (WHERE)
> Analyse causes (WHY)
> Generate possible options (HOW)

> Evaluate options on:
Technical, environmental and economic feasibility
> Select best options

> Option implementation
> Monitoring and evaluation
> Sustain and continue

The recognized need for Cleaner Production

1.Planning and Organization

2.Assessment

3.Feasibility Analysis

4.Implementation

Successfully implemented Cleaner Production projects

Sustain & Continue (EMS)

2 steps:
1) Initial assessment and 2) detailed assessment

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Module 4. Material flow analysis

- What is a material flow analysis?
- How to carry out a material flow analysis?
- Cases studies
- Material flow analysis for water.
- The use of data sheets.

Many resources on Earth are on the edge of depletion.

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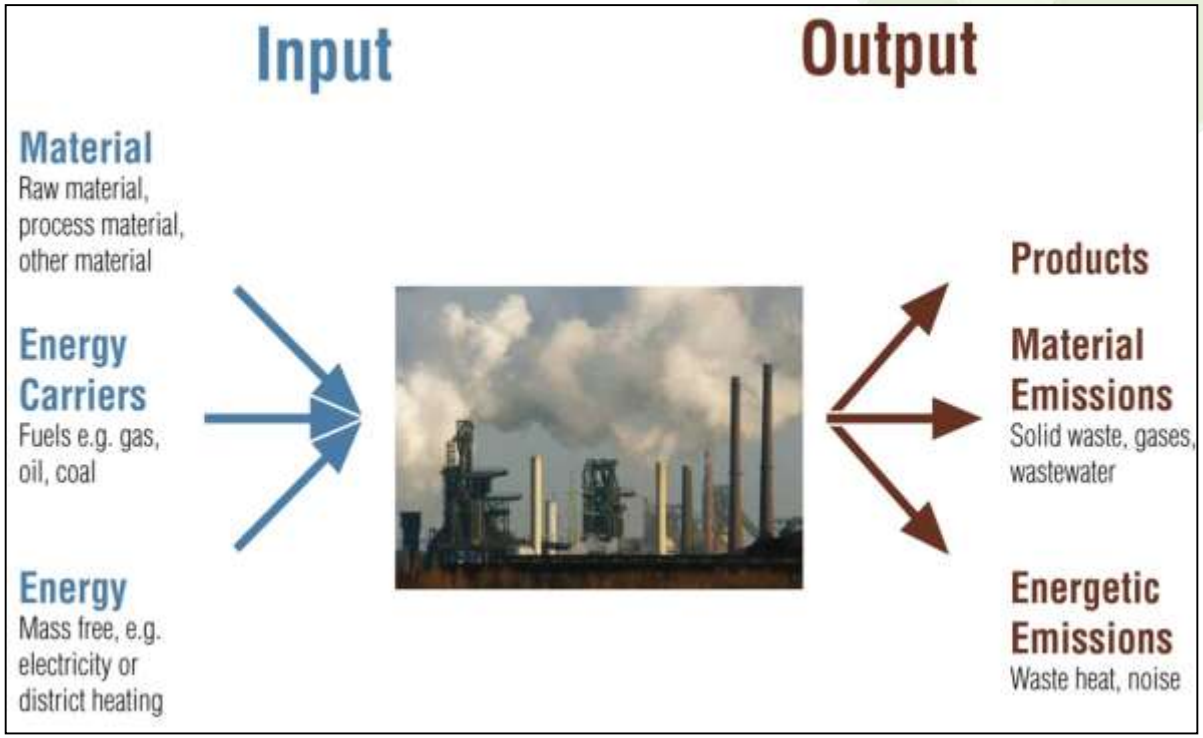
Objectives of a material flow analysis

- Trace the flow of raw materials through the company to establish connections within the process
- Retrace waste and emissions to the point where they are generated
- Identify weak points (inefficiencies)
- Define the basis for evaluation
- Edit data in a decision-oriented way
- Set priorities for appropriate measures to minimize waste and emissions

What are materials?

- Goods/raw materials (e.g. wood, gravel, PVC)
- Elements (e.g. carbon, cadmium)
- Compounds (e.g. benzene, methane)



What is a material flow analysis?

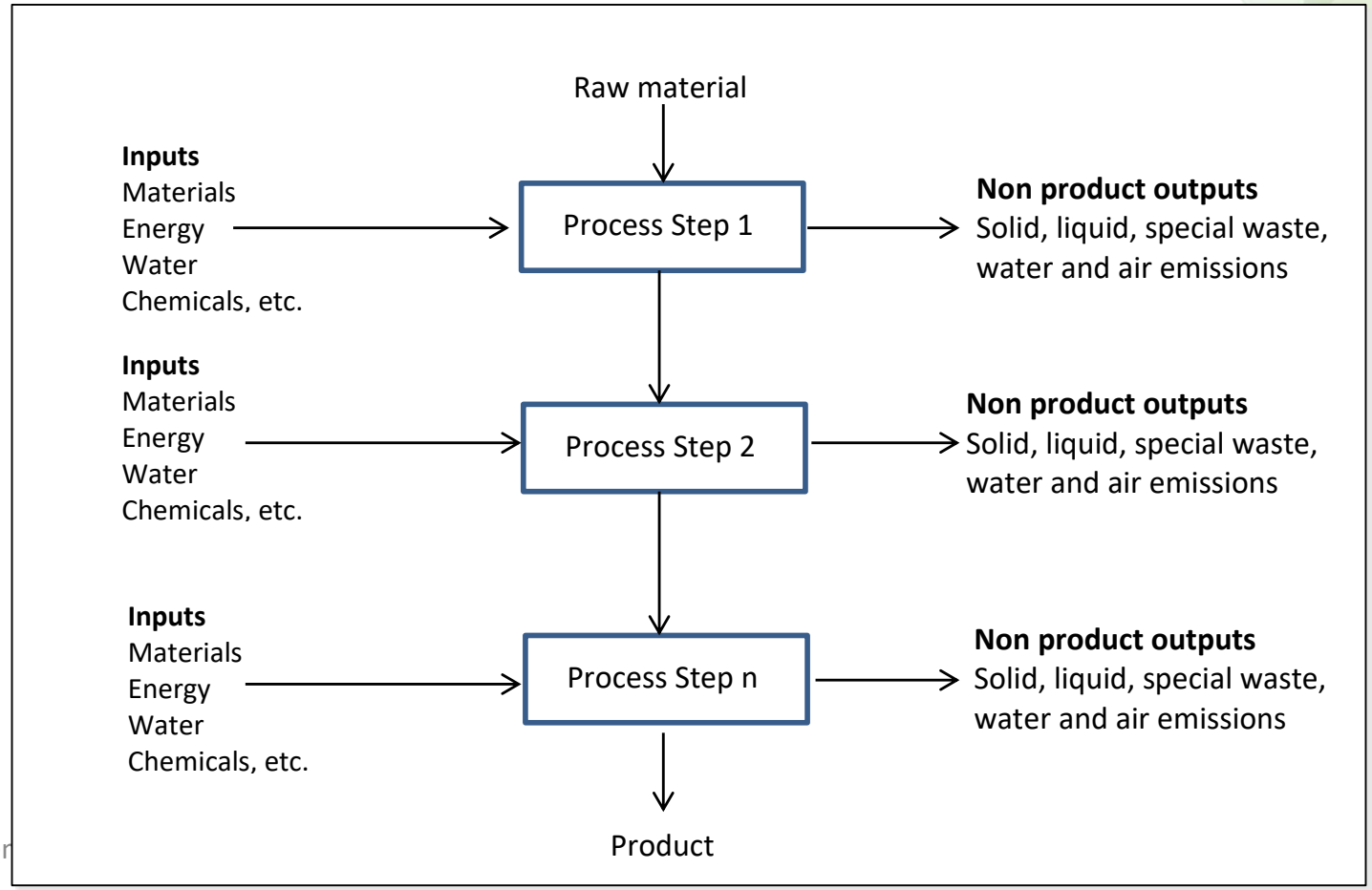
A material flow analysis is a systematic reconstruction of the way a chemical element, a compound or a material takes through a natural and/or economic cycle.

A material flow analysis is generally based on the principle of physical balance.

Several indicators are used to evaluate the inventory stocks efficiency – material unit average profitability, average consumption of material, average return on a unit of material.

How to carry out a material flow analysis

Initial assessment: 1. Develop a process flow diagram

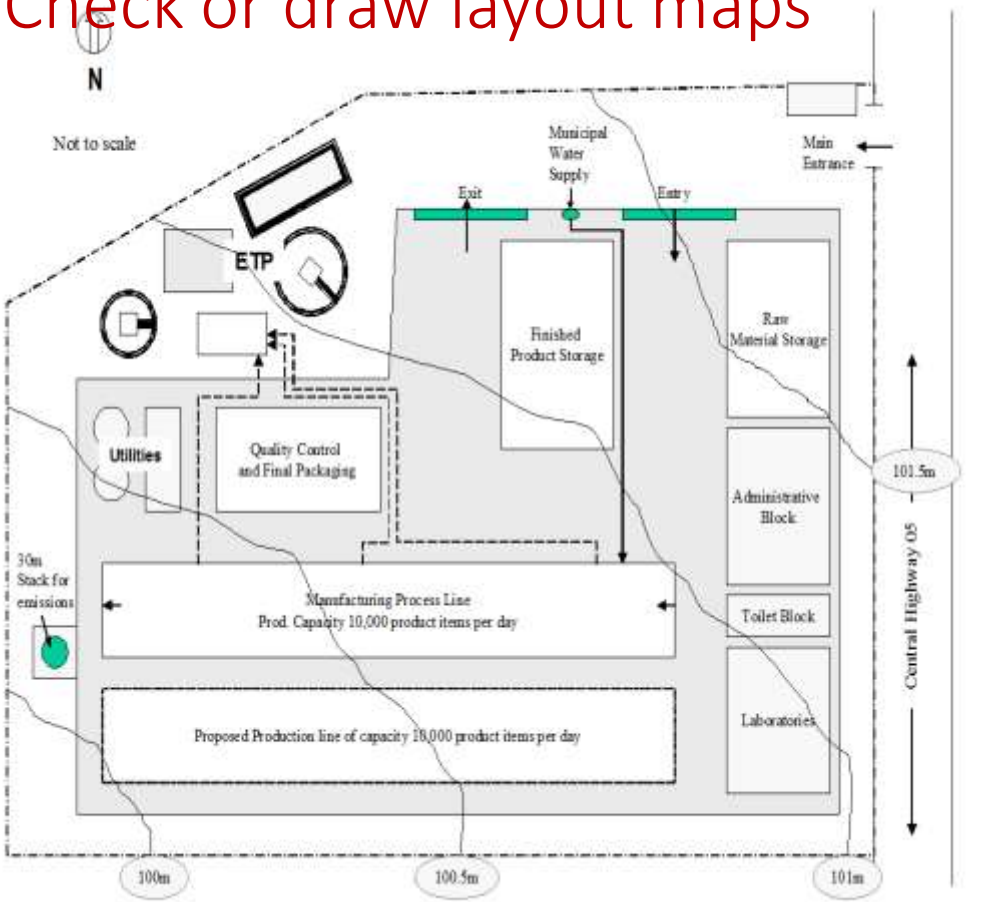


How to carry out a material flow analysis

Initial assessment: 1. Check or draw layout maps

Layout map of the entire operations in the organization: Show the internal roads, entry and exits, waste storage, processing, disposal facilities, utilities, wastewater outlets

Layout map of key departments: Layout maps may be drawn for departments of concern indicating the positions of the major equipment, water piping, steam lines, drains and vents / stacks.



How to carry out a material flow analysis

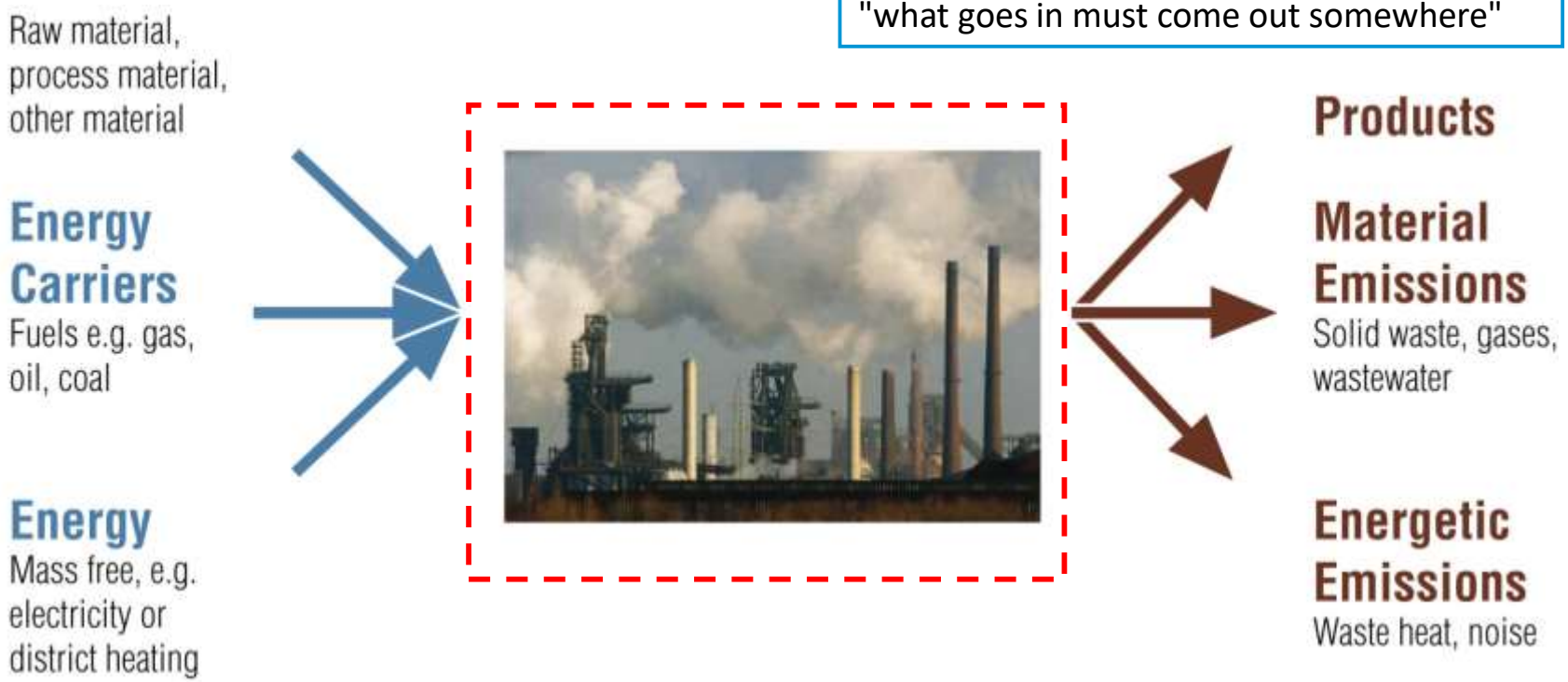
Ecomapping may be used for specific themes, such as:

- Water consumption
- Wastewater discharge
- Solid waste generation
- Fugitive emissions and odours
- Noise
- Dust
- Environment and safety risks

How to carry out a material flow analysis

Initial assessment: 2. Input/Output analysis at company system boundary

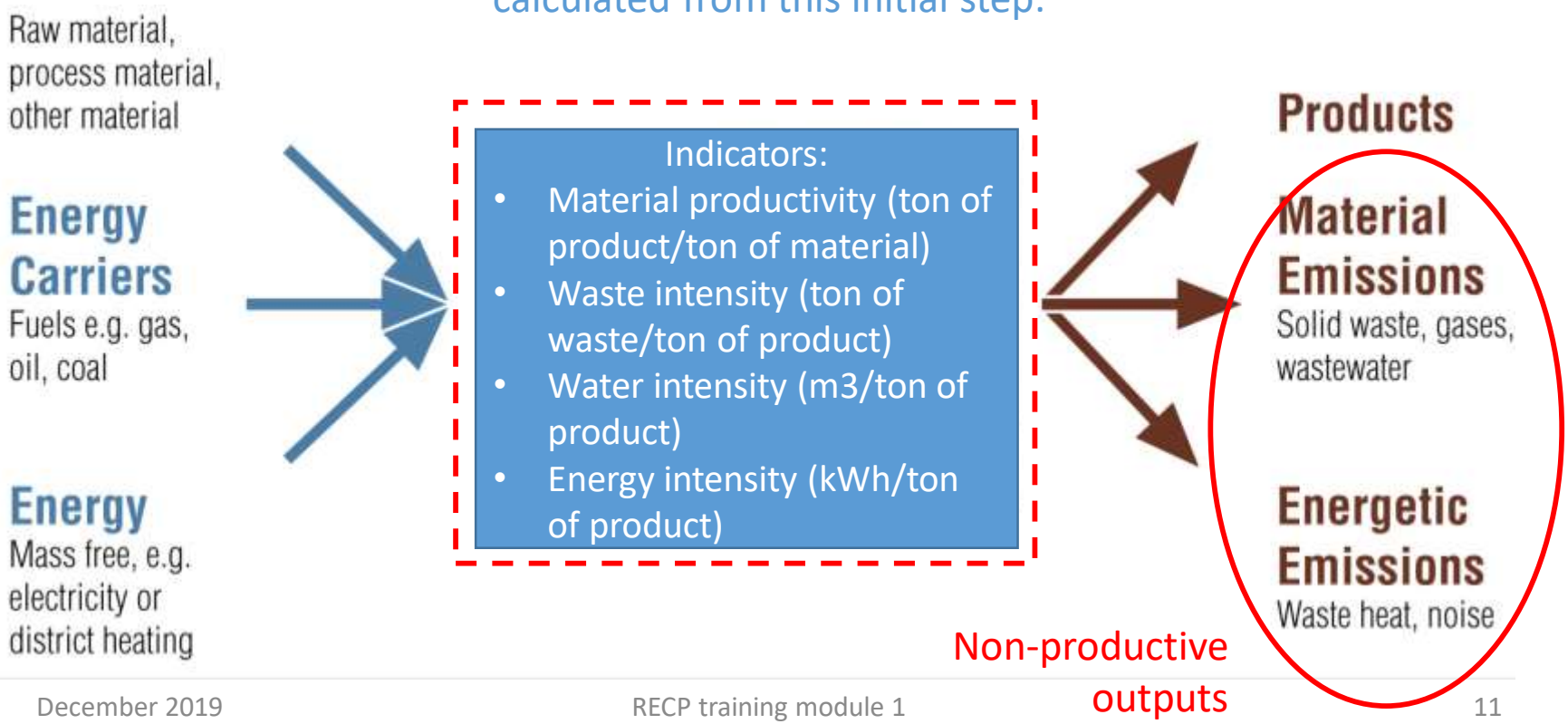
The law of mass conservation is applied:
"what goes in must come out somewhere"



How to carry out a material flow analysis

Initial assessment: 2. Input/Output analysis at company system boundary

Baseline indicators at company level can be calculated from this initial step:



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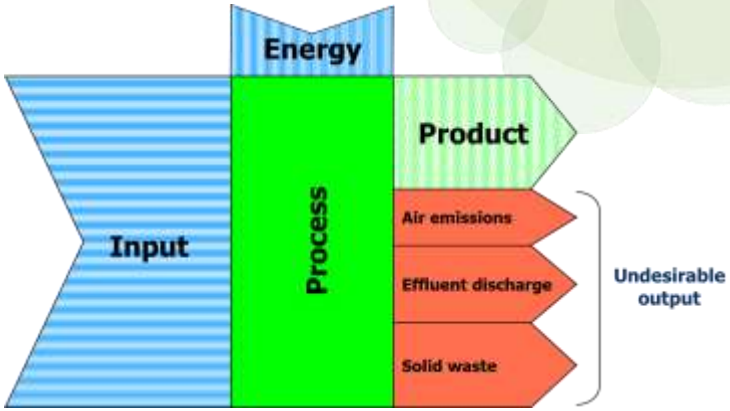
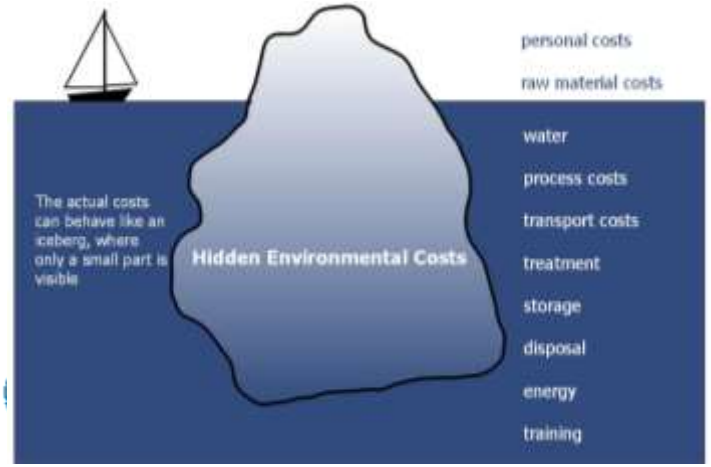
How to carry out a material flow analysis

What are the non-productive outputs?

Non productive outputs are:

- **undesirable** outputs
- raw materials **not turned** into products the company paid for..
- **by products ,** including **waste**…
  - Solid waste
  - Liquid waste
  - Effluent
  - Emissions
  - Dust
  - Heat
  - Energy losses





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How to carry out a material flow analysis

Collecting information: Plant walkthrough

Inspection of the plant's operations by the team:

- Observe location and scale of waste/pollution sources
- Observe usage of energy, materials and water
- Appraise status of equipment and operations
- Note general factory appearance and staff and management attitudes

How to carry out a material flow analysis

Collecting information: Plant walkthrough

- Follow the production process flow
  - Start at the raw materials receiving area and end at the department of finished products
- Cover all the support utilities
  - Boilers, power generators, fuel storage tanks, pump-house, refrigeration plant, raw water treatment plant, wastewater treatment facility, etc.
- During operations and while idle for specific tasks
  - Identification of leaks, steam, compressed air, water etc.
- Consider incidents
  - What if: supply interruptions, maintenance, external emergencies
- Involve staff and collect their comments and ideas

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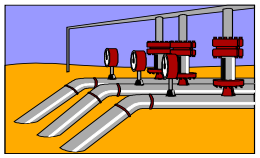
How to carry out a material flow analysis

Initial assessment: 3. Set priorities

Criteria for the selection of a material



- Quantity of the material flow

- Costs of the material flow

- Toxicity of the material flow

- Legal aspects of the material flow

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Detailed assessment
Build a Material Balance

1. Define the objectives and parameters to be monitored
2. Limit the balance scope
3. Limit the balance period
4. Identify and define the process steps or priority areas
5. Draw revised flowcharts: material flows – quality
6. Draw up the balances: material flows – quantity
7. Interpret the results: identify sources of pollution

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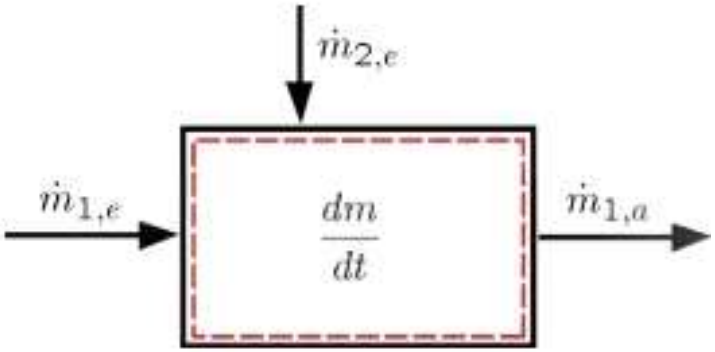
Material and energy balances

The temporal change of the mass in a system is equal to the difference of the incoming and outgoing mass flows:

$$\frac{dm(t)}{dt} = \sum_i \dot{m}_{i,e}(t) - \sum_j \dot{m}_{j,a}(t)$$



Without storage or reaction follows:

$$\frac{dm(t)}{dt} = 0 \quad \Rightarrow \quad m = const$$

Source of data

Input materials data

- Accounting documents
- Documents from suppliers
- Internal records and software

Waste output data

- Waste transfer notes
- Waste disposal /recycling weighting notes
- Internal records
- Calculations

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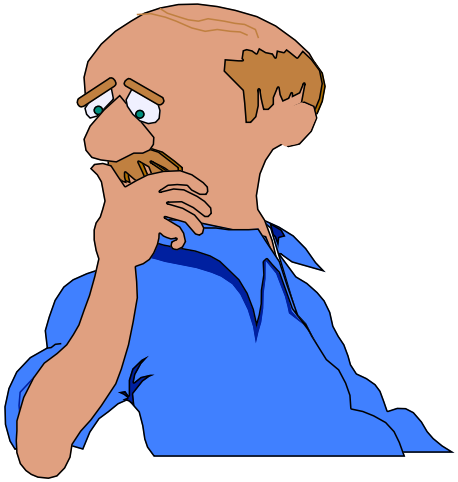
Interpretation of results through efficiency parameters and indicators.

Example from a material flow analysis of a painting machine:

Calculation of the so-called "application efficiency":

$$\text{Efficiency} = \frac{\text{Dry surface film mass}}{\text{Input solid state mass}}$$



In this case for small pieces < 10%

In this case on average < 20%

What is the state-of-the art?

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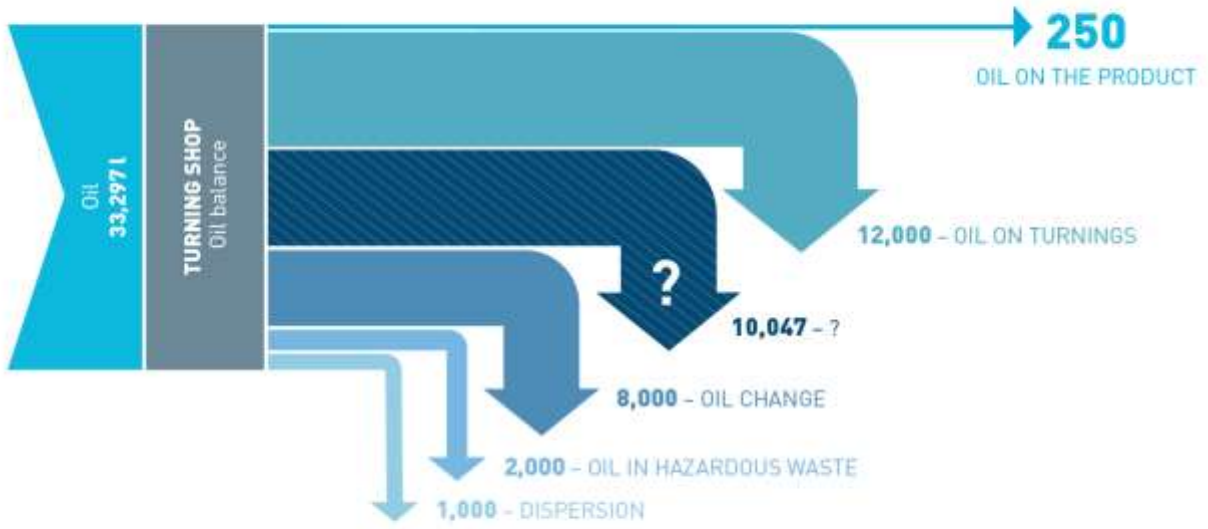
Example of material balance definition – quantitative

Oil balance implemented within an SME producing ball bearings. Balance of cutting oil was implemented for previous fiscal year within the turning shop.



Oil imbalance of 10,047 l/y, almost 30 % of the total input – Why?

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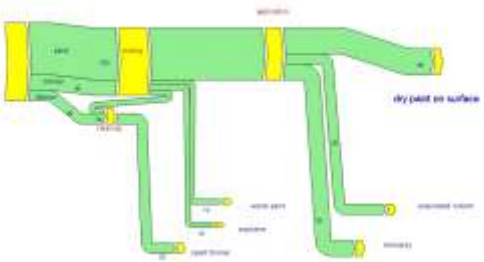
Recommendation 1

for a material flow analysis

- Carry out the material flow analysis in steps
- An estimate is better than doing nothing at all
- Even with estimates it is possible to improve
- 80 – 90% of accuracy is sufficient
- Use simple measuring instruments
- Use indicators
- If necessary, contact the supplier or plant manufacturer



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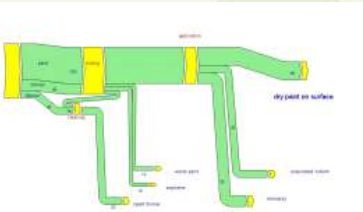
Recommendation – 2
for a material flow analysis



- It is not essential to follow the instructions or procedures in great detail, a creative approach is often helpful.
- Even by simply working with the balances you can sometimes achieve improvements.
- It is important to translate the results into the language of the respective target group (monetary units, kg, pictures, comparisons, etc.)

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Module 5. Energy analysis

- Main components of a corporate energy system,
- Data collection and energy saving potential,
- Energy data - Specific energy consumption – benchmarks,
- Conversions,
- Distribution,
- Consumers,
- Heat recovery,
- Typical areas with high potential for optimization.

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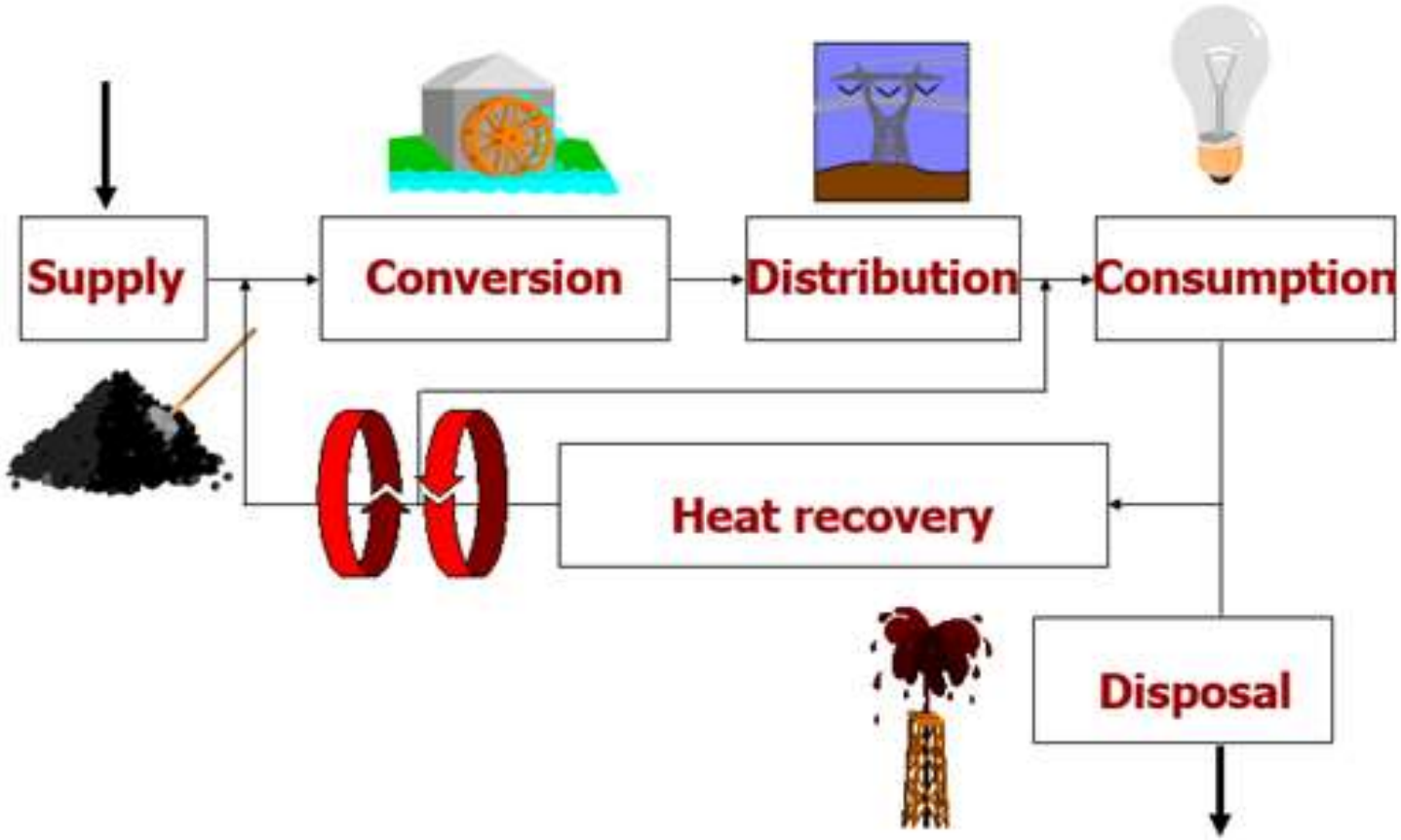
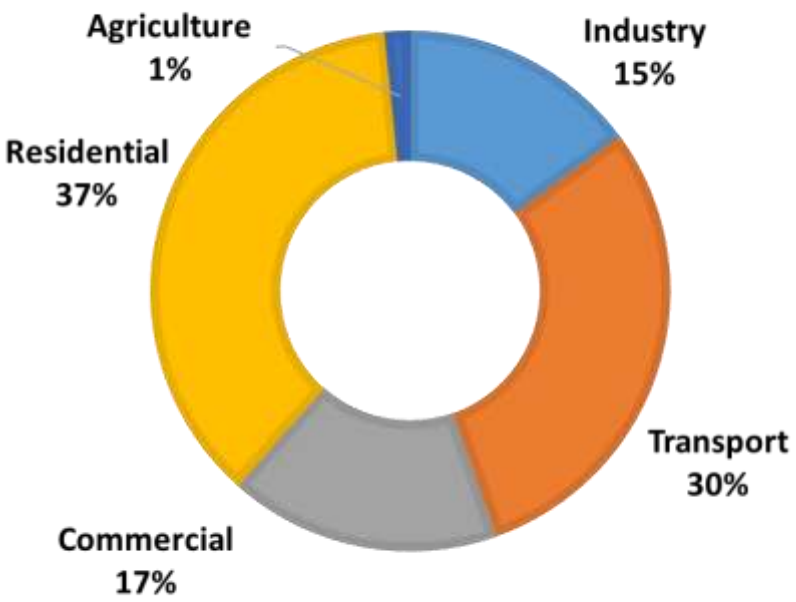
Structure of a company's energy system



Final energy consumption in Armenia by Sectors, 2017



Industry and construction sector

A different types of fuel are used industry and construction – mostly natural gas (88.2%), followed by diesel fuel in a much smaller quantities (11.7%), coal consumption is negligible.

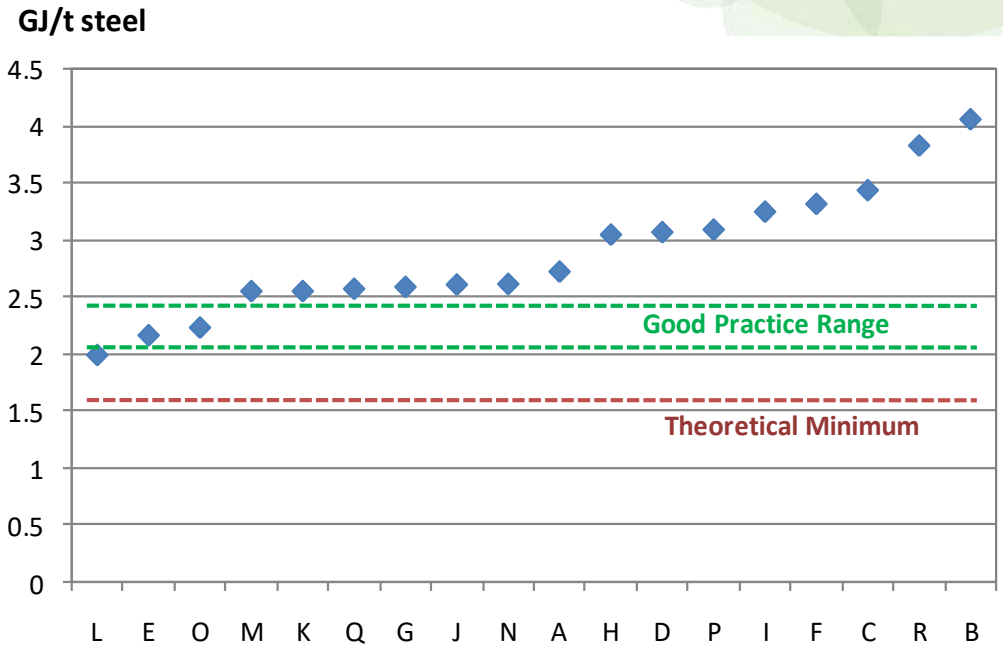
Greenhouse gas emissions generated in industry and construction in 2016 amounted to 440.8 Gg $CO_{2eq.}$ and made 7% of the Energy Sector emissions.

Energy data collection at company level

- Overview of energy input
  - Types of energy sources
  - Monthly and annual consumption: Collect energy bills
  - Analyze performance per month, by production volumes, etc.
- Energy cost
  - Cost of energy/fuel consumption.
  - Connection, base-load and peak demand charges
  - Penalties and other charges
- Overview of energy consumers
- Compile a list of energy consuming equipment
- Identify most relevant consumers.
- Overview of energy output
  - Types of energy flows
  - Energy lost with energy flows
  - Cost of lost energy

Benchmark consumption

Compare to data from IFC, BREF-notes, sector analyses, suppliers



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Energy types, units, unit prefix, etc.

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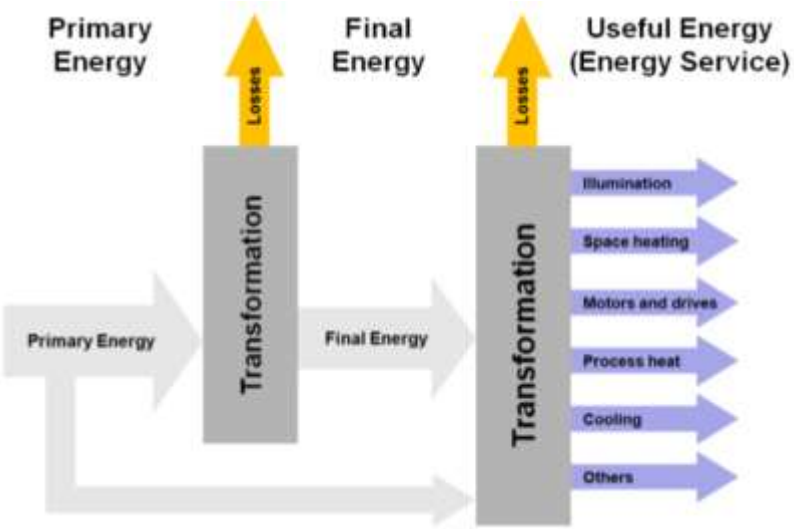

Metric prefixes in everyday use

Text	Symbol	Factor	Power
tera	T	1 000 000 000 000	10^{12}
giga	G	1 000 000 000	10^{9}
mega	M	1 000 000	10^{6}
kilo	k	1 000	10^{3}
hecto	h	100	10^{2}
deca	da	10	10^{1}

Joule (J), kilojoule (kJ), Mega joule (MJ), Tera joule (TJ)
kilowatt-hour (kWh), Megawatt-hour (MWh), Gigawatt-hour (GWh)
calorie (cal), kilocalorie (kcal), Mega calorie (Mcal),Giga calorie (Gcal)
tons of oil equivalent (toe), kilotons of oil equivalent (ktoe)
Barrel of oil (bbl); Horsepower (hp); etc.

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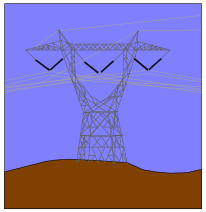
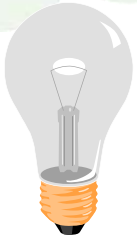
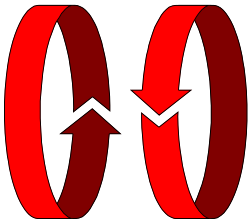
Energy efficiency

Typical areas of improvement

- Cooling/refrigeration
- Heating
- Compressed air
- Insulation
- Heat recovery
- Separation processes
- Lighting
- …

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Energy efficiency

“MEGRATUN” LLC
Honey young wine production

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Energy management

- **Organization** — Set up an organizational unit, identify responsibilities and determine the budget
- **Analysis and Planning** — Inventory and description of the energy situation, search for energy saving options
- **Control** — Control of the energy plants, work out energy indicators
- **Consulting** — Energy reports, internal consulting and market analysis
- **Implementation** — Implementation of energy saving options maintenance

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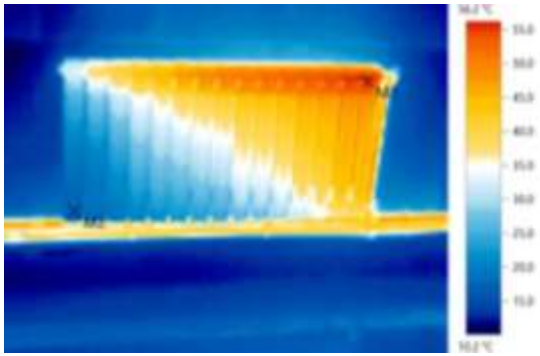
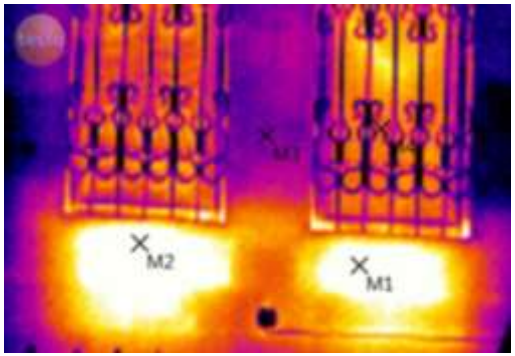
Energy Efficient Retrofits in Production Buildings





Applying thermal insulation to buildings can potentially save about 50% of energy consumption.

"Ashtarak Dzoo" LLC an Egg production facility

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Reducing electricity consumption for lighting

Replacement of external lighting system from metal halogen luminaries to LED ones

Reduction of electricity consumption and annual savings 8,400 kWh Electricity or 378,000 AMD (700 Euro) per year. Investments 2,700 Euro, Simple payback period 3.8 years. CO_2 reduction 3.7 tons, IRR 26 %, NPV 2,963 Euro.

Internal lighting system options

1200 Lumen lamps Comparison			
Incandescent	Metal Halogen	Compact Fluorescent	LED
			
100 W 1,000 hours 150-450 AMD 4.10 AMD /hour	80 W 4,000 hours 1,500-2,500 AMD 3.45 AMD /hour	20 W 8,000 hours 1,500-3,500 AMD 1.07 AMD /hour	12 W 30,000 hours 9,000-11,000 AMD 0.79 AMD /hour

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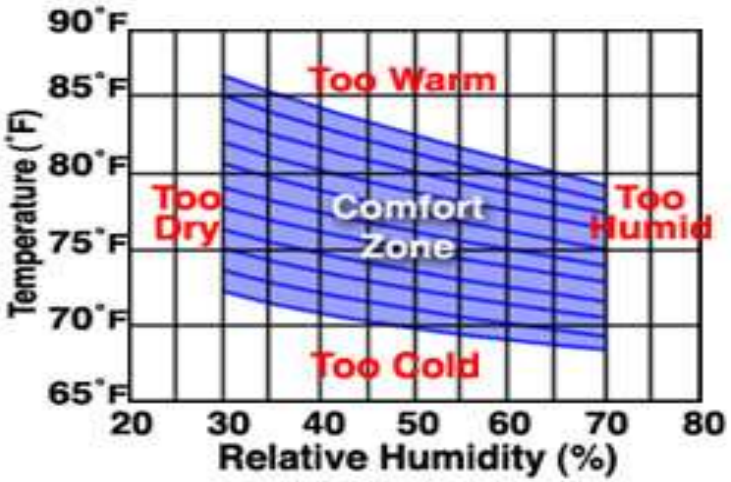
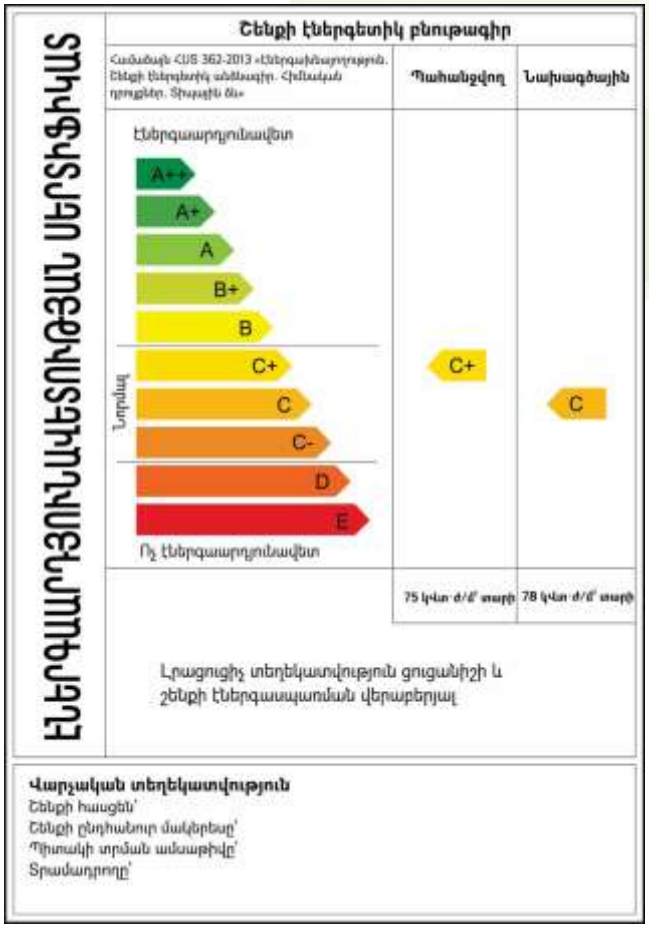
National Standards

Two new National Standards were developed
AST 362-2013 ENERGY CONSERVATION. Building energy passport. Basic rules. Standard form.
AST 371- 2016 Methodology for performing energy audit in residential and public buildings**.**





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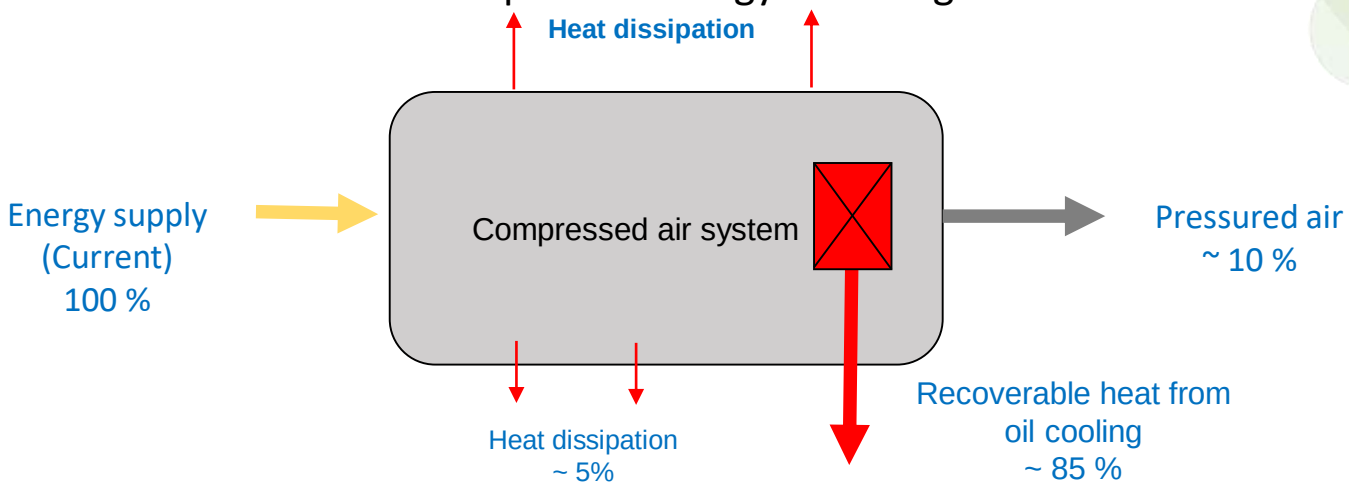
Compressed air

Compressor energy flow diagram



- About 10% from the electric power is converted into compressed air. The rest is given off as heat.
- About 85% of energy in the form of heat can be recovered and re-used from the cooling oil. The remaining 5% are emitted as radiation losses into the environment.

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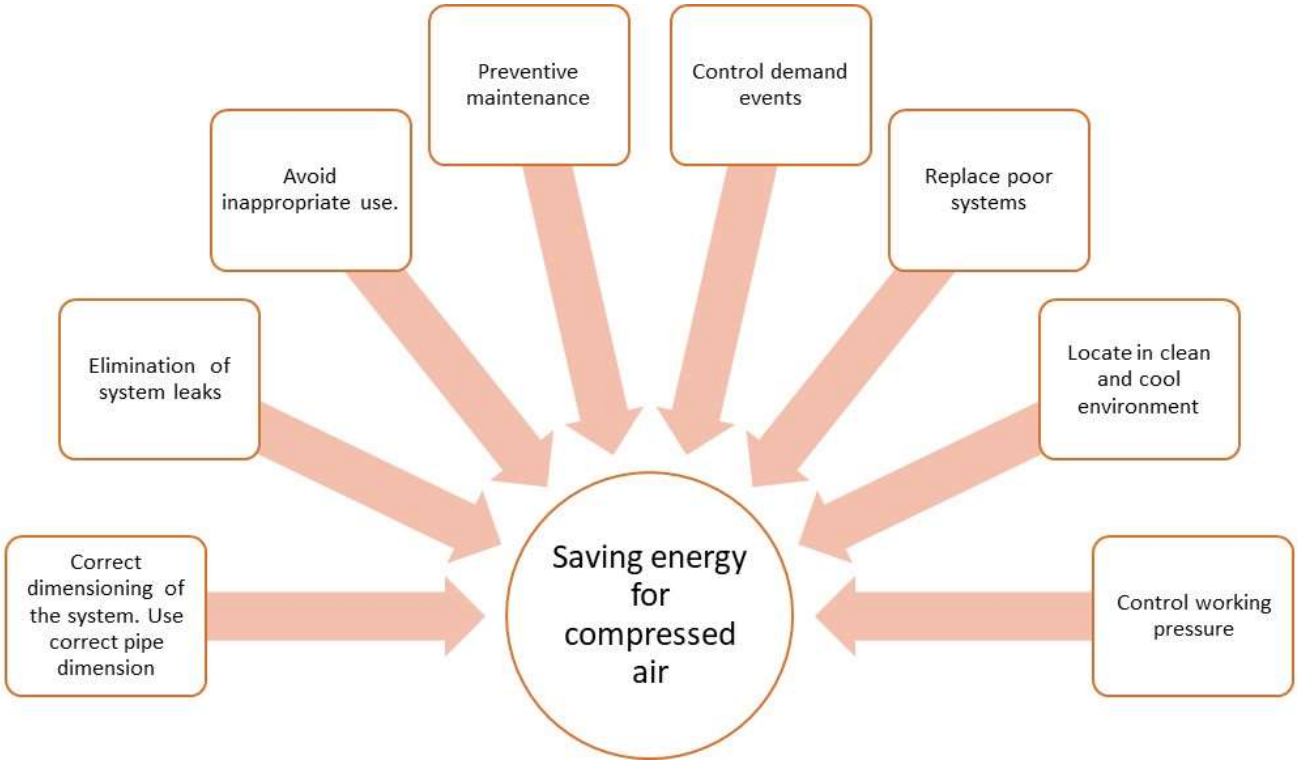
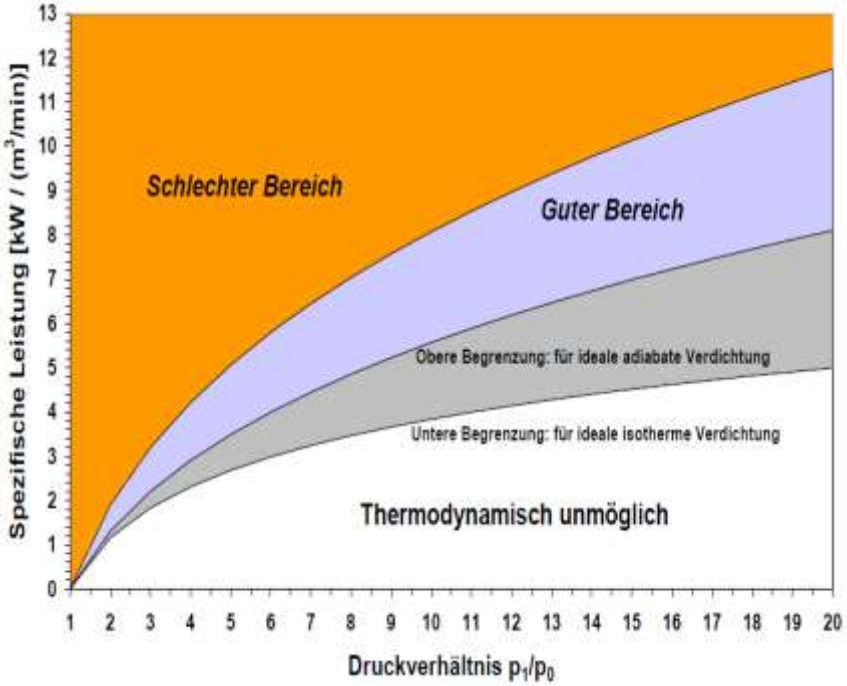
Typical solutions to save energy for compressed air



- Check pressure: keep it as low as possible (6 – 7 bars).
- Check inlet air temperature: keep it as cool as possible
- Check potential of heat recovery: 80% of compressor power can be recovered as heat at 50 °C.
- Check air system for leaks: up to 65% of air can be lost from leakages.

Benchmarks for an air compressor

- 85Wh/sm^3 to 100Wh/sm^3 is good
- 100Wh/sm^3 to 120Wh/sm^3 is acceptable
- more than 120Wh/sm^3 indicates problems



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Typical solutions to save energy for cooling systems

Cold supply