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 Options 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.

P 1.7 – Options generation and feasibility analysis

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

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Table of content

- Overview of options generation
  - Open the scope of possible solutions
  - Utilise preventive techniques first
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  - Exercise
- Overview of feasibility analysis
  - Evaluation process
  - Case studies
  - Examples of eco-innovative technologies
  - Advanced economic analysis
  - Sustainable design
  - Tips

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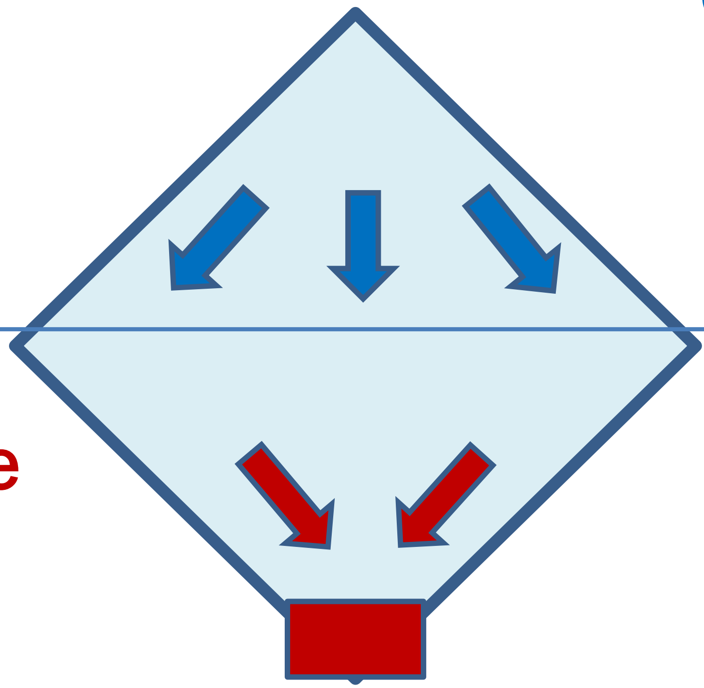
Rationale

Building on knowledge of causes of losses from step 1.6

To broaden the scope of potential solutions

OPTIONS GENERATION



in order to get

An optimised set of feasible measures

FEASIBILITY ANALYSIS

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Overview of Step 1.7
Options generation

Inputs	Activities	Outputs
Inventory of pollution sources and related causes List of preliminary ideas identified in previous steps (including recommendations for improving the information system) External expertise including sector experts or sector-specific guides	Generate improvement options, giving priority to using preventive techniques: • options should not be evaluated at this stage, • only clearly unfeasible options should be dismissed	Long list of improvement options ready for the feasibility analysis

Open the scope of possible options

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Creativity

Options should not be evaluated at this stage, but the scope of potential solutions should be as open as possible

and traditional „idea killers“ should be overcome

Ideas killing your creativity

1. Don't forget, we have to make money, too.
2. You will never be able to sell these ideas to the management.
3. Let's think about the details later.
4. I know that it won't work.
5. We are too big/too small for this.
6. We have tried/thought about this before.
7. This is bound to be too expensive.
8. This is neither the time nor the place for such a discussion.
9. It means work.
10. We have always done it like this – why should we change now?
11. You don't seem to get the problem.
12. Let's discuss this later.

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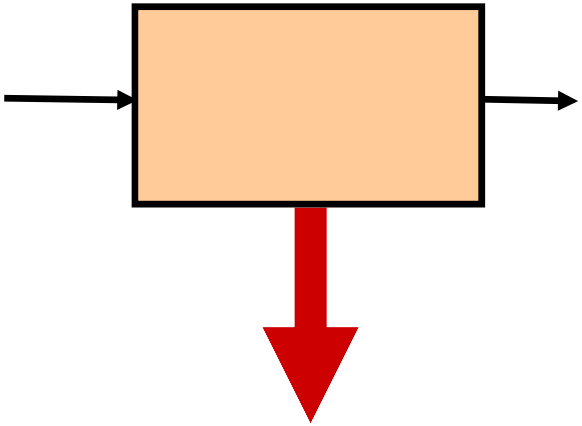
Ideas killing your creativity

13. Our company (our situation) is different.
14. Let somebody else try this first.
15. This does not fit in our long-term plans.
16. Talk to such and such, that's his task.
17. We have already overspent/used up this year's budget.
18. It won't work and it is against our strategy.
19. We have no time to lose for this.
20. It sounds good in theory, but in practice it is another story ...
21. We don't have enough/not the right employees.
22. We are not ready for this idea yet.
23. It is too late to change now ...

For each cause of resource inefficiency & pollution



Causes :

SOURCE 1

- Input material
- Technology

Source/ Priority area	Causes	**RECP options**
1	1.1 1.2	1.1.1 1.1.2 1.1.3 1.2.1 Etc.
n	n.1 n.2 ….	n.1.1 n.1.2. Etc.

generate as many RECP options as possible

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Example of addressing different flows, sources and causes

Priority flow	Source/Priority areas	Causes (category)	Causes (description)	RECP option
PET (Packing materials), Water consumption and raw materials	Filling line 12	Choice of technology and quality of specific equipment	Cold bottles get wet due to high Humidity and warm weather causing them to be rejected at the checkpoint	Installation of a blower to dry 1.5-liter bottle caps before HEUFT testing machine in line 12
Glass bottles & Cans (Packing materials), Water consumption and raw materials	Filling line 8 & 9	Choice of technology and quality of specific equipment	When the flow of bottles/cans on the line is stuck, the conveyor keeps going and good bottles may fall through the waste gate after the checkpoint.	Installation of barrier to prevent loss of good bottles in case of malfunction after checkpoints in lines 8 & 9
Packing materials*	Filling lines 9,12,13,14	Method (way of operating technology) Man (mindset, knowledge, skills and motivation of people)	There is no marker for the electronic eye to identify the end of a label cylinder. Therefore, the operator replaces the carton core cylinder when he feels it approaches the end and throws the cardboard cylinder with the remaining plastic labels to the landfill trash bin	Full utilization of cylinder labels in lines 9,12,13,14. Adding a marker before the end of the carton core cylinder
All raw materials and packaging materials in the plant	Monitoring system - all production/filling/packing lines	Information flows (inc. measurement and communication) Man (mindset, knowledge, skills and motivation of people)	Lack of a plant materials losses monitoring system	Establishment of a raw materials losses monitoring system in the plant.

Example of options generation

Source/priority areas	Causes	Options Generation
Source: All pipes subject to Clean In Place (CIP) **Focus area/Priority flow:** CIP/Water	1. High frequency of product change over; 2. Short time intervals before pipe cleaning (best practice every 96-120 hrs, while company practice every 72 hrs). 3. No utilization of final rinse water. 4. Using conventional CIP process	a) Reduce product change over. b) Increase duration before requesting pipe cleaning. c) Recover final rinse water for first rinse. d) Collect first rinse water for floor washing. e) Use pipe pigging instead of first rinse. f) Introduce gas purging (compressed air, N_2 or CO_2) instead of first rinse. g) ICE-Pigging

Utilise preventive techniques first

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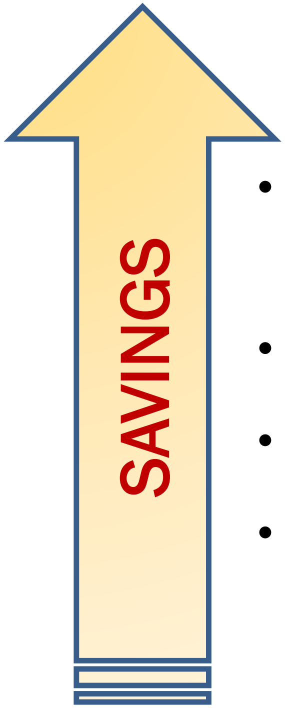
Techniques to address sources of losses (pollution)

A hierarchy of 4 LEVELS:



- LEVEL I - Reduction of production inputs and waste generation at Source
- LEVEL II – Internal recycling and product valorization
- LEVEL III – External recycling and product valorization
- LEVEL IV – End of Pipe

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Preventive techniques

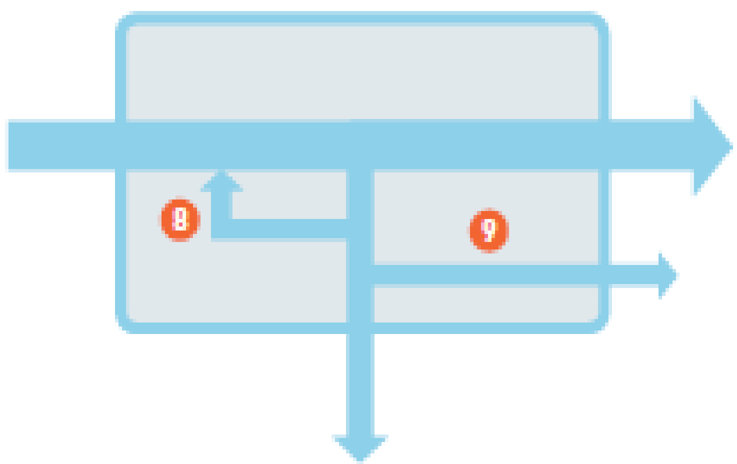
LEVEL I:

Reduction of process consumption levels and waste stream generation at source

1) Good housekeeping
2) Raw and process materials substitutions
3) Better process controls and production planning
4) Technology upgrades
5) Technology/process modifications

Product modification:

6) Product modifications
7) Packaging modifications



LEVEL II:

Internal recycling and by-product valorisation:

8) Internal recycling
9) Valorisation of by-products

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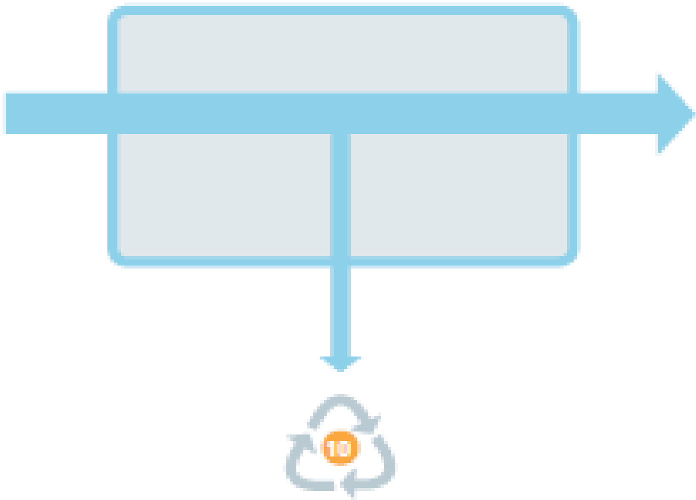
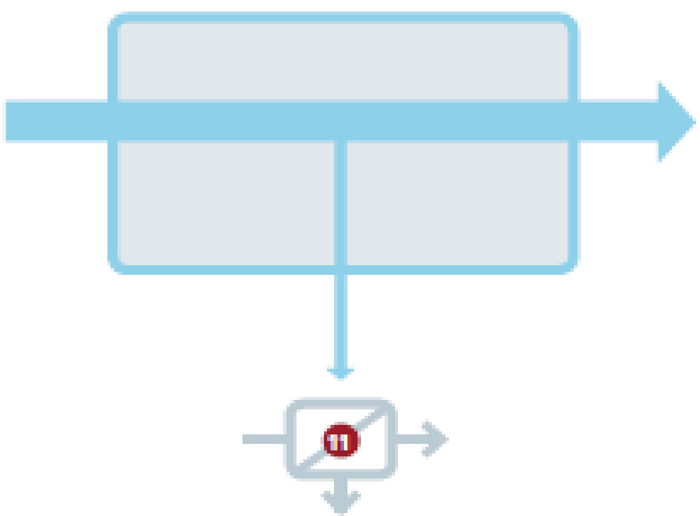
Other techniques



LEVEL III:

External recycling and product valorisation

- *no NPO reduced*
- *no neatural resources saved at the source*



LEVEL IV:

End-of-pipe technology

- *last chance how to meet environmental regulations*
- *economically non productive*
- *shifting pollution among environmental media*

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Best Available Techniques (BATs)

Definition (EU-IPPC Directive): The techniques with highest environmental performance that can be combined with:

- As many positive associated environmental trade-offs as possible (cross-media effects balance)
- No negative effects on product quality
- No major difficulties to apply it (distinguish between new and existing situation)
- Lowest possible costs – reasonably available for an operator

Sources of information - examples

- **Sector specific information like IFC Industry Sector Guidelines**
- **Sector specific EU BREFs –**
  Best Available Techniques Reference Documents
  http://eippcb.jrc.ec.europa.eu/reference/
  - State of the art by sector
  - BATs
  - Emerging technology
- **Best Practice catalogue (MED TEST II)**
- **......Others?**

Checklist for specific preventive techniques

Product and packaging change

- Substitute the product
- Increase the product life-time
- Change the materials
- Change the product design
- Use recycled materials
- Avoid critical components
- Reconsider packaging

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Good housekeeping

- Improve information
- Change dosage/concentration
- Increase the utilization of process capacities
- Check cleaning and maintenance period
- Foster standardization/automation
- Improve purchasing, storage and distribution
- Carry out a material flow analysis

Technological modification

- Substitute thermo-chemical processes by mechanical alternatives
- Use counter current cascades instead of single-static rinse techniques
- Manage separate waste and wastewater streams
- Improve process conditions
- Foster recovery and reuse of materials
- Increase life time of chemicals/materials
- Reduce the infiltration of impurities
- Ensure airtight sealing of equipment

Internal (on-site) recycling

- Reuse materials (solvents, etc.)
- Reuse materials for different purposes (paper, solvents for lower-quality use, e.g. pre-cleaning, etc.)
- Close internal loops (water)
- Use returnable systems (packaging materials)
- Reclaim materials with high value

Waste logistics

Separation of waste and wastewater to:

- Set up closed cycles
- Facilitate recovery and re-utilization
- Minimize quantities of hazardous waste
- Minimize disposal costs
- Minimize cleaning expenses (wastewater, exhaust gases, etc.)

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Exercises

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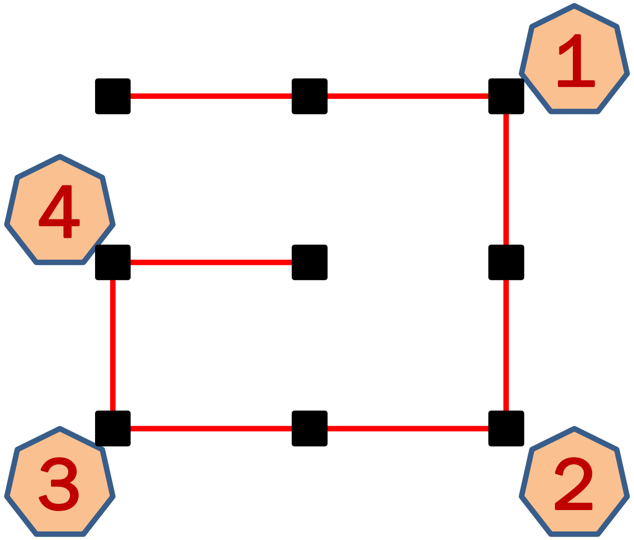
EXERCISE 1: „9 machines “

Link the 9 machines (symbolised by black sqares) with straight lines, which are connected. Your goal is to minimise number of turns as they are cause of inefficiency within this system. Here is an example of linking the machines with 4 turns. Your first target is to reduce the number of turns to 3. Ideal („zero waste“) situation would be to identify solution with zero turns.

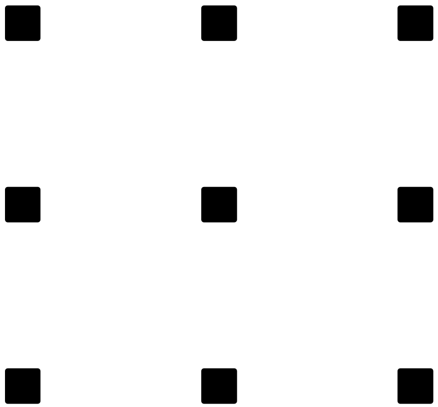


EXERCISE 1: „9 machines“ hand out

Link the 9 machines (symbolised by black squares) with straight lines, which are connected. It is not possible to move the sqares on the paper.

Your goal is to minimise number of turns connecting particular sqares as these turns cause inefficiency within this system.

Your first target is to reduce the number of turns to 3. Ideal („zero waste“) situation would be to identify solution with zero turns.



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Option generation – EXERCISE 2

- Select source of pollution
- List causes of pollution generation
- Generate as many options as possible (utilising preventive techniques)
- Do not criticise options generated – **GOAL OF EXERCISE IS TO GENERATE AS MANY OPTIONS AS POSSIBLE**

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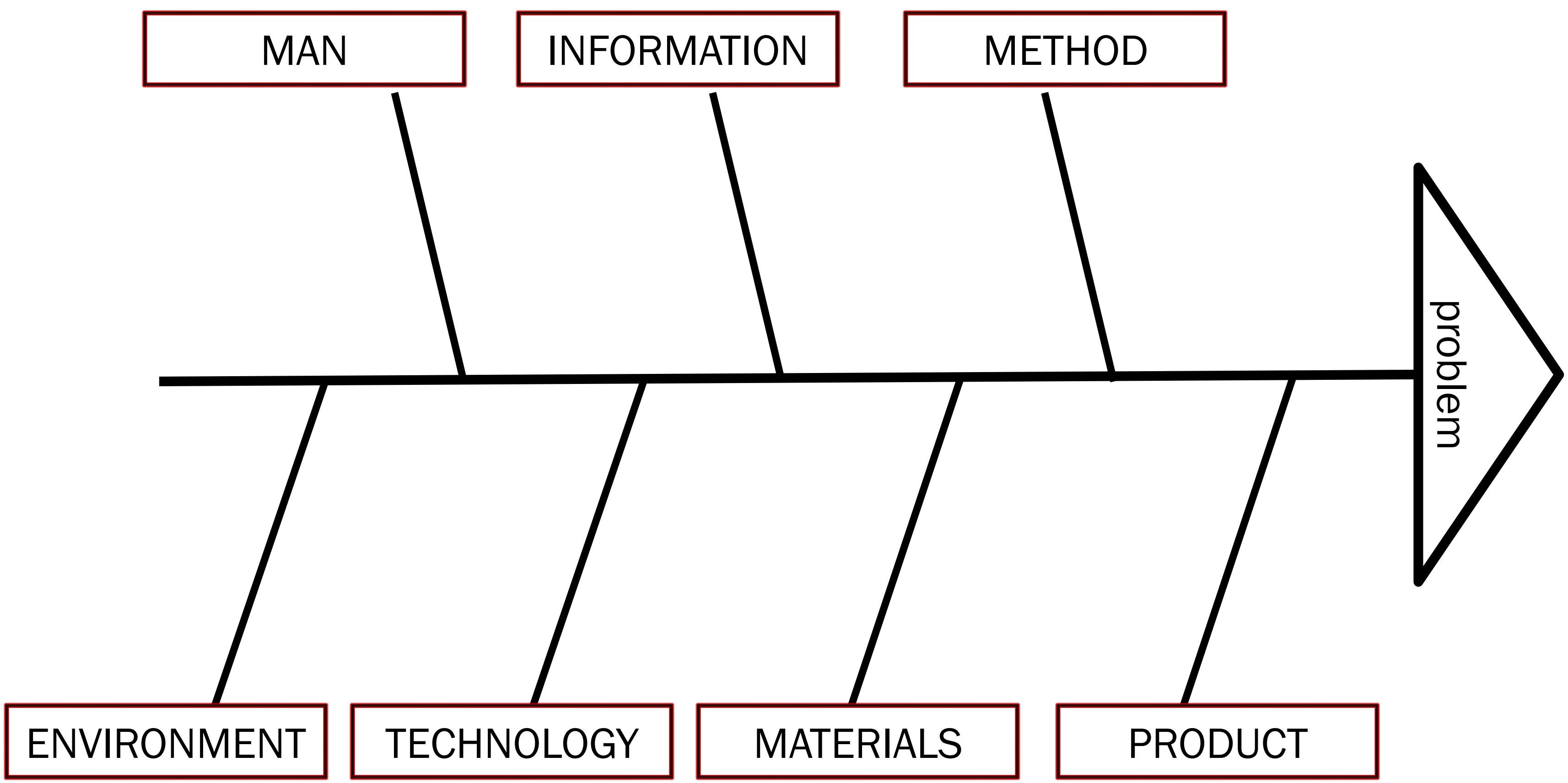
Cause and Effect Analysis in Resource Efficiency



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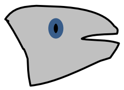
Inspiration for plenary discussion



- What is value added of option generation within a broader team? Did you inspired each other? Did some clearly unrealistic idea brought some new option which could be potentially feasible?

- Did you suceeded to generate options without criticising specific ideas? Why is it difficult to be creative without criticising new ideas?

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Conclusions

- Some ideas for improvement options are usually already available from the previous TEST steps, but it is important to focus on exploring additional options
- The focus during this step should be on the quantity of options: More options lead to better measures
- Brainstorming is an effective and recommended technique for option generation
- Preliminary ideas for improving the information systems could be also recorded here

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Overview of Step 1.7
Feasibility analysis

Inputs

The long list of improvement options

Material and energy flow data for specific process steps

Technology and process operational parameters (baseline)

Technology suppliers' information and technical requirements

Activities

Evaluate each option using technical, environmental and economic criteria

Classify measures based on economic criteria

Prepare summary report/ presentation to inform top management and support its decision-making process

Outputs

Savings catalogue (set of project fiches with pre-feasibility data and key indicators)

Terms of reference for detailed technical and financial appraisal of measures needing high investments

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Evaluation process

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Multicriterial feasibility analysis

Each functional unit in a company has different priorities:

1. **Production manager:** increase productivity, product quality, minimize maintenance requirements
2. **Environmental manager:** compliance with legislation, minimize pollution generation
3. **Financial manager:** minimize NPV of investment

Start with Technical evaluation

- ✓ Possible changes in product quality
- ✓ Technical requirements for energy and material inputs and labour workforce
- ✓ Impact on productivity, production bottlenecks and capacity
- ✓ Need for additional resources (compressed air, water, etc.)
- ✓ Additional need for maintenance, spare parts, control

Objective: *exclude options that might have an adverse impact on product quality, productivity or which would be technically not acceptable*

Continue with Environmental criteria

- ✓ Reduction of waste streams, pollution, emissions
- ✓ Internal and external environmental management procedures
- ✓ Legal environmental requirements
- ✓ Impact on health and safety of employ
- ✓ Potential need for additional permits
- ✓ Additional need for operator training

***<u>Objective:</u>** exclude options that might cause cross-media environmental side effects that could potentially offset the expected benefits*

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Financial evaluation

- Simple cost-benefit analysis: economic savings, preliminary estimates of capital and operating costs, Pay-Back-Period (PBP).

- Advanced financial evaluation: ROI, NP

TOOL: Financial metrics

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Source of data for feasibility analysis

- Data from previous steps (MFCA, I-O analysis, balances)
- Technology suppliers and technical specifications sheets
- Production, process and utilities parameters
- Water, energy, raw materials and labour costs
- CO_2 emission factors for energy sources
- Pollution intensity benchmarks (e.g. 1 l of milk in wastewater generates 90-120 g of BOD - source EU BREFs)
- Expert knowledge

Classification of measures

Three types of measures:

1. **Good housekeeping measures**, requiring no/low cost
2. **Low-medium cost measures** can be implemented using a company's technical and economic resources
3. **High investment needing solutions** complex technical and financial appraisal, possible external financing

Consider changing parameters

Step 1

- Results of TEST is a set of feasible measures which can be interrelated:
  - The implementation of specific measures may change the process parameters and therefore the baselines for calculating the feasibility of other measures
  - Particularly, technical specifications of investment needing measures changes after implementation of no and low cost measures

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Case studies

1. changing parameters of individual measures
2. resource efficiency measures modify parameters of WWTP

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Case study 1: Starting points

Dairy company (milk products)

Two priority flows: water and raw material

Water priority flow, two major sources:

- Cleaning in place
- Direct cooling (after homogenization stage) = 22% of total water use (120,000 m^3/y just for cooling)

Focus – Eliminate direct cooling to reduce costs and volumetric load to the WWTP

Case study 1: Measures

- Two measures:
  1. Closing the loop with the chilled water circuit, new investments required for additional chiller capacity
  2. Partial milk homogenization (reducing the cooling demand of the process)

How does the feasibility of option 1 change when partial milk homogenization is implemented first?

Case study 1: Changing parameters

Process needs (homogenizer)	Elimination of direct cooling (closing the cooling water loop at homogenizer with chilled water circuit)	
	Without partial milk homogenization	
Water for direct cooling:		
Volume (m3/y)	120,299	
Cost (USD/y)	100,569	
Cooling demand (chilled water):		
kWh/y	1,117,440	
cost (USD/y)	24,583	
Payback period (PBP)	**> 5 y**	

Process water (η=90%)	0.836	USD/m³
Chilled water 3°C (R717, COP = 3,2)	0.022	USD/kWh
Cooling tower water	0.002	USD/kWh

Case study 2: Overview

Company	Production of tiny fancy articles made of metal and plastics (pins, zips, clipping and rivet buttons), 300 employees
Products	Tiny fancy articles made of metal and plastics (pins, zips, clipping and rivet buttons)
Key Processes	Nickel plating (about 80% of all production is galvanised)
Stakeholder concern	Local authorities request WWTP
Objective of RECP assessment	• To reduce water consumption • To reduce use of chemicals • To verify correctness of parameters of WWTP which was already designed (however too expensive for company to afford it)

Case study 2: Workflow

Phase I

Good Housekeeping

- OUTPUTS
- Reduced water consumption
- Reduced use of galvanising chemicals
- Reduced nickel consumption
- Reduced electricity consumption

- **Additional effects:**
- reduced health and safety risks
- lower number of rejects (for some articles up to 50% lower)

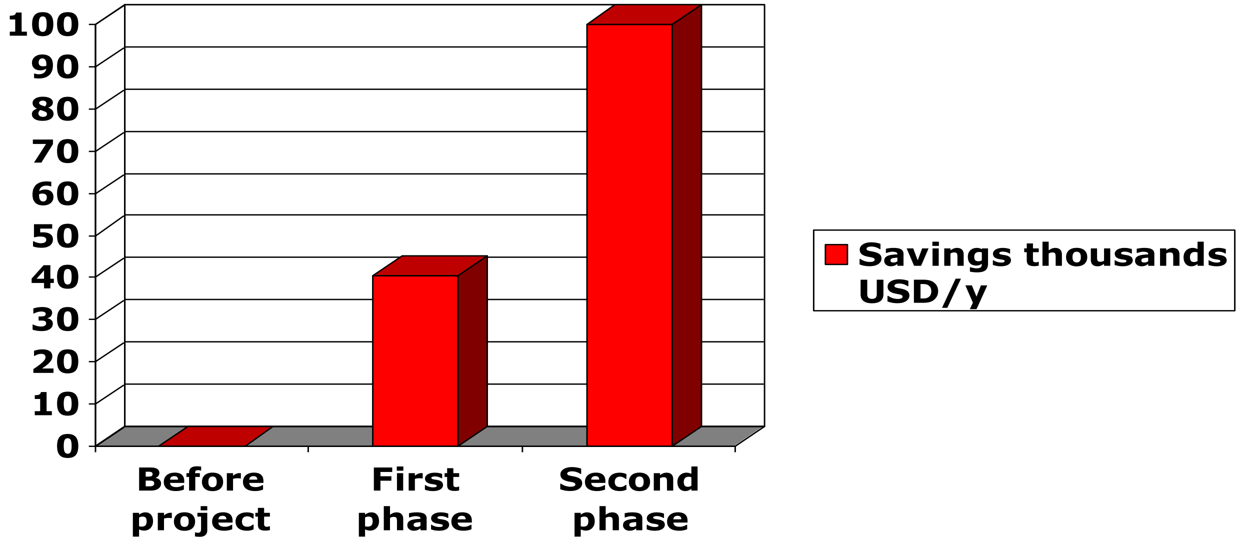
Phase II

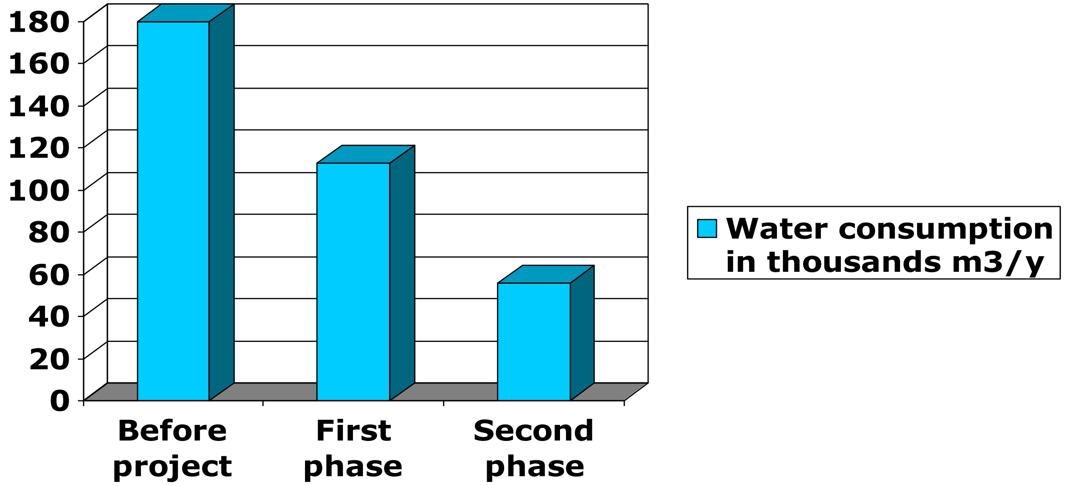
Investments

- Reconstruction of water and sewerage system (to prevent losses of clean water and improve logistics in collection of waste water) - total investment of USD 9,000

- Installation of nickel recovery unit used for waste water from surface finishing plant (on-site recycling of nickel) - total investment of USD 36,000

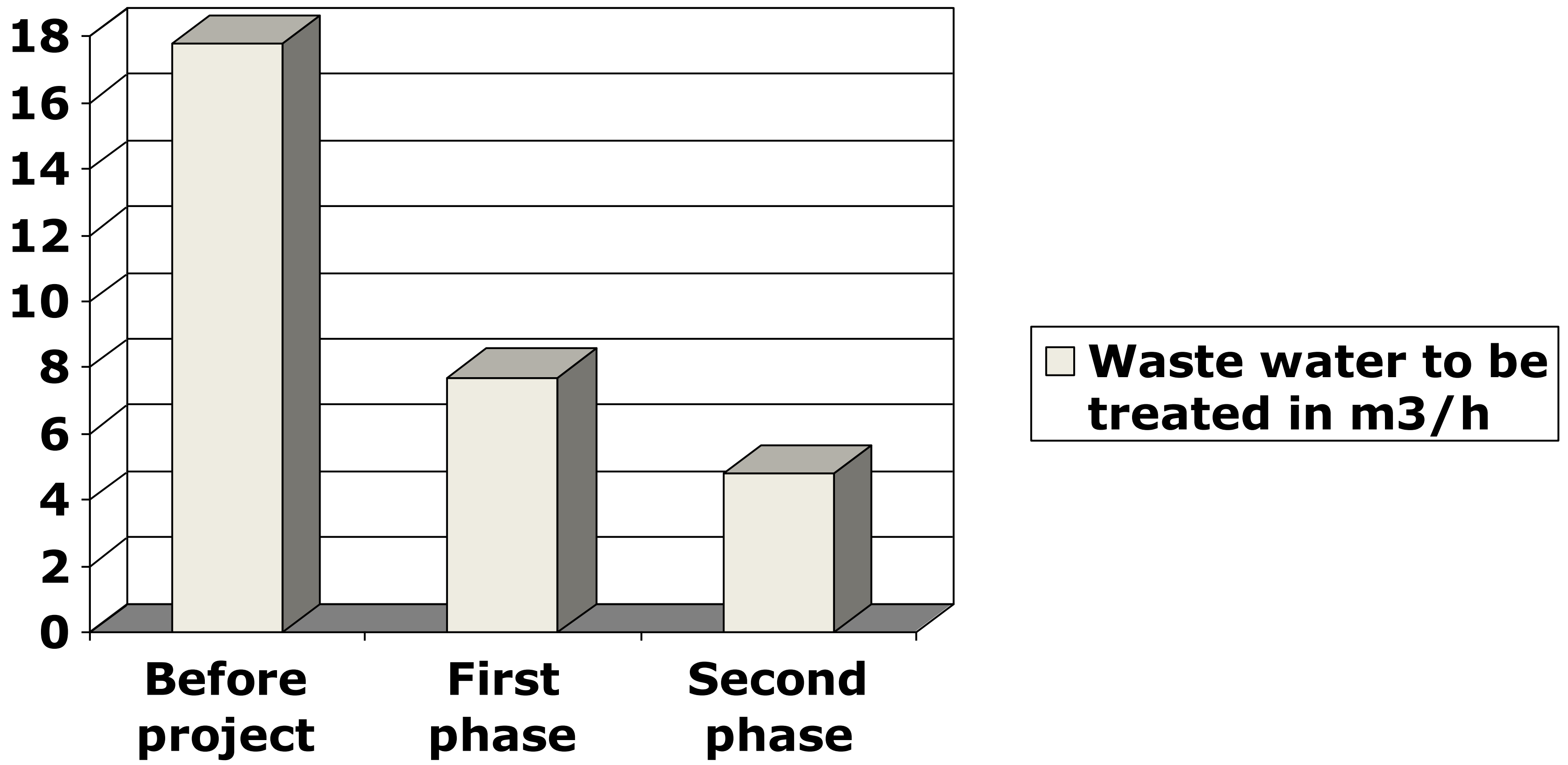
Case study 2: Savings



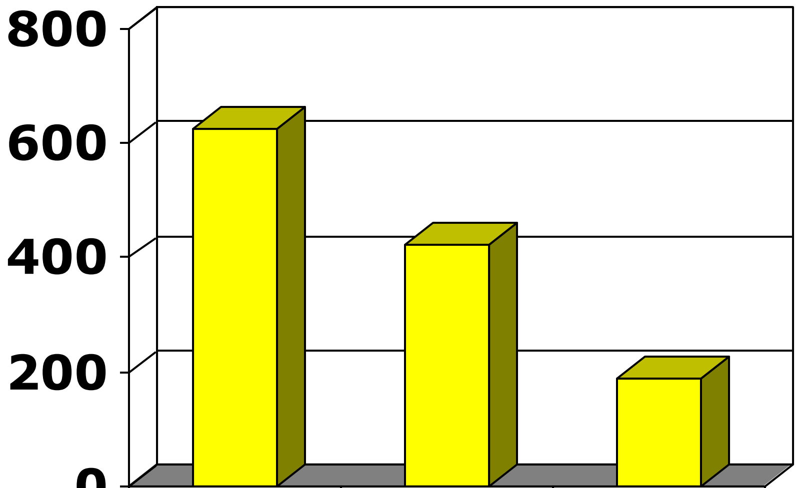


Case study 2:

Impact volumetric flow to WWTP



Case study 2:
Impact on costs of WWTP



	Before project	First phase	Secon d
Costs of WWTP th. USD	624	424	188

In addition the company is annualy saving

USD 40,000 on operational costs of WWTP

OUTPUT of feasibility analysis is Savings catalogue

The savings catalogue is for top management decision-making proces. It includes for specific feasible measures :

- technical description
- environmental benefits
- economic savings and payback period (PBP)

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Savings catalogue (for case study 1)

	MEASURE	Cost savings [EUR/y]	Investment [EUR]	Payback [y]	Reduced CO_2 emissions [t/y]	Reduced water consumption [m3/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	-	0	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	-	0	39	-	–	–	–
10	Elimination of direct cooling (after implementation of option 5 above)	22,871	57,600	2.5	65	42,105	–	–	–

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Technology transfer of Environmentally Sound Technology

- State of the art and/or eco-innovative
- More resource efficient Equipment, Process lines, new production methods
- Medium- High investments (not always!)
- Complex evaluation: **SECTOR expertise required**
- Not only Environmental consideration:
  - Productivity gains
  - Product quality improvements

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Examples of technology transfer

Sector	Title of the technology	Investment (EUR)	Savings (EUR)	PBP
Food industry / Confectionery	New wafer machine	750,000	250,000	3
Food / Fish processing	New technology for defrosting fish (aerosol)	6,500	25,000	0.3
Food Industry / Fruits and vegetables	Ice Pigging	275,000	268,906	1
Food industry / Salts	Evaporator upgrade and production increase	7,500,000	1,508,750	5
Textile / Manufacture of other textile	Upgrading of CAD cutting software	25,000	29,600	0.85
Food industry / Edible oils	Dry condensing system	1,000,000	662,625	1.51
Food industry / Coffee	Spent coffee grounds as biomass fuel	300,000	170,370	1.8

- Installation of machines with ozone generator

Without Ozone =

- 80.lit water / pc
- Dyes / lacquers ...
- Dryer 45 min

Production 2016: **302205** pcs per year
Water in m3 per year: **24176,4**

With Ozone =

- 1. lit water / pc
- No chemicals
- Dryer 15 min

Production 2016 : **302205** pcs per year
Saving of Water in m3 per year:
23874,2

99% of reduction

Eco-Green

- Installation of machines with a Jet system

Reduces water use: 1/3 ratio

Installation of machine (E-flow):

This technology gets the air from the atmosphere and transforms it into nanobubbles mixed with treatment products (resins, softener...)

consume minimum proportions of water and functional elements,

Without E-flow =

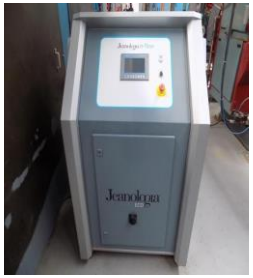
- **1l of water/pc**
- **0.1l resins/pc**

Production 2016 : **2653** pcs per year
Water in m3 per year: **2,7**
Resine in L: **265,3** per year

With E-flow =

- **0.1l of water/pc**
- **0.02l resins/pc**

Production 2016 : **2653** pcs per year Saving of Water in m3 : **0,27** per year (**90% of reduction**)
Saving of Resine in L: **53** per year (**80% of reduction**)



Advanced economic analysis for investment needing solutions

Step 1

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TEST Training kit

Investment needing solutions

- The TEST approach can assist companies in optimizing basic technological parameters
- For evaluation of specific high investment needing solutions utilise established company procedures
- Payback period utilised for economic evaluation of low investment measures is not sufficient here, consider indicators reflecting changing price of money such as return on investment (ROI) or internal rate of return (IRR).

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Simple Pay Back Period

SPB = Cost in $ / Savings in $ p.a.

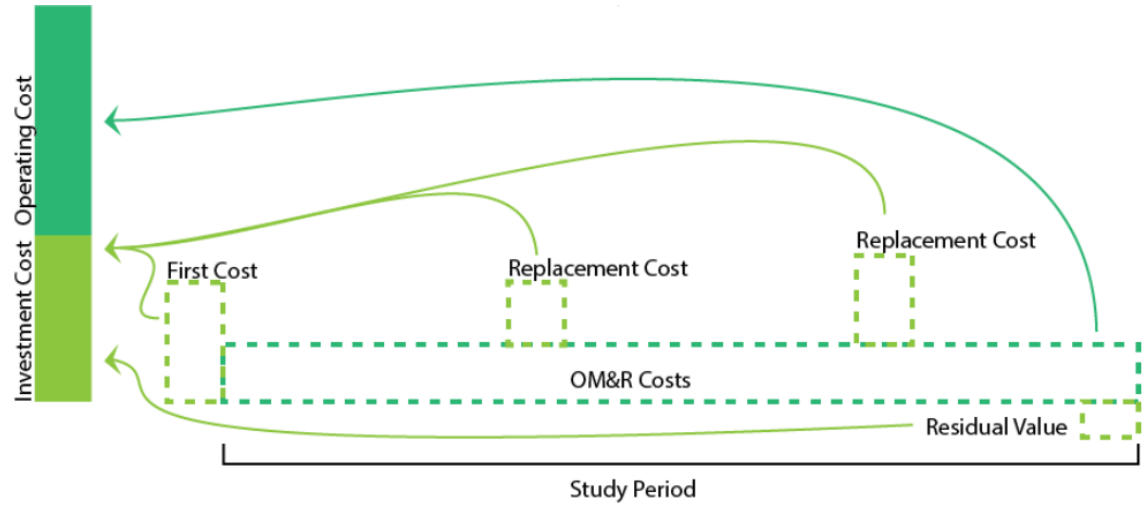
Usually organisations have a limit e.g. only opportunities with a payback of less than 2 years will be considered

- Advantages
  - Simple
  - Quick
  - Good rule of thumb
  - Useful as a quick estimate
  - Useful for low cost opportunities

- **Disadvantages**
  - Too simple
  - What is the effect of the life of the item?
  - Should not be used for major decisions, either high cost or organisationally critical

Life Cycle Cost Analysis (LCCA)

- Total cost of ownership of a product over its life cycle, including: installation, operation, maintenance, decommissioning/disposal.
- It enables comparison of alternative project's solutions based on the present value of the future investment using a discount rate % that is specific to the investor's requirements.
- It consider residual value at the end of the life cycle (resale value, salvage value)



Life Cycle Cost Analysis

The MFCA tool can be used as a supporting tool to identify all the relevant environmental costs. Some "cheap investments" can turn out to be very expensive at the end of the technology life cycle when all operational costs are considered, compared with more resource efficient equipment!

$$LCC = IC + \sum_{t=1}^{N} OC_t / (1+r)^t$$

where:

LCC = life-cycle cost ($),
IC = total installed cost ($),
$\sum$ = sum over the lifetime, from year 1 to year N,
where N = lifetime of equipment (years),
OC = operating cost ($),
r = discount rate, and
t = year for which operating cost is being determined.

Procurement of goods: EXAMPLE

- Two options for equipment (Chiller)
  - One cost 50,000 USD and total running costs 8,000 USD/yr
  - Another one cost 75,000 USD and total running costs 4,000 USD/yr

Which one do I buy?

Procurement of goods: EXAMPLE

G	H	I	J	K	L
	Option 1	Option 2			
Cost	- 50,000.00	- 75,000.00		Discount Rate	10%
Year 1	- 8,000.00	- 4,000.00		Savings Inflation	3%
Year 2	- 8,240.00	- 4,120.00			
Year 3	- 8,487.20	- 4,243.60			
Year 4	- 8,741.82	- 4,370.91			
Year 5	- 9,004.07	- 4,502.04			
Year 6	- 9,274.19	- 4,637.10			
Year 7	- 9,552.42	- 4,776.21			
Year 8	- 9,838.99	- 4,919.50			
Year 9	- 10,134.16	- 5,067.08			
Year 10	- 10,438.19	- 5,219.09			
LCC	-€95,518.14	-€93,213.61			

Sustainable design

Can be employed for analysing large investments in new production lines and green-field projects.

This technique is:

- carried out in parallel to the traditional engineering design process
- systemically applies resource efficiency to virtual material and energy flows (through calculated baselines)
- 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
- the engineering company then revises the design of the new investment accordingly
- 2% investment cost

Implementing resource efficiency at the design stage is more cost effective than retrofitting or modifying existing processes after the initial investment has been made.

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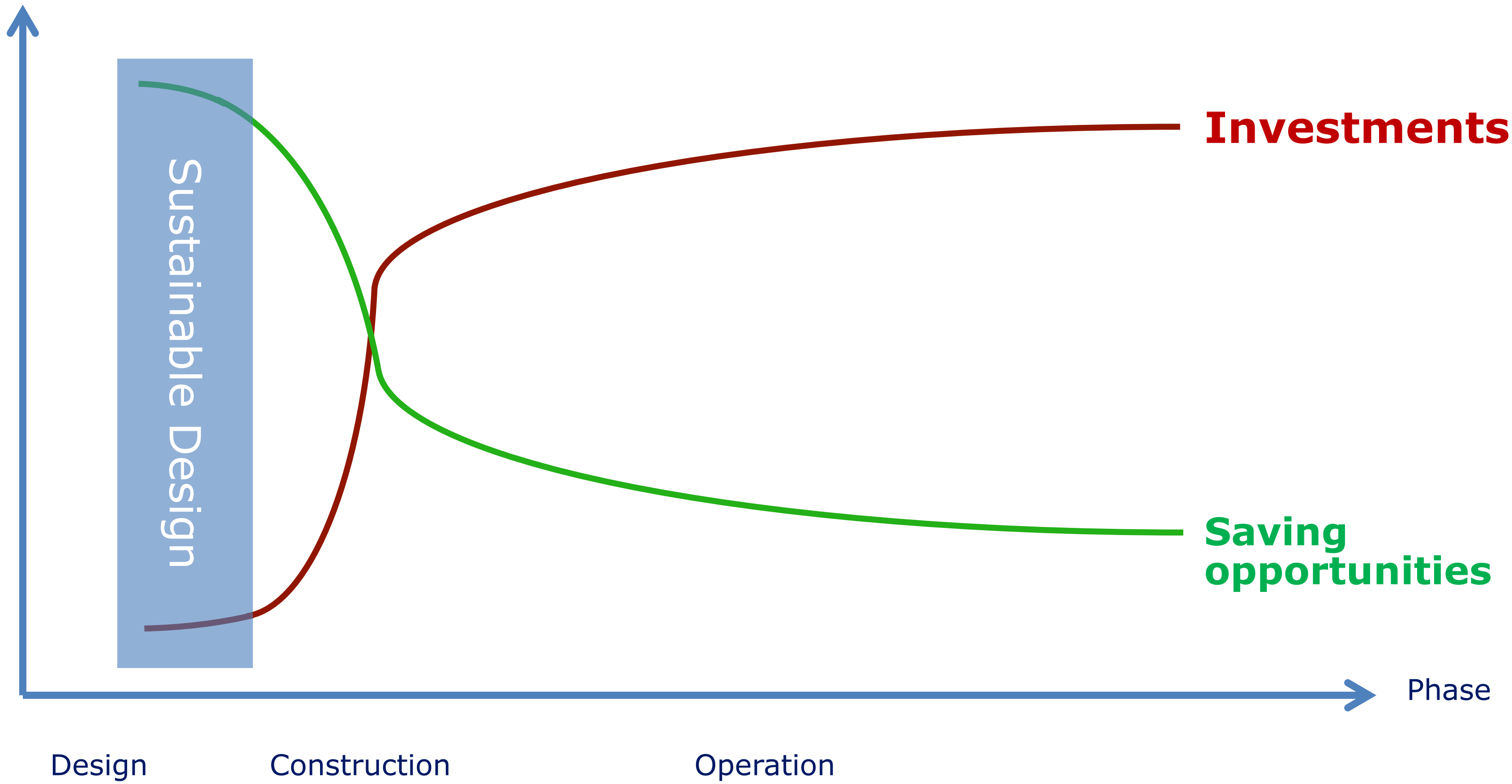
A Lifetime of Opportunities



[Sustainable Design for new equipment _ Checklist]

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TEST Training kit

Example: new cold storage room

Scope: revision of the design of new cold storage room (sustainable design)

Output:

- Layout modification for more effective positioning of the evaporators to facilitate homogeneous circulation of cold air (5% savings on annual energy bill)
- Revised procurement specifications for energy efficient equipment

Savings USD/yr	Investment USD	PBP	Energy savings
7,000	14,000	2 years	100 Mwh/yr

Management system integration

EMS Not in place

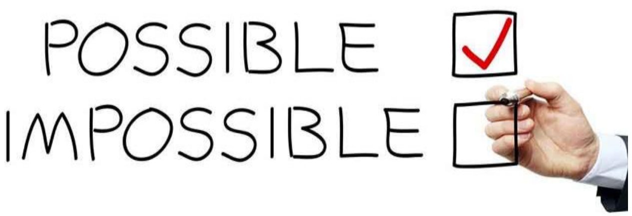
- Integrating preventive techniques into the company's operational decision-making processes can lead to better performance.
- The output of this TEST step provides a sound basis for developing a company's Environmental/Energy Management action plans.

EMS In place

- 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.
- Existing EMS/EnMS action plans can be reviewed and updated to include newly identified feasible measures.

Highlights

- 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.
- MFCA data can be used during the economic feasibility assessment.
- The savings catalogue of feasible measures should also include measures for improving the information systems on material and energy flows in the company.
- 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.



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Thank YOU for your Attention