Treatment of industrial wastewater

Prof. Dr. D. A. Aznar Jiménez
Dpto. C. e I. de Materiales e I. Química
UNIVERSIDAD CARLOS III DE MADRID

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WATER IN THE INDUSTRY: USES

- Energy production: vaporization
- Heat transport
- Raw materials transport
- Waste transport
- Mechanical action
- Product manufacturing
- Transport of ions
- Cleaning or washing-up of pieces
- Extinction of incandescent products
- Gas washing
- Bath preparation
- Air conditioning
- Pressure maintenance
- ...

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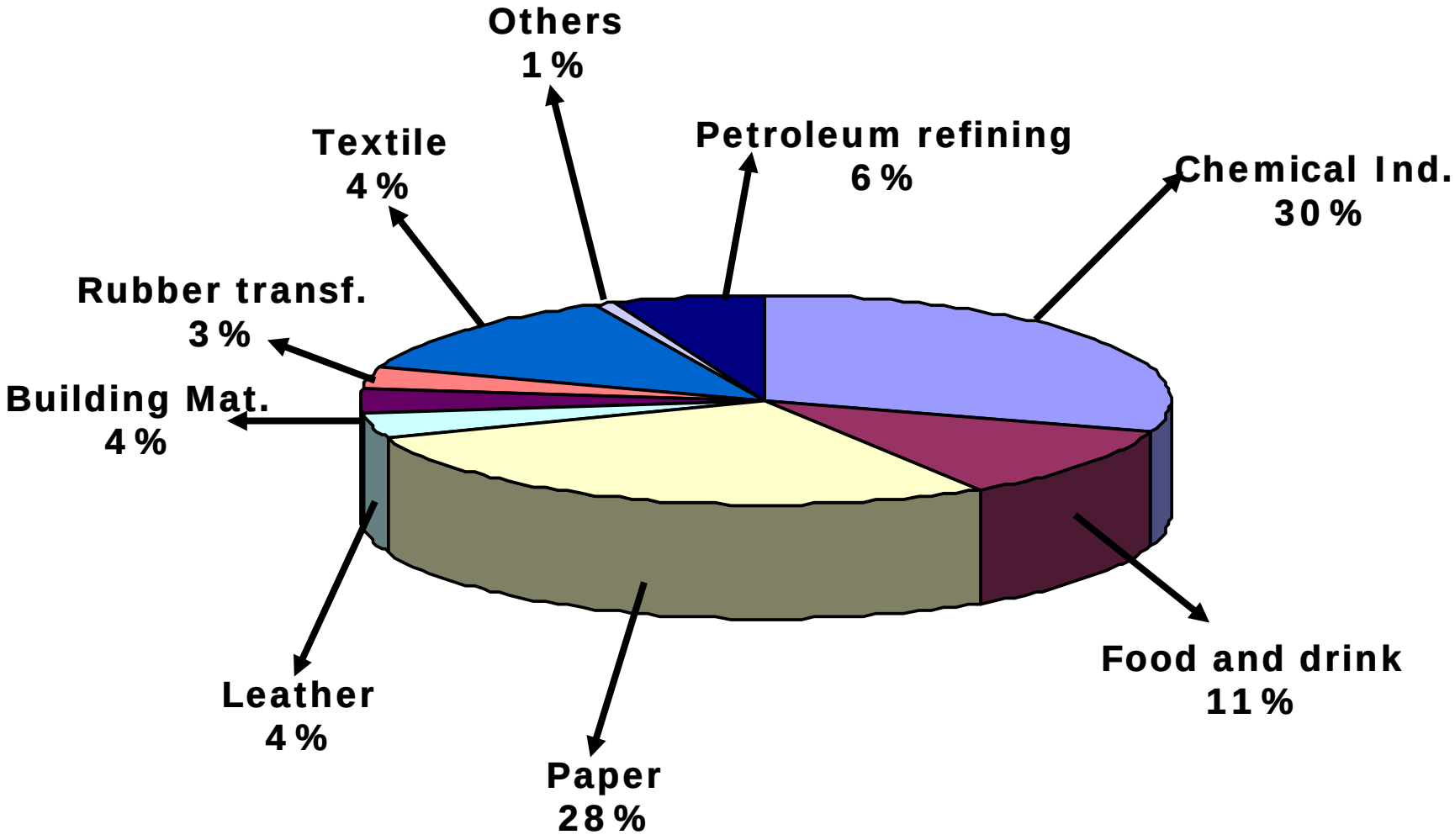
WATER CONSUMPTION IN FACTORIES




Water
input
PROCESS
Effluent (95%)
Product (5%)

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INDUSTRIAL PROCESSES

- Chemical reactors
- Heat exchangers
- Drying/ Evaporation
- Crystallization
- Distillation
- Absorption
- Extraction
- Adsorption
- Other operations

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Chemical reactors

- Core of the production proces
- Main source of waste
  - Partial conversion and lateral reactions
- Performance improvements
  - Mixing
    - Use of baffles
    - Higher speed stirring
    - Modification of blades
  - Distribution improvements (in beds)
  - Improvement of the process control
- Washing processes

Heat exchange

- Direct contact (Cooling towers)
- Indirect contact (exchangers)
- Waste generation
  - Crud formation. Reduces efficiency
    - Addition of chemical products
    - Cleaning improvements
  - Formation of sediments and sludge
    - Reduction of vapor temperature or hot fluid
  - Leaks

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Evaporation / Drying

- Use of energy to remove water from a material.
- Operations with an intensive consumption of energy.
  - Use of mechanical means (filtration) previous to thermal drying
- Evaporated gases must be condensed and reprocessed or be treated as a waste.
- Inappropriate operation will cause the detachment of solids and their transfer as waste in the gaseous flow

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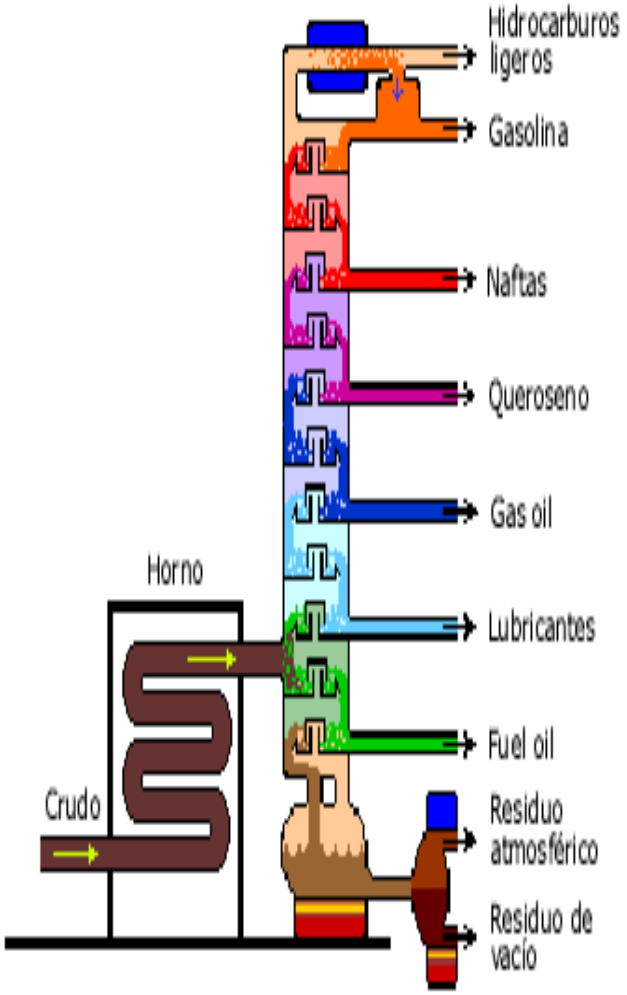
CRYSTALLIZATION

- Generation of upstream water oversaturated with crystalline material
- Adhesion of material to reactor walls

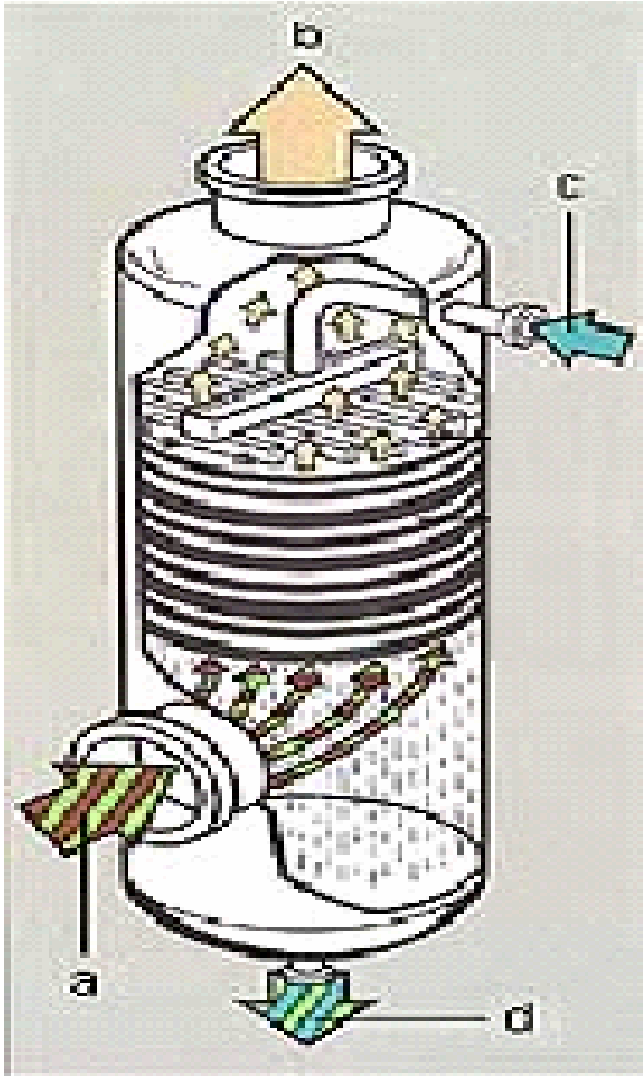
DISTILLATION

- Energy intensive process. Need of energetically efficient systems. Can be improved by:
  - Increase the reflux ratio
  - Increase column height
  - Improve feeding distribution
  - Changes in filler type
  - Isolating or preheating influent
  - Reducing pressure loss in column
- Used for material recovery
- Possible formation of subproducts in the column
- Emissions of volatiles (purge, tanks,...)
- Tails are sometimes useless materials



Absorption / Stripping

- If transfer is not efficient a high consumption of water and energy is produced



Adsorption

- Can be used to separate and concentrate a product, and therefore a later step is necessary
- The absorber must be replaced or regenerated, thus generating another waste

Extraction

- Used in the removal of oil and grease from waste (soil, water or sludge)
- Removal of phenol in effluents from petroleum industry (with methyl isobutyl ketone)
- Recovery of acetic acid from industrial wastewater (with ethyl acetate)
- Extraction with supercritical fluids
  - Pharmaceutical industry
  - Waste treatment

OTHER OPERATIONS

	SOLID-FLUID	SOLID-SOLID	FLUID-FLUID
MECHANICAL SEPARATION	Sedimentation Flotation Filtration Centrifugation Powder collection	Manual screening Magnetic separation	Decantation Flotation
MOLECULAR SEPARATION	Drying Adsorption Ion exchange Crystalization	Extraction with solvents (lixiviation)	Evaporation Distillation Adsorption / desorption Extraction with solvents Membranes

Each one is a potential source of waste

AUXILIARY EQUIPMENT

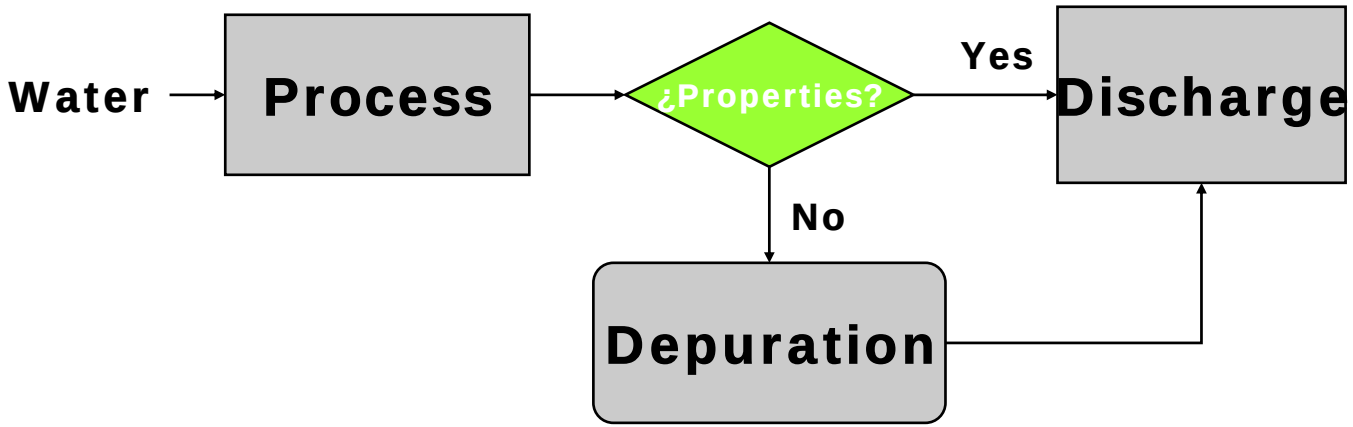
- Other equipment must also be considered:
  - Fluid transport (pipes, joints, chimney)
  - Pumps, aerators, compressors
  - Storing equipment
- Main problems:
  - Leaks
  - Spills
- Fugitive emissions

Analyzing the discharge problem

- **Palliative solutions:**

  CONTAMINATE-DECONTAMINATE

  - ✓ **Destroy: incineration, biodegradation, ...**
  - ✓ **Concentrate: sludge, precipitates, solutions, ...**
  - ✓ **Dilute: emissaries, ponds, ...**



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Preventive solutions:

DECONTAMINATE ≡ NOT-CONTAMINATE

- ✓Do not produce effluents or minimize their production.
- ✓Reuse the effluent, decreasing the consumption of raw materials, energy and facilities.
- ✓Substitute raw material, producing less effluents.
- ✓Segregate some effluents for separate treatment attending to their special characteristics.

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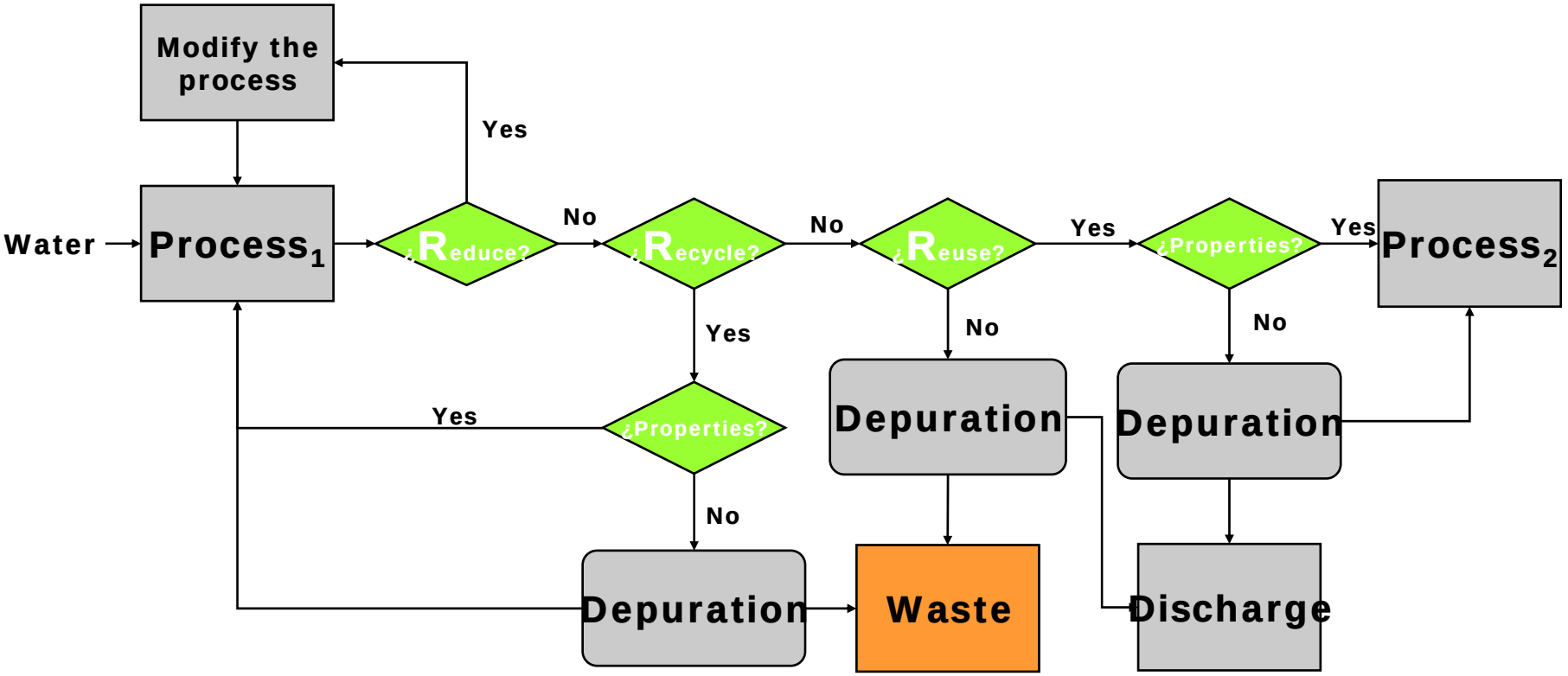
ALTERNATIVE CONCEPTION (R3)



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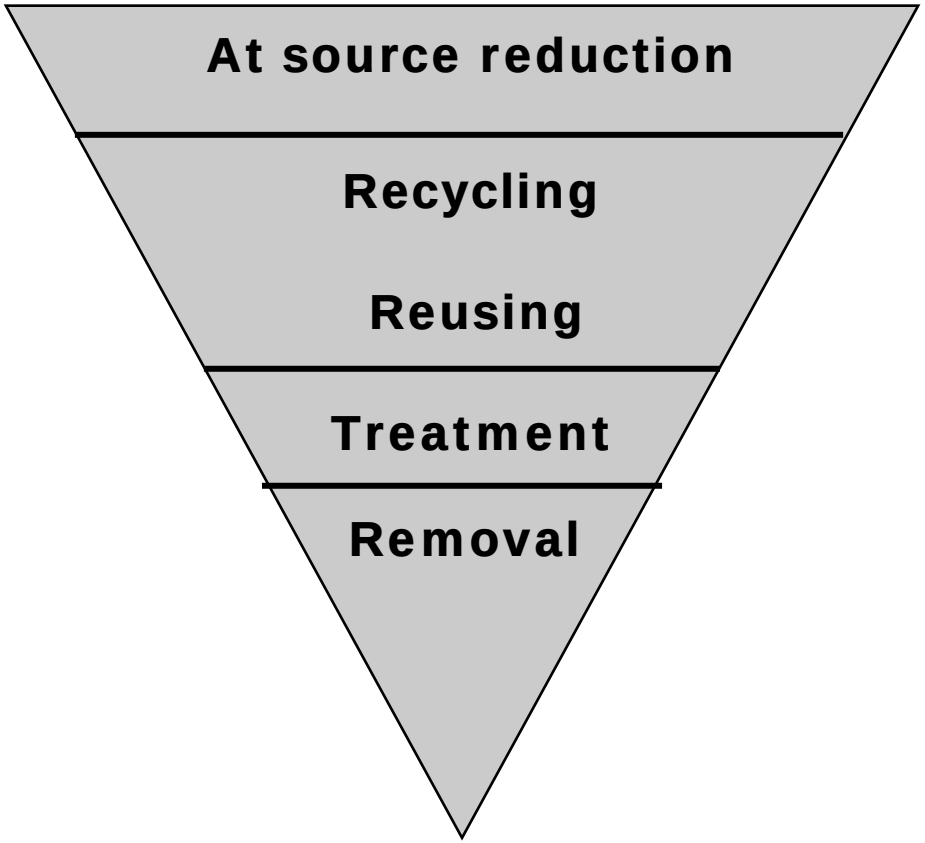
OBJECTIVE OF MINIMIZATION

Zero discharge

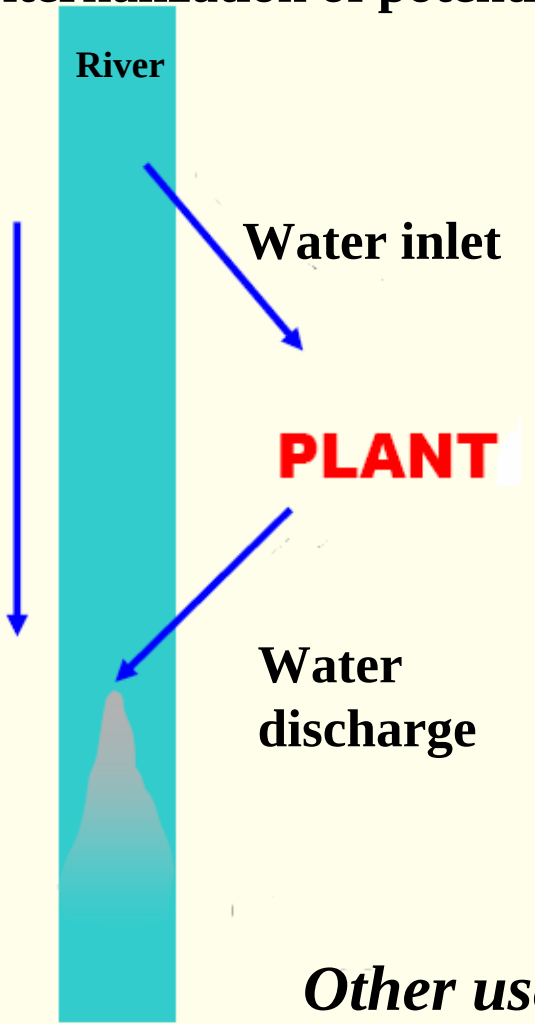
- Most of the processes generating waste are removed through changes in the processes.
- As much as possible of the waste produced is reused, recycled or valorized.
- The final waste is removed.
- As not all waste production can be prevented, the objective is that the removed volume is small enough so that elimination can be performed in a safe way.

PREVENTION OF POLLUTION HIERARCHY

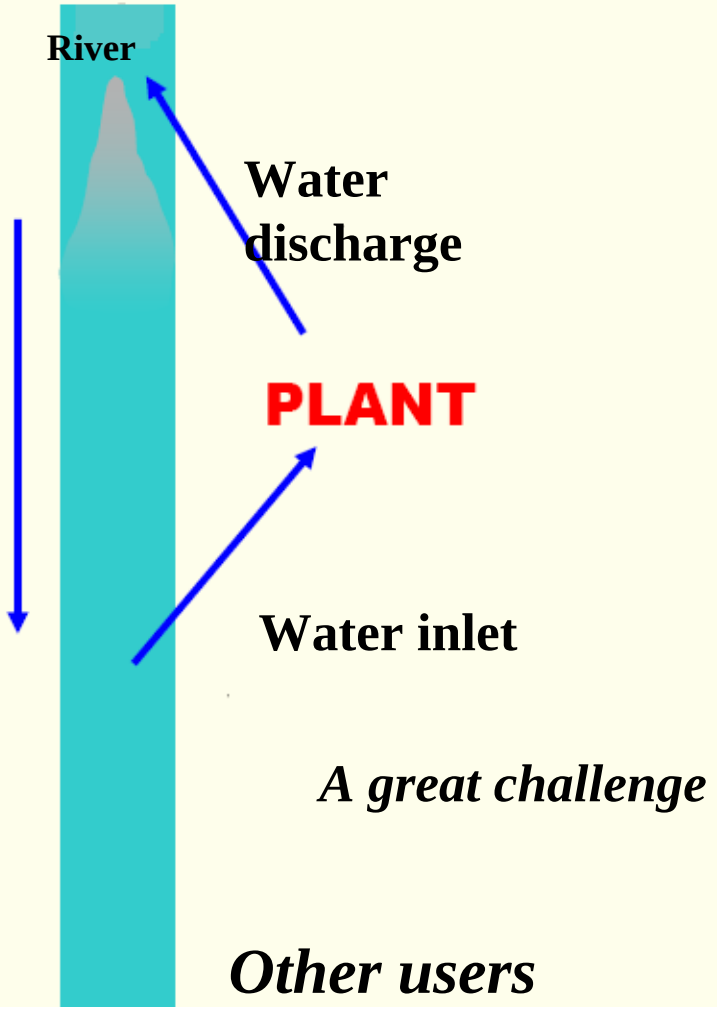


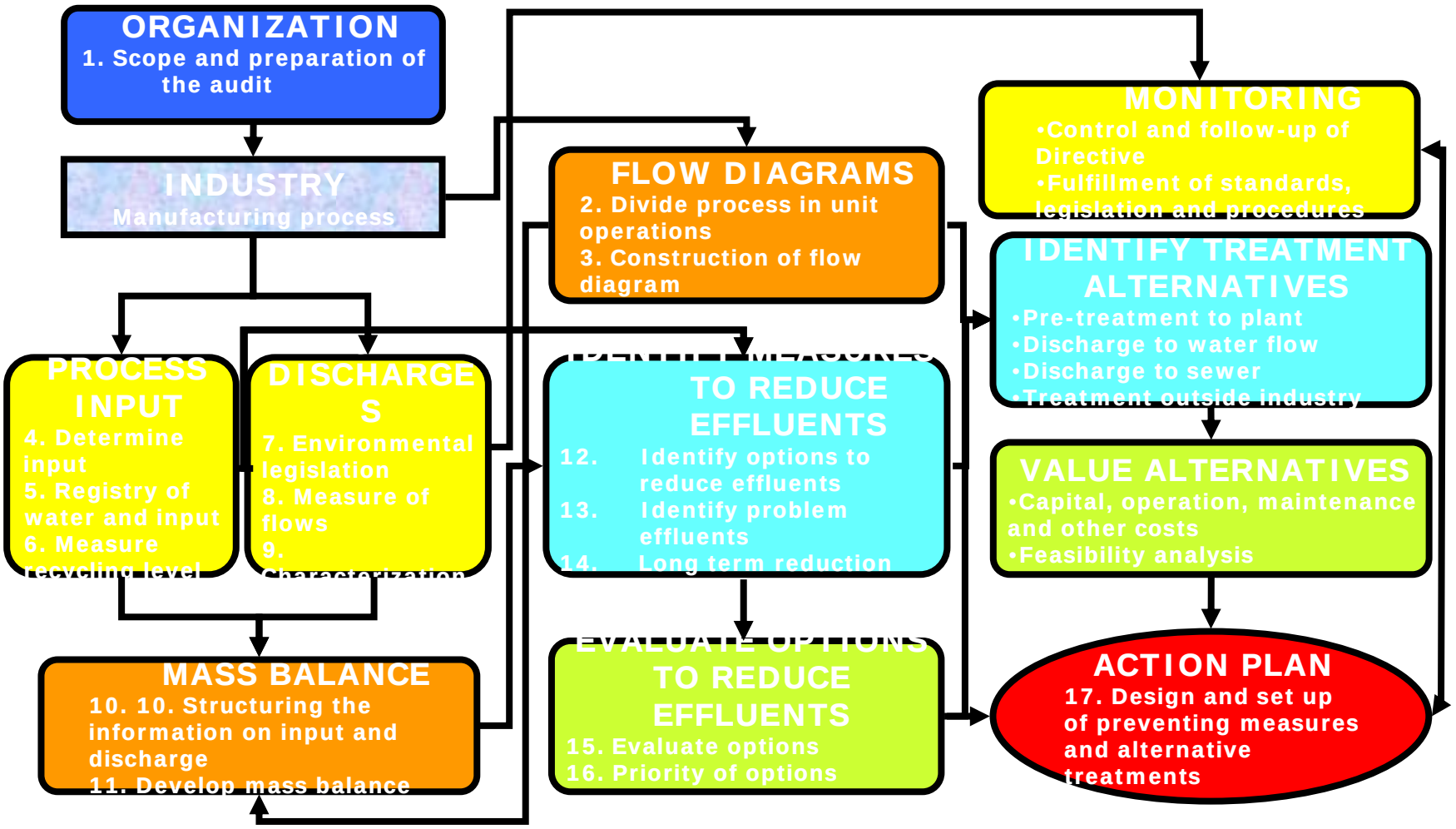
Zero discharge

Externalization of potential impacts



Internalization of potential impacts




ORGANIZATION
1. Scope and preparation of the audit
INDUSTRY
Manufacturing process
FLOW DIAGRAMS
2. Divide process in unit operations
3. Construction of flow diagram
MONITORING
•Control and follow-up of Directive
•Fulfillment of standards, legislation and procedures
IDENTIFY TREATMENT ALTERNATIVES
•Pre-treatment to plant
•Discharge to water flow
•Discharge to sewer
•Treatment outside industry
PROCESS INPUT
4. Determine input
5. Registry of water and input
6. Measure recycling level
DISCHARGES
7. Environmental legislation
8. Measure of flows
9. Characterization
TO REDUCE EFFLUENTS
12. Identify options to reduce effluents
13. Identify problem effluents
14. Long term reduction
VALUE ALTERNATIVES
•Capital, operation, maintenance and other costs
•Feasibility analysis
MASS BALANCE
10. 10. Structuring the information on input and discharge
11. Develop mass balance
TO REDUCE EFFLUENTS
15. Evaluate options
16. Priority of options
ACTION PLAN
17. Design and set up of preventing measures and alternative treatments

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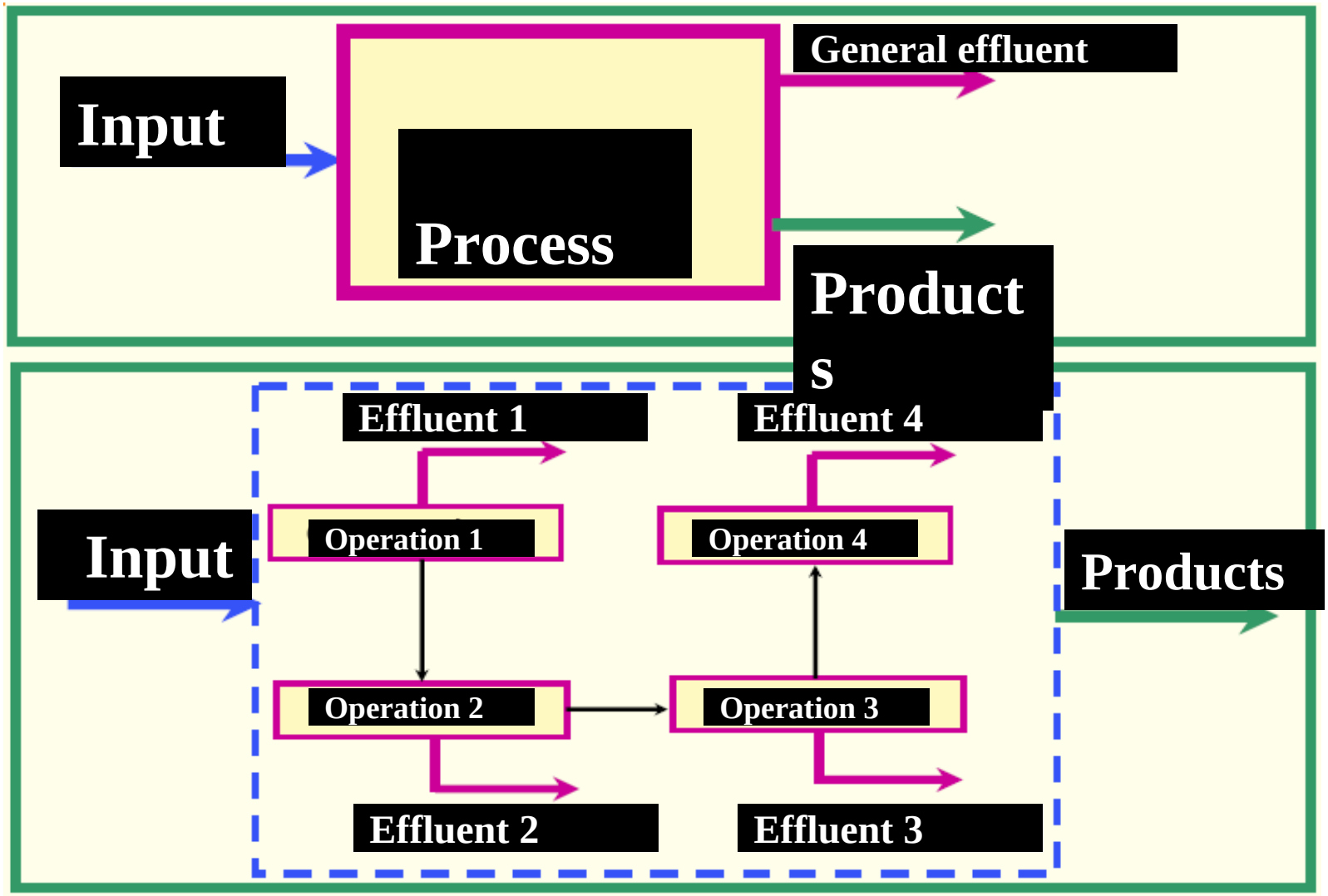
Pollution prevention
Definition

- The use of materials, processes or practices that reduce or eliminate the creation of pollution or wastes at the source.
- Practices that reduce the use of hazardous materials, energy, water and other resources.
- Practices that protect natural resources through conservation or more efficient use.

(Environmental Protection Agency)


Input
Process
General effluent
Product
s
Input
Effluent 1
Effluent 4
Operation 1
Operation 4
Products
Operation 2
Operation 3
Effluent 2
Effluent 3

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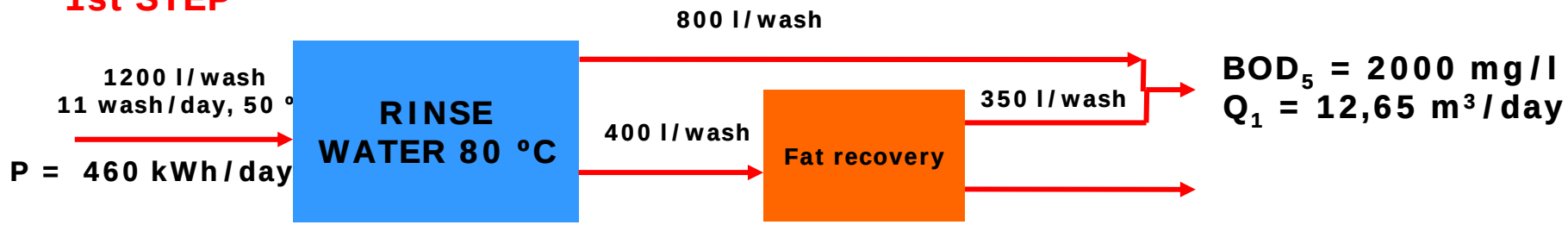
REDUCTION AT THE SOURCE

DAIRY INDUSTRY

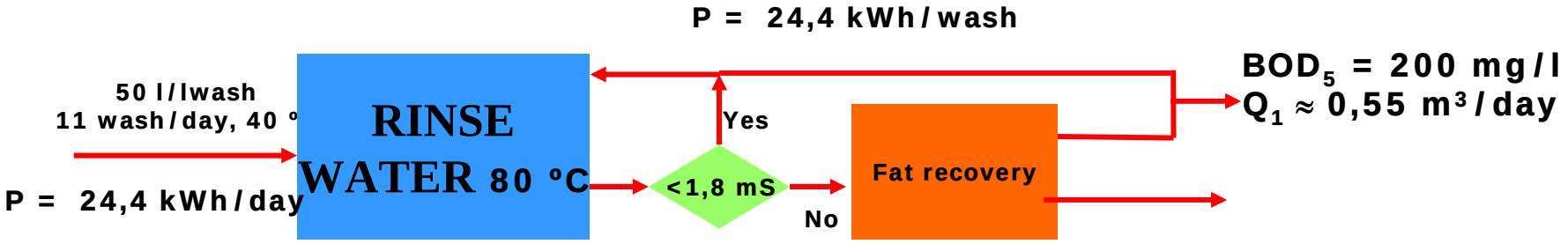
ORIGINAL PROCESS

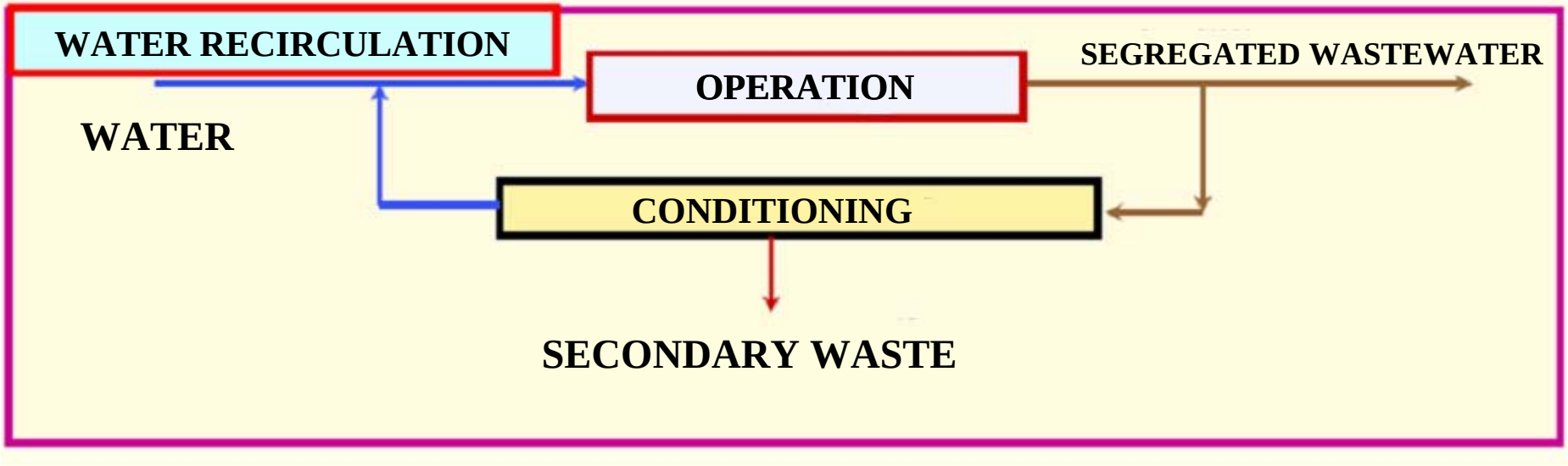
1st STEP



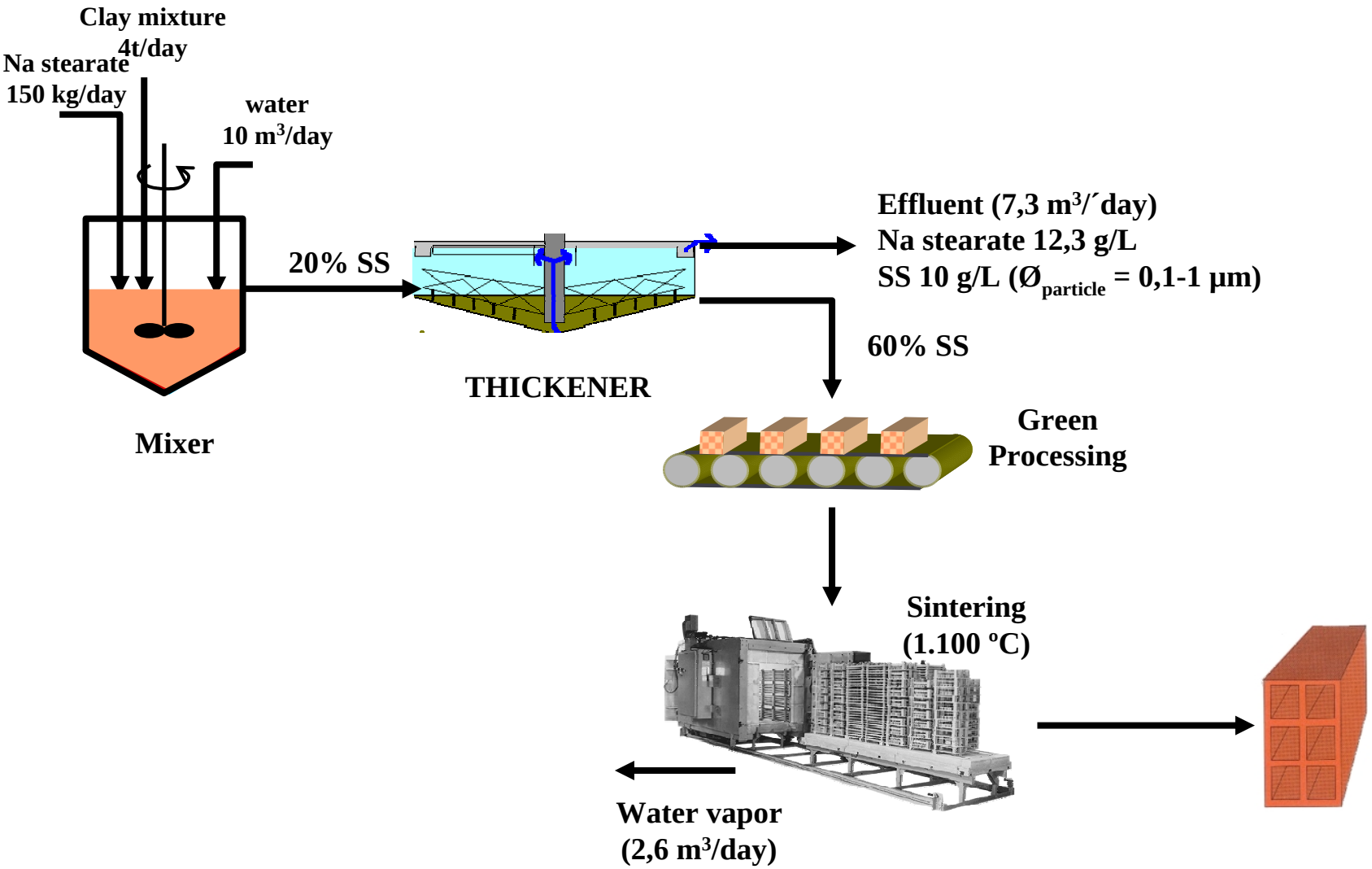
MODIFIED PROCESS

1st STEP




WATER RECIRCULATION
OPERATION
SEGREGATED WASTEWATER
WATER
CONDITIONING
SECONDARY WASTE

CERAMIC INDUSTRY (I)



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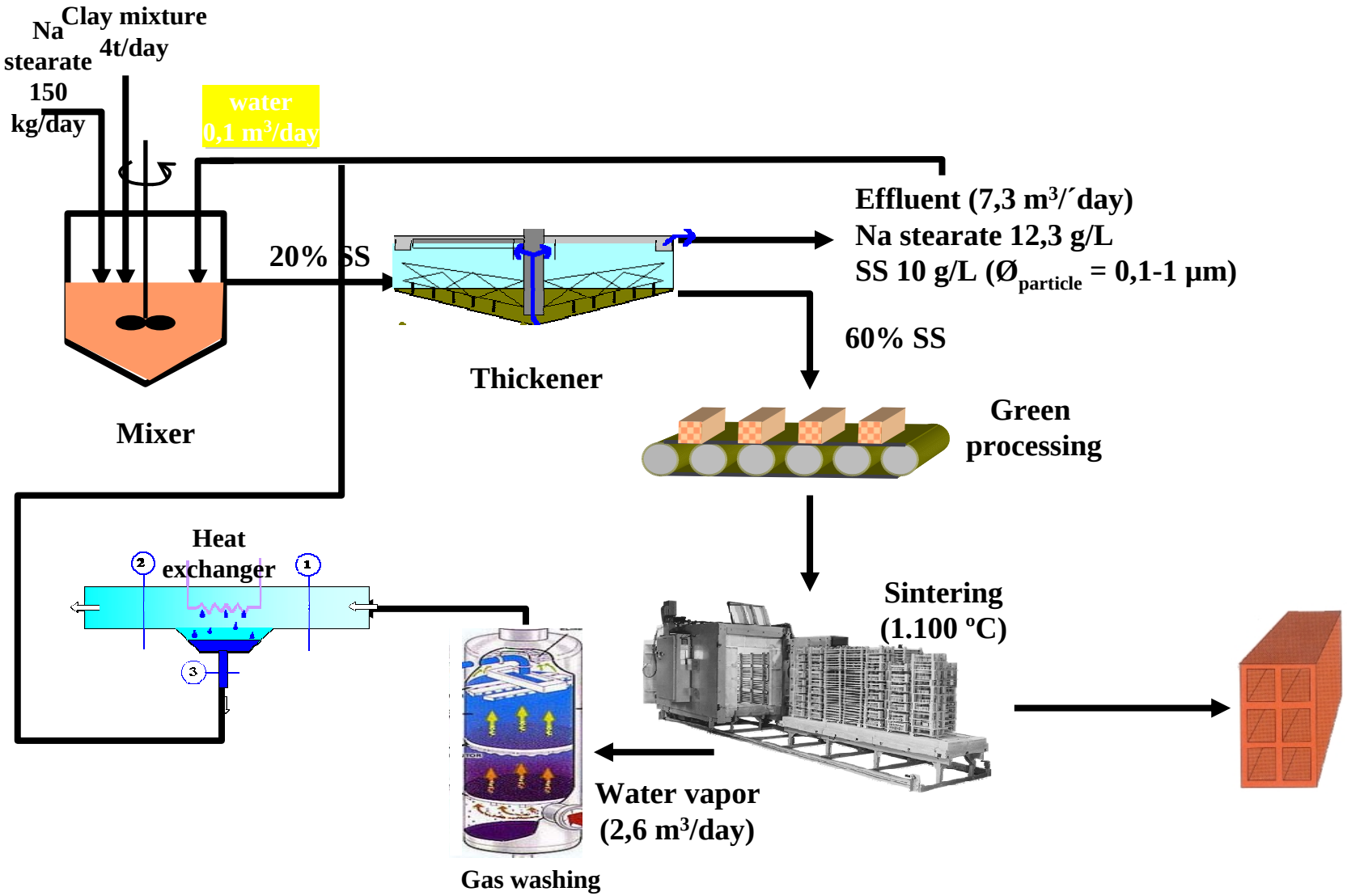
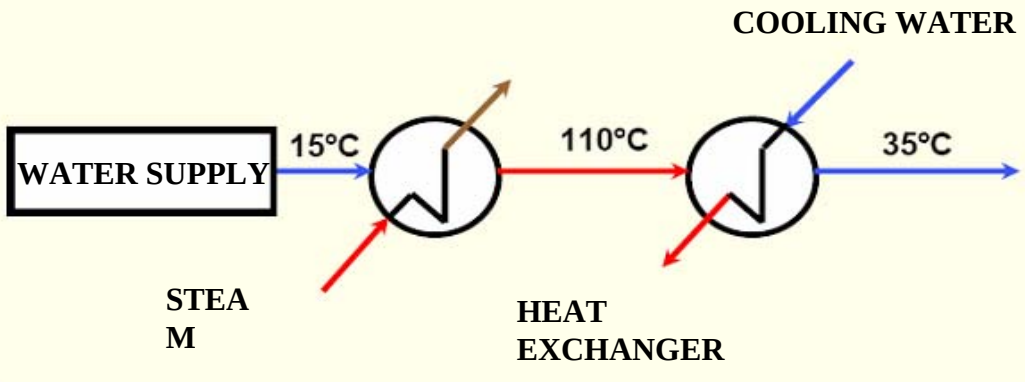
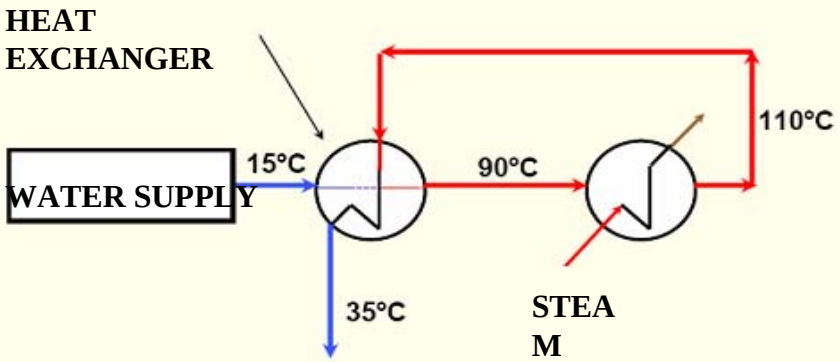
CERAMIC INDUSTRY (II)



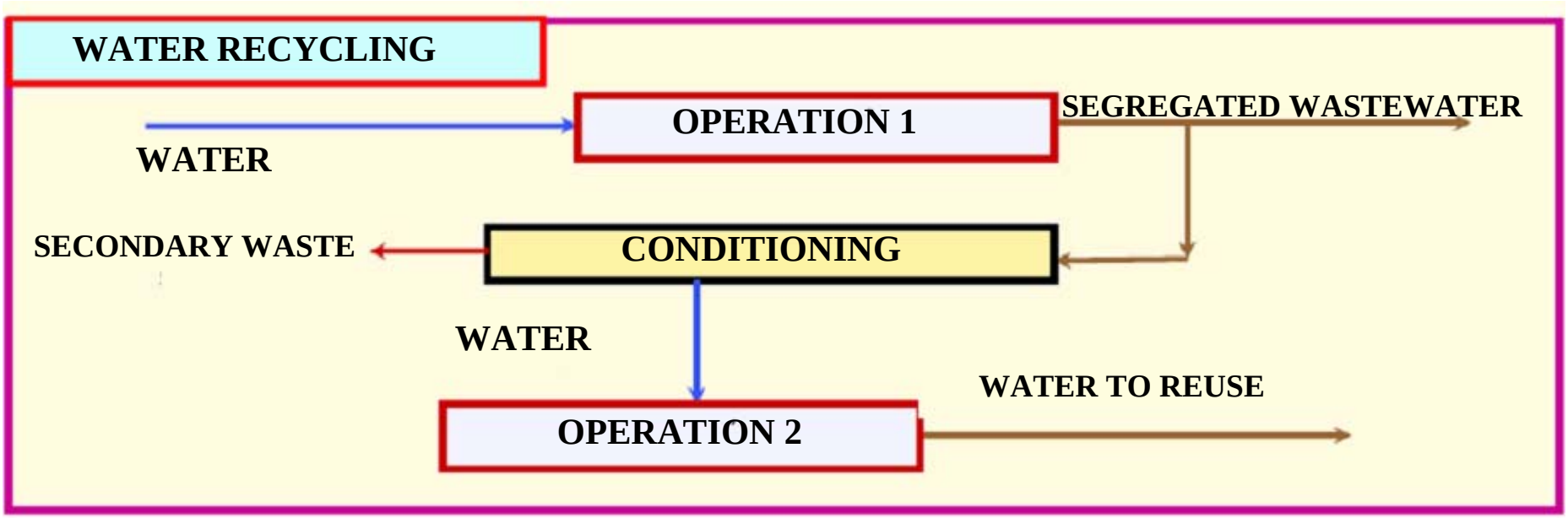
ENERGY RECOVERY



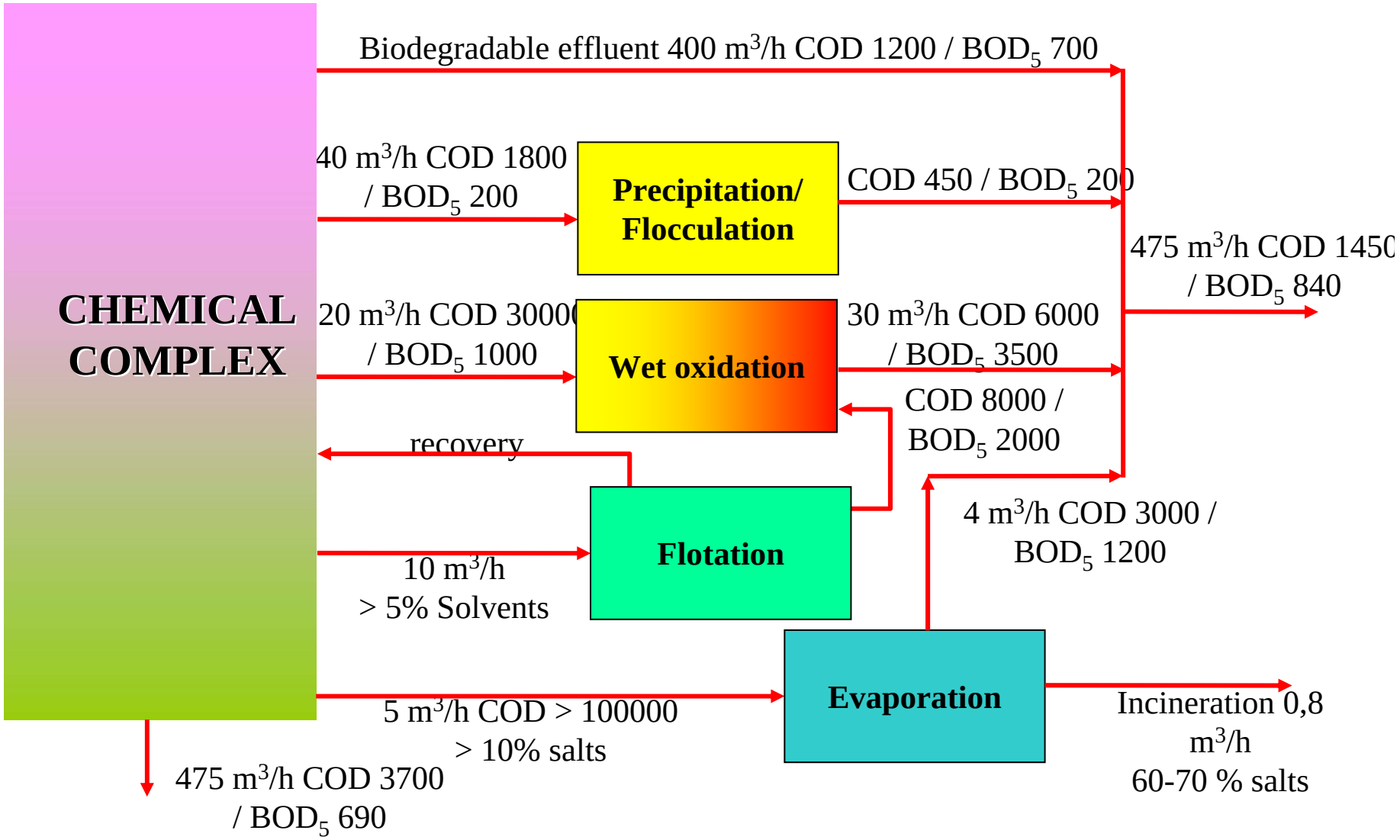
CONVENTIONAL HEATING AND COOLING SYSTEMS



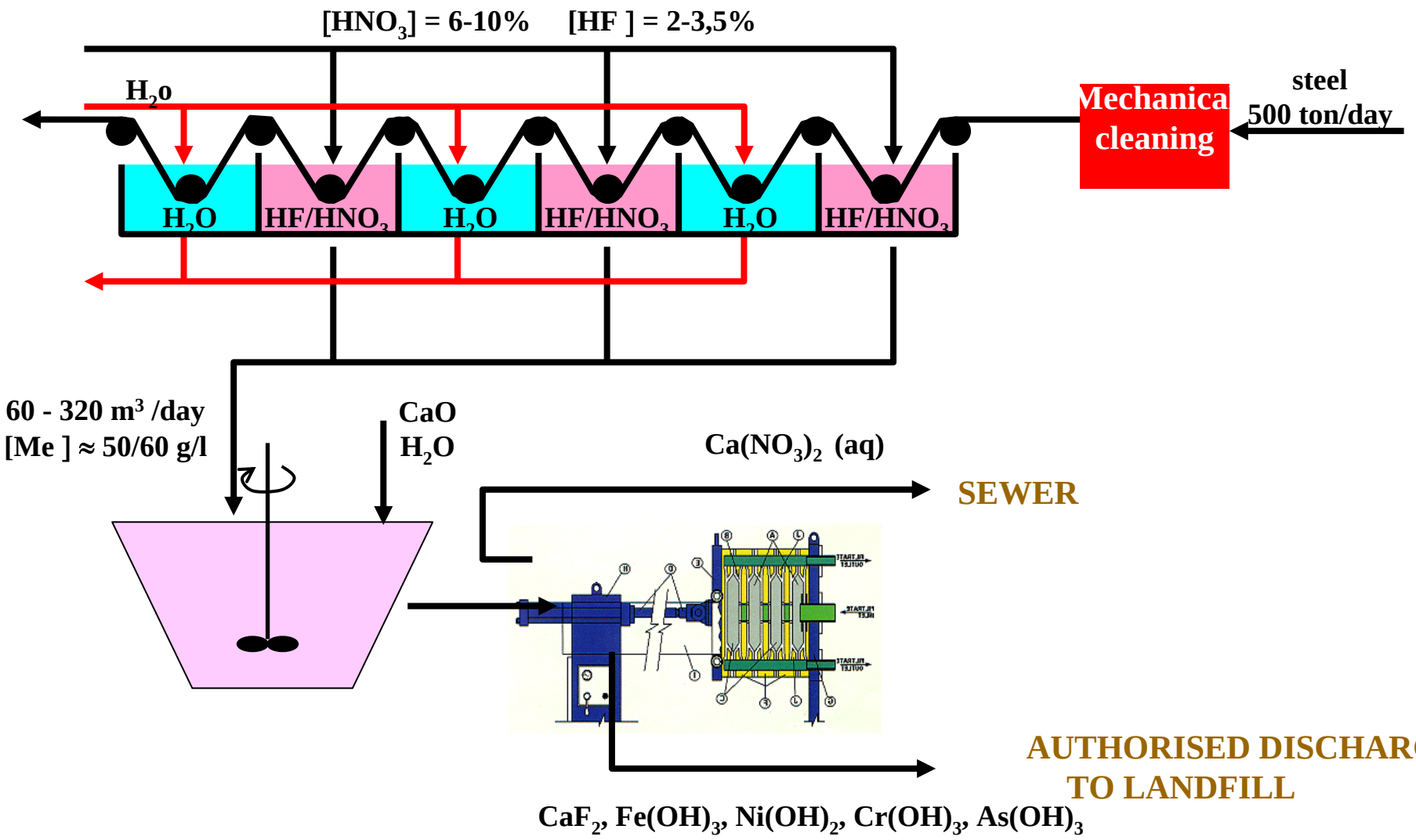
ENERGETIC INTEGRATION OF PROCESSES: REDUCTION IN STEAM AND COOLING WATER


WATER RECYCLING
OPERATION 1
SEGREGATED WASTEWATER
WATER
SECONDARY WASTE
CONDITIONING
WATER
WATER TO REUSE
OPERATION 2

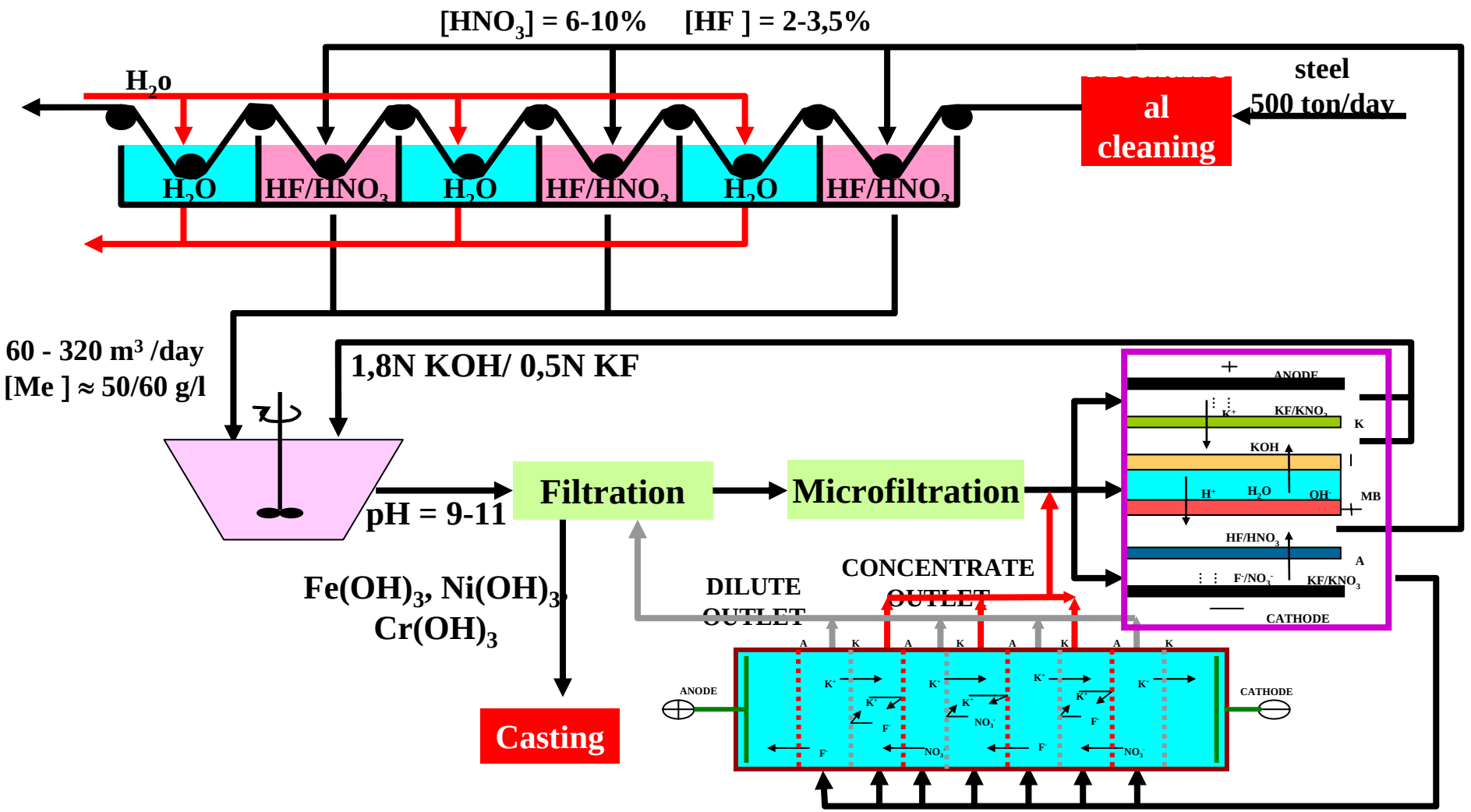
SEGREGATE


CHEMICAL COMPLEX
Biodegradable effluent 400 m3/h COD 1200 / BOD5 700
40 m3/h COD 1800 / BOD5 200
Precipitation/ Flocculation
COD 450 / BOD5 200
475 m3/h COD 1450 / BOD5 840
20 m3/h COD 30000 / BOD5 1000
Wet oxidation
30 m3/h COD 6000 / BOD5 3500
COD 8000 / BOD5 2000
recovery
Flotation
10 m3/h
> 5% Solvents
4 m3/h COD 3000 / BOD5 1200
Evaporation
5 m3/h COD > 100000
> 10% salts
Incineration 0,8 m3/h
60-70 % salts
475 m3/h COD 3700 / BOD5 690

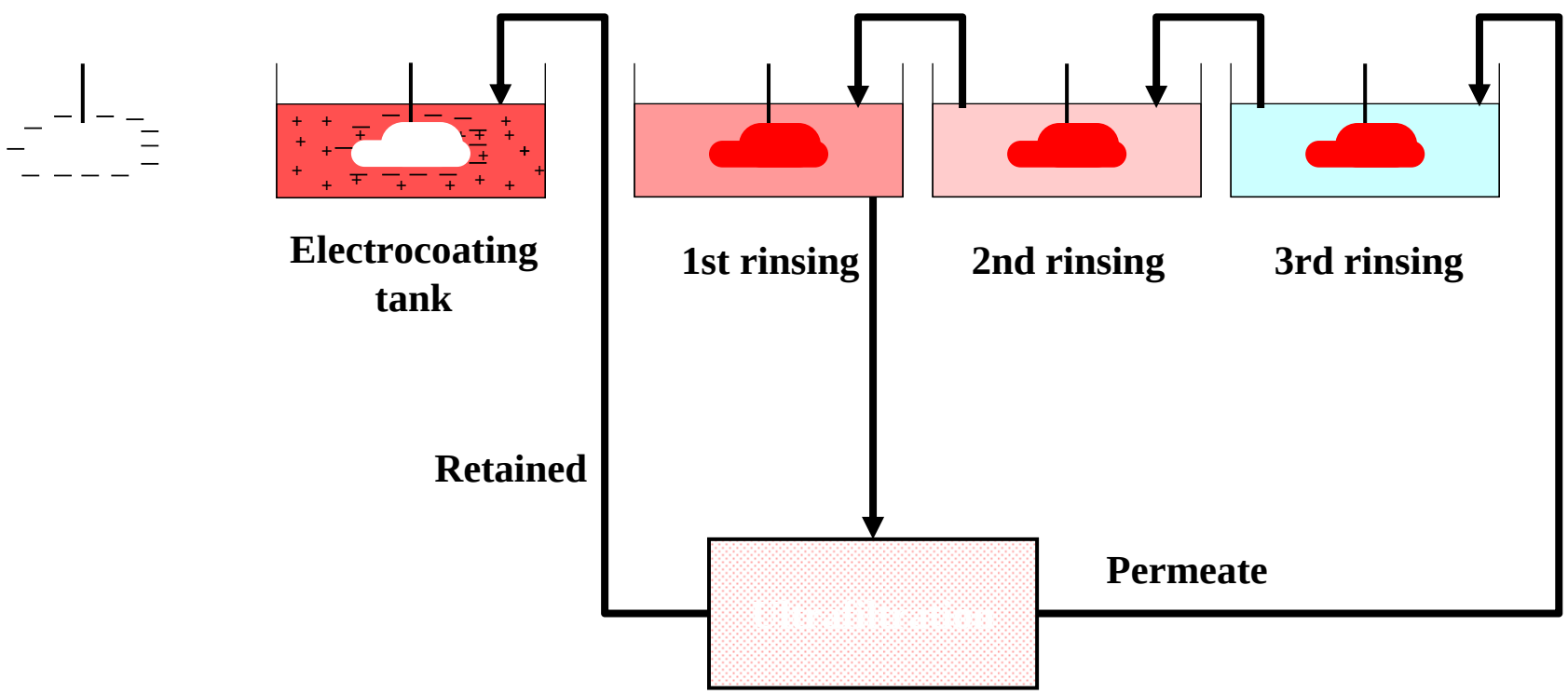
STEEL PICKLING (I)



STEEL PICKLING (II)



VEHICULE PAINTING LINE



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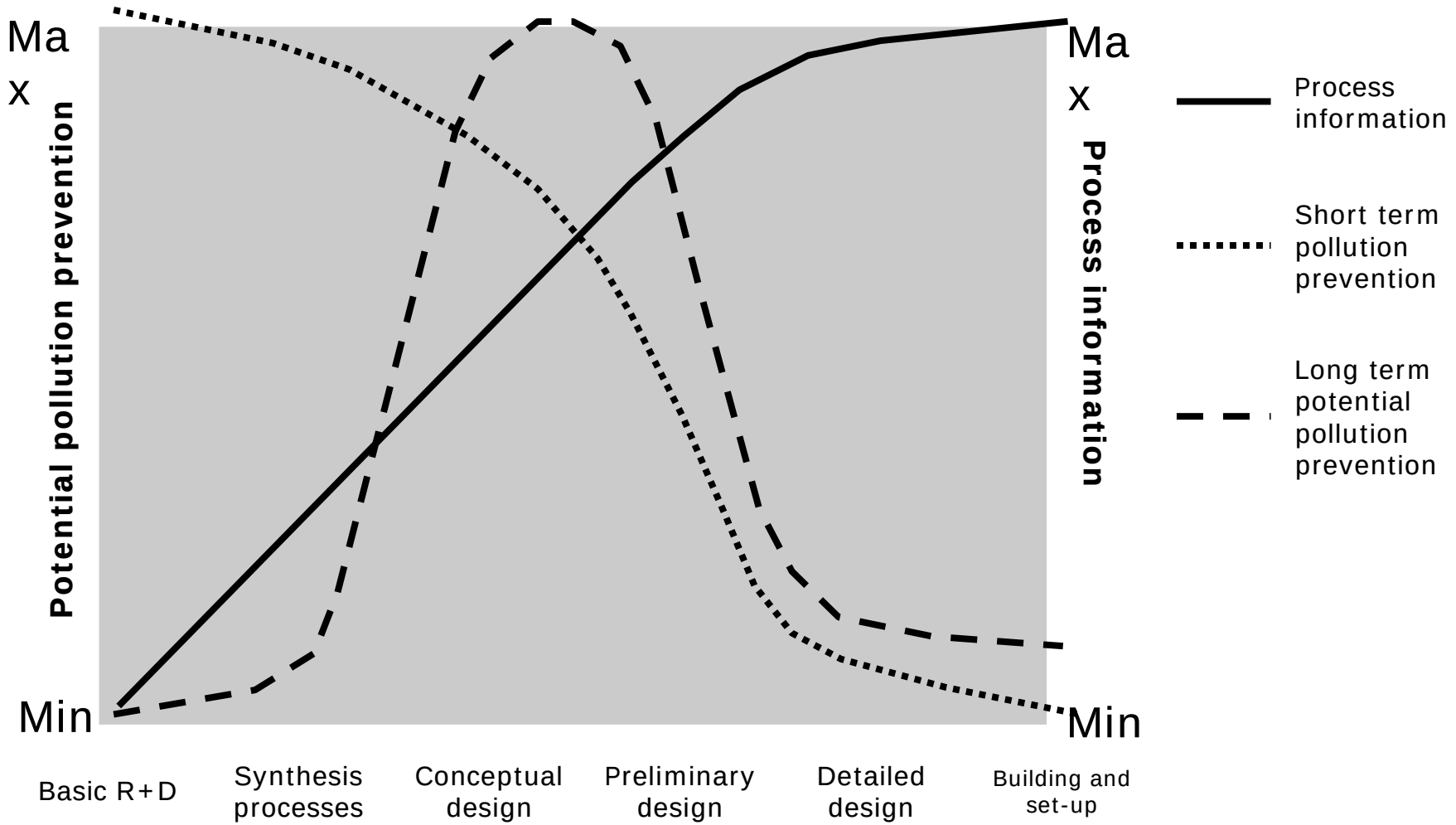
PREVENTION OF POLLUTION AT DESIGN



Process modifications

- An improvement in the efficiency of productive processes minimizes the generation of waste.
- These modifications may include
  - More advanced technologies
  - Change to less polluting reactants
  - Change in cleaning processes
  - Use of catalyzers
  - Segregation of waste
  - Improve operation and maintenance

IPPC

IPPC: Integrated pollution prevention and control (Ley 16/2002)

➢Integrated approach

✓***CONSIDER*** **all and every stages of the productive process.**

✓***DETERMINE*** **an adequate ratio between the amount of pollutant emissions produced and the characteristics of the receiving environment.**

✓***TAKE INTO ACCOUNT*** **the possible transfer of pollution from a pollution receiving medium to a different medium.**

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BEST AVAILABLE TECHNOLOGY (BAT)

- ✓*Generation of less waste.*
- ✓*Use of less dangerous substances.*
- ✓*Development of recovery and recycling techniques.*
- ✓*Processes, facilities or methods checked at industrial scale.*
- ✓*Implement scientific and technical improvements.*
- ✓*Characteristics, effects and volume of the discharge.*
- ✓*Date at which facility begun operation.*
- ✓*Time period required to install a BAT.*
- ✓*Reduction of raw materials consumption.*
- ✓*Increase of energetic consumption efficiency.*
- ✓*Prevent or reduce the discharge impact.*
- ✓*Reduction of accident risk.*
- ✓*Information published by EU or international organisms.*

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BEST AVAILABLE TECHNOLOGY (BAT)

THE USE OF A SPECIFIC TECHNOLOGY WILL NOT BE IMPOSED

- ✓*Generation of waste.*
- ✓*Use of less dangerous substances.*
- ✓*Development of recovery and recycling techniques.*
- ✓*Processes, facilities or methods tested at industrial scale.*
- ✓*Implement scientific and technical improvements.*
- ✓*Characteristics, effects and volume of the discharge.*
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USE OF BEST AVAILABLE TECHNOLOGY

- Optimize the quantity of reactants (do not use too much).
- Avoid adsorption if the adsorbent cannot be regenerated
- Use of vacuum columns for labile products
- Use of high performance columns to reduce pressure losses
- Use continuous process if washing generates a large amount of waste
- Use of wall scrapers in exchangers with viscous products.

BEST TECHNOLOGY

- Improve reactor design
  - Ease cleaning
  - Minimize valves and obstructions
  - Recover fugitive product from drains, venting,...
- Improve reactor control
  - Improve efficiency
  - Decrease side reactions
- Improve separation processes
  - Use mechanical separations if more than one phase exists
  - Avoid over-dimensioning. Use designs effective for a wide range of conditions
  - Favor the transference of the minority component
  - Use high separation factors

BEST TECHNOLOGY

- Improve cleaning/degreasing
  - Reduce frequencies
  - Countercurrent tank cleaning
  - Automatic systems for pressure cleaning
  - Minimize the loss of solvents
  - Cleaning with ultrasounds
- Recycling
- Recovery of materials
- Change product
- Storage
- Internal management
  - Good practices
  - Formation
  - Existence of procedures