Water intensive industries and treatment technologies: opportunities and challenges

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CentrEau
Centre québécois de recherche sur l'eau
Quebec Water Research Centre

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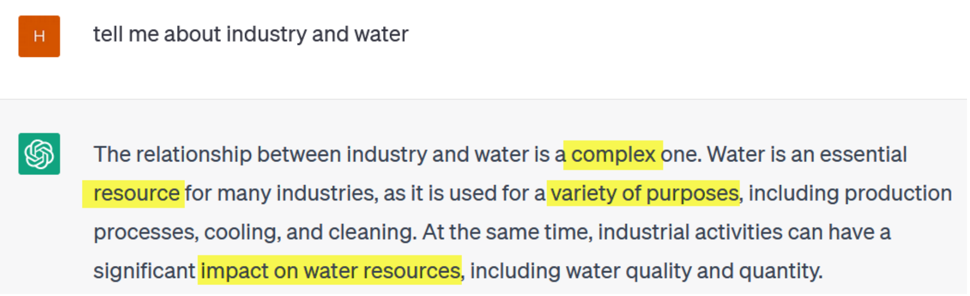
Chat.openai.com



H

tell me about industry and water

The relationship between industry and water is a complex one. Water is an essential resource for many industries, as it is used for a variety of purposes, including production processes, cooling, and cleaning. At the same time, industrial activities can have a significant impact on water resources, including water quality and quantity.

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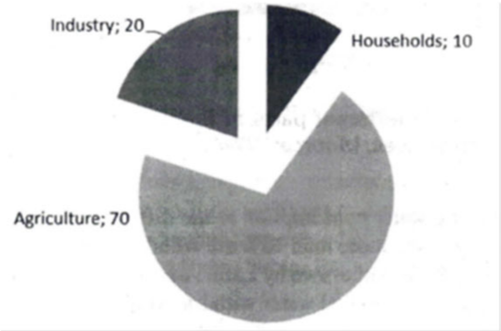
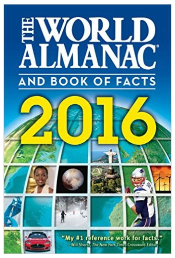
Global water demand

Europe: 40-57%




THE WORLD ALMANAC
AND BOOK OF FACTS
2016

World Almanac 2011

Industry

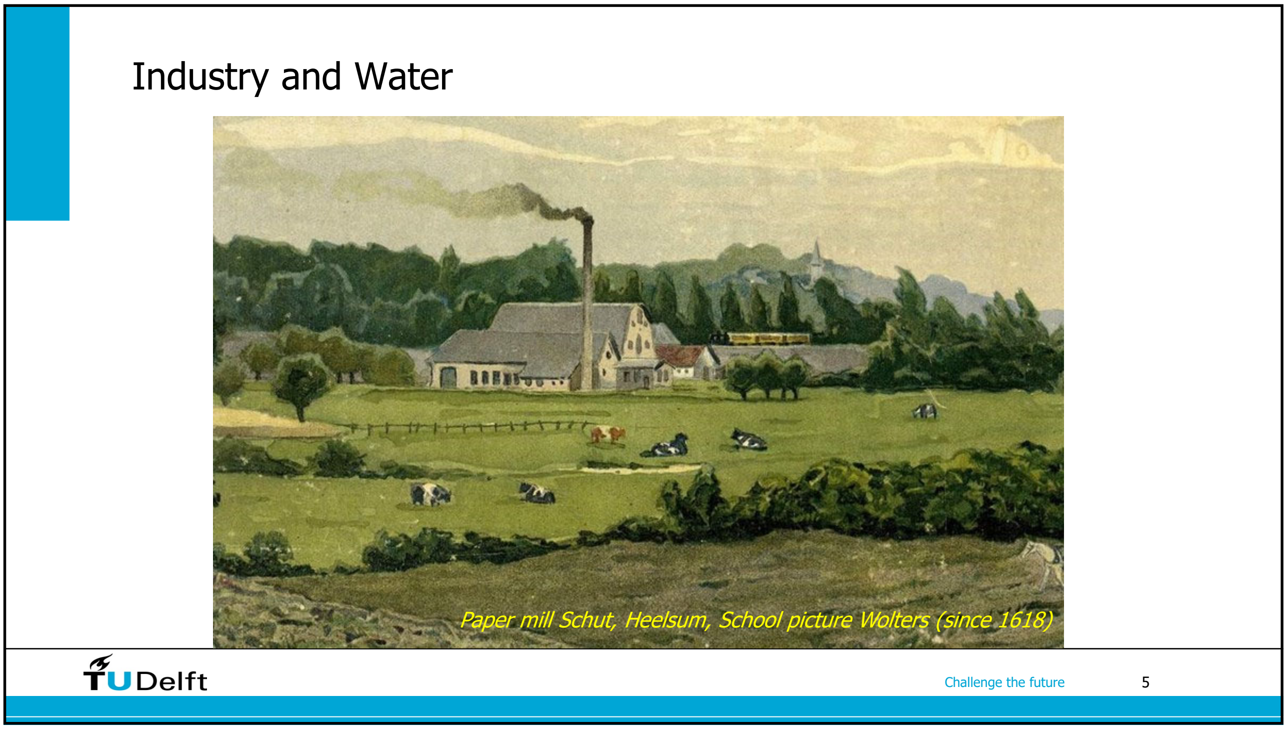
- Production of goods and services
- Group of manufacturers or businesses
- Manufacturing industry: Development, design, production, sale

Agriculture & Fisheries

Tourism & Services

Mining & Manufacturing

Financial & Data centers

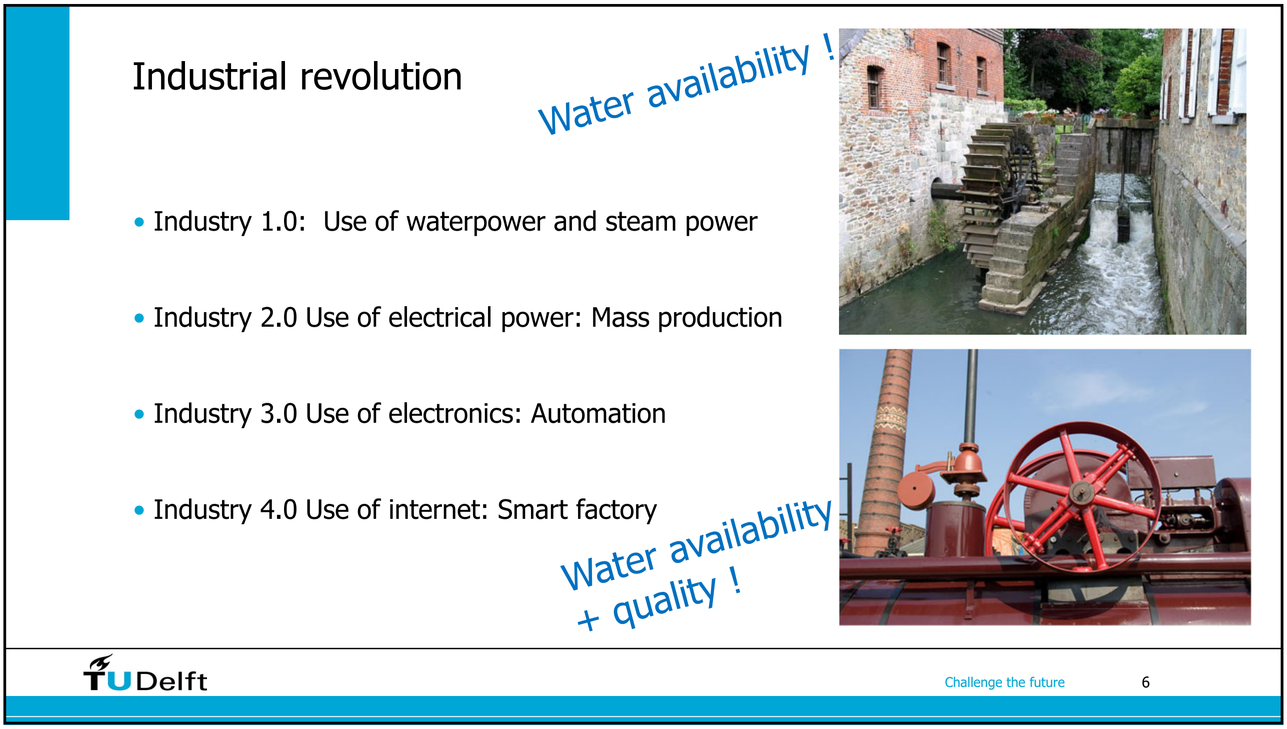


Industry and Water

Paper mill Schut, Heelsum, School picture Wolters (since 1618)

Challenge the future 5

5



Industrial revolution

Water availability !

- Industry 1.0: Use of waterpower and steam power
- Industry 2.0 Use of electrical power: Mass production
- Industry 3.0 Use of electronics: Automation
- Industry 4.0 Use of internet: Smart factory

Water availability
+ quality !

Challenge the future 6

6

Steam powered textile mill

Used water Quality !

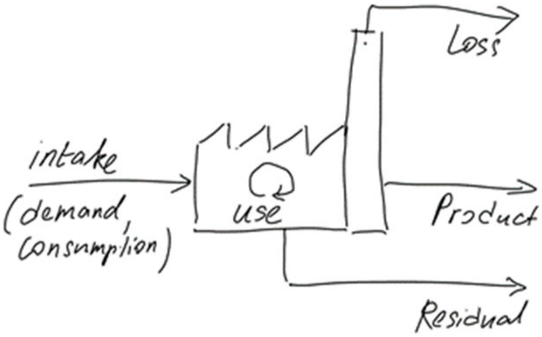
Ahmed Baban

Lancashire cotton mill, 1914

Aquatuta.com

Definition water intensive industry ?

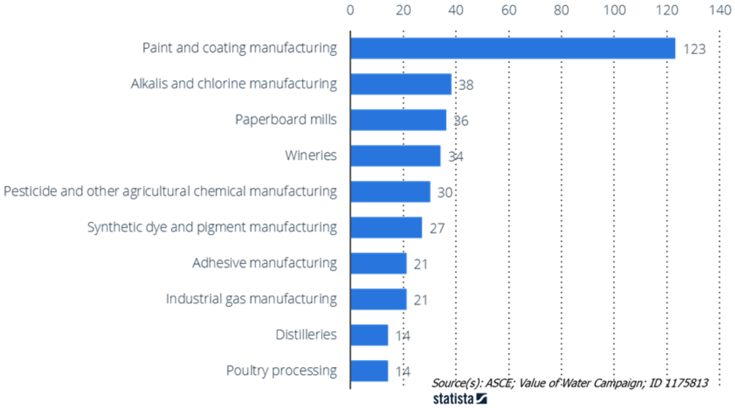
Water demand
- Water withdrawal / extraction ?
- Water use ?
- Water consumption ?
- Wastewater production ?


Loss
intake
(demand, consumption)
use
Product
Residual

“Intensity” depends on
- Definition of water demand
- Definition of industrial sector

Definition water intensive industry (examples)

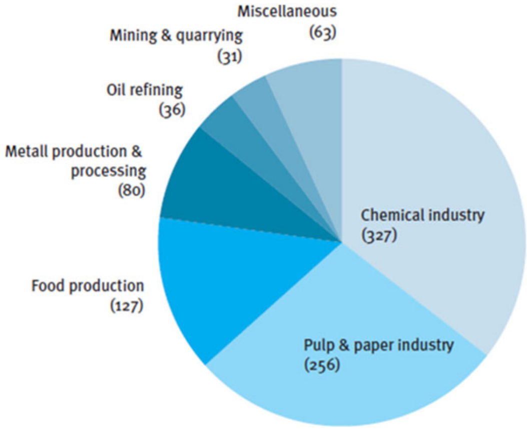
Volume / US$ output



Source(s): ASCE; Value of Water Campaign; ID 1175813

statista

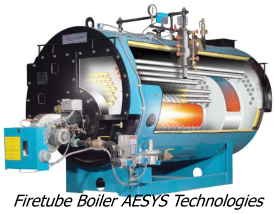
Volume of wastewater



Uses of water in industry
Water intensive processes

https://www.youtube.com/watch?v=sMyd8d-6lu0&nohtml5=False

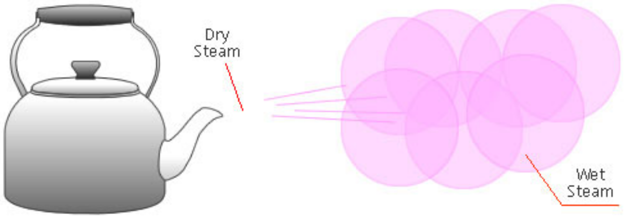
- Steam production
- Cooling
- Transport (beets “flume”)
- Washing (beets, potatoes,…)
- Cleaning, cleaning in place (CIP)
- Gas or fume washing (cokes)
- Reaction medium (biotech, pharma, chemistry,…)
- Ingredient (food, drinks, detergents,…)
- Pulping (paper)
- Sanitary



Firetube Boiler AESYS Technologies

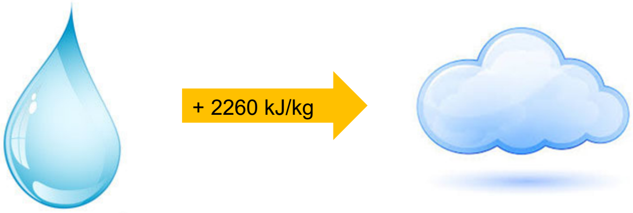
Steam

- Propulsion/Drive
- Heating/Sterilization
- Motive
- Atomization
- Cleaning
- Moisturization
- Humidification
- Drying

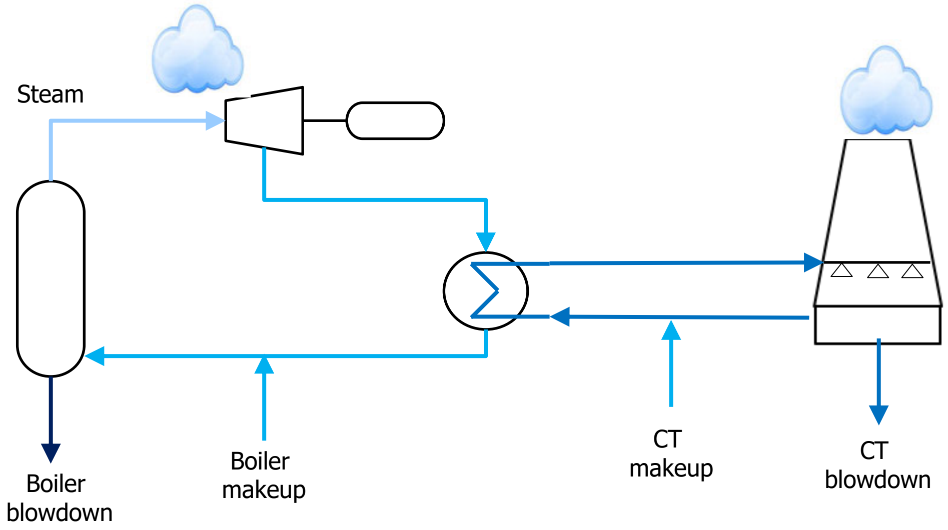


Cooling

- Condensate steam
- Condensate hot process gasses
- Cooling exothermic reactions
- Refrigeration
- Cooling water electrolysis
- Data centers
- … and more



Thermal cycle: steam and cooling


Steam
Boiler
blowdown
Boiler
makeup
CT
makeup
CT
blowdown

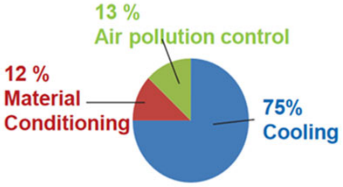
Types of water within companies

- Boiler (feed or makeup) water
- Cooling tower (feed or makeup) water
- Blowdown water from boiler or cooling tower
- Produced water: by-product (oil & gas, sugar beet, dairy, …)
- Process water: used in the production process
- Condensates
- IEX regeneration brine
- Membrane filtration concentrate
- …. Etc.

Metcalf & Eddy

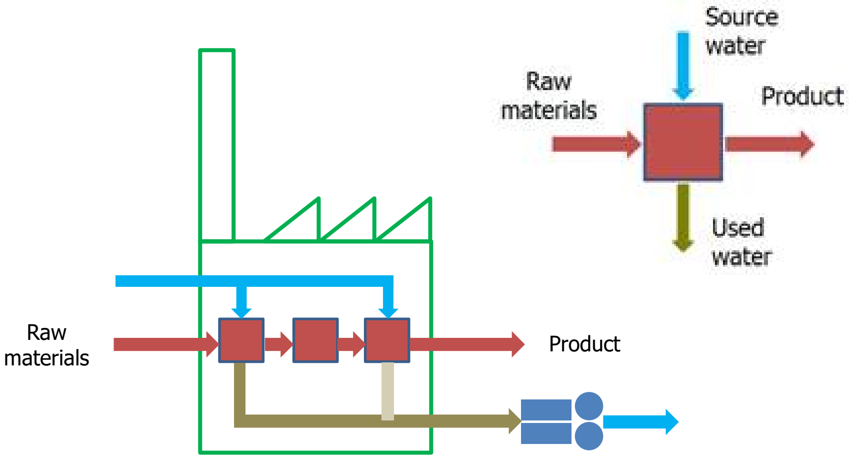
Types of water steel mill (Example Tata Steel)

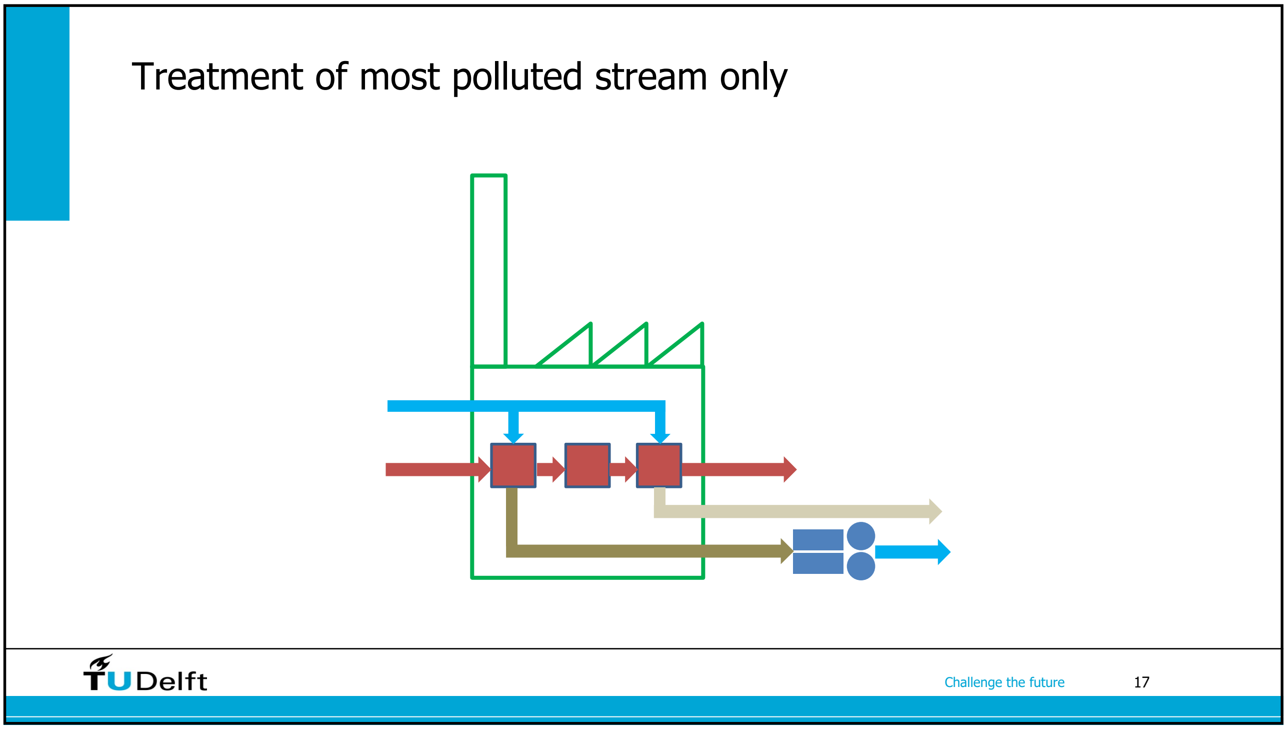
- A-water: base quality demin water for e.g. flushing
- M-water: high quality demin water for makeup steam boilers
- Drinking water: sanitary, emergency showers
- Sea water: for secondary cooling in blast furnaces
- Brackish water: for slag granulation
- G - water: softened water as intermediate product
- Cooling water: various applications
- Saline ground water: secondary cooling production halls, processes
- WRK-water/Lekwater: surface water for various applications: dust prevention, Feed water for direct & indirect cooling, fire extinguishing, demin production



ArcelorMittal, Industrial Water 2018

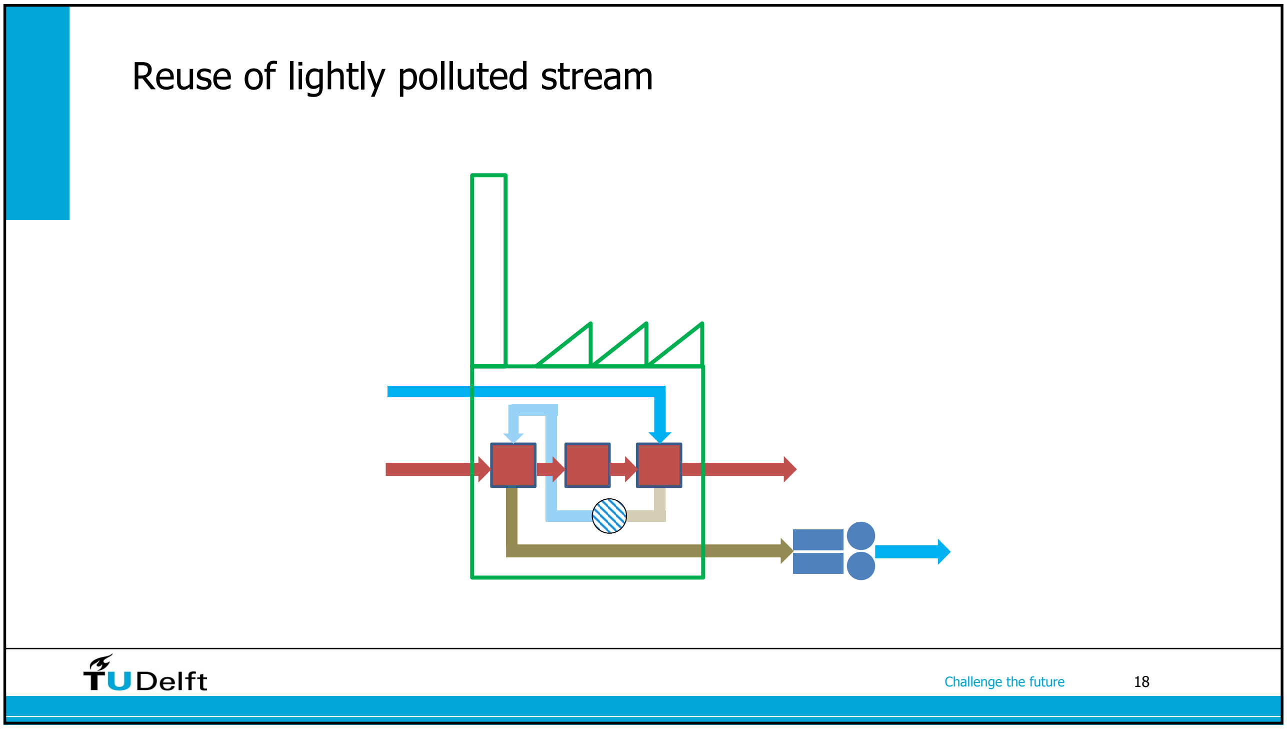
Treatment of combined streams





Treatment of most polluted stream only

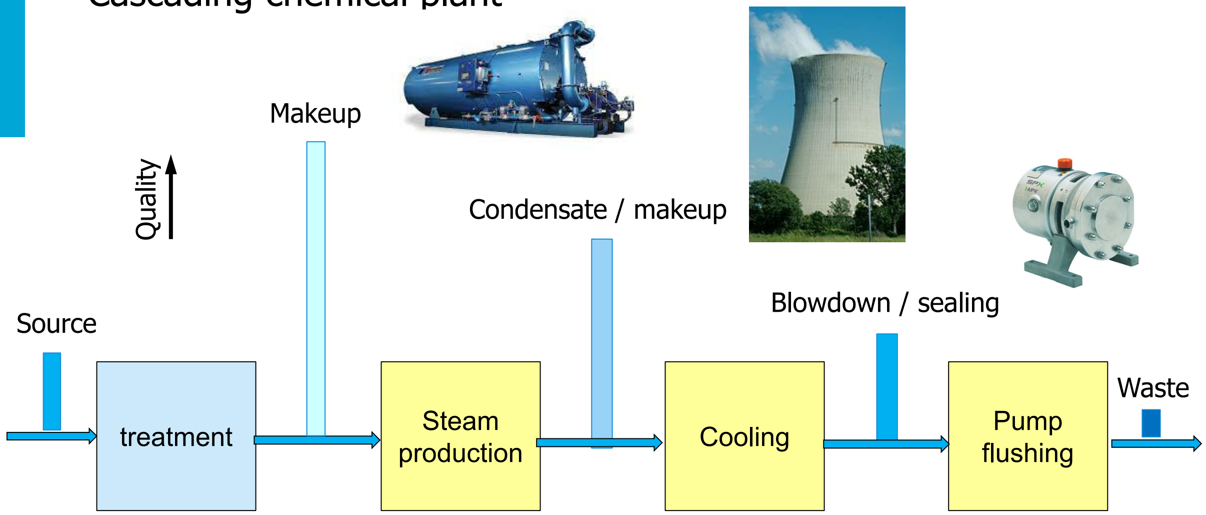
17



Reuse of lightly polluted stream

18

Cascading chemical plant



Makeup

Quality

Condensate / makeup

Blowdown / sealing

Source

treatment

Steam production

Cooling

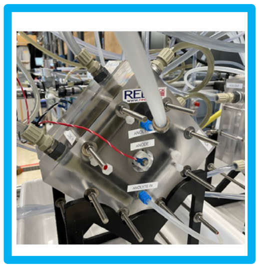
Pump flushing

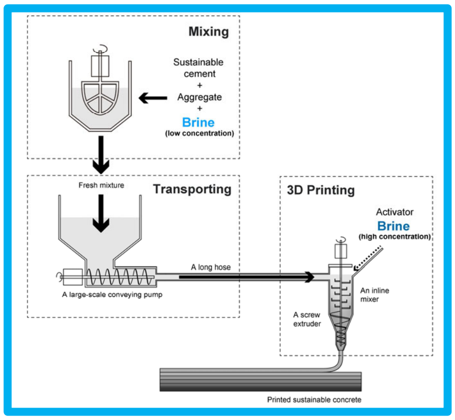
Waste

Challenges (Technical)

- Separate streams (decision support, water pinch, …)
- Redesign water intensive processes (water use, chemical use,…)
- Recycling / Reuse / Cascading
- Brine handling
- Treatment of (Xtreme) streams (recovery, destruction, **…..**)
  - Organic streams
  - Saline organic streams
  - Brines
  - Condensates

Use of residual brine in production new materials: Brine2Beton

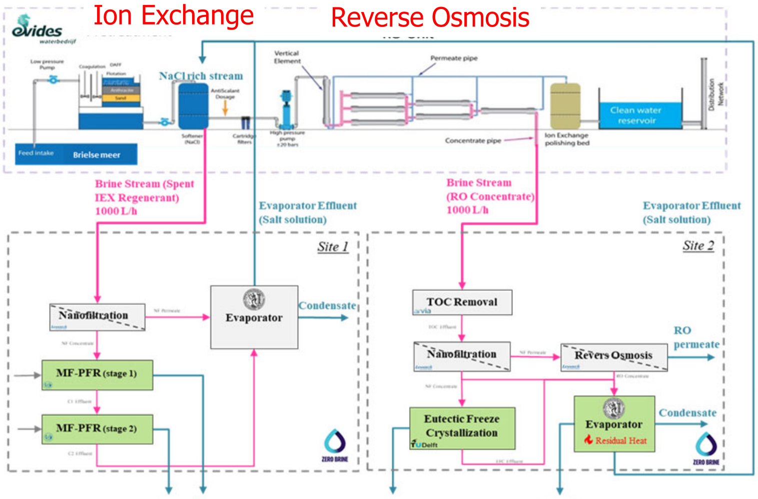



Mixing
Sustainable cement
+
Aggregate
+
Brine
(low concentration)
Fresh mixture
Transporting
A long hose
A large-scale conveying pump
3D Printing
Activator
Brine
(high concentration)
An inline mixer
A screw extruder
Printed sustainable concrete

Rogelio Peschard

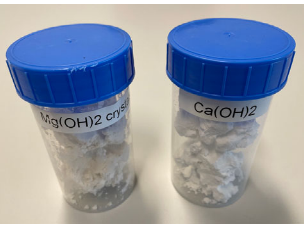
Brine handling and treatment: Zero Brine

ZERO BRINE


Ion Exchange
Reverse Osmosis
evides waterbedrijf
Low pressure Pump
Coagulation
DAFF
Flotation
Anthracite
Sand
Feed intake
Brielse meer
NaCl rich stream
AntiScalant Dosage
Softener (NaCl)
Cartridge filters
High pressure pump ±20 bars
Vertical Element
Permeate pipe
Concentrate pipe
Ion Exchange polishing bed
Clean water reservoir
Distribution Network
Brine Stream (Spent IEX Regenerant) 1000 L/h
Evaporator Effluent (Salt solution)
Brine Stream (RO Concentrate) 1000 L/h
Evaporator Effluent (Salt solution)
Site 1
Nanofiltration
NF Permeate
Evaporator
Condensate
NF Concentrate
MF-PFR (stage 1)
C1 Effluent
MF-PFR (stage 2)
C2 Effluent
ZERO BRINE
Site 2
TOC Removal
TOC Effluent
Nanofiltration
NF Permeate
Revers Osmosis
RO permeate
NF Concentrate
RO Concentrate
Eutectic Freeze Crystallization
TU Delft
EFC Effluent
Evaporator
Residual Heat
Condensate
ZERO BRINE

NaCl

evides industriewater


Mg(OH)2 cr
Ca(OH)2

Hamed Rastegarian

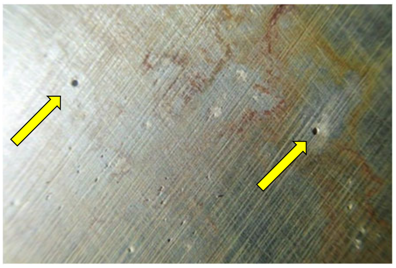
$Ca(OH)_2$ $Mg(OH)_2$ – Na_2SO_4 — $NaHCO_3$

2 months operation
Oct.2019 – Dec.2019

6 months operation
Dec.2019 – June2020

Challenges: Brine handling and treatment

- Tweaking production and water use/treatment
- Organics (NOM)
- Corrosion and scaling
- Chemical engineering technologies



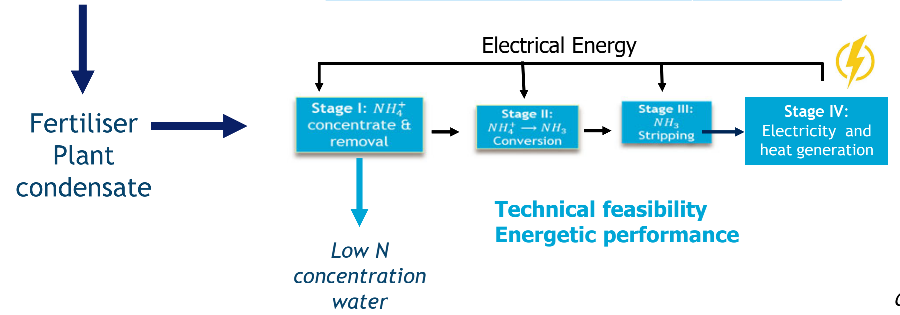
Pitting corrosion inner side brine storage tank

Treatment of fertilizer plant condensate

YARA

Yara Sluiskil

pH	7.5
Temperature	35 °C
Total ammonia nitrogen	0.8 g/L
Electrical conductivity	4.8 mS/cm
Bicarbonate	3.7 g/L



Fertiliser Plant condensate

Electrical Energy

Stage I: NH_4^+ concentrate & removal

Stage II: $NH_4^+ \longrightarrow NH_3$ Conversion

Stage III: NH_3 Stripping

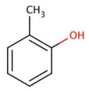
Stage IV: Electricity and heat generation

Low N concentration water

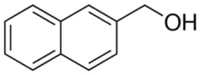
Technical feasibility
Energetic performance

Giacomo Bandinu et al 2020

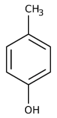
Treatment of bitumen fume condensate: AnMBR 89% removal



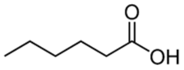
2-methyl phenol



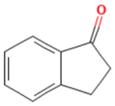
2-naphtalenemethanol



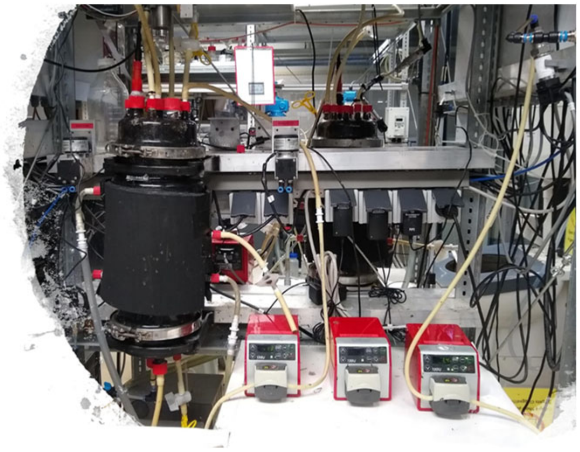
P-cresol



hexanoic acid



2,3-dihydro-1H-Inden-1-one



Victor Garcia Rea et al.

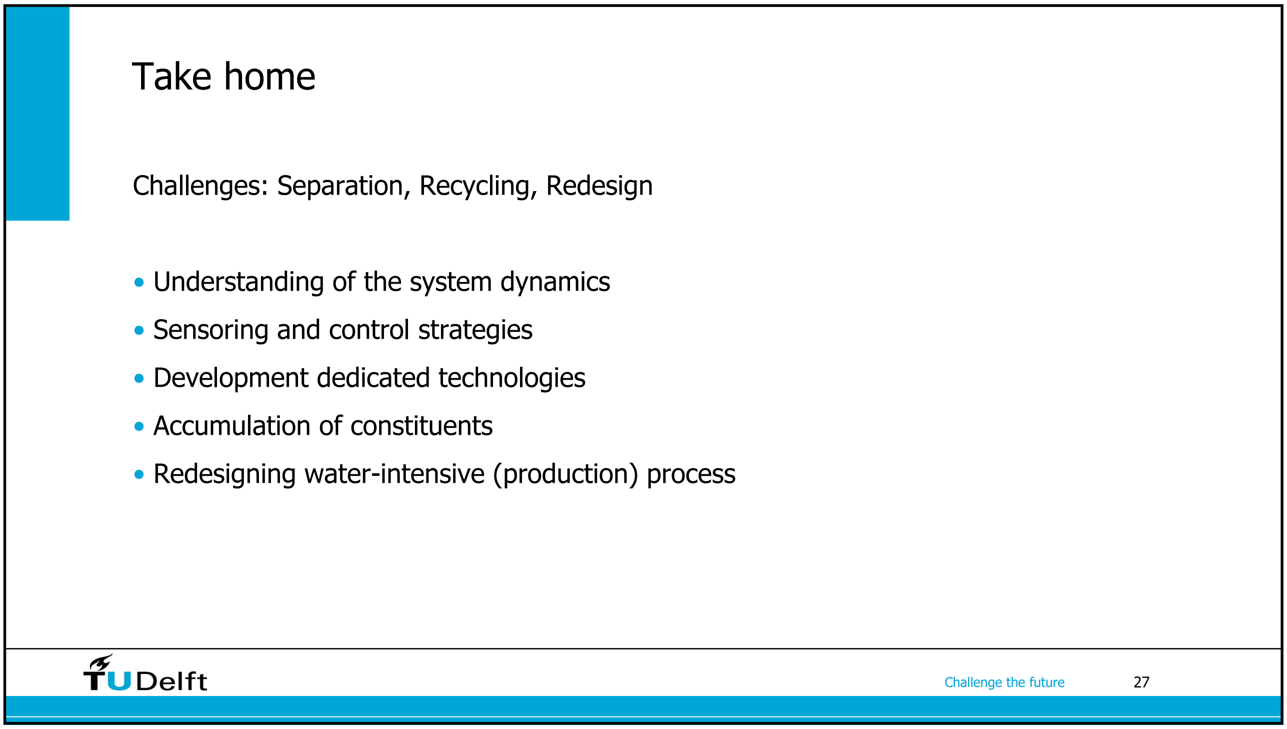
Challenges: Treatment of condensate

Physical treatment (ED, BPMED):

- High costs: CAPEX and Energy

Bio-treatment (AnMBR):

- Membrane fouling as a result of salinity and high temperature
- Inhibition microorganisms by phenol, salinity
- Slow growth microorganisms
- Nutrients needed



Take home

Challenges: Separation, Recycling, Redesign

- Understanding of the system dynamics
- Sensoring and control strategies
- Development dedicated technologies
- Accumulation of constituents
- Redesigning water-intensive (production) process