IMPROVED
industrial water use

INTEGRALE
MOBIELE
PROCESWATERVOORZIENING
VOOR EEN
ECONOMISCHE
DELTA

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End conference

IMPROVED
industrial water use

course of the day

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MOBIELE
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Europees Fonds voor Regionale Ontwikkeling

Stef Denayer
Cleantech Flanders

Stef Denayer
Cleantech Flanders

Maarten Everaert
Aquafin

Marjolein Vanoppen
Universiteit Gent

Paul Van Elslande
Yara Sluiskil

Kristof De Neve
BASF Antwerpen

Niek Van Belzen
Dow Benelux

PROGRAMME

10.30: Introduction ‘The VALUE of our WATER-world’ by Maarten Everaert (Aquafin)

10.45: Welcome by Marjolein Vanoppen (UGent)

11.00: Results & conclusions IMPPROVED:
Paul Van Elslande (Yara Sluiskil)
Kristof De Neve (BASF)
Niek Van Belzen (Dow)

11.45: Q&A

12.00: Walking lunch

PROGRAMME

13.15: Workshops:

- Pitches
  - Thomas Van Hoestenberghe (Fluves)
  - Ruben Props (Ugent)
  - Dominique Corbisier (Engie)
  - Hans-Jürgen Wedemeyer (Lanxess)
  - Emile Cornelissen (UGent)
- IMPROVED researchers (UGent)
  - Steffen Symoens
  - Tim De Seranno
  - Jorien Favere
  - Youri Amerlinck
  - Dorien Gaublomme
- Virtual tour in IMPROVED containers

16.30: Drinks

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The VALUE of our WATER –world

Maarten Everaert
Aquafin

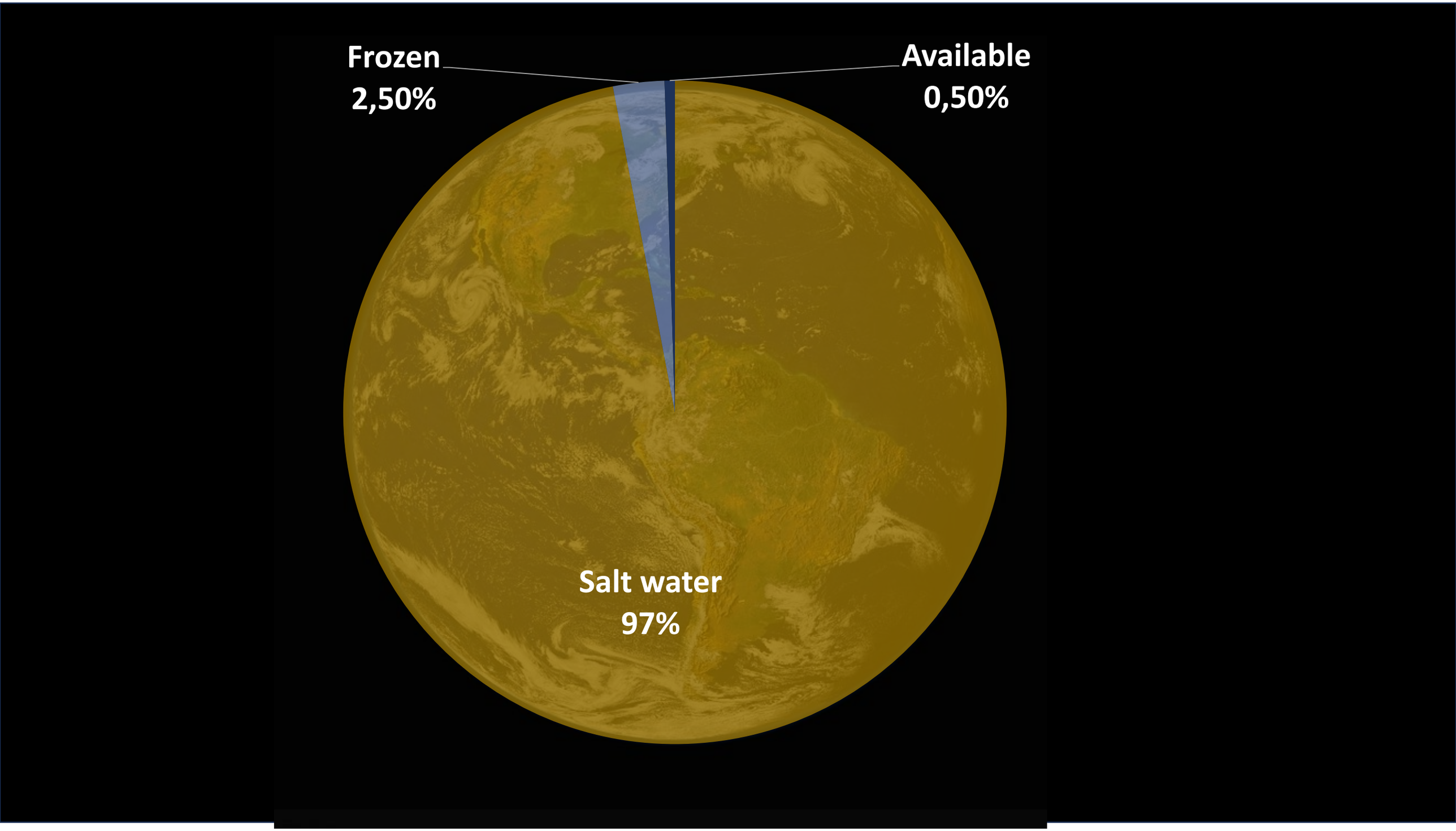
the VALUE of our WATER - world

Maarten Everaert

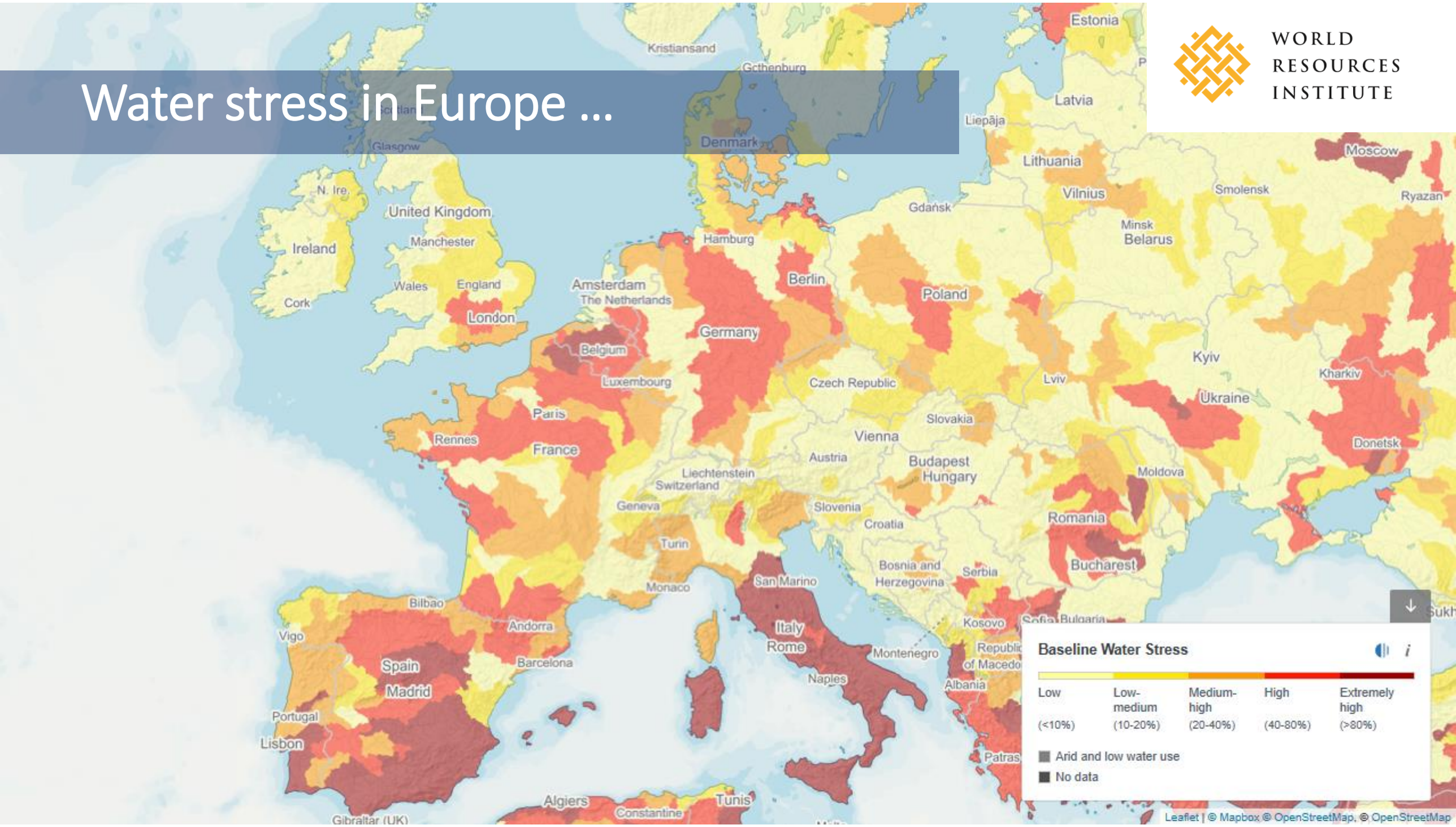
Manager public affairs on water policy

IMPROVED end conference – Interreg - 26/9/2019

www.aquafin.be

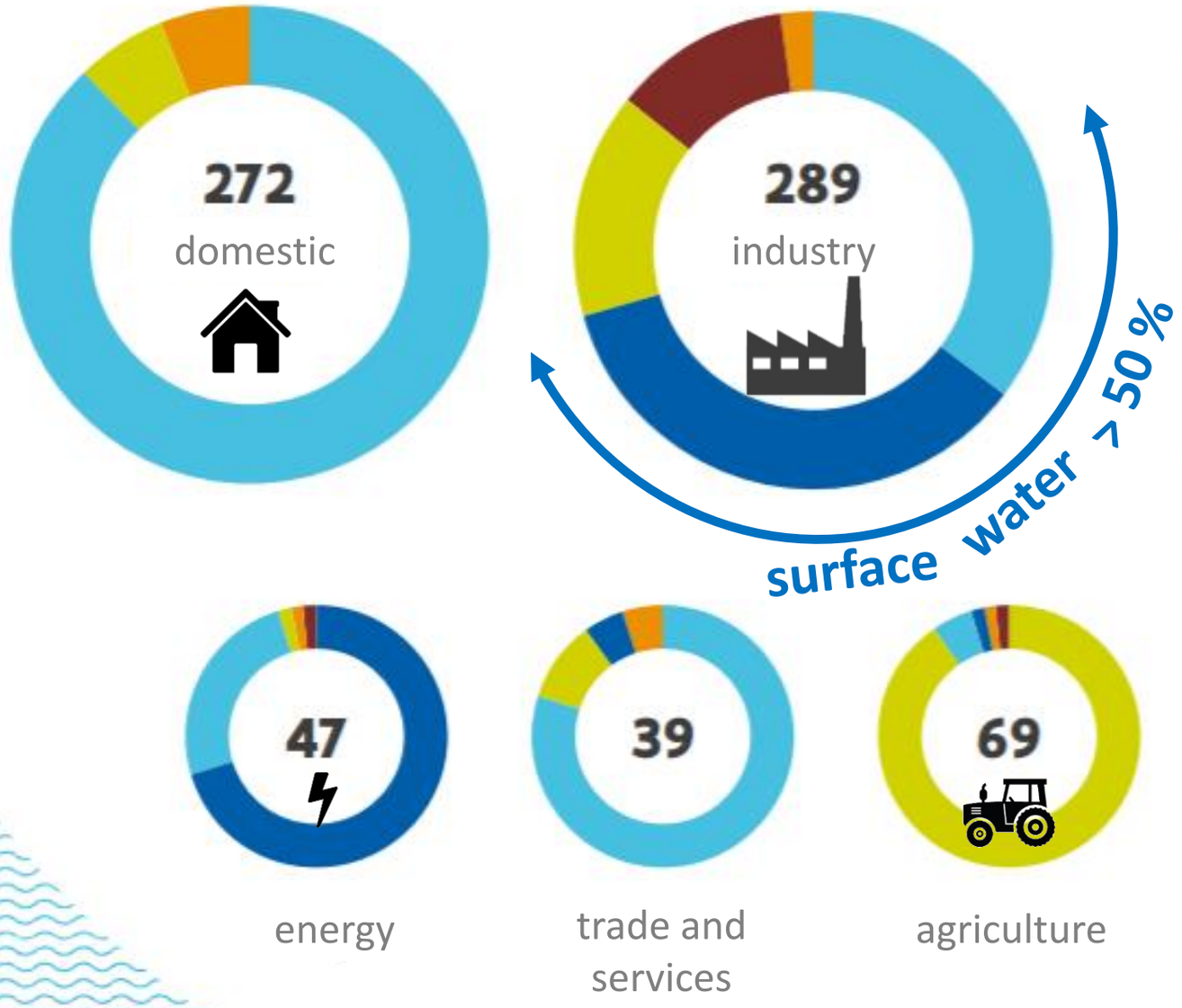

Frozen
2,50%
Available
0,50%
Salt water
97%

Water stress in Europe …



Water DEMAND in Flanders

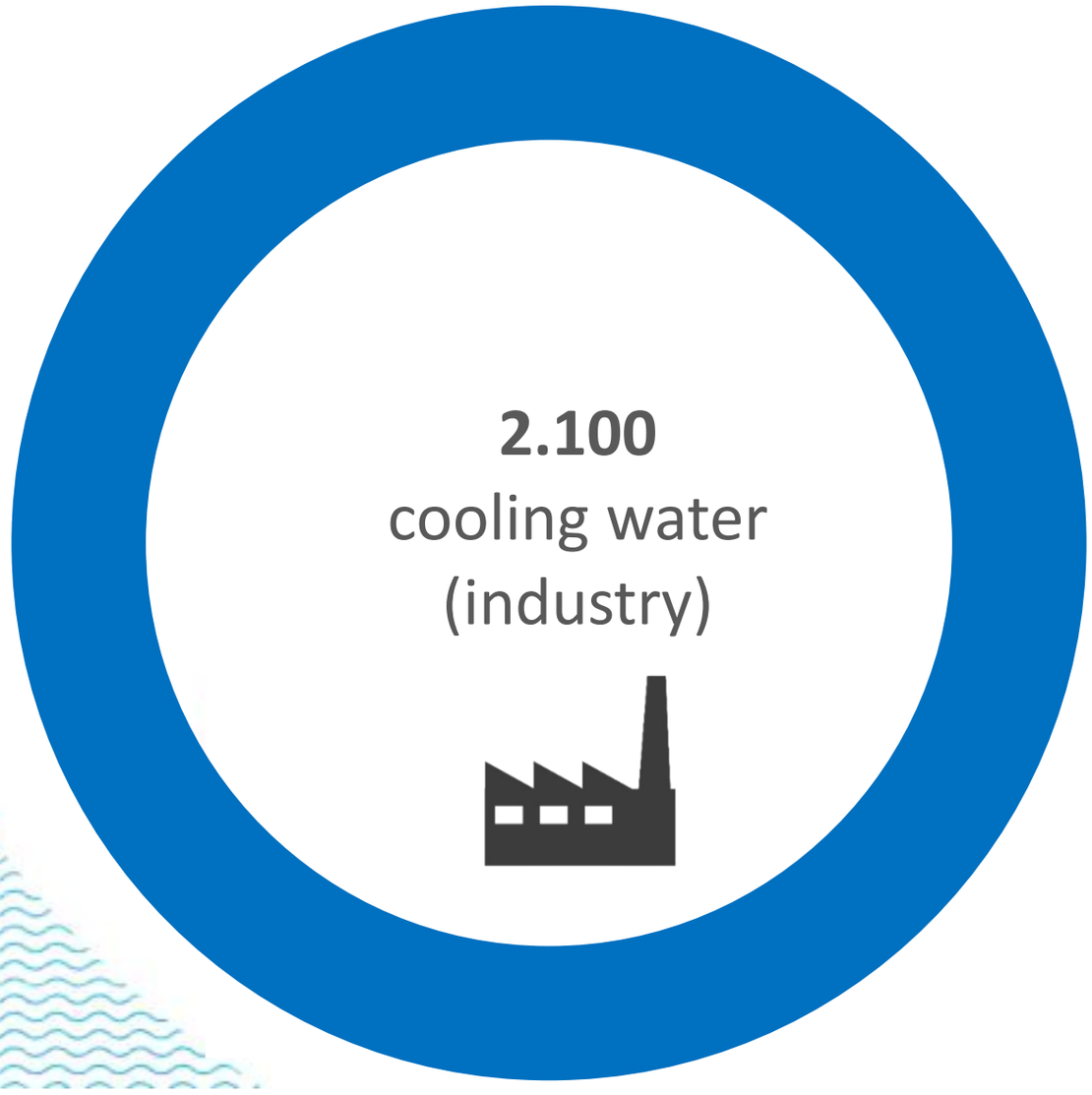
million m³ / Y



Kostbaar water – CIW - 2017

Water DEMAND in Flanders

million m³/ Y



- other water
- rain water
- surface water (excl. cooling water)
- ground water
- drinking water

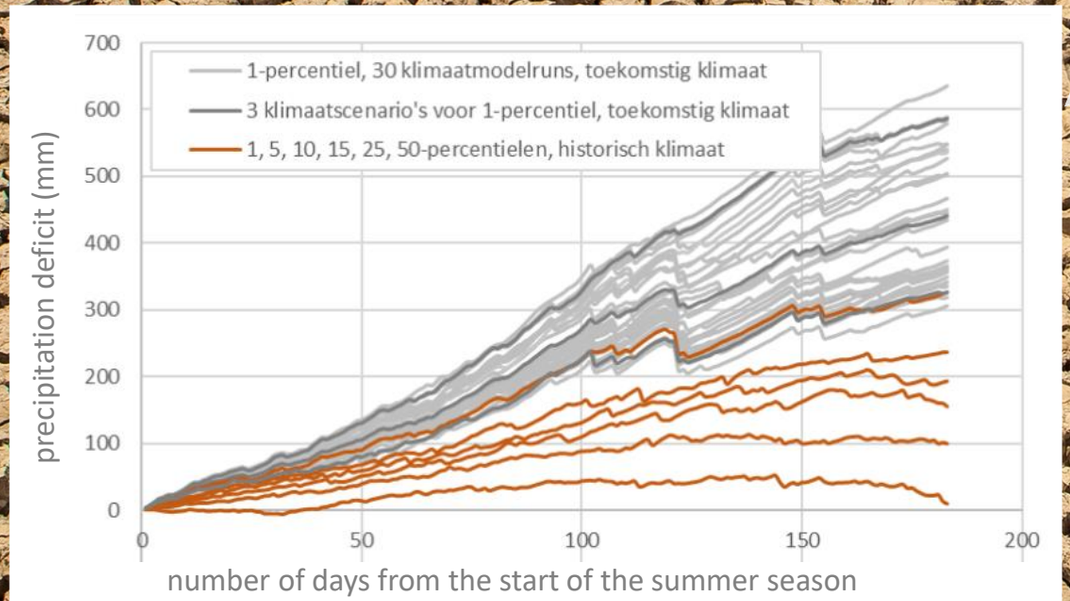
....
Shipping

...
Nature

Climate change

Flanders

extreme drought cfr. 2018
can occur
every 4 to 5 years in 2100



Ref. : Impact van klimaatverandering op meteorologische droogte in Vlaanderen, 2018, VMM

Climate impact on surface water ?

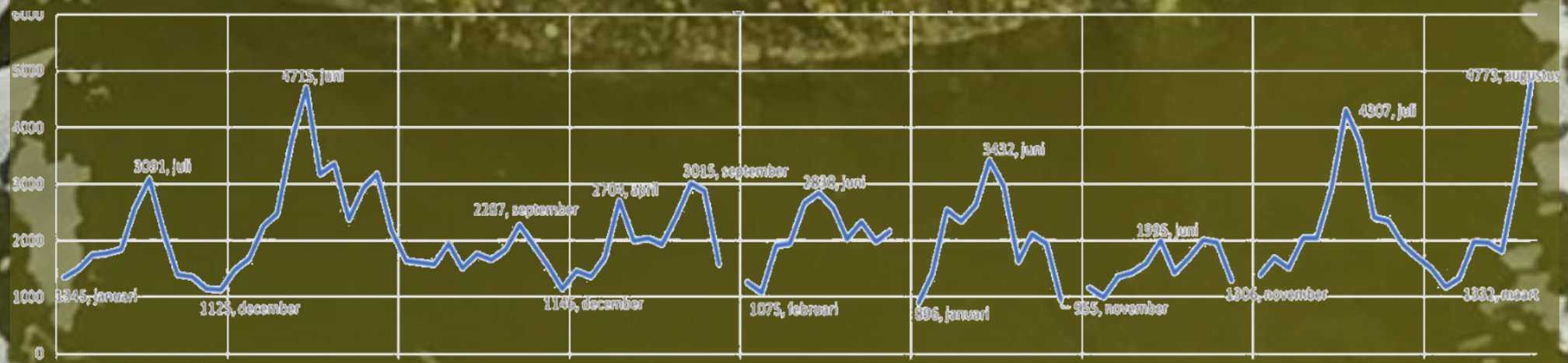
?

20-70% decrease in lowest summer flow

Ref. actualisatie en verfijning klimaatscenario's tot 2100 voor Vlaanderen, MIRA, 2015

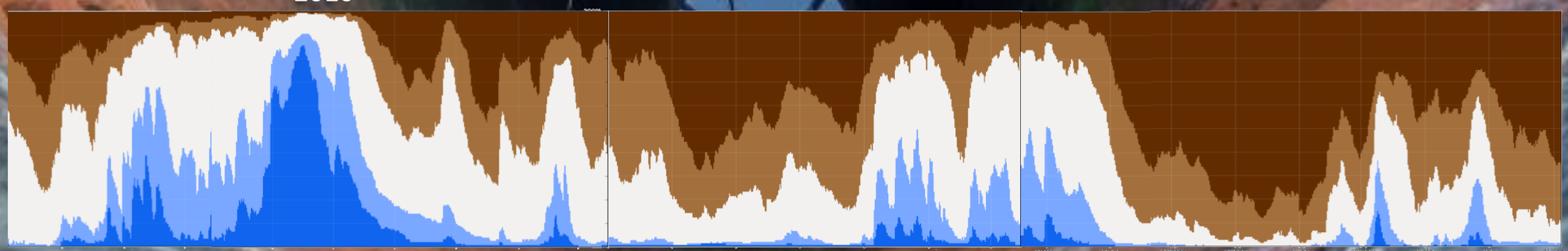
Climate impact on water quality and salination ?

Average conductivity in coastal area of Flanders 2010 - 2018



Ref. CIW, sept. 2018 monitoring geleidbaarheid in de kustpolders

Is ground water an alternative ?



Ref. Databank Ondergrond Vlaanderen, 2019

Opportunities

Water reuse

Treated wastewater - Aquafin – 5 milj m³/y

Co-operation

Opportunities

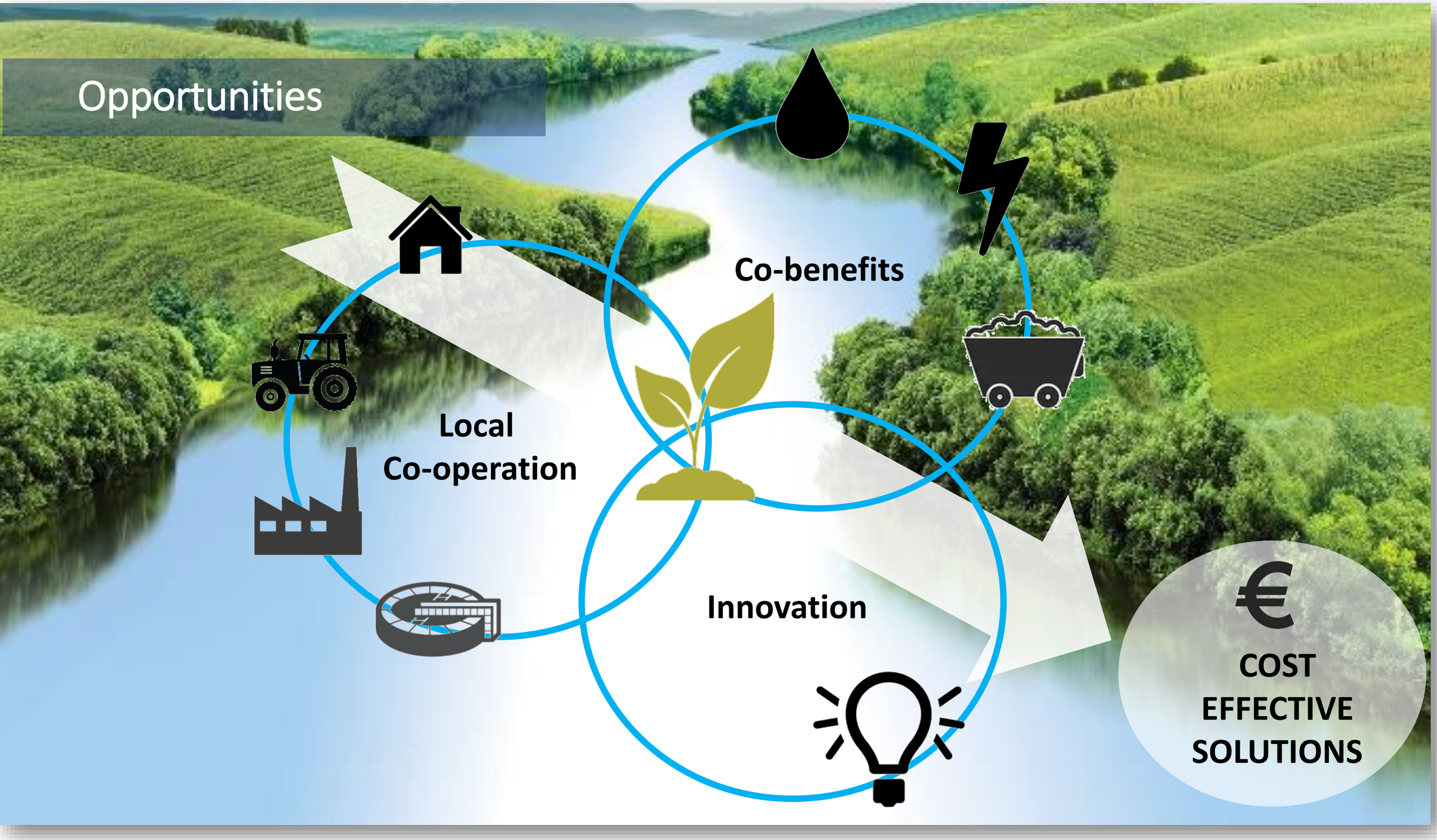
Co-benefits

Co-operation

Circular water + nutrients

ex. Aquafin pilot project Kruit(water)fabriek

Opportunities



More information?

maarten.everaert@aquafin.be

www.aquafin.be

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Welcome

Marjolein Vanoppen
Universiteit Gent

Looking back…

#IMPROVEDWater #InterregVlaNed

72 online meetings – **14** project management meetings

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Europees Fonds voor Regionale Ontwikkeling

250 e-mails last month

± 10 000 e-mails since 1-1-2016

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4 workshops

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120 m² of research infrastructure

Water treated in module 1: **>5 000 000 L**

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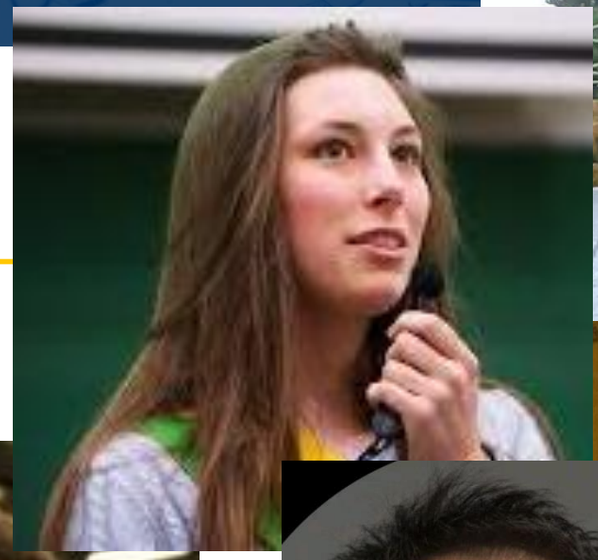
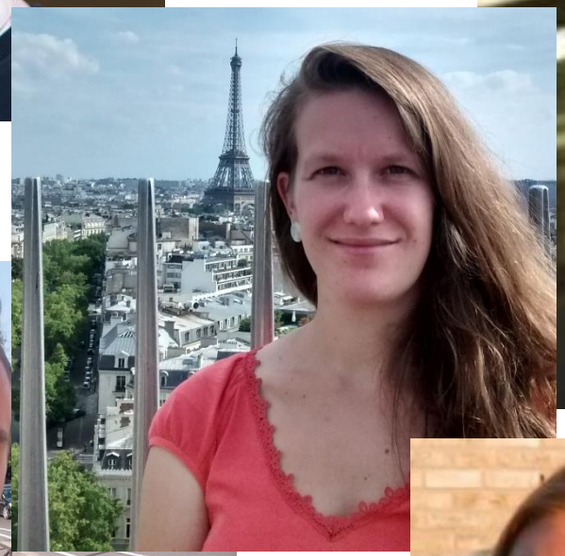
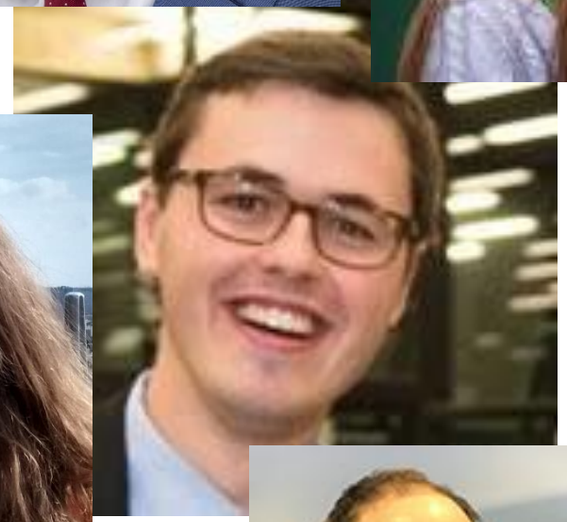
Investigated streams for reuse: **20 000 000 m³/year**

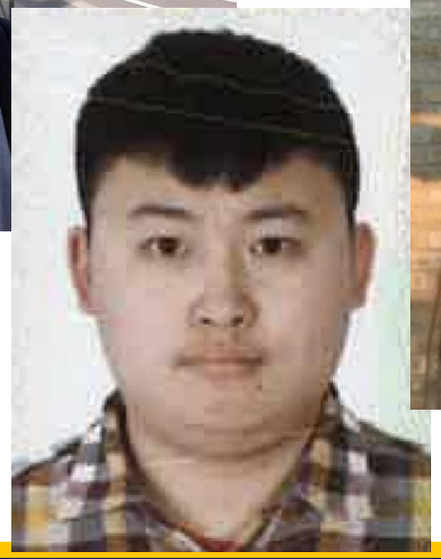


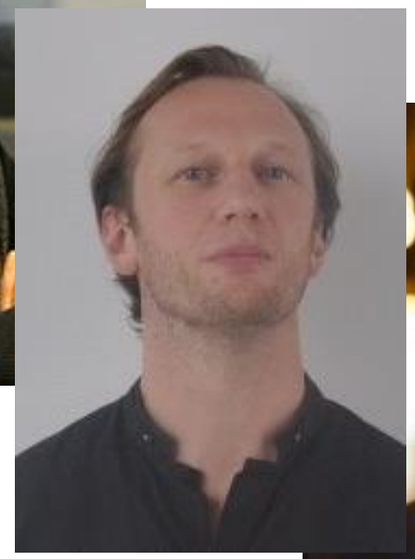





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THANK YOU

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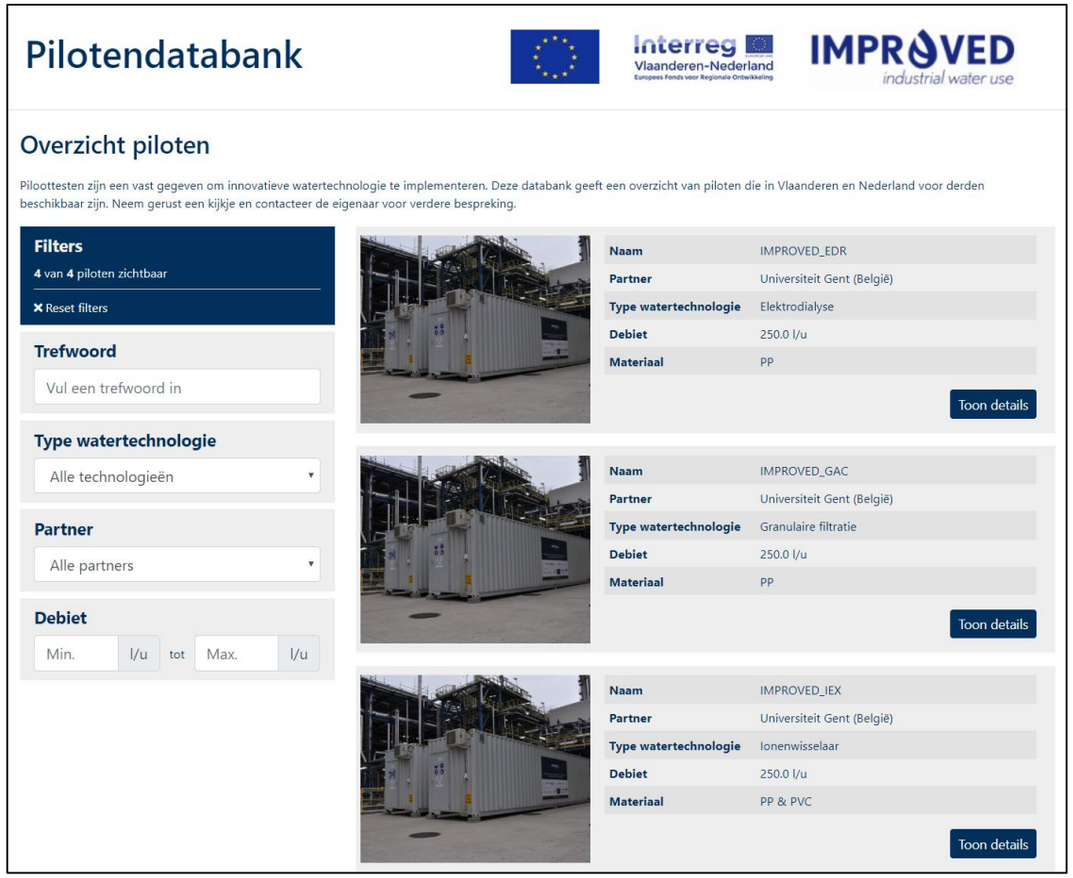
Database water treatment infrastructure

- Apply the circular economy approach to water treatment infrastructure
- https://improvedwater.eu → 'PILOTENDB'



Pilotendatabank

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IMPROVED industrial water use

Overzicht piloten

Piloottesten zijn een vast gegeven om innovatieve watertechnologie te implementeren. Deze databank geeft een overzicht van piloten die in Vlaanderen en Nederland voor derden beschikbaar zijn. Neem gerust een kijkje en contacteer de eigenaar voor verdere bespreking.

Filters

4 van **4** piloten zichtbaar

✖ Reset filters

Trefwoord

Vul een trefwoord in

Type watertechnologie

Alle technologieën

Partner

Alle partners

Debiet

Min. l/u tot Max. l/u

Naam	IMPROVED_EDR
Partner	Universiteit Gent (België)
Type watertechnologie	Elektrodialyse
Debiet	250.0 l/u
Materiaal	PP

Toon details

Naam	IMPROVED_GAC
Partner	Universiteit Gent (België)
Type watertechnologie	Granulaire filtratie
Debiet	250.0 l/u
Materiaal	PP

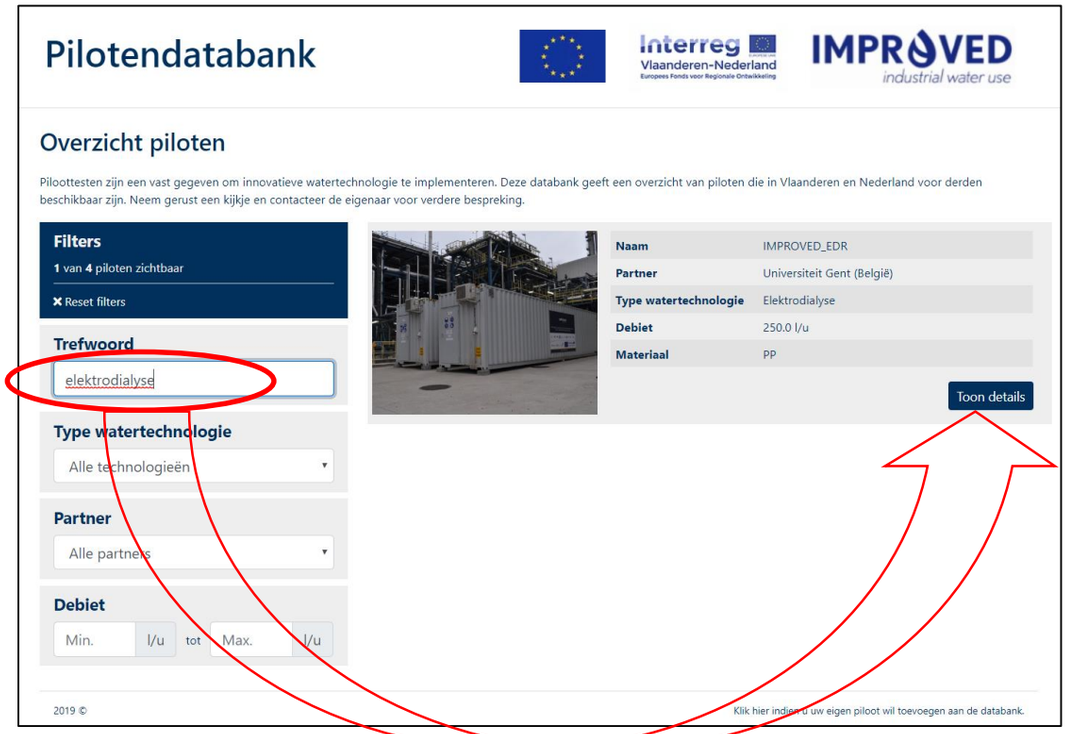
Toon details

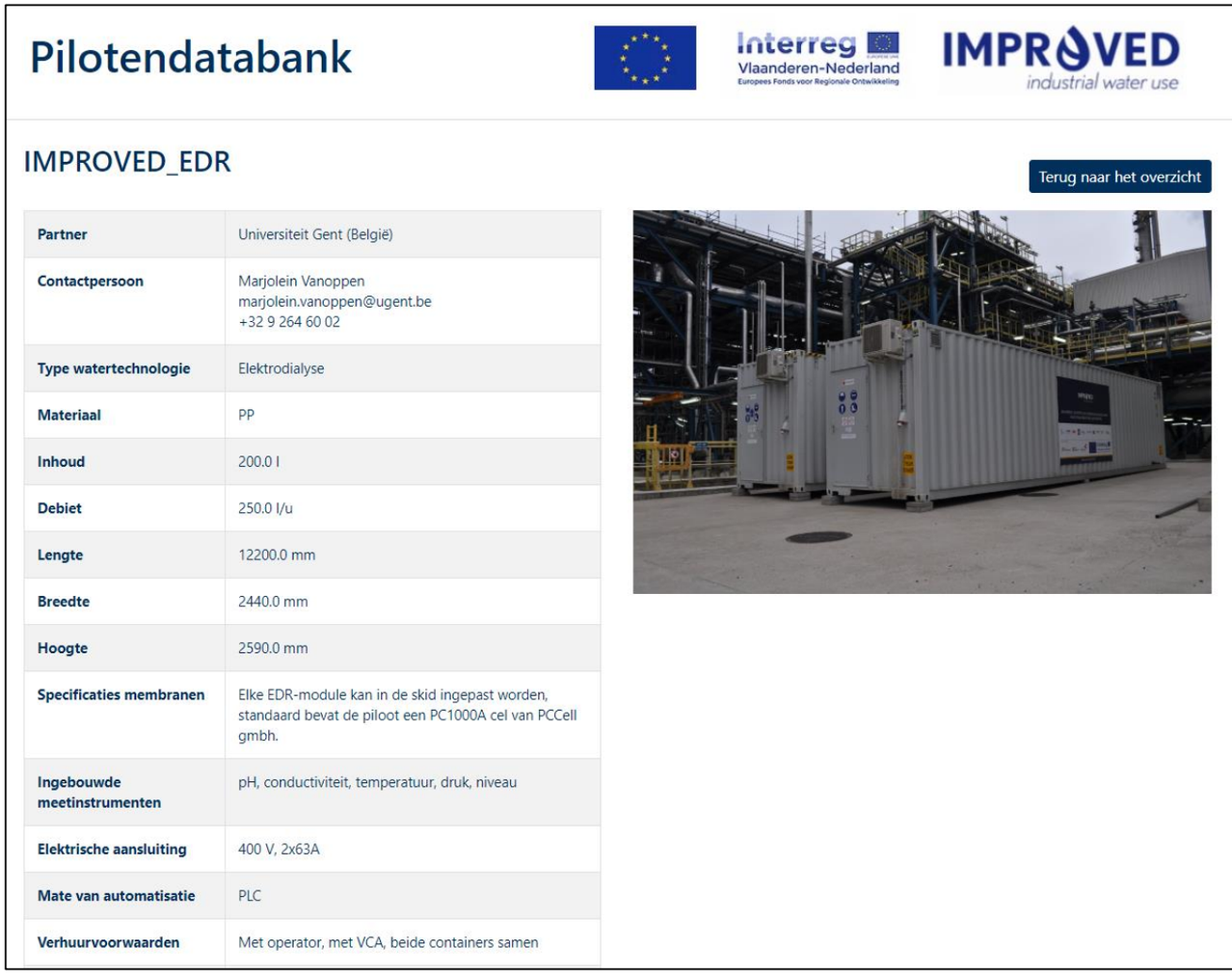
Naam	IMPROVED_IEX
Partner	Universiteit Gent (België)
Type watertechnologie	Ionenwisselaar
Debiet	250.0 l/u
Materiaal	PP & PVC

Toon details

Database water treatment infrastructure

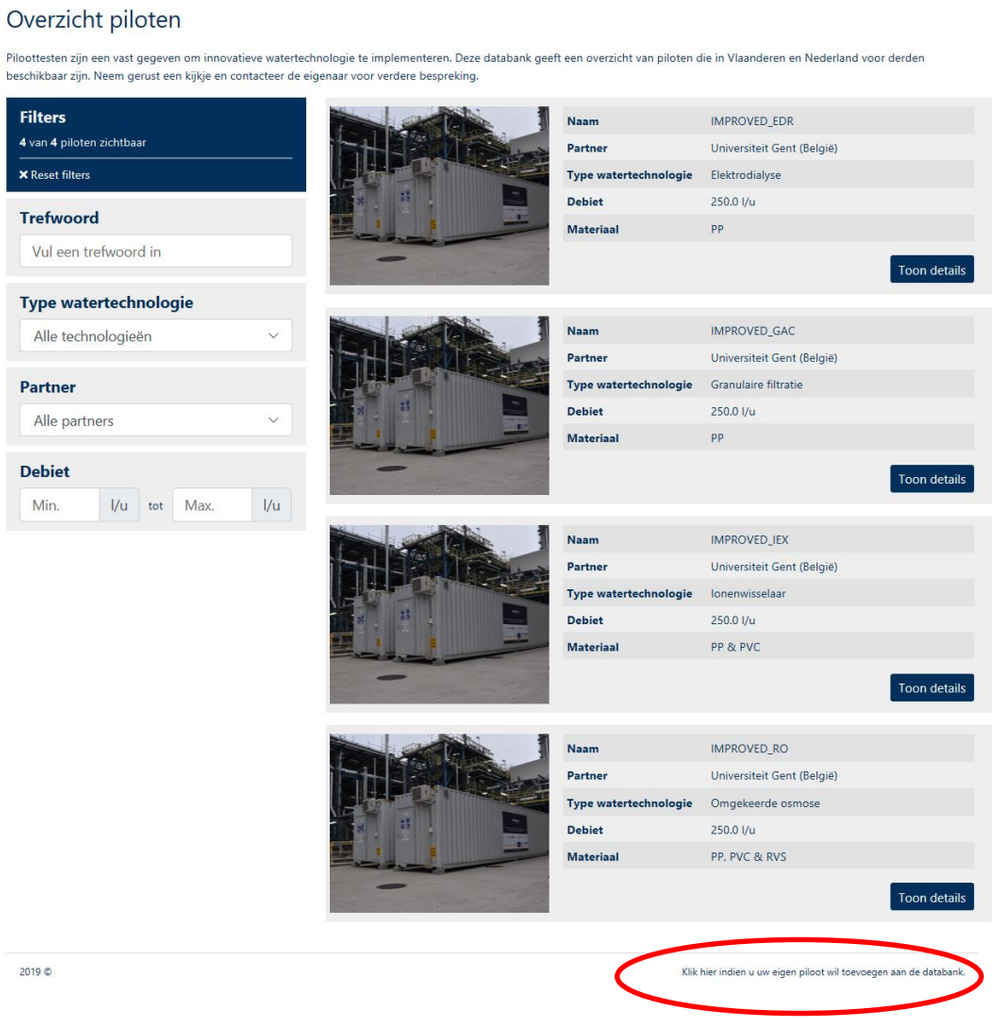
- Find the infrastructure you're looking for





Database water treatment infrastructure

- Infrastructure to offer?



Mail to VLAKWA:

- Name organisation
- Name contact person
- Mail + telnr

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Results & Conclusions

Paul Van Elslande
Yara Sluiskil

YARA

Yara International & Yara Sluiskil B.V. – General information

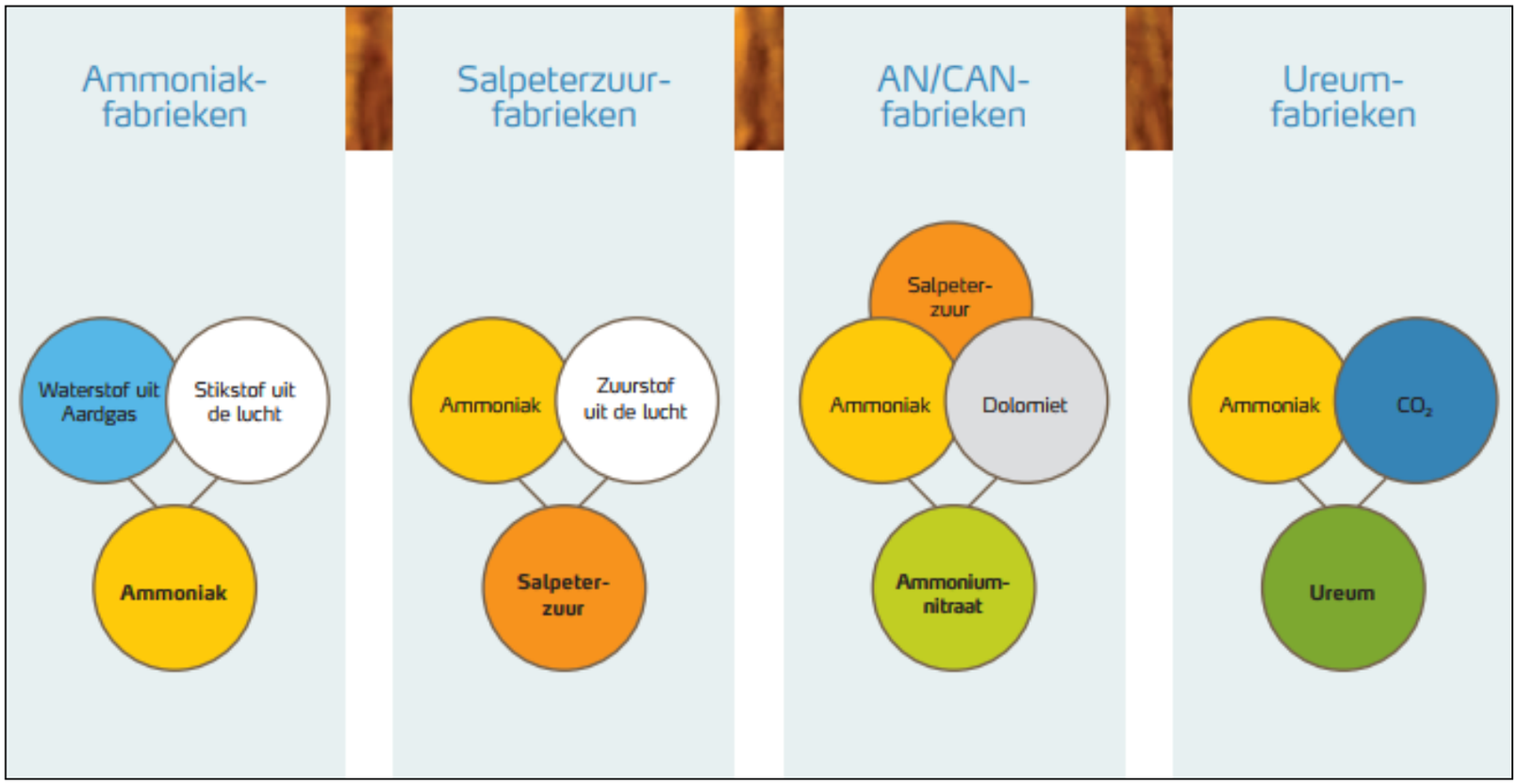
Yara International

- Worldwide ± 17.000 employees
- Head office: Oslo
- Production in 29 countries , present in 52 countries
- Sales in 160 countries

Yara Sluiskil B.V.

- Founded 1929
- ± 600 employees
- Yearly 5 million tons of product
- 2 segments: fertilizer and industrial products
- New urea plant in 2018: Urea with sulphur addition (Amidas)

Yara Sluiskil
Fertilizer Products



Yara Sluiskil
Industrial Products

- **Air 1®** = AdBlue solution
  - ➢ reducing NOx emission trucks with 85 %

- **CO_2**
  - ➢ Delivered (together with residual heat; WarmCO2) towards greenhouses in Zeeuws-Vlaanderen
  - ➢ Also used in soda, beer and medical sector

Yara Sluiskil
Water usage

- Yearly usage of 3.5 million m^3 fresh water, originating from
  - Local groundwater
  - Biesbosch surface water
- Polished water (EVIDES) reused in our production processes
- Demin water used in end product (Air 1®)

PROJECT REVIEW – YARA SLUISKIL

Initial goals

- Test innovative water treatment techniques
- Gather useful information on different (Yara) condensate streams
- Strong local water network

Timeline

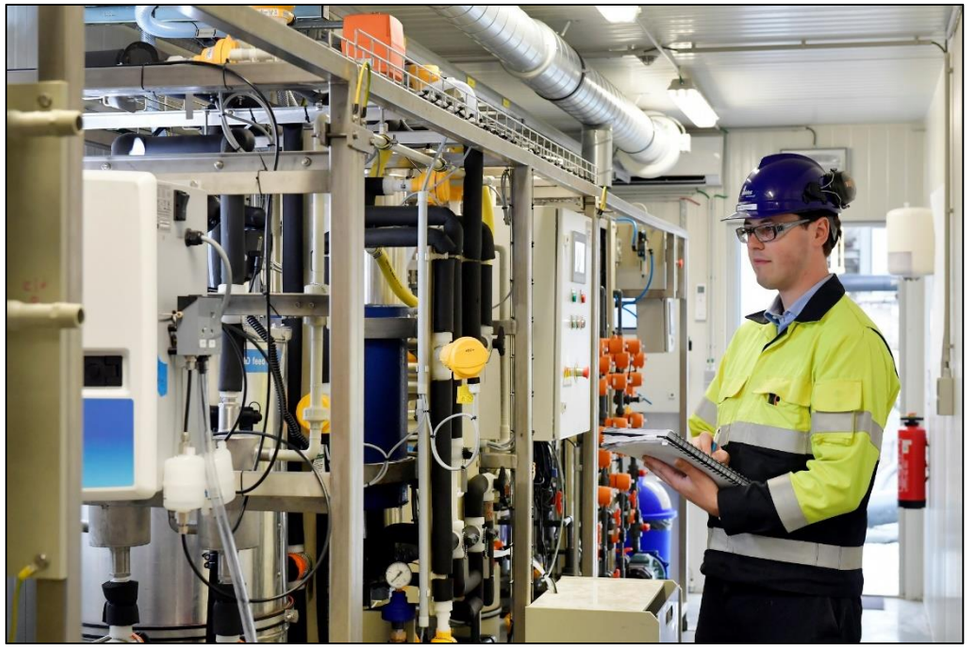
- Started project in 2016
- August 2016 – June 2017: Lab scale tests
- September 2017 – April 2018: Pilot scale tests

Workshop improved @Yara Sluiskil, 18-09-2017

PROJECT REVIEW – YARA SLUISKIL
WATER STREAMS - OVERVIEW

Condensate 1

Parameter	Average value (mg/L)
NH_4^+	10-20
NO_3^-	30-70



Condensate 2

Parameter	Average value (mg/L)
NH_4^+	250-800
MeOH	600-800
MDEA	5-25

PROJECT REVIEW – YARA SLUISKIL
WATER STREAM TESTS: CONDENSATE 1

Main goal
Removal of NH_4^+ and NO_3^-

Parameter	Average value (mg/L)
NH_4^+	10-20
NO_3^-	30-70

Outcome
- Reverse osmosis
  - ➢ Not suitable for this stream due to high fluctuations in effluent quality
- Electrodialysis
  - ➢ Best performer on water production
  - ➢ Decent effluent quality
- Membrane distillation
  - ➢ Best effluent quality
  - ➢ Fluxes very low

PROJECT REVIEW – YARA SLUISKIL
WATER STREAM TESTS: CONDENSATE 2

Main goal
Removal of NH_4^+, methanol and MDEA (solvent for removal of carbon dioxide)

Parameter	Average value (mg/L)
NH_4^+	250-800
MeOH	600-800
MDEA	5-25

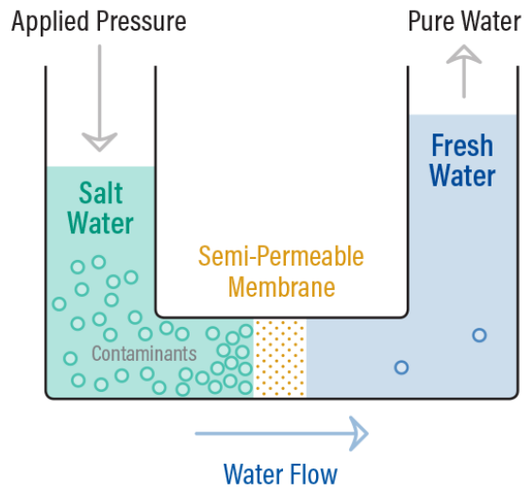
Outcome
- Reverse osmosis
  - Selective MDEA removal
  - NH_4^+ partially concentrated
- Electrodialysis
  - Partially selective MDEA removal
  - NH_4^+ partially concentrated
- Membrane stripping
  - Selective MDEA removal
  - NH_4^+ highly concentrated

PROJECT REVIEW – YARA SLUISKIL
WHAT AFTER IMPROVED?

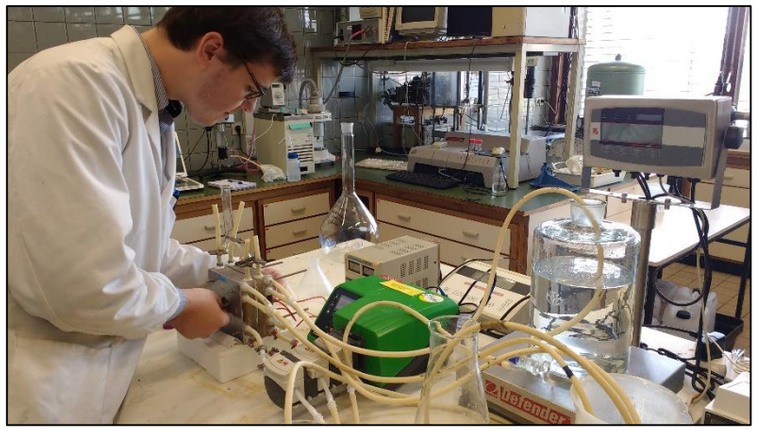
Make use of gathered information to implement techniques on a larger scale →Reverse Osmosis

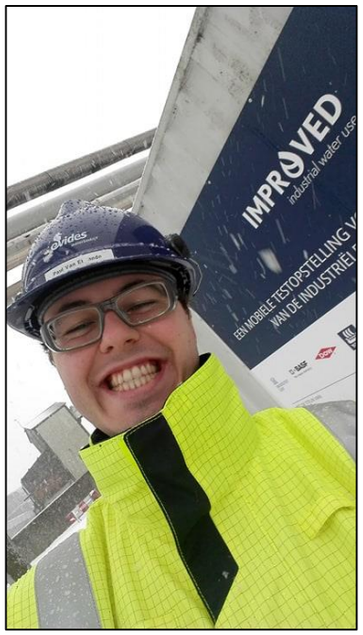
Recent developments:

- Pre-engineering already done to scale up techniques tested within IMPROVED
- Full scale technique (RO) to be implemented on condensate 2 beginning 2020 with:
  - ➢ Reuse of water, Nitrogen and MDEA (within Ammonia plants)
  - ➢ Reduction of Nitrogen discharge waste water of 25 up to 50 %



PROJECT REVIEW
THE END – LOTS OF FUN!





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Results & Conclusions

Kristof De Neve
BASF Antwerpen

BASF
The Chemical Company

IMPROVED @ BASF Antwerp

Interest BASF Antwerp in IMPROVED

- Process water & Demineralized water production @ BASF Antwerp
- Why? → negative effects surface water

Results & conclusions IMPROVED

- (Process) Demineralized water treatment (Biesbosch water)
- Return condensate treatment
- Process condensate: re-use

Future perspectives

- New demineralisation plant with optimized treatment
- New concept condensate treatment

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BASF
We create chemistry

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BASF Antwerp at a glance

# Employees	3.159
Total site surface	598 ha
Turnover	6,06 billion EUR
# Plants	54
Internal roads	60 km
Internal railways	44 km
Pipelines (above ground)	580 km
Gas consumption (vs Belgian consumption)	4.1%
Electricity consumption (vs Belgian consumption)	3.2%
Water consumption	1500 m^3/h

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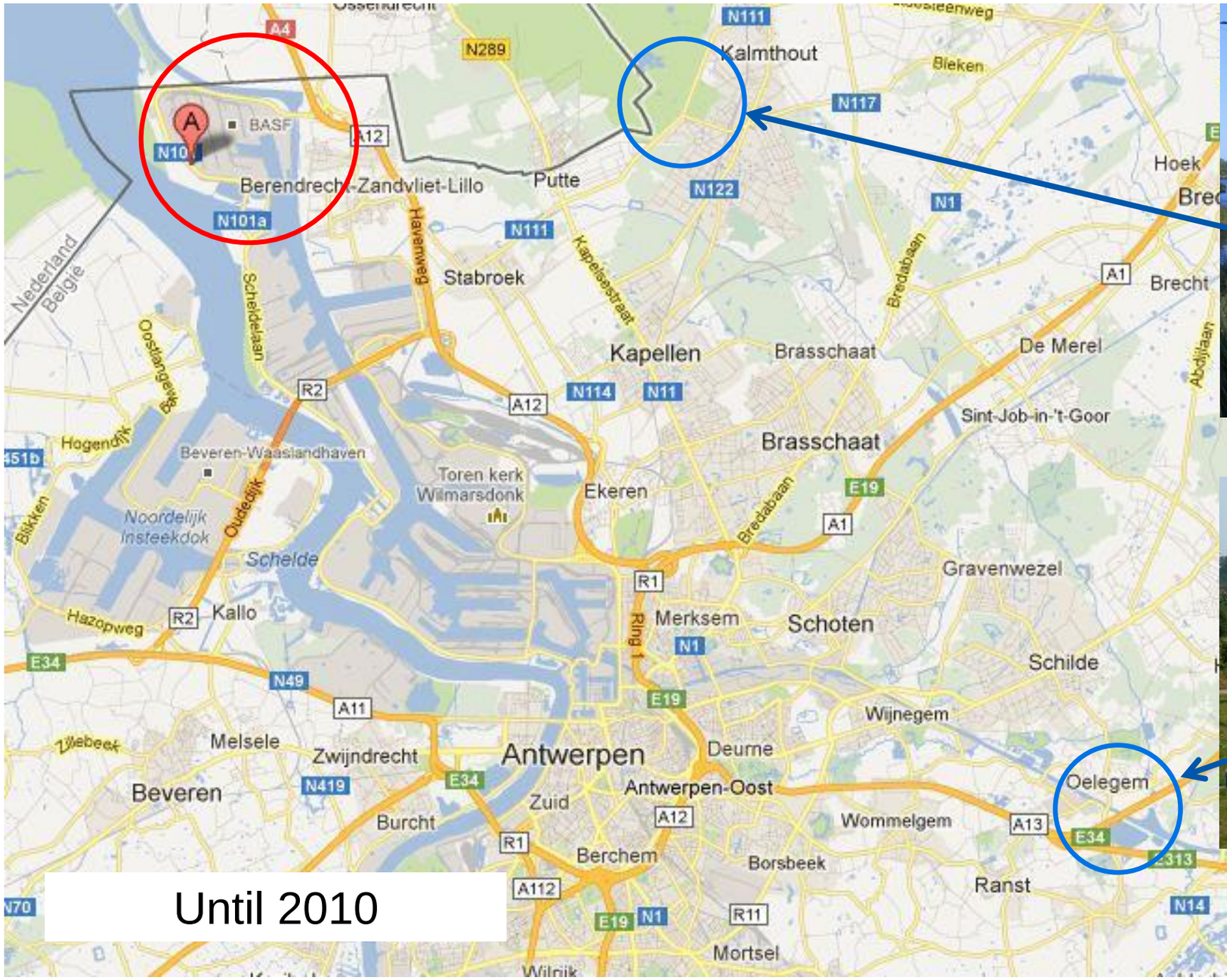
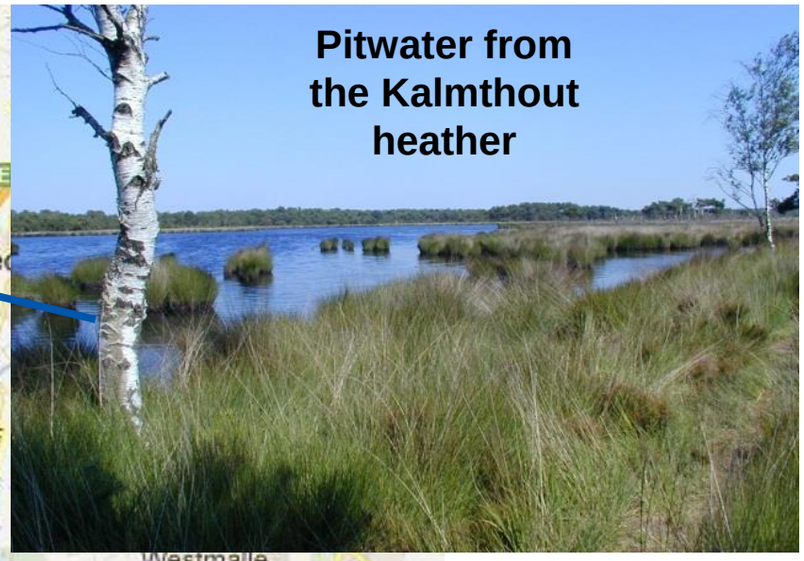
INTEREST BASF ANTWERP IN IMPROVED

Drinking water → Surface water Biesbosch



Until 2010



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INTEREST BASF ANTWERP IN IMPROVED

Drinking water → Surface water Biesbosch

Grevelingenmeer
Middelharnis
Zuid-Beijerland
Strijen
Numansdorp
Nieuwe Merwede
De Biesbosch
Amer
Raamsdonk
Made
Oude-Tonge
Willemstad
Hollands Diep
Helwijk
Moerdijk
Klundert
Volkerak
Krammer
Dinteloord
Fijnaart
Zevenbergen
Terheijden
Breda
Oosterschelde
Steenbergen
Oudenbosch
Etten-Leur
Veerse Meer
Bolnes
Halsteren
Roosendaal
Rucphen
Sint Willebrord
Wemeldinge
Goes
Yerseke
Kapelle
Markiezaatsmeer
's-Gravenpolder
Kruiningen
Krabbendijke
Rilland
Hoogerheide
Kloosterzande
Zundert
Terneuzen

Since 2011

Benefits

1. Reliable and redundant supply of Process water
2. Decreased production cost for Process water
3. Sustainability: reduction drinking water consumption & no more use ground water for industrial processes

Water management @ BASF Antwerp

± 1500 m³/h

90%
1000 m³/h BASF
400 m³/h Evides

± 1300 m³/h

Process water

DEMIN cold

<1%

70%

GDW warm

70%

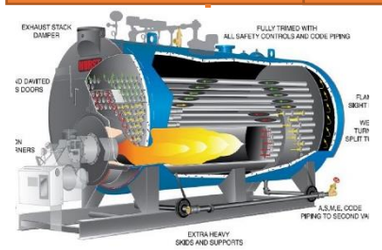
STEAM

LD
HD

80%
20%

Condensate Return

Condensate loss



10%

30%

Direct to production plants

High DEMIN quality needed

INTEREST BASF ANTWERP IN IMPROVED

In 2011 : switch from drinking to surface water sourcing
→ More organics in process water

MIC = Microbial Induced Corrosion

Ongereinigd

Gereinigd

Results & conclusions IMPROVED

Application 1: BB water treatment optimization

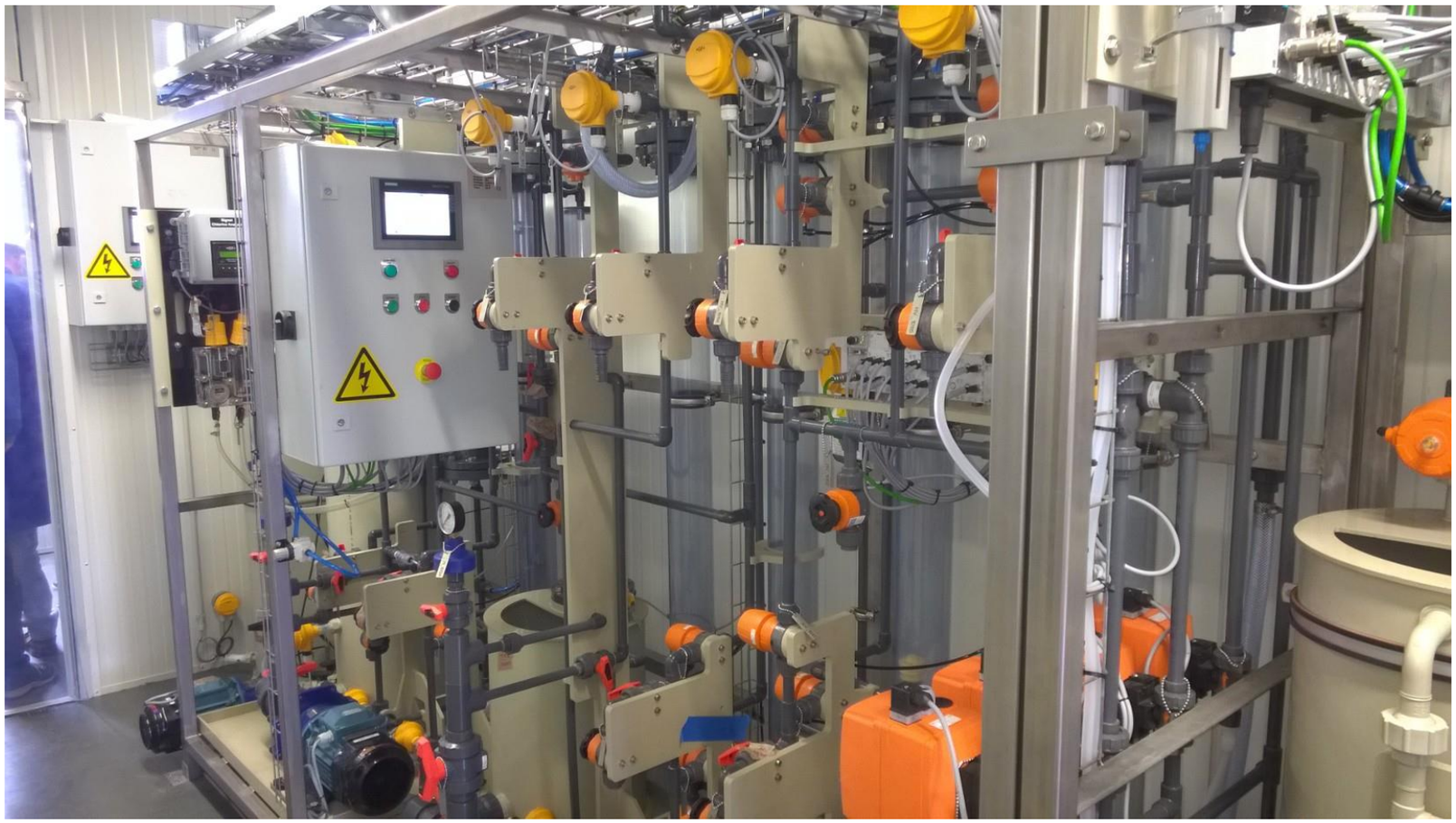
→ GOAL: TOC reduction in DEMIN water

→ GOAL: meet specifications high pressure steam quality

- Pilot test from 24/05 till mid November 2018
- IX-MB, RO, MD & EDR tested
- UF, GAC & AOP not tested (unavailable or low potential)

Results & conclusions IMPROVED

Application 1: BB water treatment optimization



- ❑ RO: stable performance
- ❑ Antiscalant needed
- ❑ 75% recovery

- ❑ IEX: reference treatment
- ❑ Good performance

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Results & conclusions IMPROVED

Application 1: BB water treatment optimization

- ❑ MD: stable operation
- ❑ No membrane fouling

- ❑ EDR: membrane leakage
- ❑ Extra pretreatment needed (UF)

Results & conclusions IMPROVED

Application 1: BB water treatment optimization

	SEC (kWh/m³)	Recovery %	Conductivity µS/cm	TOC (Rejection) µg/l	CapEx (M€)	OpEx/year (M€)
IEX	0.02	96	2.1	130-200 (90-95%) (after MB)	2.5	1.89
RO	0.23	75	8.2	46 (98%)	2.0	1.08
MD	0.68	25	4.2	87 (95%)	23	4.63
EDR	0.09	95	384	2388 (0%)	4.3	0.65

SEC: specific energy consumption

Included in the calculation	Excluded from the calculation
Media (resins, membranes, etc.)	Engineering costs
(Pressure) Vessels	Hours for building
Pumps	Raw water costs
Chemical storage and dosing	Discharge costs
Piping and valves	Permits and inspections
Electrics and instrumentation	Risk and profits
Civil costs	Sampling and analysis
Process automation	Man hours for operation
Chemicals	Redundancy
Electricity	Power supply from grid
	Transformers
	Frequency drives and MCC's
	Neutralization

- All technologies except EDR provide good end quality
- RO lowest TOC; IEX seasonal variations
- EDR: potentially interesting as pretreatment IX (low SEC)

Results & conclusions IMPROVED

Application 2: Return condensate treatment

→ GOAL: reliable & alternative technology
→ GOAL: decrease # regenerations with chemicals (HCl, NaOH)

- Return condensate already good quality (DCC, SiO_2)
  - MB: reference treatment (frequent regeneration NH_3)
  - RO: stable performance, 85% recovery, no NH_3 rejection, no antiscalant
  - SAC-MB: cation exchanger as pretreatment (NH_3)
  - EDR: membrane fouling

	SEC (kWh/m³)	Recovery %	Conductivity µS/cm	TOC µg/l	CapEx (M€)	OpEx/year (M€)
RO	0.21	85	10.7 0.22 DCC	41	1.3	0.48
MB	-	> 95	< 0.4 DCC	36	0.8	0.27
SAC-MB	-	> 95	0.11 DCC	39	1.2	0.32
EDR	0.05	90	2.4	95	2.6	0.36

Results & conclusions IMPROVED

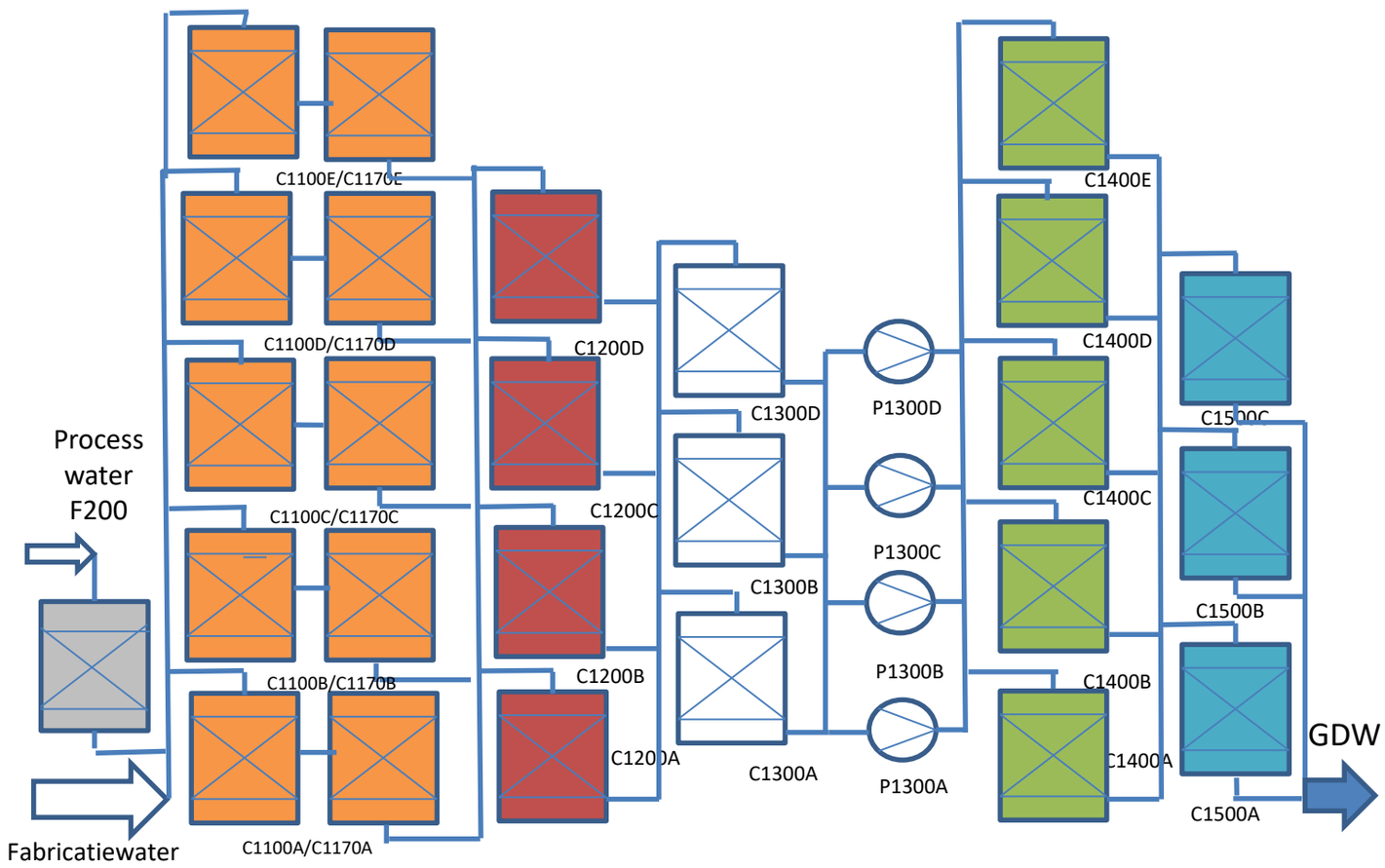
Application 3: Process condensate treatment

- Re-use process condensate as process water
  - Actual treatment: GAC
  - Low rejection of LMW organics (methanol, IPA, acetone, t-Butanol)
  - RO: stable performance, 75 - 85% recovery, good permeate quality
  - RO: TOC rejection 80%, membrane fouling (Fe)
  - MS: possible membrane leakage, unreliable results

	SEC (kWh/m³)	Recovery %	Conductivity µS/cm	TOC (Rejection) µg/l	CapEx (M€)	OpEx/year (M€)
RO	0.28	85	11.2 0.18 DCC	103 (78%)	0.7	0.10
MS	0.16	100	-	-	4.3	0.69

Future perspectives

Actual treatment DEMIN plant



- ❑ Since 1969 operational
- ❑ Expansion I: 1974 – 1978
- ❑ Expansion II: 80’s
- ❑ Defective rubber lining
- ❑ Best suited for drinking water

Future perspectives

Optimized treatment for new DEMIN plant

Process condensate

1295 m³/h

Process water BB

tank

Demin water HQ

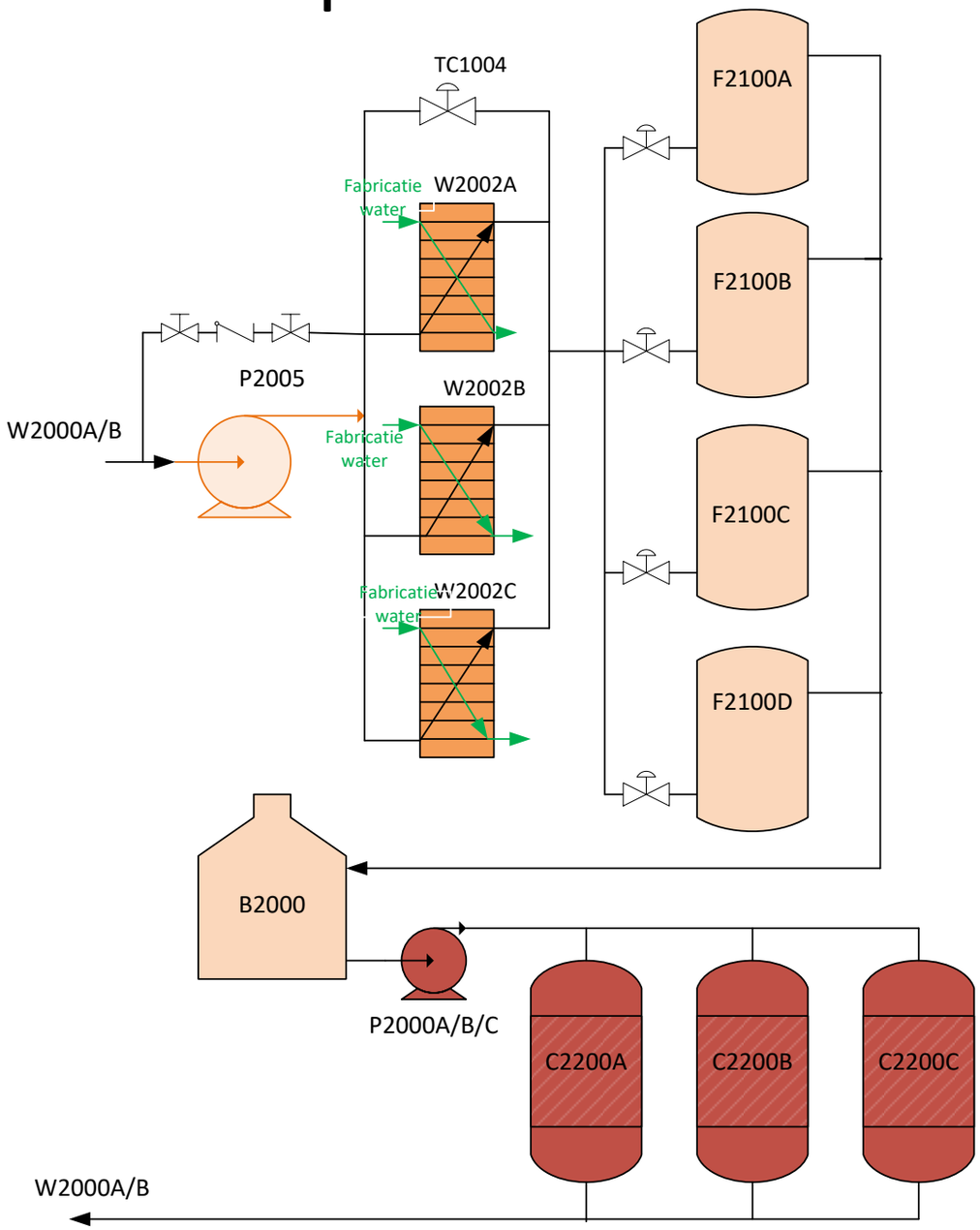
1050 m³/h

Q2 2022

Future perspectives

Actual treatment return condensate plant

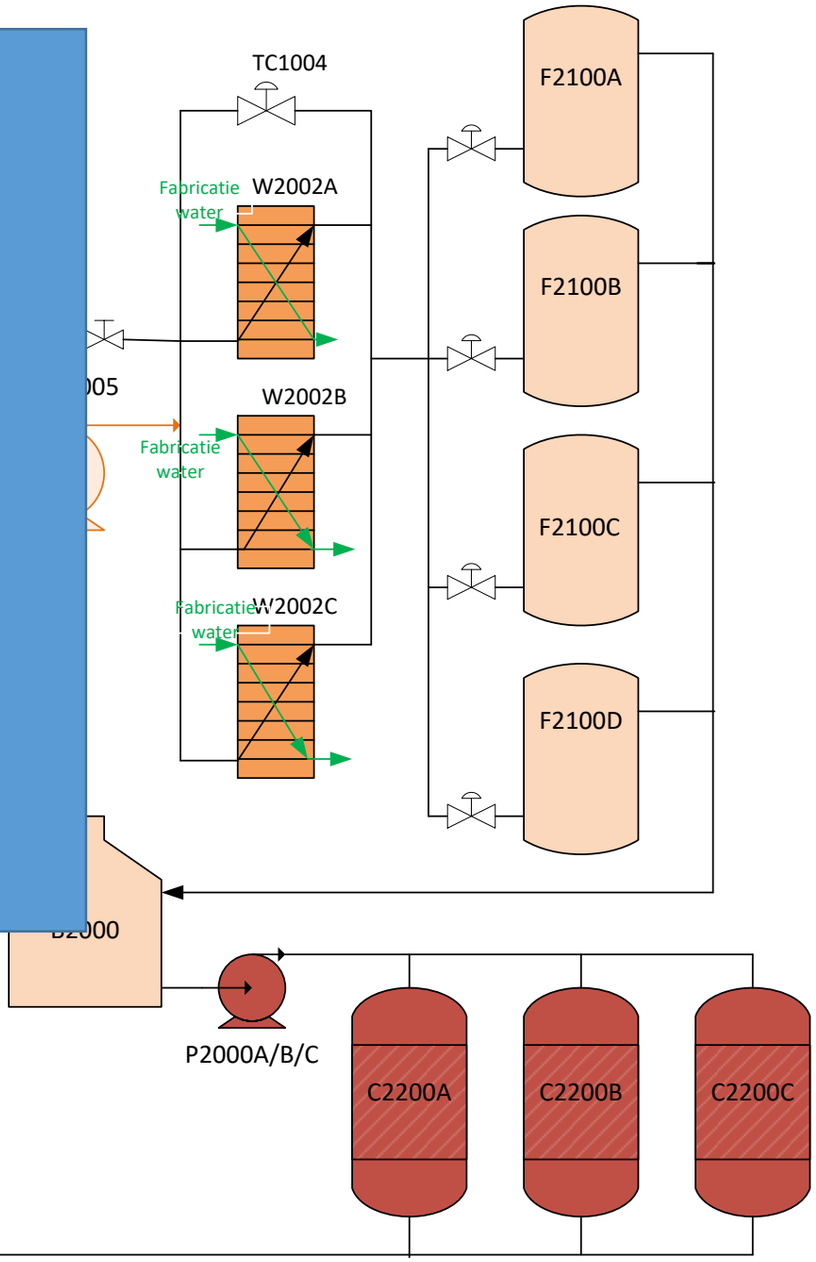
- ❑ Since 1980 operational
- ❑ Defective rubber lining
- ❑ High operational costs (regeneration)



Future perspectives

Optimized treatment new return condensate

- ❑ SAC - MB
- ❑ EDI
- ❑ …



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BASF

We create chemistry

Interreg Vlaanderen-Nederland

Europees Fonds voor Regionale Ontwikkeling

IMPROVED @ BASF Antwerp

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industrial water use

Results & Conclusions

INTEGRALE
MOBIELE
PROCESWATERVOORZIENING
VOOR EEN
ECONOMISCHE
DELTA

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Vlaanderen-Nederland
Europees Fonds voor Regionale Ontwikkeling

Niek van Belzen
Dow Benelux BV

IMPROVED @ DOW

Content

- Introduction Dow
- Why did we participate
- Our contributions
- Initial conclusions from the testperiod at Dow
- Future plans

Industry Park “Dow Terneuzen”

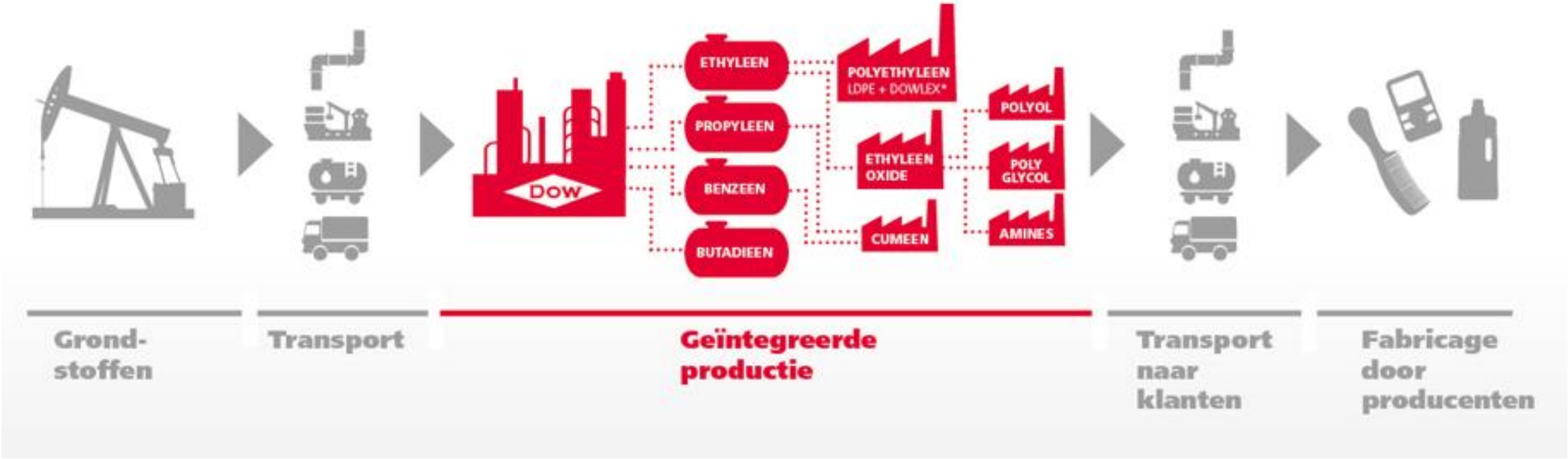
Different companies

- Dow
- Trinseo
- Olin
- Maschem

- 3000+ employees on I-park
- 440 hectare

- Dow Terneuzen
  - 17 production plants
  - >800 different products
  - 85% export

Production processes Dow Terneuzen



Dow's ambition

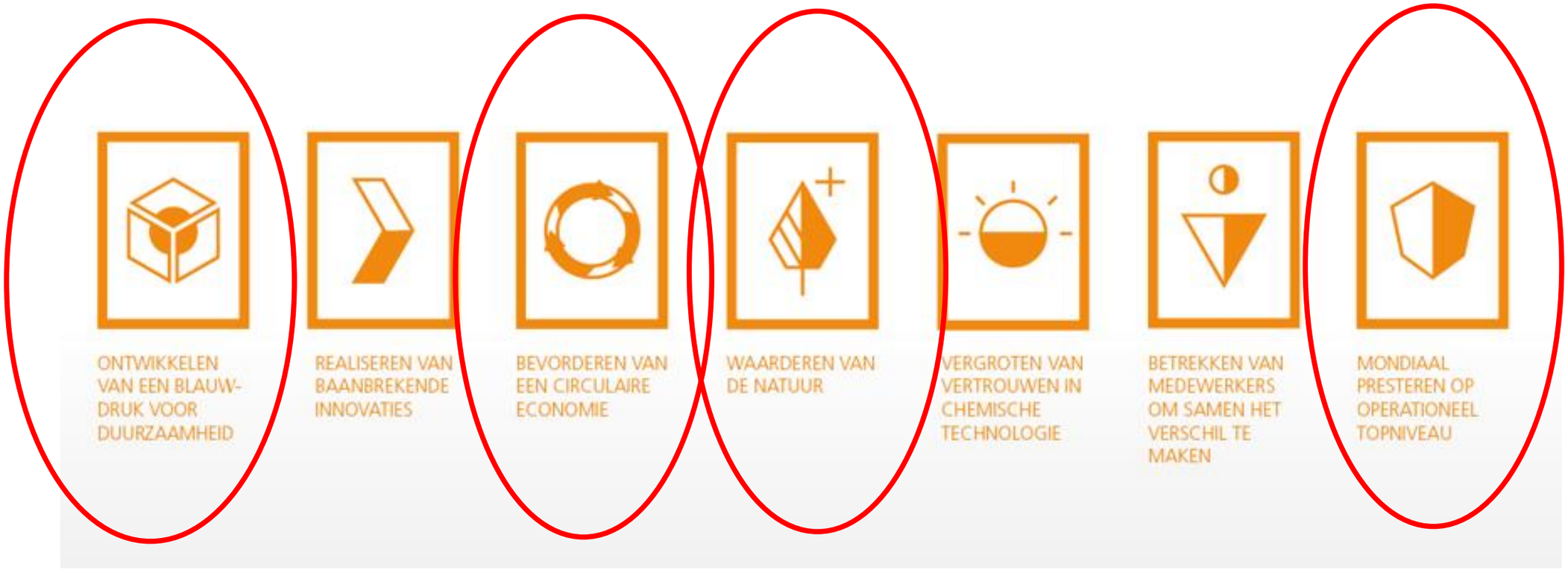
We want to become the most innovative, customer-centric, inclusive and **sustainable** materials science company in the world. Our goal is to deliver value growth and best-in-class performance.

"In everything we do, we strive for positive impact on society and the planet"

DOW®

Seek Together™

Dow's 2025 Sustainability goals



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Dow Terneuzen:
As bulk consumer of freshwater in the region Dow strives to a ‘responsible’ use of this scarce natural source.

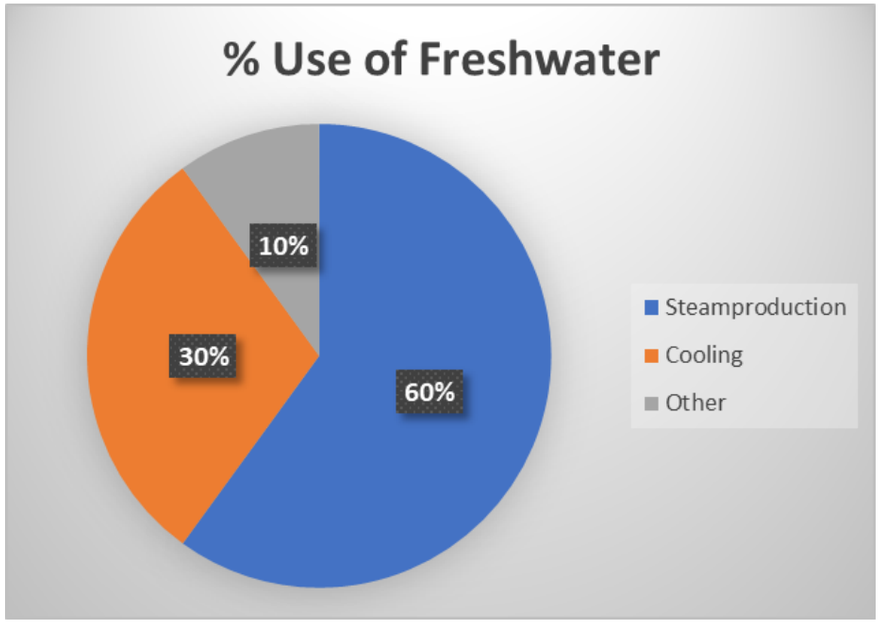
2025 goal : No (structural) import of freshwater from the Biesbosch area by optimizing re-use or us of alternative sources

Industrial water use *

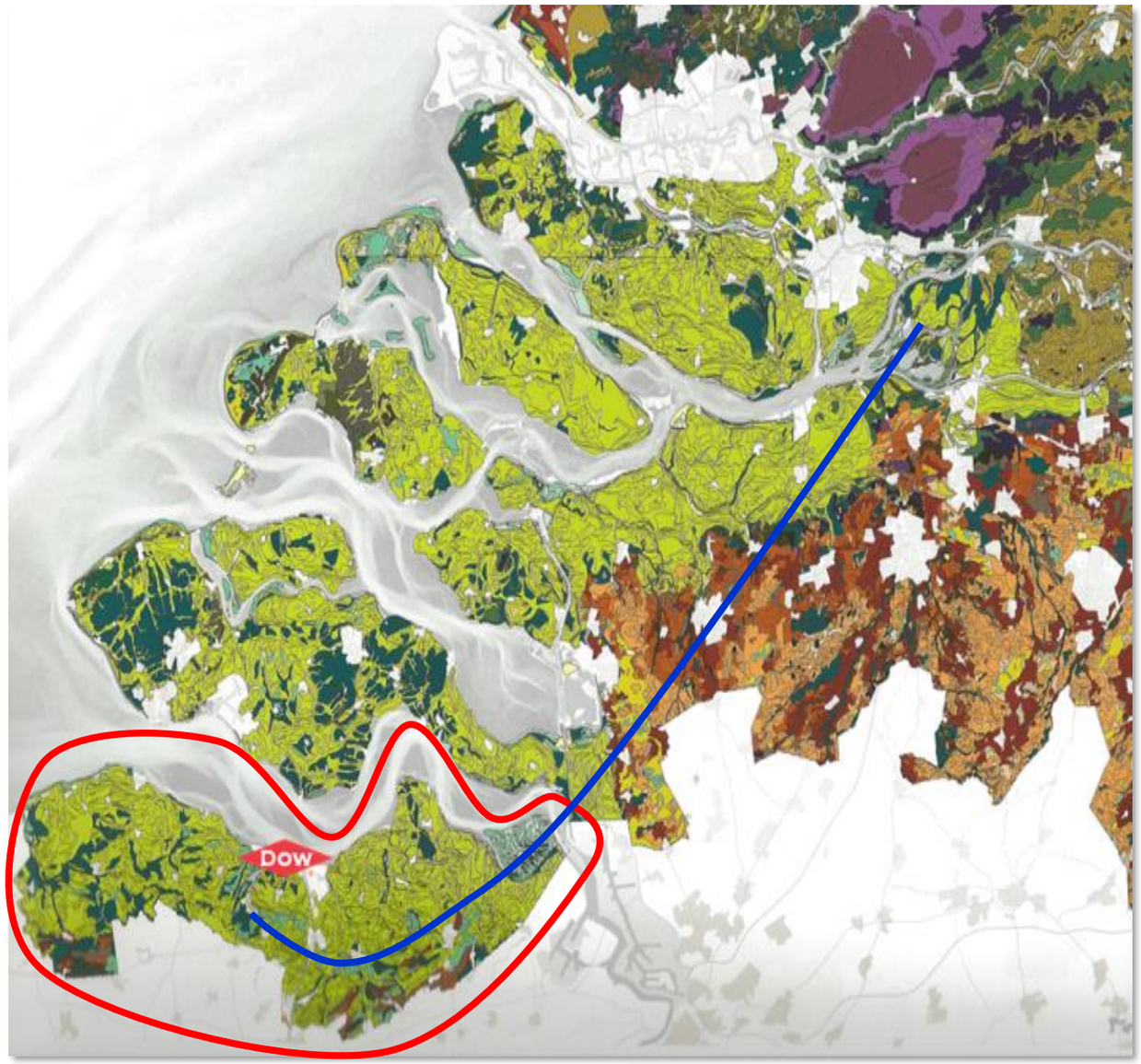
- Seawater – ‘once through cooling’

- Fresh water
  - Firewater
  - Process water – cooling towers, rinsing water, sealwater
  - Drinking water – consumption, sanitary, emergency showers
  - Demi water – products, steamproduction
  - Polished water – high pressure steam

*representative for petrochemical industry



Availability / Quality / Costs



Zeeuws-Vlaanderen

Wat are the local issues ?

- Scarce freshwater in the region
- Surface water and groundwater are “brackish”
- Expected rise of seawater level -> intrusion of salt water
- 1-2 million m^3/yr water sourced from region
- Significant amount of water piped from Biesbosch area (120 km)

What has been done till now to reduce import of freshwater ?

- Optimize/minimize use of water in production plants
- Source reduction to minimize wastewater load to WWTP
- Separation and independent treatment of freshwater and saltwater streams on site
- Re-use of treated freshwater from Dow WWTP as cooling water
- Use of effluent from WWTP Terneuzen city to produce demi water

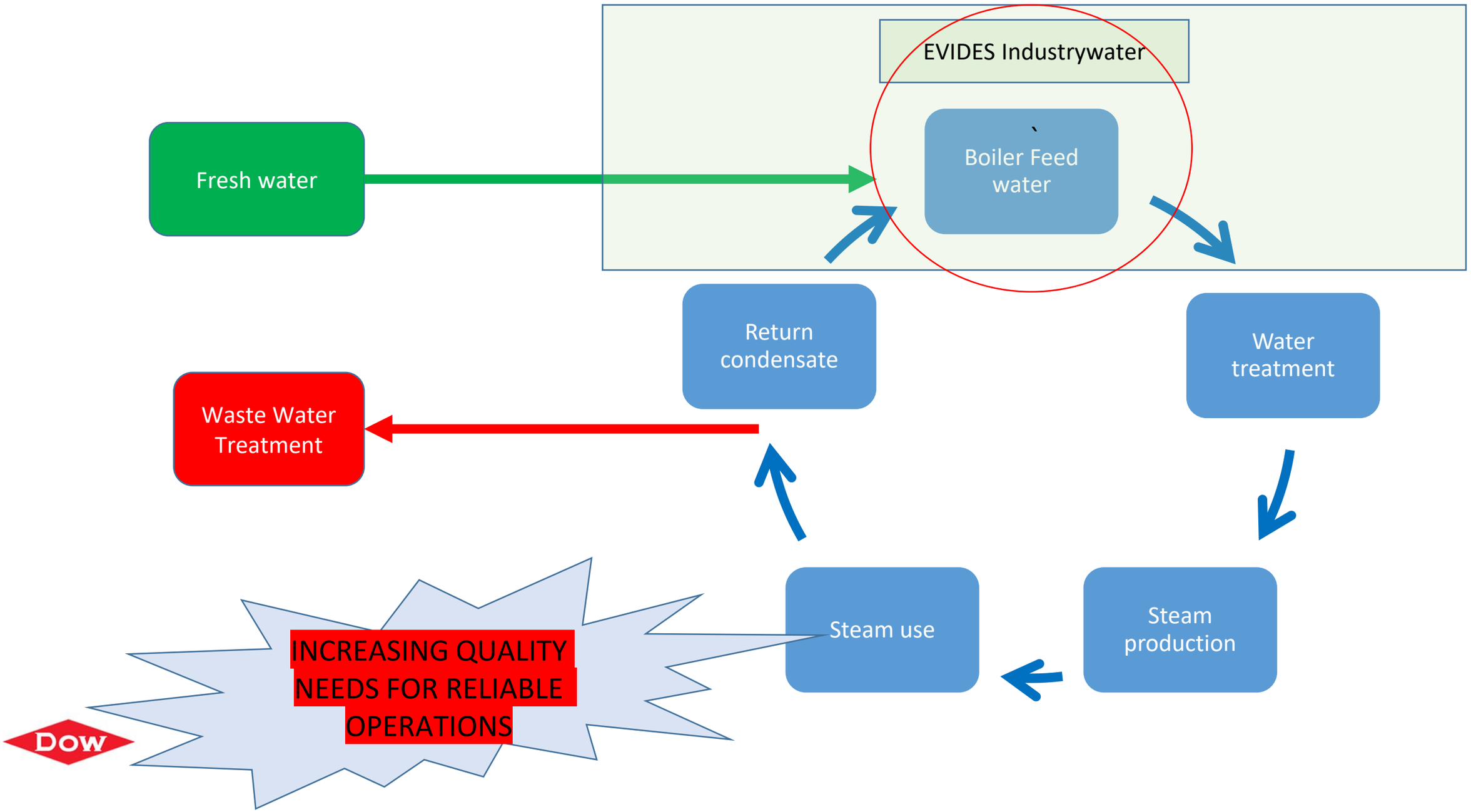
What has been done till now to reduce import of freshwater ?

Research projects/external collaboration projects

- E4-water -> technology for mild desalination
- Water Nexus -> “Tailor salt/fresh sources to fit-for-use applications”
- ISPT Condensate Quality -> Treatment of heavily polluted condensate streams
- Robust water system -> broad regional partnerships to identify solutions that benefit industry/agriculture/nature/citizens
- Improved -> Design, built, test mobile research facility for fit-for-use water treatment

IMPROVED @ DOW – The Dow Case

How to maximize the re-use of steam condensates ?



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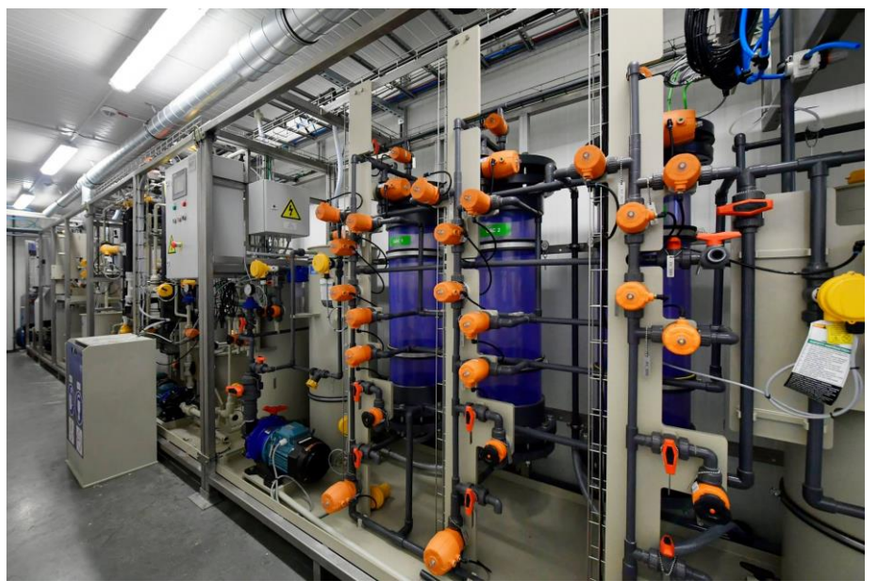

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Plug and Play ??

No way !

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IMPROVED @ DOW – our involvement

2016-2017 — Design/Build

- Make sure Dow/industry safety standards are respected
- Definition of Dow case for test period @ Dow
- Technical support Dow WPS (now DuPont)

2017-2018 — Prepare test site

- Site preparation – concrete slabs
- Connections to condensate lines/electrical connections
- Alarm signals to control room

2019 — Perform testing

- Cooling needs for hot condensates
- Site access for operators/procedures/procedures...
- Variation in condensate streams

Communication/Declaration requirements

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Design/Build

- Make sure Dow/Industry safety standards are respected
- Definition of Dow case for test period @ Dow
- Technical support Dow Water and Process Solutions (now DuPont)

- Ventilation requirements
- Air monitoring requirements
- Alarm signals
- Material specifications
- Allowed connections
- ……

- Request operating permit
- Review design with Process Safety Department
- Review design with EH&S

DOW Water and Process Solutions – EVIDES – DOW Operations

- Specific knowledge on Dow case/water qualities
- Technical advise on resins /membranes

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Prepare test site

- Site preparation – concrete slabs
- Connections to condensate lines/electrical connections
- Alarm signals

Engineering/Construction project ……

- Involvement of multiple disciplines
- Temporary vs Fixed installation….

- Introduction of chemicals on site
- Storage of chemicals and supplies

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Perform testing

- Cooling needs for hot condensates
- Site access/procedures/procedures...
- Variation in condensate streams

- Selection/Installation of coolers
- Variations in quality of incoming condensates
- Instrument problems
- Arrange analytical support
- Sample collection/storage/shipment

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The testperiod….Februari – July

Three different condensate streams tested

- Stream 1
- Stream 2
- D1 (mixture different return condensates and demi water)

Different technologies/combinations tested

- MB (benchmark)
- SAC - MB
- RO
- SAC - MB – RO
- MB - RO
- GAC - MB
- GAC - SAC – Degasser – MB

Note:

MB: Mixed Bed IEX – AMBERLITE M20

SAC: Strong Acid Cationic IEX – DOWEX 650C-H

RO: Reversed Osmosis – DOW FILMTEC LC HR-400

GAC: Granular Activated Carbon

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Initial conclusions from the testperiod

- Reference technology - MB-only - works well from quality perspective (TOC and conductivity removal)

- Treating mix of demi water with return condensates create treatment issues

- Minor variations in conductivity removal between different technology combinations

- Combination SAC-MB gives higher TOC removal. Additional advantage: SAC can be backwashed

- For low quality feedwater GAC acts as “aerobic biological degradation” filter -> Very good TOC removal when GAC is added to treatment train

Final report Dow case in preparation, will be available on IMPROVED WEBSITE

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How will results be used in the future

Dow/Evides are currently working on new and improved boiler feedwater treatment.

- Results confirm that SAC-MB is appropriate combination of technologies for the return condensates
- Results confirm that separate treatment of return condensate and demiwater is prefered

- Use of GAC in BFW-treatment trains is not commonly used
  - Aerobic degradation of amines/hydrocarbons on GAC looks promising
  - More research needed

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Co-financiering

Provincie Antwerpen

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