Cross cutting issue conference

Holistic approaches for water and resource efficiency in process industry

25 - 26 March 2020

Please register for free at:
https://online.cme24.de/index.php?id=1191
**WEDNESDAY, 25 MARCH 2020**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>09:30</td>
<td>Web conference room is open</td>
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<tr>
<td>10:30</td>
<td>Start of the conference program</td>
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<td></td>
<td>Moderation: DECHEMA (Dennis Becker), CTP (Eric Fourest)</td>
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<tr>
<td>10:30</td>
<td>Welcome DECHEMA and CTP</td>
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<td>10:40</td>
<td>Welcome and Introduction from SPIRE</td>
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<td></td>
<td>Angels Orduna (SPIRE)</td>
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<tr>
<td>10:45</td>
<td>Introduction of INSPIREWATER and SPOTVIEW</td>
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<td></td>
<td>Staffan Filipsson (IVL), Eric Fourest (CTP)</td>
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<tr>
<td>11:00</td>
<td>KEYNOTE: Challenges for the chemical industry – creating the next level of sustainable water usage</td>
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<td></td>
<td>Niels Groot (Dow Benelux B.V.)</td>
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<tr>
<td>11:10</td>
<td>KEYNOTE: Water and Resource efficiency in the Steel Industry: current challenges and new solutions under an ecosystem perspective</td>
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<td>Sophie Carlier (Jernkontoret)</td>
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<td>Jori Ringman (Confederation of European Paper Industries)</td>
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<tr>
<td>11:30</td>
<td>KEYNOTE: Recent development in EU Water Policy</td>
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<td>Bettina Doeser, Head of Clean Water Unit, European Commission</td>
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<tr>
<td>11:40</td>
<td>PANEL DISCUSSION: Challenges for Water Management in Industry</td>
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<td>Moderator: Brian Maguire (EBX MEDIA)</td>
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<td></td>
<td>Participants: Niels Groot (Dow Benelux B.V.), Sophie Carlier (Jernkontoret), Jori Ringman (CEPI), Bettina Doeser (EC), Angels Orduna (SPIRE)</td>
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<tr>
<td>12:15</td>
<td>Lunch break</td>
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<tr>
<td>13:15</td>
<td>Innovative and sustainable solutions in the steel industry – new developments in water management (INSPIREWATER/SPOTVIEW)</td>
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<td>Martin Hubrich, VDEh-Betriebsforschungsinstitut (BFI), Elena Piedra Fernández, Beatriz Padilla Vivas (ArcelorMittal)</td>
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<tr>
<td>13:30</td>
<td>Innovative and sustainable solutions in the steel industry – recovery of acids (INSPIREWATER)</td>
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<td>Andreas Rosberg (Sandvik), Fredrik Hedman (IVL)</td>
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<td>13:45</td>
<td>New strategies and technologies for process water recycling in tissue paper industry (SPOTVIEW)</td>
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<td>Antti Grönmöös (VTT), Jenni Vaino (Essity), Pasi Nurminen (Valmet), Lotta Sorsamäki (VTT)</td>
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<td>14:00</td>
<td>New strategies for effluent reuse in packaging paper industry (SPOTVIEW)</td>
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<td>Stéphanie Frasse (Centre Technique du Papier), Serge André (Saica EL)</td>
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<td>14:15</td>
<td>Coffee break</td>
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<tr>
<td>14:45</td>
<td>Improved technology solutions in the chemical industry (INSPIREWATER)</td>
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<td>Jozef Kochan, Friedhelm Zorn (Clariant)</td>
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<td>15:00</td>
<td>Innovative and sustainable solutions in the dairy industry (SPOTVIEW)</td>
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<td>Anastasios Karabelas, Dimitris Sioutopoulos (CERTH), Konstantinos Georgakidis (MEVGAL)</td>
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<tr>
<td>15:15</td>
<td>Resource recovery from industrial waste water by cutting edge membrane technologies – Outcomes of the ReWaCEM project</td>
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<td>Daniel Winter (Fraunhofer Institute for Solar Energy Systems ISE)</td>
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<td>15:30</td>
<td>End of the first day</td>
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**THURSDAY, 26 MARCH 2020**

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<tr>
<th>Time</th>
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<tbody>
<tr>
<td>08:30</td>
<td>Web conference room is open</td>
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<tr>
<td>09:00</td>
<td>Wrap-up Day 1</td>
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<td></td>
<td>Moderation: DECHEMA (Dennis Becker), CTP (Eric Fourest)</td>
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<tr>
<td>09:10</td>
<td>KEYNOTE: The Energy Footprint of Water Treatment</td>
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<td></td>
<td>Joachim Koschikowski (Fraunhofer Institute for Solar Energy Systems ISE)</td>
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<tr>
<td>09:20</td>
<td>KEYNOTE: Water Footprint, financing industrial water through Blue Bonds</td>
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<td>Jaap Feil (iWater – Water Footprint Implementation)</td>
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<td>09:30</td>
<td>KEYNOTE: The Value of Water</td>
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<td></td>
<td>Thomas Track (DECHEMA e.V.)</td>
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<tr>
<td>09:40</td>
<td>PANEL DISCUSSION: How to save costs with water in industry?</td>
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<tr>
<td></td>
<td>Moderator: Brian Maguire (EBX MEDIA)</td>
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<tr>
<td></td>
<td>Participants: Joachim Koschikowski (Fraunhofer ISE), Jaap Feil (iWater), Thomas Track (DECHEMA e.V.)</td>
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<tr>
<td>10:15</td>
<td>Coffee break</td>
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<tr>
<td>10:45</td>
<td>Holistic water management (INSPIREWATER)</td>
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<tr>
<td></td>
<td>Agata Andersson, Henrik Kloo (IVL)</td>
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<tr>
<td>11:00</td>
<td>Environmental impacts of water optimization strategies developed within SPOTVIEW</td>
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<td>Elorri Igos (LIST)</td>
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<tr>
<td>11:15</td>
<td>Environmental and economic assessment of INSPIREWATER solutions for resource recovery in process industries</td>
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<td>Fredy Dinkel (FHNW)</td>
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<tr>
<td>11:30</td>
<td>Next steps towards creating sustainable impact through business exploitation (INSPIREWATER/SPOTVIEW)</td>
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<td>Presentation of the exploitation opportunities of both projects by PDC and IMCG</td>
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<td>11:45</td>
<td>Opportunities and challenges to implement new innovative technologies into existing industrial environments (INSPIREWATER/SPOTVIEW)</td>
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<td>Panel discussion moderated by PDC/IMCG. Interactive session with technology providers and end users from both projects</td>
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<tr>
<td>12:15</td>
<td>Wrap-up and some closing words</td>
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<tr>
<td>12:30</td>
<td>End of the conference</td>
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www.inspirewater.eu / www.spotview.eu
NEW ABSTRACT SUBMISSION DEADLINE: Submit your abstract by 30 April 2020 or become part of the exhibition
www.industrial-water.org
Cross-cutting issue conference (INSPIREWATER + SPOTVIEW):
Holistic approaches for water and resource efficiency in process industry
On line, 25 March 2020

SPIRE 2050
Climate Neutral and Circular EU Process Industry (P4Planet)

Àngels Orduña Cao
Executive Director
A.SPIRE
Closing the climate technological gap

Development of the required solutions to fully contribute to the EU Climate Neutrality scenarios

Scale-up Circular Resources for zero-landfilling

Spread the Hubs for Circularity across Europe to develop the required solutions to move towards zero-waste-to-landfill and near zero-water discharge.

Global competitiveness

Development of technologies which create new investment opportunities for globally competitive EU Process Industries

SPIRE 2050 Ambitions: our share to the EU Green Deal

-2030 Key technologies of SPIRE Vision 2050 ready for deployment (TRL9)
-2050 Net-zero CO2 emissions
-2030 37% in CO2eq emissions versus 1990
-2030 Key technologies of SPIRE Vision 2050 ready for deployment (TRL9)
-2050 ZERO landfiling of recyclable / recoverable waste in the EU
-2021 Kick-off Horizon Europe
SPIRE 2050 FUNNEL towards first-deployment

14 Innovation Areas

36 Innovation Programmes

The “Marbles”

- Large-scale demonstrators, pilot or first-of-a-kind plants
- proof the feasibility of highly ambitious CO2 abatement plants
- acting as Hubs of bulk amounts of resources from industry and the municipalities.

PRIVATE INVESTMENTS

- Industry commitment
- When technical and economic feasibility is proved
- Public support needed to de-risk
Towards near zero wastewater discharge by 2050:
Enabling increased/full recycling of wastewater and its components

DEDICATED IP: A-10.d Wastewater Valorisation

• **Separation technologies for the water components**, captured in innovative, energy-efficient and cost-efficient manners

• **Increased valorisation of solutes from wastewater treatment.** **Ambition:** 25% of the solutes recovered from wastewater by 2030 and 100% by 2050. Including innovative conversion technologies and modular solutions.

• **Increase valorisation of solids from wastewater treatments into new materials or recovery for energy production:** cellulose toilet paper, recovery of biopolymers, photocatalytic techs, etc...

• **Optimise recovery of the energy value in wastewater:** optimal cascading of wastewater streams, electrodialysis technology (co-digestion of organic municipal waste, biogas technologies, low temperature heat systems, reductive processes...)

• **Develop optimised wastewater treatment for freshwater substitution.** **Ambition:** 40% acquisition of fresh water in 2030 and full recycling of water by 2050

• **Develop alternative processes with reduced water use** (cooling water systems, solid state fermentation processes)

• **Improve sensors and monitoring of water quality** for fast (semi) automatic decision making and reliable prediction

• Develop robotics for inspection and maintenance in water systems

Estimated investment level needed:
€1,7 bn

Building on the results of:

• **INSPIRE WATER:** (water recycling systems to TRL7)

• **SPOTVIEW** (techs to reduce freshwater intake for pulp and paper and steel industry)
Hubs for Circularity

Regional demands
- Societal needs
- Customer needs
- Stakeholder demands

Regional community
- RTOs
- SMEs
- Civil society
- Across sectors
- Process industry
- Financial institutions
- Public sector

Sustainable business model
- Business-to-territory plan
- Co-investments model

Disruptive innovation
- Social innovation
- Business models
- Technology
- Processes

Exporting innovations

Regional benefits
- Industrial-Urban Symbiosis
- Economic growth
- Understanding regional demands

Knowledge sharing through Community of Practice
WHY JOIN A.SPIRE

LARGER INDUSTRIES:
• Continuous dialogue on R&I across SPIRE sectors and beyond
• Channel to raise your voice on R&I for HEU & other programmes
• Access to a pool of knowledge & talent (in Universities, research centres….)
• Direct access to SME providers
• Collaboration with the innovation ecosystem and value chain
• Access to developments by other projects, SMEs, universities...
• Protection of intellectual property
• Dialogue with the EC, MS, regions, MePs & other stakeholders

Further benefits to other members

SMEs:
• Direct Access to growth opportunities
• Direct Access to new markets
• Direct Access to large industry customers

RTOs, NGOs Innovation agencies et al.:
• Direct Access to applied innovation
• Link to deliver impact to society and regions
• Collaboration for disruptive innovations
A.SPIRE upcoming events / meetings 2020

- **23 January:** A.SPIRE at Public Hearing on Partnerships at the European Parliament – Brussels/Belgium
- **March**
  - Roadmap shared with members
  - Board Meeting + IRIAG Meeting
- **March to June:**
  - Webinars on Added Value for membership
  - Webinars to develop the first topics of Horizon Europe (only for members)
  - On line dialogues with regions & relevant stakeholders on the H4C
- **May:** BoD meeting + IRIAG meeting + Meeting with DG R&I
- **24 June 2020:** A.SPIRE General Assembly, Brussels + SET PLAN Networking event (tbc)
- **Sept- Oct** (date tbc): Topics workshop in Brussels or on line (only for members)
- **27-28 October:** INDTECH – Mainz/Germany + side event / meeting on H4C & German Presidency
- **November:** BoD meeting in Poland (tbc) + side Processes4Planet event (tbc)
- **Oct- Dec 2020:** Signature of new SPIRE MoU + BoD meeting
- **Nov. – Dec 2020,** Brussels: launch of Processes4Planet partnership + SPIRE projects day (date tbc)

**MAIN ACTIONS ALONG 2020:**

- **Review and update of roadmap** (with members and new sectors in A.SPIRE)
- **Preparation of Guidance Document** (how the new Partnership will work)
  - April 2020: members consultation + open consultation
- **Preparation of the first set of Processes4Planet topics for the first Work Programme of HORIZON EUROPE**
  - March – April: First list proposal (Advisory Group – IRIAG)
  - May – June: Second draft proposal discussed with the European Commission (Partnership Board / IRIAG)
  - Working Groups and IRIAG develop the topics content further + Discussions with the EC, MS and relevant regions
  - Sept- Oct: Topics workshop in Brussels or on line (date tbc)
- **A.SPIRE contributes to SET PLAN #6 new Implementation Plan**
  - IRIAG and WGs to develop proposals of content
SPIRE 2050 ROADMAP – NEW WGs
BE PART OF IT: JOIN US TO DEFINE THE FIRST TOPICS OF HORIZON EUROPE

SPIRE 2050 AMBITIONS:
Climate Tech gap: Net-zero emissions
Hubs4Circularity Zero-landfilling
Competitiveness

SPIRE 2050 TRANSFORMATIONS
T2. Process Industries as enablers of carbon-neutral economy
T3. Process Ind., regions & cities deploying circular economy at scale
Integration of Process Industries

SPIRE NEW WGs (1 chair + 1 co-chair/group)
WG1 - Energy mix
WG2 - Electrification
WG3 - H2
WG4 - CCU - CO2
WG5 - Resource & Process Efficiency
WG6 - Industrial & Urban Symbiosis
WG7 - Digital

TRANSVERSAL TASK FORCE
Social & non-tech innovations
CONTACT OUR EXECUTIVE DIRECTOR:

aor@spire2030.eu
www.spire2030.eu

Connected across borders and to citizens
A very brief introduction to:

**Innovative Solutions in the Process Industry for next generation Resource Efficient Water management**

staffan.filipsson@ivl.se
agata.anderssson@ivl.se
What was INSPIREWATER about?

Supporting the transformation of water management from linear...
What was INSPIREWATER about?

...to more circular solutions...

Steel industry

Chemical industry
What was INSPIREWATER about?

...that helps the circular economy to take a step towards reality.
Background and insights

...that lead us to the INSPIREWATER approach:

• It is crucial for industry to develop efficient water technologies

• Water use is closely linked to energy, chemicals and raw materials

• Process-integrated systems could:
  - minimize: Waste and wastewater volumes
  - maximize: Recovery of valuable materials including water

• A holistic approach is needed to avoid sub-optimisation
The aim

...of INSPIREWATER was:

• To reduce the demand for water, energy and chemicals
• To reduce production of waste
• To underpinned a holistic water management framework
• To support implementation of new efficient innovative technologies and concepts
• To support Europe to become the leader in the industrial water treatment market
The concept

...of INSPIREWATER was based on:

- Integrating and exploiting new solutions into company structures at two levels:

  The first level:  - Water management
    - Demonstrate a generic framework
    - Provide a more holistic and life-cycle based approach
    - Include resource efficiency as key performance indicator
    - Include facilitation of technology implementation

  The second level:  - New solutions for different treatment challenges
    - Demonstration and exploitation of new solutions
    - Enable the solutions for other sectors
Demonstration of innovative technologies

In steel industry:
• Magnetic separator for metal removal
• Biocide free control of microorganisms
• Nanofiltration for pickling bath recovery

In chemical industry: towards Zero-liquid-discharge
• Membrane filtration including both Forward osmosis and Reverse osmosis
• Catalyst technology for fouling control
The results

✓ A framework for a holistic water management approach was developed

✓ Key performance indicators (KPI) were defined that support the activities within water saving and process optimisation

✓ A life-cycle assessment (LCA) was carried out that clearly shows the reduction in total environmental impact of the solutions developed

✓ Adaptable innovative water solutions were demonstrated in three case studies
The results

✓ Existing selective separation processes were combined with new technologies

✓ Innovative technologies were demonstrated and developed

✓ Conclusions and recommendations has been delivered to the industry
The impact

• Reduction of:
  - fresh water use (40 – 80 %)
  - use of resources/chemicals (up to 55 %)
  - wastewater production (80 – 99 %)
  - energy use (15 ->75 %)

• Adding economic benefits
  - due to less resource and energy consumption

• Process optimisation
  - achieved by the holistic water management approach and the KPI’s
We have shared quite a lot...
...and we have learned a lot from each others...
... and we will take the opportunity to thank all our colleagues of the great INSPIREWATER team!
So very welcome to the conference and we wish you a very exciting time!

staffan.filipsson@ivl.se

agata.andersson@ivl.se
InspireWater - SpotView final web conference:
“Holistic approaches for water and resources efficiency in process industry”

Sustainable Processes and Optimized Techniques for Industrially Efficient Water use

March 25th, 2020

Eric Fourest – Centre Technique du Papier (CTP, France)
Concept of the project

Objectives:

- To develop and demonstrate innovative, sustainable and efficient processes and technology components, in order to optimize the use of natural resources, especially water, in three industrial sectors (Dairy, Pulp and Paper and Steel)

- 14 existing and new technologies will be assessed, including solid/liquid separation, ultrafiltration, deionization, biological treatment, disinfection and chemical heat pump

- 9 water management practices assessed in simulated or operational environment for in the three industrial sectors

- 7 selected technologies demonstration in industrial environment
European consortium

The XV of Europe

from 9 EU countries
Concept of the project

Pilot scale processes
- Separation technologies
  - Filtration, flotation of suspended solids (KL, AMI)
  - Ultrafiltration of colloids (VAL)
  - Deionization (BFI, AMI)
  - Aerobic/Anaerobic MBR (CERTH)
- Disinfection technologies
  - Elevated Pressure sonication (SER)
  - Biocontrol concept (XC)
- Chemical Heat pump (CAL)

Applications demonstrated in the project
- Industrial water sources
  - **PAPER industry** (SCA, EL, CTP, VTT)
    - Pulp and paper processes water
    - WWTP effluents
  - **STEEL industry** (AMI, BFI)
    - Steel processes water
      - Cooling water
      - Sea water
  - **DAIRY industry** (MEVGAL, CERTH)
    - Dairy product process effluents
      - Wash water
      - WWTP effluents

Technical & Economical benefits
- Productivity / competitiveness
- New technologies development
- Valuable substance recovery
- Biogas production
- Efluent re-use
- Heat recovery
- Reduced chemical usage
- Reduced water  
  - Reduced fresh water usage
  - Reduced wastewater
  - Reduced energy consumption
  - Minimized water footprint
  - Reduced greenhouse gases emissions

Environmental benefits & Process sustainability
Task 6.2 – Innovation outreach

- SpotView results Video
Thank You!

Contact:
Eric.Fourest@webCTP.com

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723577
KEYNOTE SESSION DAY 1

CHALLENGES FOR WATER MANAGEMENT IN INDUSTRY

KEYNOTES

PANEL DISCUSSIONS
CHALLENGES FOR THE CHEMICAL INDUSTRY

CREATING THE NEXT LEVEL OF SUSTAINABLE WATER USAGE

INSPIREWATER Final Conference – March 25th 2020

Niels Groot
Dow Benelux BV
Environmental Technology Center
**Key Facts About the “New Dow”**

- **2014 Sales of $58,167 million**
- **Agricultural Sciences**: $7,290
- **Infrastructure Solutions**: $8,429
- **Performance Materials & Chemicals**: $15,114
- **Performance Plastics**: $22,386

**Dow Sites Around the World**

**Corporate**

- **2019: 37,000 employees**
- **Portfolio**: - performance materials
  - industrial intermediates
  - plastics businesses
- **Sectors**: construction, paints, automotive, food, consumer goods and energy

**Dow’s Water Vision & Strategy**

**Challenges and Expectations**

**Approach**

**Concluding Remarks**
Which are these industrial challenges?

**Raw material and Energy transition**
- Climate change related objectives (CO₂, fossil fuels)
- Exhaust of fossil raw materials
- Striving for circularity
- Food provision (soil, emissions)
- Industry, agriculture, urban areas

**Europe’s quest to meet the Paris agreement**
- Dutch targets for CO₂ reduction are 49% in 2030 and 95% in 2050
- Circularity (raw material and energy transition for industry and agriculture)

**Fresh water availability and supply (climate change / sealevel rise)**

**Plastic waste / microplastics**

**Reliable and robust operation (can we raise the bar)**

What does this mean for WATER ????
Dow’s Approach

- Identify gaps and demand per site and business unit
- Generate knowledge that can be used and leveraged
- Internal R&D (core and business) and Technology Centers
- Cooperate “over the fence” in non-competitive areas both regional, national, and international

Dow’s priority water stressed sites


Dow’s Sustainability Goal #7: World-Leading Operations Performance
By 2025, Dow will reduce its freshwater intake intensity at key water stressed sites and its waste intensity footprint by 20 percent.

Dow’s water vision:
- Sustainable water use and management
- Innovative technologies
- Set new levels for efficient water use
- Creative partnerships

Site specific:
- (Fresh) water availability
  - Location (sea, river, inland, local climate)
  - Surrounding
    - industry, cities, rural area
    - nature, recreation
- Focused on process (footprint reduction)
- Minimize wastewater to be treated
- Zero liquid discharge (when it makes sense)

Water Balance:
- Reuse options
  - Cooling tower make-up
  - Boiler feed
  - Cascading
- Miscellaneous (service, firewater)
- Potable
Initiatives and results

- Water reuse examples:
  - Terneuzen
  - Tarragona

- Regional cooperation on raw materials, waste, by-products, and energy
  - Transfer of hydrogen between Dow and Yara
  - Pilot projects among chemical and steel to reuse CO, CO2, H2 for producing a new generation of feedstocks

- Reliable & Robust operation
  - Meet business expectations
  - Regulatory requirements
  - How strong is the chain?
Concluding remarks

• The chemical industry embraces water sustainability objectives
• Over the fence collaborations are excellent vehicles to create benefits for multiple stakeholders
• True value of water for industry is in long term robust risk management generating sound business cases – new smart data management tools (Industry 4.0) are key enabler
• Short term success and image building are great, but not the ultimate solution for water and circularity
Each drop counts!

Seek

Connects Chemistry & Water with passion!

Together™
Water and Resource Efficiency in the Steel industry
Current challenges and new solutions under
an ecosystem perspective

Sophie Carler, Ph. D., Senior Advisor
Jernkontoret - The Swedish Steel Producers´ Association
Facts about the steel industry

• Steel is produced via blast furnaces (integrated route using iron ore), and via electric arc furnaces (scrap-based steel plants)

• Most production processes are hot and water is used to cool down the processes and to control the quality of the steel – water affects final quality of steel product

• Part of the water intake is returned back to source uncontaminated, another part goes into steelmaking process and is therefore cleaned before return

- both quality and quantity of water matters
Water – critical ecosystem service
Challenges from the Swedish perspective
it’s about resource efficiency altogether – some examples

• Allocate resources for expensive water treatment technique when it’s time to shift technique towards fossil-free production (ex HYBRIT) – economical
• New infrastructure not compatible with old industrial sites - technical
• Disproportionate costs high in relation to actual effects. Possible negative effects on compliance – regulatory
• Change in water quantity and water quality due to climate change - a challenge on it’s own

• Need to think outside the box
  ➢ Ecosystem perspective
  ➢ Nature-based solutions
Examples of innovative water solutions
How to face new planetary challenges – climate change

- Need for increased knowledge, new methods/tools and governance models
- Apply a holistic perspective
- Coherence with European policy framework
- Strong collaboration between researchers, policymakers, and companies
Water and Resource efficiency in the Pulp and Paper Industry: situation and new challenges with digitalisation
About Cepi

**Represents in Brussels**
- 500 pulp, paper and board producing companies
- 895 mills across Europe
- 180000 people employed directly
- 18 member countries

95% of the European production
22% of the world production

Working across the value chain – from forest owners to converters and along the whole life cycle
We are renewable and recyclable, sourced and made in Europe, a responsible industry towards the environment, its customers and workers.

Transforming pulp wood into cellulose and bio-based products >92% of our raw materials is sourced in Europe and certified as sustainable.

Keeping the fibres in the loop >72% recycling rate of EU paper-based products.

Producing
- Pulp & fibres
- Nano-cellulose
- Bio-energy
- Green chemistry
- Print & graphic paper
- Packaging solutions
- Hygiene and tissue
- Speciality papers
Starting point as an industry leader

- Pioneers in water stewardship
- Leaders in circularity, including
  - 91% of the water we use is returned to the environment, in good condition
  - All production sites have multiple water recycling loops, some closed loop
  - Also pioneered reuse of treated municipal waste water

But: Paper cannot be made without
- Paper = Fibres + Water (+ Energy)

European paper has decoupled water use from growth

When starting with already a remarkable performance and considering it a necessity, it is difficult to improve further...
LCA perspectives

• Spot View result from LCA: water recycling or reuse strategies for reducing direct fresh water have low impact on
  • net fresh water consumption, and
  • on overall water footprint that highly depends on indirect water use for raw material, energy and additives production.
Water has many other sustainability implications

Water = Energy
Water = CO₂
Water = Risk

...which may be addressed with the increasingly digital and artificial intelligence-based process systems
  - More agile adjustments
  - Better process optimisation between use of raw materials, energy and water

...and solutions found in
  - Extracting valuable components from effluent
  - Operating according to industrial symbiosis

...until we find the breakthrough in waterless papermaking
Recent developments in EU water policy
Various uses, demands, pressures and impacts

Water is a cross-cutting issue

Nature protection
Tourism
Industrie
Drinking water
Agriculture
Waste Water
Navigation & hydropower
Flood protection
EU Freshwaters – instruments

**Water Framework Directive (WFD)**
Ensure all surface and groundwaters meet a range of quality and quantity requirements

**Groundwater Directive**
Specifies requirements for groundwater

**Environmental Quality Standards Directive**
Specifies requirements for chemical pollutants in water

**Floods Directive**
Ensure flood risks are identified, mapped and managed

**Urban Waste Water Treatment Directive**
Collection and treatment of urban waste water

**Strategic approach to pharmaceuticals in the environment**
(non-binding strategy)

**Water re-use Regulation**
Minimum criteria for urban waste water reused in agriculture

**(Recast) Drinking Water Directive**
Minimum criteria for drinking water

**Groundwater Directive**
Specifies requirements for groundwater

**Nitrates Directive**
Limit use of nitrates in agriculture

**Sewage sludge Directive**
Safe use of sewage sludge in agriculture

**Bathing Water Directive**
Minimum criteria for good bathing water

**Other related instruments:**
- Plastics Strategy
- Industrial Emissions Directive
- ...
Stock-taking process of EU waters

1. EEA Reports: ‘European waters – assessment of status and pressures’ (July 2018); ‘The European environment — state and outlook 2020’ (December 2019)

2. Commission’s 5th implementation report on WFD and FD (February 2019)

EU water law under evaluation

Fitness check of the Water Framework Directive and the Floods Directive
SWD (2019)439 final
- Water Framework Directive (WFD) – Dir 2000/60/EC
- Environmental Quality Standards Directive (EQSD) – Dir 2008/105/EC
- Groundwater Directive (GWD)
  – Dir 2006/118/EC
- Floods Directive (FD)
  – Dir 2007/60/EC

Evaluation of the Urban Waste Water Treatment Directive
SWD (2019)700 final
- (UWWTD) Dir 91/271/EEC
Fitness Check of the Water Framework Directive and the Floods Directive
SWD (2019)439 final
Conclusions: Broadly fit for purpose, with room for improvement

Water Framework Directive
- Governance structure set up for integrated water management; deterioration of water status slowed down; pollution reduced
- BUT implementation significantly delayed and less than half of EU's water bodies in good status (despite 2015 deadline)
- The objectives have not yet been reached fully largely because of:
  1) Slow implementation
  2) Insufficient funding
  3) Insufficient integration of environmental objectives in sectoral policies

Floods Directive
- Too early to draw conclusions (first implementation cycle started only in 2016) but analysis shows flood risk management has improved
- Further efforts needed to strengthen awareness and improve co-ordinated flood prevention, in line with climate change projections
Lessons learnt

Progress towards good status remains slow but steady. Results are slow. The One-out-all-out principle can make showing progress challenging.

The Directives are prescriptive and flexible to address new challenges. Climate change pollutants of emerging concern (pharmaceuticals, micro-plastics) remain a concern.

Implementation needs to accelerate substantially and become more effective. The 3rd RBMPs due in 2021 will be crucial. Less room for exemptions of Art. 4 WFD. Joint implementation: cooperation Commission – Member States. Enforcement measures included.

Room for improvement in chemicals. Differences between Member States and River Basins. Mixtures and combined effects not assessed. Lengthy process to update the list of priority substances.

Integration of the Directives with other policy areas needs to be advanced. Agriculture. Energy - hydropower. Waterborne transport.

The financing gap needs to be addressed. Investments and operation and maintenance financing. Sources: National funding; EU funding; international financial institutions. Cost-recovery principle Art. 9 WFD.

Limited room for simplification and reduction of administrative burden. Streamlining of monitoring and electronic reporting. Digitalisation ongoing.
Evaluation of the Urban Waste Water Treatment Directive
SWD(2019)700 final
Main Conclusions

The UWWTD has delivered on the reduction of loads and thereby contributed to the improvement of water quality.

Biochemical Oxygen Demand (BOD) loads (tonnes/year in treated waste water)

Main Lessons & Room for improvement

Main lessons learnt

- Effective tool – Tangible effects
- Simple and targeted instrument
- Carrot and stick
- Costs <<< Benefits

Room for improvement

- Remaining pollution
- Contaminants of emerging concern
- Energy use, sludge management
- Governance – planning/enabling conditions, transparency/reporting, investments/affordability
KEYNOTE SESSION DAY 1

CHALLENGES FOR WATER MANAGEMENT IN INDUSTRY

KEYNOTES

PANEL DISCUSSIONS
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30</td>
<td>Welcome</td>
<td>DECHEMA and CTP</td>
</tr>
</tbody>
</table>
| 10:30  | KEYNOTE: Challenges for the chemical industry – creating the next level of sustainable water usage  
Niels Groot (Dow Benelux B.V.) |
| 10:45  | Introduction of INSPIREWATER and SPOTVIEW                                
Staffan Filipsson (IVL), Eric Fourest (CTP) |
| 11:00  | KEYNOTE: Water and Resource efficiency in the Steel Industry: current challenges and new solutions under an ecosystem perspective  
Sophie Carler (Jerncontoret)  
Niels Groot (Dow Benelux B.V.) |
Jori Ringman (Confederation of European Paper Industries) |
| 11:30  | KEYNOTE: Recent development in EU Water Policy  
Betina Doeser, Head of Clean Water Unit, European Commission |
| 11:40  | PANEL DISCUSSION: Challenges for Water Management in Industry  
Moderator: Brian Maguire (EBX MEDIA)  
Participants: Niels Groot (Dow Benelux B.V.), Sophie Carler (Jerncontoret), Jori Ringman (CEPI), Betina Doeser (EC), Angels Orduna (SPIRE) |
| 12:15  | Lunch break                                                             |
| 13:15  | Innovative and sustainable solutions in the steel industry – new developments in water management (INSPIREWATER/SPOTVIEW)  
Martin Hubrich, VDEh-Betriebsforschungsinstitut (BFI), Elena Piedra Fernández, Beatriz Padilla Vivas (Arcelor Mittal) |
| 13:30  | Innovative and sustainable solutions in the steel industry – recovery of acids (INSPIREWATER)  
Andreas Rosberg (Sandvik), Fredrik Hedman (IVL) |
| 13:45  | New strategies and technologies for process water recycling in tissue paper industry (SPOTVIEW)  
Antti Grönroos (VTT), Jenni Vaino (Essity), Pasi Numminen (Valmet), Lotta Sorsamäki (VTT) |
| 14:00  | New strategies for effluent reuse in packaging paper industry (SPOTVIEW)  
Stéphanie Frasse (Centre Technique du Papier), Serge Andres (Saica EL) |
| 14:15  | Coffee break                                                            |
| 14:45  | Improved technology solutions in the chemical industry (INSPIREWATER)  
Jozef Kochan, Friedhelm Zorn (Clariant) |
| 15:00  | Innovative and sustainable solutions in the dairy industry (SPOTVIEW)  
Anastasios Karabelas, Dimitris Sioutopoulos (CERTH), Konstantinos Georgakis (MEVGAL) |
| 15:15  | Resource recovery from industrial waste water by cutting edge membrane technologies – Outcomes of the ReWaCEM project  
Daniel Winter (Fraunhofer Institute for Solar Energy Systems ISE) |
| 15:30  | End of the first day                                                   |
Innovative and sustainable solutions in the steel industry: new developments in water management

Martin Hubrich, Matthias Kozarischczuk, BFI
Beatriz Padilla Vivas, Elena Piedra Fernández, AMI3

“The projects have received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreements No 723577 and No 723702”
Situation - Solutions
Water use in steel industry

- Cooling applications (material: casting, hot rolling; machines): 75%
- Gas washing (blast furnace, basic oxygen furnace): 13%
- Material conditioning (e.g. slag granulation): 12%
Situation

- Process related intake of solids and organic causing wear and biological activity
- Concentration of salts/hardness components leading to corrosion and scaling
- Addition of treatment chemicals: corrosion inhibitors, antiscalants and biocides
- Decreasing/stronger limited water availability in semi-arid areas

Challenge

- Complex and varying water matrix causing insufficient economic/technical levels of available water treatment technologies and preventing water reuse
- Components mostly inhibiting water reuse: chloride, sulphate, hardness, oil, solids and possible interactions of technologies with treatment chemicals

Solution

- Use of innovative technologies as capacitive deionisation, precipitation reactor (softening, disinfection), magnetic separator and water management (cascade)
- Determination of concerted combinations of water treatment chemicals (e.g. flocculent, biocide), solid removal and desalting/softening technologies
Global project aims
• Saving of fresh water and reduction of waste water
• Decoupling of production and fresh water demand

INSPIREWATER - focused view on a selected circuit
• Decrease of corrosion and scaling by use of suitable technologies for longer
  water use reducing the freshwater demand/waste water occurrence

SPOTVIEW - holistic view of a site including water sources
• Reuse of low loaded waste/process water in a cascade considering the
  required water qualities
• Recycle of loaded waste/process waters as e.g. back wash water from sand
  filters by e.g. solid and salt removal for an internal reuse
• Use of alternative water sources (sea / rain water) or optimization of river water
  treatment by innovative desalting technologies as capacitive deionization
Innovative technologies
Magnetic separator:
Chemical free and pressure less solid removal with permanent strong field magnets

Combined flotation / microfiltration
Oil and suspended solid removal by flotation with rotating discs followed by microfiltration

Capacitive Deionisation
Ion removal by electrostatic adsorption at electrodes and subsequent desorption during regeneration

Innovative Reactor
Input of high-frequency electrical pulses to hinder bacteria adaptation and changes of forces of repulsion balance for “not sticking dust”
Results
Demonstration of selected technologies at AM Gijon

Selection in lab trials
- Magnetic separator
- 3layer-filtration
- Reverse Osmosis
- Innovative reactor
Magnetic separator:
- Treatment of approx. 31,000 m³ cooling water
- Outlet solid contents down to 10–15 mg/L (LOD: 10 mg/L) even in case of about factor 3 -5 varying inlet solid contents
- High solid contents in sludge between 19–31 wt.-% compare to 0.2 wt.-% at 3layer-filtration or operations and filter
- Low ratio of back flush water to treated volume with 0.001 - 0.006% compared to 1.2 – 4.3% for 3-layer-filtration or operations and filter

3layer filtration:
- Confirmation of lab results achieving outlet solid contents below 10 mg/L.
- Increased removal efficiency from 65% to 96% by 3layers of different filter material compared to operational sand filter or up to 83% by decreasing velocity

Reverse osmosis:
- Flux up to 50 lm²/h possible in case of pH-adjustment and concentration factor 4
- Significant decrease of corrosion potential compared to untreated water

Innovative reactor: Inconclusive results in field and lab trials
Investigated approaches and applications SPOTVIEW

Recycling of back wash water of sand filtration by new water treatment

- Biocide Anti Scalant
- Oil/Grease Scale
- Coagulant Flocculant

Cooling water

Hot Rolling Mill

Sand Filtration

- Back wash water

Solid Removal
Combined flotation-membrane filtration

Desalting
CDI RO

Steel production process

Cascade reuse of process waters with different qualities

- Cooling Water (Indirect: oven cooling)
- Cooling Water (Direct: hot rolling, casting)

Solid Removal Desalting

Gas washing water

Solid Removal

Slag granulation

Treatment - Discharge

Saving of fresh water by use of alternative water sources

- Sea Water
- Rain Water
- River Water

Solid Removal Multilayer Filtration Ultrafiltration

Desalting RO
Desalting CDI
Desalting CDI

Steel production process

25.03.2020

Innovative and sustainable solutions in the steel industry - new developments in water management
Applications for reuse back wash / river water /sea water

<table>
<thead>
<tr>
<th></th>
<th>Back wash water</th>
<th>River water</th>
<th>Sea Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Rolling Mill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reheat furnaces</td>
<td>pH adjustment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct cooling</td>
<td>pH adjustment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous Casting Circuits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mould cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Arc Furnace (EAF)</td>
<td></td>
<td>Further softening required</td>
<td></td>
</tr>
<tr>
<td>Indirect closed cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converter Circuits</td>
<td>Indirect cooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast Furnace Circuits</td>
<td>Indirect cooling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **CDI treated river and two steps RO treated sea water** can be directly for all applications beside indirect closed loop cooling at the electric arc furnace.
- **Direct use of CDI treated back wash water** in: cooling processes in hot rolling mill, EAF and blast furnace possible - pH-adjustment from 6.5 to 7 or 7.5 necessary for further applications.
Back washing water treatment

- Suitable combination: flotation/microfiltration (oil/solid removal) flowed by CDI or RO for desalting/softening in 3 month field trials

<table>
<thead>
<tr>
<th>Technology</th>
<th>Water Recovery [%]</th>
<th>Energy Demand [kWh/m³]</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flotation with MF</td>
<td>89</td>
<td>0.3</td>
<td>TSS&lt; 3mg/L</td>
</tr>
<tr>
<td>CDI</td>
<td>78</td>
<td>0.95</td>
<td>Fulfilling AM requirements:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Conductivity: &lt; 200 µS/cm</td>
</tr>
<tr>
<td>RO</td>
<td>85</td>
<td>1.4</td>
<td>Chlorides: &lt; 50 mg/L</td>
</tr>
</tbody>
</table>

River water treatment

- CDI: fulfillment of AM requirement with water recovery of 79% and 0.95 kWh/m³ - same as RO/IX

Sea water

- Multimedia and Ultrafiltration fulfills turbidity requirement (< 1NTU).
- Two RO passes required (water recovery: 40%, energy demand: 4 kWh/m³)

Cascadic Water Reuse – 9 possible applications in the area cooling water

- 10 - 31% water saved from direct reuse applications without any treatment.
- CDI treated back wash water: direct in 4/9 or after pH-adjustment in 2/9 cooling water applications - treated river water in 8/9 cooling water applications
Summary of technical results and evaluation
Evaluation of project results

INSPIREWATER

- 66% energy saving by use of pressure less magnetic separator for solid removal compared to pressurized sand filter
- 80% blow down saving and up to 13% fresh water saving by RO treatment of the blow down waste water reduction by removal of solids, salts and hardness components

SPOTVIEW

- Between 10 and 30% fresh water saving by reuse process water and further 38% by desalination technologies.
- 89% reduction of backwash water by solid and desalination to recycle back into the process.
- Reduction of dependency on fresh water availability and minimization of fresh water use per ton of steel of 50% by using alternative water resources.
Contact
Efficient water use in steel industry by innovative and sustainable solutions
Thank You For Your Attention

Innovative and sustainable solutions in the steel industry - new developments in water management
Innovative and sustainable solutions in the steel industry – Recovery of acids (INSPIREWATER)

Andreas Rosberg, Sandvik Materials Technology
March 25, 2020
Brussels, Belgium
Background

- Pickling of high-alloy tubes
  - Phosphoric-sulphuric acid used for pickling
  - Life of acid limited by metal content (Fe, Cr, Ni)

- Rinsing in tap water
  - 3 different baths
  - Water is changed regularly to keep a low amount of acid

- Waste management
  - Picking acid to landfill at Landøya in Norway
  - Rinse water to wastewater treatment plant
Goal and Purpose of the project

● Demonstrate the recovery of phosphoric- and sulphuric acid from a mixed acid solution used for pickling of stainless and high-alloy tubes
● Demonstrate a rinse water recovery aiming for zero liquid discharge
● Investigate long-term behaviour in the process
Present situation
The INSPIREWATER solution
Acid recovery by nanofiltration

- Introduction to technology
- Reduction
- Pre-filtration
- Nanofiltration
- Evaporation

High metal retention
Low P retention

Pre-treated spent acid
NANOFILTRATION

Pure $\text{H}_3\text{PO}_4$ solution
Metal rich coproduct
Nanofiltration results

- AMS 3012 membrane operated at 70 bar and 40 °C
- Up to 75% permeate recovery
- Dilution was demonstrated as a way to increase yield
Rinse water recovery by reverse osmosis

- High metal retention
- High P retention

Pre-treated spent rinse water → Reverse Osmosis → Pure water for rinsing

Acid and metal rich concentrate

- Introduction to technology
- Reduction
- Pre-filtration
- Reverse osmosis
INSPIREWATER Results
LCA - ILCD

- Calculated on 20% reduced phosphoric acid consumption
- Reduced environmental impact 20%
- Reduced consumption of phosphoric acid 52%
INSPIREWATER Results
LCA - EcoS

- Calculated on 20% reduced phosphoric acid consumption
- Reduced environmental impact 30%
- Reduced consumption of phosphoric acid 52%
INSPIREWATER Results

LCC

- Reduced consumption of phosphoric acid with 52% and 61% for sulphuric acid

![Graph showing cost breakdown for Pickling acid recovery and Pickling acid and rinse water recovery]
Summary

- Successful process for acid recovery demonstrated
  - Reduction of use of phosphoric acid – over 50% savings of phosphoric acid possible
  - Amount of landfill can be significantly reduced
  - Cost reductions is feasible as well as enhancement of sustainability
- Reduction of water usage and amount of wastewater
  - Almost closed loop water recycling technically possible
- Continuation of the project
  - Sandvik interested in taking the process to full scale operation
  - Study of implementation to be initiated
InspireWater - SpotView final web conference:
“Holistic approaches for water and resources efficiency in process industry”


March 25th, 2020

Antti Grönroos (VTT Technical Research Centre of Finland Ltd), Jenni Vaino (Essity), Pasi Nurminen (Valmet), Lotta Sorsamäki (VTT)
Presentation outline

- Sustainable strategies for process water and reuse in tissue paper industry
- Background of the case mill - Essity Nokia tissue
- Target and scope of the process simulation work
- The process simulation work - Case definitions
- Valmet Ultrafiltration T / High Technology Ultrafiltration
- Process water reuse strategy with kidney technology – How we did it?
- Reuse water production by CR1010/30 – Results of Essity Nokia
- Process simulation work - Results; new water balances of Essity Nokia
- Conclusions
Sustainable strategies for process water and reuse in tissue paper industry

- The objective of the work was to establish **sustainable process water reuse strategies for tissue mills**
- Strategies were created based on process **modelling and simulation** of process circuits
- The **kidney technologies, Valmet Ultrafiltration T**, were the main technologies in the strategies
Essity is a global hygiene and health company manufacturing products and solutions such as tissue paper, baby diapers, feminine care, orthopedics and wound care.

Water usage of Essity Nokia has decreased over the years, however the age of the mill, combined with the prominent deinking and paper making process means that water use is still fairly high.

Annual water consumption of fresh water is approx. 2.4M m³/year i.e. around 380 m³/h.

Essity Nokia is aiming towards lower total fresh water consumption by

- realizing rearrangements in water circuits in deinking plant (DIP) and paper machines (PM)
- implementing a CR-filter to produce clean shower water from white water

The target of the work was to decrease the total fresh water consumption by 30%
Target and scope of the process modelling and simulation work

• To verify mill wide the influence of Essity’s predefined and realized water reduction changes on the
  1. Fresh water consumption
  2. TSS-level and
  3. Soluble COD level.
• To evaluate new strategies aiming for reduced fresh water consumption.
• Three cases were evaluated and compared with the Reference case presenting the state of the mill before any water reduction changes were made.
• During SpotView project, four measurements campaigns were performed in Essity Nokia mill to study the operation of the mill before and after the water loop changes.
• Used tool: Balas® steady-state simulation software
The process simulation work - Case definitions

1. Reference case
   - Essity Nokia mill until the end of 2017: no water reduction changes made.

2. Case 1
   - Nokia Essity mill since January 2018: Re-arrangements in water circuits both in DIP and in PMs.

3. Case 2
   - Nokia Essity mill since September 2018
   - Same process configuration as in Case 1
   - Implementation of one pilot-scale Valmet Ultrafilter to PM7
     - The ultrafilter treats part of PM7’s white water → used as shower water

4. Case 3
   - Nokia Essity mill potential future setup
   - Same process configuration as in Case 1
   - Implementation of two pilot-scale ultrafilters to PM7 and one to PM9
     - The ultrafilter treats part of PM7’s and PM9’s white water → used as shower water and in chemical dilutions
Valmet Ultrafiltration T / High Technology Ultrafiltration

- Valmet Ultrafiltration T process is designed to produce colloidal and bacteria free ultrapure water from Tissue mill white waters to
  - Reduce fresh water consumption
  - Improve tissue machine runnability and efficiency
- Compact and modularized process
  - Includes all needed components for fully operational process
- Based on Membrane Technology with Valmet Ultrafilter CR
Process water reuse strategy with kidney technology – How we did it?

• Semi pilot trials with lab scale Valmet Ultrafilter CR250 for membrane and water selection
• Road map of Valmet Ultrafilter CR1010/30 proto for Tissue
  – Building, testing, construction, updating, …
  – Installation to mill, …
  – Long pilot scale trials in Nokia Essity (Sept. 2018 →

| Membrane area | 42 m² |
| Membrane diameter | 1 000 mm |
| Filter cassettes | 30 pcs |
| Membranes | 60 pcs |
| Motor | 45 kW (input power < 30 kW) |
| Size, ca | 1,8 x 2,1 x 1,4 m |
| Membrane pore size | 0.02–0.1 μm |
Reuse water production by CR1010/30 - Results of Essity Nokia

- Pure water for reuse from clear filtrate 8 m³/h
- Pure water for reuse from cloudy filtrate 12 m³/h
- PM7’s high pressure showers need 8 m³/h fresh water – Great!
### Process simulation work - Results; new water balances of Essity Nokia

<table>
<thead>
<tr>
<th></th>
<th>REF</th>
<th>CASE 1</th>
<th>CASE 2</th>
<th>CASE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
</tr>
<tr>
<td>Fresh water</td>
<td>375</td>
<td>292</td>
<td>283</td>
<td>261</td>
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<tr>
<td>Effluent</td>
<td>361</td>
<td>276</td>
<td>267</td>
<td>244</td>
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<tr>
<td><strong>DIP</strong></td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
</tr>
<tr>
<td>Fresh water</td>
<td>90</td>
<td>13</td>
<td>13</td>
<td>13</td>
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<tr>
<td>PM7 water</td>
<td>91</td>
<td>102</td>
<td>102</td>
<td>102</td>
</tr>
<tr>
<td>PM9 water</td>
<td>95</td>
<td>108</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>Effluent</td>
<td>189</td>
<td>118</td>
<td>118</td>
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</tr>
<tr>
<td><strong>PM7</strong></td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
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<tr>
<td>Fresh water</td>
<td>85</td>
<td>85</td>
<td>76</td>
<td>67</td>
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<tr>
<td>Effluent</td>
<td>70</td>
<td>63</td>
<td>54</td>
<td>41</td>
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<tr>
<td><strong>PM9</strong></td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
<td>m³/h</td>
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<tr>
<td>Fresh water</td>
<td>110</td>
<td>104</td>
<td>104</td>
<td>95</td>
</tr>
<tr>
<td>Effluent</td>
<td>100</td>
<td>93</td>
<td>93</td>
<td>84</td>
</tr>
</tbody>
</table>

Final conference; Holistic approaches for water and resource efficiency in process industry; (25th-26th March 2020 Brussels Belgium)
Conclusions

- Sustainable water reuse strategies for Tissue paper industry were done
- The water reuse strategies were created based on process modelling and simulation of process circuits together with kidney technologies
- By exploiting water circuit rearrangements and kidney technology for producing ultrafiltrated process water to substitute fresh shower and chemical dilution water in both paper machines, a reduction of 31% in total fresh water consumption in Essity Nokia tissue mill was achieved
- Used simulation tool “Balas® stady-state simulation software” is a part of VTT’s simulation and modelling platform
- Kidney technology used “Valmet Ultrafiltration Tissue process” is a part of Valmet Water Management portfolio and thus available through on sales activities.
- Both “tools” are available for sustainable water reuse strategies for Tissue paper industry as well as other Pulp and Paper industry all over the Europe/World
Thank You!

Contact:
antti.gronroos@vtt.fi

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723577
Essity is a global hygiene and health company manufacturing products and solutions such as tissue paper, baby diapers, feminine care, orthopedics and wound care.

Essity has approximately 90 production sites, 47,000 employees and net sales of ~€11.6bn as of 2018. Sales are conducted in approx. 150 countries under the leading global brands Lotus, Tena, Tork, Plenty and Cushelle among others.

Essity Finland’s Nokia mill operation includes a deinking plant, two paper machines, six converting lines and an effluent treatment plant.

The BREF Pulp, Paper and Board defines the water consumption of a tissue mill with integrated deinking plants around 10-25 m3/t tissue. Essity Nokia mill is currently in the level of ~35 m3/t tissue.
CR1010/30 proto connection – Case Essity
Nokia

Final conference; Holistic approaches for water and resource efficiency in process industry; (25th-26th March 2020 Brussels Belgium)
Final web conference: “Holistic approaches for water and resources efficiency in process industry”

New strategies for effluent reuse in packaging paper industry

25th March, 2020

Stéphanie PRASSE, Patrick HUBER, Eric FOUREST, Jérôme LEMERCIER, Catherine DESCHAMPS, (CTP) Serge ANDRES (SAICA)
Effluent reuse for fresh water reduction

• Water circuits closure is still a hot topic due to
  – environmental and regulatory constraints and
  – simultaneously Industry self commitment to further progress in sustainable papermaking processes

• Reducing fresh water volume has environmental and techno-economical advantages:
  • Reduction of natural resources needs, energy consumption, effluent flow,
  • Fresh water and effluent treatment cost reduction,

• But…
Fresh water reduction consequences

- **Process water load increases:**
  - Suspended fine solids not retained in paper web,
  - Organic and colloidal substances (released by raw material or produced by bacterial activity)
  - Salts build up (from raw material, chemicals, fresh water)
- Decrease in fiber bonding ability (zeta potential is crushed)
- **Temperature** increase – up a point this is beneficial
- **Oxygen** content decrease,
- **Volatile fatty acids increase and H$_2$ builds up** due to bacteria fermentation (anaerobic conditions) ⇒
  - pH $\downarrow$
  - flammable explosive biogas $\uparrow$
Water management

• Strategies to control COD build-up
  - Water loop separation principle combined to counter-current circulation of process waters: BAT
  - Effluent reuse after biological treatment: Kidney
Water management

• Thanks to efficient water management (BAT), detrimental effects due to organic matters can be well controlled nowadays but **mineral salts still build up**.

• Consequences of salinity increase:
  – Additives become ineffective (retention agents, wet-ends additives, flocculants)
  – Weak fibre bonding
  – Scaling, deposits, corrosion

• What is the main source of conductivity?
  – Raw material?
  – Fresh water?
  – Additives?
  – Effluent reuse?

Use of modelling
Method

- Digital model of process circuit design
  - Design of flowcharts with all process equipment, inputs, outputs and the different connections between them.
  - Data collection during on-site campaigns through:
    - Data collection from DCS control system
    - On site flow measurements
    - Physico-chemical analyses on pulp and process waters
  - Design of digital model of the process circuit with CTP simulation tool (PS2000).
Method

• Build mass and hydraulic balances simulation of the mill (PS2000) and implement ionic sources (PhreeQC)

[Diagram with labels: Caustic soda, Fresh water, Raw material, Bisulfite, VFA, Polymers (counter-ions)]
Conductivity sources

- Conductivity « balance »

Major impact of broke repulping chemicals

(contribution without considering reduced soda + bisulfite)
Case study: Containerboard mill

• Proposed scenarios for clarified effluent reuse
Case study: Containerboard mill

- Options for process water and effluent reuse
  - DAF effluents reuse as dilution water for stock preparation + substitution of fresh water by super-clear filtrates on some low pressure PM showers (sheet forming section)
  - Bio-treated effluent reuse as substitution of fresh water on low pressure PM showers (forming section)
  - Bio-treated effluents reuse as kidney loop in stock preparation facility + substitution of fresh water on low pressure PM showers.
    • This scenario requires to flush part of the super-clear filtrates out of the process, into the WWTP, in order to be able to increase the recirculated bio-treated flow
Case study: Containerboard mill

- Bio-treated effluent recirculation (fresh water substitution)
- DAF recirculation to pulper dilution + super-clear filtrates recirculation (fresh water substitution)
- SCF treated + bio-effluent recirculation (fresh water substitution and kidney)
Case study: Containerboard mill
Case study: Containerboard mill

- Bio-treated effluent recirculation (fresh water substitution)
- DAF recirculation to pulper dilution + super-clear filtrates recirculation (fresh water substitution)
- SCF treated + bio-effluent recirculation (fresh water substitution and kidney)
Case study: Containerboard mill

- Bio-treated effluent recirculation (fresh water substitution)
- DAF recirculation to pulper dilution + super-clear filtrates recirculation (fresh water substitution)
- SCF treated + bio-effluent recirculation (fresh water substitution and kidney)
## Case study: Containerboard mill

### Synthesis

<table>
<thead>
<tr>
<th></th>
<th>DAF recirculation to pulper dilution + SCF* recirculation (FW substitution)</th>
<th>Bio-effluent recirculation (FW substitution)</th>
<th>SCF* bio-treated + bio-effluent recirculation (FW substitution + kidney)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>-</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Conductivity</td>
<td>- - -</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>T°</td>
<td>- - -</td>
<td>-</td>
<td>- - -</td>
</tr>
<tr>
<td>pH</td>
<td>- -</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Calcium</td>
<td>- - -</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

- Fresh water reduction from 7.0 to 3.5 m³/t
- Temperature decrease ⇒ heat pumps implementation
Conclusions

- To go further on fresh water reduction:
  - Need case by case of a specific local study taking into account
    - Pulp and water process circuits, existing and retrofit program
    - Water management rules
  - Identification of chemicals sources
    - Raw materials, fresh water, chemicals
  - Modeling of the mill
    - Mass and hydraulic balances
    - Chemical equilibrium
  - Simulation of bio-effluent reuse according to different scenarios to predict COD, conductivity and pH outcomes
Exploitation’s outlook in an OCC mill

- During Spotview, many scenarios concerning the reuse of water and recovery of heat have been investigated.
- From this we forecast extensive **stepwise reuse of bio-treated effluent**
  1. **as a kidney** to limit contaminant build-up in circuit water
  2. **as fresh water substitution**

  - Preliminary reduce pulp and water retention times in circuits to limit starch release and hydrolysis:
    - Limit tanks volumes, piping routes, storage levels…

  - Complete the water circuits rearrangement with specific additional satellite processes to overcoming rising bottlenecks:
    - Heat exchangers/pumps,
    - Sand/membrane filters
    - Deionization units,
    - Antimicrobial treatments…
Extensive reuse of clarified effluents

- **Implement effluent reuse as kidney**
  - Additional loop with high circulating flows
  - Operates specifically in the pulp preparation area.
  - Solubilised species are washed out, including starch, VFAs, COD and free calcium.
    - Washed out starch is converted into useful biogas in WWTP
    - Free calcium settles in form of precipitated lime and is disposed of
  - Depending on circuit closure rate, this can be based on
    - current WWTP
    - or an new extra short loop with small bioreactor next to the pulp building, completed by a lime trap (to avoid calcium building up)

- **Constraints**
  - Significant impact on process temperature. Heat recovery is recommended
  - Small specific bioreactor would be less impacting with regard to temperature loss
Outlook – Reuse of clarified effluents

• **Substitute Fresh water**
  – Possibly wide use in many applications with low quality requirements
    • Dilution of chemical additives and cooked starch,
    • Washing hoses around PM (house keeping),
    • Wet end showers…To be investigated case by case

• Constraints
  – Out of scope applications due to mild effluent temperature and unsecured cleanliness
    • Cooling water for air compressors or hydraulic power units (several x10 m3/h).
    • Few high demanding technical applications like HP showers on felts
  – Costs of water circuits rearrangements may increase fast.
    • Concept is easier and cheaper to implement in a mill under construction
  – Preliminary antimicrobial treatment needed
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723577
WEDNESDAY, 25 MARCH 2020

09:30 Web conference room is open

10:30 Start of the conference program
   Moderation: DECHEMA (Dennis Becker), CTP (Eric Fourest)

10:30 Welcome
   DECHEMA and CTP

10:40 Welcome and introduction from SPIRE
   Angels Orduna (SPIRE)

10:45 Introduction of INSPIREWATER and SPOTVIEW
   Staffan Filipsson (IVL), Eric Fourest (CTP)

11:00 KEYNOTE: Challenges for the chemical industry – creating the next level of sustainable water usage
   Niels Groot (Dow Benelux B.V.)

11:10 KEYNOTE: Water and Resource efficiency in the Steel Industry: current challenges and new solutions under an ecosystem perspective
   Sophie Carler (Jernkontoret)

   Jori Ringman (Confederation of European Paper Industries)

11:30 KEYNOTE: Recent development in EU Water Policy
   Bettina Doeser, Head of Clean Water Unit, European Commission

11:40 PANEL DISCUSSION: Challenges for Water Management in Industry
   Moderator: Brian Maguire (EBX MEDIA)
   Participants: Niels Groot (Dow Benelux B.V.), Sophie Carler (Jernkontoret), Jori Ringman (CEPI), Bettina Doeser (EC), Angels Orduna (SPIRE)

12:15 Lunch break

13:15 Innovative and sustainable solutions in the steel industry – new developments in water management (INSPIREWATER/SPOTVIEW)
   Martin Hubrich, VDEh-Betriebsforschungsinstitut (BFI), Elena Piedra Fernández, Beatriz Padilla Vivas (ArcelorMittal)

13:30 Innovative and sustainable solutions in the steel industry – recovery of acids (INSPIREWATER)
   Andreas Rosberg (Sandvik), Fredrik Hedman (IVL)

13:45 New strategies and technologies for process water recycling in tissue paper industry (SPOTVIEW)
   Antti Grönroos (VTT), Jenni Vaino (Essity), Pasli Numminen (Valmet), Lotta Sorsamäki (VTT)

14:00 New strategies for effluent reuse in packaging paper industry (SPOTVIEW)
   Stéphanie Frasse (Centre Technique du Papier), Serge Andres (Saica EL)

14:15 Coffee break

14:45 Improved technology solutions in the chemical industry (INSPIREWATER)
   Jozef Kochan, Friedhelm Zorn (Clariant)

15:00 Innovative and sustainable solutions in the dairy industry (SPOTVIEW)
   Anastasios Karabela, Dimitris Sioutopoulos (CERTH), Konstantinos Georgakidas (MEVGAL)

15:15 Resource recovery from industrial waste water by cutting edge membrane technologies – Outcomes of the ReWaCEM project
   Daniel Winter (Fraunhofer Institute for Solar Energy Systems ISE)

15:30 End of the first day

THURSDAY, 26 MARCH 2020

08:30 Web conference room is open

09:00 Wrap-up Day 1
   Moderation: DECHEMA (Dennis Becker), CTP (Eric Fourest)

09:10 KEYNOTE: The Energy Footprint of Water Treatment
   Joachim Köschikowski (Fraunhofer Institute for Solar Energy Systems ISE)

09:20 KEYNOTE: Water Footprint, financing industrial water through Blue Bonds
   Jaap Feil (iWater – Water Footprint Implementation)

09:30 KEYNOTE: The Value of Water
   Thomas Track (DEHEMA e.V.)

09:40 PANEL DISCUSSION: How to save costs with water in industry?
   Moderator: Brian Maguire (EBX MEDIA)
   Participants: Joachim Köschikowski (Fraunhofer ISE), Jaap Feil (iWater), Thomas Track (DEHEMA e.V.)

10:15 Coffee break

10:45 Holistic water management (INSPIREWATER)
   Agata Andersson, Henrik Kloos (IVL)

11:00 Environmental impacts of water optimization strategies developed within SPOTVIEW
   Elorri Igos (LIST)

11:15 Environmental and economic assessment of INSPIREWATER solutions for resource recovery in process industries
   Fredy Dinkel (FHNW)

11:30 Next steps towards creating sustainable impact through business exploitation (INSPIREWATER/SPOTVIEW)
   Presentation of the exploitation opportunities of both projects by PDC and IMCG

11:45 Opportunities and challenges to implement new innovative technologies into existing industrial environments (INSPIREWATER/SPOTVIEW)
   Panel discussion moderated by PDC/IMCG. Interactive session with technology providers and end users from both projects

12:15 Wrap-up and some closing words

12:30 End of the conference
Improved technology solutions in the chemical industry
Table of Contents

– Motivation and Challenges
– Water management in Tarragona
– Pilot concept – Aim and Technologies
– Experience during piloting
Project Motivation: Water scarcity and stricter discharge limits by governments require higher efforts and cost for WWT.
Towards Zero Liquid Discharge (ZLD)
Total effluent treatment in chemical industry

General aim: Demonstrate the reliability of the technological concept proposed

Water in products, Educts, evaporation, rainfall, gardening, etc.

70% water saving potential at full ZLD

Insirewater
Modular process is developed and tested at Clariant’s Tarragona site

Site Description

Production for Clariant BU’s ICS and OMS*
Production: 71 K t / year
WWTP: 60 m³/h / 5,000 TOC
Third companies: IQOXE, National Container Group and others.

Site effluent characteristics
- Secondary effluent possesses a high fouling and scaling potential
- Discontinuous processes of 4 companies and multi-purpose pilot plant producing surfactants, detergents, polymers, emulsifiers etc.
- Significant variation in the composition

* BU = Business Unit, ICS = Industrial and Consumer Specialties, OMS = Oil and Mining Services
Piloting concept tested in INSPIREWater

- Duration of pilot operation: 18 months (Q3/2017 - Q1/2019) in 24/7 operation mode
- **Treatment of secondary effluent** (real conditions) 5 m³/h
- Neutralization in the existing WWT process changed from Ca(OH)₂ to NaOH

* MK = heterogeneous metal catalyst
Technologies involved in the pilot study (impressions)

- **Ultrafiltration** (IntegraFlux™ SFP-2880XP)

- **Reverse Osmosis** (FILMTEC™ FORTILIFE™ CR100)

- **MOL catalyst**

- **Forward Osmosis** incl. draw solution recovery by RO/MD
1st piloting phase: Moderate permeate yields of the proposed concept

- Due to high organic loads on RO stage only moderate water recovery (<40%)
- Pilot concept operation instable with frequent interruptions (real production conditions, high variation in wastewater composition from MPPP)
  - Filtration performance deteriorated by fouling and scaling
  - Frequent backwashing and cleaning necessary
- RO permeate quality suitable for medium water quality applications like washing water

FAZIT: Reduction of organic load inevitable!

Concept to be adjusted
Pre-treatment of effluent by GAC results in achieving 65% RO permeate recovery

- GAC (Organosorb 20, Desotec) reduced the COD content <100 mg/l upfront the membrane system

Installation of GAC resulted in

- More **stable operation** of membrane units
- Reduced number of cleaning and backwashing cycles
- **Higher RO permeate yields**
- Permeate quality suitable for **higher grade** recycling purposes
- High removal rate for 1,4-dioxane (>99%) (GAC, RO)

* GAC = Granular activated carbon
Reverse Osmosis (RO) brine treatment by innovative BLUE-tec FO-HBRO™

- Extraction of water from RO brine through a FO membrane by osmotic pressure difference
- Subsequent water reclamation from draw solution by HBRO (installed in Tarragona) or MD (tested in Renkum NL)
- FO works at “ambient” pressure with lesser fouling propensity

* FO = Forward osmosis, HBRO = High brine reverse osmosis, MD = Membrane distillation
Cost efficient reduction of wastewater volume through FO technology

- Vol. concentration factor (CF) of 2.3 observed meaning **additional 57% water recovery** from the RO brine (CF~9 in lab tests)
- Spec. energy FO-HBRO 36kWh/m³ estimated (20 kWh/m³ for full-scale plant with pressure recovery in place)
- TRL lifted from 4 to 5.
Conclusions

• End-of-the-pipe application of membranes for treatment of industrial water from the speciality chemicals industrial site is technically challenging

• **WATER RECOVERY** of 85% demonstrated with the piloted concept
  
  • Blended permeate (RO and FO) can be used for medium and low quality applications

• Removal of 1,4-dioxane to below regulatory limits

• FO-HBRO is a promising alternative for brine treatment
Acknowledgement

This work has been conducted with the financial support of the Horizon 2020 Programme of the European Commission within the framework of the INSPIREWater project (Grant Agreement Nº 723702)

https://www.spire2030.eu/inspirewater

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Thank you for your attention!

what is precious to you?
Innovative and sustainable solutions in the dairy industry

Webconference, March 26th 2020
Dimitrios Sioutopoulos, Anastasios Karabelas (CERTH), Konstantinos Georgakidis (MEVGAL)

CROSS CUTTING ISSUE CONFERENCE
Holistic approaches for water and resource efficiency in process industry
Outline

- Introduction - Dairy industry

- Technologies and results for valuable compounds recovery - Lab tests
  - Laboratory set-ups
  - Experimental procedure
  - Outcomes of lab tests

- Technologies and results for valuable compounds Pilot unit tests
  - Pilot unit description
  - Parameters of testing
  - Pilot unit tests

- Final conclusions
Dairy industry in EU-28

Total milk production (million tonnes)

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (million tonnes)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>148.471</td>
<td>+2.6%</td>
</tr>
<tr>
<td>2015</td>
<td>152.334</td>
<td>+0.6%</td>
</tr>
<tr>
<td>2016</td>
<td>153.177</td>
<td>+1.9%</td>
</tr>
<tr>
<td>2017</td>
<td>156.086</td>
<td>+0.9%</td>
</tr>
<tr>
<td>2018</td>
<td>157.415</td>
<td>+0.5%</td>
</tr>
<tr>
<td>2019</td>
<td>158.234</td>
<td></td>
</tr>
</tbody>
</table>

Country’s share in 2018
Dairy industry in EU

What is the milk in the EU used for?

Fabrication of:

- Cheese: 37.7%
- Butter: 29.4%
- Cream: 11.9%
- Drinking milk: 11.0%
- Acidified milk: 4.3%
- Powder products: 2.9%
- Other products: 2.7%

Milk refers to whole milk which is processed (98.1% of the available milk). The remains (1.9%) is non-processed milk, which is delivered to the national non-dairy industry (agri-food, feedstuff industries etc.), returned to farms or lost.

Data for 2018.
Water consumption in EU dairy industry

Annual milk production

158 millions tonnes

Specific water consumption

4 m³/ton

Annual water consumption

630 millions tonnes

SpotView Target:

25% reduction

130 millions tonnes
Separation Capabilities of Membranes

**Microfiltration, MF**
- Suspended solids
- Colloidal matter
- Microorganisms

**Ultrafiltration, UF**
- Organic macromolecules
- Pathogens

**Nanofiltration, NF**
- Multivalent ions
- Hardness removal
- Low molecular weight organic compounds

**Reverse Osmosis, RO**
- Dissolved salts
- Low molecular weight organics
Membranes in dairy industry

**Rejection of milk components**

- Somatic cells
- Fat globules
- Bacteria and spores
- Casein micelles
- Whey proteins
- NPN, Lactose Polyvalent minerals
- Monovalent minerals
- Water

**Membrane usage**

- ESL Milk
- Skimmed Milk
- Milk Protein Concentrate
- Milk Protein Isolate
- Milk Protein Hydrolysate
- Milk Lactosefree
- Jogurt
- Cottage Cheese
- WPC 60,70,80
- Whey Protein Isolate
- WPC Demineralized
- Lactose Concentrate
Separation technologies for the recovery of valuable compounds - Lab tests

Pressurized membrane cell

UF/NF membrane Lab pilot
Experimental set-up and conditions

- **Treated sample**
  1. Flushing yogurt
  2. Flushing milk

- **Membrane type**
  1. UF PAN 20 kDa (AMI®)
  2. UF PES 20 kDa (ALVA LAVAL)
  3. MF 0.20 μm (MILLIPORE)
  4. NF NF-270 (FILMTEC)
Experimental results

<table>
<thead>
<tr>
<th>#</th>
<th>Feedwater</th>
<th>Membrane</th>
<th>Applied pressure</th>
<th>Permeability Clean water (LMH/bar)</th>
<th>Permeability (LMH/bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flushing milk</td>
<td>UF PAN 20 kDa</td>
<td>0.5 bar</td>
<td>550</td>
<td>8</td>
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<tr>
<td>2</td>
<td>Flushing milk</td>
<td>UF PES 20 kDa</td>
<td>3.0 bar</td>
<td>60</td>
<td>0.8</td>
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<tr>
<td>3</td>
<td>Flushing milk</td>
<td>UF PES 20 kDa</td>
<td>5.1 bar</td>
<td>80</td>
<td>1.2</td>
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<tr>
<td>4</td>
<td>Flushing yogurt</td>
<td>UF PES 20 kDa</td>
<td>3.0 bar</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Flushing yogurt</td>
<td>MF 0.20 μm</td>
<td>0.14 bar</td>
<td>12,000</td>
<td>40</td>
</tr>
</tbody>
</table>

UF membranes exhibit high COD retention (80%-90%)

UF PAN (#1) membrane has less fouling tendency compared to UF PES (#2)

MF membrane has poor COD retention
Retention characteristics

Valuable compounds (proteins, fat) are effectively retained by UF membranes.

Lactose is totally rejected by NF, whereas UF membranes retain approx. 10%-20% of lactose.

In general, higher recovery of valuable compounds using flushing yogurt compared to flushing milk.

<table>
<thead>
<tr>
<th>Membrane type</th>
<th>Lactose (%)</th>
<th>Proteins (%)</th>
<th>TOC (%)</th>
<th>COD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF</td>
<td>83.6</td>
<td>25.6</td>
<td>18.5</td>
<td>18.3</td>
</tr>
<tr>
<td>UF PAN</td>
<td>92.2</td>
<td>42.6</td>
<td>23.9</td>
<td>18.2</td>
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<tr>
<td>UF PS</td>
<td>93.8</td>
<td>38.2</td>
<td>30.5</td>
<td>49.1</td>
</tr>
<tr>
<td>NF</td>
<td>100.0</td>
<td>99.3</td>
<td>99.0</td>
<td>99.0</td>
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</tbody>
</table>

<table>
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<th>Membrane type</th>
<th>Lactose (%)</th>
<th>Proteins (%)</th>
<th>TOC (%)</th>
<th>COD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF</td>
<td>27.5</td>
<td>38.2</td>
<td>39.6</td>
<td>39.6</td>
</tr>
<tr>
<td>UF PAN</td>
<td>40.5</td>
<td>49.1</td>
<td>45.1</td>
<td>45.1</td>
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<tr>
<td>UF PS</td>
<td>53.0</td>
<td>53.0</td>
<td>53.0</td>
<td>53.0</td>
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<tr>
<td>NF</td>
<td>100.0</td>
<td>98.0</td>
<td>99.3</td>
<td>99.3</td>
</tr>
</tbody>
</table>

Flushing milk

Flushing yogurt
Separation technologies for the recovery of valuable compounds – Pilot unit tests

Submerged UF pilot

Design parameters

- **Feed Tank Volume**: 500 L
- **Module membrane area**: 3.4 m²
- **Membrane module volume**: 12 L
- **Feedwater Concentrating factor**: up to 10
- **Hydraulic Retention Time (HRT)**: 35 min
- **Membrane Flux - Forward**: 4-10 LMH
- **Membrane material**: PVDF
- **Membrane pore size**: 0.04 μm
- **Mean Volumetric Rate**: 20 L/h
- **Effective Membrane Flux**: 6.0 LMH
Separation technologies for the recovery of valuable compounds – Pilot unit

- Fully automatic, remotely controlled pilot unit through a PC, tablet, or smartphone
- Allows the operator to monitor - in real time - the trends of the most important system operating parameter (i.e. suction pressure, backwash pressure, permeation rate, pH, temperature, etc)
- Warning alarms and safety alerts in case of increased pressure for pilot unit protection
Separation technologies for the recovery of valuable compounds – Pilot unit tests
Separation technologies for the recovery of valuable compounds – Pilot unit tests

**Temperature effect**

- **Severe fouling**
  - $T = 4 \, ^\circ \text{C}$

- **Moderate fouling**
  - $T = 20 \, ^\circ \text{C}$

- **Low fouling**
  - $T = 40 \, ^\circ \text{C}$
Separation technologies for the recovery of valuable compounds – Pilot unit tests

Permeation rate effect

- **Low fouling**
  - Low permeability
  - 4 L/m²h

- **Moderate fouling**
  - Moderate permeability
  - 6 L/m²h

- **Severe fouling**
  - High permeability
  - 10 L/m²h
General conclusions

✓ Microfiltration due to large pore size exhibits poor useful compounds retention, whereas, nanofiltration is characterized by the best retention/selectivity; however, due to increased feed-pressure requirements, energy consumption is significant.

✓ Ultrafiltration (UF) exhibits satisfactory selectivity and modest energy consumption.

✓ The implementation of a submerged Ultrafiltration (UF) system was selected as the best option for further pilot testing.

✓ The results of Submerged Ultrafiltration (sUF) pilot unit confirm that sUF is characterized by low fouling tendency, high selectivity and low energy consumption.

✓ The effect of temperature in the filtration process is crucial. In particular, it is observed that higher temperature (in the range of 40°C) results in lower fouling and higher concentration factors.

✓ Permeation flux values smaller than 8 L/m²h, severe fouling phenomena could be avoided, thus ensuring smooth operation of the pilot unit.
RECOVERY OF ACIDS AND METALS FROM PICKLING SOLUTIONS OF THE METAL PROCESSING INDUSTRY

D. Winter et. al

23.03.2020, Freiburg
InspireWater Webinar

Fraunhofer Institute for Solar Energy Systems ISE

www.ise.fraunhofer.de
AGENDA

- ReWaCEM – Consortium and Objective
- Demonstration Cases
- Results of Selected Show Case
- Summary
Introduction

Consortium – 14 Project Partners

R&D Institutes and Universities

- Fraunhofer ISE
- BFI (Bundesforschungsanstalt für Materialwissenschaft und Werkstofftechnik)
- University of Stuttgart
- Ciemat
- Università degli Studi di Palermo
- AEE INTEC

SMEs

- SolarSpring
- membrane solutions
- DEUKUM
- PSE
- alz

Industry

- TecnoZinco
- ELECTRONIQUE
- DEUTSCHE EDELSTAHLWERKE
- AT&S
Introduction

Objective

The overall objective of the project is to reduce the:

- fresh water demand
- demand for make-up acids
- amount of disposed waste water
- amount of disposed valuable metals

in metal plating industry by a combination of innovative membrane separation technologies as Diffusion Dialysis (DD), Membrane Distillation (MD) and advanced filtration systems for pre treatment.
Demonstration Cases

Show-Case A: TecnoZinco (Carini, Italy)  
Commissioning 3/2019

Recovery of HCl and Iron from hot dip galvanizing pickling solutions
Demonstration Cases

Show-Case A: (Carini, Italy)  
Recovery of HCl and Iron from hot dip galvanizing pickling solutions  
Commissioning 3/2019

Show-Case B: (Gijon, Spain)  
Recovery of H$_2$SO$_4$ and Copper from electroplating pickling solutions  
Commissioning 4/2019
Demonstration Cases

Show-Case A: **TecnoZinco** (Carini, Italy)  
Commissioning 3/2019  
Recovery of **HCl** and **Iron** from hot dip galvanizing pickling solutions

Show-Case B: **ElectroniQuel** (Gijon, Spain)  
Commissioning 4/2019  
Recovery of **H₂SO₄** and **Copper** from electroplating pickling solutions

Show-Case C: **DEU** (Hagen, Germany)  
Commissioning 2/2019  
Recovery of **HF** and **HNO₃** from mixed acid pickling solutions from stainless steel wire rod production
Demonstration Cases

Show-Case A: (Carini, Italy)  
Recovery of HCl and Iron from hot dip galvanizing pickling solutions

Show-Case B: (Gijon, Spain)  
Recovery of H₂SO₄ and Copper from electroplating pickling solutions

Show-Case C: (Hagen, Germany)  
Recovery of HF and HNO₃ from mixed acid pickling solutions from stainless steel wire rod production

Show-Case D: (Fehring, Austria)  
Recovery of rinsing water and gold in printed circuit board production
Demonstration Cases

Show-Case A:  
(TecnoZinco)  
(Carini, Italy)  
Commissioning 3/2019

Recovery of HCl and Iron from hot dip galvanizing pickling solutions

Show-Case B:  
(Electroniquel)  
(Gijon, Spain)  
Commissioning 4/2019

Recovery of H$_2$SO$_4$ and Copper from electroplating pickling solutions

Show-Case C:  
(DEUTSCHE EDELSSTAHLWERKE)  
(Hagen, Germany)  
Commissioning 2/2019

Recovery of HF and HNO$_3$ from mixed acid pickling solutions from stainless steel wire rod production

Show-Case D:  
(AT&S)  
(Fehring, Austria)  
Commissioning 3/2019

Recovery of rinsing water and gold in printed circuit board production
Selected Show Case A – Hot Dip Galvanization

Problem Statement

- Pickling – Surface (pre-)treatment by reactive chemical etching for
  - removal of oxide layers
  - formation of surface textures

Illustration of the total process chain for hot dip galvanizing

- Similar pickling processes in
electro galvanization, stainless steel production, silicon wafer production
Selected Show Case A – Hot Dip Galvanization

Problem Statement

- **Pickling baths**
  - Acids are consumed, introduction of reaction products and particles into the pickling bath
  - Continuous or batch-wise recovery of pickling bath necessary
  - Disposed pickling solutions still contain free acid next to reaction products (metal salts) and particles
  - Economic and ecologic benefits possible through recycling of spent pickling solutions
    - Reduced demand on make-up acid
    - Reduced disposal quantities
    - Process intensification and advanced process control possible
Selected Show Case A – Hot Dip Galvanization

Recycling of Acids and Metals in a ZLD Approach

- Acid Recovery
  - Diffusion Dialysis (DD)
- Acid Recovery and Water Recovery
  - Membrane Distillation (MD)
- Metal Recovery
  - Reactive Precipitation (RP)
Selected Show Case A – Hot Dip Galvanization

Selected Results

- Recovery of free HCl: ~80%
- Oxidation and precipitation Fe(OH)₃: ~99%
- HCl retention on FeCl₂: ~65%

Pickling solution:
~100g/l free HCl / ~265g/l FeCl₂ (consumed HCl)

Conc. factor: 1.2-1.4
HCl retention: 72%

ReWaCEM plant Demo A, arrival at industrial site in Carini, IT
Summary

Four industrial scale Demonstrators for waste acid, metal and rinsing water recovery were successfully designed, built and operated.

- **Capacity**
  - 10-100l/h

- **DD Membrane**
  - 10-70m²

- **MD Membrane**
  - 6.5-25m²

- **RP Reactor**
  - 20l
Summary

Four industrial scale Demonstrators for waste acid, metal and rinsing water recovery were successfully designed, built and operated.

Results were rated by applying LCA and water footprint methods and showed positive ecologic impact on various impact categories.

Diffusion Dialysis (DD)
- Very high acid recovery rates in DD (80-90%) for all tested acid systems
  - Future challenge: Additional recovery of consumed/bound acid (FeCl₂) - substitution thermal pyrolysis with advanced membrane approaches (CO₂ efficient and not only for huge capacities)
- Slight metal passage in DD modules observed
  - Future challenge: Minimization of metal passage through DD membranes
Summary

Membrane Distillation (MD)
- New MD concept for hazardous media was developed
- Waste heat is (and should be) applied to achieve economic feasibility
- Acid concentration and rinsing water recovery works fine, but volatile acid compounds pass the membrane

-> Future Challenge: Optimization of concentration concept specifically for volatile acids

Reactive Precipitation (RP)
- CSTR process control works well, high metal recovery (~90%) and purity achieved
Thank you for your attention!

Fraunhofer Institute for Solar Energy Systems ISE

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09:30   Web conference room is open
10:30   Start of the conference program
        Moderation: DECHEMA (Dennis Becker), CTP (Eric Fourest)
10:30   Welcome
        DECHEMA and CTP
10:40   Welcome and introduction from SPIRE
        Angels Orduna (SPIRE)
10:45   Introduction of INSPIREWATER and SPOTVIEW
        Staffan Filipsson (IVL), Eric Fourest (CTP)
11:00   KEYNOTE: Challenges for the chemical industry – creating the next level of sustainable water usage
        Niels Groot (Dow Benelux B.V.)
11:10   KEYNOTE: Water and Resource efficiency in the Steel Industry: current challenges and new solutions under an ecosystem perspective
        Sophie Carler (Jernkontoret)
        Jori Ringman (Confederation of European Paper Industries)
11:30   KEYNOTE: Recent development in EU Water Policy
        Bettina Doesser, Head of Clean Water Unit, European Commission
11:40   PANEL DISCUSSION: Challenges for Water Management in Industry
        Moderator: Brian Maguire (EBX MEDIA)
        Participants: Niels Groot (Dow Benelux B.V.), Sophie Carler (Jernkontoret), Jori Ringman (CEPI), Bettina Doesser (EC), Angels Orduna (SPIRE)
12:15   Lunch break
13:15   Innovative and sustainable solutions in the steel industry – new developments in water management (INSPIREWATER/SPOTVIEW)
        Martin Hubrich, VDEh-Betriebsforschungsinstitut (BFI), Elena Piedra Fernández, Beatriz Padilla Vivas (ArcelorMittal)
13:30   Innovative and sustainable solutions in the steel industry – recovery of acids (INSPIREWATER)
        Andreas Rosberg (Sandvik), Fredrik Hedman (IVL)
13:45   New strategies and technologies for process water recycling in tissue paper industry (SPOTVIEW)
        Antti Grönroos (VTT), Jenni Vaino (Essity), Pasi Nummenen (Valmet), Lotta Sorsamäki (VTT)
14:00   New strategies for effluent reuse in packaging paper industry (SPOTVIEW)
        Stéphane Frasse (Centre Technique du Papier), Serge Andres (Saica EL)
14:15   Coffee break
14:45   Improved technology solutions in the chemical industry (INSPIREWATER)
        Jozef Kochan, Friedhelm Zorn (Clariant)
15:00   Innovative and sustainable solutions in the dairy industry (SPOTVIEW)
        Anastasios Karabelas, Dimitris Sioutopoulos (CERTH), Konstantinos Georgakidis (MEVGAL)
15:15   Resource recovery from industrial waste water by cutting edge membrane technologies – Outcomes of the ReWaCEM project
        Daniel Winter (Fraunhofer Institute for Solar Energy Systems ISE)
15:30   End of the first day

08:30   Web conference room is open
09:00   Wrap-up Day 1
        Moderation: DECHEMA (Dennis Becker), CTP (Eric Fourest)
09:10   KEYNOTE: The Energy Footprint of Water Treatment
        Joachim Koschikowski (Fraunhofer Institute for Solar Energy Systems ISE)
09:20   KEYNOTE: Water Footprint, financing industrial water through Blue Bonds
        Jaap Feil (iWater – Water Footprint Implementation)
09:30   KEYNOTE: The Value of Water
        Thomas Track (DECHEMA e.V.)
09:40   PANEL DISCUSSION: How to save costs with water in industry?
        Moderator: Brian Maguire (EBX MEDIA)
        Participants: Joachim Koschikowski (Fraunhofer ISE), Jaap Feil (iWater), Thomas Track (DECHEMA e.V.)
10:15   Coffee break
10:45   Holistic water management (INSPIREWATER)
        Agata Andersson, Henrik Kloo (IVL)
11:00   Environmental impacts of water optimization strategies developed within SPOTVIEW
        Elorri Igos (LIST)
11:15   Environmental and economic assessment of INSPIREWATER solutions for resource recovery in process industries
        Fredy Dinkel (FHWN)
11:30   Next steps towards creating sustainable impact through business exploitation (INSPIREWATER/SPOTVIEW)
        Presentation of the exploitation opportunities of both projects by PDC and IMCG
11:45   Opportunities and challenges to implement new innovative technologies into existing industrial environments (INSPIREWATER/SPOTVIEW)
        Panel discussion moderated by PDC/IMCG. Interactive session with technology providers and end users from both projects
12:15   Wrap-up and some closing words
12:30   End of the conference