PRODUCED WATER SOCIETY
SEMINAR 2018

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Ceramic Membranes as a Kidney Technology for Water Reuse

DAY 1

February 13, 2018

STRAND 1: DEVELOPMENTS IN PRODUCED WATER MANAGEMENT

Optimizing Water Handling

Ceramic Membranes as a Kidney Technology for Water Reuse

Elena Meabe PhD, *Likuid Nanotek*

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The challenge and the opportunity

DRIVERS FOR PW REUSE

- Increasing water cuts
- Water scarcity
- Environmental concerns
- Demanding legislation
- Treatment & disposal costs

REUSE is not only environmentally friendly but also involves increased **cost-efficiency**.

USERS' DEMANDS

ROBUSTNESS

RELIABILITY

VERSATILITY

OUR VALUE PROPOSITION

Innovative **CERAMIC MEMBRANE** solution for highly-efficient removal of emulsified oil.

- CleanOil membranes for oil removal
- Fully automated filtration system
- Devices for enhanced filtration
- CleanFlux monitoring and control

European Commission

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PW treatment&reuse: Why ceramic membranes

- Membranes for demanding applications and conditions, such as…
  - High temperatures
  - High and variable oil content
- Chemical resistance.
  - Inert to solvents, oxidants, etc.
- Harsh cleaning protocols,
  - in the case of unexpected scaling events.
- High and consistent effluent quality (free of solids, O&G, turbidity and bacteria),
  - due to the narrow pore size distribution.
- High hydraulic output and minimum fouling, due to…
  - the high hydrophilicity,
  - the cross-flow operation.

ROBUSTNESS **VERSATILITY** **RELIABILITY** **MODULARITY** **COMPACTNESS**

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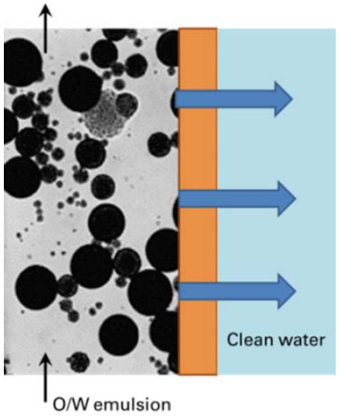
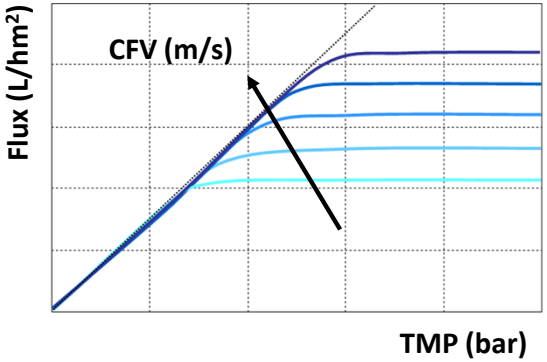
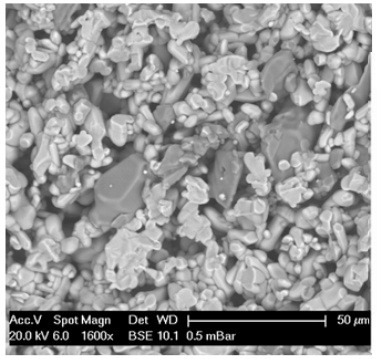
Ceramic membrane filtration for oil removal - Fundamentals

The CROSS-FLOW concept





MEMBRANE characteristics



EXTERNAL MEMBRANES. INTENSIVE OPERATION

CFV creates high turbulence inside the membrane channels:

- High permeate fluxes.
- Minimum fouling.
- Reduced membrane area/footprint.

CERAMIC material (Al_2O_3, TiO_2, Zr_2O_3)

Highly hydrophilic: 'attracts' water and rejects oil

Multitubular (geometry acc. to O&G content).

25/50/100 nm (pore size acc. to oil droplet size).

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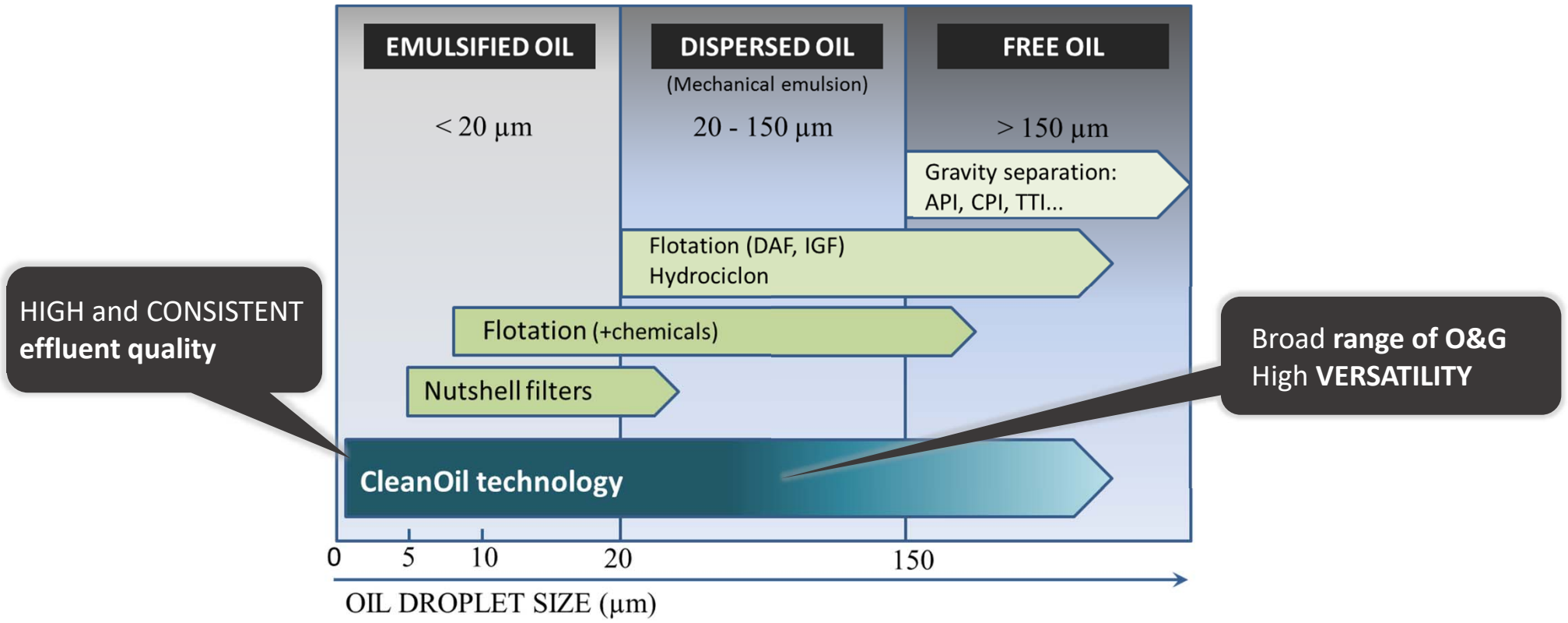
Ceramic membrane filtration for oil removal - Fundamentals



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Contents lists available at ScienceDirect
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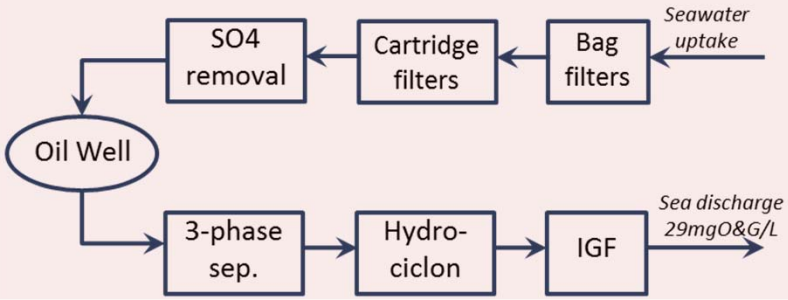
CleanOil technology – Application

Evaluation of ceramic membranes for oilfield produced water treatment aiming reinjection in offshore units

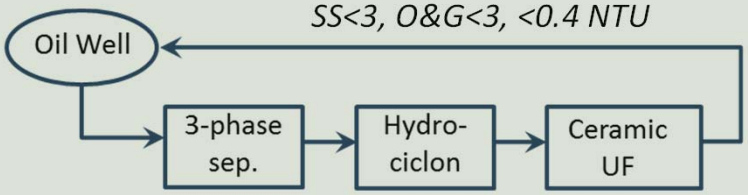
Silvio E. Weschenfelder [a,d,*], Ana M.T. Louvisse [a], Cristiano P. Borges [b], Elena Meabe [c], Javier Izquierdo [c], Juacyara C. Campos [d]

OFFSHORE PW treatment for reinjection

CONVENTIONAL:

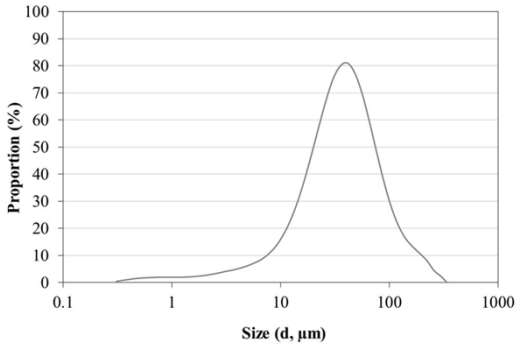


CERAMIC UF:



PW from a Brazilian well:

Component	Unit	Value
Barium (Ba^{2+})	mg/L	2
Stroncium (Sr^{2+})	mg/L	48.8
Calcium (Ca^{2+})	mg/L	1,940
Magnesium (Mg^{2+})	mg/L	1,021
Cloride (Cl^{-})	mg/L	58,900
Salinity ($NaCl$)	mg/L	98,800
Iron (Fe^{2+})	mg/L	6.3
Conductivity	mS/cm	100
Suspended Solids	mg/L	60
Oil and Grease	mg/L	250



- Reduced environmental impact
- Compactness (footprint&weight)
- Cost-efficiency (Total cost 0.2$/m^3)

REUSE is competitive with the conventional approach

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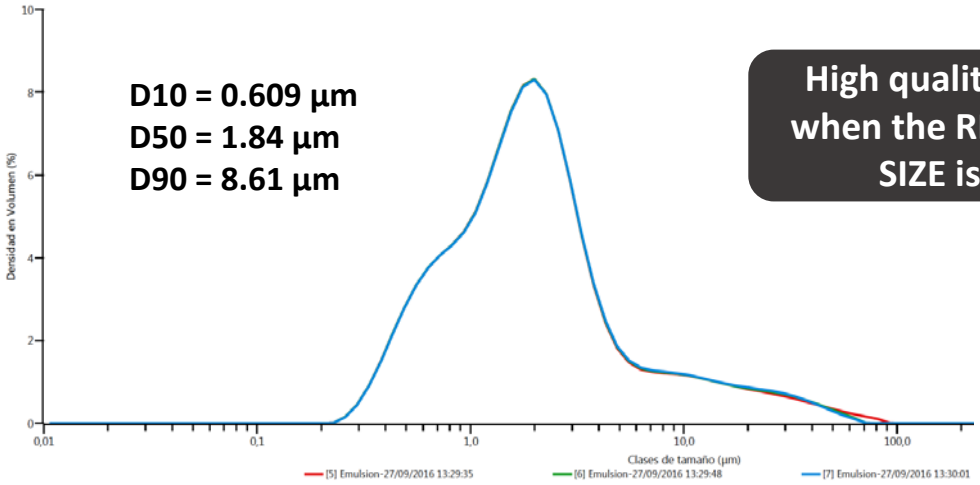
CleanOil technology – Application

Study with CHEMICALLY EMULSIFIED OIL

TEST FLUID: **Highly stable synthetic emulsion.**

- Mineral oil + Water
- Surfactant (Triton X-100)
- Intense mixing

D10 = 0.609 µm
D50 = 1.84 µm
D90 = 8.61 µm

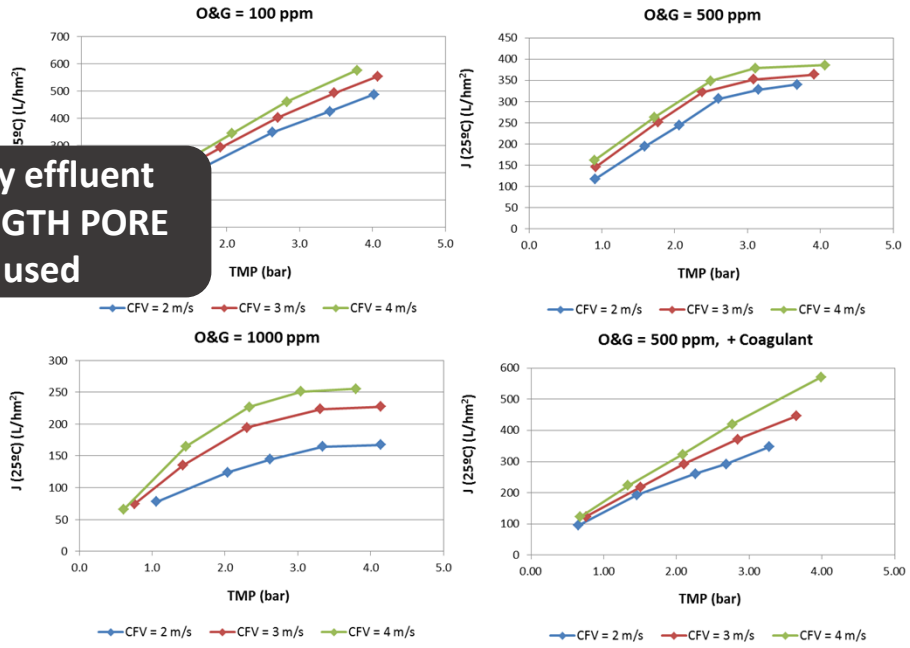


High quality effluent when the RIGTH PORE SIZE is used

Selection of optimum membrane (Permeate turbidity < 1 NTU):

100 nm: Limit TMP = 1.3 bar

<u>50 nm</u>: Limit TMP > 2.5 bar



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CleanOil technology – Application

ONSHORE PW – Offsite commercial disposal facilities.

CASE 1: 500-1000 bbl/day.

PARAMETER	UNITS	INFLUENT	PERMEATE
O&G	mg/L	180 - 560	< 3
TSS	mg/L	65 - 210	< 3
Turbidity	NTU	170 - 600	< 1

CASE 2: 6000 - 8000 bbl/day.

PARAMETER	Unit	INFLUENT	PERMEATE
O&G	mg/L	130	< 3
TDS	mg/L	123000	123000
TSS	mg/L	190	< 2
Turbidity	NTU	138	< 0.4
Benzene	mg/L	4.8	3.4
Toluene	mg/L	4.40	2.6
Ethylbenzene	mg/L	0.201	0.09
Xylenes	mg/L	0.68	0.36
C6 - C10 (exc. BTEX)	mg/L	5.3	2.0
C10 - C16	mg/L	11.6	0.4

- Reject < 5%
- Maintenance cleaning: 4-6 weeks
- High quality effluent

ROBUST technology under VARIABLE PW

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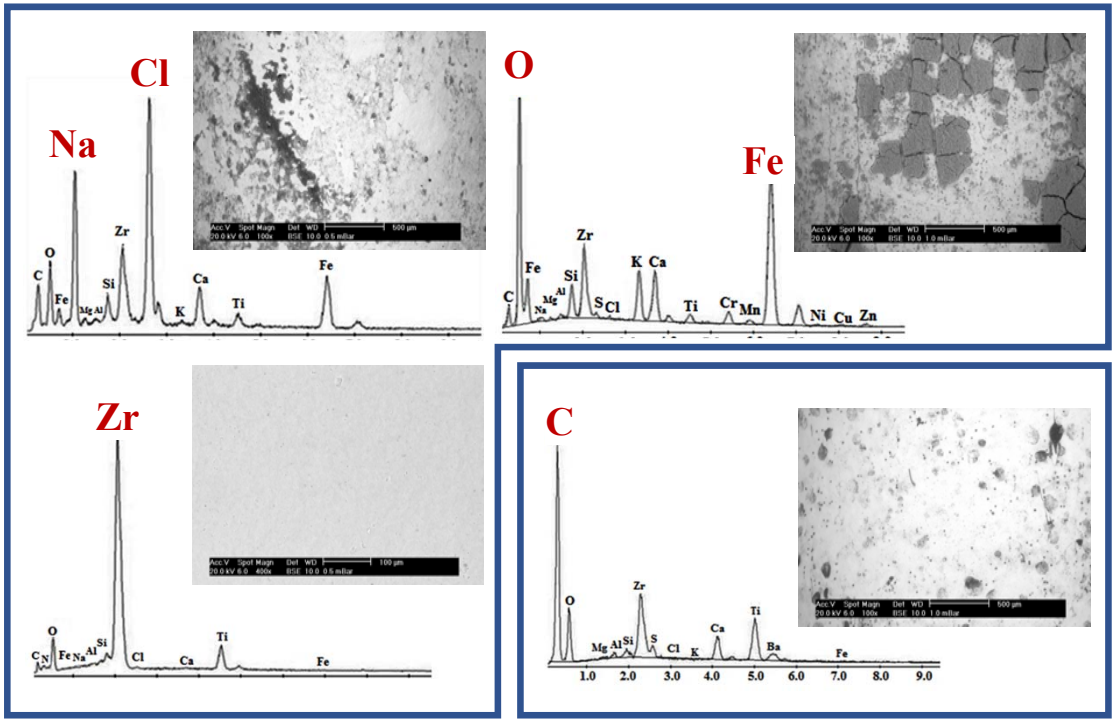
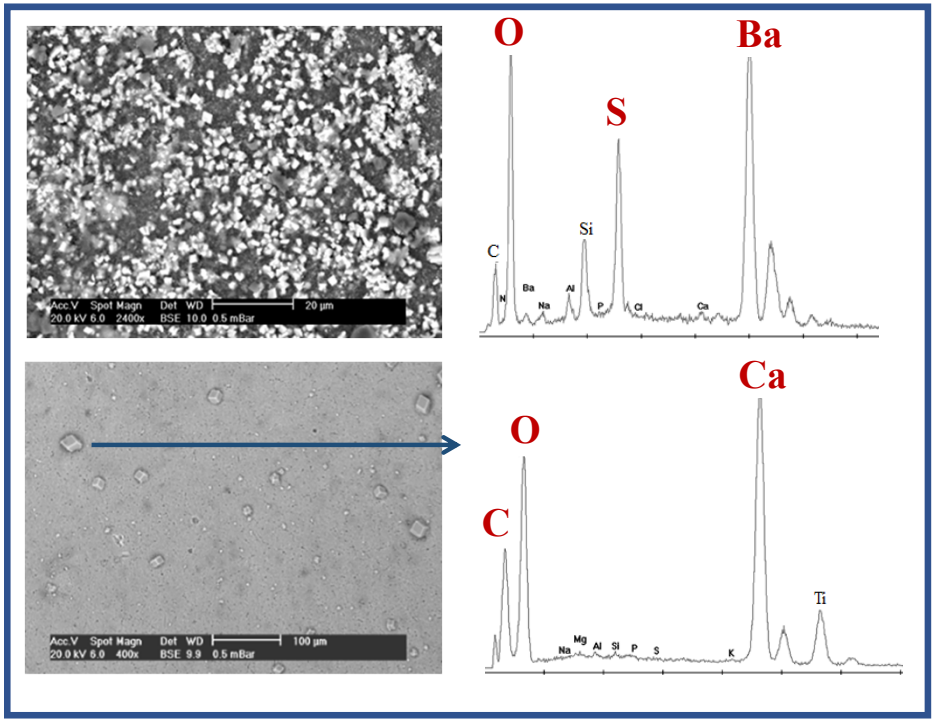
Operation & Maintenance – Chemical regeneration

Membrane autopsy studies for optimizing the chemical cleaning protocol

CASE 1: O&G+IRON fouling. ALKALINE/ACID CLEANING



CASE 2: BaSO4 scaling. ALKALINE CLEANING WITH **DTPA + OXALIC ACID**.



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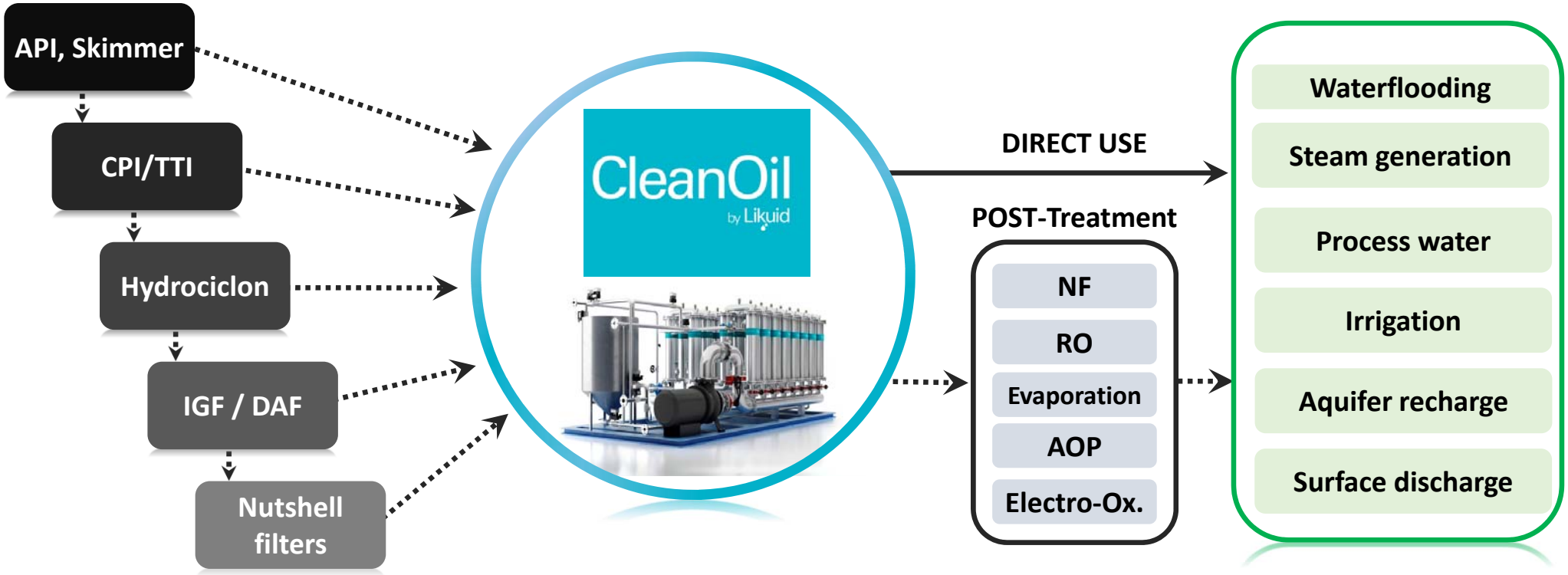
CleanOil technology – Integration in the whole process



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Thanks for your attention.

Questions and comments are welcome.

Elena Meabe, PhD.
Head of process & Engineering Department
emeabe@likuidnanotek.com

For more info:

Likuid www.likuid.com

CleanOil by Likuid www.likuid-cleanoil.com

INTEGROIL www.integroil.eu

CONTACT US:

Likuid Nanotek S.L.

San Sebastian Technological Park
Paseo Mikeletegi 71, 1st Floor
San Sebastian (Spain)

Phone +34 943 223841
info@likuidnanotek.com