AVANSERT BEHANDLING AV PRODUSERT VANN – EN CASE STUDY I DANMARK

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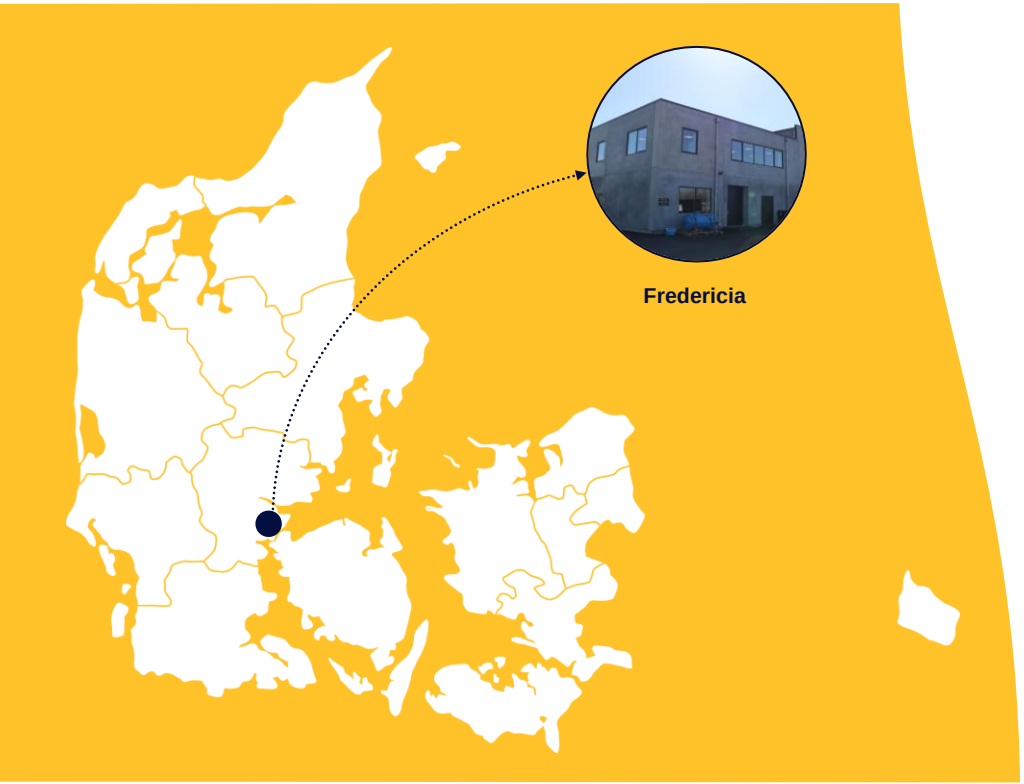
About the case



- CLIENT IS DANISH OIL PIPE (DOP)
- DOP IS A PART OF ØRSTED, THE WORLDS MOST SUSTAINABLE POWER COMPANY
- THE PLANT IS LOCATED IN ON OF DENMARK'S INDUSTRIAL HUBS IN FREDERICIA
- TREATMENT OF PRODUCED WATER FROM DANISH OIL&GAS PRODUCTION IN THE NORTH SEA
- NEW TREATMENT SOLUTION WAS REQUIRED TO COMPLY WITH STRENGTHENED DISCHARGE PERMIT FOR THE TREATED PRODUCED WATER

Key challenges of the case

Raw water with extreme salinity
(60-70 g/l)

Highly variable raw water quality
COD* peaks up to 12,000 mg/L

Strict regulations in both environmental and discharge permit

OPEX very important for the client

Pilot tests proofed MBBR as a very robust biological treatment

DEMONSTRATION BY PILOTING

TIMEFRAME	2019-2023
FLOW UP TO	180 m^3/d
TOTAL DISCHARGE	114.000 m^3
COD INLET	1.000-12.000 mg/L

POSSIBLE TO ACHIEVE COD AND NITRIFICATION INHIBITION TARGETS IN THE EFFLUENT

Timeline

2019	2021	2023	up to 2050
Pilot plant implemented and operational	SUEZ-MT Højgaard consortium granted DB contract for permanent plant	Commissioning of permanent plant Pilot plant is closed	SUEZ responsible for Operations and Maintenance of permanent plant

PILOT PLANT

- Mobile treatment plant for feasibility study
- Capacity of treating up to **120 m3/d,** expanded up to **180 m3/d** of Produced Water
- Discharge requirements on nitrification inhibition **(<20%)**

PERMANENT PLANT

- Design flow of **700 m3/d** of highly saline wastewater
- Secure, simple to use to cut down on operational expenses
- A local purifying procedure that considerably contributes to environmental benefits

Outlet requirements of permanent plant

Key criteria

- Have a COD concentration of ≤ 1000 mg/l.

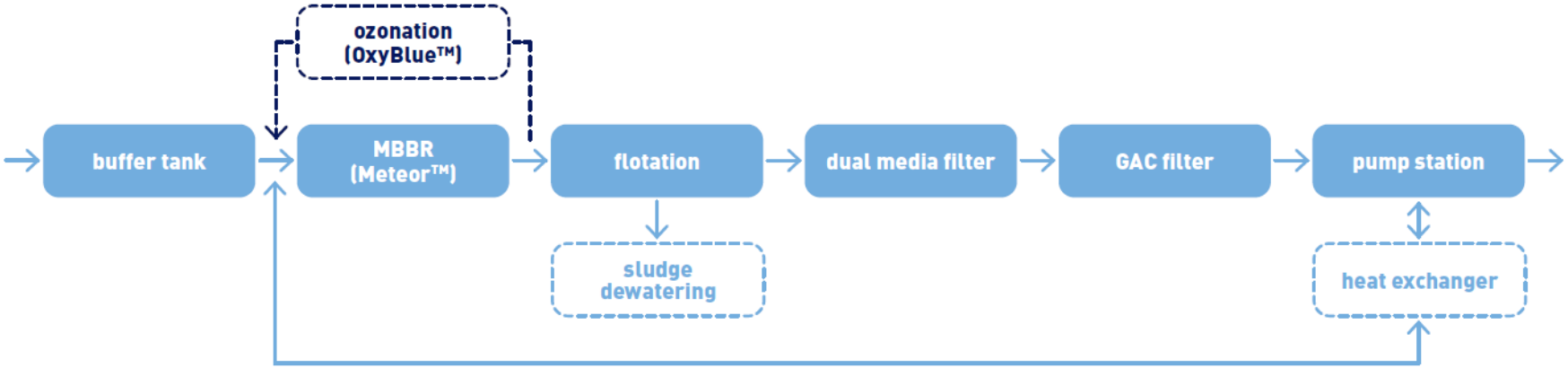
OR

- Have a COD concentration of ≤ 2000 mg/l and a nitrification inhibition of ≤ 20%. Max nitrification inhibition must no go over 50%

Parameter		Units	Value
Temperature	Absolute	°C	50
COD	Absolute	kg/d	1 400
TSS	Absolute	mg/l	200
OIW	Absolute	mg/l	20
Total Nitrogen	Absolute	mg/l	150
Total Phosphor	Absolute	mg/l	20
Phenol index	Absolute	mg/l	1
Total sulphur	Absolute	mg/l	600
Sulphide	Absolute	mg/l	3
Sulphate	Absolute	mg/l	1 600
Chloride	Absolute	mg/l	50 000
pH	Absolute	-	6,5
	Absolute	-	9
Nikkel	Absolute	µg/l	70
Arsenic	Absolute	µg/l	13
Lead	Absolute	µg/l	100
Cadmium	Absolute	µg/l	3
Copper	Absolute	µg/l	100
Cobalt	Absolute	µg/l	10
Mercury	Absolute	µg/l	3
Selenium	Absolute	µg/l	8
Silver	Absolute	µg/l	250
Tin	Absolute	µg/l	60
Zink	Absolute	µg/l	3000
NPE	Guiding	µg/l	2
PAH	Guiding	µg/l	3
BTEX	Guiding	µg/l	1
THPS	Guiding	µg/l	3

The permanent plant: An innovative multi-barrier approach

Process flow diagram



PROCESS SCHEME BASED ON PILOT PLANT

A MULTI-BARRIER APPROACH INCLUDING FOLLOWING KEY STEPS:

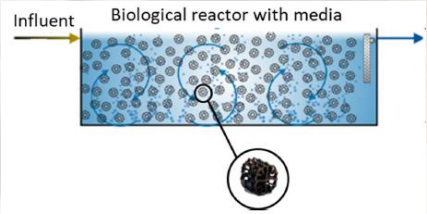
- Biological treatment based on Moving Bed Biofilm Reactor (MBBR)
- Integrated ozonation
- Granular Activated Carbon (GAC) filter

The permanent plant

Process steps
Implemented solutions

METEOR

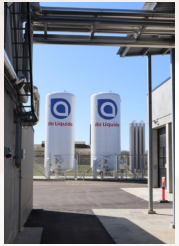
Biological purification of wastewater by Moving Bed Biofilm Reactor (MBBR)



TWO MBBR IN SERIES

OXYBLUE

Advanced wastewater treatment for polishing treatment associating ozonation



Oxygen TANKS

OZONE GENEATOR

GAC FILTERS

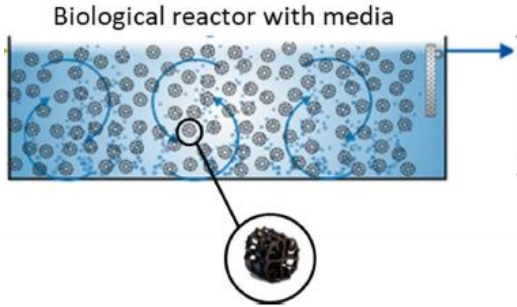
Treatment of large variations in inlet water quality and biodegradability of the contaminants

GAC FILTER

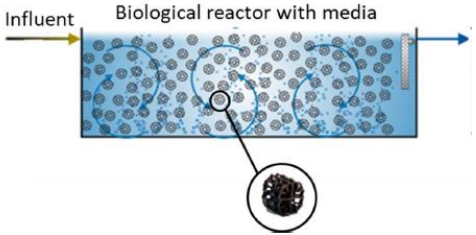
METEOR
MBBR solution

BIOLOGICAL PURIFICATION OF WASTEWATER BY MOVING BED BIOFILM REACTOR (MBBR)

- Meteor-MBBR combines a biological solution and a compact separation system
- Total volume of 2800 m^3
- Biofilm media is integrated into each zone of the basin and equipped with retention screens
- Works continuously and does not require any washing of the materials
- Fixed biofilm provides natural protection for sensitive bacteria



TWO MBBR IN SERIES



OXYBLUE
Ozonation treatment

OXYGEN TANKS

OZONE GENERATOR

POLISHING TREATMENT TO INITIATE AND BOOST THE RESIDUAL ORGANIC MATTER DEGRADATION PROCESS

- This treatment is implemented through a return pumping pipeline including an ejector where the ozone is dosed and mixed into the water phase
- 2 main units: oxygen tanks and ozone generator
- record level of COD elimination allowing discharge into sensitive environmental areas
- chemical / biological oxidation synergy allowing optimal elimination of persistent COD

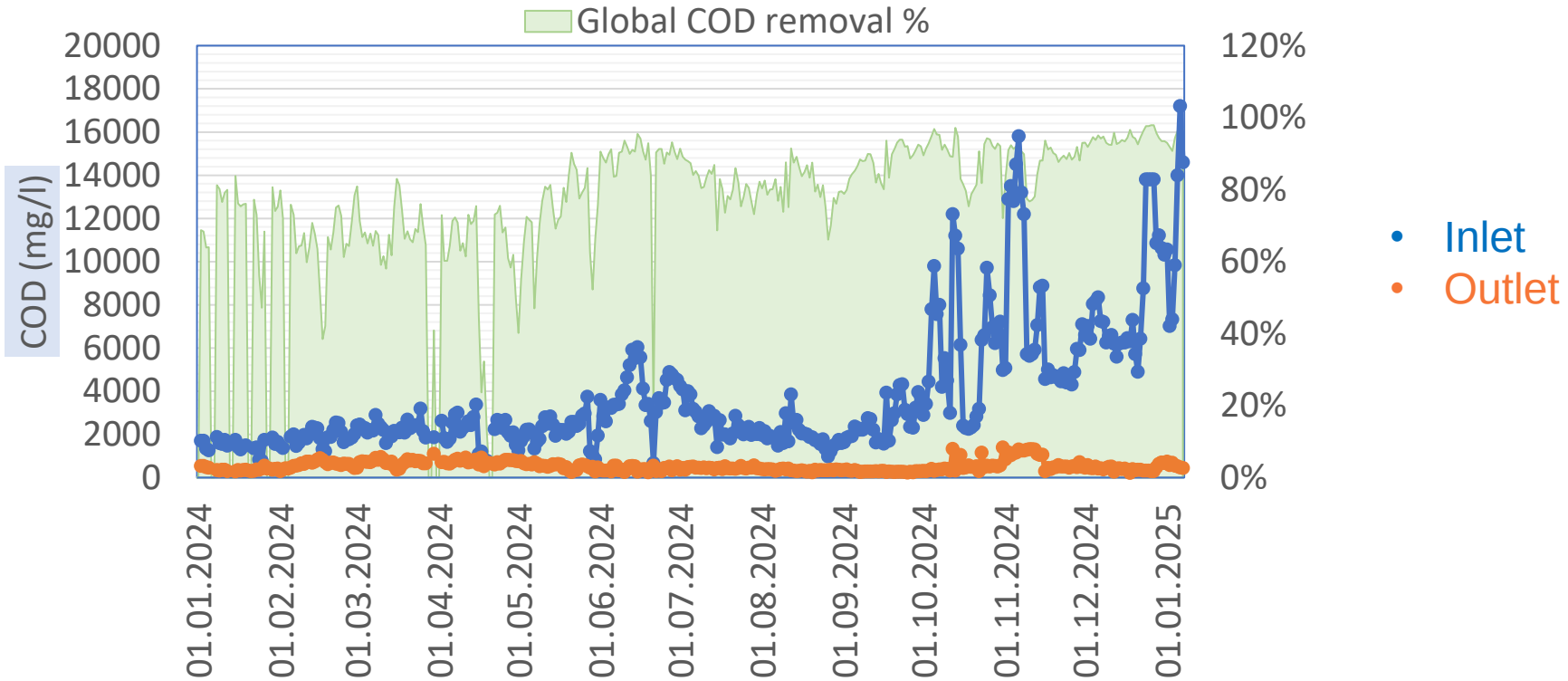
GAC FILTERS
Granular Activated Carbon filter

FINAL POLISHING STEP TO TREAT LARGE VARIATIONS IN INLET WATER QUALITY AND BIODEGRADABILITY OF THE CONTAMINANTS

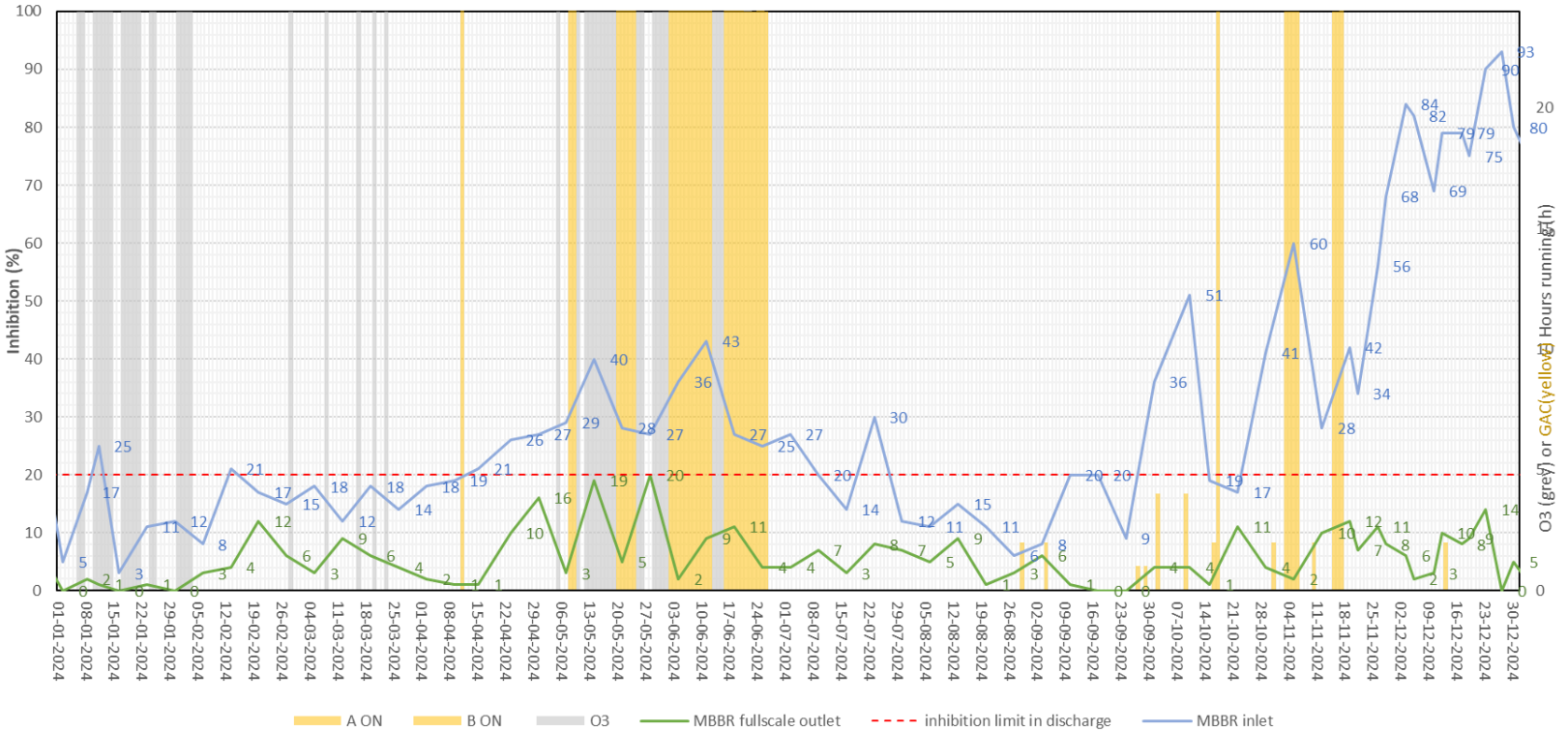
- Two identical sized filter arranged in series to enhance elimination of non-biodegradable compounds and to enhance process security
- Designed for downflow filtration
- Removes remaining hard COD and TSS in filtered water

GAC FILTER

COD reduction (without ozone and GAC)



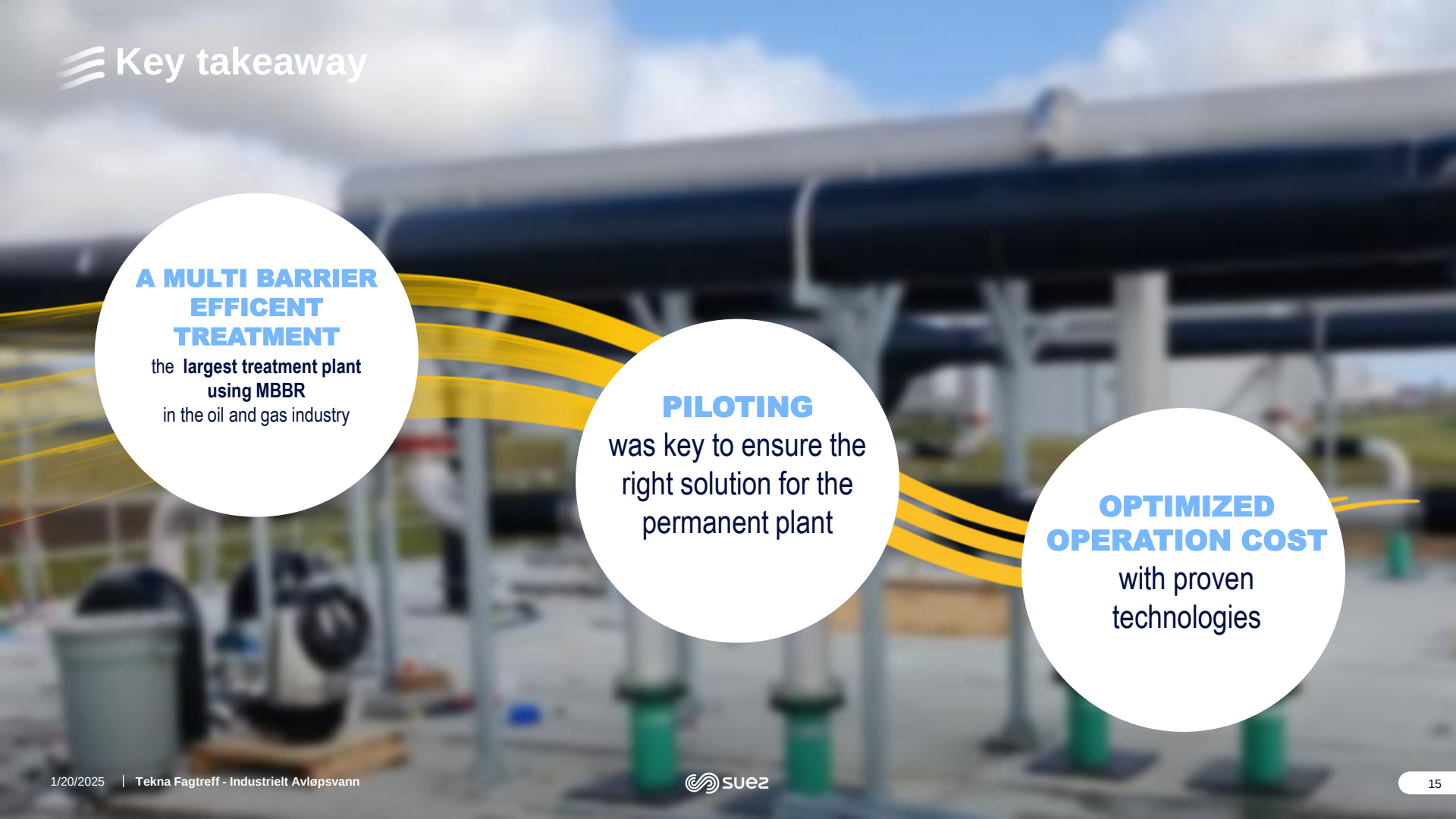
Reduction of nitrification inhibition



- Inlet
- Outlet

The areas highlighted in orange indicate the operating periods of GAC filters A & B for a minimum of 24 hours.
Grey areas indicate ozone operation in the MBBR recirculation loop for a minimum of 24 hours.

Key takeaway



A MULTI BARRIER EFFICENT TREATMENT

the **largest treatment plant using MBBR** in the oil and gas industry

PILOTING

was key to ensure the right solution for the permanent plant

OPTIMIZED OPERATION COST

with proven technologies

THANK YOU

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