



One year of practical experience with artificial intelligence controlled nitrous oxide emission reduction from wastewater treatment plant Amsterdam West

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Nitrous oxide from WWTP's: a hot topic



Europe Wastewater Utilities

NITROUS OXIDE EMISSIONS FROM WASTEWATER: THREE NATIONS UNITE IN NET ZERO PARTNERSHIP

Tuesday, 19 September 2023

Wastewater treatment plants: On the trail of the climate pest nitrous oxide

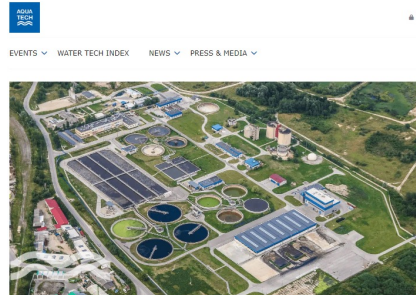
April 11, 2023 | Claudia Carle

EMISSION FACTORS (% N ₂ O-N/T-N _{inlet})		
EPA REPORT 2020	PREVIOUS DANISH 2019	IPCC 2019
0,84%	0,32%	1,6%

Environmental Protection Agency report on nitrous oxide (N₂O) emissions from Danish wastewater treatments plants (WWTP)

Uitgelicht

Vallei en Veluwe: daling CO₂-uitstoot, stijging emissie lachgas en methaan



Water Wastewater Climate

N₂O CHALLENGE FOR WATER

Global Water Research Coalition

N₂O and CH₄ emission from wastewater collection and treatment systems
State of the Science Report

Report of the GWRC Research Strategy Workshop

Home » Onderwerpen » Terugdringen emissies » Community of Practice Lachgas

Community of Practice Lachgas

In de Community of Practice (CoP) Lachgas delen waterschappen kennis en ervaringen over het inschatten van de risico's op lachgasemissies vanuit rioolwaterzuiveringen, en worden ze ondersteund bij het opzetten van lachgasmetingen.

stowa VERVOLGONDERZEK

EMISSIE BROEIKASGASSEN VANUIT RWZI'S

RAPPORT 2020

stowa RESULTATEN METONDERZEK VOOR VERIFICATIE EENVOUDIGE RISICO-INSCHATTING

RISICO-INSCHATTING EMISSIE LACHGAS VANUIT NEDERLANDSE RIOOLWATERZUIVERINGEN

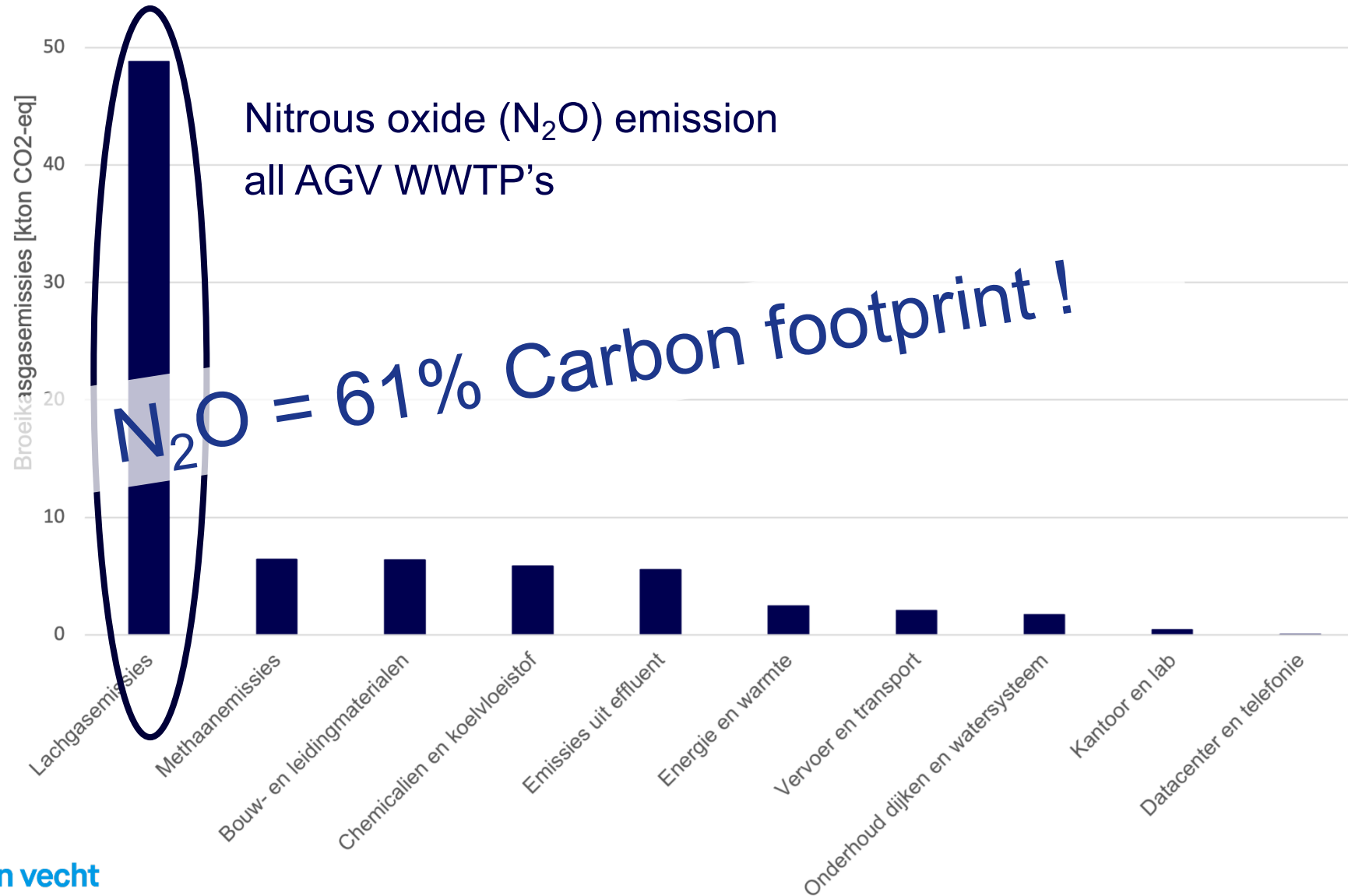
RAPPORT 2019 05

N₂O emissions from (Dutch) WWTP's

- Nitrous oxide (N₂O) is a 265 times stronger greenhouse gas than CO₂
- Nitrous oxide emissions of WWTP's are determined with emission factors
- IPCC emission factor 1.6% from the incoming nitrogen (IPCC 2019)

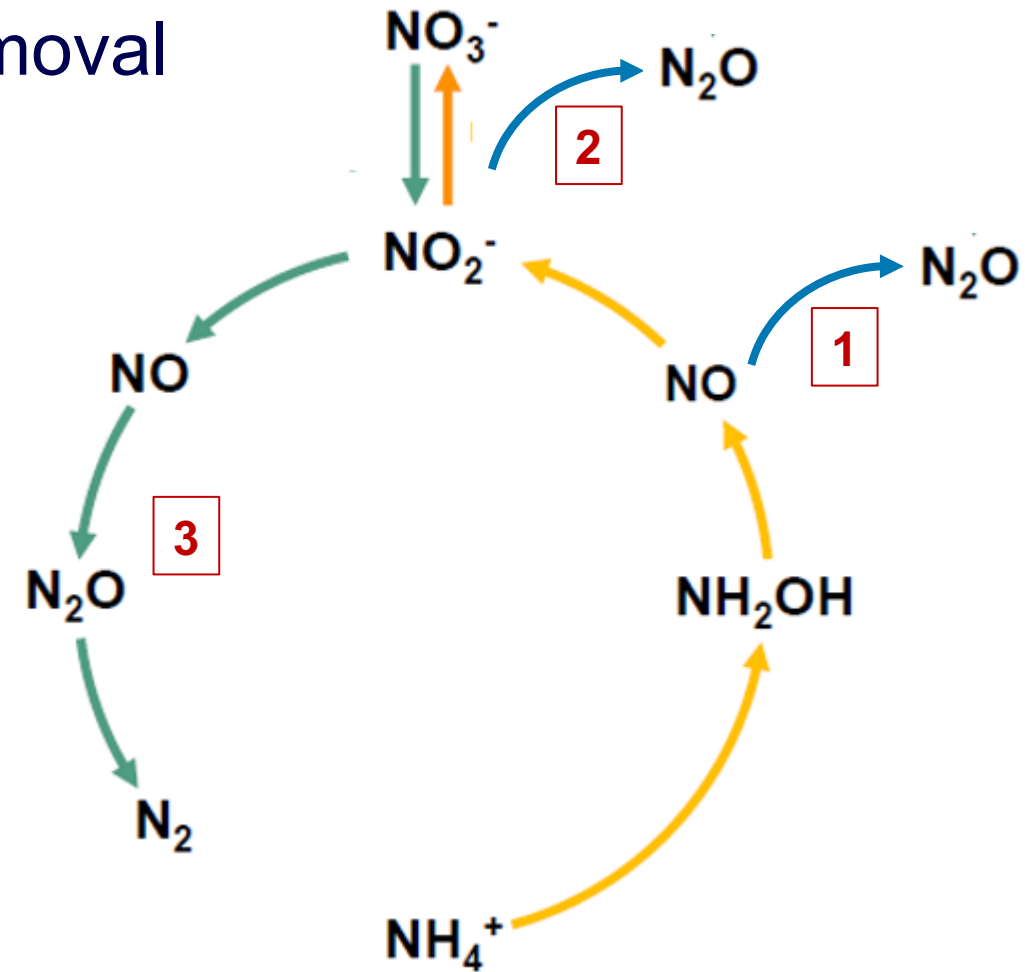
- Dutch WWTP's emission:
 - 624 kton CO₂-equivalents N₂O
 - 62% carbon footprint of water authorities
 - 8.7% total Dutch N₂O emission

Carbon footprint AGV 2022



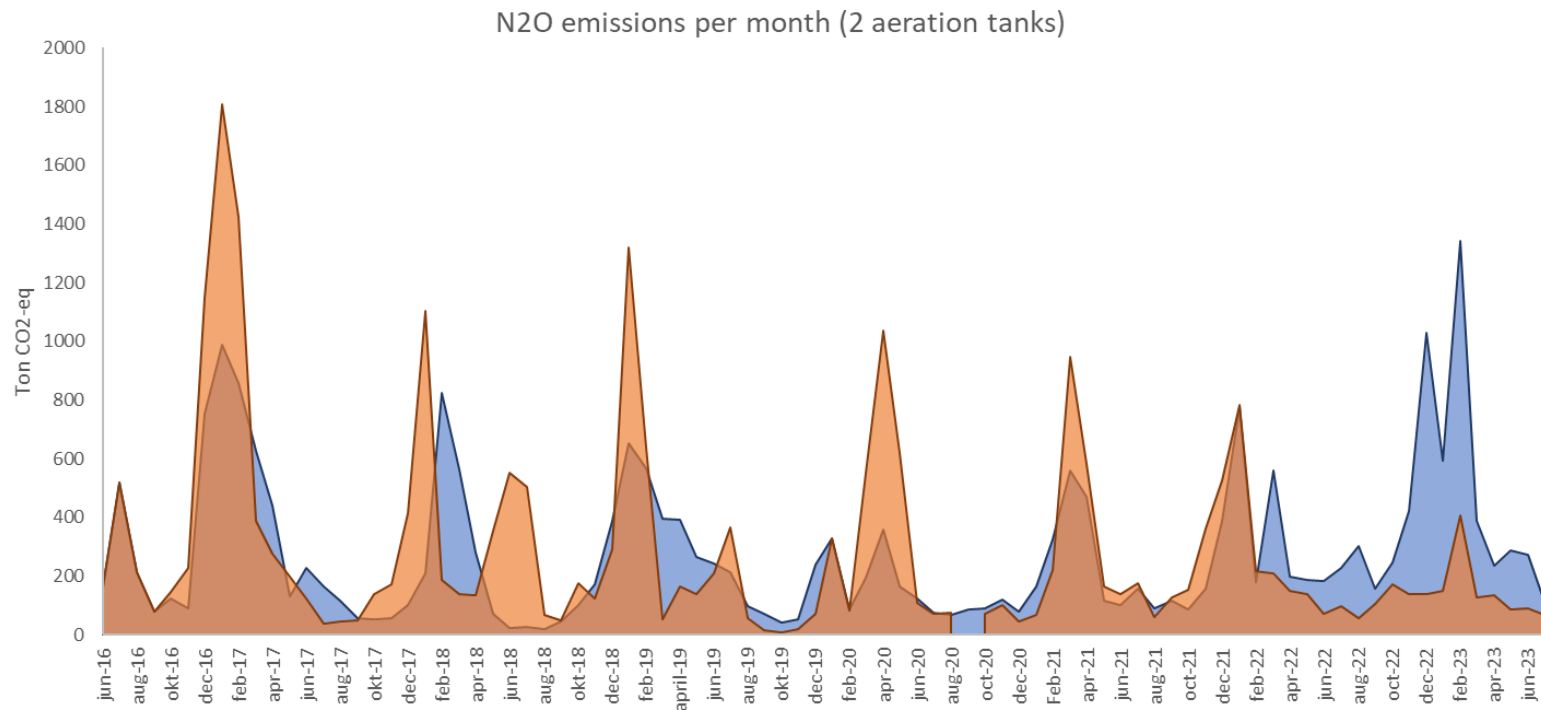
N₂O formation

- N₂O is formed during biological nitrogen removal



Unique dataset

- Real-time N₂O since 2016
- Off-gas 2 of 7 (covered) aeration tanks
- More sensors (Research lane)



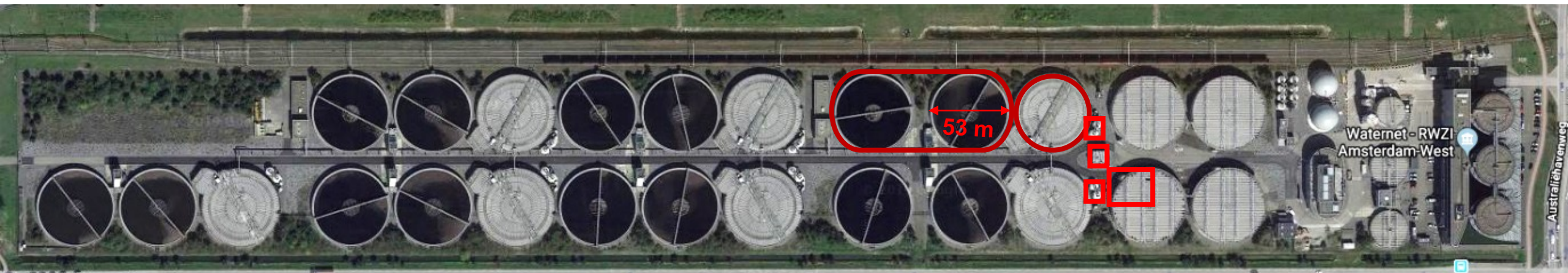
Full-scale research lane

Objective: Reduction of nitrous oxide emission

Strategy: Real-time control

Challenges:

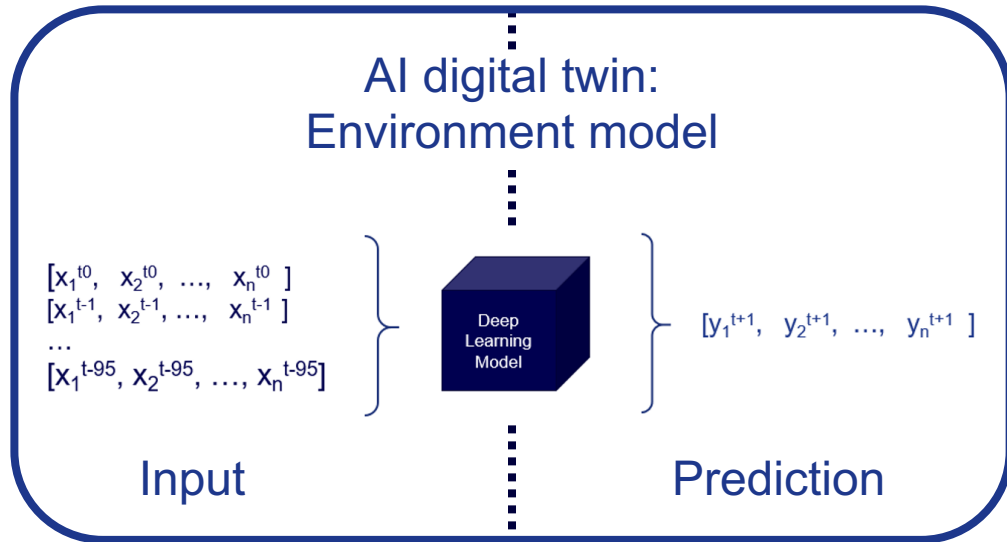
- N_2O reduction control strategies still in their infancy
- Seasonal peaks are not well understood



N₂O Control with AI

- **Digital twin** of the process is an AI model purely based on data:
 - Because the theoretical basis of N₂O emission is still incomplete and insufficiently validated
 - To account for anything in practice that deviates from theory
 - Faster than white box, white box not designed for RL training
- **Control agent** is AI model trained with **Reinforcement Learning (RL)**:
 - To explore the vast number of possibilities with a different control than in the past
 - AI RL model can quickly determine the optimal control setpoint, useful in real-time control

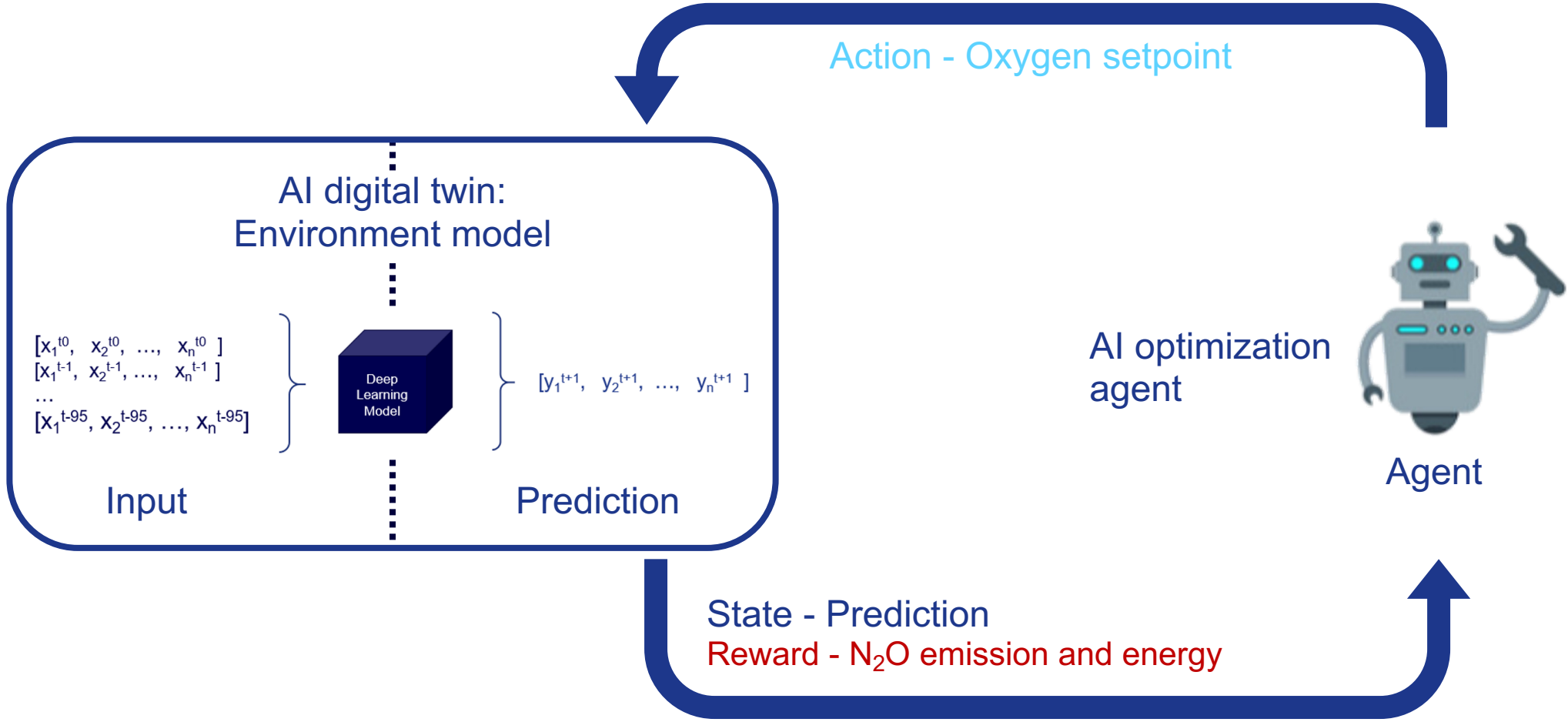
AI digital twin



Process model
predicting near future

AI control agent training

Reinforcement learning



AI control agent live



Oxygen setpoint

AI optimization agent

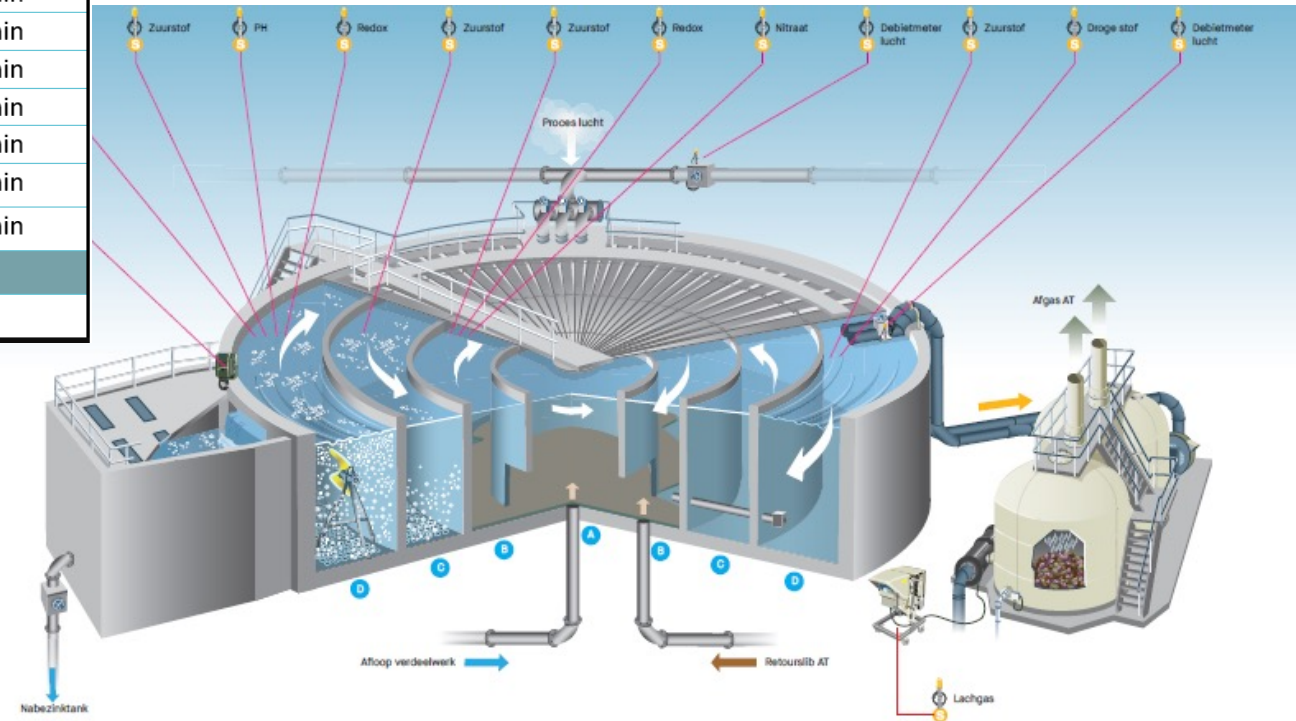


Agent

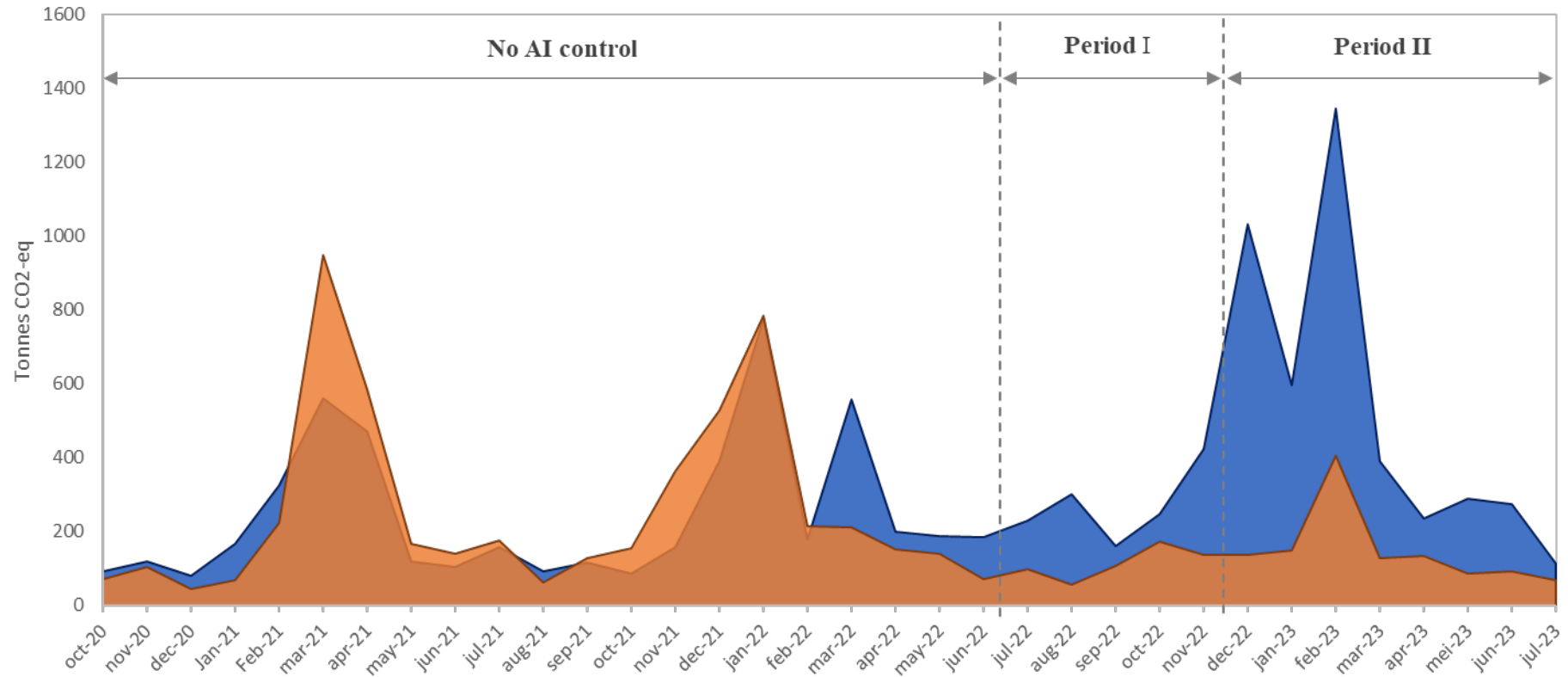
Real-time data

Model input

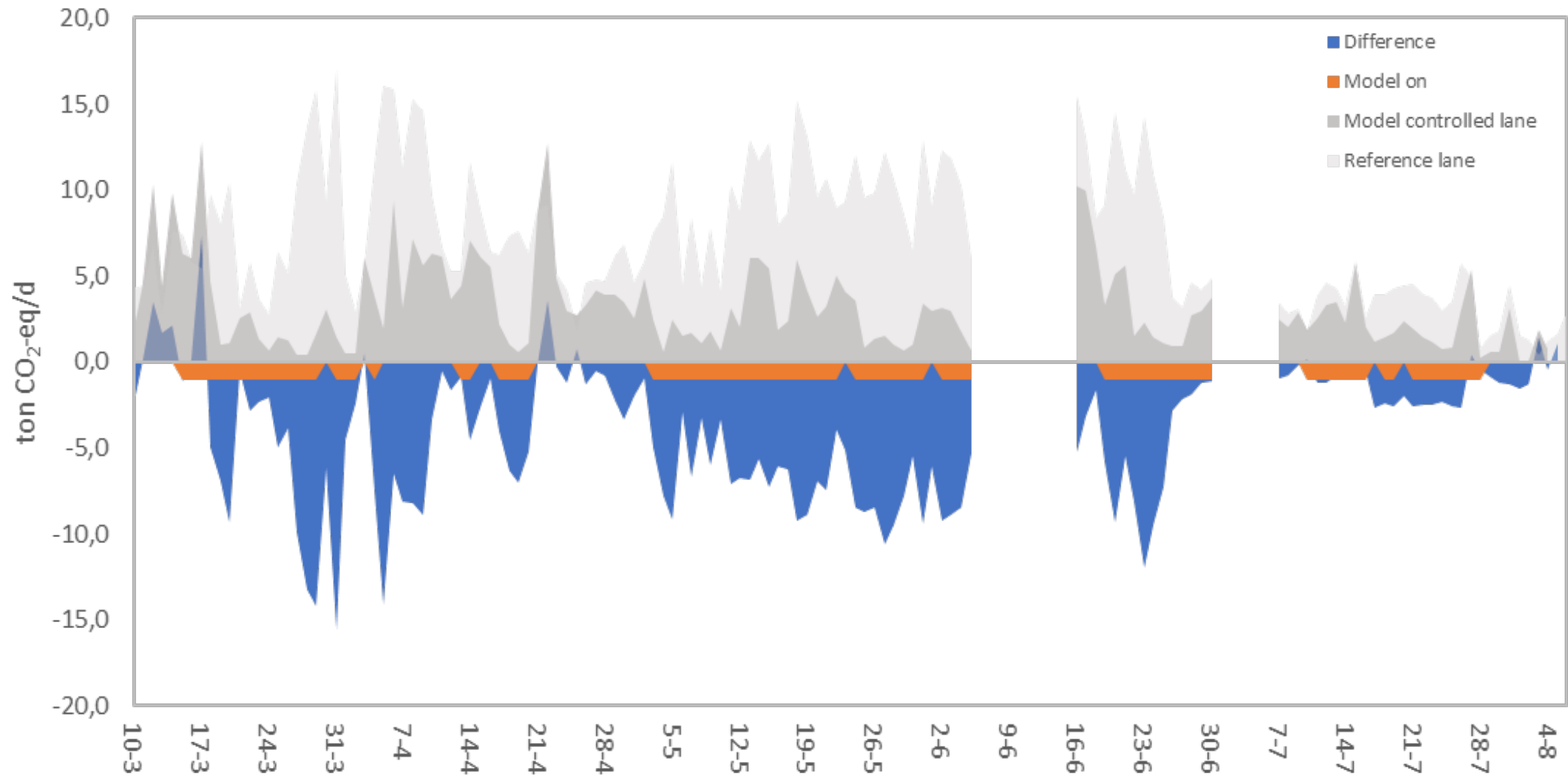
Parameter	Unit	Number of actual sensors	Number of model inputs/outputs	Input length	Granularity
Sensor					
Influent flow	m ³ /h	1	1	1 day	1 min
Airflow estimation	m ³ /h	1	1	1 day	1 min
Energy AT2	kW	7	1	1 day	1 min
Valves own FCT	%	1	1	1 day	1 min
NO3-NIT	kg/h	1	1	1 day	1 min
O2	mg/l	1	1	1 day	1 min
NH4	kg/h	1	1	1 day	1 min
Dry Solids	mg/l	1	1	1 day	1 min
Out N2O mass flow	kg/h	1	1	1 day	1 min
Control recirculation	m ³ /h	5	3	1 day	1 min
Temperature (FCT)	°C	1	1	1 day	1 min
Influent derivative	-	-	1	1 day	1 min
Redox NIT	mV	1	1	1 day	1 min
Redox DNT	mV	1	1	1 day	1 min
Actuator					
O2 setpoint	mg/l	1	1	1 (actual value)	-



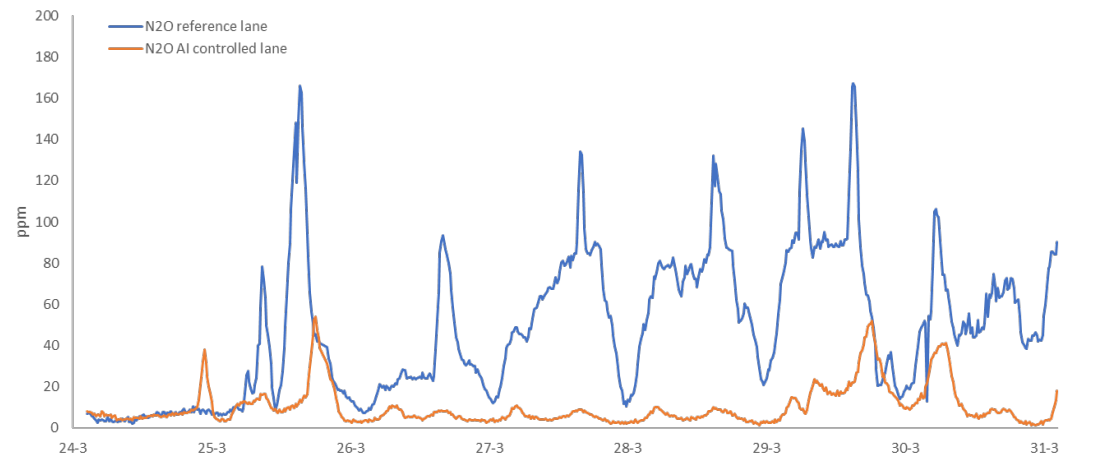
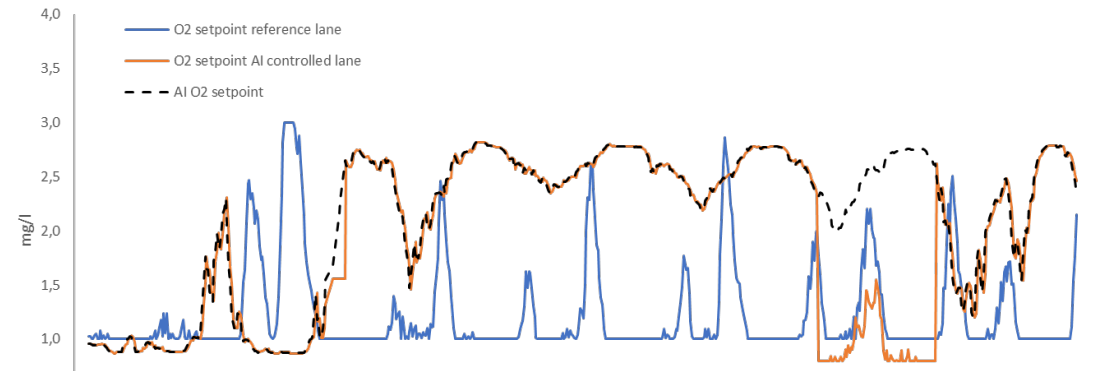
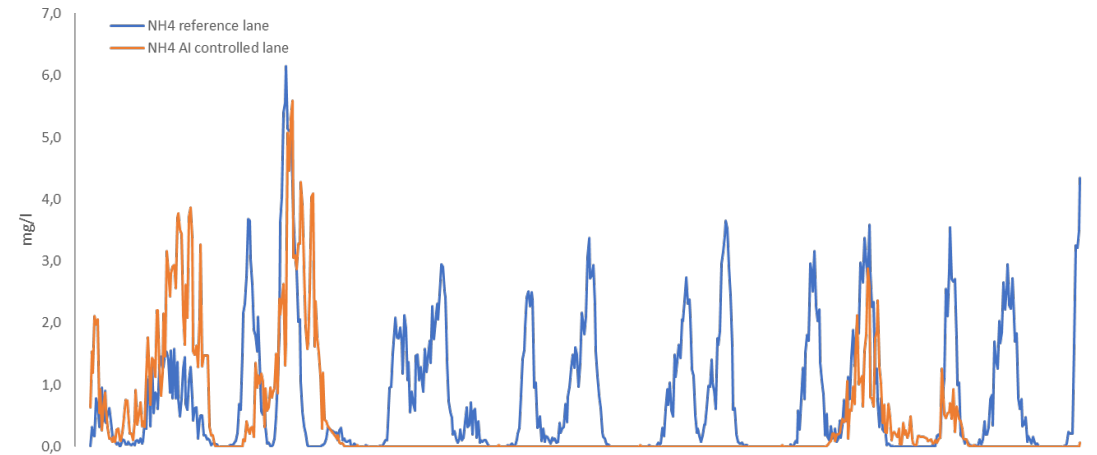
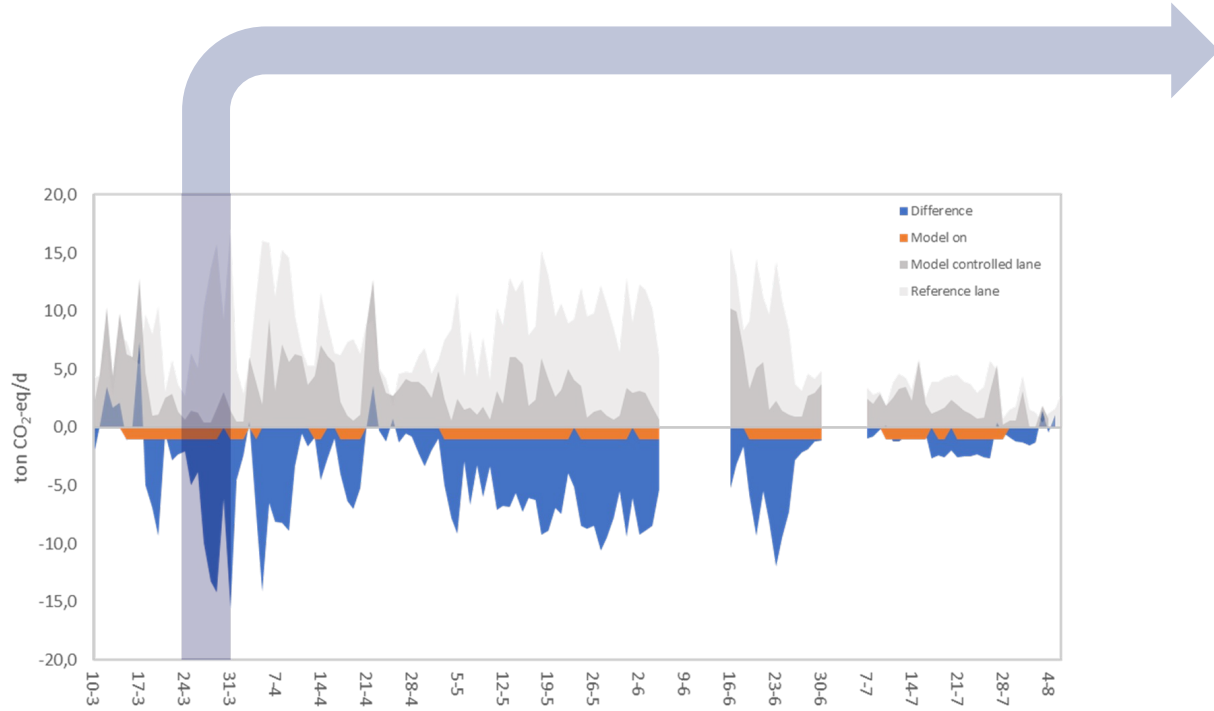
Effect of AI control



AI control on/off



Ammonia and N₂O peak shaving



Future

- Further develop model control
- One winter 'fully' on model control
- Dot on horizon; expand to all treatment lanes



AI control on/off

