Jacobs Challenging today. Reinventing tomorrow.

Taking action to reduce Scope 1 emissions – Where to start, progress and excel?

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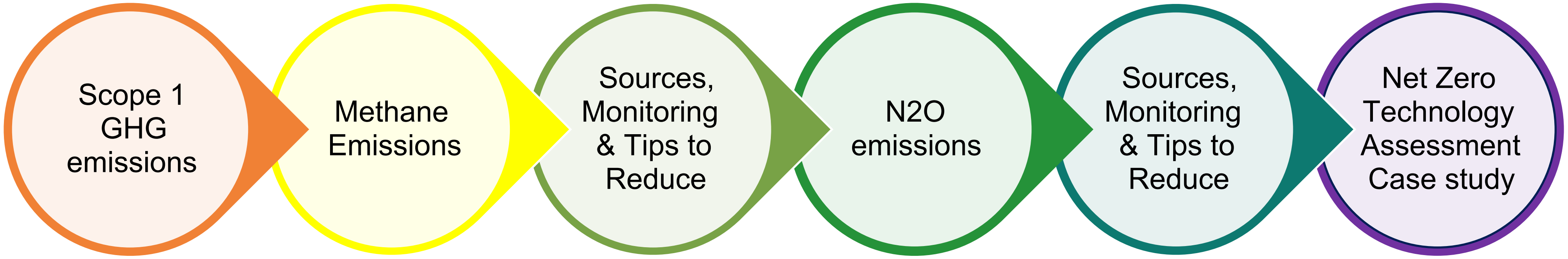
Overview


Scope 1 GHG emissions
Methane Emissions
Sources, Monitoring & Tips to Reduce
N2O emissions
Sources, Monitoring & Tips to Reduce
Net Zero Technology Assessment Case study

Why action is required on emissions from wastewater treatment

"The cumulative scientific evidence is unequivocal: climate change is a threat to human well being and planetary health.

Any further delay in action on adaptation and mitigation will miss **a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all.** "

IPCC Sixth Assessment Report, 2022

GHG Emissions Reduction in the AU and NZ Water Industry – Example Net Zero Targets

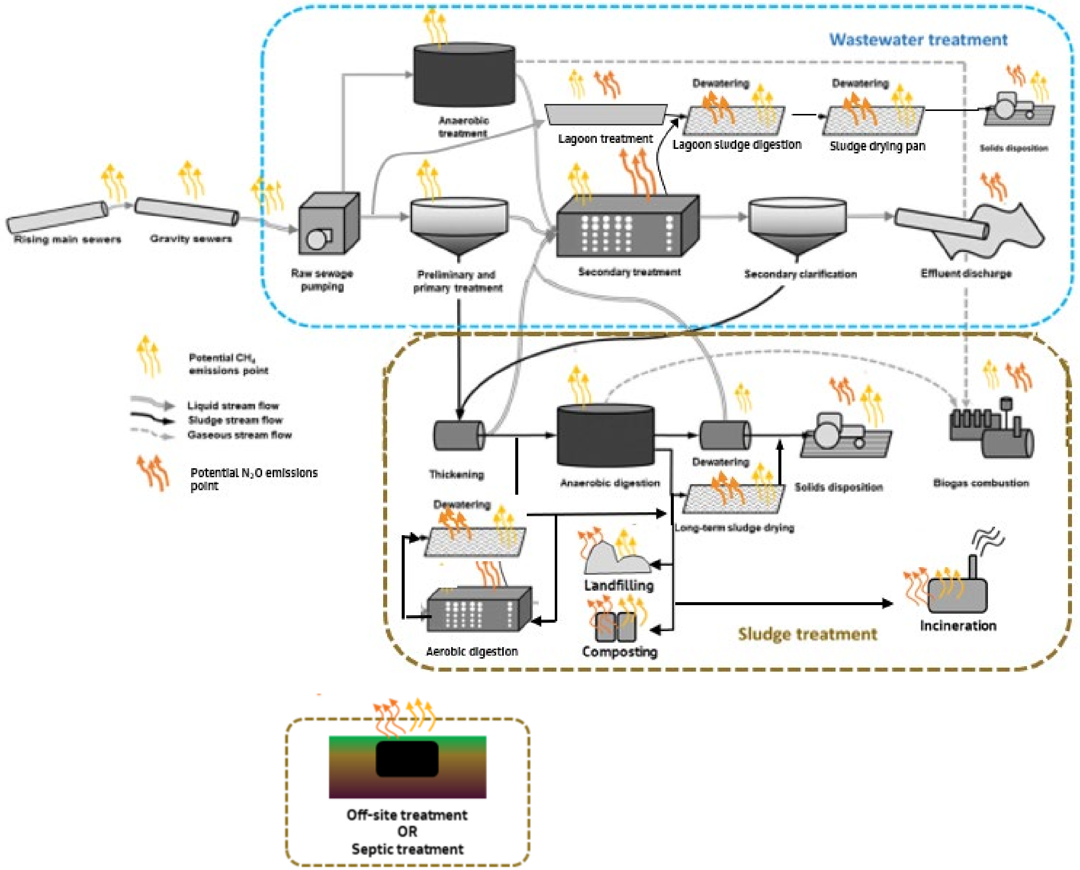
	2025	2030	2032	2040	2050
Melbourne Water	100% renewables	Net zero			
Sydney Water		Net zero Supply chain		Net zero Business	
Watercare		↓ 50% operational emissions		↓50% construction emissions	Net zero
Unitywater					Net zero
Urban Utilities			Net zero		

Scope 1 Methane & N_2O Emissions from WW Treatment

Scope 1 emissions a key contributor to Water Authority GHG emissions from:

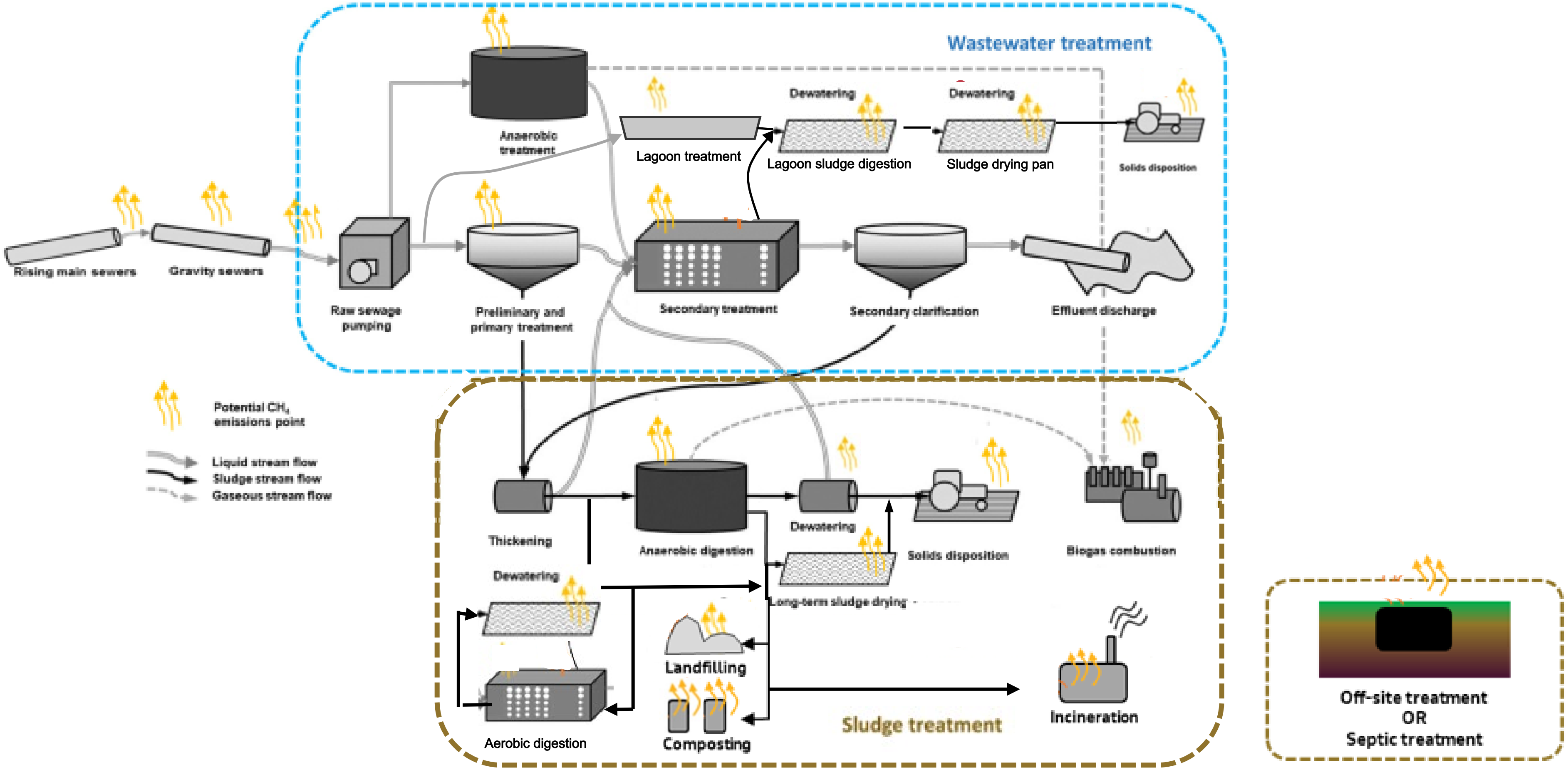
- **Methane** – generated in anaerobic digestion
  GWP of 28
- **N_2O** - generated in biological nitrogen removal
  GWP of 260
- CO_2 – generated from fossil fuel usage and from the treatment of non-biogenic carbon (influent and added in the treatment process)
  GWP of 1 (non-biogenic)

Biogenic CO_2 not 'counted'



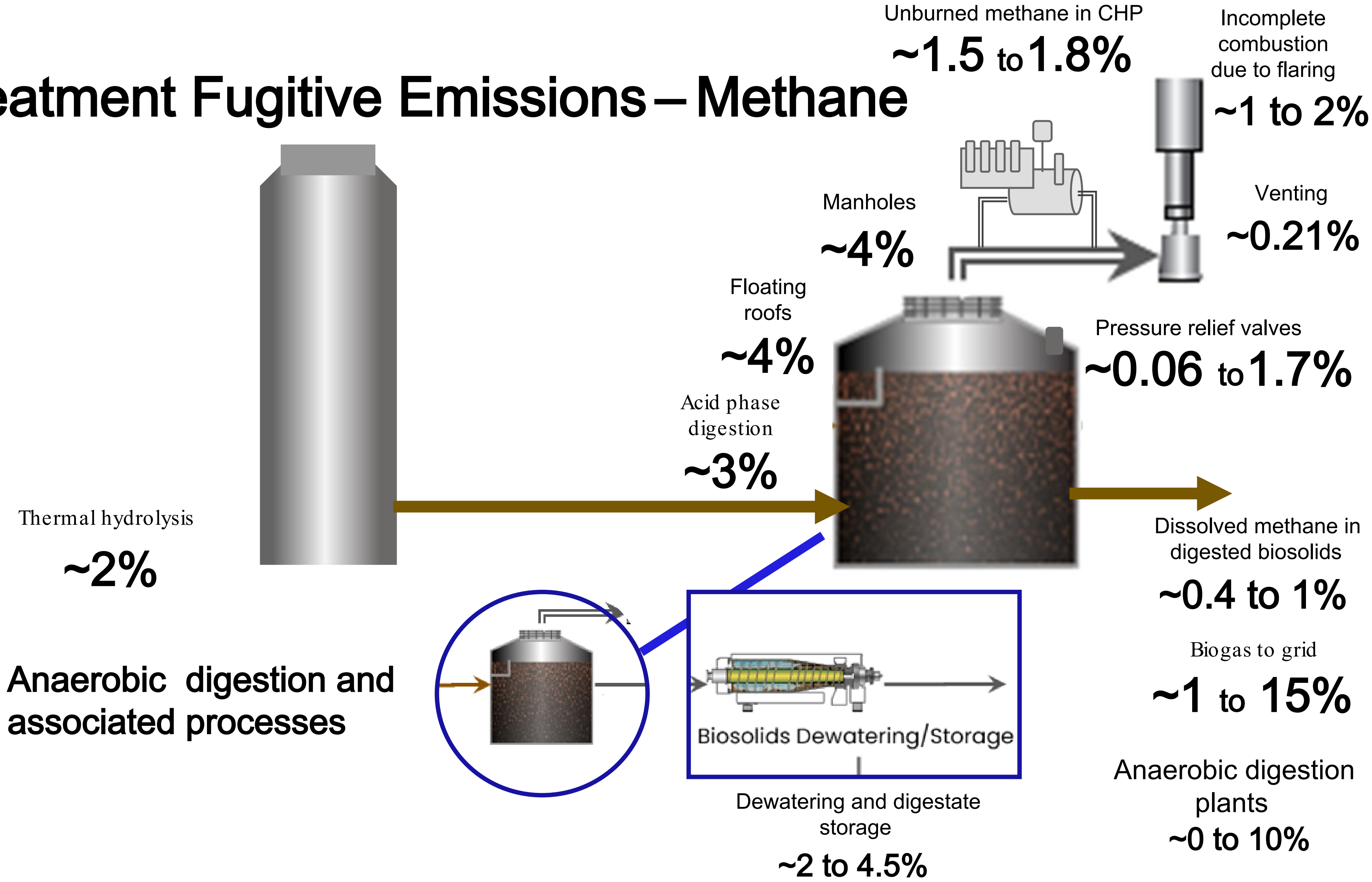
Sources of CH_4 emission points from wastewater transport and treatment (adapted from Quantification and Modelling of Fugitive GHG emissions from Urban Water Systems)

Scope 1 Emissions from WW Treatment- Methane



Sources of CH_4 emission points from wastewater transport and treatment (adapted from Quantification and Modelling of Fugitive GHG emissions from Urban Water Systems)

Wastewater Treatment Fugitive Emissions – Methane



GWP: Global Warming Potential

Adapted from WEF Factsheet "GHG Sources and Sinks for WRRFs" (2021)

Methane Emissions Monitoring Options

Plant-wide quantification used for GHG inventories/reporting or to prioritise sites.

- Facility-wide Monitoring of Methane Emissions
  - Mobile Tracer Gas Dispersion Method
  - Inverse Dispersion Modelling Method
  - Differential Absorption Lidar (DIAL)

Process unit quantification used for estimating process unit emissions and identifying leaks.

- Process Unit Monitoring of Methane Emissions
  - Flux Chambers
  - Hi-Flow Sampler
  - Thermal Infrared (IR) Imaging Camera
  - Optical Gas Imaging (OGI) Camera
  - Headspace Sampling of dissolved CH_4 in Liquid Phase

Practical tips – methane

1. Prevent generation where not captured
2. Prevent fugitive emissions where generated
3. Capture and Utilisation
4. Capture and Treatment

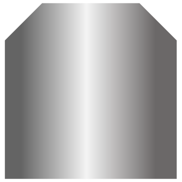
Good practice ≠ Cost effective

Good practice :

mitigation

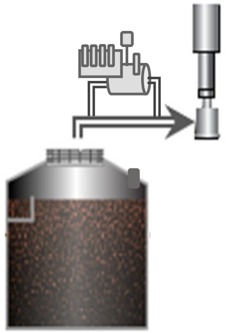
actual measured vs.
assumed data

Practical tips – To Reduce Fugitive Emissions



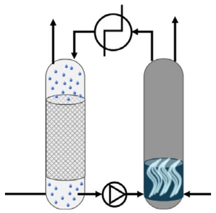
Digested sludge storage

- Gas tight covers and gas utilisation
- Treatment to halt methanogenesis



Sludge digestion

- High SRT (>14 days)
- Operating volume 75%
- Optimal process conditions:
  - Sludge mixing
  - Optimal temperature
  - Constant feed
- Frequent digester cleaning



Biogas upgrading

- Exhaust treatment
- Frequent function control
- Performance monitoring

Source: [1]

Pressure relief valves and flares

- Enclosed flares
- Automatic flare operation
- Manage filling levels – flare before PRV loss
- Accurate level measurement
- Adequate sizing – pipe, blowers, controllable air pressure in air inflated roofs to achieve balanced fill and management
- PRV monitoring

CHP

Source: [2]

- Control and maintenance
- Post combustion of exhaust gas
- Selective catalytic reduction (SCR)

Pipeline Leaks

Source: [3]

- Replace worn valves and seals in manhole covers

Sources:
[1] https://www.varec-biogas.com/dprv/
[2] https://planet_biogas.com/en/chp_module/
[3] https://taraenergy.com/blog/gas -leaks/

Practical Tips for Capturing and Utilising more Methane

- Covering tanks that create conditions for methanogenesis
  - Sludge storage tanks
  - Digested sludge storage tanks including open secondary digesters

- Vacuum extraction technology
  - Captures additional biogas from anaerobically digested sludge

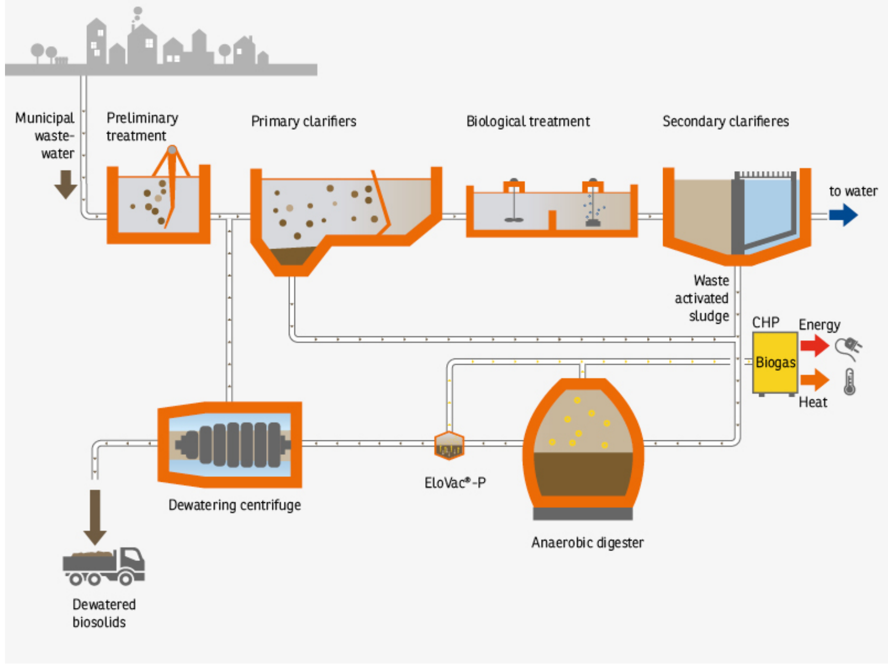
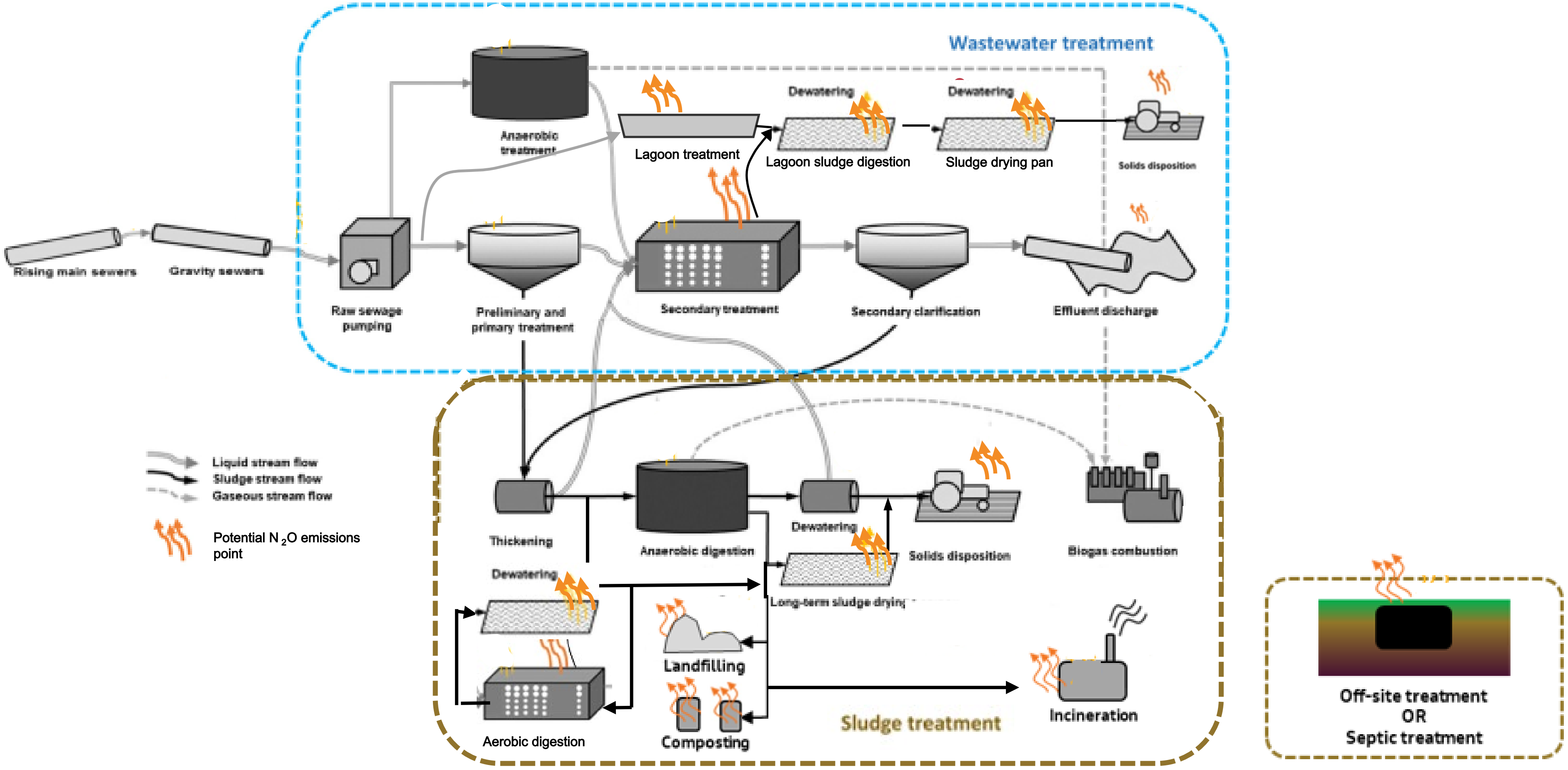


Figure 4: Process flow diagram of a typical WRRF that includes vacuum extraction technology for capturing methane from the digested sludge (credit: ELIQUO)

Methane Emissions – Capture and Treatment

- Convert Methane into CO_2 if the emissions cannot be prevented or cannot be used for energy generation:
  - Thermal Oxidation (flare) (minimise, preferable to convert to renewable energy/resource recovery)
  - Post-aerobic digestion (PAD)
  - Biological Oxidation (e.g. dedicated biofilter for methane oxidation)

Scope 1 Emissions from WW Treatment– N_2O

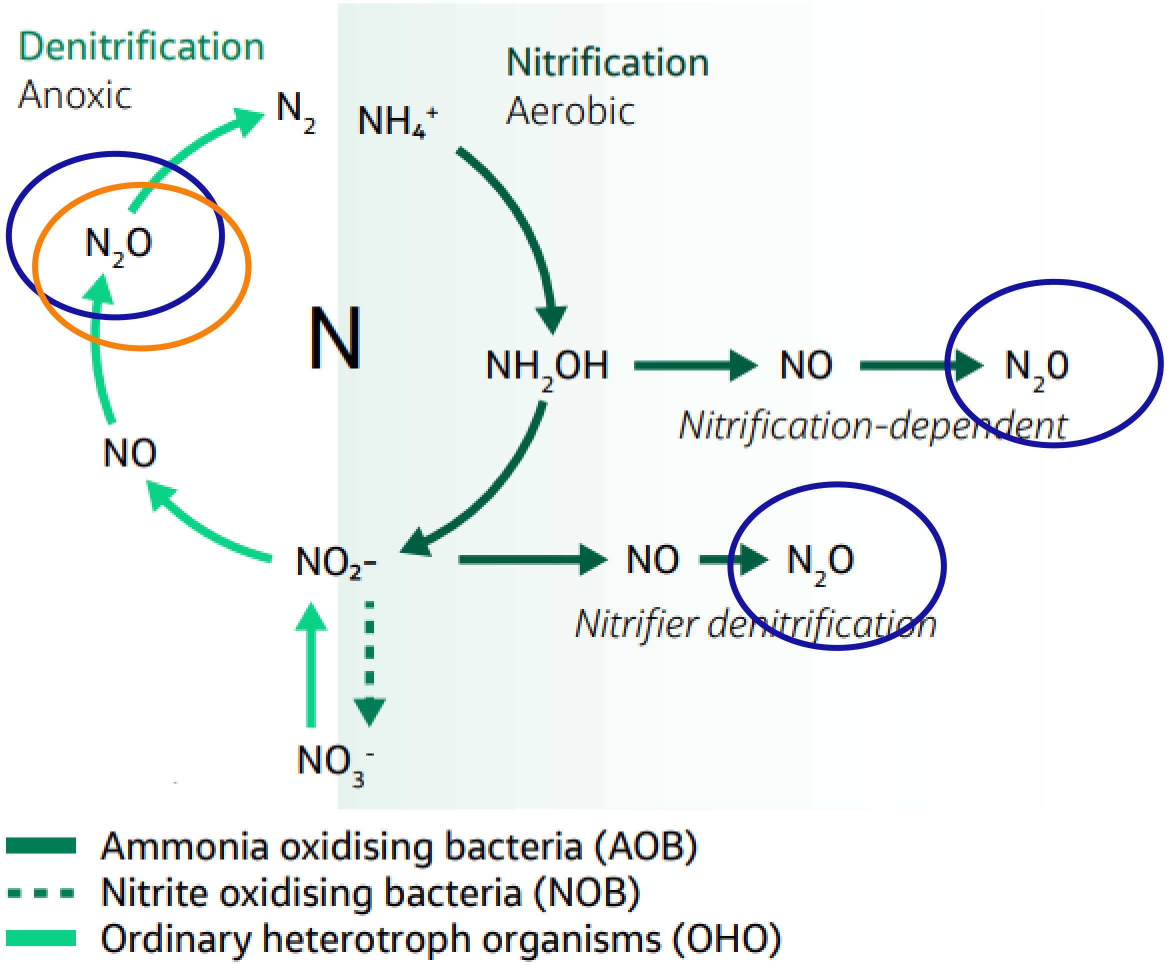


Sources of CH_4 emission points from wastewater transport and treatment (adapted from Quantification and Modelling of Fugitive GHG emissions from Urban Water Systems)

Known biological pathways of N_2O production in the Nitrogen Cycle

Sources of N_2O Emissions in more detail

- N_2O can be produced both during nitrification and denitrification, and consumed in denitrification
- Pathways and factors leading to biological N_2O formation and emissions from wastewater are highly complex and site-specific – further research required to improve industry understanding
- Abiotic pathways exist – not considered as significant but work ongoing



Scope 1 Emissions from WW Treatment– N_2O emissions

- Important to know!
- Global research has shown there is wide variation in process emissions:
  - Over diurnal and seasonal conditions
  - Over a range of treatment plants - due to combinations of operating conditions
  - Within trains of the same plant (likely due to different loading and operating conditions)

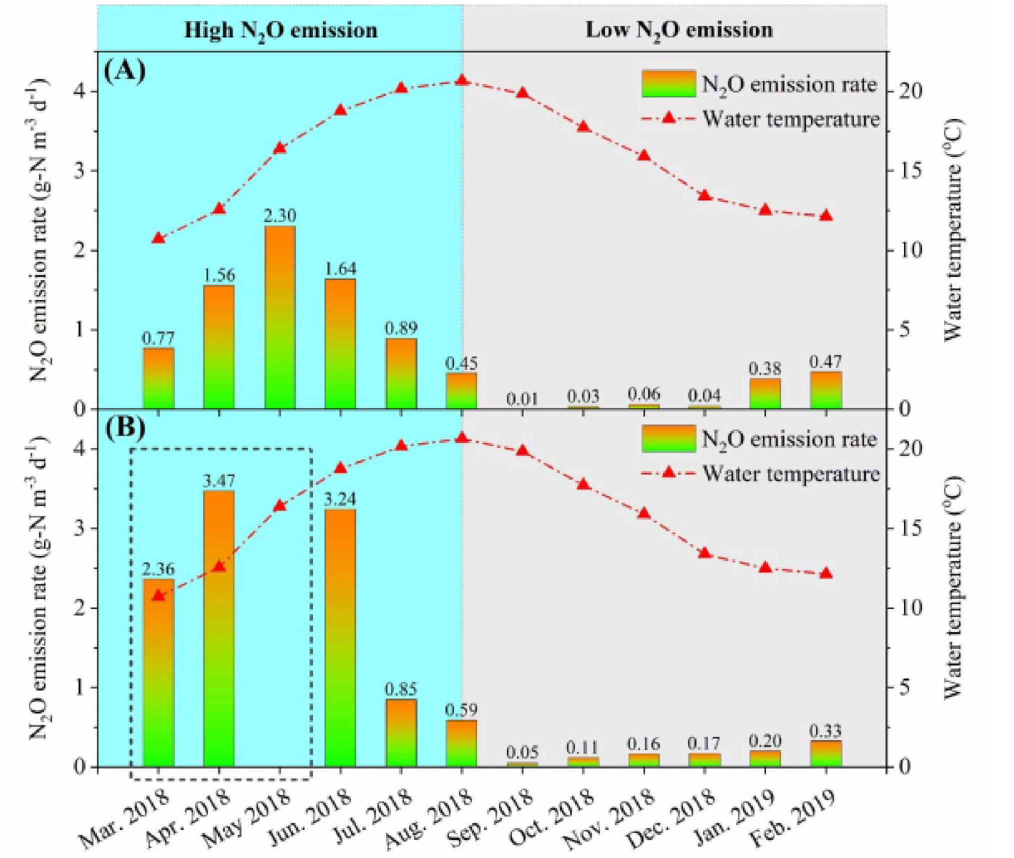


Figure 5. Seasonal N_2O emission pattern in **(A)** Reactor 3 and **(B)** Reactor 1 (Highlighted box in **(B)** indicates months when N_2O was only monitored in one compartment or both N_2O sensors were not in service).

Quantification and Analyses of N_2O Emission and Testing of Relevant N_2O Control Technology at Avedøre Wastewater Treatment Plant

N_2O Emission Monitoring Options

- Three key methods to N_2O monitoring have been adopted across a range of studies:

1) Site wide, e.g. Mobile tracer gas dispersion method (MTDM), drone monitoring

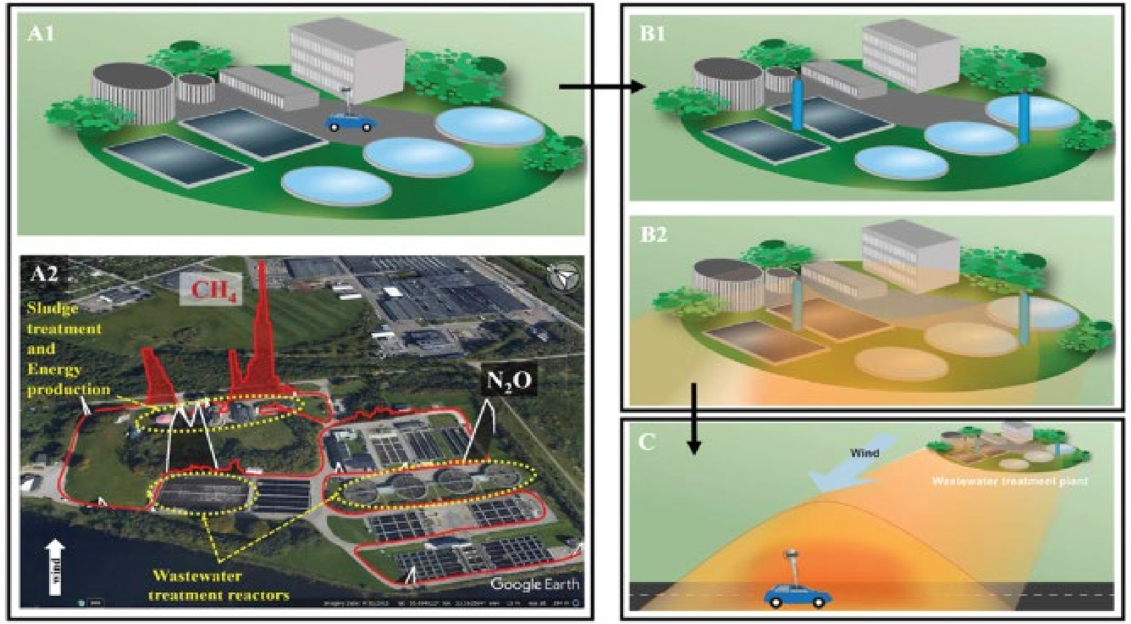


Figure 5.5 Illustration of the tracer gas dispersion method applied at wastewater treatment plants. (a) The initial screening phase with A1 showing on-site measurements of atmospheric concentrations of target and tracer gases and A2 showing an example of on-site screenings performed at Källby (SE) visualized on a Google Earth © image. CH_4 (marked in red) and N_2O (marked in white) concentrations are shown above the background level. The white arrow shows the wind direction. (b) Tracer placement with B1 showing the location of the tracer gas for source simulation and B2 showing the release of the tracer gas into the atmosphere. (c) The quantification phase showing downwind gas concentrations measurement performed along a plume transect. This figure was published in in Science of Total Environment, Vol number 605–606, Delre A., Mønster J., Scheutz C., Greenhouse gas emission quantification from wastewater treatment plants, using a tracer gas dispersion method, Page Nos 258–268, Copyright Elsevier (2017).

Plant-wide quantification used for GHG inventories/reporting or to prioritise sites.

With variable daily and seasonal emissions difficult to capture representative emissions.

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Chapter 5

Full-scale quantification of N_2O and CH_4 emissions from urban water systems

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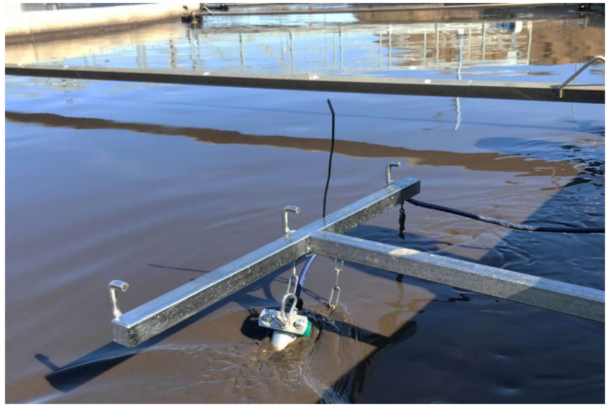
N_2O Emission Monitoring Options

Two process unit specific methods:

1) Off-gas hood N_2O monitoring
2) Liquid phase dissolved N_2O monitoring

Process unit specific monitoring used for model development and mitigation measures – currently being undertaken by a growing number of water authorities.



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Practical Tips for Reducing N_2O emissions

- Monitor, Assess, Implement process optimisation to reduce N_2O emissions

- **Example - Avedore WWTP, Denmark**
  - 12 month monitoring campaign
  - A decreased DO set-point in Reactor 3 led to 60% lower N_2O emissions than Reactor 1 (15% aeration savings)
  - Increasing MLSS by ~500mg/L further reduced emissions

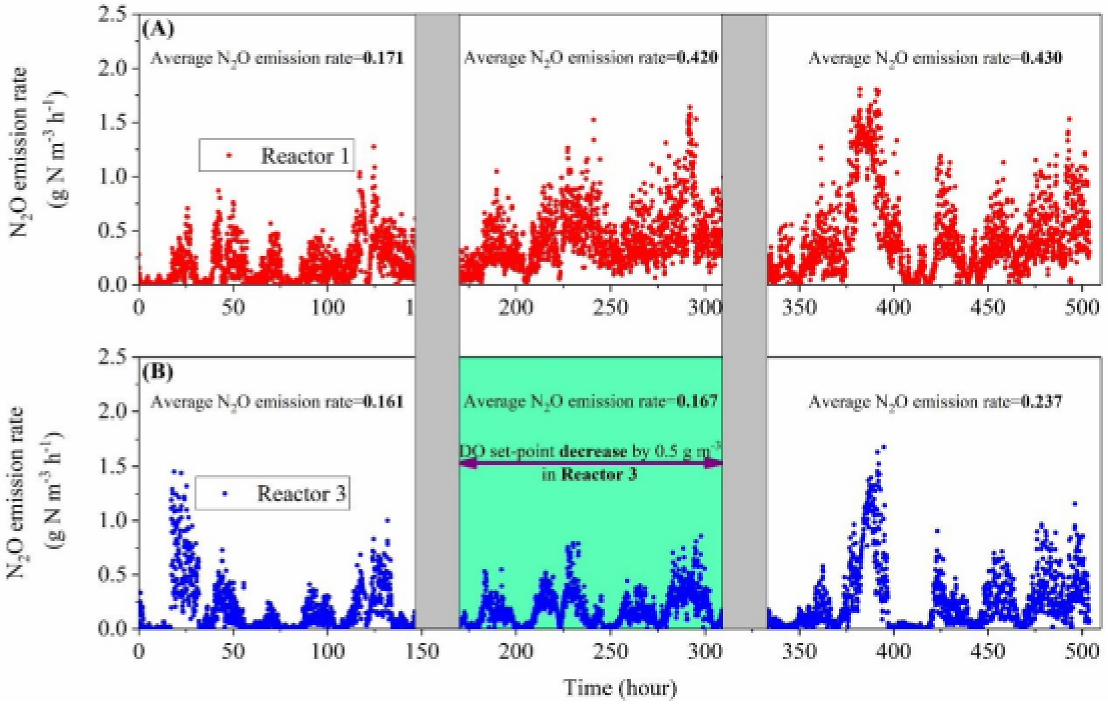
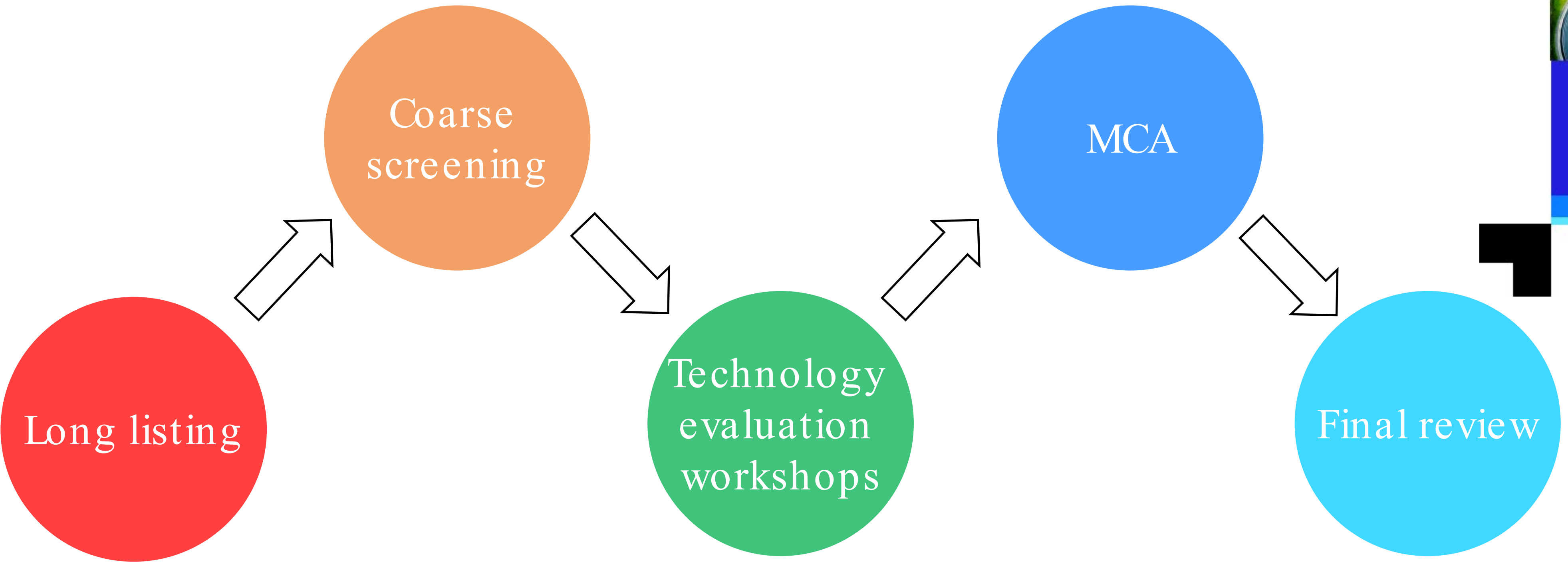


Figure 10. Comparison of N_2O emission rate between (**A**) Reactor 1 without decreased DO set-point and (**B**) Reactor 3 with decreased DO set-point.

Case Study

- Net Zero Technologies Case Study investigation for Ofwat (Water Services Regulation Authority for England and Wales)
  - Evaluated near term solutions which can be implemented by the water sector, key opportunities and challenges



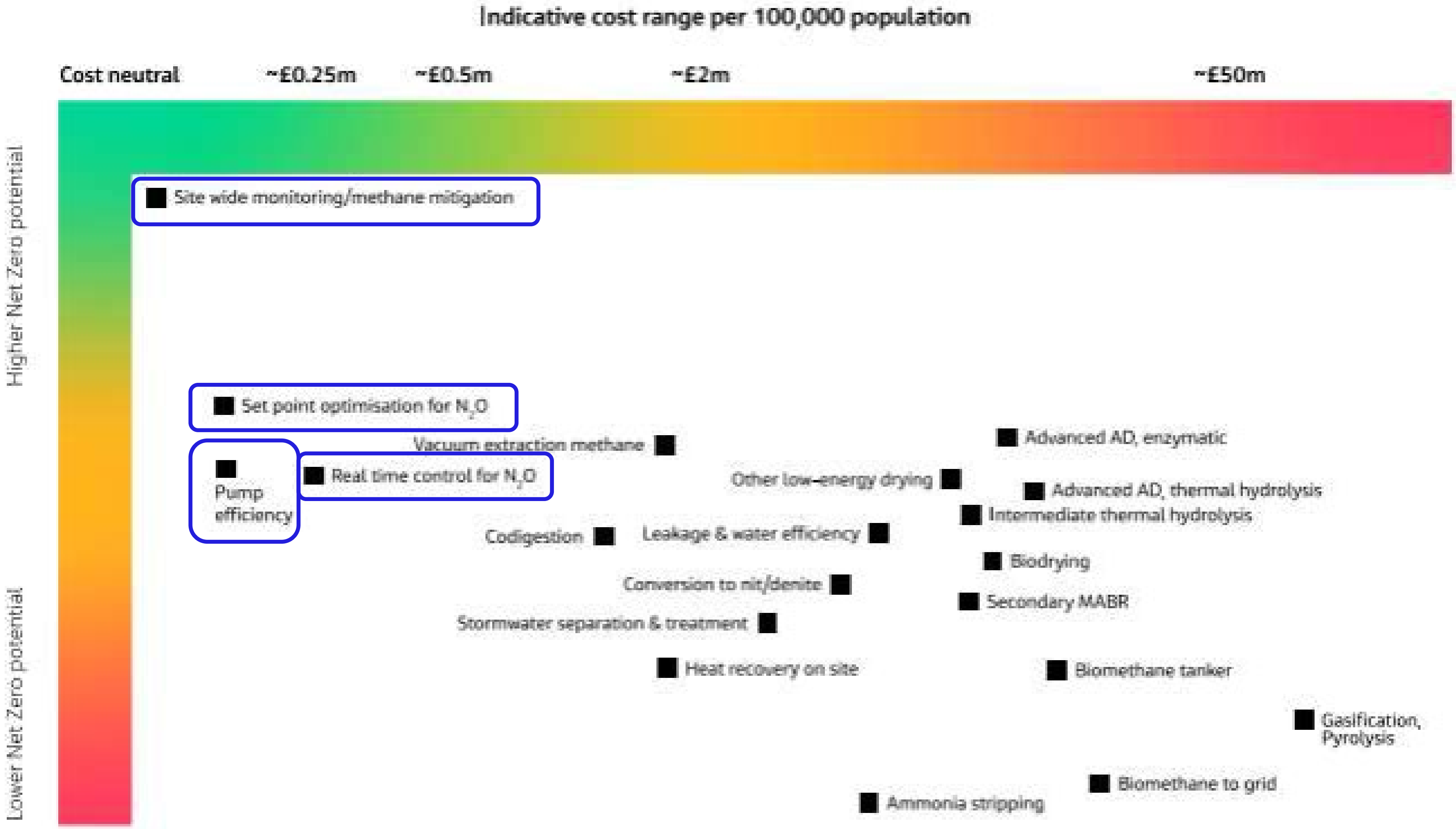
Case Study on Net Zero Technologies

- Wide range of options/technologies investigated

- Water efficiency across urban water cycle
- Pump efficiency
- Power purchase agreements
- CH_4 monitoring and mitigation
- MABR
- Nit/ denit conversion
- N_2O setpoint optimisation
- Real-time N_2O control
- AAD THP
- AAD EH or APD
- iTHP
- Codigestion
- Gasification/pyrolysis
- Biodrying
- Low-energy drying
- N stripping
- Tanker (biomethane)
- Heat recovery (onsite)
- Biomethane to grid
- Stormwater separation & treatment with NBS

Case Study on Net Zero Technologies

Indicative cost and carbon impacts



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Thank you

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