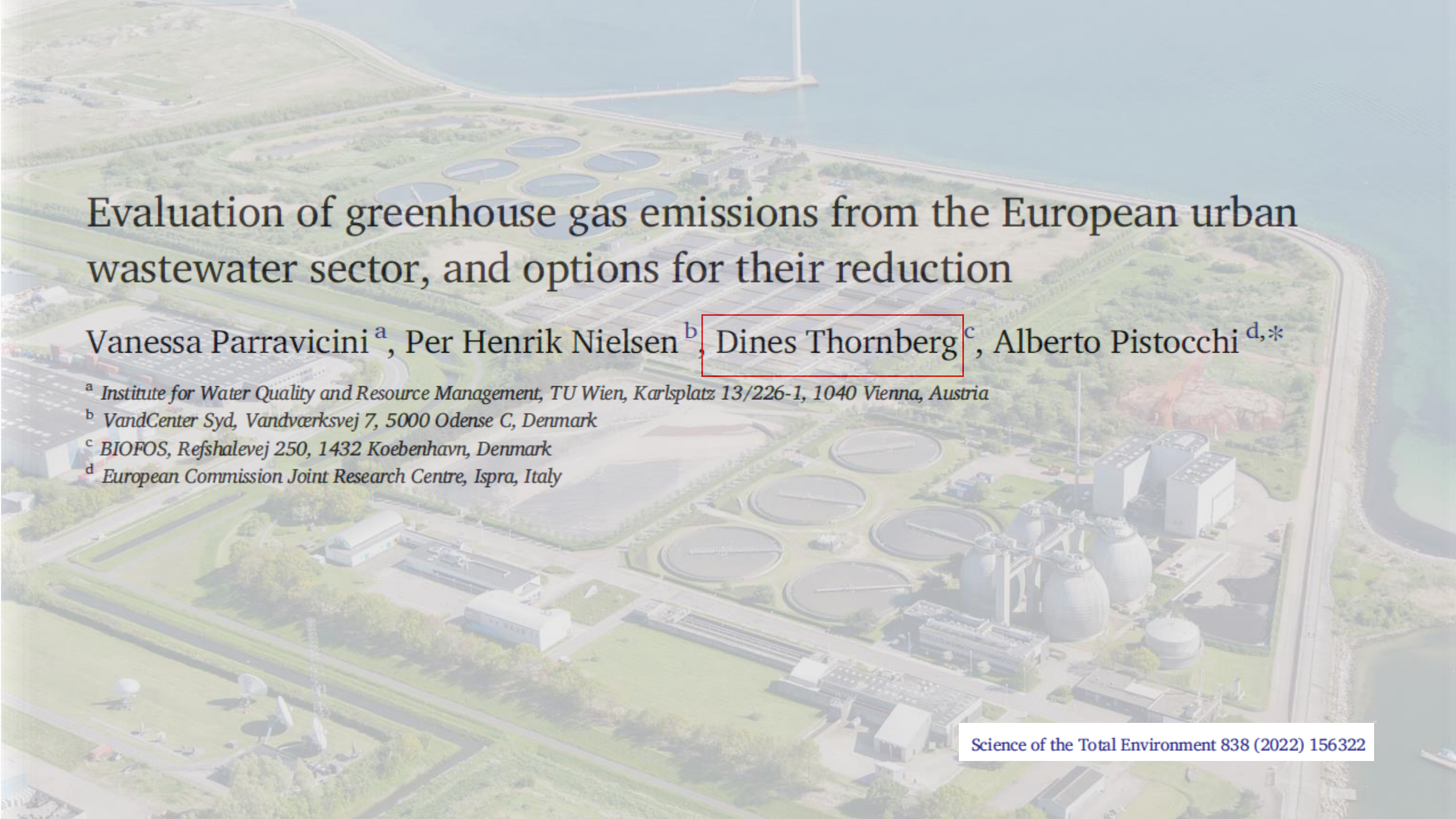

Evaluation of greenhouse gas emissions from the European urban wastewater sector, and options for their reduction

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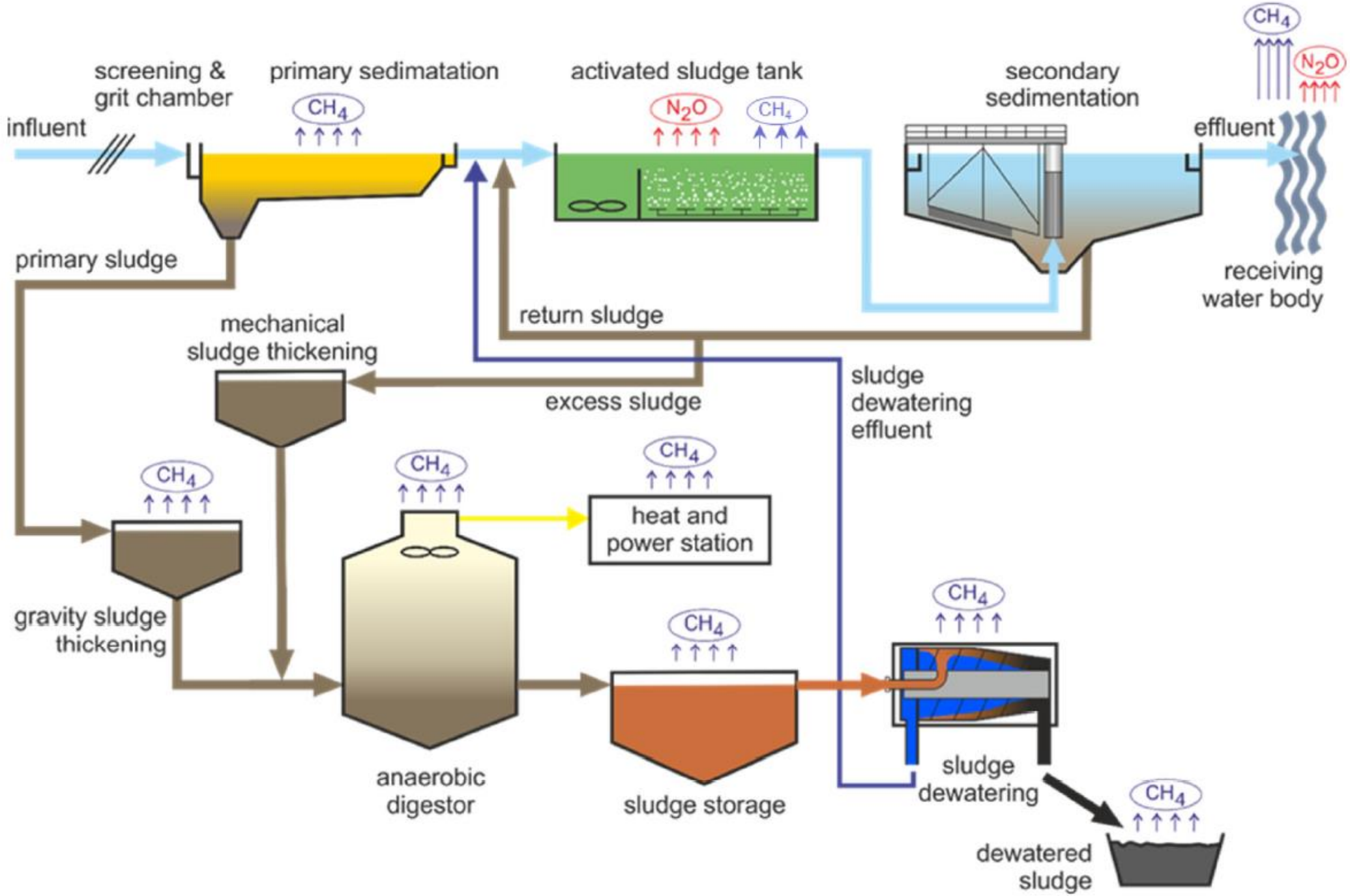

screening &
grit chamber
primary sedimatation
activated sludge tank
secondary
sedimentation
influent
effluent
CH_4
N_2O
CH_4
CH_4
N_2O
primary sludge
receiving
water body
return sludge
mechanical
sludge thickening
excess sludge
sludge
dewatering
effluent
CH_4
CH_4
CH_4
heat and
power station
gravity sludge
thickening
CH_4
CH_4
CH_4
anaerobic
digestor
sludge storage
sludge
dewatering
CH_4
dewatered
sludge

B)

The assessment includes

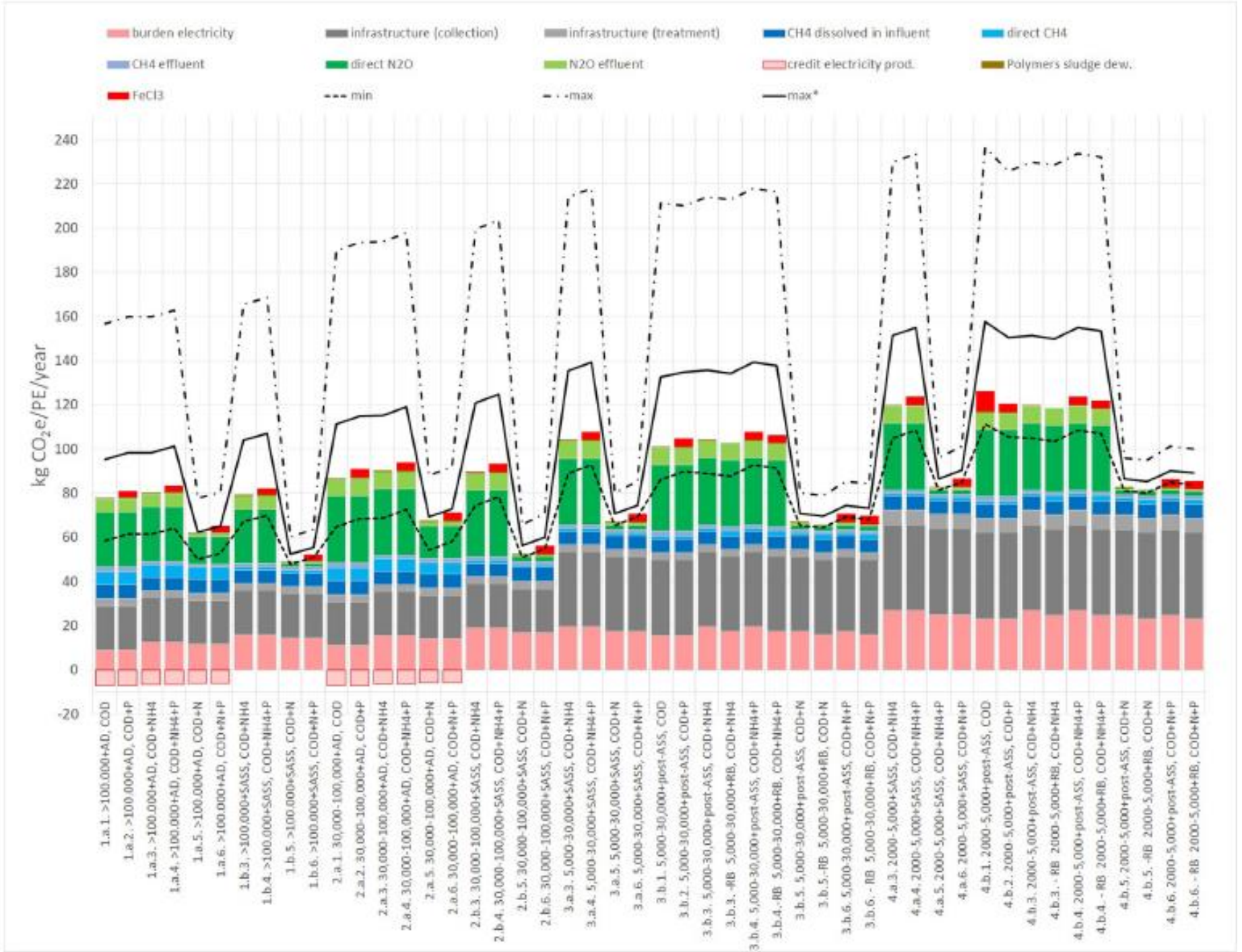
1. Life-cycle emissions of infrastructure
2. Emissions of dissolved methane in the sewer networks
3. Direct emissions of nitrous oxide and methane from the treatment processes
4. Emissions due to COD and nitrogen in the effluents
5. Indirect emissions due to the generation of electricity and the production of reagents
6. Emission credits due to energy recovery or biomethane export associated with the anaerobic digestion of sludge.

Scenarios

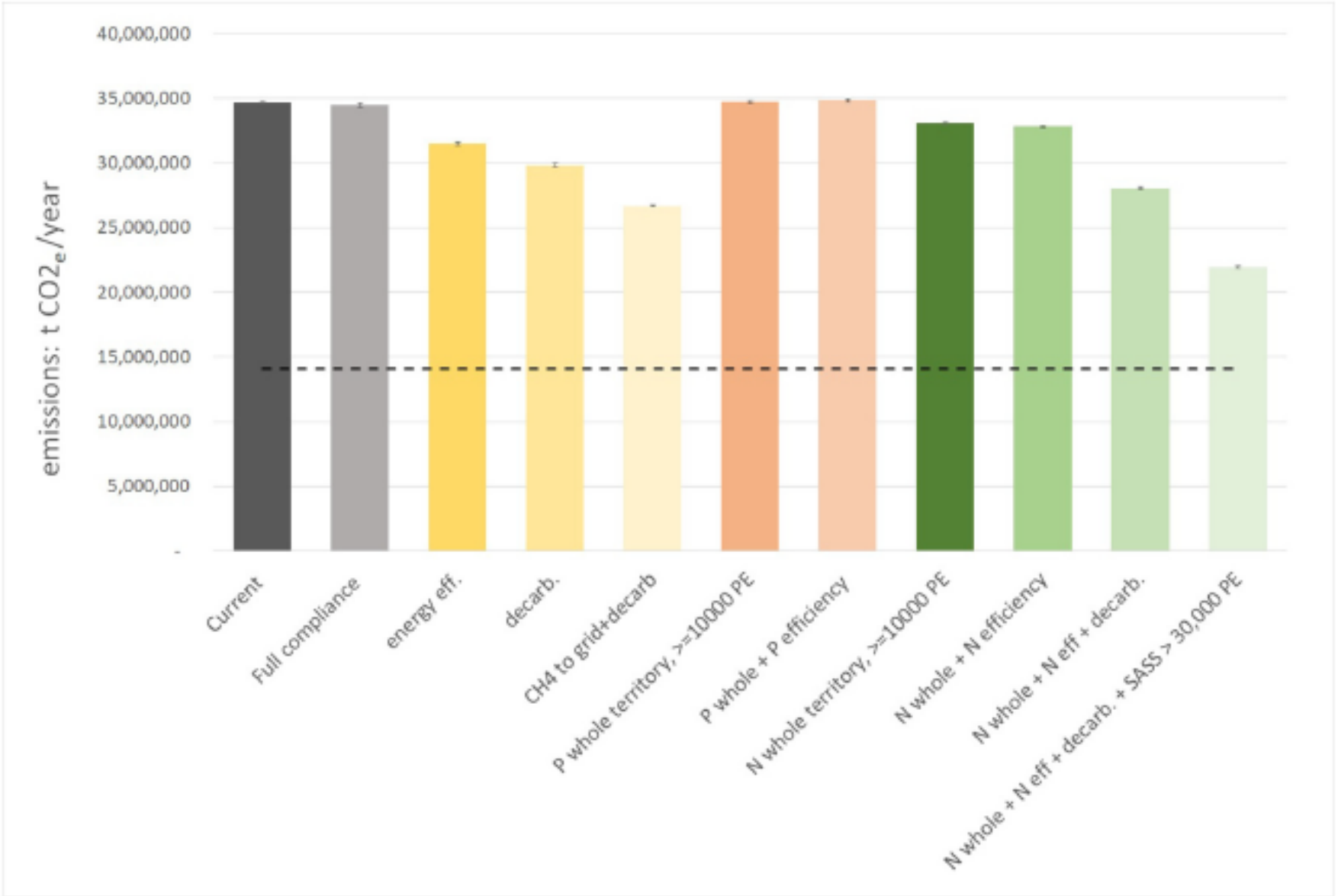
- **Size** >100.000 PE > 30.000 PE > 5.000 PE
- **Sludge stabilisation** AD or SASS
- **Removal degree** COD, COD+P, NH4, NH4 + P, Total N, Total N+P

- Calculation of GHG emissions based on literature constants

Scenarios Result



Total GHG emissions EU



Conclusions

- Emisions 50-125 kg CO_2e/PE/Year
  - 35 million tonnes for the EU (14 due to infrastructure)
- Primary sources: N_2O and power. CH_4 second
- Low or zero footprint from power is important and expected (2050)
- Full Nitrogen removal and methane recovery are important tools in the reduction of carbon footprint

- N_2O emissions are more dynamic than a constant factor can describe.

  ->We need to measure

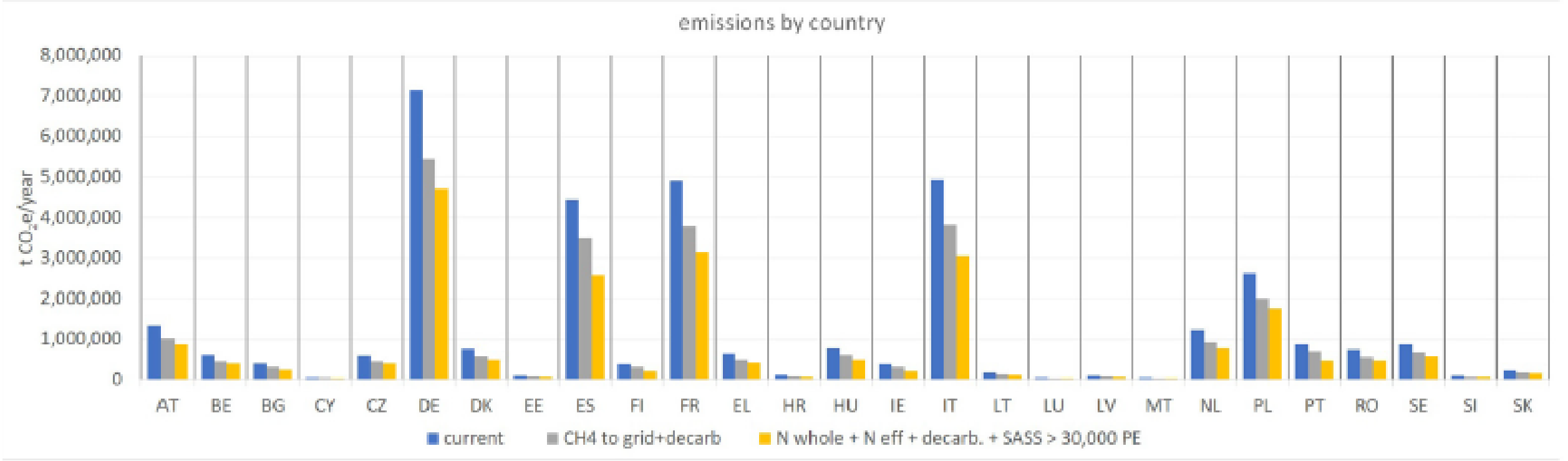
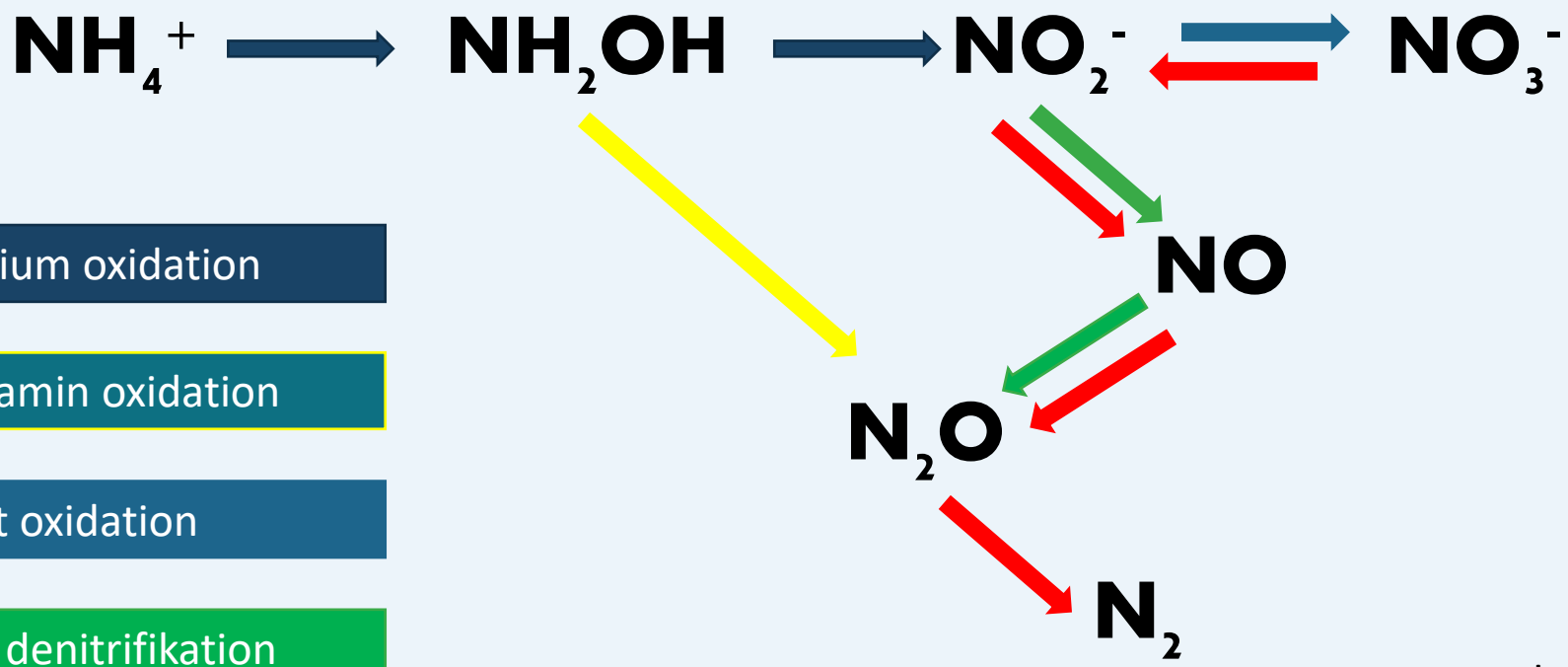

emissions by country
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
t CO2e/year
AT
BE
BG
CY
CZ
DE
DK
EE
ES
FI
FR
EL
HR
HU
IE
IT
LT
LU
LV
MT
NL
PL
PT
RO
SE
SI
SK
current
CH4 to grid+decarb
N whole + N eff + decarb. + SASS > 30,000 PE

Table 2
Scenarios quantified in the assessment.

Scenario	Rationale	Assumptions
Current	Conditions corresponding to the currently reported level of treatment (secondary, N and P removal) of WWTPs.	WWTPs removing COD: range of combinations X.a.1, X.a.3, X.b.1, X.b.3 WWTPs removing COD and P: range of combinations X.a.2, X.a.4, X.b.2, X.b.4 WWTPs removing COD and N: range of combinations X.a.5, X.b.5 WWTPs removing COD, P and N: range of combinations X.a.6, X.b.6 (X = 1, 2, 3, 4)
Full compliance	Conditions corresponding to the level of treatment required for WWTPs, depending on whether they fall in a sensitive area or not.	Same as current.
Energy efficiency	Full compliance configuration. Reduction of specific electric energy use (kWh/PE/year) as a consequence of energy efficiency measures.	For all plants, electricity demand is reduced from a median value to an efficient standard, corresponding to the 10th best percentile of the model by Ganora et al., 2019.
Decarbonisation	Full compliance configuration. Reduction of GHG emissions by using electricity 100%-derived from renewable energy sources.	For all plants, the emissions associated with electricity demand is set to 0 kg CO_2/kWh.
N whole territory	Extension of N removal requirements to all WWTPs above a given capacity.	All plants are attributed to typology X.Y.5 if outside a P-sensitive zone, or X.Y.6 if inside (X = 1, 2, 3, 4, Y = a, b) if they exceed a given capacity.
P whole territory	Extension of P removal requirements to all WWTPs above a given capacity.	All plants are attributed to typology X.Y.2 or X.Y.4 if outside a N-sensitive zone, or X.Y.6 if inside (X = 1, 2, 3, 4, Y = a, b) if they exceed a given capacity.
N whole territory + N efficiency	Requirement to remove 85% of influent N (instead of 75%) at plants >30.000 PE in addition to N whole territory.	The default N removal efficiency of 75% assumed for plants with AD of typology X.Y.Z is replaced by 85% (X = 1, 2, Y = a, Z = 5, 6)
P whole territory + P efficiency	Requirement to remove 90% of influent P (instead of 85%) at all plants in addition to P whole territory.	The default P removal efficiency of 85% assumed for plants of typology X.Y.Z is replaced by 90% (X = 1, 2, 3, 4, Y = a, b, Z = 2, 4, 6).
CH_4 to grid + decarbonisation	Full compliance configuration. Effect of using biogas to produce grid methane instead of combined heat and power (CHP) in addition to decarbonisation.	At WWTP with AD, the produced biogas is upgraded and conveyed to the gas grid instead of CHP.
N whole territory + efficiency + decarb. + SASS > 30,000 PE	"N whole territory + efficiency" configuration. Simultaneous aerobic sludge stabilization applied to plants larger than 30,000 PE in addition to decarbonisation.	For plants of typologies X.a.Y, we assume AD is replaced by SASS (X = 1, 2, Y = 3, 4, 5, 6). No plants attributed to typologies X.a.1 and X.a.2.

Varga



Ammonium oxidation

Hydroxylamin oxidation

Nitrit oxidation

Nitrifier- denitrifikation

Denitrifikation

Kampschreuer et al., 2009