POWERSTEP

YOUR FLUSH, OUR ENERGY

FULL SCALE DEMONSTRATION OF ENERGY POSITIVE SEWAGE TREATMENT PLANT CONCEPTS TOWARDS MARKET PENETRATION

- *Boris Lesjean*
- *Veolia Germany*

- ISEC, 05.10.2018, Graz

Funded by
the Horizon 2020
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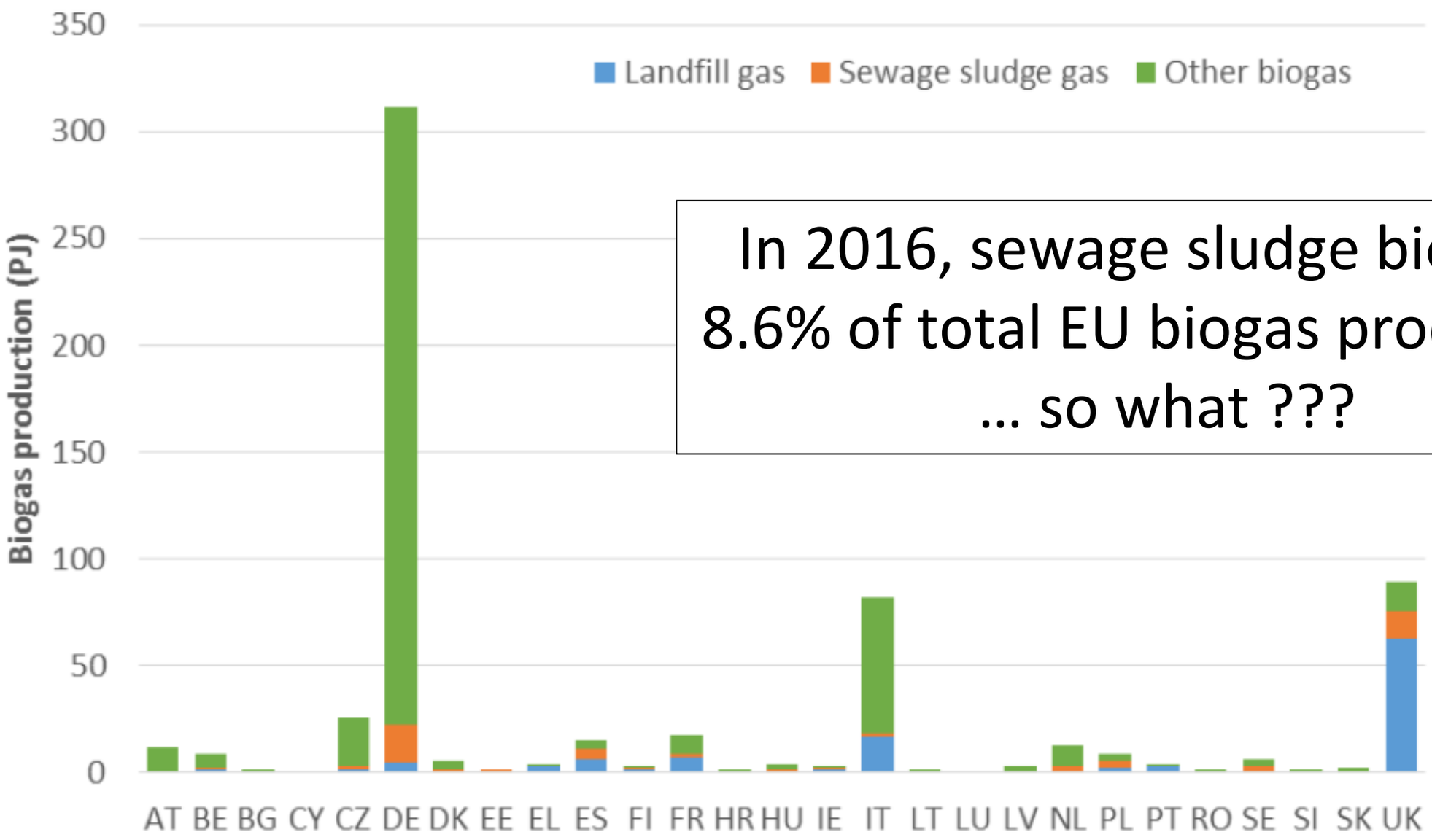
Energy from municipal wastewater: an overview of best practices in Europe

Boris Lesjean, Veolia Germany

ISEC, 05.10.2018, Graz

Current situation

Figure 1 Biogas production per Member State in 2014, differentiated by source (EurObserv'ER, 2015) [1]



In 2016, sewage sludge biogas = 8.6% of total EU biogas production
… so what ???

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POWERSTEP

Content

1. Introduction on PowerStep project

2. Market potential and first users

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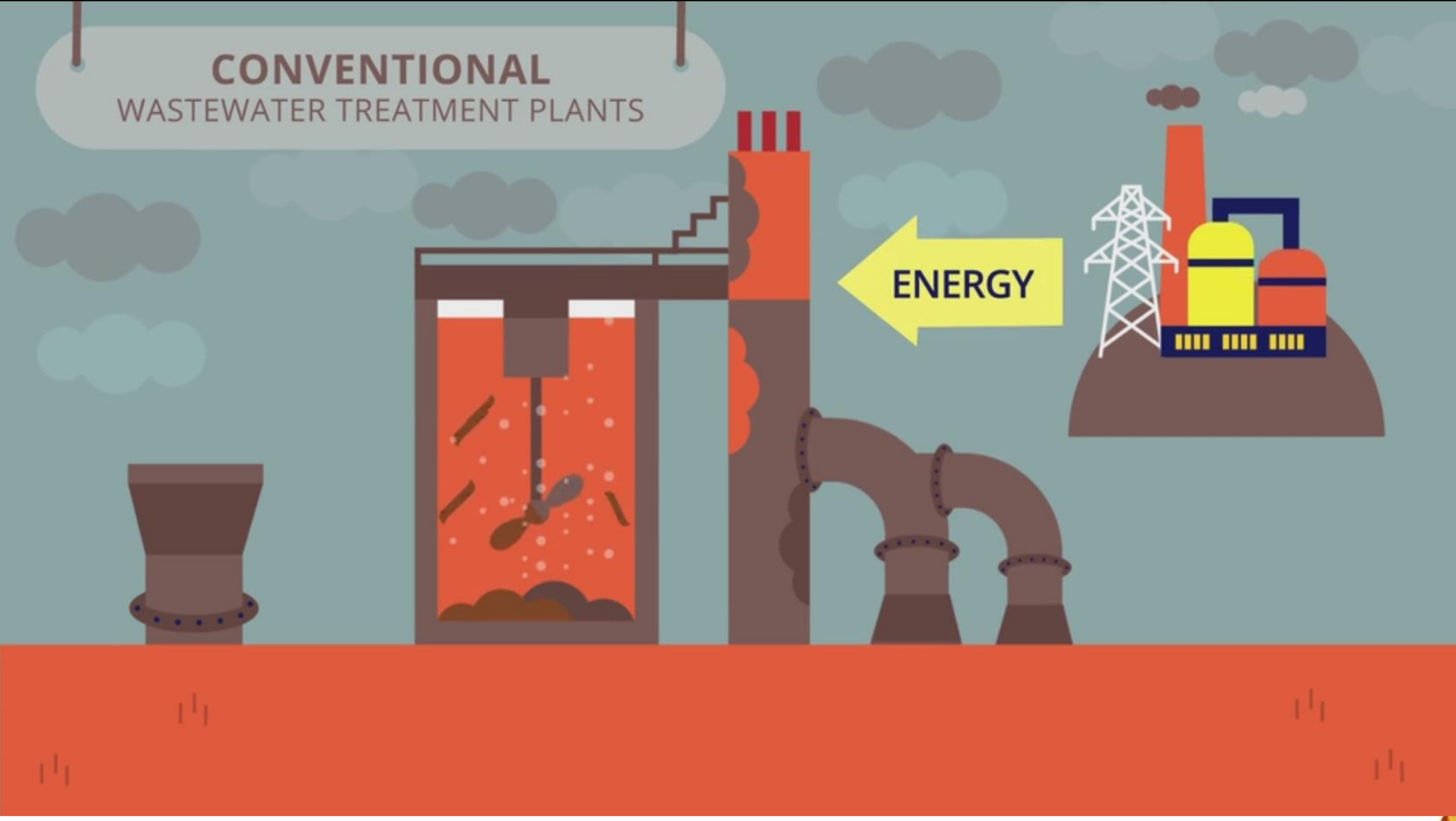

WWTPs are the highest energy consumer in a municipality!

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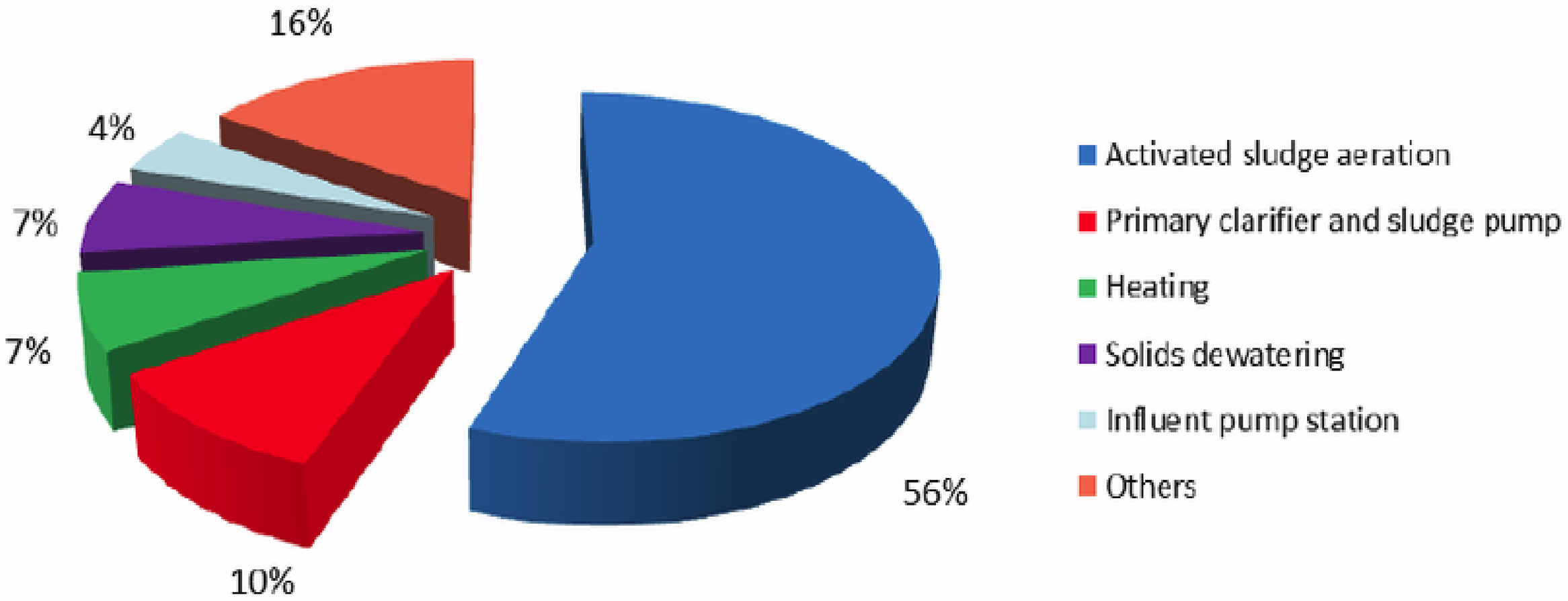
WWTP the “Energy consumer”



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BUT WWTPs try to improve themselves!

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Energy-positive WWTP – a DREAM?

Is there a potential by treating your **„Pooh“** to become **energy-neutral** or **energy-positive** as WWTP?

(without using external renewable sources)

Are **energy-positive WWTPs** without external renewable sources still **a DREAM**?

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We as a consortium say “NO” it’s no dream, energy-positive WWTPs are possible!

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175 kWh/pe*a
4 kWh/m³
(120 g COD/pe*d,
120 L/pe*d,
1000 mg/L COD)

Mineralisation

Less aeration

105 kWh/pe*a
2.4 kWh/m³

Heat losses

Sludge

53 kWh/pe*a
1.2 kWh/m³

CO_2

42 kWh/pe*a
0.96 kWh/m³

Heat losses

17 kWh/pe*a
Waste heat

17 kWh/pe*a
0.38 kWh/m³

More biogas

Theoretical energy potential in wastewater organics

WWTP:
60% of COD
in sewage
sludge

Digestor:
50% of COD
into biogas

Methane yield:
320 L CH_4/kg COD

CHP plant:
40% electrical
efficiency

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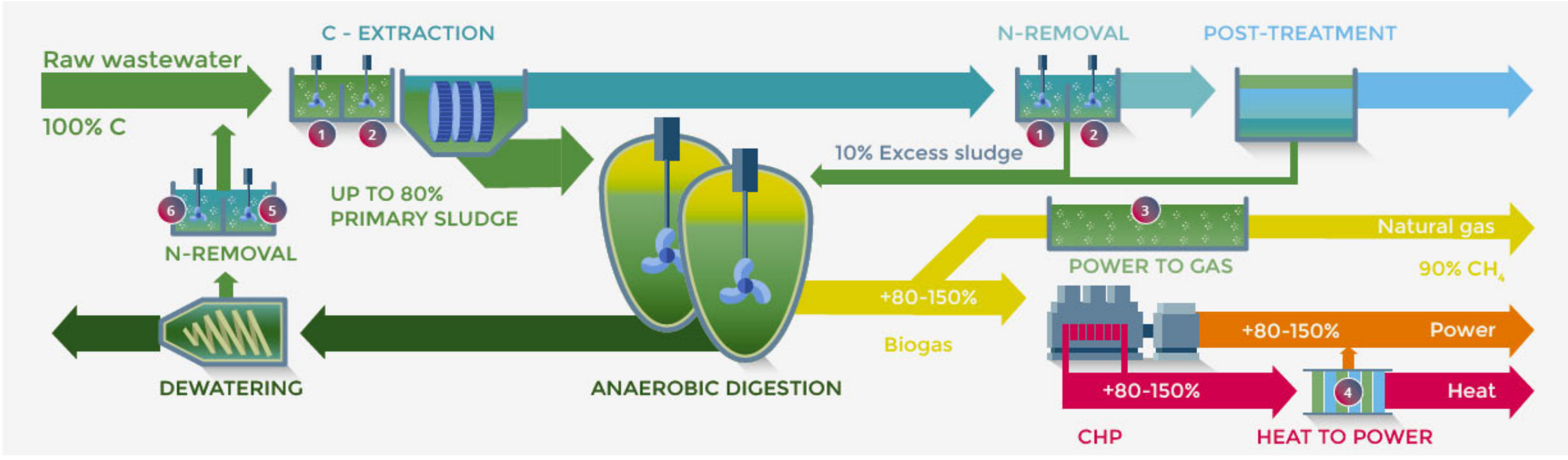
The POWERSTEP concept



The POWERSTEP case studies

CASE STUDY 1: WESTEWITZ (DE) 1

GOAL: enhanced Carbon extraction + Nitrogen removal

TECHNOLOGY: drum filter + SBR or duckweed reactor

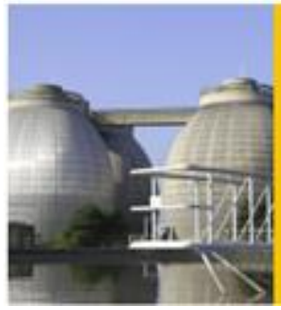
SIZE: 2.000 pe (full-scale)

CASE STUDY 2: SJÖLUNDA (SE) 2

GOAL: enhanced Carbon extraction + Nitrogen removal with innovative biological process

TECHNOLOGY: disc filter + 2-stage MBBR for nitritation/anammox

SIZE: 4 x 50m³ reactors (large pilot)

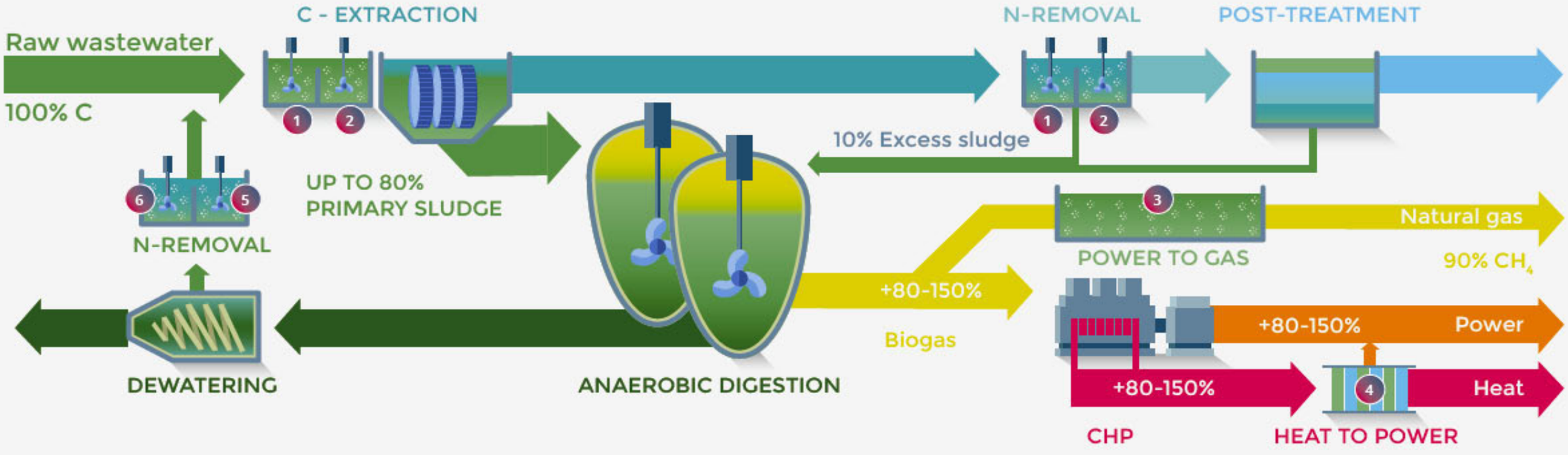


CASE STUDY 3: AVEDORE (DK) 3

GOAL: biogas upgrade to improve methane content („power-to-gas")

TECHNOLOGY: biological methanisation

SIZE: 50Nm³ CO2/h (large pilot), 1 MW electrolyzer



CASE STUDY 6: ALTENRHEIN (CH) 6

GOAL: recovery of Nitrogen as a fertilizer in sidestream

TECHNOLOGY: membrane NH3 stripping

SIZE: 75.000 m³/a (full-scale)

CASE STUDY 5: KIRCHBICHL (AT) 5

GOAL: treatment of Nitrogen in sidestream and recovery of oxygen in mainstream

TECHNOLOGY: nitritation

SIZE: 100.000 pe (full-scale)

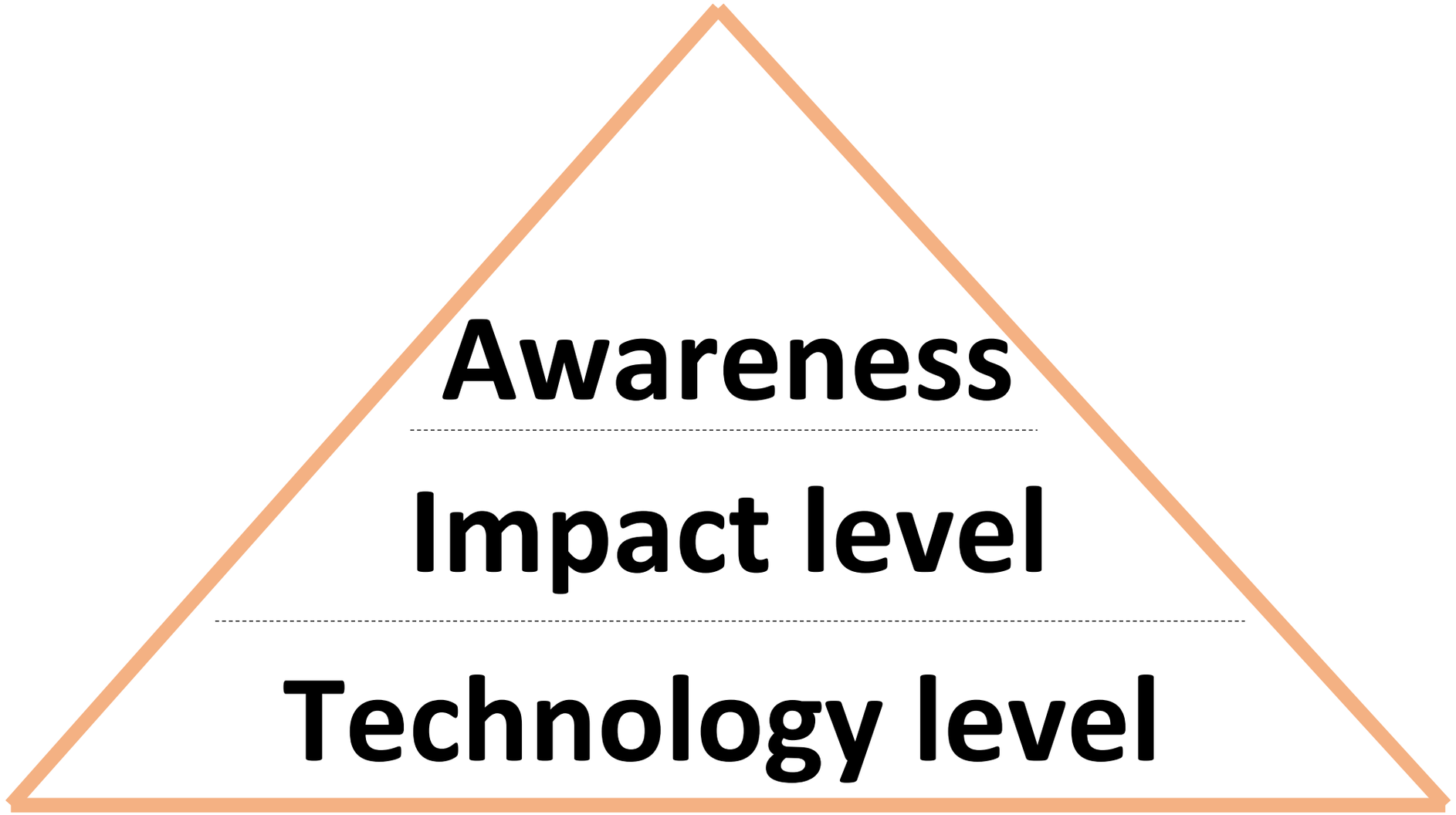
CASE STUDY 4: BRAUNSCHSWEIG (DE) 4

GOAL: increase the efficiency of CHP and implement a „smart-grid" strategy

TECHNOLOGY: thermoelctric generators for"heat-to-power" + energy sales modelling

SIZE: upgrade of 1 CHP (pilot) and model (full)

Results within www.POWERSTEP.eu



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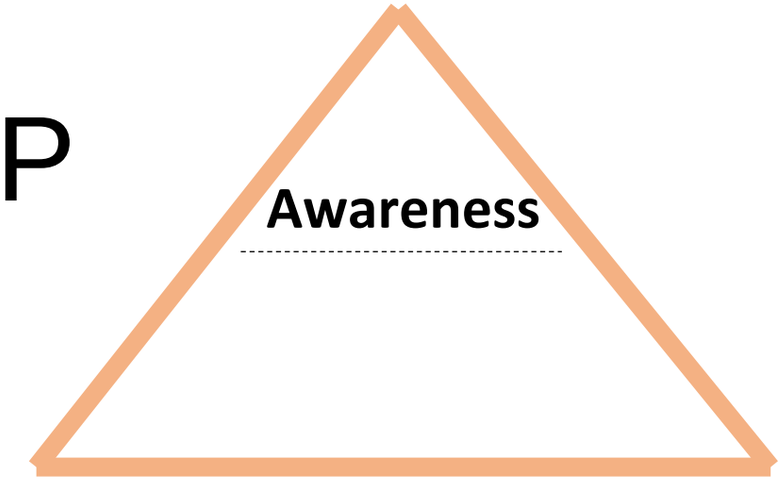
Results within POWERSTEP



34 deliverables

Deliverable 1.1 - Optimised design of the microscreen and periphery for primary filtration

d1-1-optimized-design-of-microscreen-and-periphery-for-primary-filtration-0.pdf

Deliverable 1.3 - Compedium of best practice of primary treatr for advanced carbon extraction

d1-3-compendium-of-best-practices-for-advanced-primary-treatment.pdf

Deliverable 2.1 - Advanced control system for energy efficient nitrogen removal

d2-1-advanced-control-strategy-for-nitrogen-removal-final.pdf

Deliverable 6.2 - Visual identity, flyer and website

020216_D.6.2 visual identity flyer website.pdf

Deliverable 6.3 - Communication kit for demosites

d6-3-communication-kit-for-demosites.pdf

Deliverable 6.4 - Innovative website

d6-4-innovative-website.pdf

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POWERSTEP

Content

1. Introduction on PowerStep project

2. Market potential and first users

Front runners (extracts from web)

Objectives

- **HAMBURG WASSER is energy-self-sufficient by 2018**
- **HAMBURG WASSER works on Zero-CO_2-Concepts**

Hamburg, D

Vienna, AT

Energy self-sufficiency by 2020

ebswien hauptkläranlage currently needs 60 GWh of electricity per ye
equating to 1% of Vienna's total electricity consumption. In accordanc
programme KliP and energy efficiency programme SEP, *ebswien* has since 2008 undertaken consistent efforts towards increasing energy efficiency and using renewable sources of energy. A number of (waste)water, solar and wind energy utilisation goals have meanwhile been accomplished in the course of "SternE – Strom aus erneuerbarer Energie", a project for electricity generation from renewable resources. This has already helped to cut energy consumption by 11%. The E_OS project goes even further:

Our Marselisborg Wastewater Treatment Plant has increased plant efficiency and reduced energy consumption by optimizing all its processes. The plant produces in 2016 40 percent more electricity than it needs and 2.5 GW of heat for the district heating system without adding external organic waste or carbon. This excess energy is enough to serve the needs of the drinking water supply and wastewater treatment facilities in the region.

Aarhus, DK

Bottrop, D

Ziel: 100% eigene Stromversorgung

Kläranlagen zählen zu den Großverbrauchern von Energie im städtischen Bereich. Das Klärwerk an der Emscher in Bottrop hat sich deshalb ein ambitioniertes Ziel gesetzt, um den Bezug von Strom aus dem öffentlichen Netz auf ein Minimum zu reduzieren. In Zukunft möchte die Emschergenossenschaft ihren kompletten Energiebedarf über einzelne, dezentrale Erneuerbare Energieanlagen decken.

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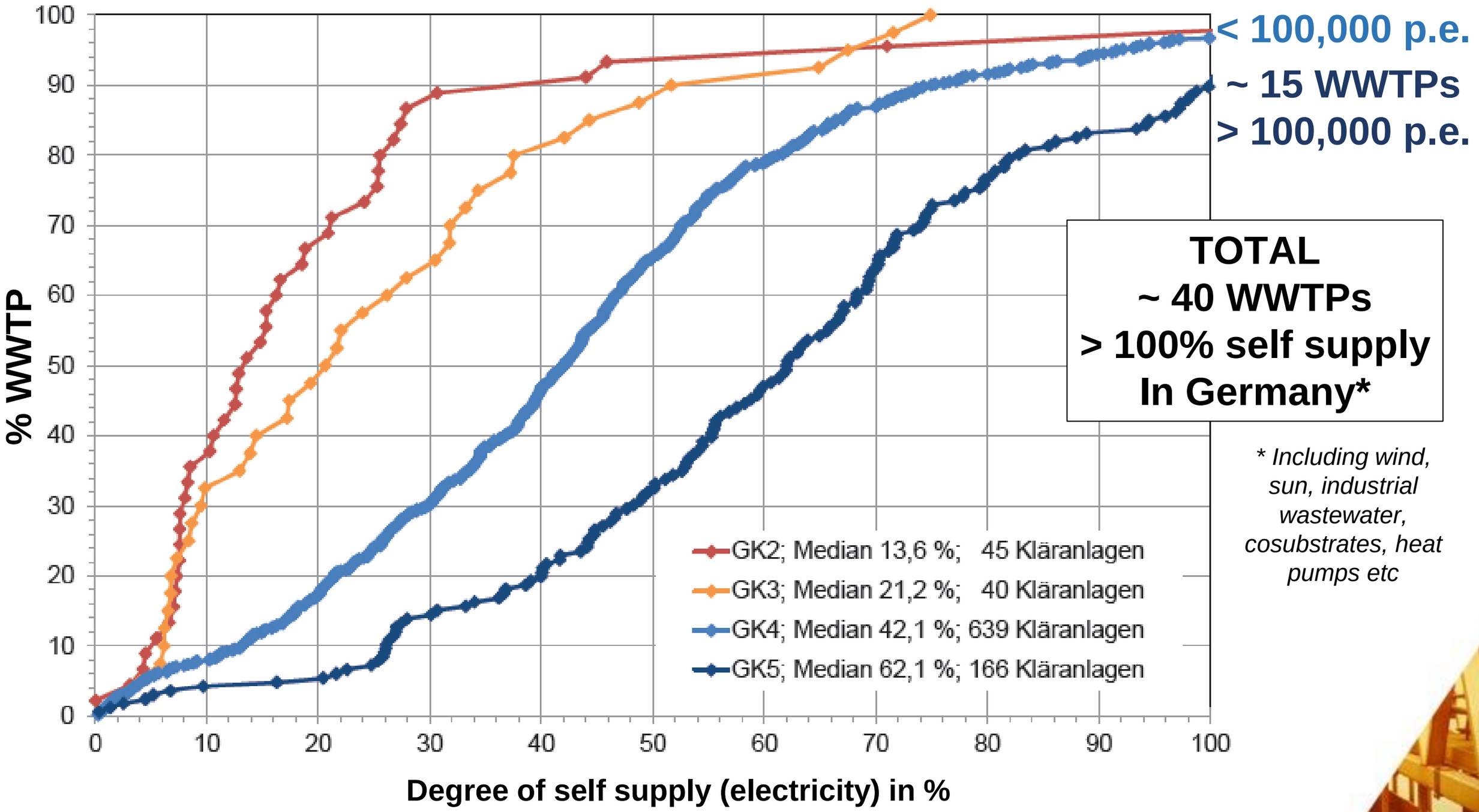
2017: statistics of German Water Association



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The German pioneer: Grevesmühlen WWTP (65,000 p.e.)

- Energy positive since 2002
- 2007: Outing!!!
- Today: > 300% self electricity supply (handling sludge from 120,000 p.e.)
- Energy neutrality for full utility

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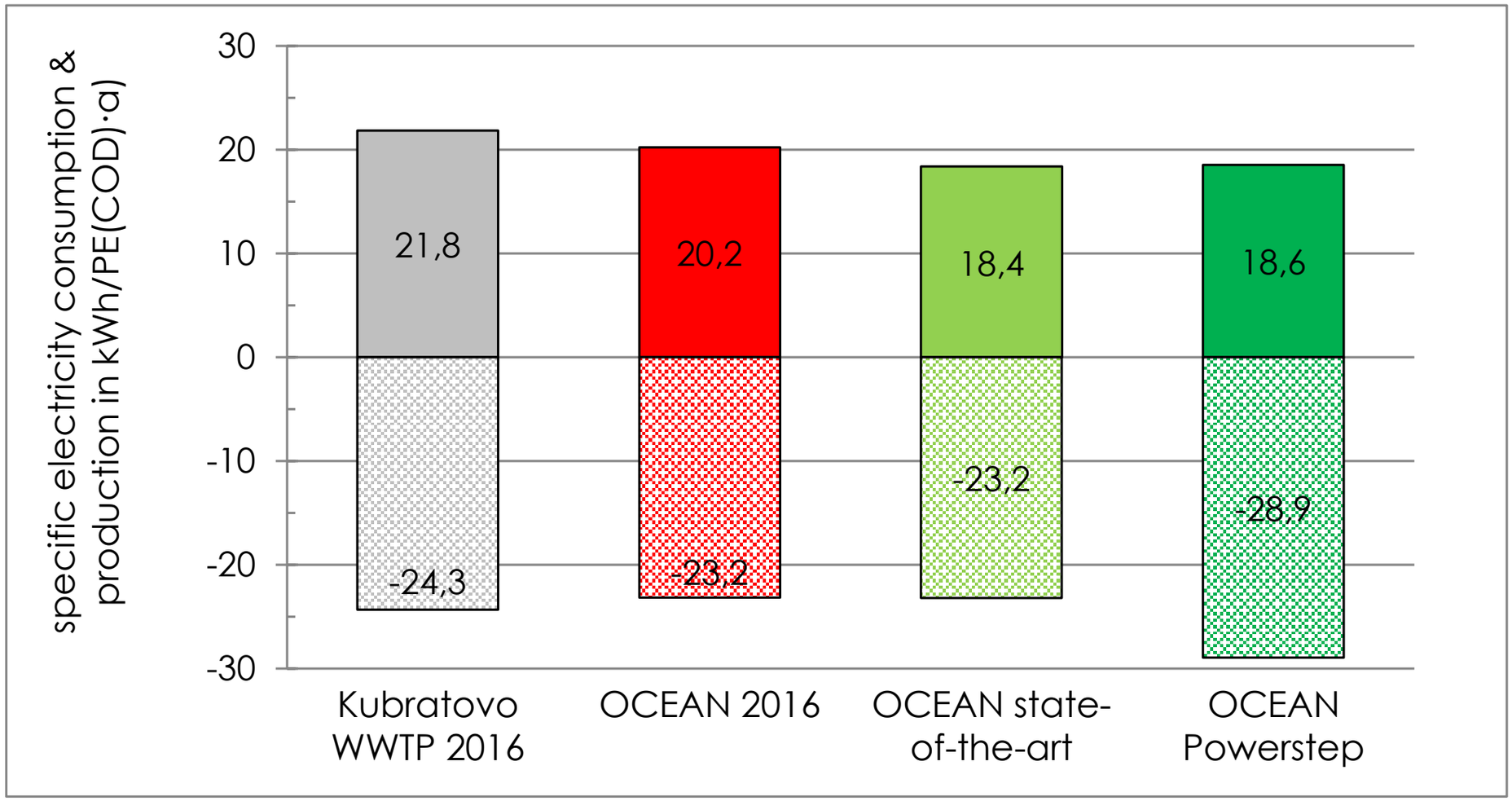
Kubratovo WWTP (Sofia, 1.3 M p.e.)

- Activated sludge + digestion (TN_{out}=10mg/L)
- Underloaded, no external carbon source (C/N ~ 10)



Self-sufficiency	112%	115%	126%	150%

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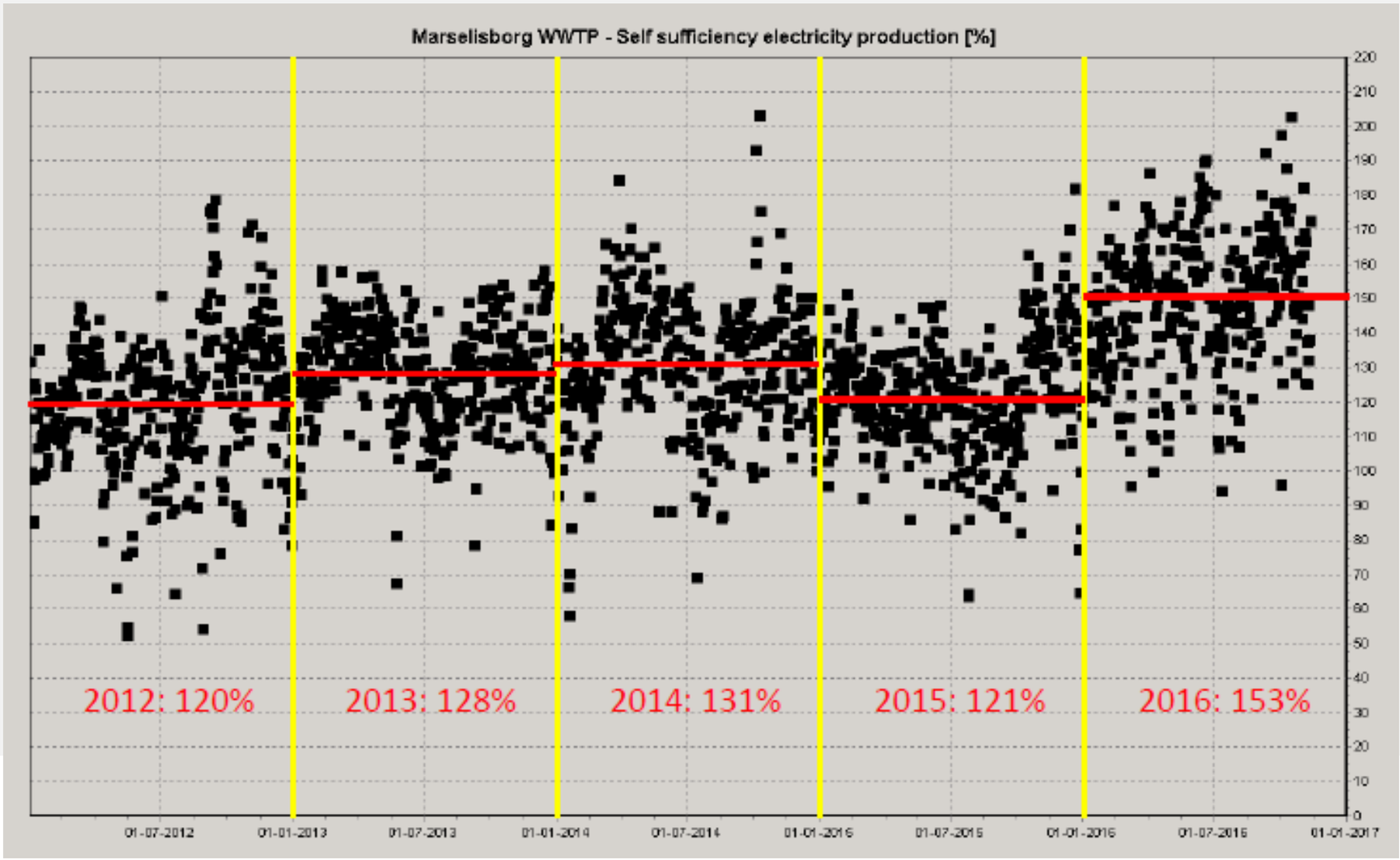
Marselisborg WWTP, Denmark (200,000 p.e.)

- State-of-the-art WWTP with simultaneous N/DN and side stream deammonificatin
- Favorable C/N > 12 but no external carbon source:
  up to 153% self sufficiency!



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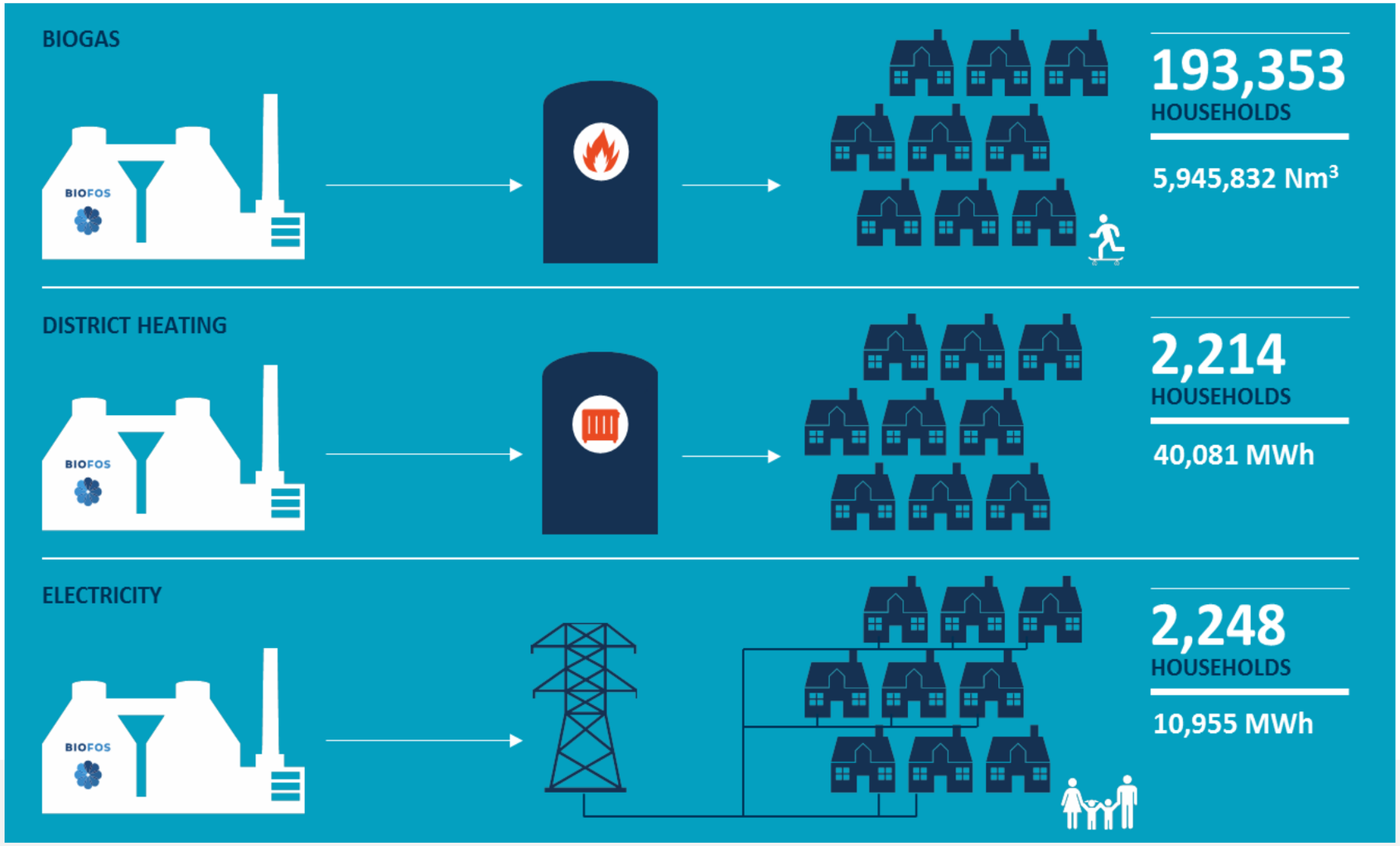
Copenhagen, 2017 > 150% energy supply and carbon neutral (3 WWTPs, 1,400,000 p.e.)



- No cosubstrate
- Digestion + incineration
- Biogas in town gas grid
- Heat and power sales

BIOFOS

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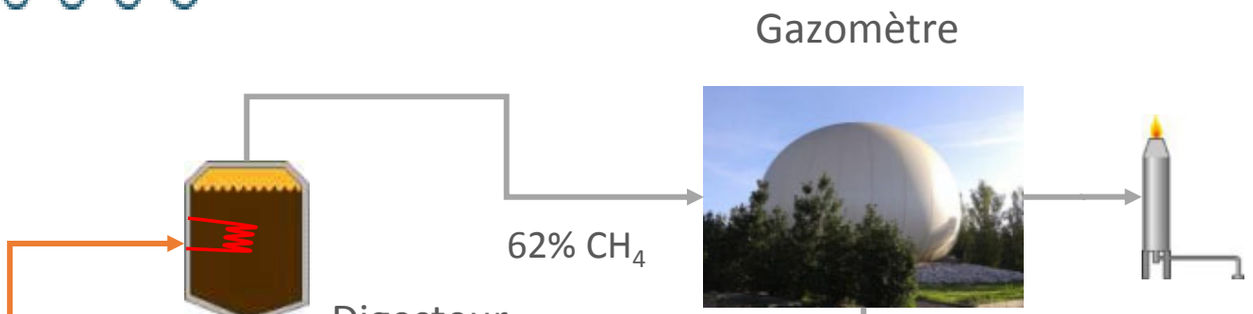
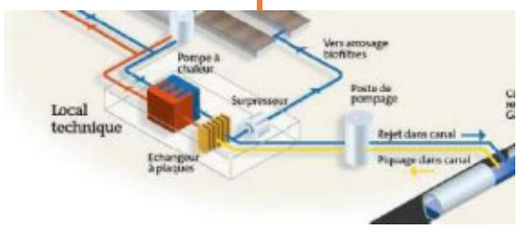
Perpignan (350,000 p.e.)
Heat pumps and biogas to gas grid





Chauffage du digesteur via PAC Energido™

- Start mid 2018
- Heat pump capacity: 400 kW
- Biogaz : up to187 Nm^3/h
- Biomethane : up to 95 Nm^3/h
- Avoided CO_2 emission: ~ 900 tonnes CO_2 eq/an

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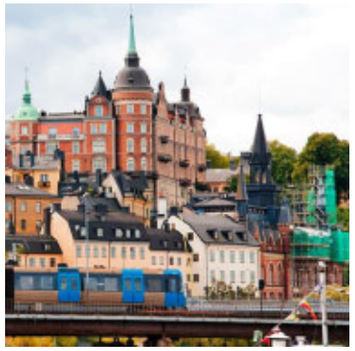
Stockholm: biogas feeds buses

Biogas bus
Public transport

External Organic Material (EOM)
- Oil/fat separator sludge 45 000 tonnes/year
- Glycerol 8 700 tonnes/year

Upgrading facility: 14 MNm^3 vehicle fuel/year
Operated by Scandinavian Biogas

Wastewater
Bromma WWTP 294 000 PE
Henriksdal WWTP 950 000 PE

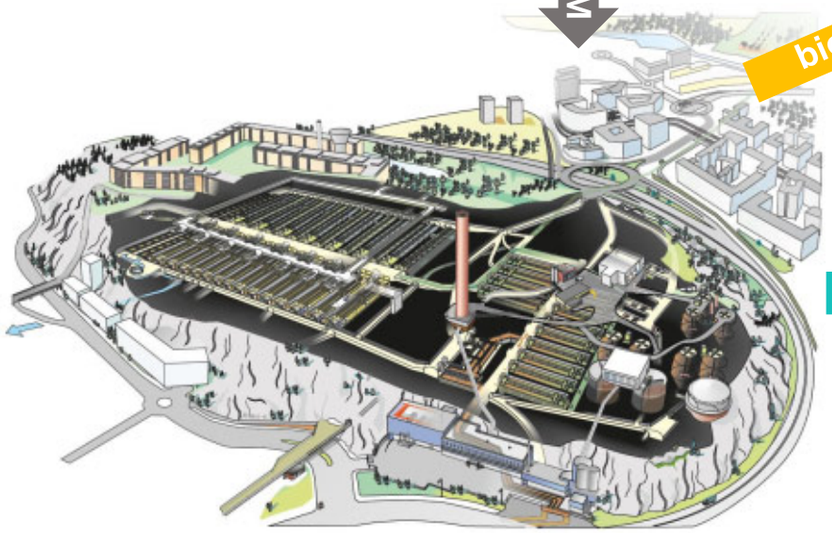


EOM

biogas

vehicle fuel

ww



treated ww

heat

heat

Henriksdal and Bromma WWTP: 22 MNm^3 biogas/year
Biogas production (60% CH4) since 1934 from digestion of WW-sludge and co-digestion of EOM (only at Henriksdal)

Hammarbyverket/Solnaverket: ~1,3 TWh/year
Heat recovery from WW for municipal district heating. Owned and operated by Stockholm Exergi and Norrenergi

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Bristol‘s Poo Buses (2015)

The Guardian

UK's first 'poo bus' goes into regular service

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Kakolanmäki WWTP, Turku, Finland: Energy recovery with heat pumps

Turun seudun puhdistamo Oy

www.turunseudunpuhdistamo.fi

- 300,000 p.e. WWTP underground
- Heat pumps on treated effluent (DT° 5-10°C)
- Coefficient of performance COP=~3,9
- Energy Balance 2017

Energy consumption	
Electricity	13 500 MWh
District Heating	540 MWh
Fuel	20 MWh
Total	**14 060 MWh**

Energy production	
Digestion (net)	15 500 MWh
Heat recovery ventilation	2 700 MWh
Heat pump district heating (net)	158 000 MWh
Heat pump district cooling (net)	26 600 MWh
Total	**202 800 MWh**

14 times more energy produced than needed

- Synergy wastewater / heat utilities:

  WWTP supplies 14% of Turku region district heating and all the district cooling!

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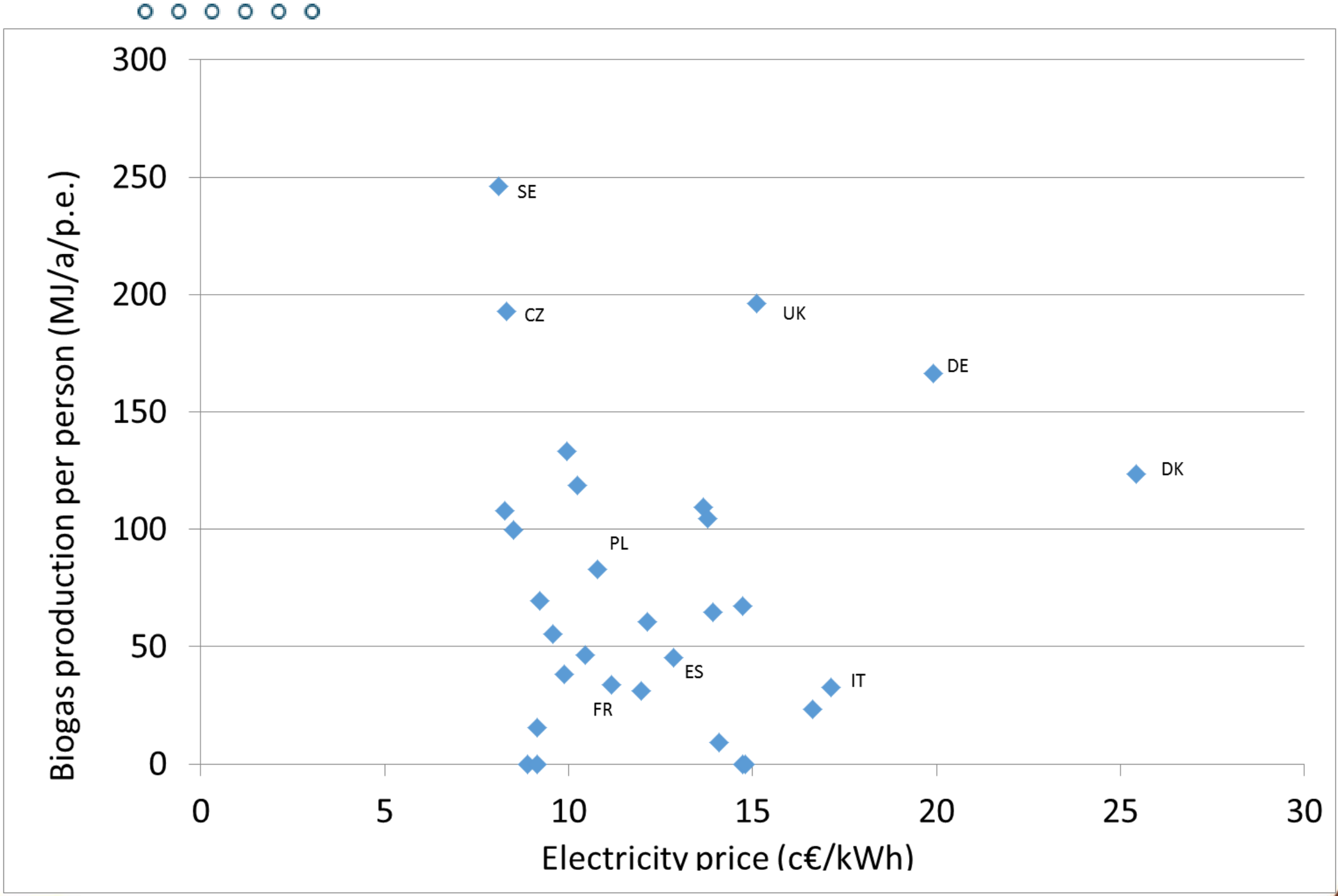
Gas yield per capita and Member State



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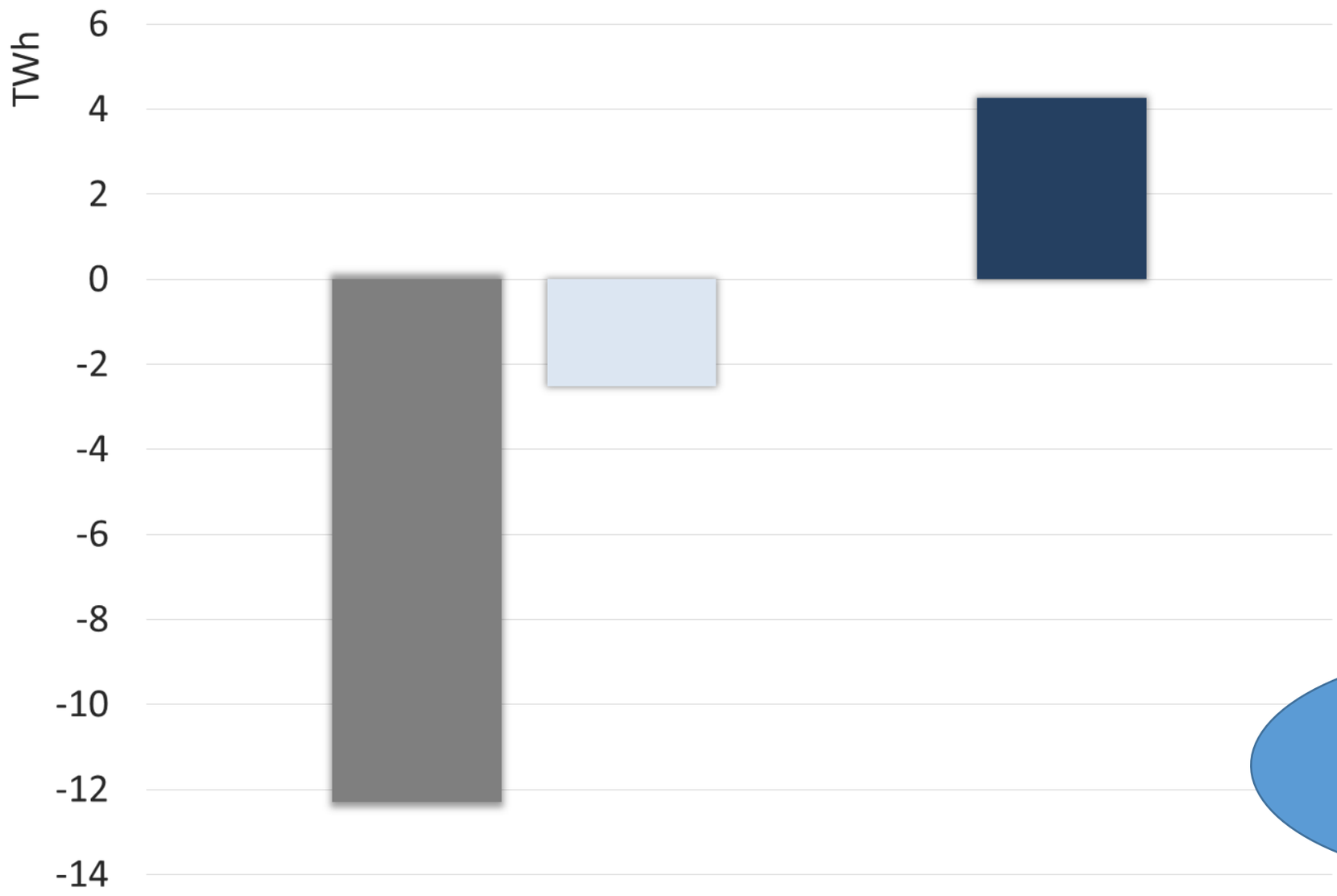
Market potential – Annual Net Electricity EU27 (WWTPs > 10,000 p.e.)

Net electricity (electricity generation – electricity demand):



Electricity production increases and electricity consumption decreases with PowerStep technologies leading to a net gain of 16 TWh/a.

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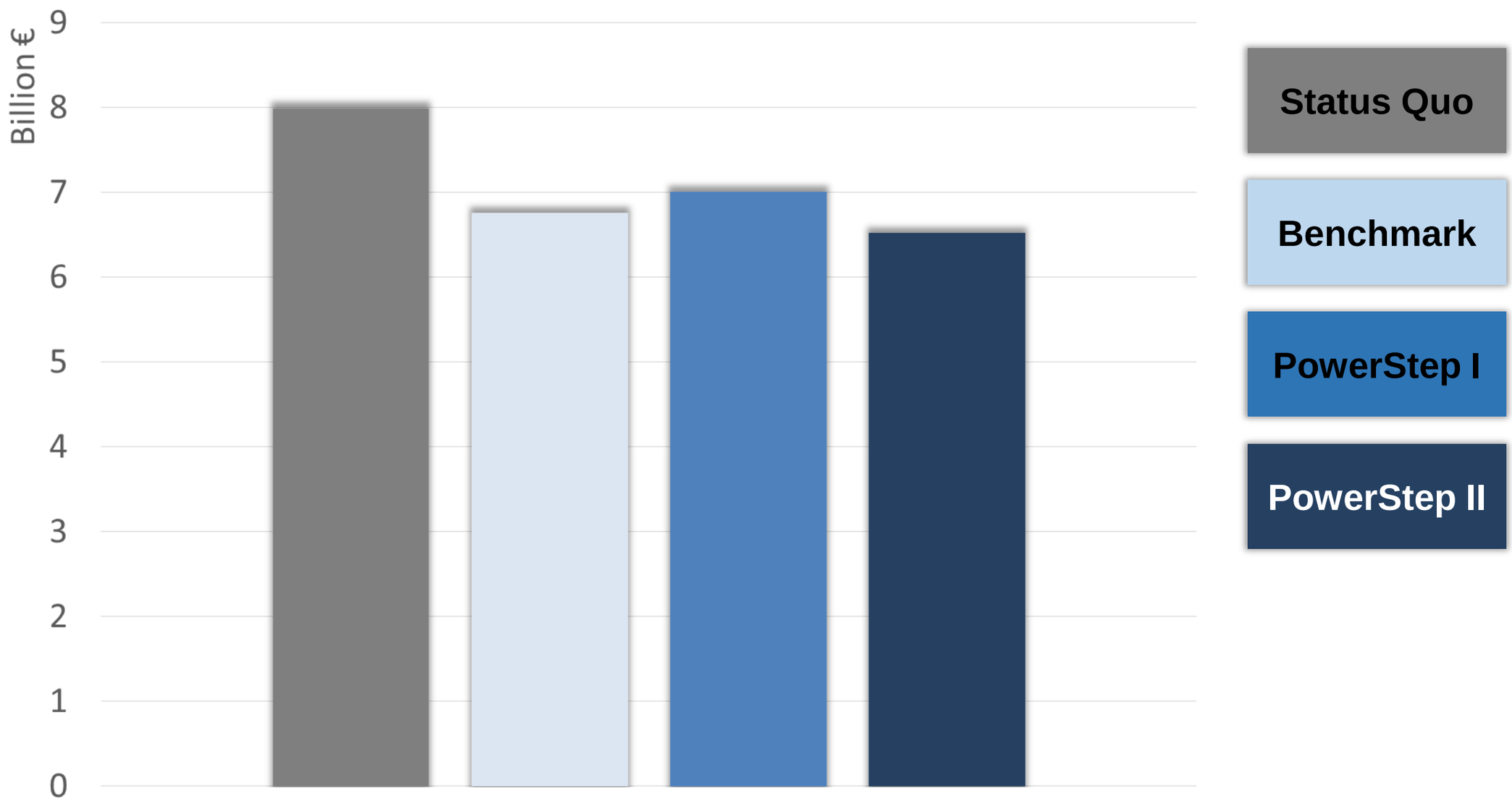
Market potential – Annual OPEX EU27 (WWTPs > 10,000 p.e.)



The OPEX of PowerStep technologies are lower than the current status quo costs (1.5 bn €/a).

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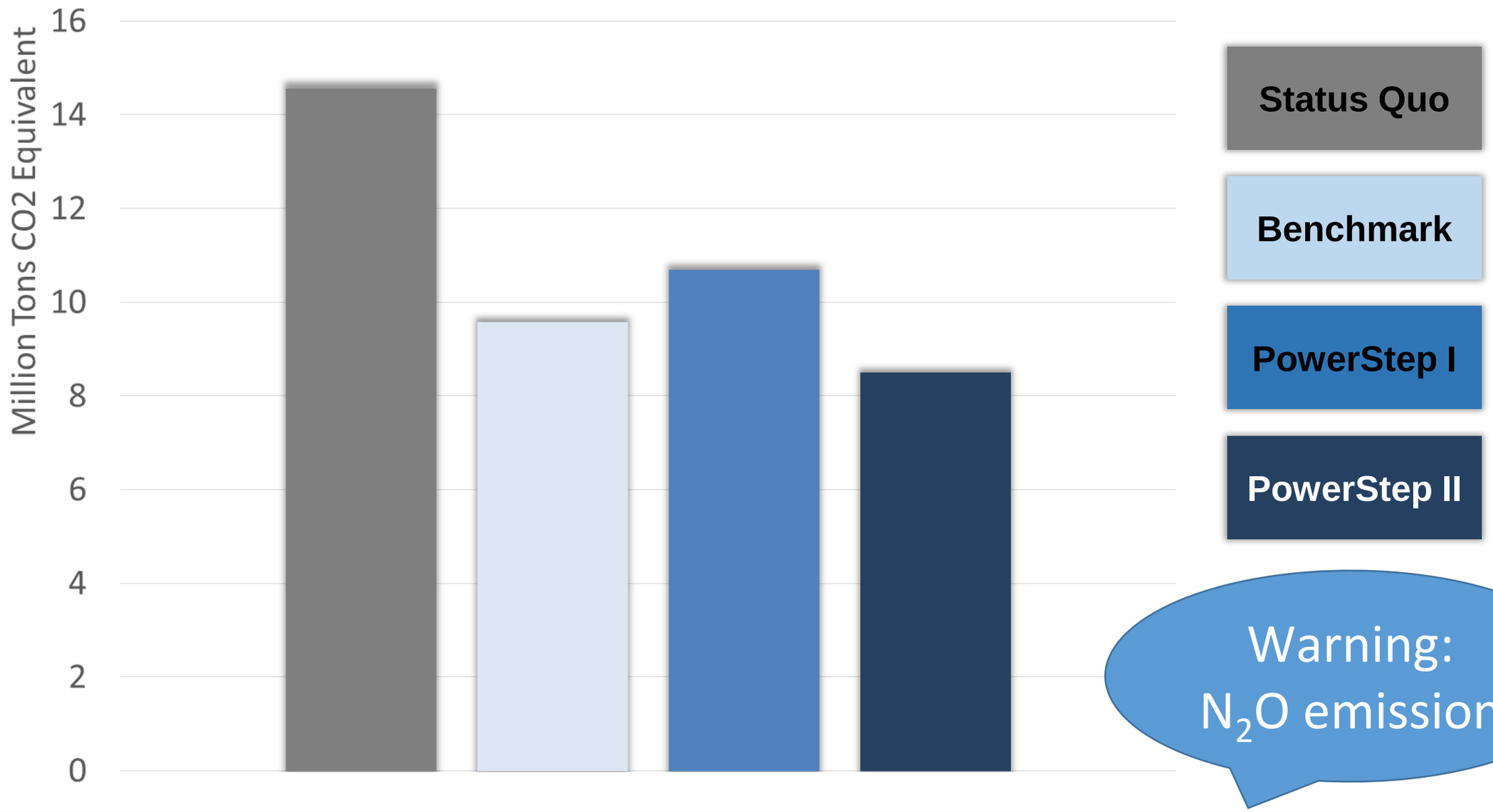
Market potential – Annual CO2-eq Emissions EU27 (WWTPs > 10,000 p.e.)



PowerStep decreases power related CO2 Emissions by up to 40%.

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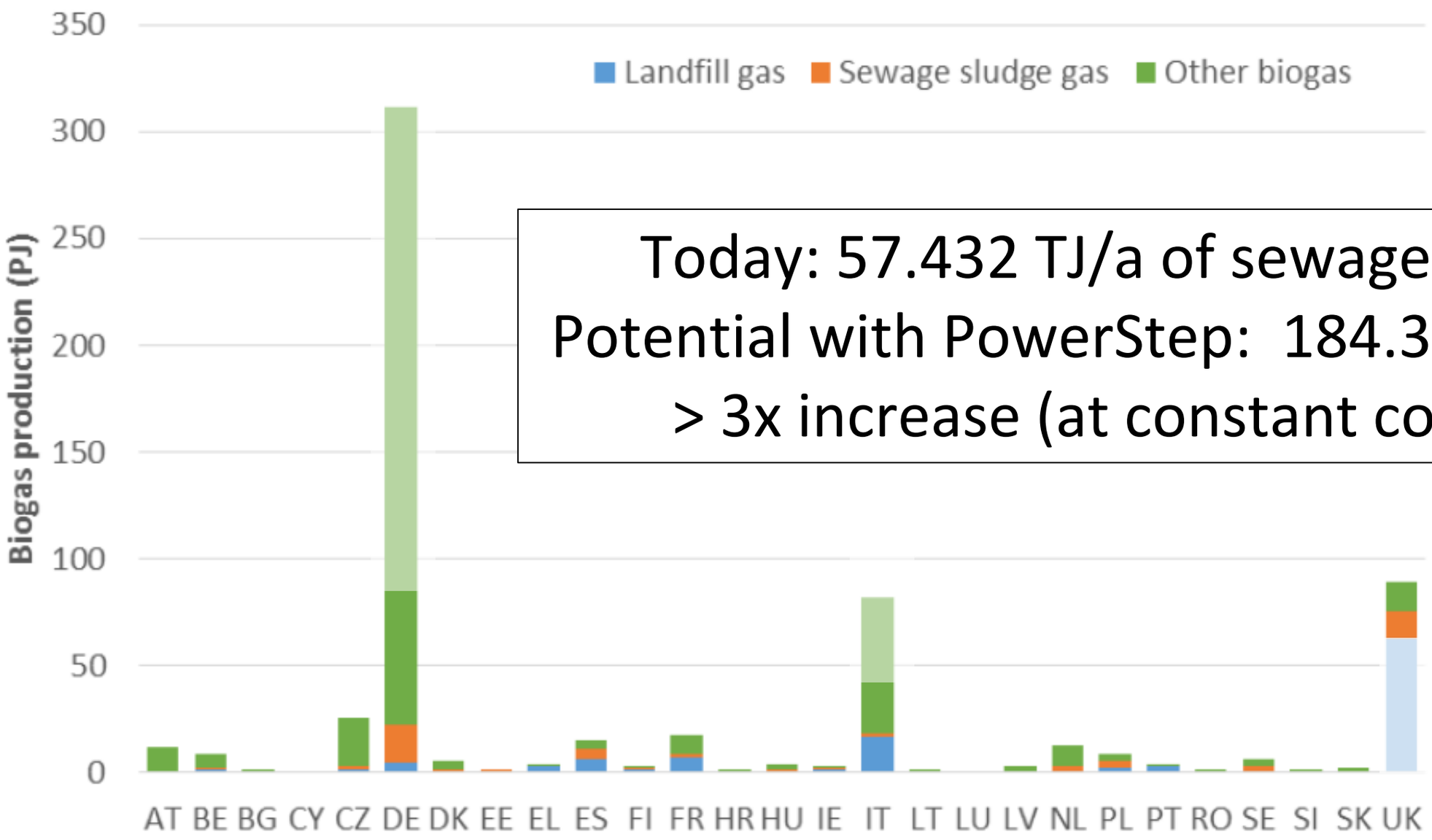
Potential of sewage biogas in EU

Figure 1 Biogas production per Member State in 2014, differentiated by source (EurObserv'ER, 2015) [1]



Today: 57.432 TJ/a of sewage gas
Potential with PowerStep: 184.325 TJ/a
> 3x increase (at constant cost)

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Take home messages

Self-sufficient WWTP is reality today!

1 **Many examples in Europe with State-of-the-Art technologies**

2 **Many concepts of energy recovery and biogas valorisation**

3 **Significant market potential and impact … no regret measure**

4 **Innovation to further push the limits and extract potential**

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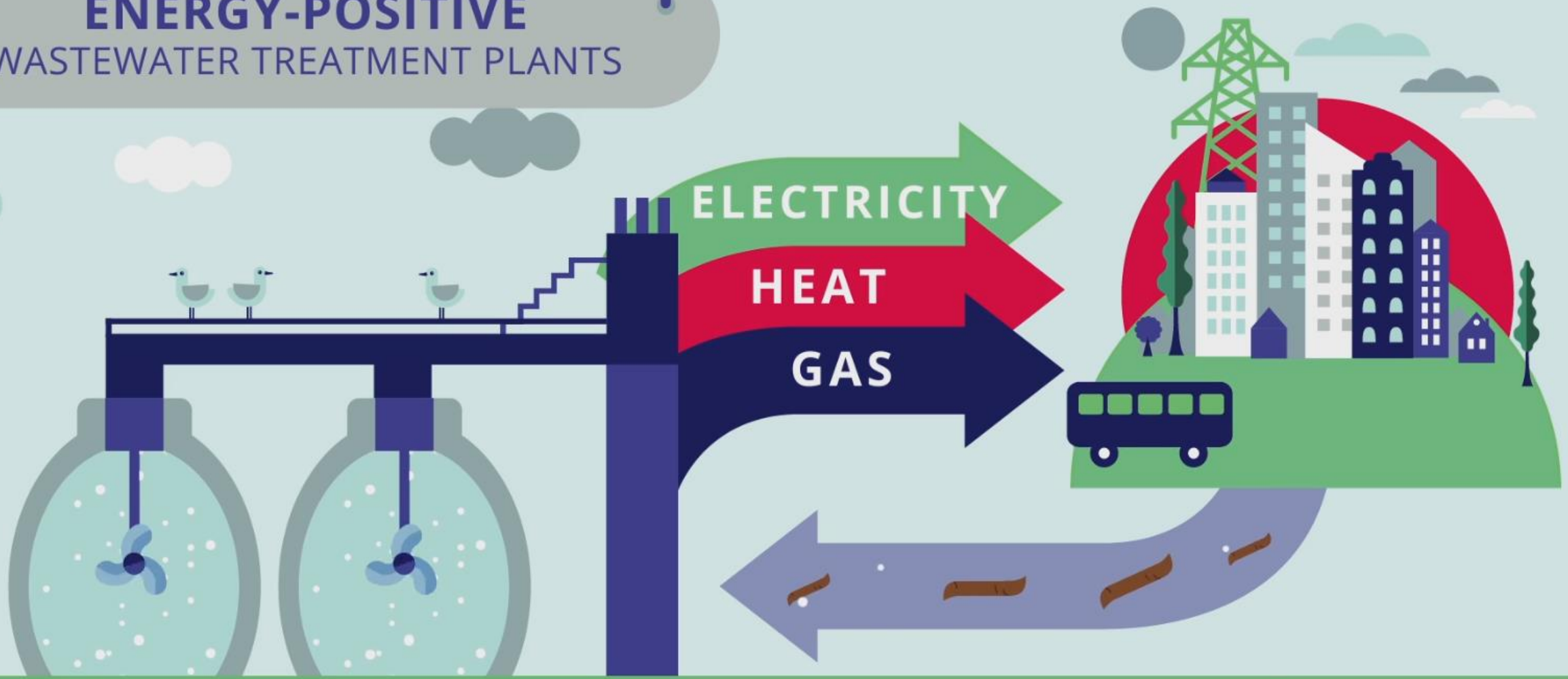
ENERGY-POSITIVE
WASTEWATER TREATMENT PLANTS



WASTEWATER HAS A GREAT ENERGY POTENTIAL!

your flush = your energy

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Credit (front runners projects)

Alphabetical order by family name

- *Sofia Andersson, Stockholm Vatten*
- *Eckhard Bomball, Zweckverband Grevesmühlen*
- *Vincent Chevalier, Veolia Eau France*
- *Cazalet Damien, Veolia Germany*
- *Célia Devinoy, Veolia Environnement SA*
- *Anders Finnson, Svenskt Vatten*
- *Mirva Levomäki, Turun seudun puhdistamo Oy*
- *Sylvie Novak, Veolia Eau France*
- *Per Overgaard Pedersen, Aarhus Vand*
- *Christian Remy, Berlin Centre of Competence for Water*
- *Christophe Sardet, Veolia Germany*
- *Risto Saarinen, Porvoon vesi*
- *Ole Steensberg Øgelund, vand og affald*
- *Dines Thornberg, BioFos*

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PowerStep partners that supplied slides to the presentation

- **Christian Loderer, KompetenzZentrum Wasser Berlin (project coordinator)**
- **Christian Remy, KompetenzZentrum Wasser Berlin**

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