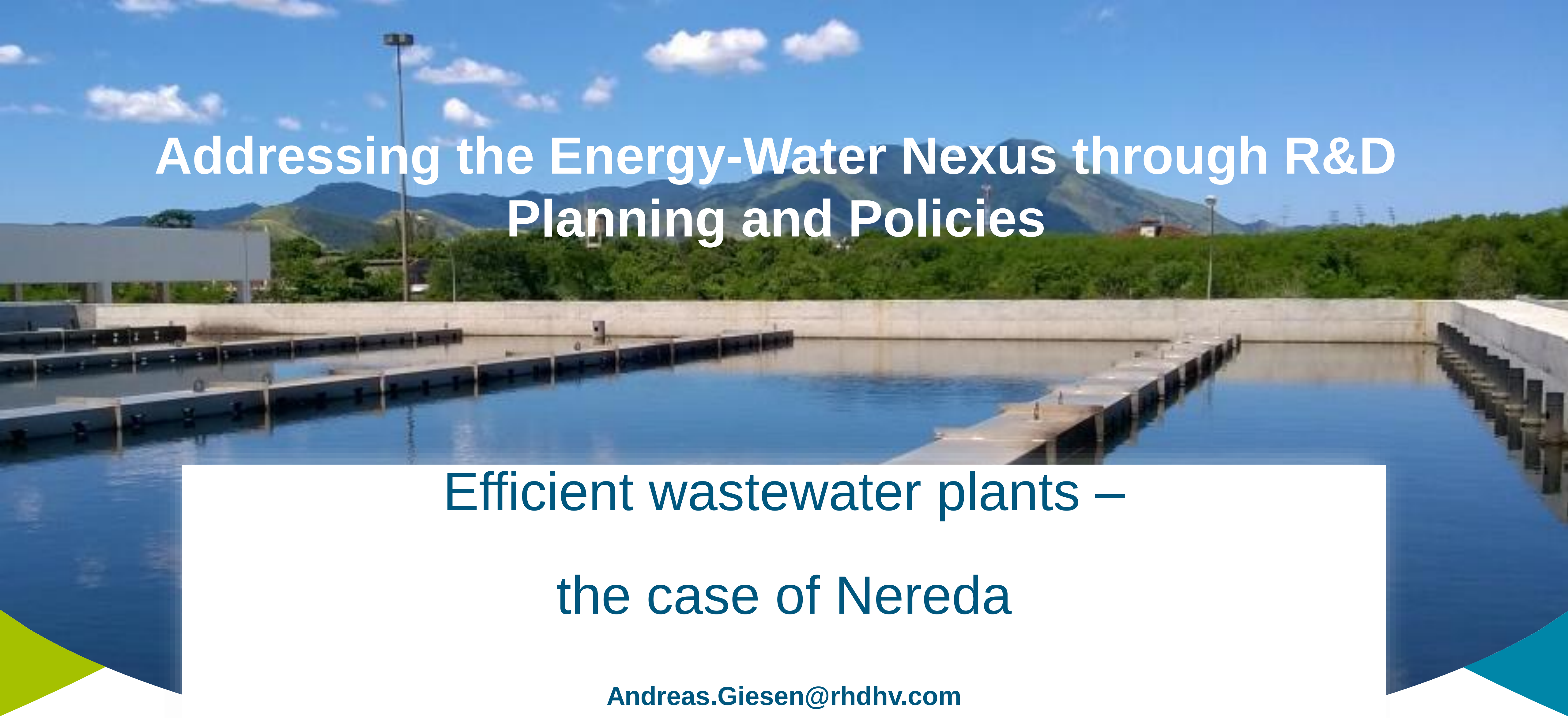


Addressing the Energy-Water Nexus through R&D Planning and Policies

Efficient wastewater plants –

the case of Nereda

Andreas.Giesen@rhdhv.com

29 May 2018

Royal HaskoningDHV
Enhancing Society Together

Consultancy, Engineering & Project Management

Royal HaskoningDHV
Enhancing Society Together

Workforce of **6,500** in more than **150** countries

One of the **top independently owned** engineering companies

Our Organisation

Aviation

Buildings

Energy

Industry

Infrastructure

Maritime

Mining

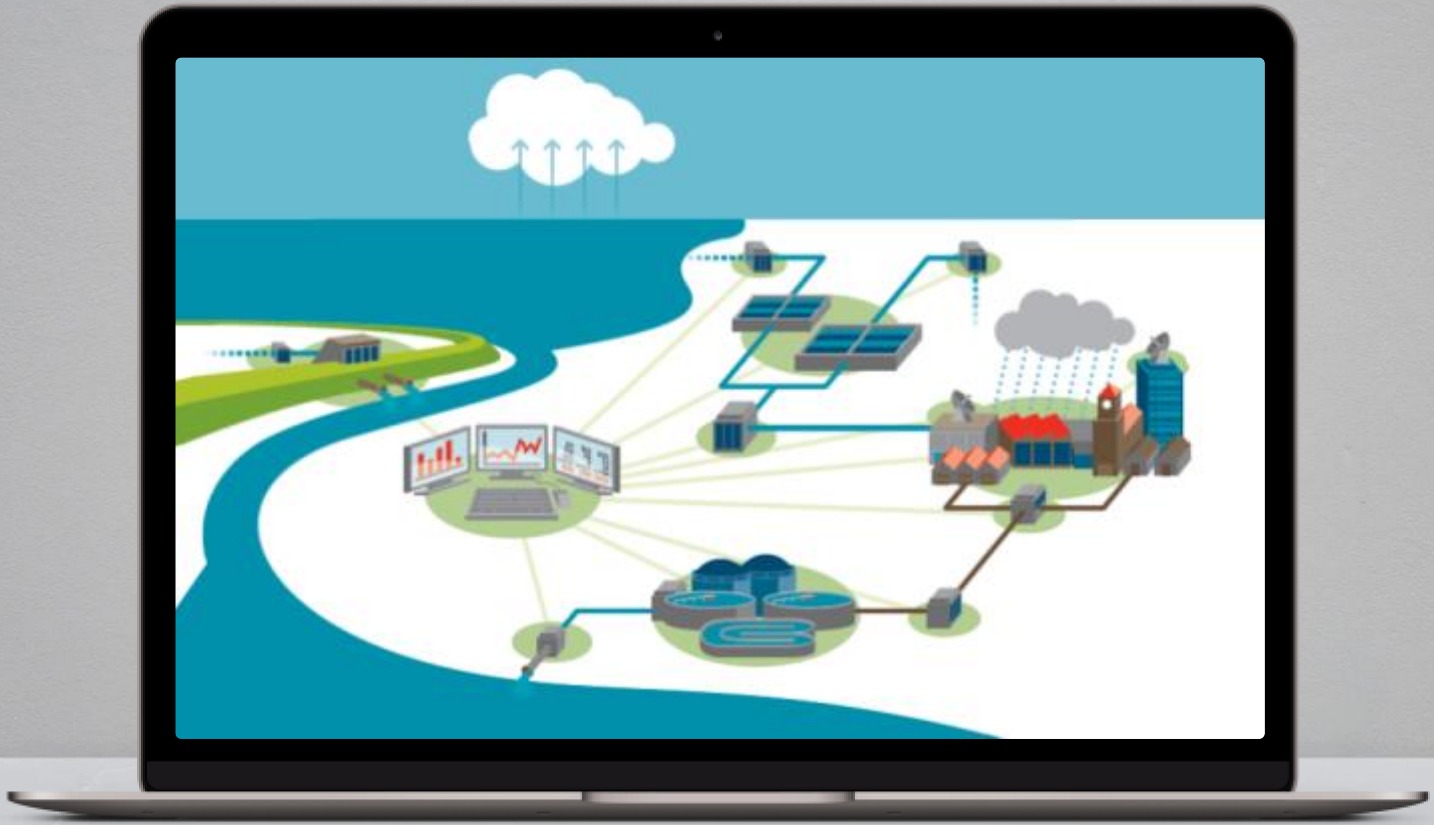
Rural Development

Urban Development

Water

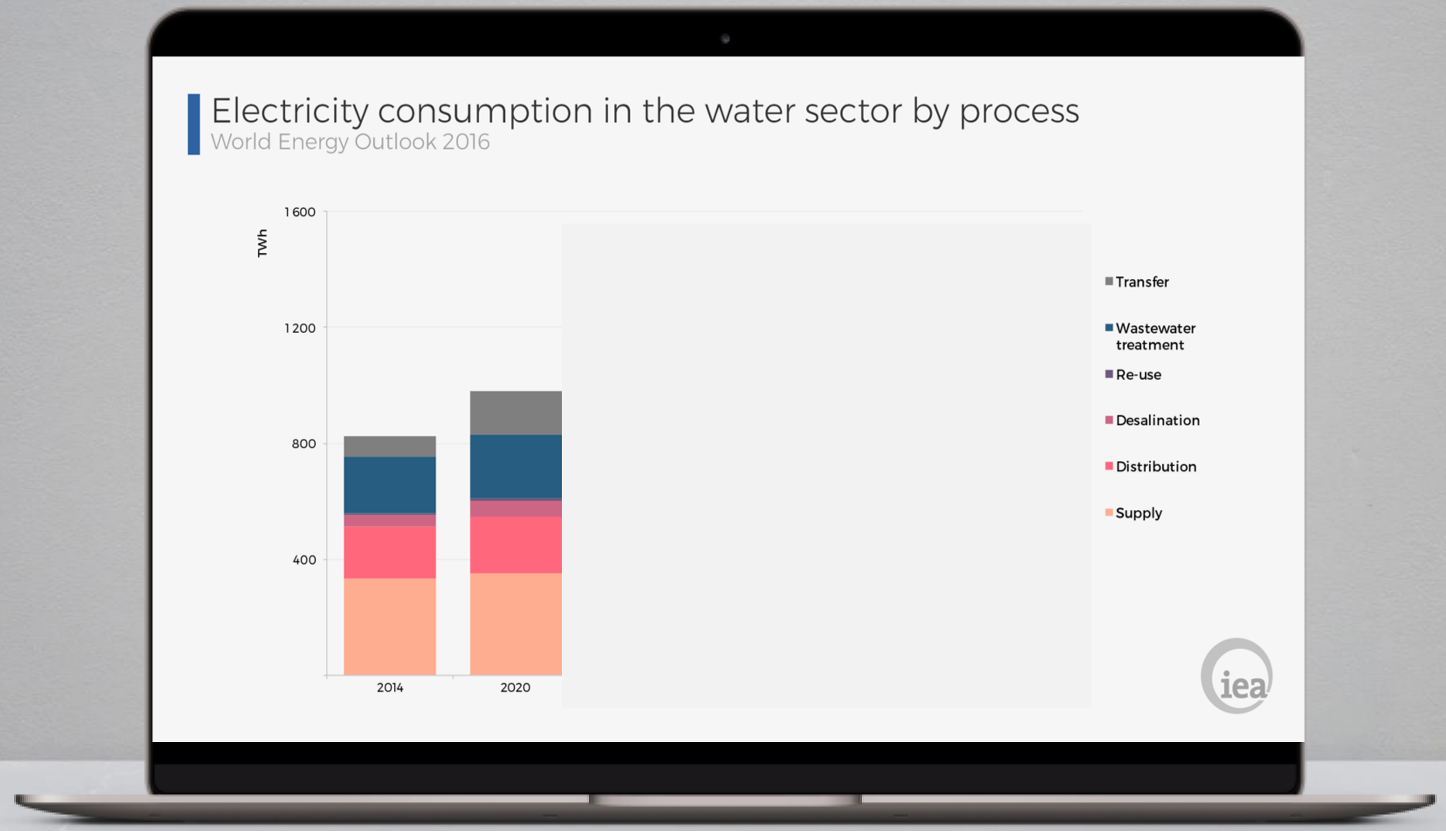
Covering the whole water cycle

Energy consumption urban water cycle

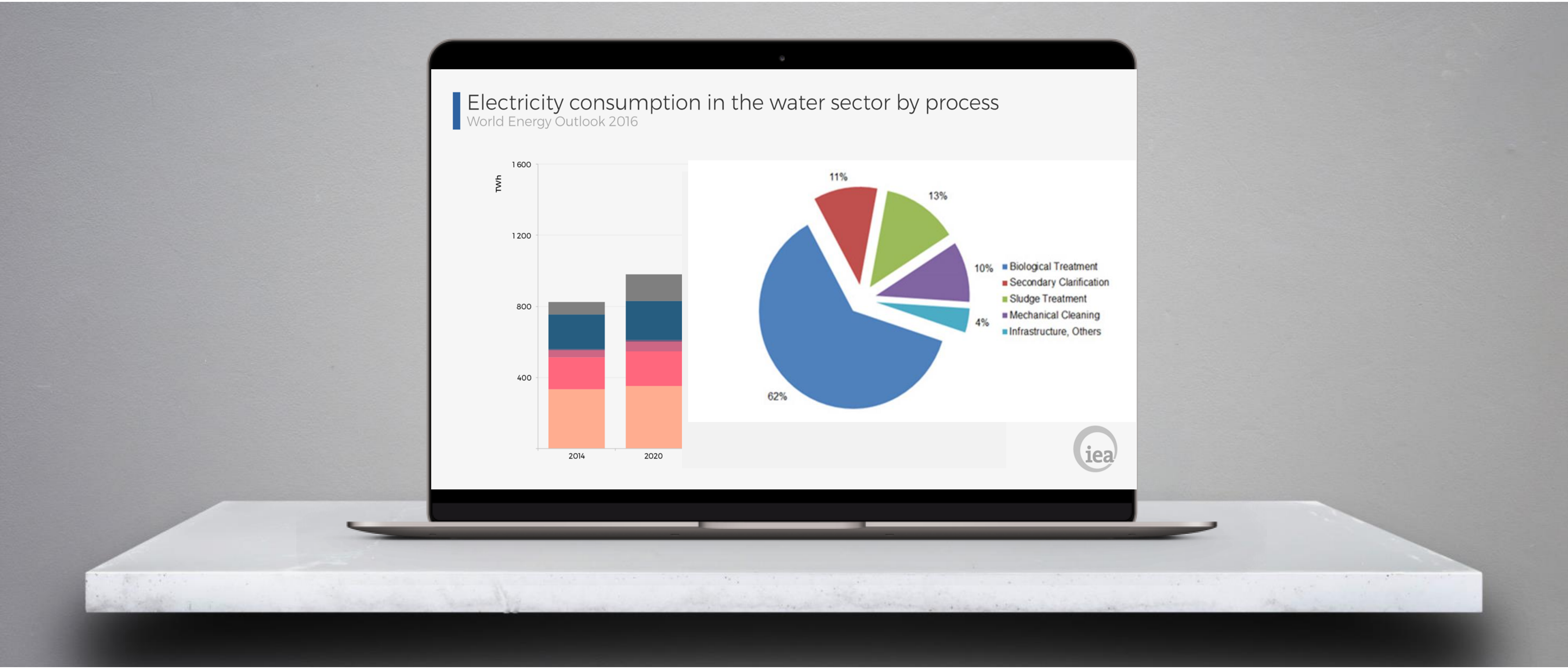


Order of magnitude: 1 – 5% of EU national energy consumption

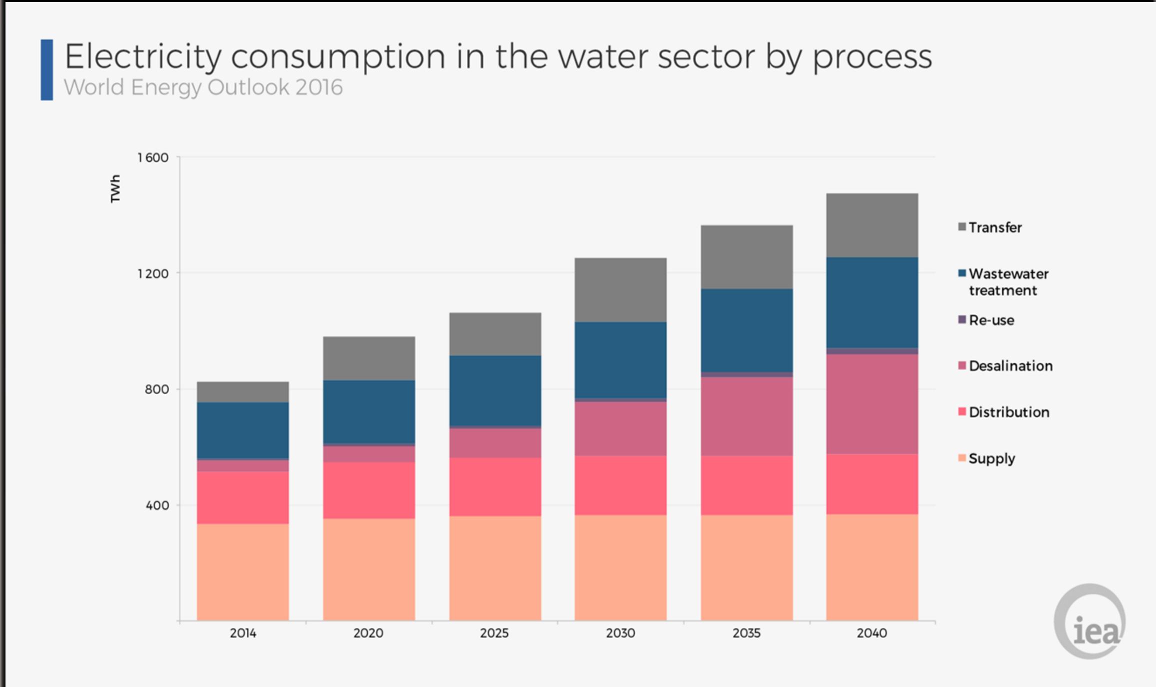
Significant part for wastewater treatment



And major part for biological treatment



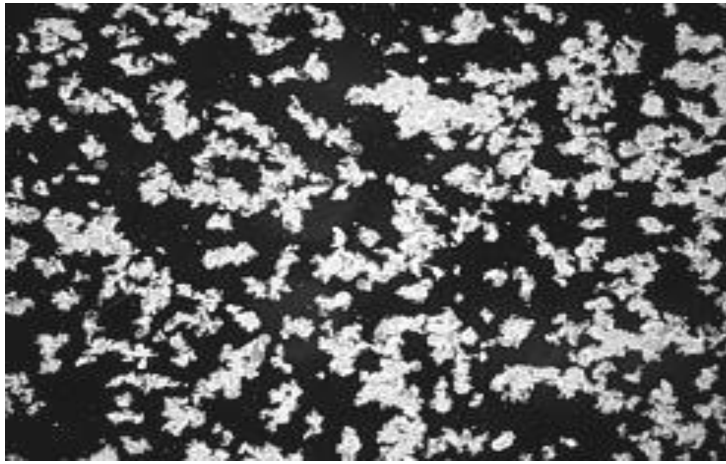
Growing consumption

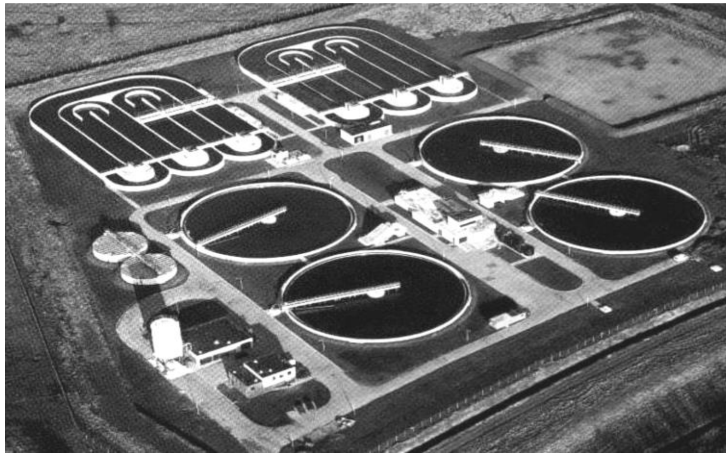


Increase in desalination and sanitation

Conventional wastewater treatment

- Activated sludge state of art since 1914
- Good effluent quality
- Poor sludge settling quality
- Low biomass concentrations
- Significant footprint
- High energy consumption
- Often high chemical consumption
- Excess activated sludge can be digested to reduce waste and improve energy efficiency of treatment
- Current aim: energy neutrality….but sofar mainly achieved by “importing organic waste” into the “wastewater plant” digester





Wastewater treatment with Nereda®

- Natural way of treating wastewater using aerobic granular sludge with excellent settling properties

GRANULES

8 g/l or more
$SVI_5 \approx SVI_{30}$

FLOCS

4 g/l
$SVI_5 > SVI_{30}$

Due to excellent settling properties

GRANULES

8 g/l or more
$SVI_5 \approx SVI_{30}$

Compact ------------------------> lower CAPEX

Easy to operate ---------------> lower OPEX

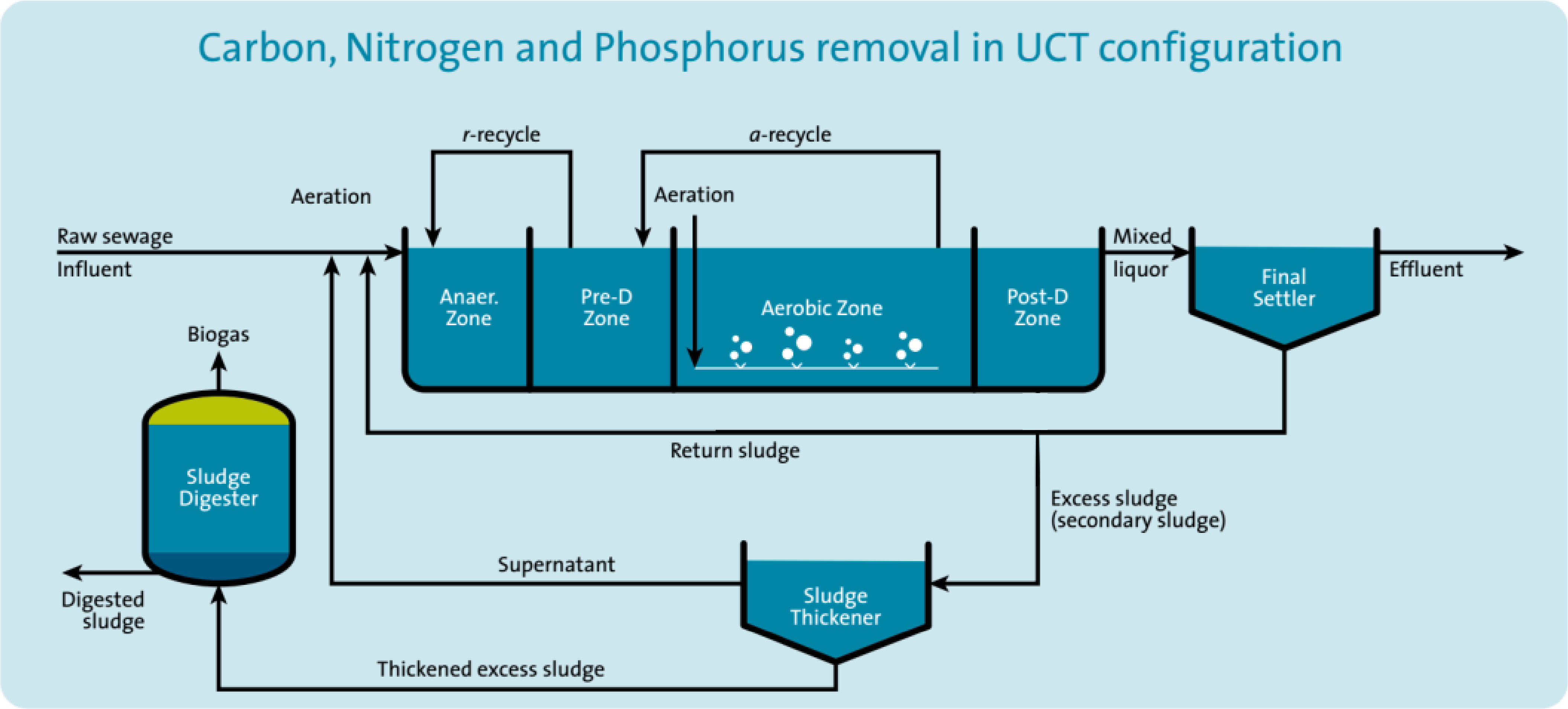
Sustainable ----------------------> lower energy/chemical consumption

FLOCS

4 g/l
$SVI_5 > SVI_{30}$

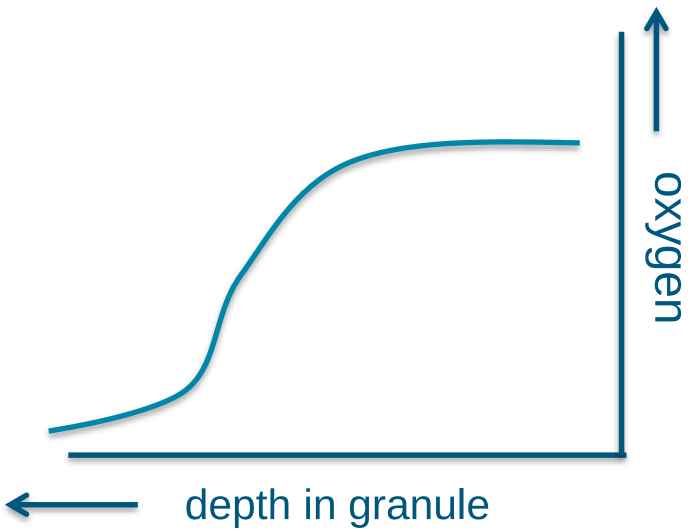
Conventional Activated Sludge Process

Biological nutrient removal in activated sludge requires many compartments and circulation flows



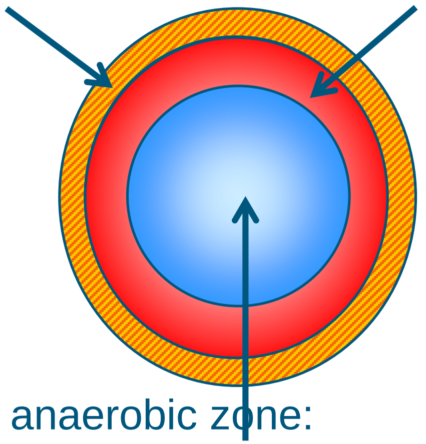
Nereda® granule – BNR in the granules

Oxygen gradient in granule
Simultaneous removal of COD, P and N
Transport by diffusion, not by pumping



Aerobic zone:
- Heterotrophic organisms
- COD oxidation

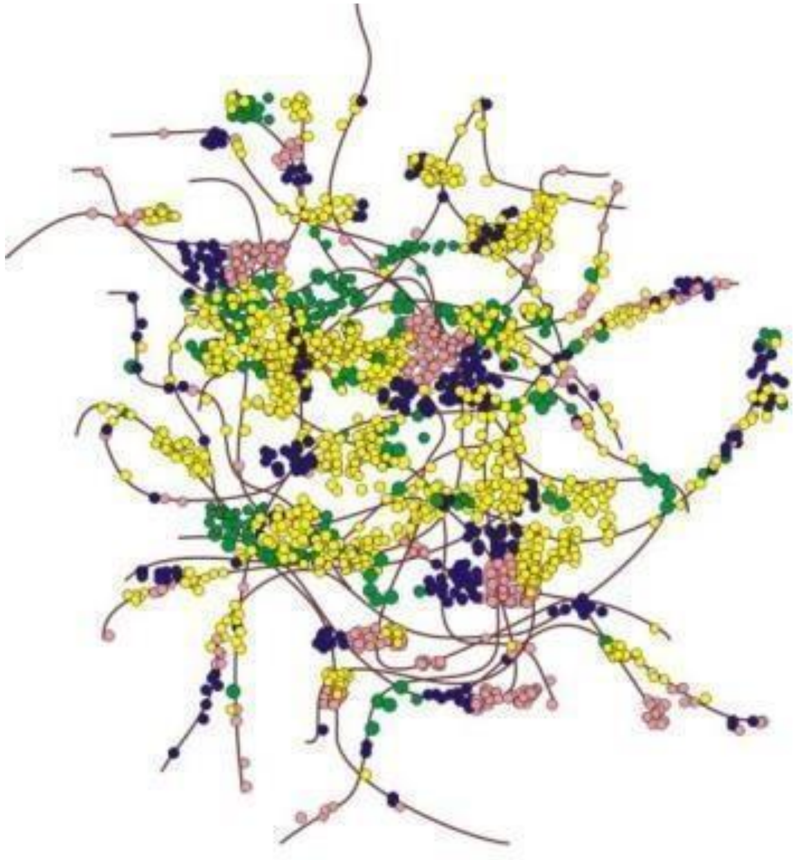
Aerobic zone:
- Autotrophic organisms
- Ammonia oxidation to nitrate



Anoxic / anaerobic zone:
- Nitrate reduction to nitrogen gas
- Phosphate release and uptake

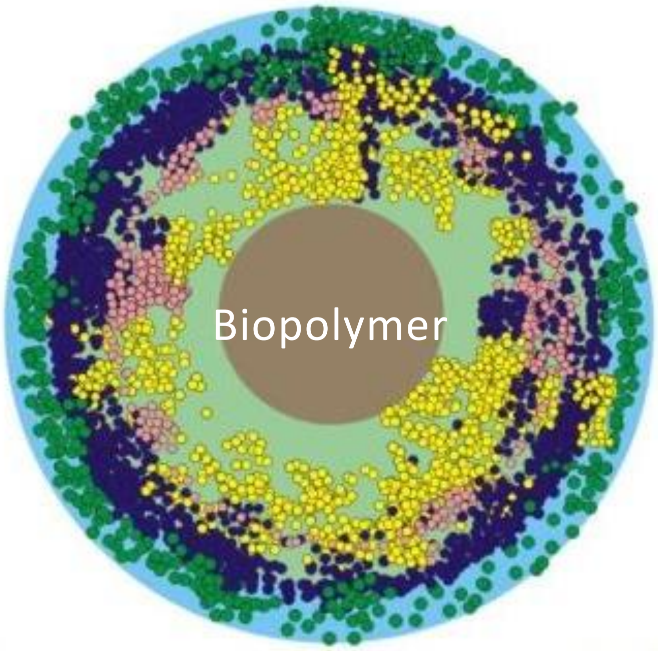
Micro-organismen in the granule

Activated sludge



Aerobic granular biomass

Anaerobic
Anoxic
Aerobic

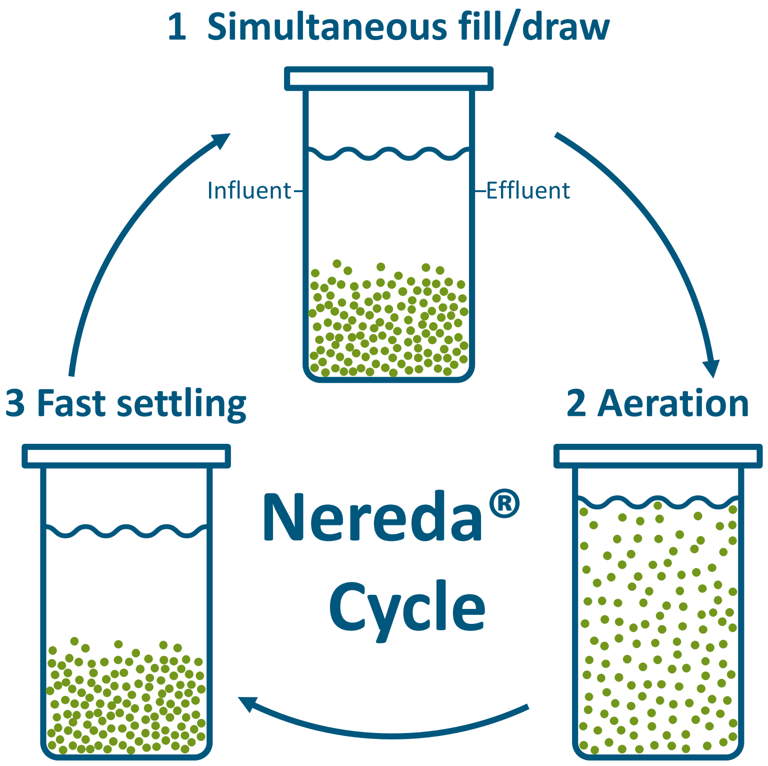


- Nitrifiers
- Denitrifiers
- Phosphate Accumulating Organisms (PAO's)
- Glycogen Accumulating Organisms (GAO's)

Courtesy Delft University of Technology

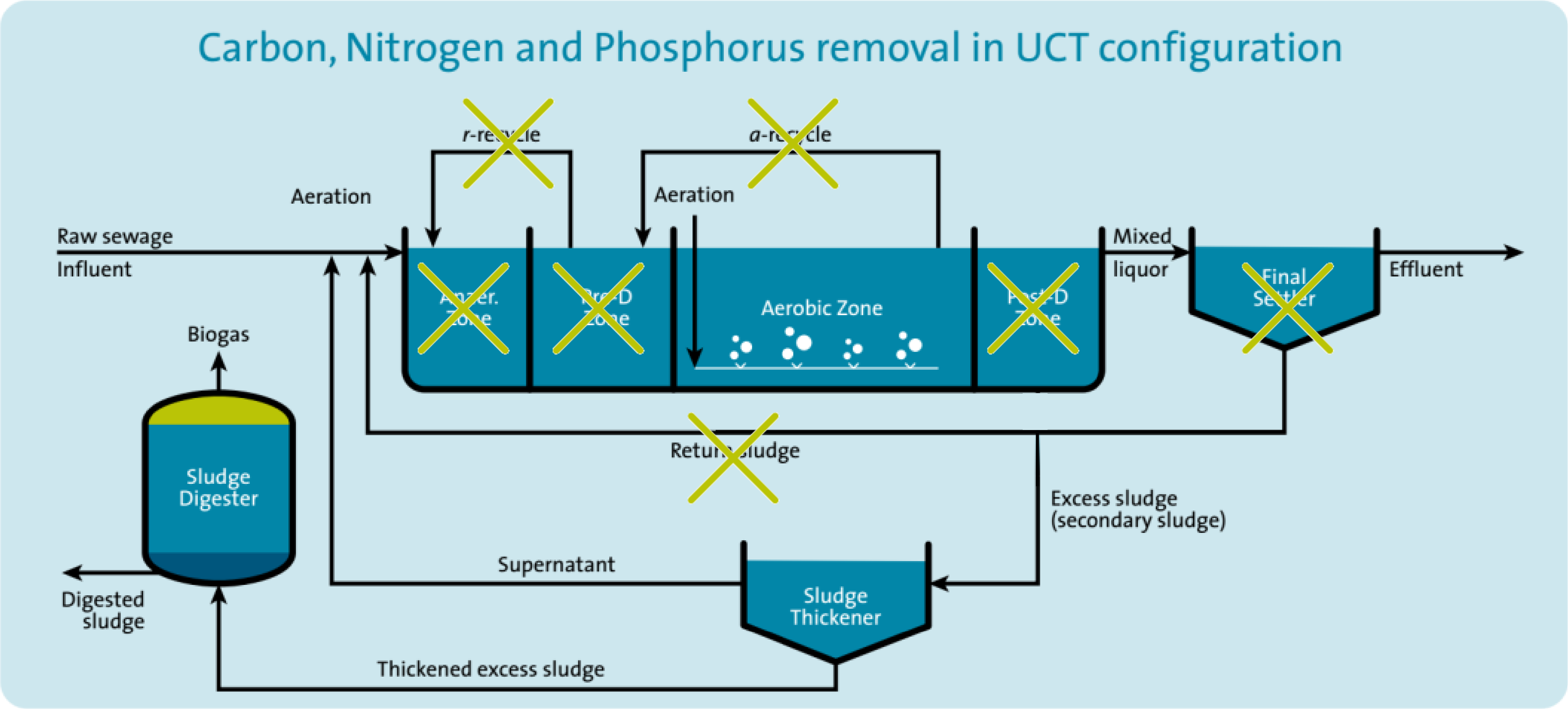
Nereda® process cycle

- Simple one-tank concept
- No clarifiers
- No moving decanter
- No mixers
- Extensive biological COD, N- and P-removal
- Low energy consumption
- Easy operation
- Low totex



Nereda® compared to Conventional

Biological nutrient removal in activated sludge requires many compartments and circulation flows



Energy efficiency example

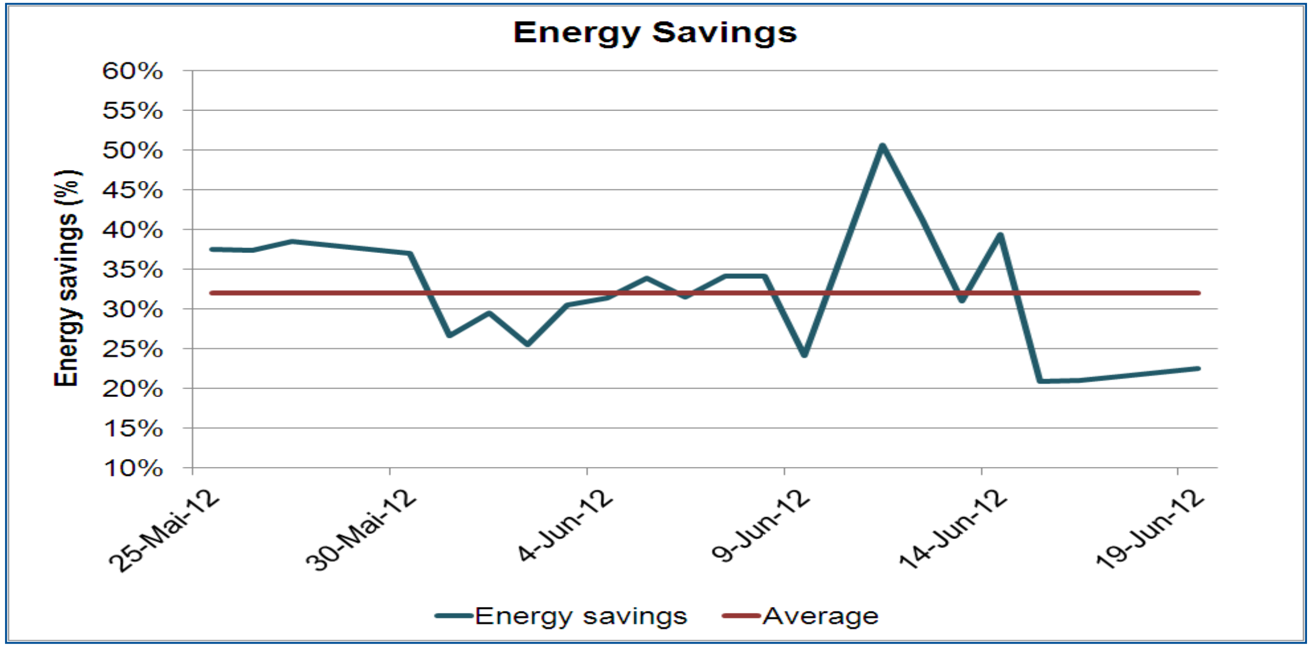
Municipal wastewater | full BNR | 100,000 pe

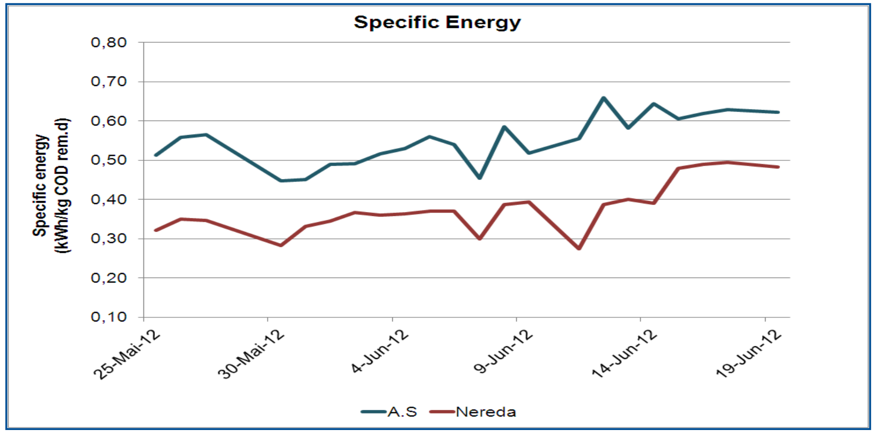
Equipment	CAS		NEREDA	
	kWh/d	%	kWh/d	%
Influent pumping station	150	3%	262	10%
Screening & Sand Removal	73	1%	73	3%
Biological reactor	4.972	86%	1.798	67%
mixers anaerobic section	192	3%		
mixers predenitrifiation	318	5%		
internal circulation for BNR	648	11%		
propulsors aerobic section	848	15%		
aeration	2.534	44%	1.798	67%
final settling tanks	60	1%		
sludge return pumping station	372	6%		
Other equipment	338	6%	348	13%
Cable and frequency converter losses	266	5%	189	7%
TOTAL ENERGY CONSUMPTION	**5.799**	**100%**	**2.670**	**46%**

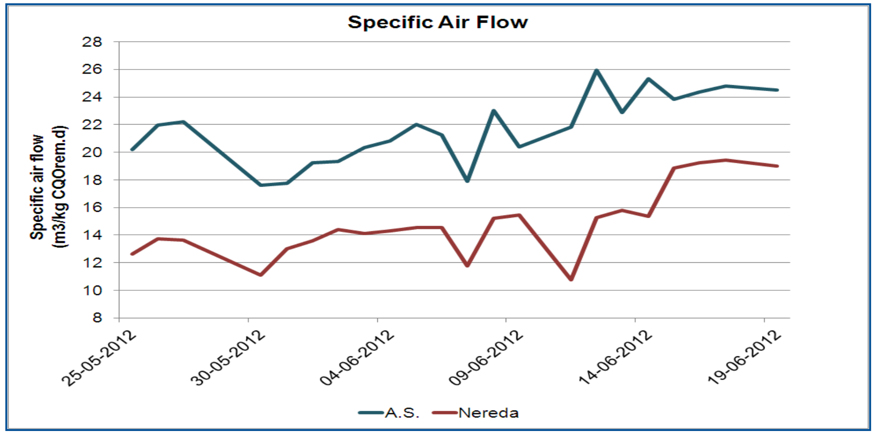
Note that is an example based on a specific plant in Dutch climate achieving full BNR and that energy consumption for both technologies depends on wastewater characteristics, targeted effluent quality, design and equipment selection.

Aeration efficiency Nereda® vs CAS

@ETAR Frielas, Portugal







- Approx. 30% less aeration than parallel operated CAS.
- Up to 50% less energy considering also savings on settler and recirculation pumps

Advantages

SMALL FOOTPRINT
Up to a factor 4 smaller

SUSTAINABLE
30-50% energy savings
No/minimal chemicals

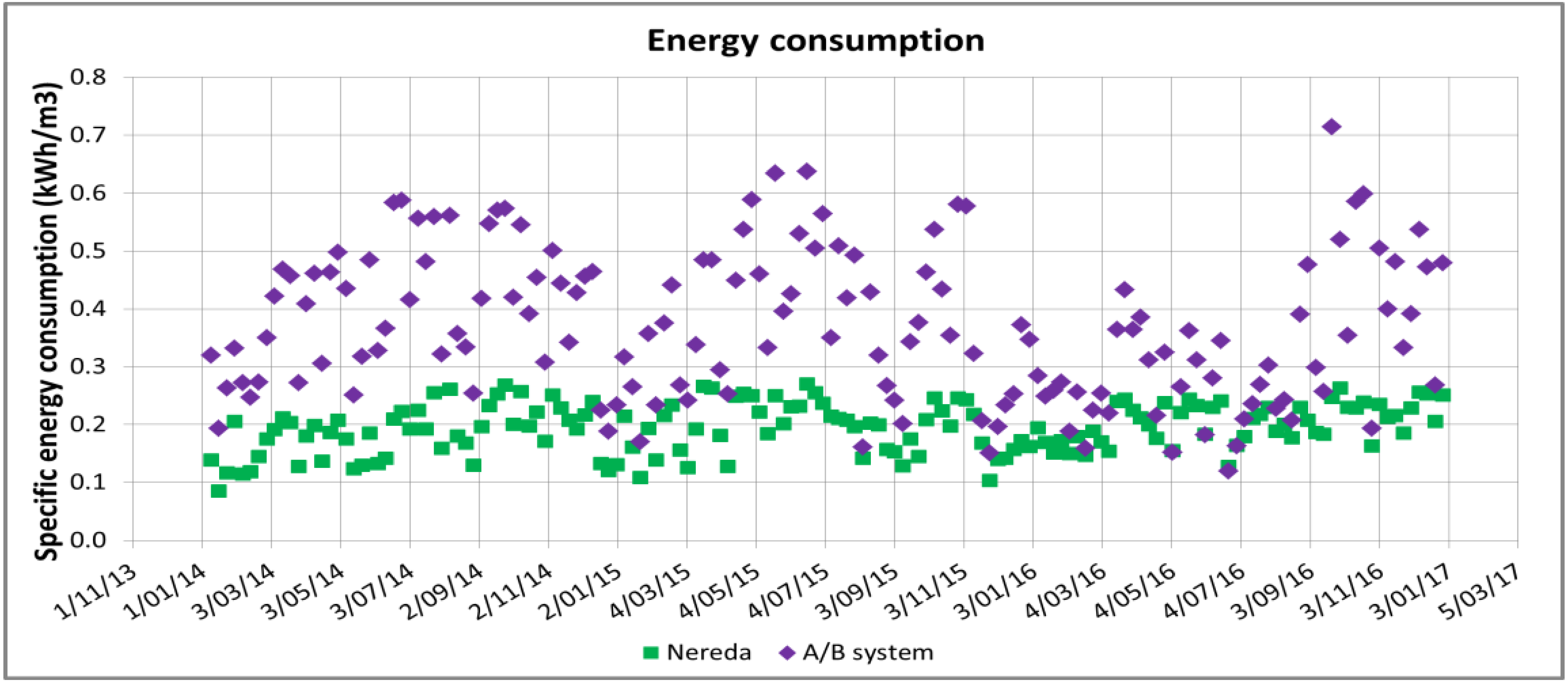
EXCELLENT EFFLUENT QUALITY
Including biological nutrient removal N/P

COST EFFECTIVE
Lower CAPEX & OPEX

EASY TO OPERATE
Automated & robust

Footprint Nereda® Garmerwolde

Energy – Garmerwolde



History & current status

Aerobic Granular Biomass Technology

Scientific inspiration and transpiration

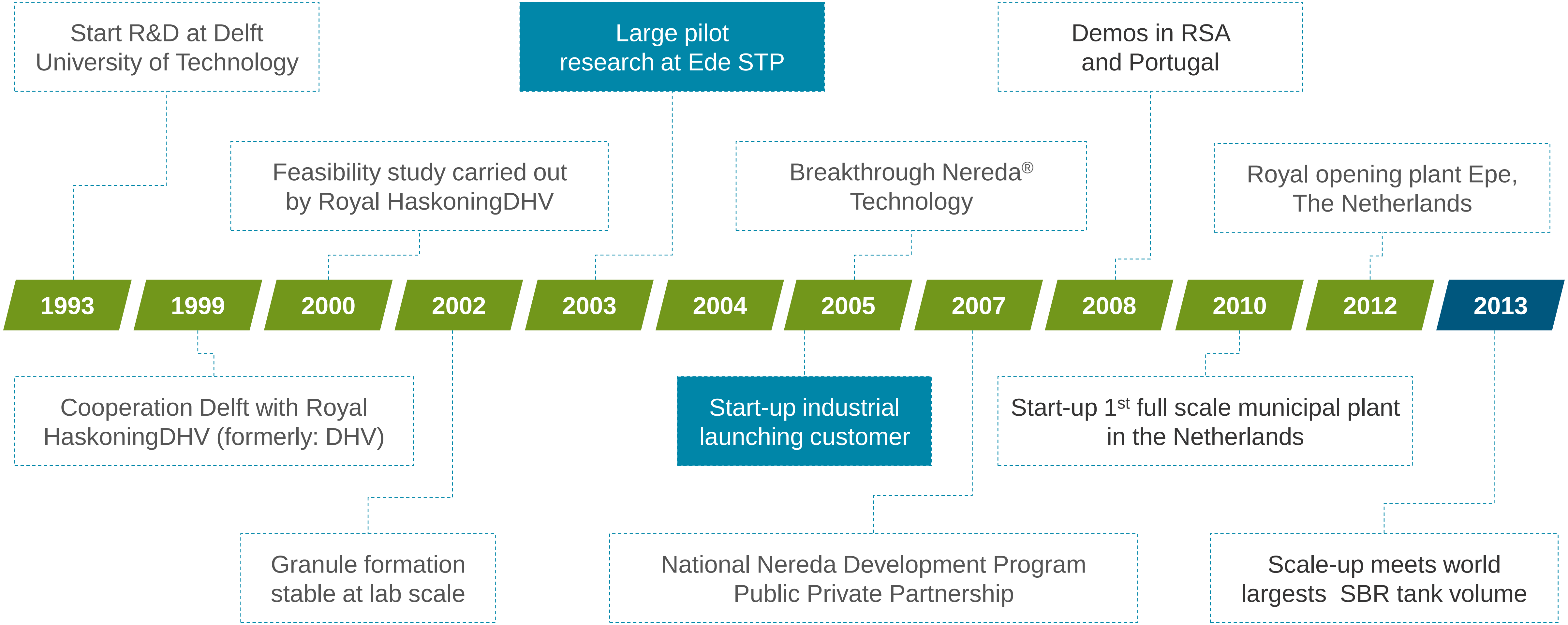
- It all started with a good discussion and collaboration between two professors at an October Fest in the 90s

Prof. Peter Wilderer
TU Munich

Prof. Mark van Loosdrecht
TU Delft

History and development

- From lab scale experiments to full scale application



From municipal pilot to industrial applications

- Prototype
- Scale-up
- Learn and create confidence

History and development

- From lab scale experiments to full scale application

1993	Start R&D at Delft University of Technology
1999	Cooperation Delft with Royal HaskoningDHV (formerly: DHV)
2000	Feasibility study carried out by Royal HaskoningDHV
2002	Granule formation stable at lab scale
2003	Large pilot research at Ede STP
2004	
2005	Breakthrough Nereda® Technology
2005	Start-up industrial launching customer
2007	National Nereda Development Program Public Private Partnership
2008	Demos in RSA and Portugal
2010	Start-up 1st full scale municipal plant in the Netherlands
2012	Royal opening plant Epe, The Netherlands
2013	Scale-up meets world largests SBR tank volume

Nereda® Frielas – Lisbon – Portugal

CLIENT

Agua de Portugal – Simtejo

WASTEWATER TYPE

Municipal & Industrial

CAPACITY

12,000 m^3/day | 44,000 p.e.

PEAK FLOW

1,850 m^3/hour

Nereda® Gansbaai – South Africa

CLIENT

Overstrand Municipality

WASTEWATER TYPE

Municipal

CAPACITY

5,000 m^3/day | 63,000 p.e.

PEAK FLOW

400 m^3/hour

PRE-TREATMENT

Screening and sand & grit removal

POST TREATMENT

Water reuse pond, reed bed infiltration

History and development

- From lab scale experiments to full scale application

Start R&D at Delft University of Technology

Large pilot research at Ede STP

Demos in RSA and Portugal

Feasibility study carried out by Royal HaskoningDHV

Breakthrough Nereda® Technology

Royal opening plant Epe, The Netherlands

1993 | 1999 | 2000 | 2002 | 2003 | 2004 | 2005 | 2007 | 2008 | 2010 | 2012 | 2013

Cooperation Delft with Royal HaskoningDHV (formerly: DHV)

Start-up industrial launching customer

Start-up 1st full scale municipal plant in the Netherlands

Granule formation stable at lab scale

National Nereda Development Program Public Private Partnership

Scale-up meets world largests SBR tank volume

Nereda® Epe – The Netherlands 2011

CLIENT

Water Authority Veluwe

WASTEWATER TYPE

Municipal & Industrial

CAPACITY

8,000 m^3/day │ 41,000 p.e. (inclusive 13,750 p.e. from industrial discharges)

PEAK FLOW

1,500 m^3/hour

PRE & POST TREATMENT

screening, sand trap and oil & grease removal (slaughterhouse emissions) & sand filtration

History and developme

- From lab scale experiments to full scale

Start R&D at Delft University of Technology

resea

RSA
gal

Feasibility study carried out by Royal HaskoningDHV

Royal opening plant Epe, The Netherlands

1993 | 1999 | 2000 | 2002 | 2003 | 2004 | 2005 | 2007 | 2008 | 2010 | 2012 | 2013

Cooperation Delft with Royal HaskoningDHV (formerly: DHV)

Start-up industrial launching customer

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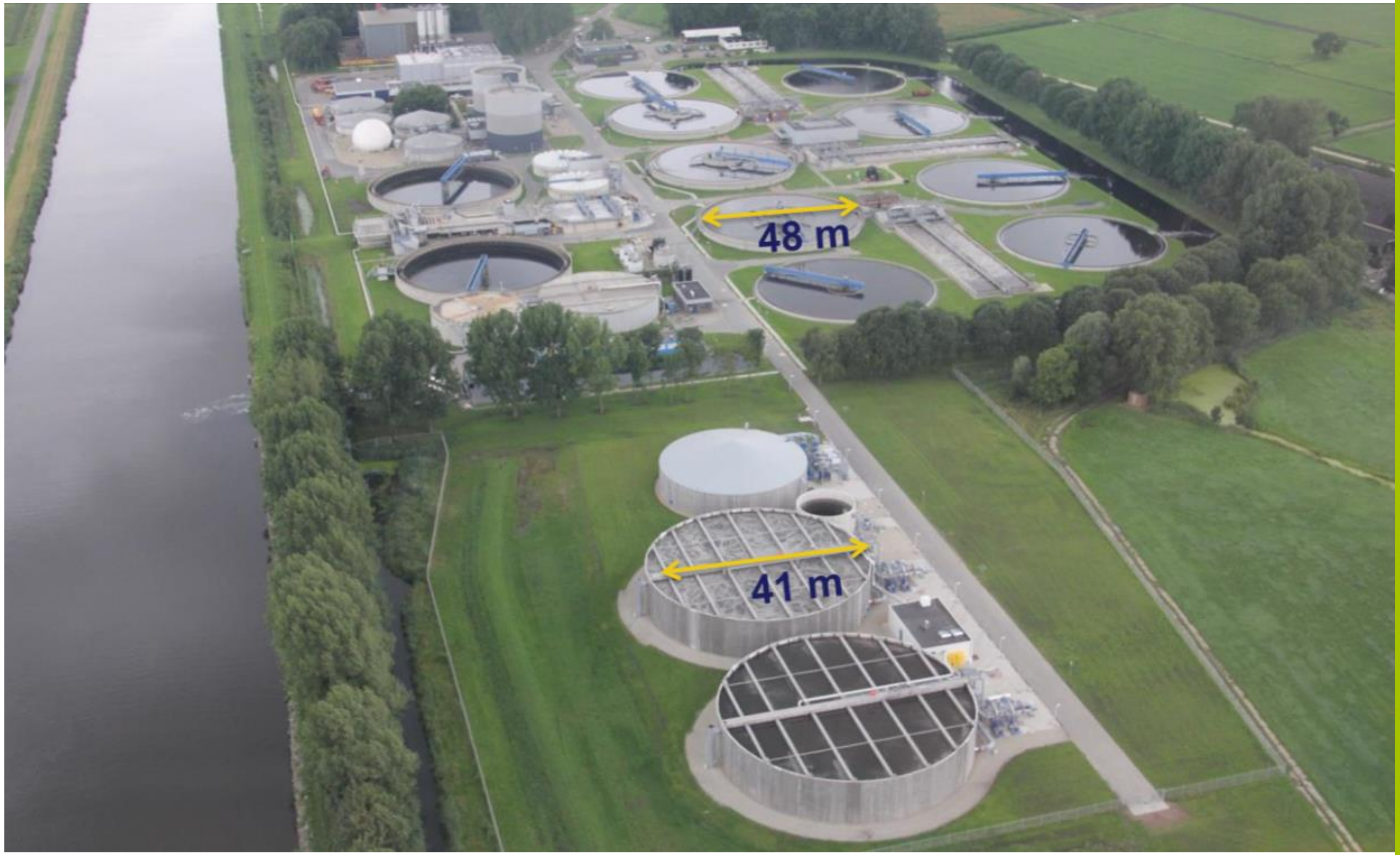
Scale-up meets world largests SBR tank volume

Nereda® Garmerwolde – The Netherlands, 2013



CLIENT

Water Authority Noorderzijlvest

WASTEWATER TYPE

Municipal

CAPACITY

30,000 m^3/day | 140,000 p.e

PEAK FLOW

4,200 m^3/hour

Implementation progress

2005: Vika, The Netherlands, 5,000 p.e.

Today: Ringsend Dublin, PPS2, first cell; Ultimate capacity 2,670,000 p.e.

Nereda® plants

Operational plants:

Vika, Ede	NL
Cargill, Rotterdam	NL
Smilde, Oosterwolde	NL
STP Gansbaai	RSA
STP Epe	NL
STP Garmerwolde	NL
STP Vroomshoop	NL
STP Dinxperlo	NL
STP Wemmershoek	RSA
STP Frielas, Lisbon	PT
STP Ryki	PL
Westfort , IJsselstein	NL
STP Clonakilty	IRL
STP Carrigtwohill	IRL
STP Deodoro, Rio de Janeiro	BR
STP Kingaroy	AUS
STP Simpelveld	NL
STP Cork Lower Harbour	IRL

Operational plants:

STP Highworth	UK
STP Ringsend	IRL
STP Jardim Novo, Rio Claro	BR

Plants under construction:

STP Hartebeestfontein	RSA
STP Alpnach	CH
STP Faro, Olhão	PT
STP Zutphen	NL
STP Utrecht	NL
STP Österröd, Strömstad	S
STP Inverurie	UK
STP Kendal	UK
STP Great Dunmow	UK
STP Morecambe	UK
STP Barston	UK
STP Breskens	NL
STP Kloten	CH

Plants under design:

STP Tatu, Limeira	BR
STP São Lourenço, Recife	BR
STP Jaboatão, Recife	BR
STP Jardim São Paulo, Recife	BR
STP Tijuco Preto, Sumaré	BR
STP Lontra, Araguaína	BR
STP Região Sul de Palmas	BR
STP Radcliffe	UK
STP Walsall Wood	UK
STP Failsworth	UK
STP Newham	UK
STP Dungannon	UK
STP Blackburn	UK
Sappi, Lanaken	BE
STP Vriezenveen	NL
STP Altena	GE
STP Stonewater Creek	US
STP Wolf Creek	US
STP Fleury	FR

Global Nereda® roll-out

Nereda: an exciting or boring story?

- Game changing technology:
  - Significant lower energy consumption
  - Facilitating energy neutrality
  - Significantly lowering CAPEX and OPEX
  - Better treated water quality
  - Compact and suitable for upgrading of existing infrastructure

- 10 years from scientific inspiration to first pilot → fast

- 2 years from pilot to first industrial full-scale → fast

- Working within a Public Private Partnership with Dutch Water Authorities as co-developpers and launching customers

- Exciting !

Nereda: an exciting or boring story?

- 6 – 8 years from pilot to first municipal applications → ?
- plus 6 – 8 year from first municipal application to “modern standard in The Netherlands” → ?
- Similar confidence building process in most other markets → slow
- 8 - 10 years after first European full-scale a (small) first Nereda in Germany and France
- Boring slow !

Key messages for discussion

- The Nereda example shows that scientific research can significantly contribute to develop game-changing and truly sustainable wastewater treatment technology
- The PPP National Nereda Development Program and roll-out of the technology is recognized in The Netherlands (just like the technology itself) as best-practice
- Whereas society would benefit from a fast implementation and valorization of successful research, the international adaptation of “elsewhere proven” game-changing wastewater treatment technologies is very slow.
  And maybe within the EU even slower than in Asian and Latin-American markets.
- How to catalyze European implementation?
- How to minimize hurdles in EU public tenders for “elsewhere proven” modern and superior solutions?