

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

Efficient wastewater plants – the case of Nereda

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Consultancy, Engineering & Project Management



**Royal
HaskoningDHV**
Enhancing Society Together

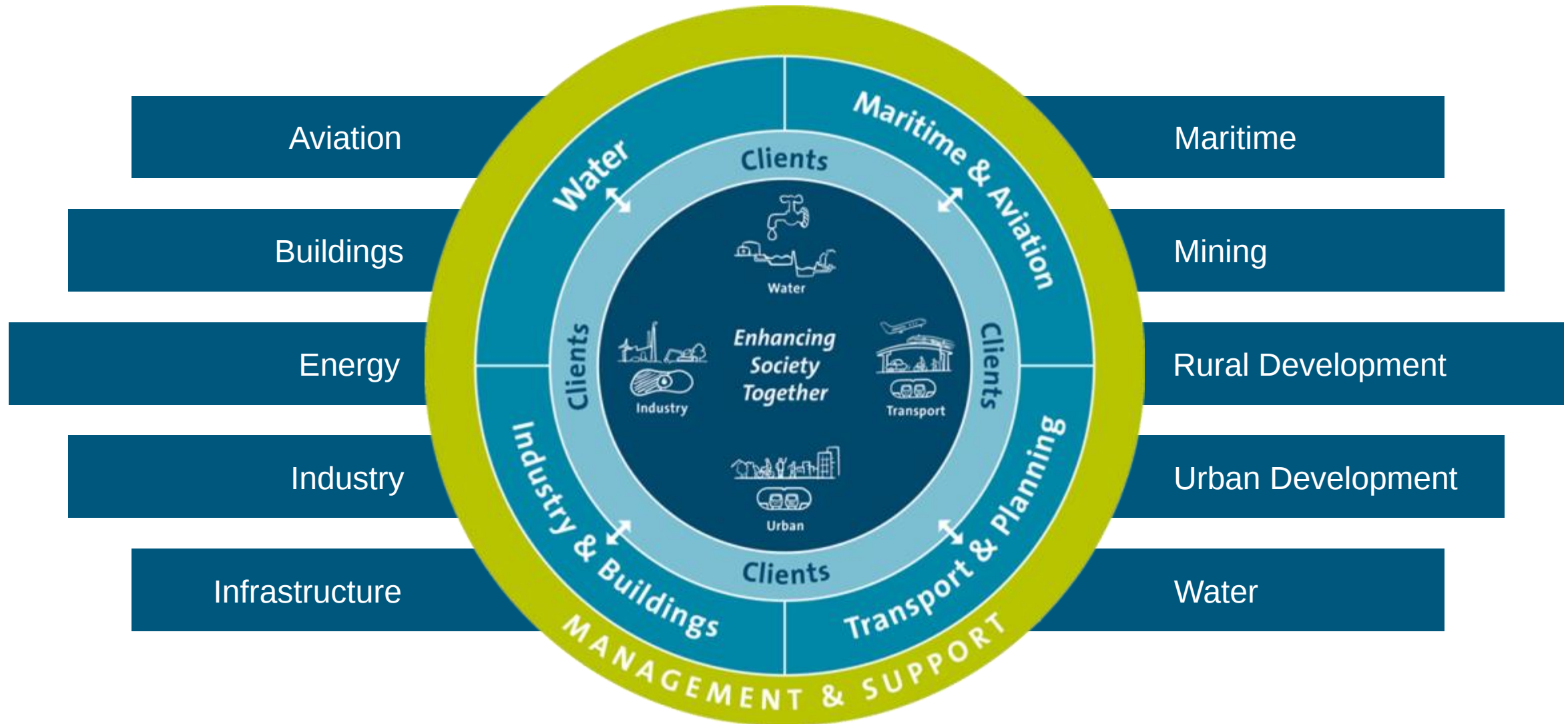


Workforce of **6,500** in
more than **150** countries

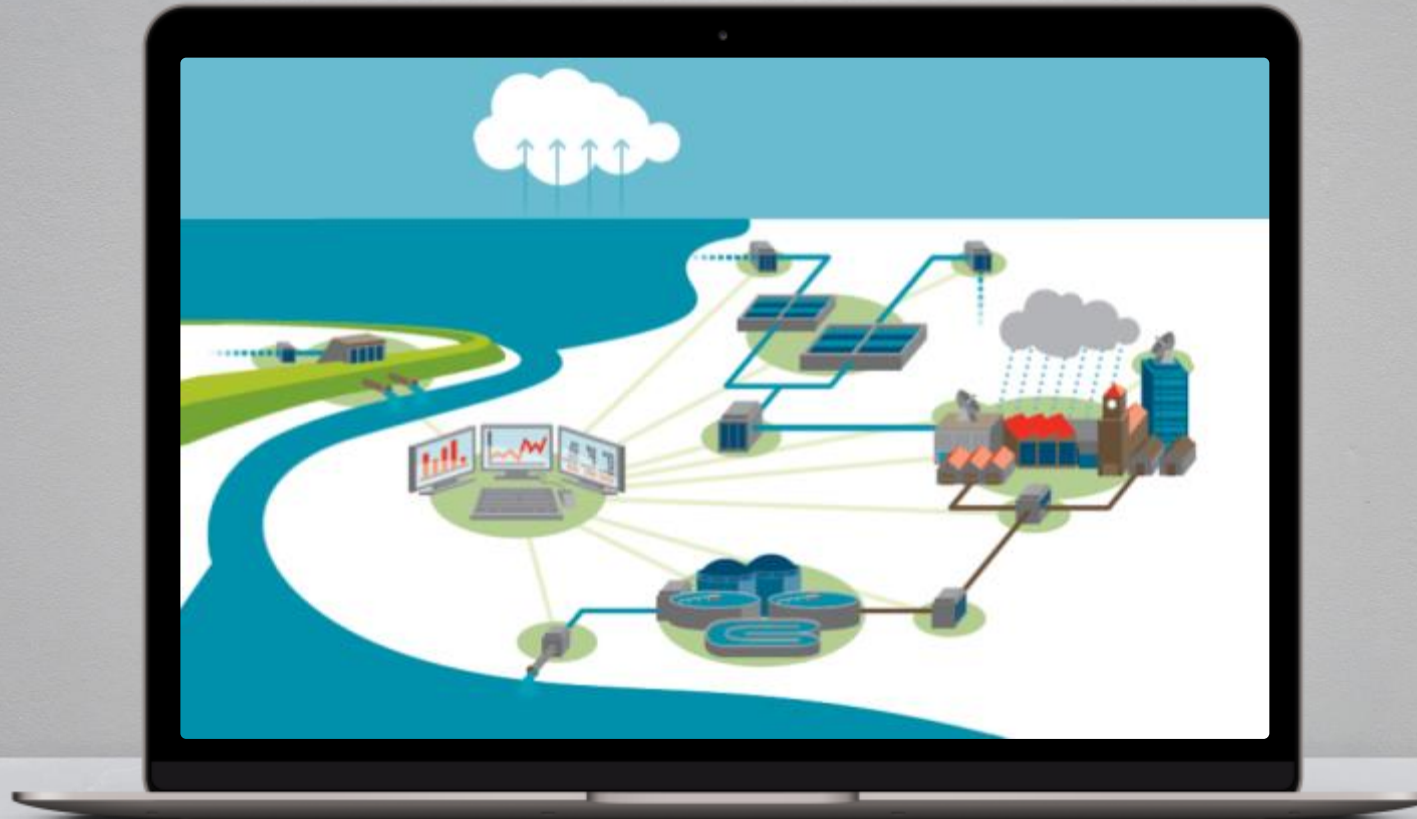


One of the **top independently
owned** engineering companies

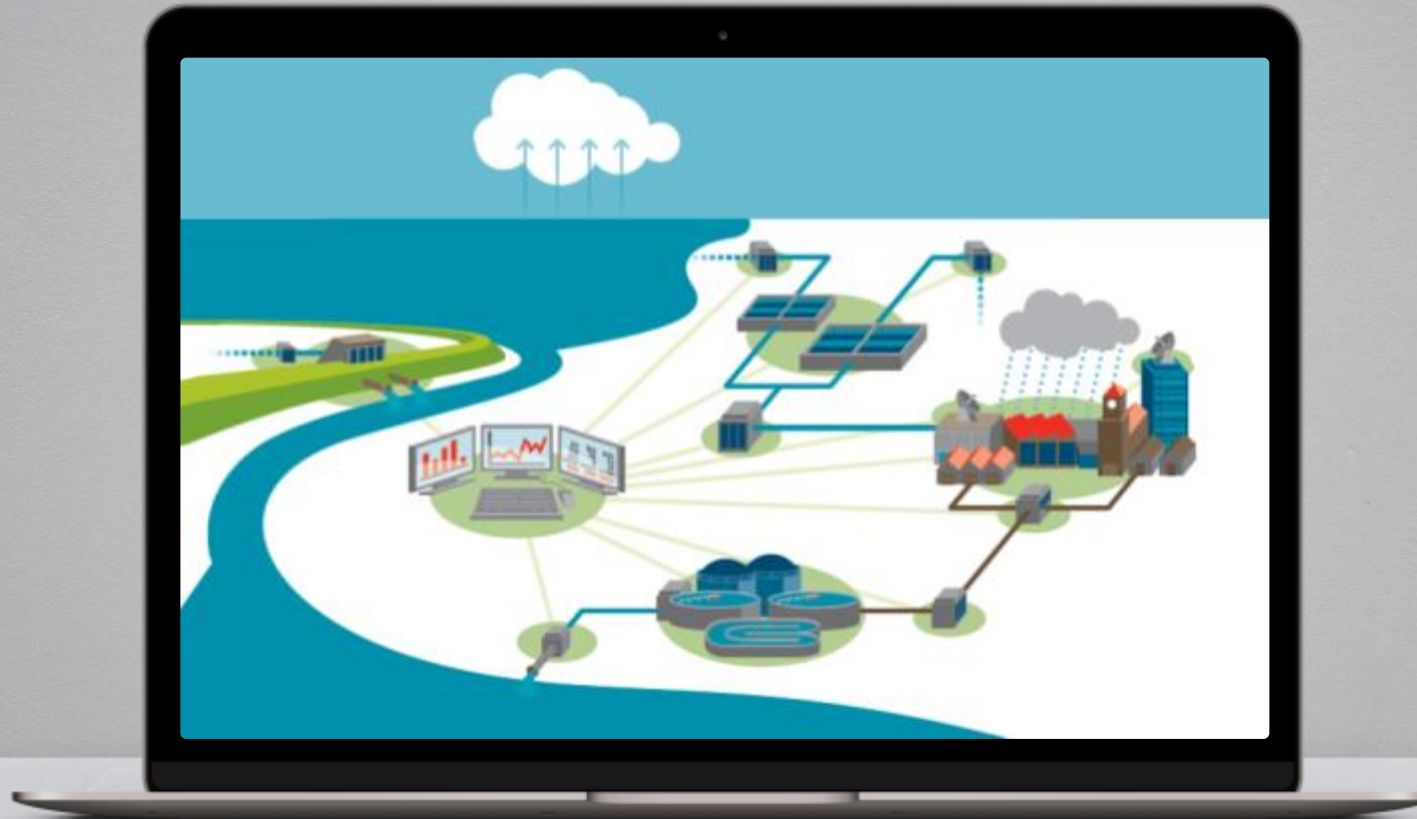
Our Organisation



Covering the whole water cycle

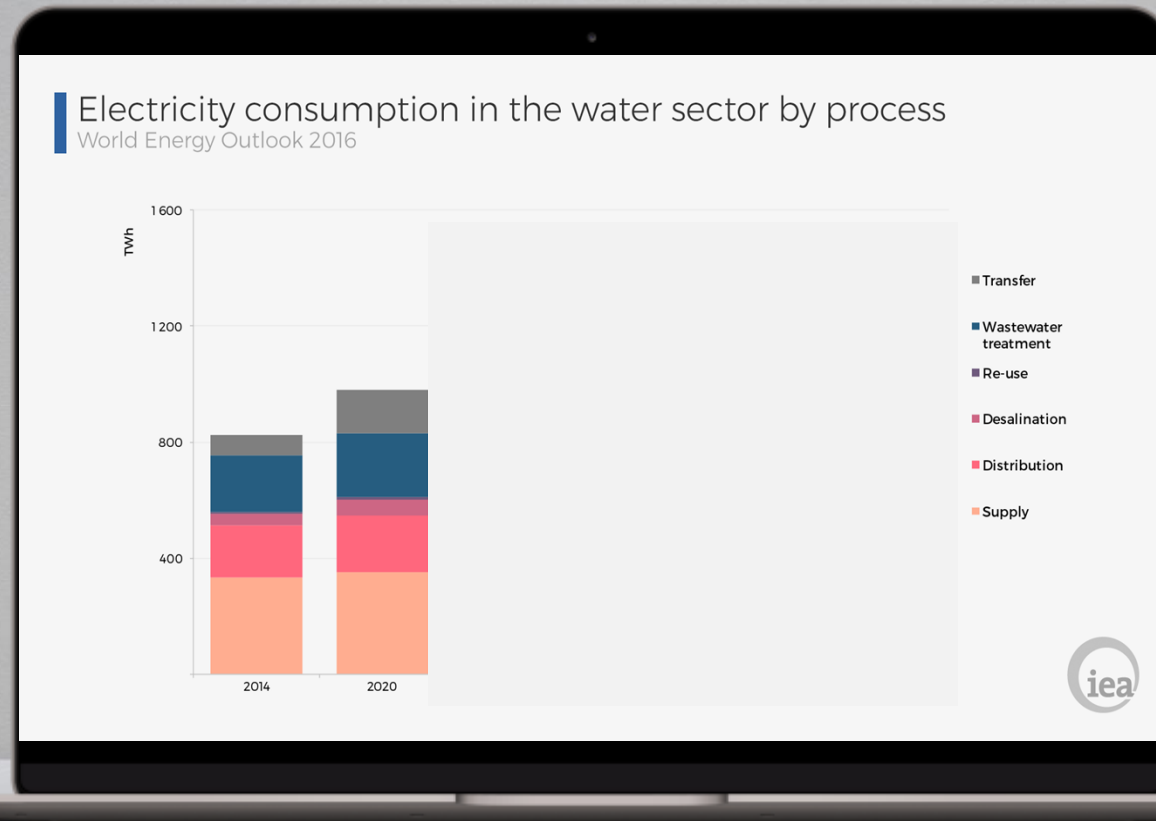


Energy consumption urban water cycle

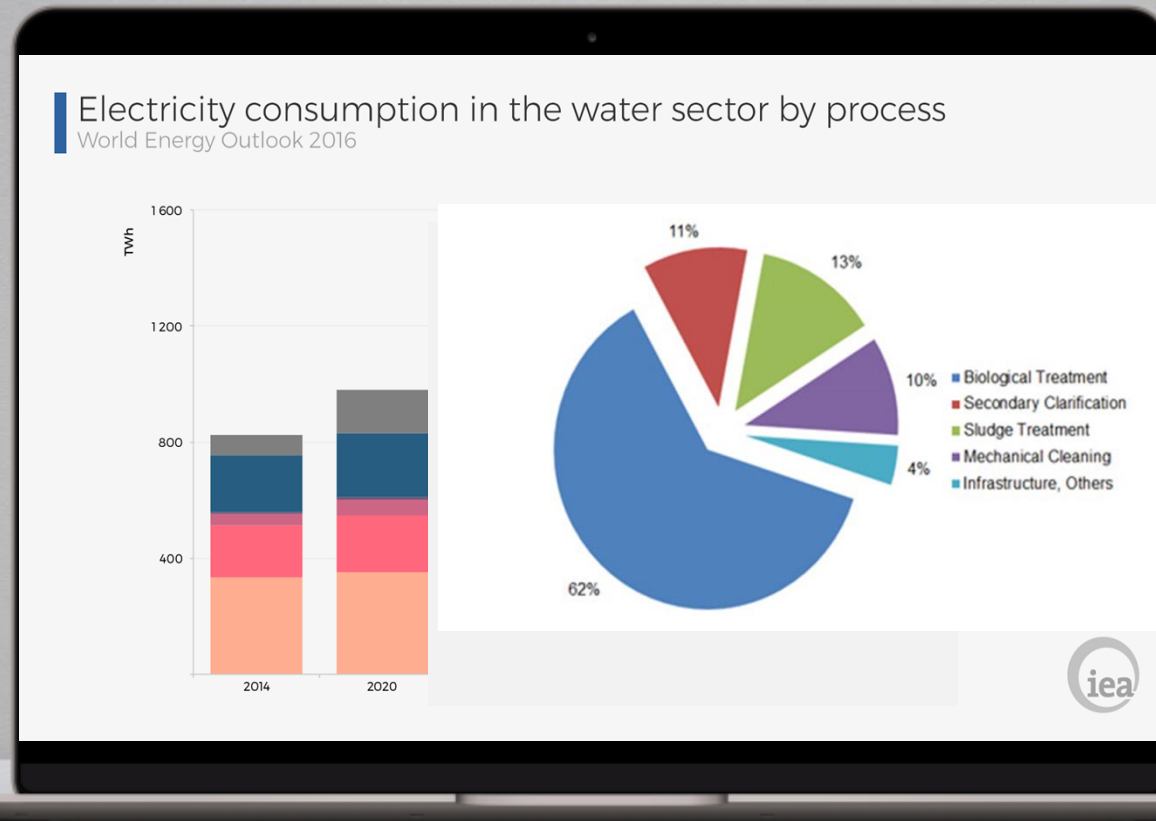


Order of magnitude: 1 – 5% of EU national energy consumption

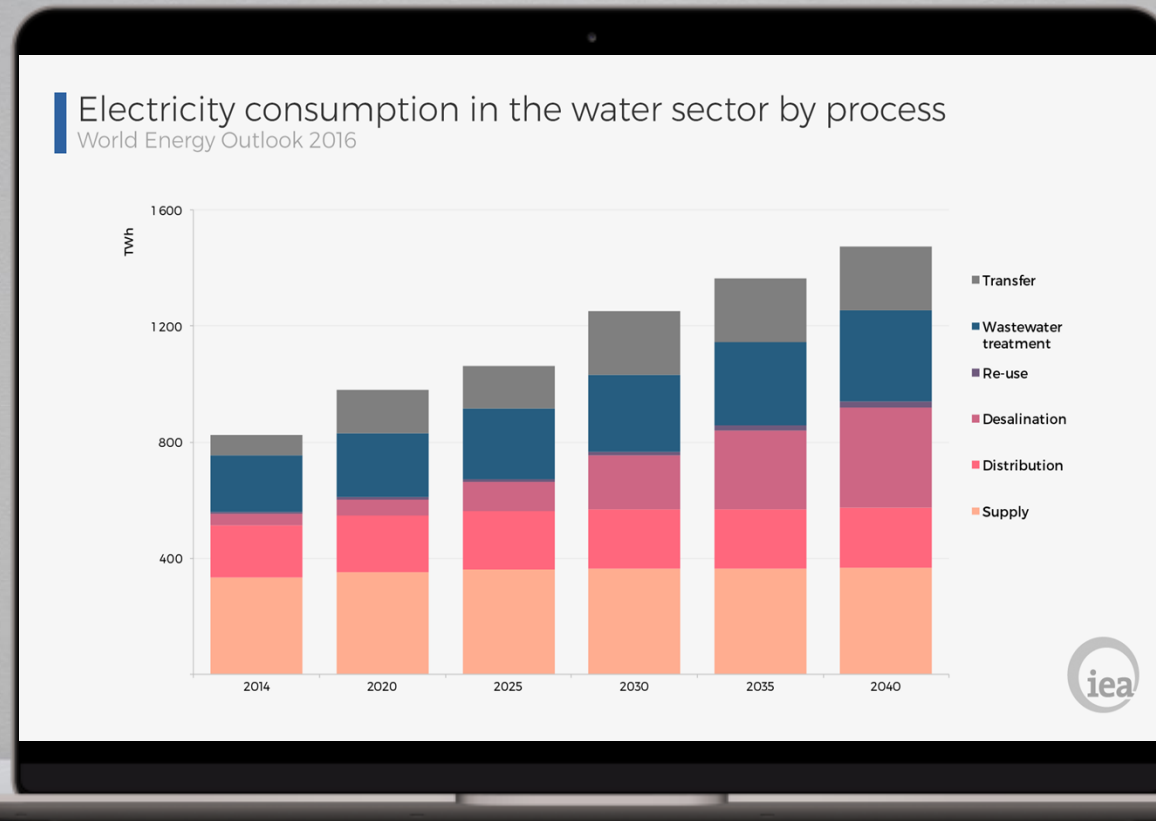
Significant part for wastewater treatment



And major part for biological treatment



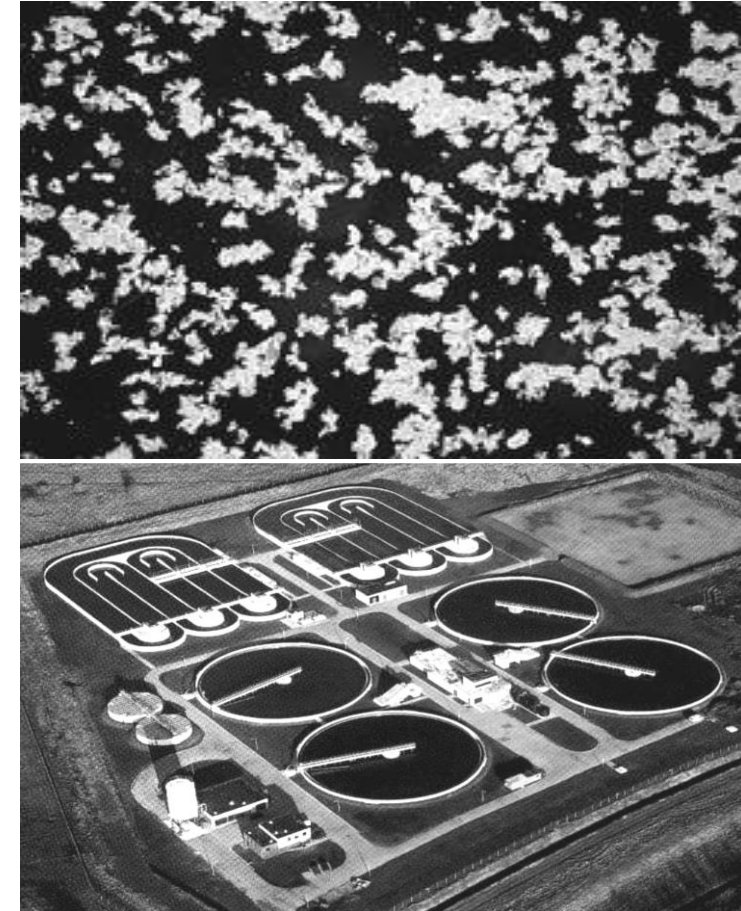
Growing consumption



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 so far 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

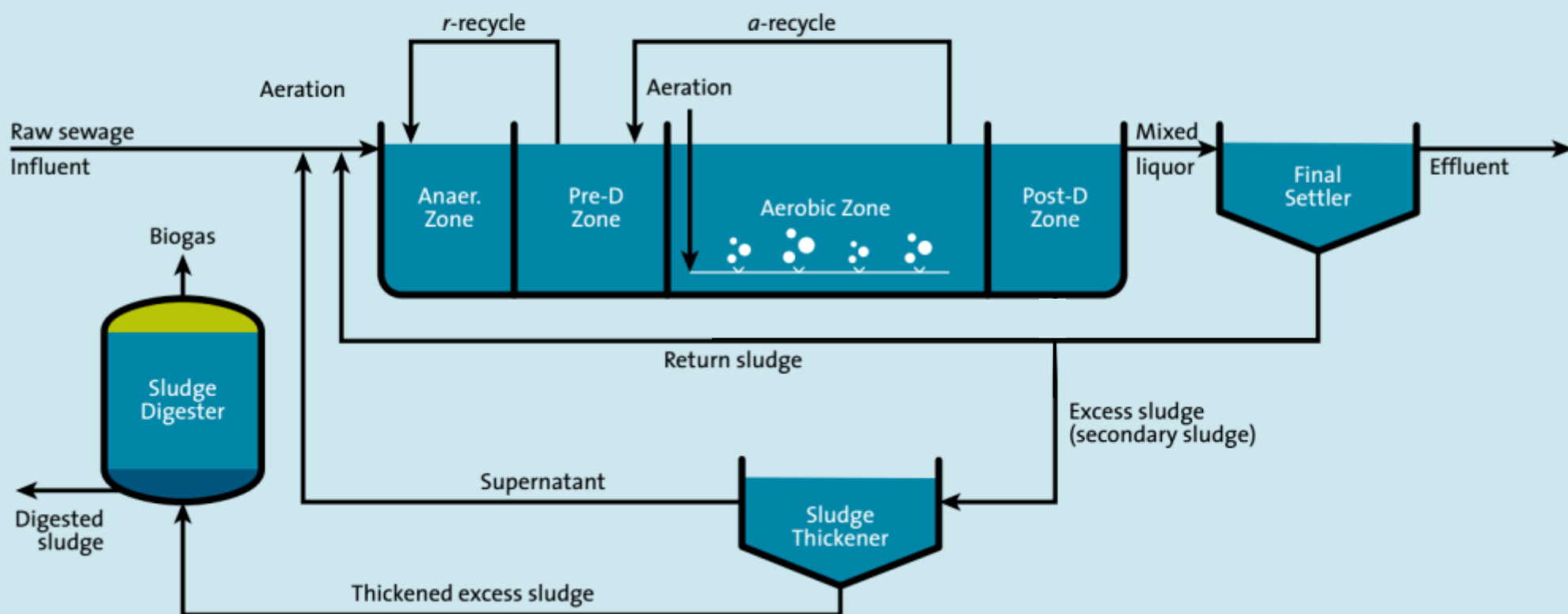
4 g/l
 $SVI_5 > SVI_{30}$

Conventional Activated Sludge Process

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

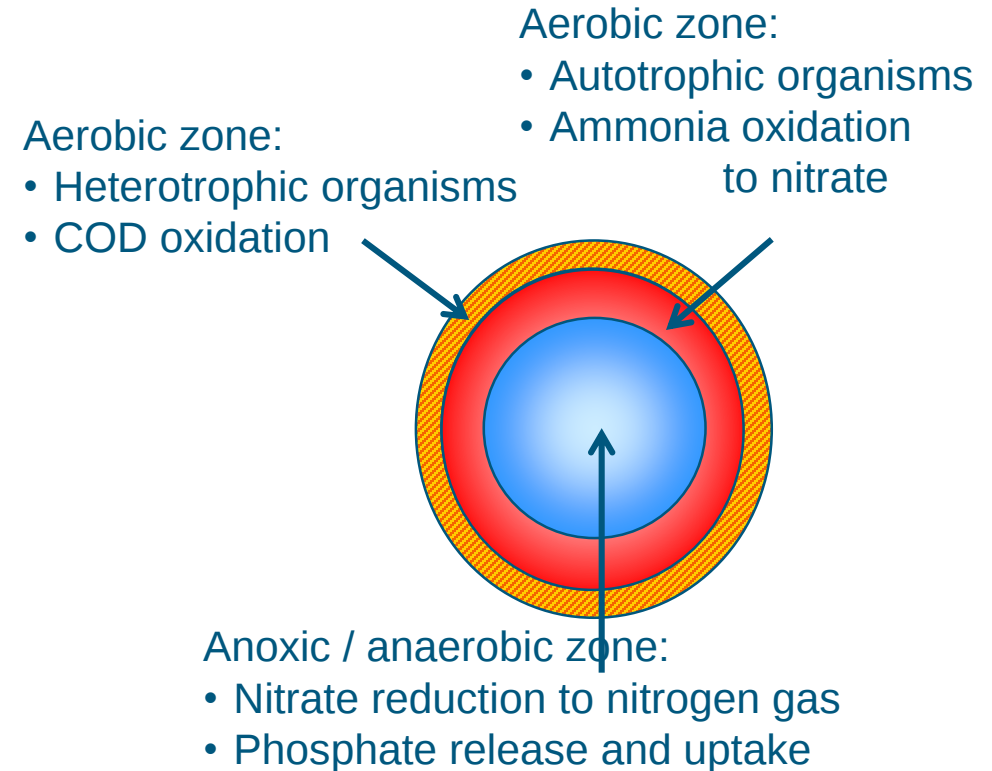
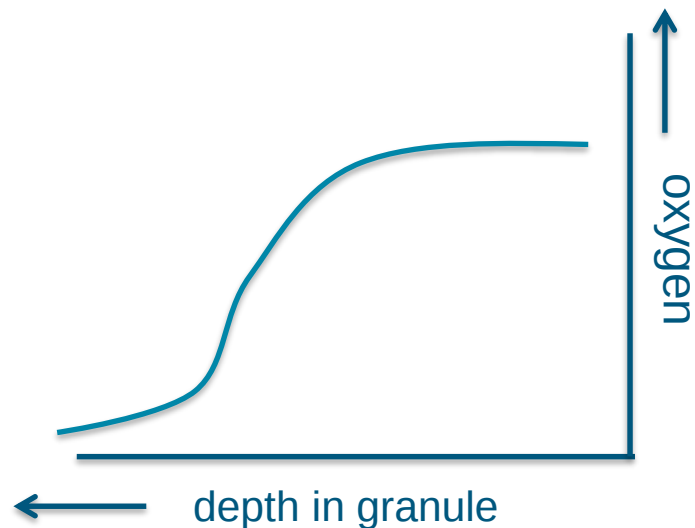


Carbon, Nitrogen and Phosphorus removal in UCT configuration



Nereda[®] granule – BNR in the granules

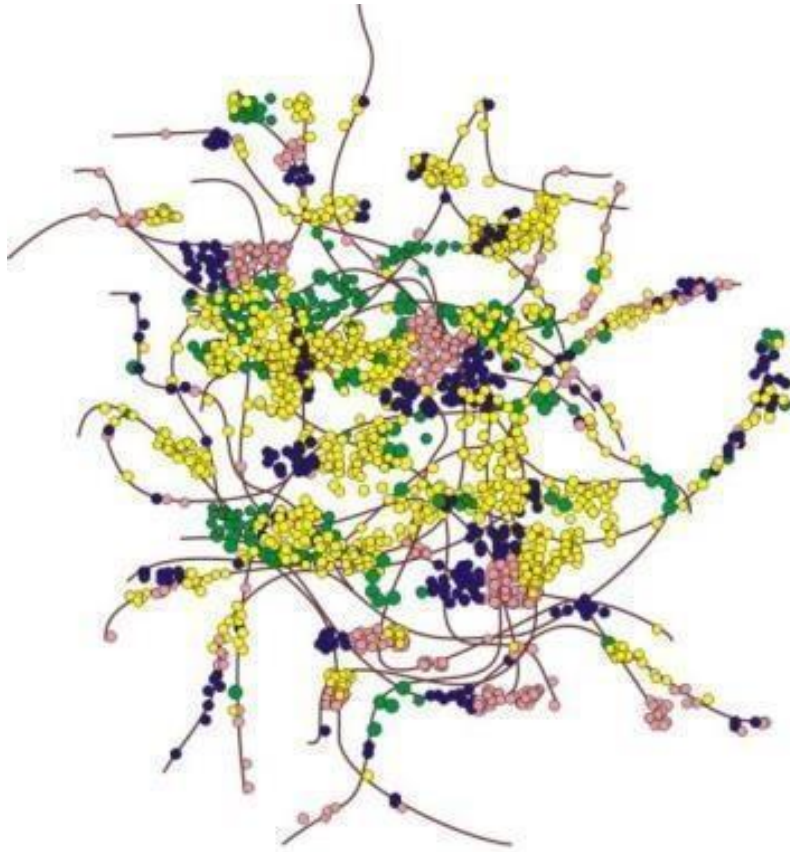
Oxygen gradient in granule
Simultaneous removal of COD, P and N
Transport by diffusion, not by pumping



Micro-organisms in the granule

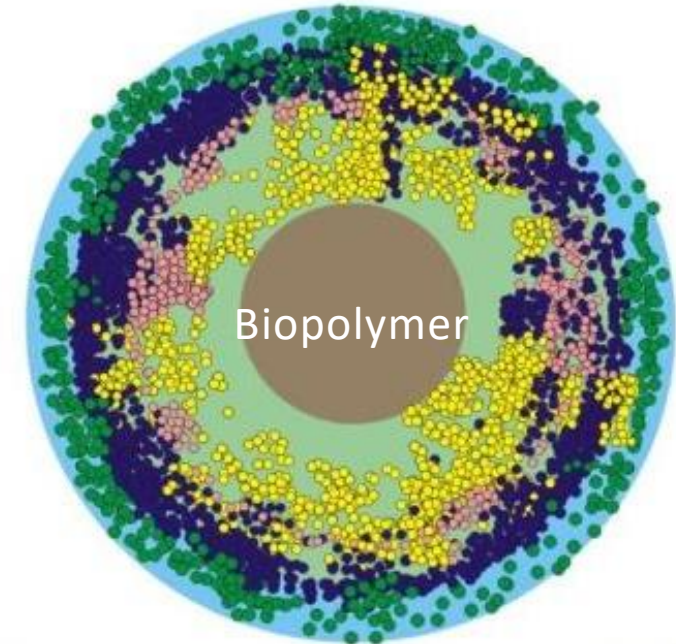


Activated sludge



Aerobic granular biomass

Anaerobic
Anoxic
Aerobic



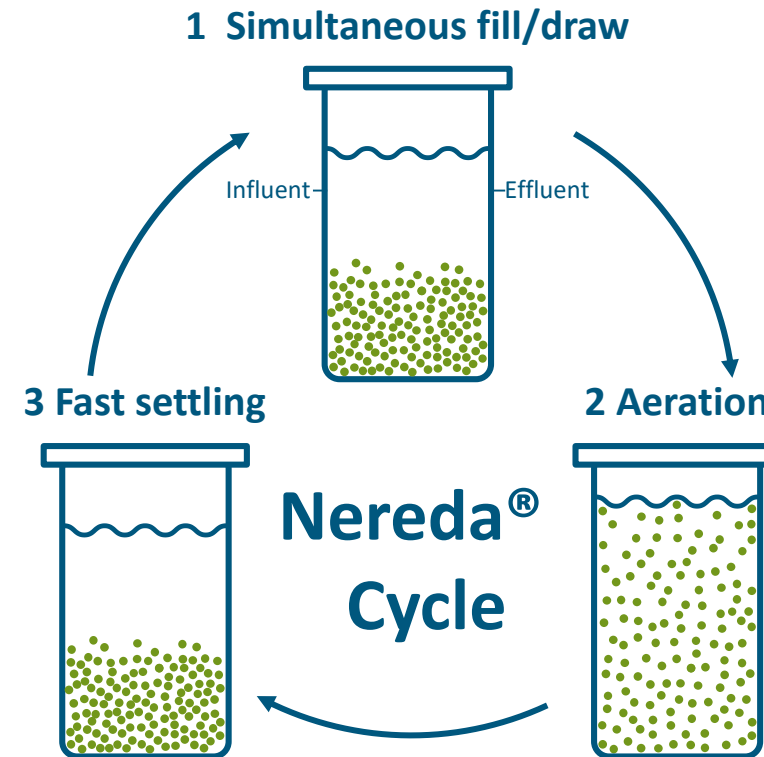
- Nitrifiers
- Denitrifiers
- Phosphate Accumulating Organisms (PAO's)
- Glycogen Accumulating Organisms (GAO's)

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

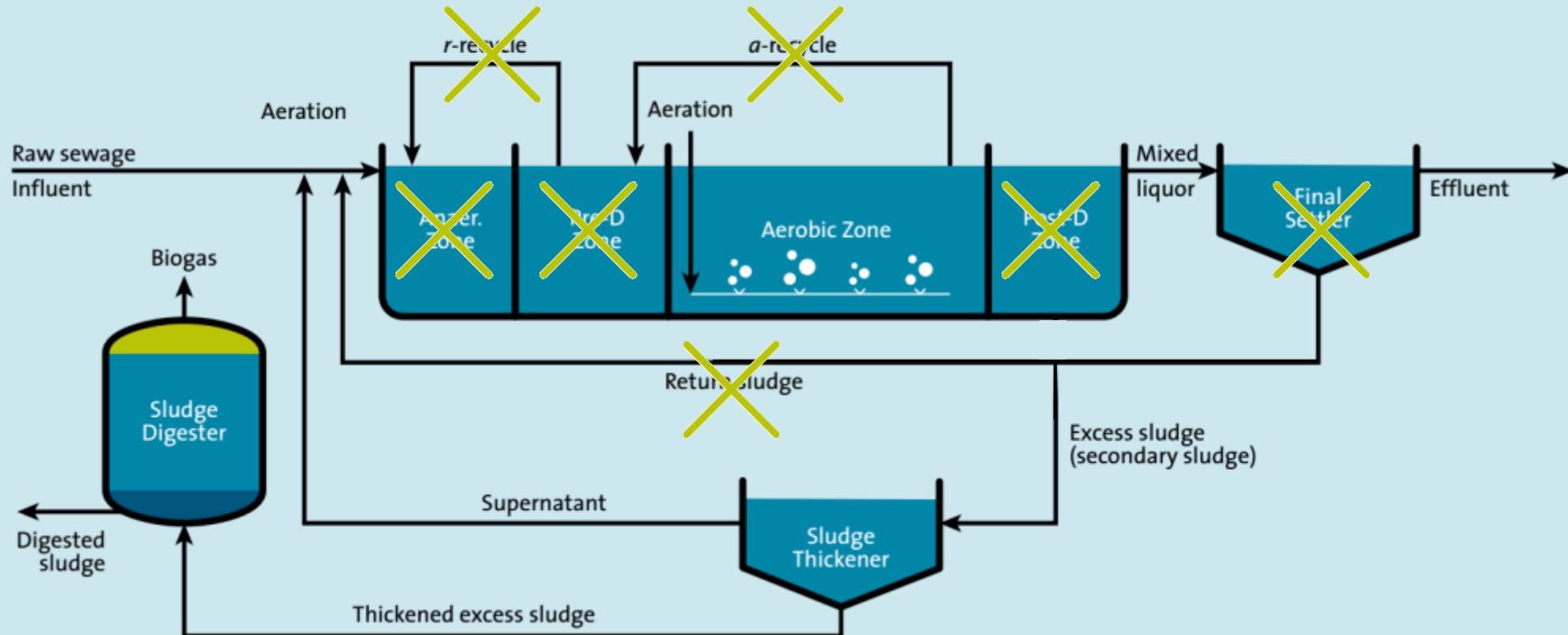


Nereda® compared to Conventional



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

Carbon, Nitrogen and Phosphorus removal in UCT configuration



Energy efficiency example

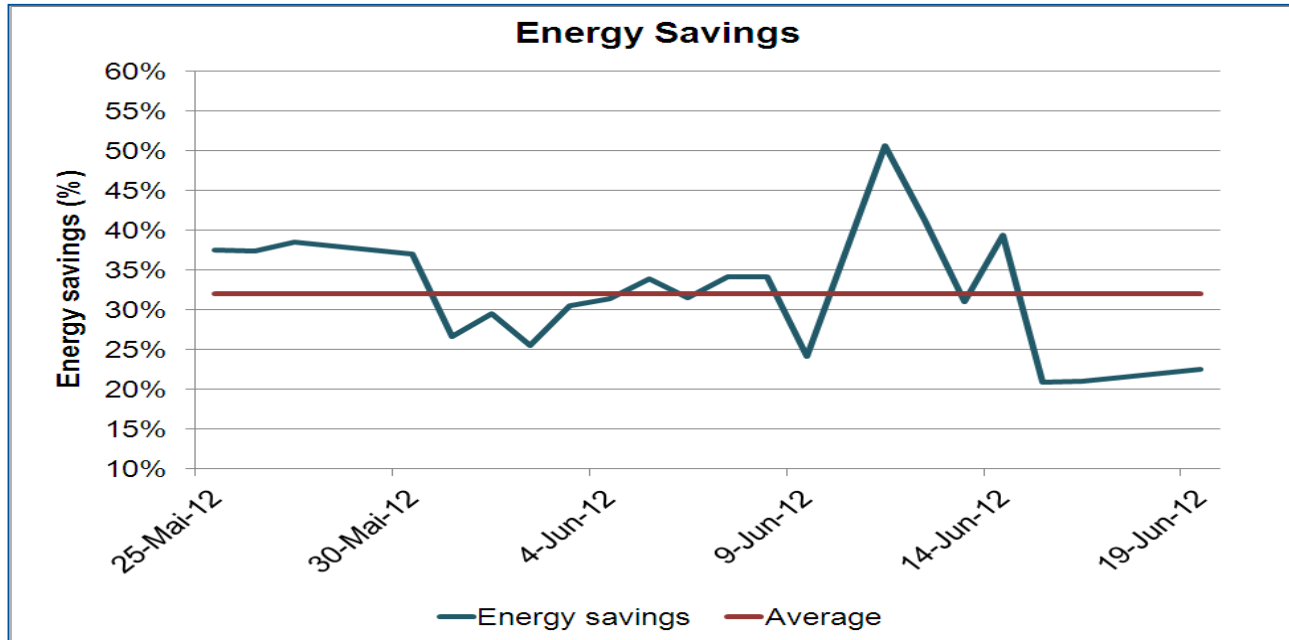
Municipal wastewater | full BNR | 100,000 pe

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 predenitrification	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%

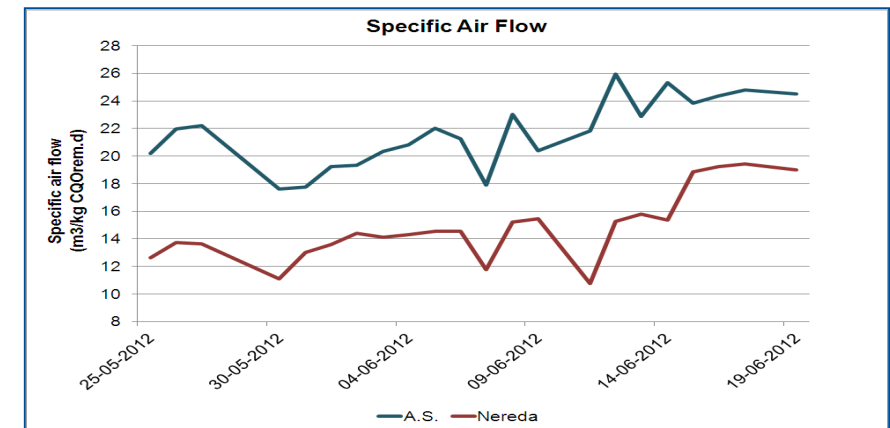
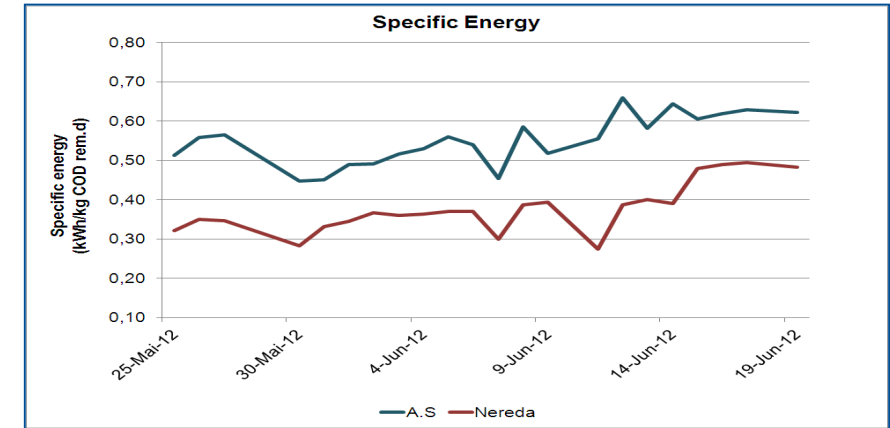
Note that is an example based on a specific plant in Dutch climate achieving full BNR and that energy consumption for both technologies depends on wastewater characteristics, targeted effluent quality, design and equipment selection.

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



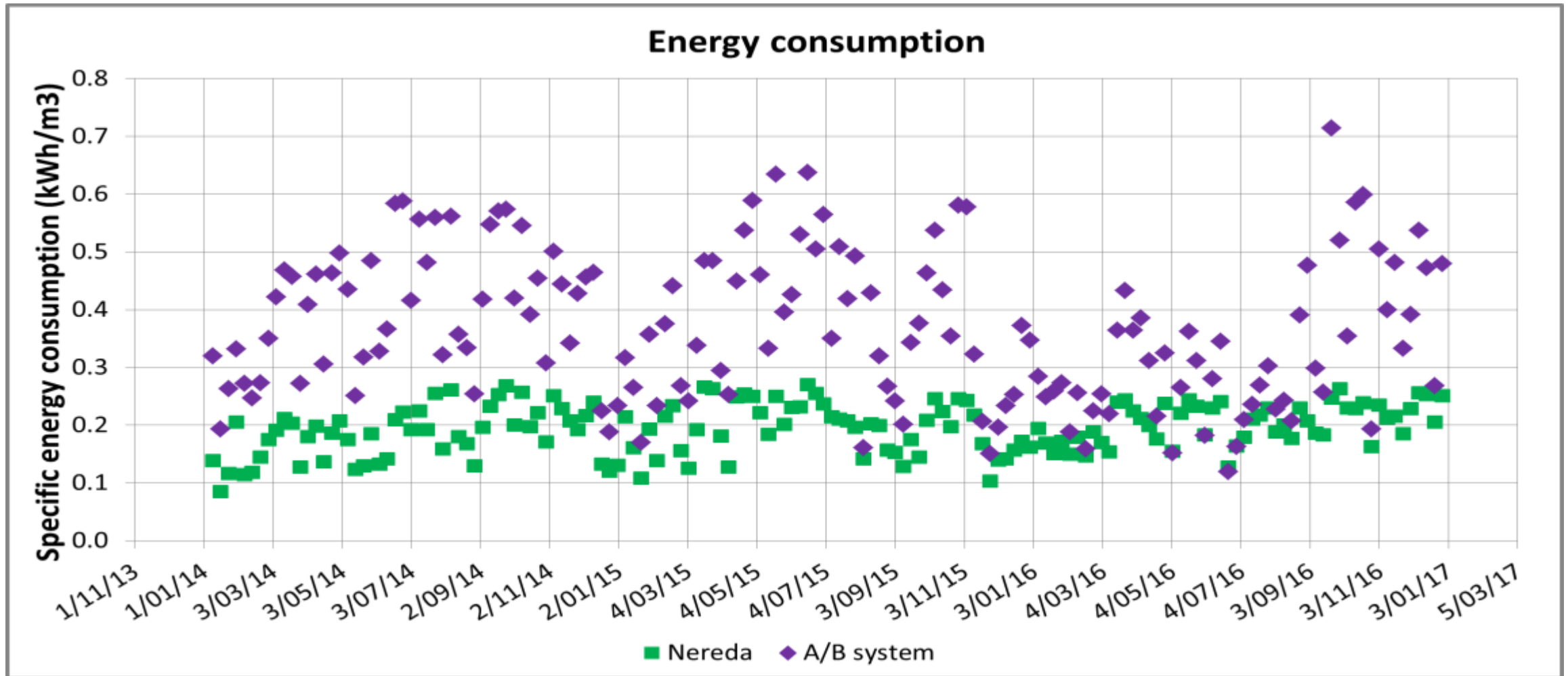
Advantages



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 Oktober Fest in the 90s



Prof. Peter Wilderer
TU Munich



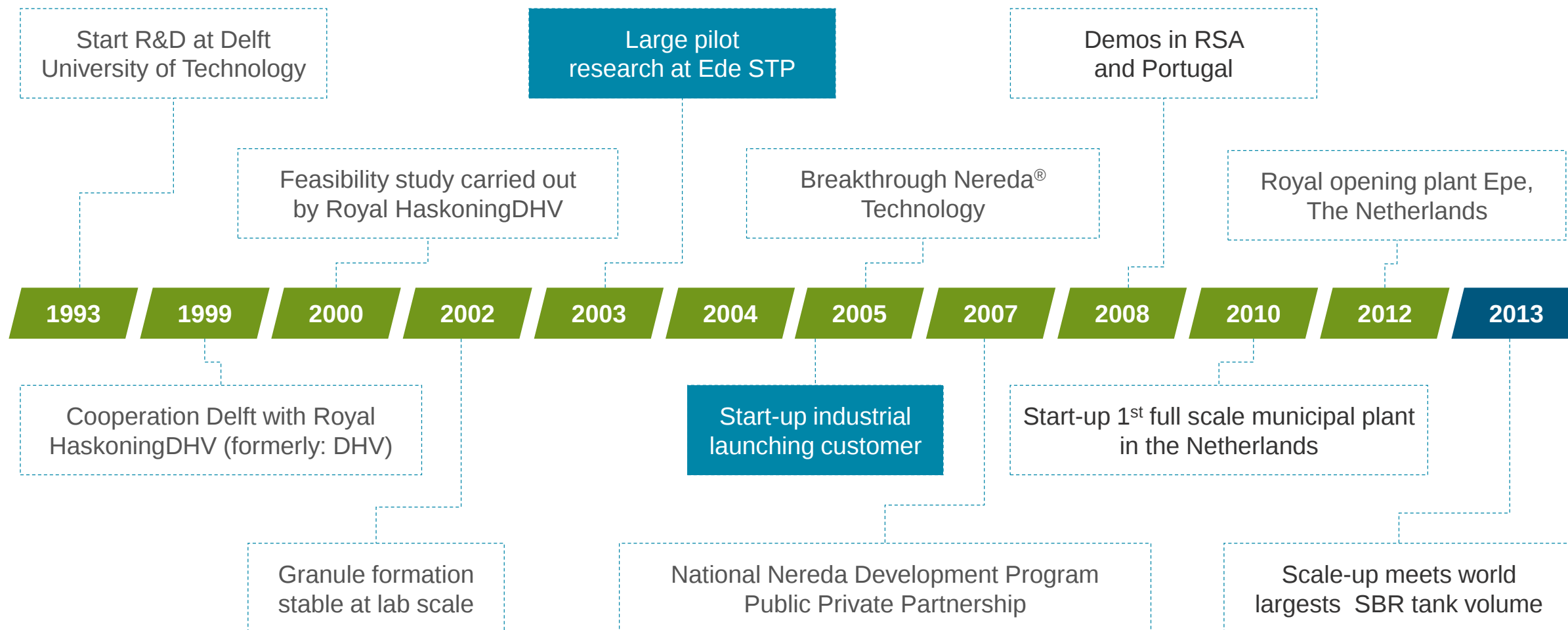
Prof. Mark van Loosdrecht
TU Delft



History and development



- From lab scale experiments to full scale application



From municipal pilot to industrial applications

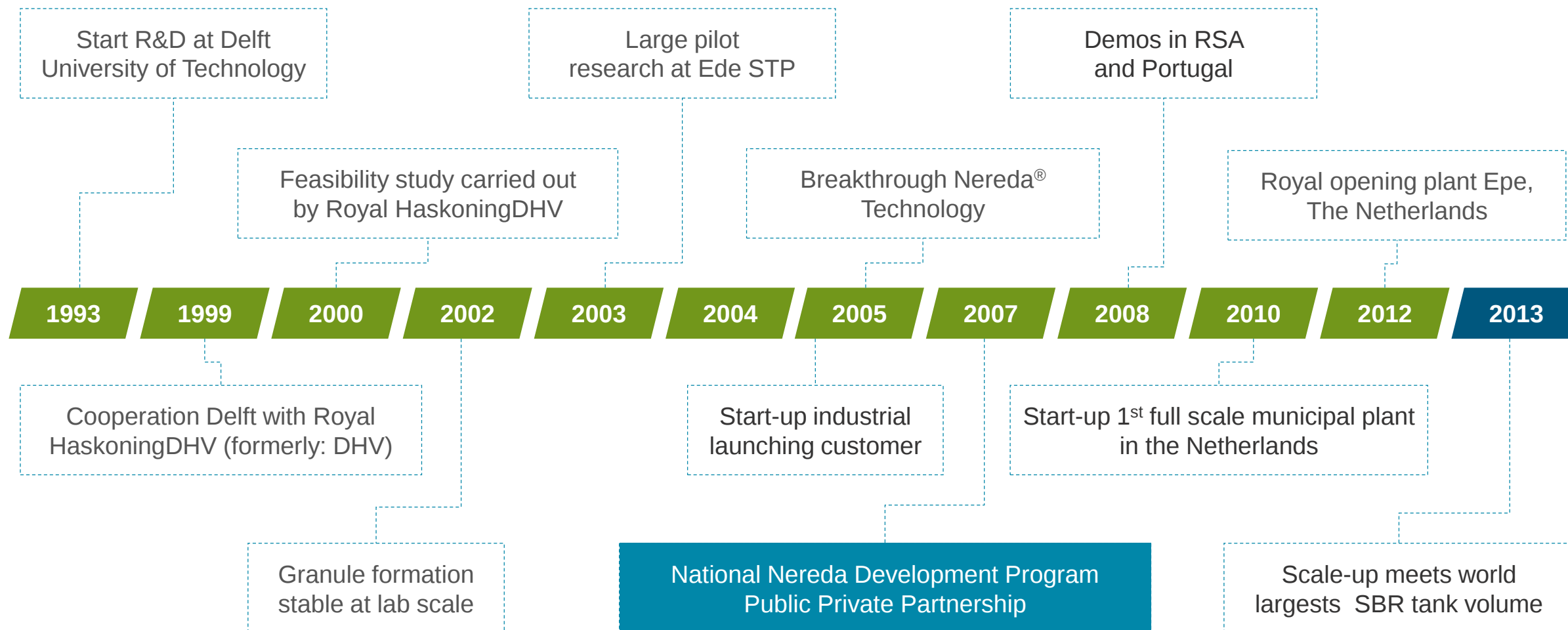


- Prototype
- Scale-up
- Learn and create confidence

History and development



- From lab scale experiments to full scale application



Nereda® Frielas – Lisbon – Portugal



CLIENT

Agua de Portugal – Simtejo

WASTEWATER TYPE

Municipal & Industrial

CAPACITY

12,000 m³/day | 44,000 p.e.

PEAK FLOW

1,850 m³/hour

Nereda® Gansbaai – South Africa



CLIENT

Overstrand Municipality

WASTEWATER TYPE

Municipal

CAPACITY

5,000 m³/day | 63,000 p.e.

PEAK FLOW

400 m³/hour

PRE-TREATMENT

Screening and sand & grit removal

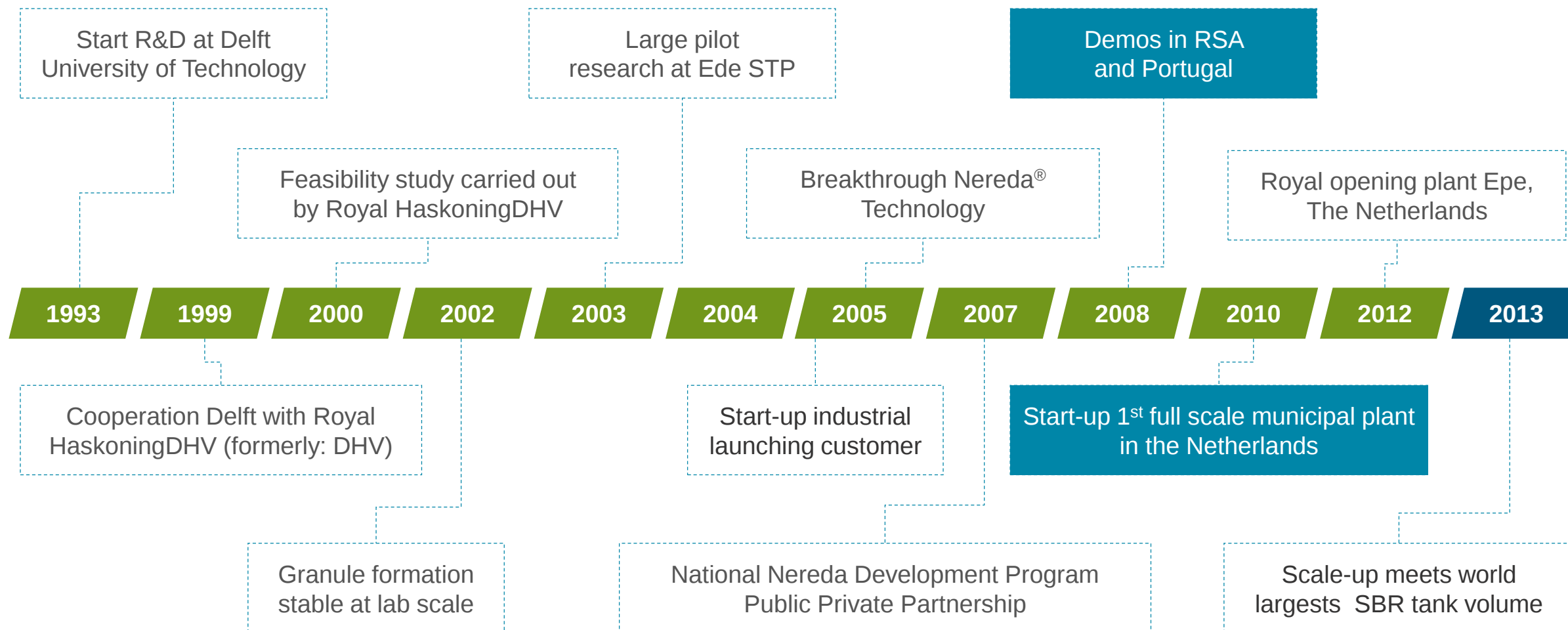
POST TREATMENT

Water reuse pond, reed bed infiltration

History and development



- From lab scale experiments to full scale application



Nereda[®] Epe – The Netherlands 2011



CLIENT

Water Authority Veluwe

WASTEWATER TYPE

Municipal & Industrial

CAPACITY

8,000 m³/day | 41,000 p.e.
(inclusive 13,750 p.e. from
industrial discharges)

PEAK FLOW

1,500 m³/hour

PRE & POST TREATMENT

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

History and development

- From lab scale experiments to full scale



Start R&D at Delft
University of Technology

research

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

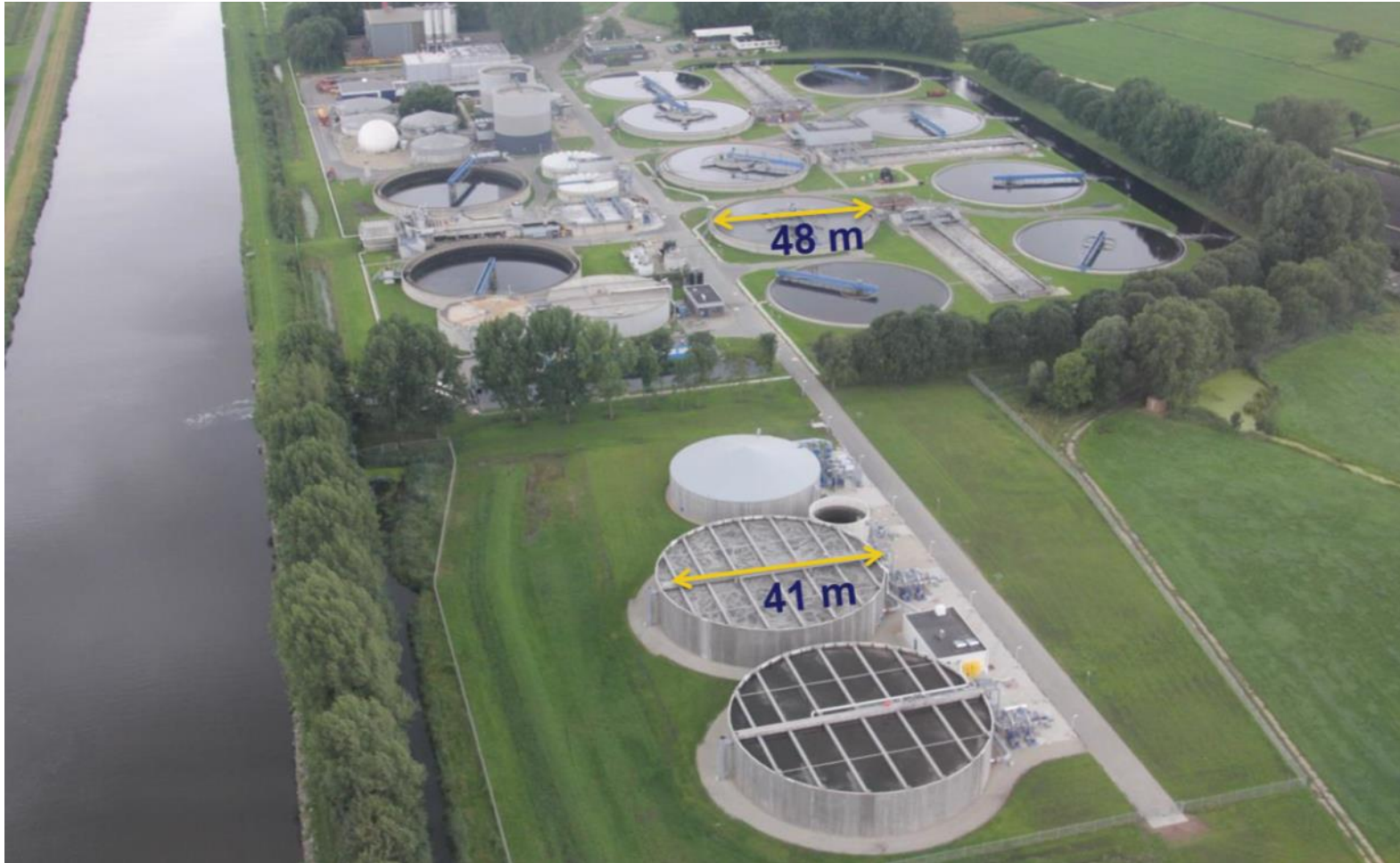
Start-up 1st full scale municipal plant
in the Netherlands

Granule formation
stable at lab scale

National Nereda Development Program
Public Private Partnership

Scale-up meets world
largests SBR tank volume

Nereda® Garmerwolde – The Netherlands, 2013



CLIENT

Water Authority Noorderzijlvest

WASTEWATER TYPE

Municipal

CAPACITY

30,000 m³/day | 140,000 p.e

PEAK FLOW

4,200 m³/hour

Implementation progress



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



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



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

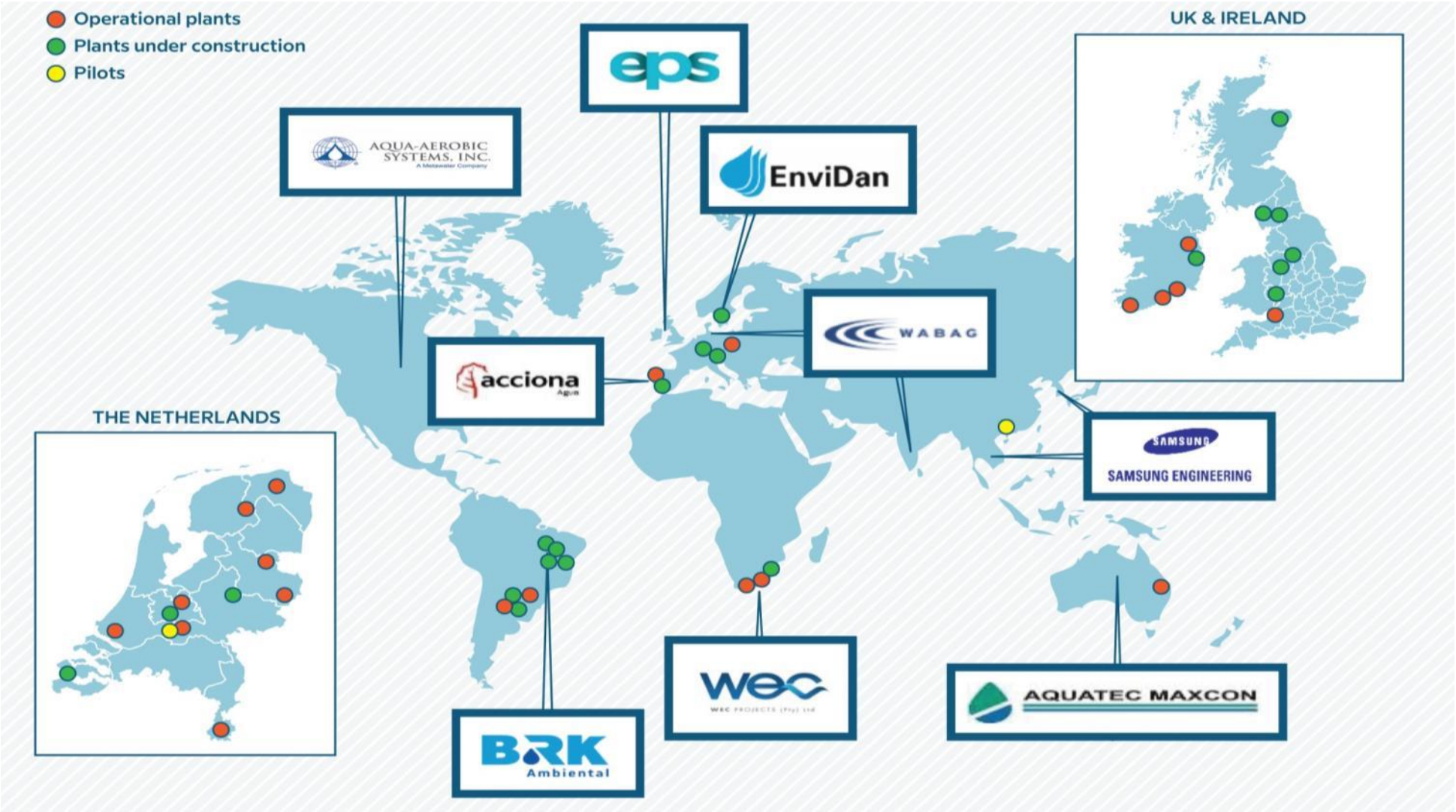
Plants under construction:

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-developers 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?