Ministry of Environment of Denmark
Environmental Protection Agency

Main achievements in Danish Water Sector

AGMA
September 6th, 2022

Henrik Dissing
International Team, Executive Office
Danish Environmental Protection Agency

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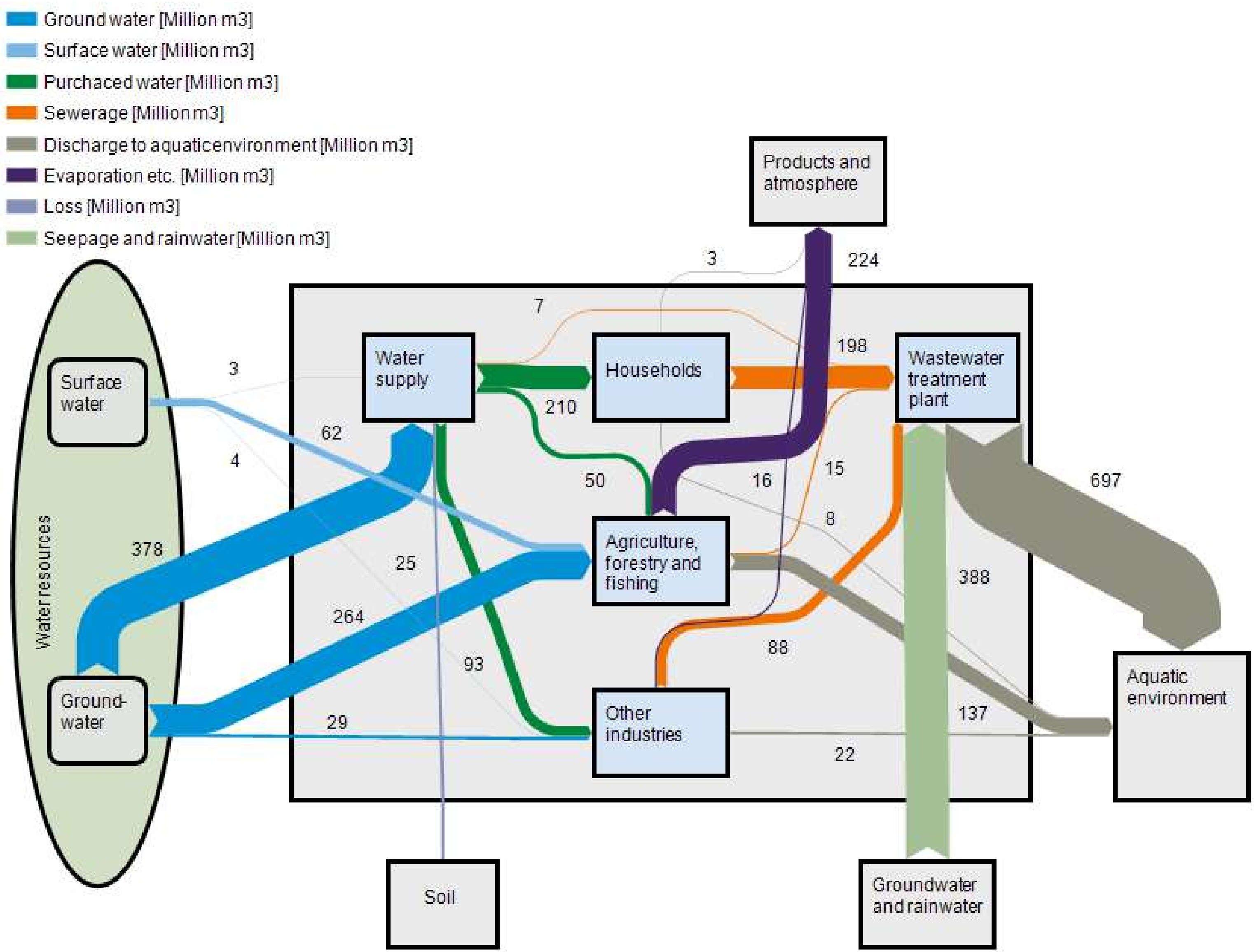
Environmental Protection Agency

Some figures about Water in Denmark, including from *Europe's Water in Figures* (2017) and *EEA Assessment of Water Resources Across Europe* (2021)

Water flows - 2016



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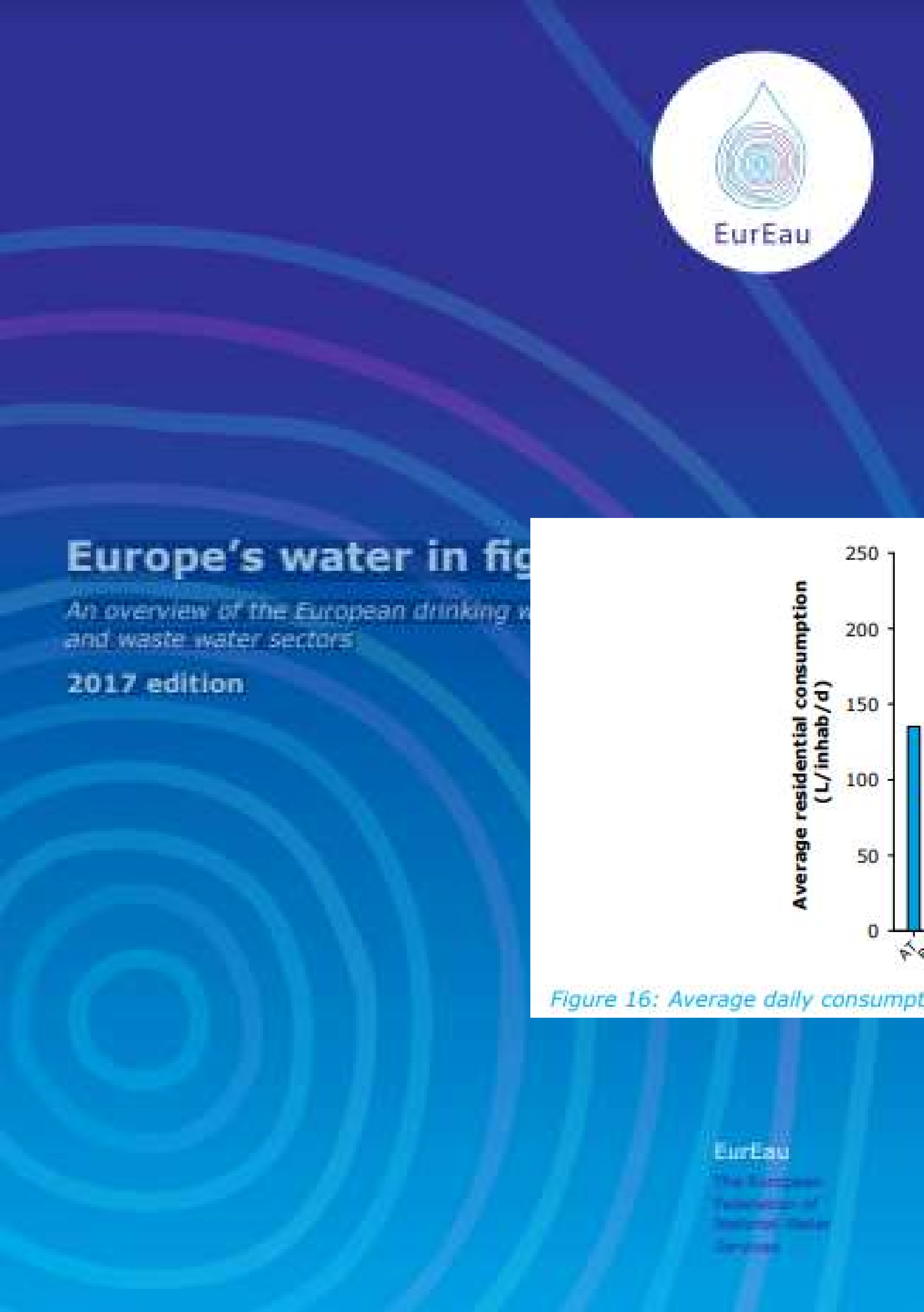

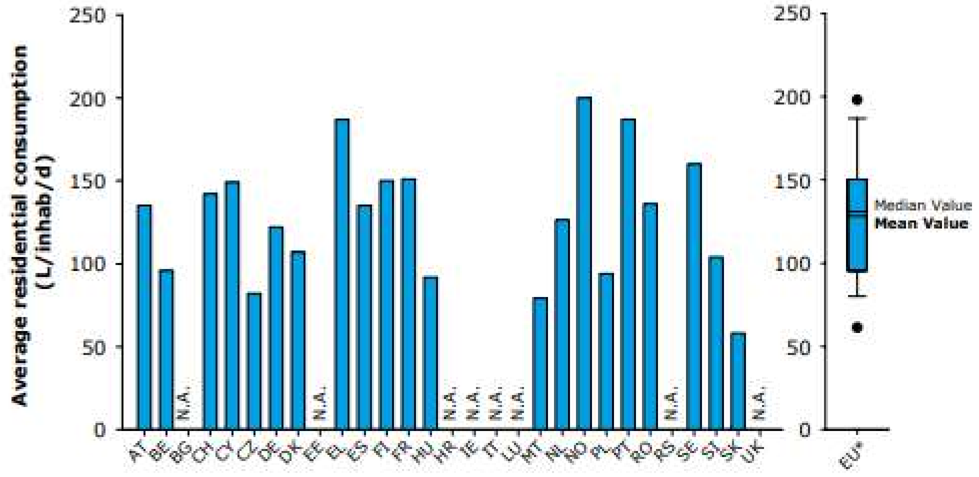

Figure 16: Average daily consumption per person

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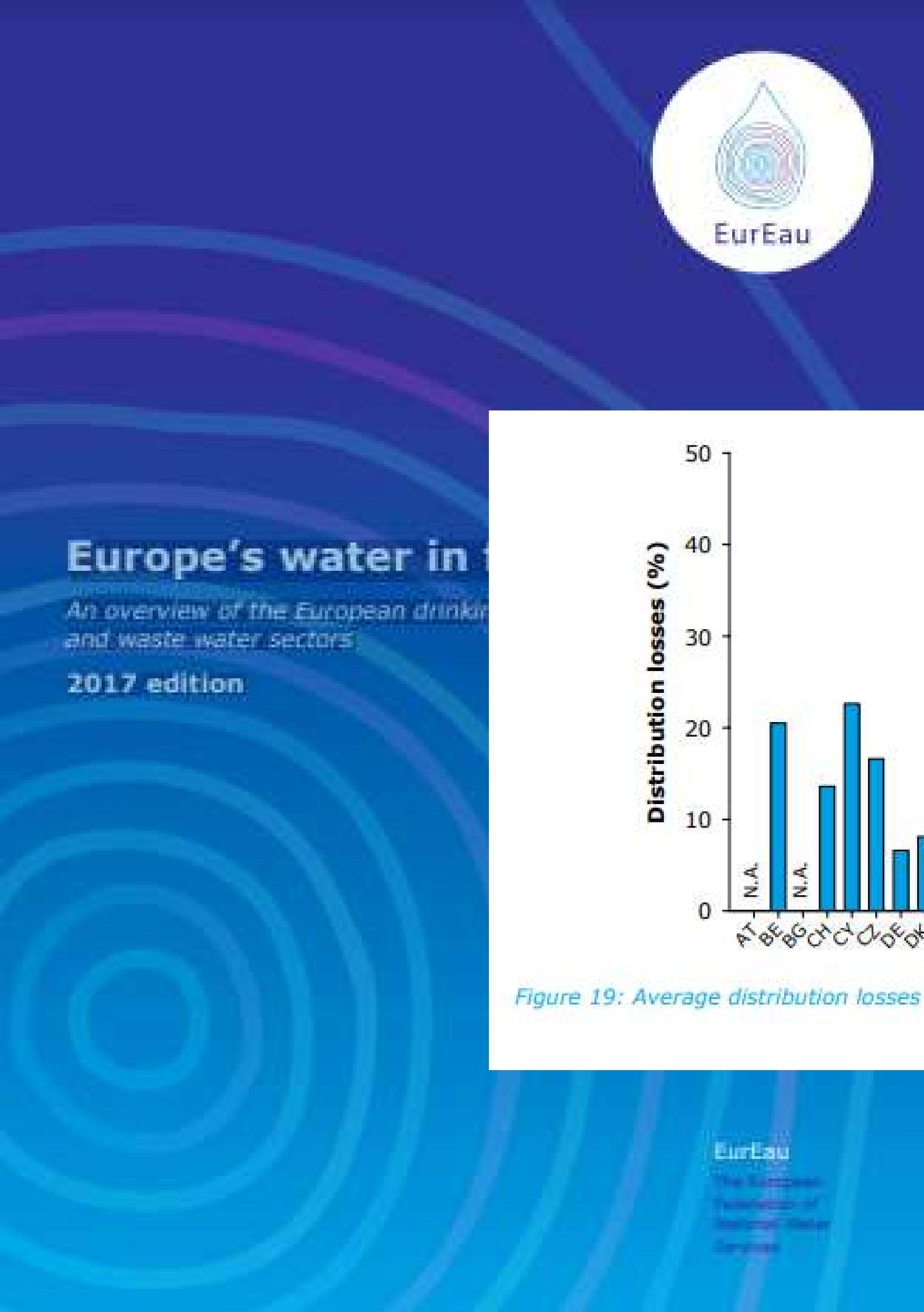

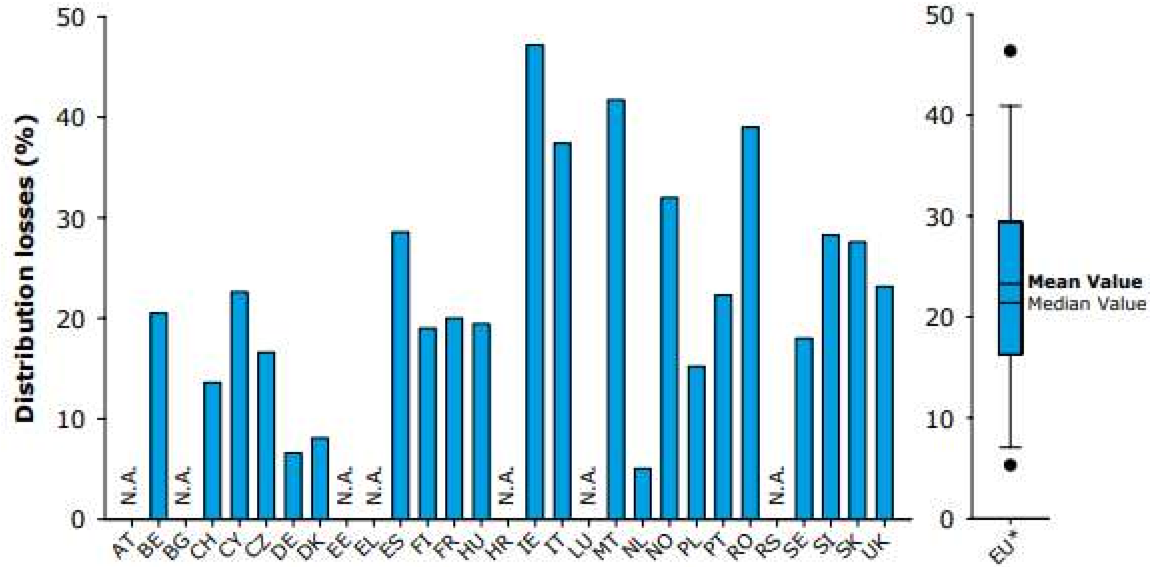

Figure 19: Average distribution losses in percentages

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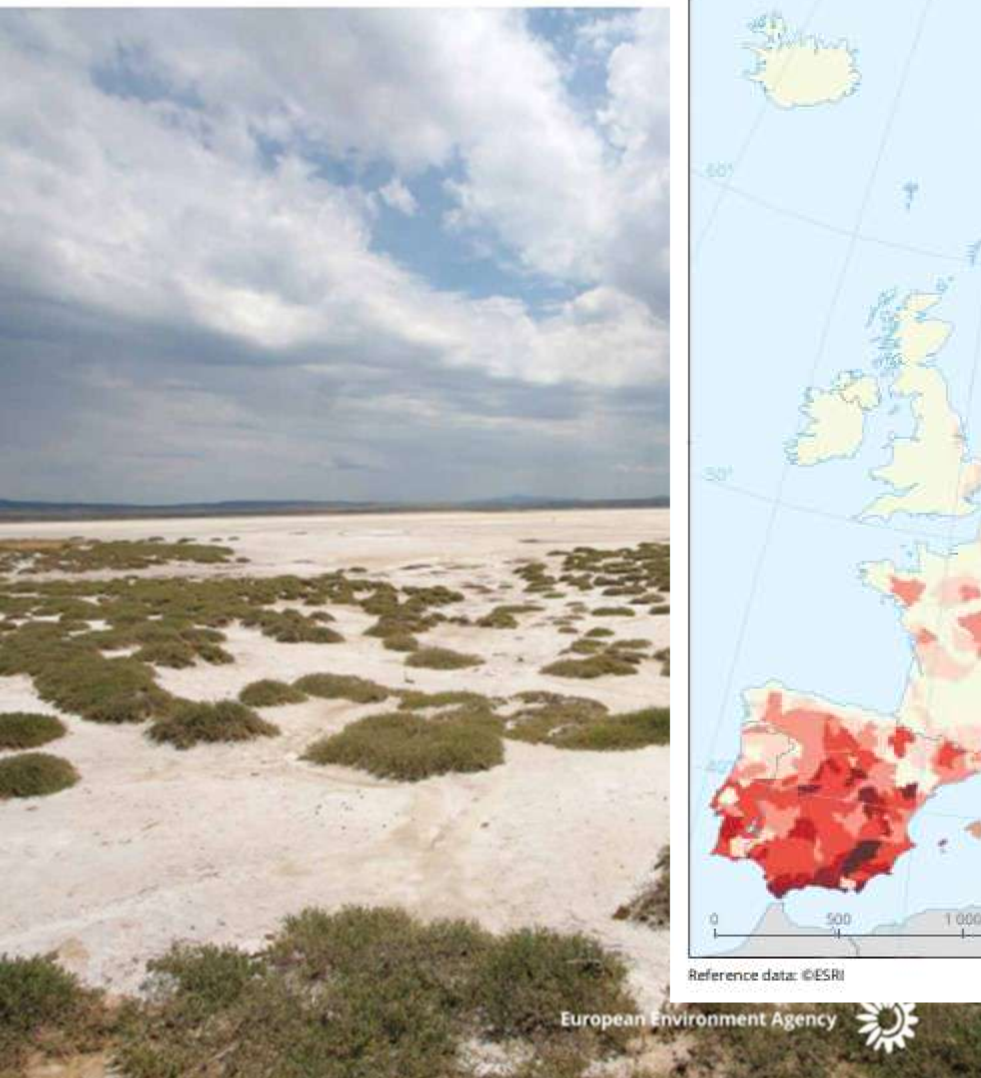
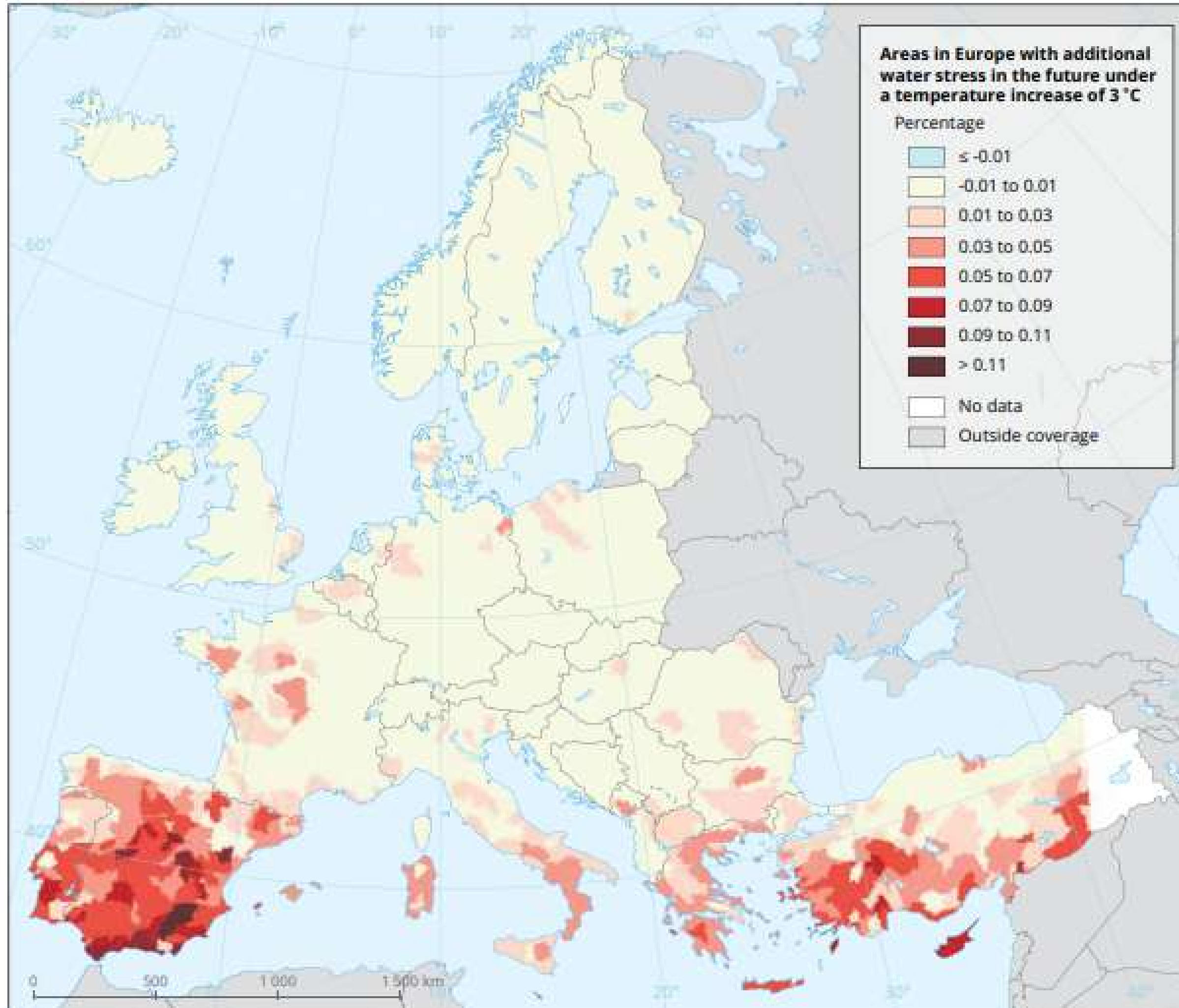
Water resources across Europe — confronting water stres updated assessmen



Map 5.2 Areas in Europe with additional water stress in future under a temperature increase of 3 °C



Reference data: ©ESRI

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Water resources across Europe — confronting water stress: an updated assessment

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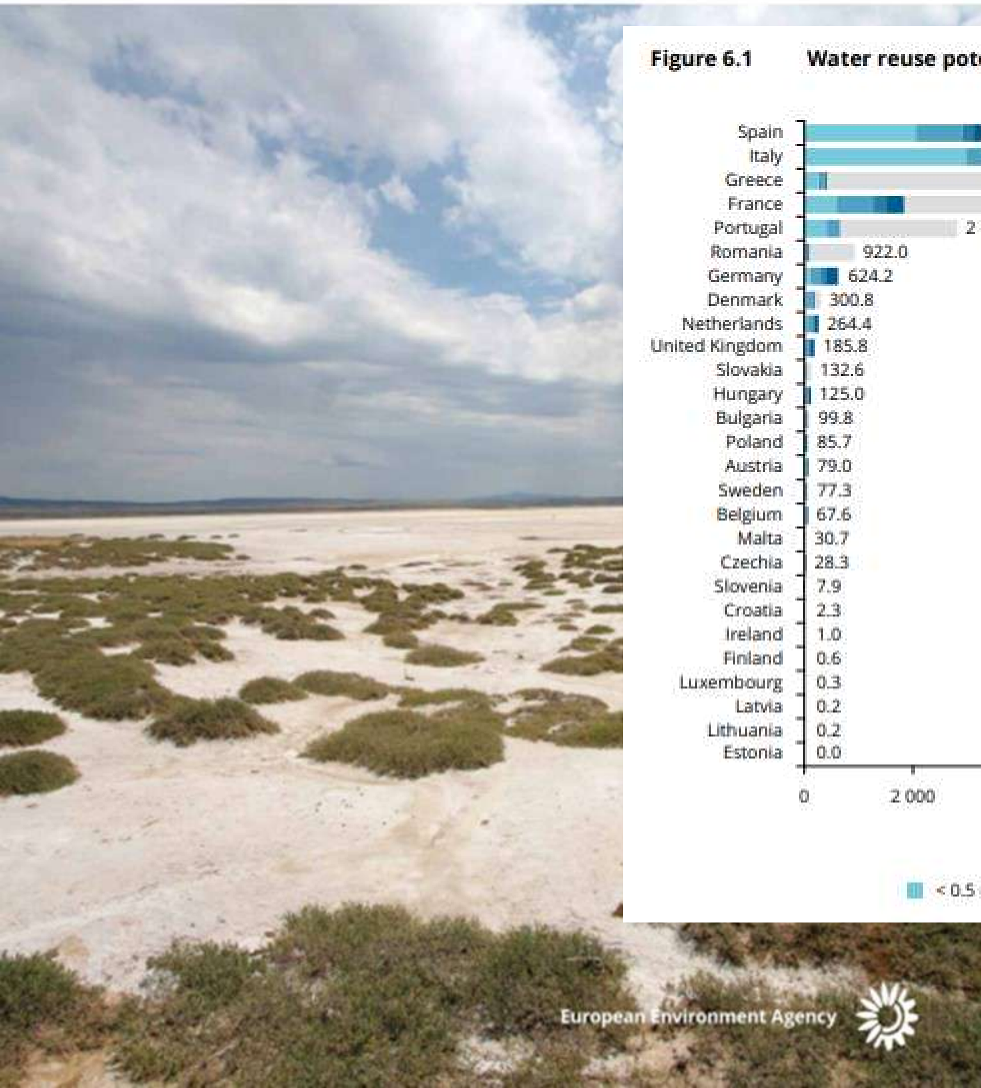
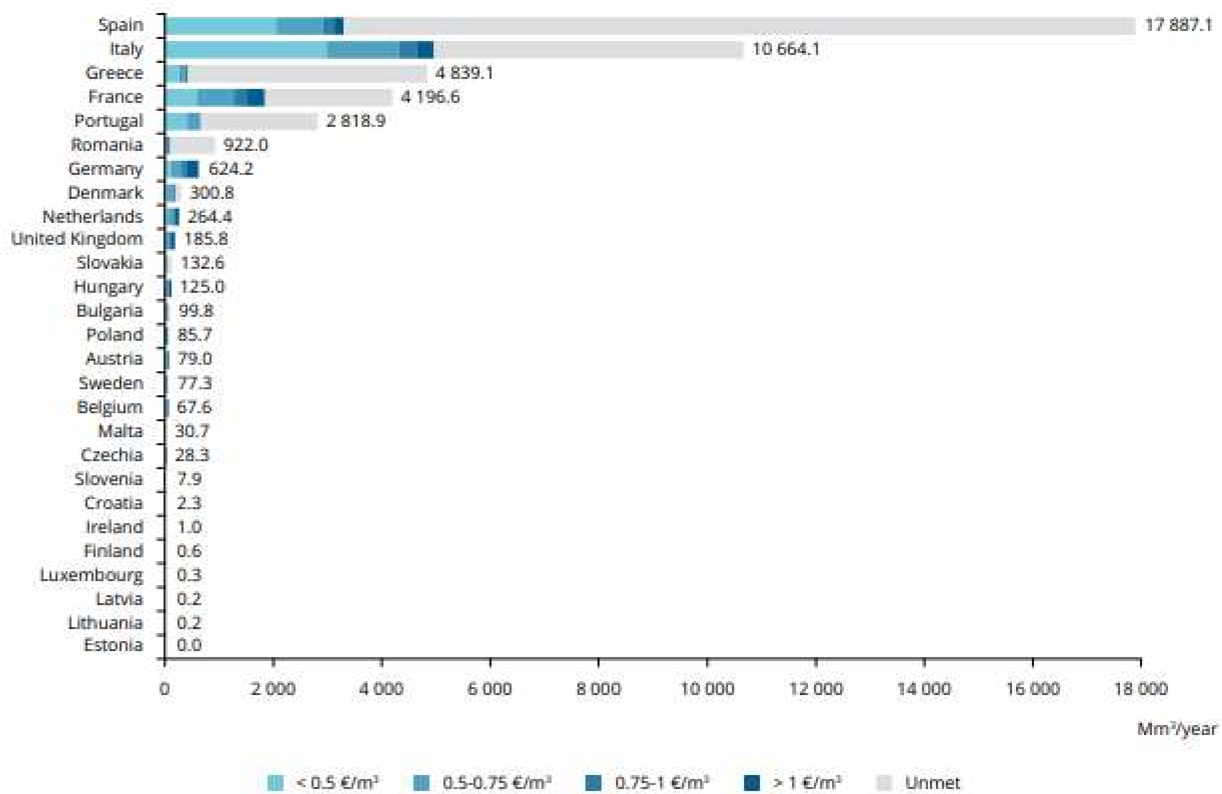


Figure 6.1 **Water reuse potential per EU Member State (Mm³ per year) for different levels of production cost**



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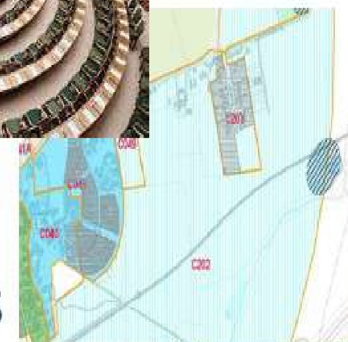
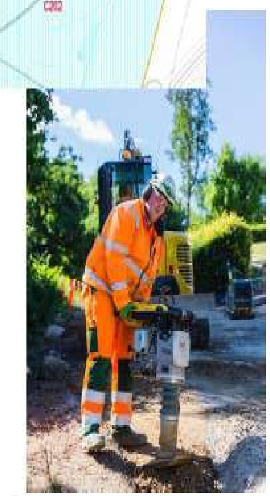
Regulatory Milestones

Coherent Danish water management

National regulation by the Parliament



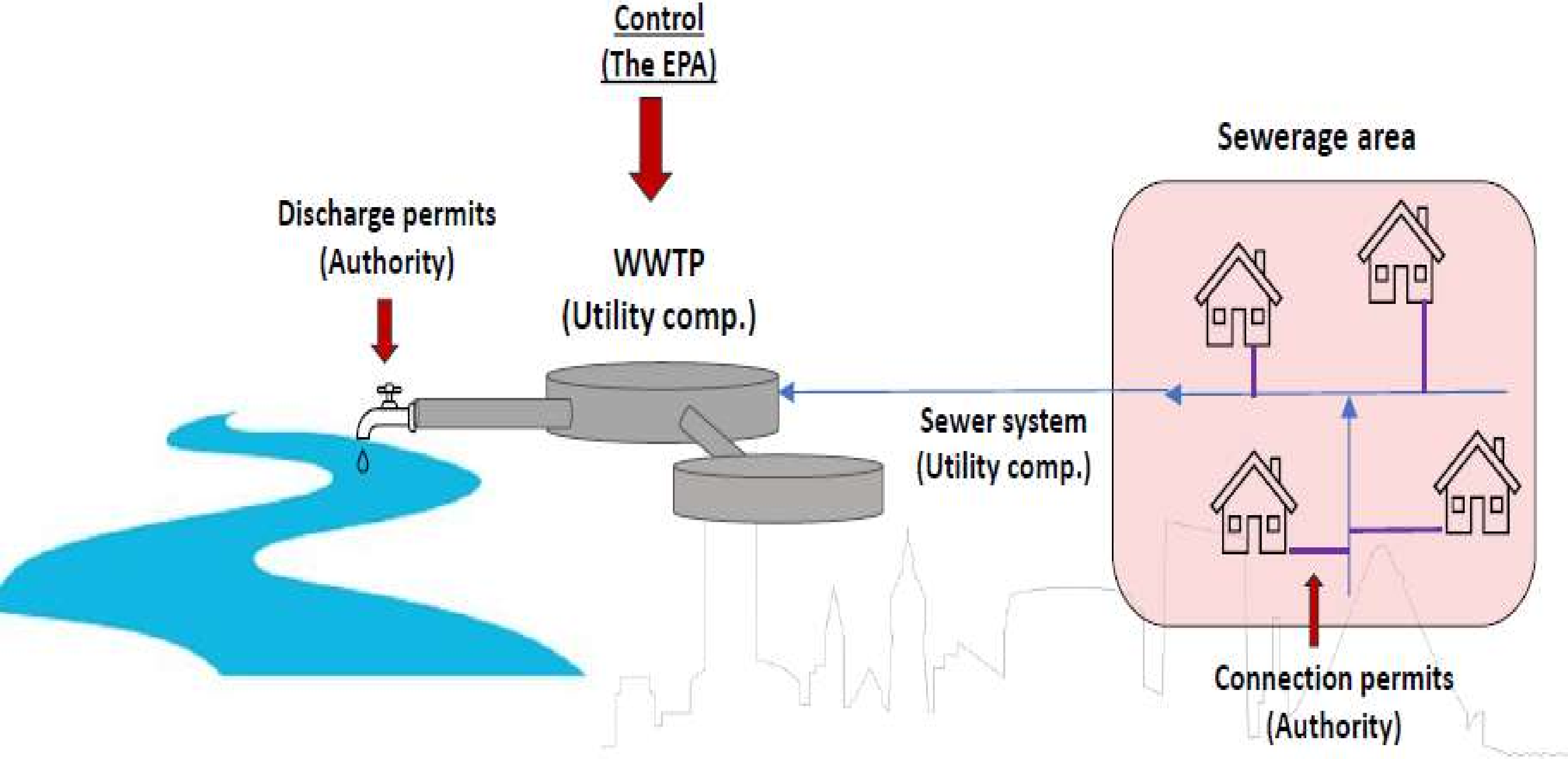
Planning and administration by the Municipalities



Operation by water utilities

Technology and consultancy, Private sector

Legislation and administration



The regulatory instruments

Incentives for enhanced performance and innovation

- ***1970-80's:*** **Environmental thresholds and quality standards**
- ***1990's:*** **Economic incentives : levies on discharges and energy comsumption**
- ***2000:*** **Water Framework Directive**
- ***2000-10's :*** **Corporatization, Efficiency requirements, economic benchmarking, environmental benchmarking**

- **+ Technology development support schemes**

Pillars of NRW regulation

1987: Environmental Protection Act

- Mandatory water metering (1996: water meters at all household connections)

1994: Non-Revenue Water Penalty Tax

10% threshold, after that utilities must pay approx. 1 Euro per 1000 L water leaked

2010: Water Sector Act

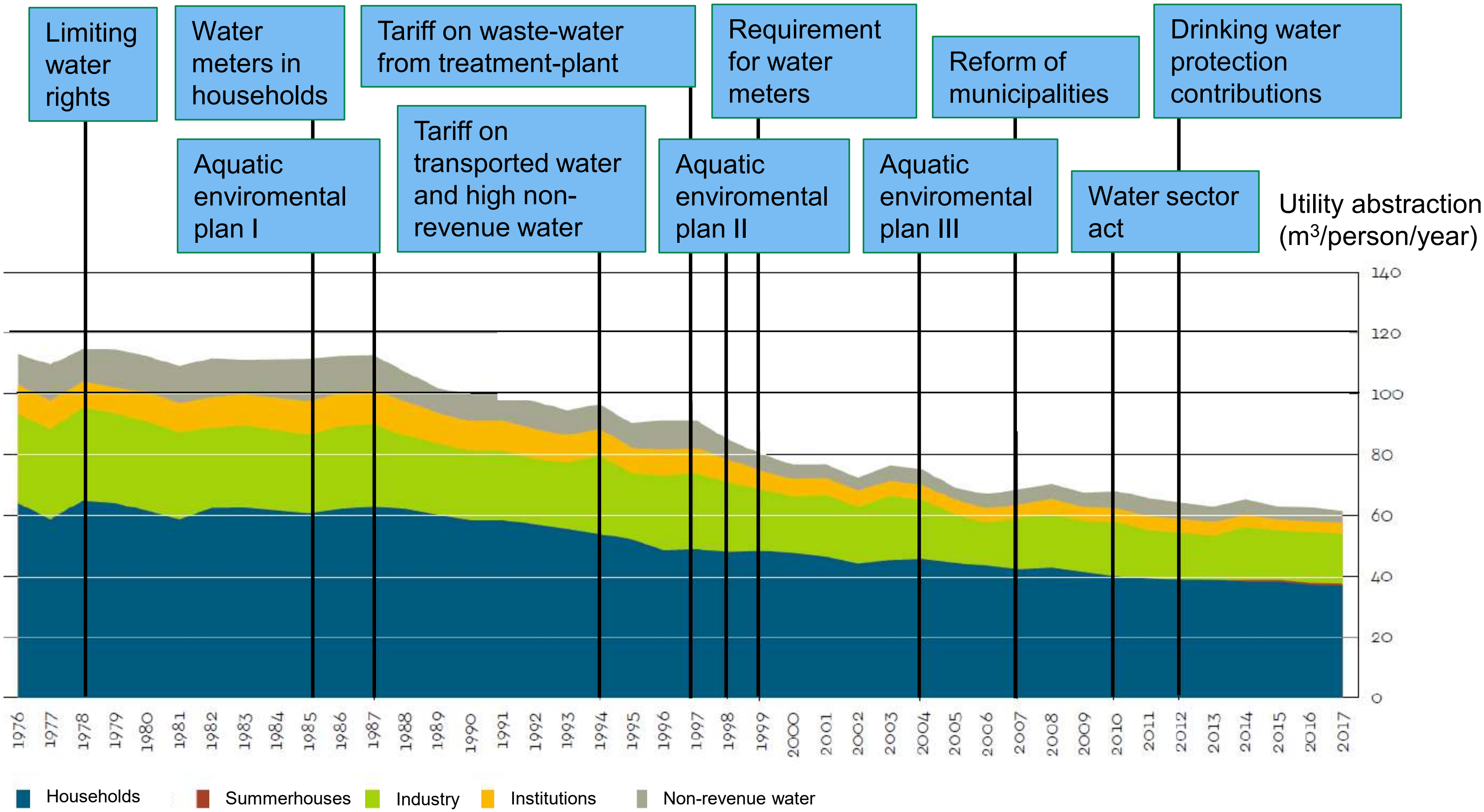
Economic efficiency requirements, corporatization

2021: Revised Drinking Water Directive

Reporting leakage/NRW on distributed water for larger utilities

Danish average, 5,51% NRW

Administrative tools to reduce water consumption



Based on DANVA, ”Vand i tal” – 2018 edition

Separation between utilities and municipalities in 2010

- **Municipal water and wastewater utilities were separated and utilities were to act as distinct entities with own accounting and balance sheets from 2010**
- **Independent entities with ring-fenced economies allowing for long-term economic approach**
- **Water tariff could no longer be used as a tool to fund other municipal projects (infrastructure, social, welfare)**
- **Increased possibility of benchmarking ”like units”**

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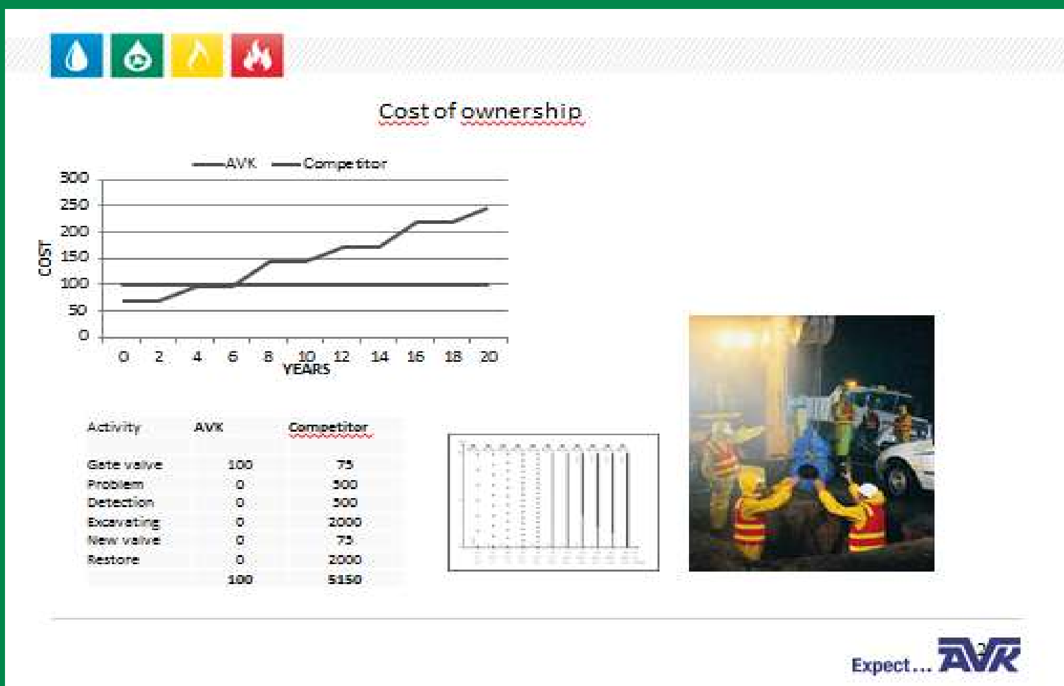
CAPEX vs OPEX



A market requesting low CAPEX at the expense of high long-term OPEX and high reinvestments costs is not economically viable for society

This IS a call for joining forces, but ALSO a call for taking on a long-term horizon in the business considerations.

Benchmarking of the water sector AND Water Sector Target (2020)

Based on data provided voluntarily by:

- **105 water supply companies**
  (75% of drinking water sold)
- **81 wastewater companies**
  (87% of wastewater received)

Danish wastewater sector expect to be:

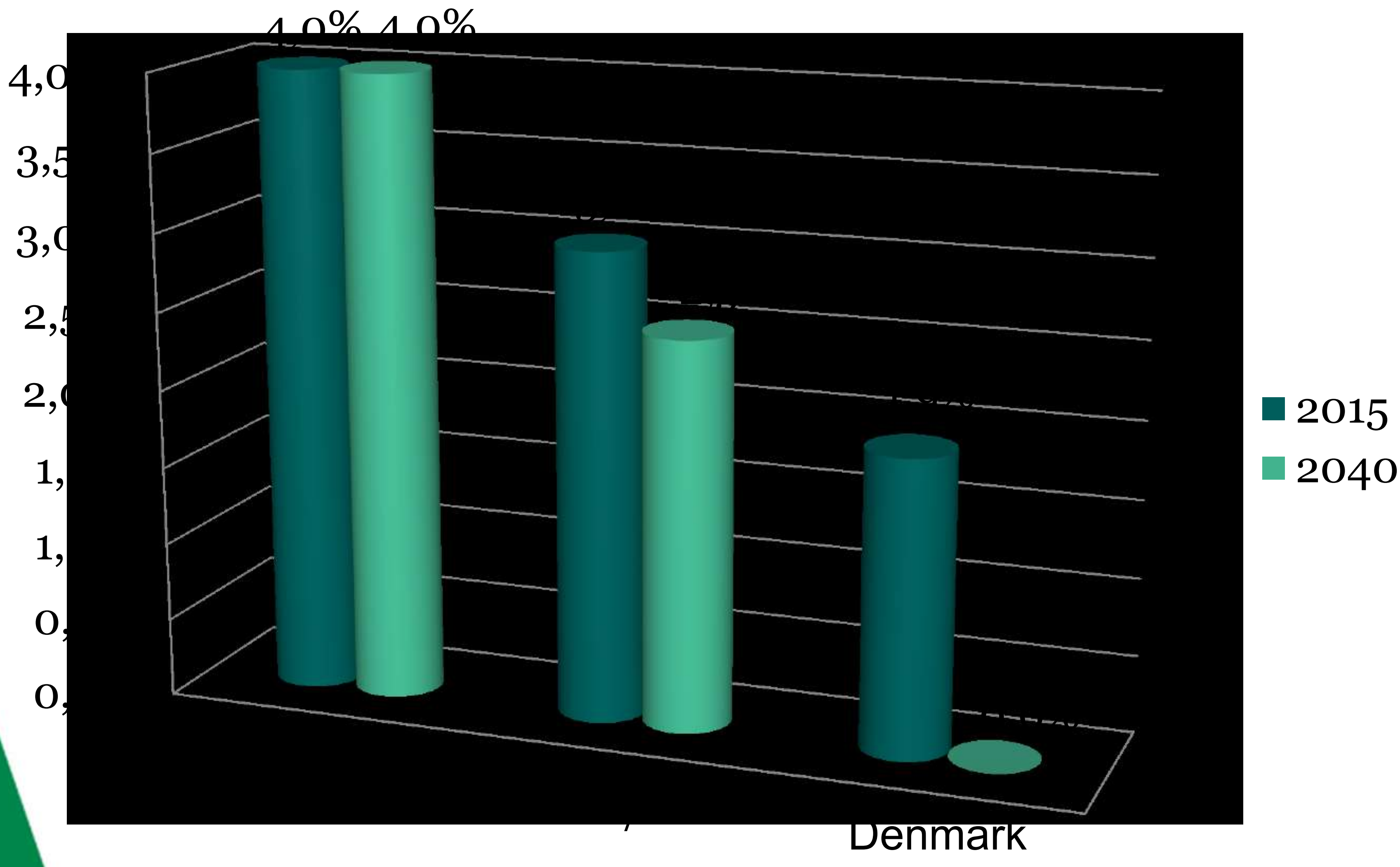
- **energy neutral before 2030**

The total water sector expect to be:

- **climate neutral before 2030**

Water supply sector is already climate positive

Water utilities' share of total electricity consumption

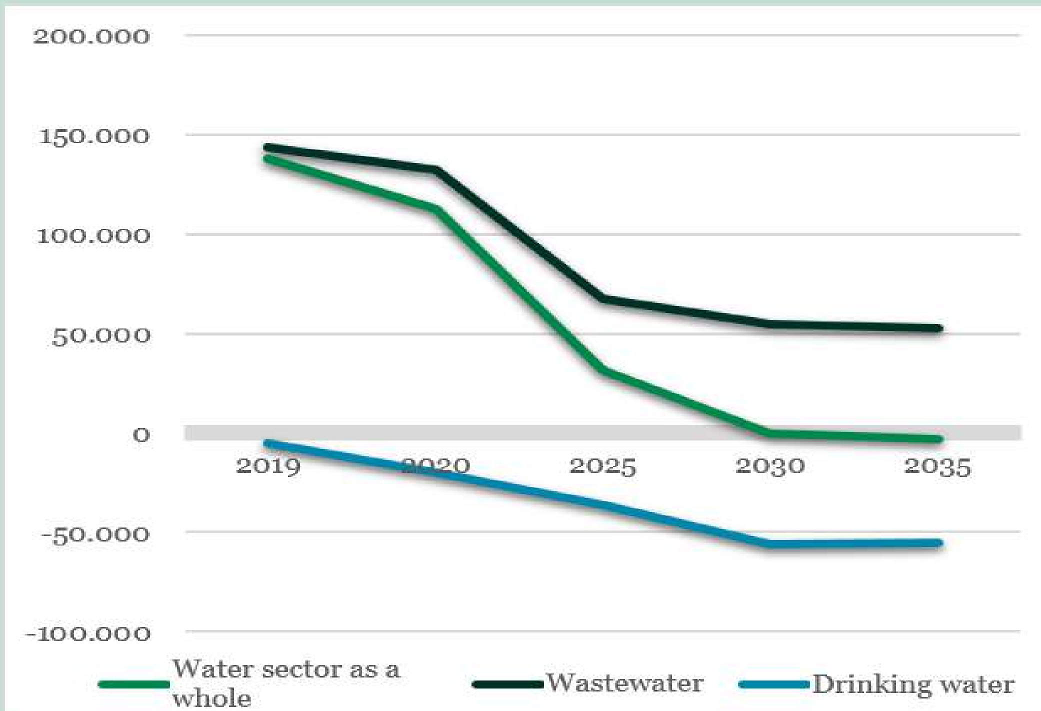


Anticipated climate foot print

FIGURE 4a. Anticipated climate contribution

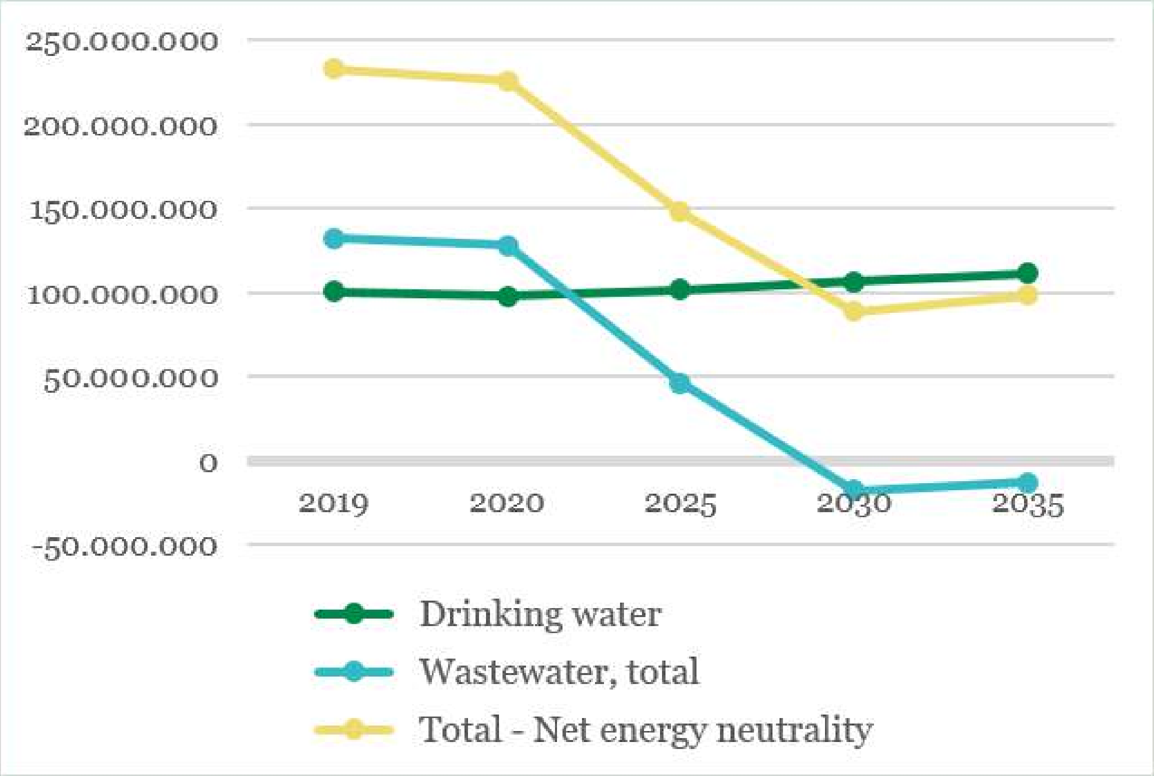
Reduction in nitrous oxide discharge into nature as a result of removing nitrogen from waste water not included

(CO2 equivalents, tonnes)



Anticipated energy consumption

FIGURE 1. Anticipated net energy consumption (kWh)



Emissions factors

Replace the right energy sources

Year	EF(Electricity), kg/kWh	EF(district heating), kg/kWh	EF(Oil), kg/kWh	EF(Natural gas), kg/kWh
2019	0.118	0.068	0.270	0.205
2020	0.111	0.059	0.270	0.205
2025	0.050	0.039	0.270	0.205
2030	0.012	0.032	0.270	0.205
2035	0.012	0.032	0.270	0.205

Climate gas emisssion from Waste Water treatment 2020

Management requires monitoring

	Ton CO2 Total
Emissions from Energy Comsumption	70.512
Methane emission - Biogas	7.250
Methane emission – Proces (Sewer Methan)	7.500
Methane emission - Septictanks	36.500
Emission of nitrogen - nitrous oxide emissions	15.917
Nitrous oxide emissions from treatment process	130.636
Climate gasemissions total - Waste water	268.315
Climate gasemissions total - Denmark	51.600.000
Waste Water - Procentage	**0,5%**
Nitrogen removed	-73.376

Approx. 3 percent

Approx. 60.000

IPCC & Danish EPA

Approx 300.000

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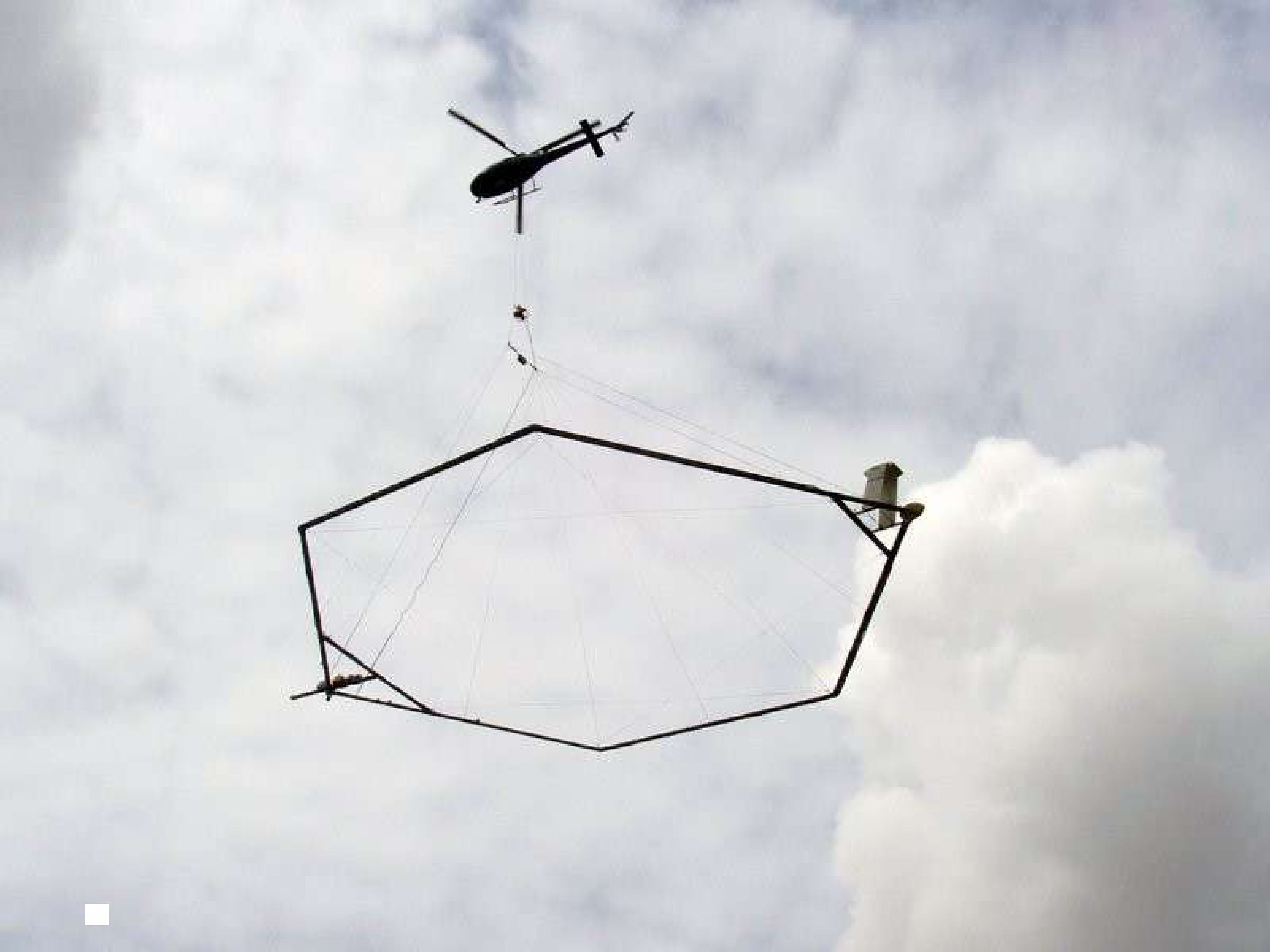
Achievements in the water cycle

Groundwater

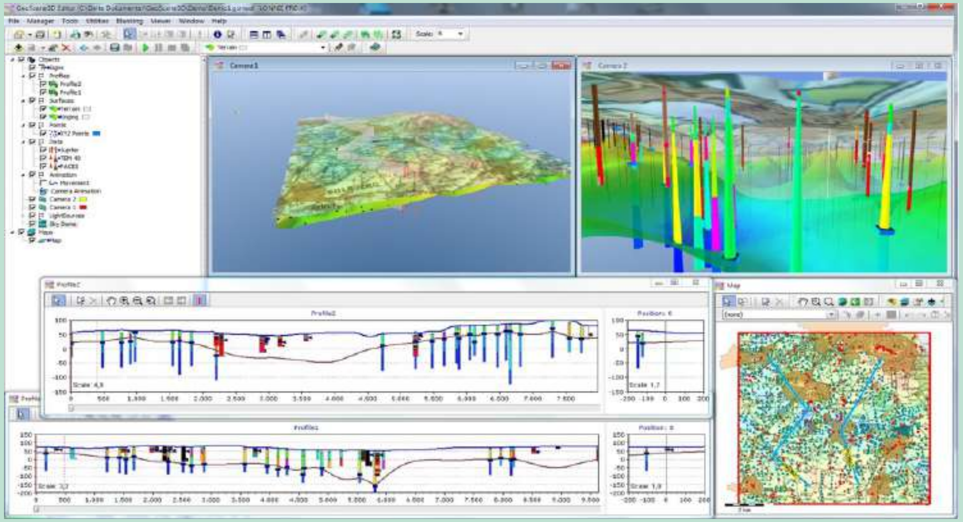
In Denmark we drink untreated groundwater

- 99% groundwater (almost no surface water, desalination etc.)
- Prevention rather than treatment
- Mapping and protection
  - Geophysical mapping methods
  - Geophysical database
  - World-class data processing tools and protocols
  - Innovative 3D geological modelling software



GAP

Groundwater Architechture Project v. Stanford University, California



The GAP Project has developed a new data management system, which will give input to multiple point geo-statistical algorithms for hydro-geological models. Methods will be developed to quantify uncertainties in 3D hydro-stratografic models. 3 pilotprojects will deliver data froum groundwater mapping in California.

Partners: I-GIS, Rambøll A/S, Aarhus Universitet, Stanford University.

Budget: Total 14 mio. kr. MUDP: 4 mio. kr.

Time: 2018-2020

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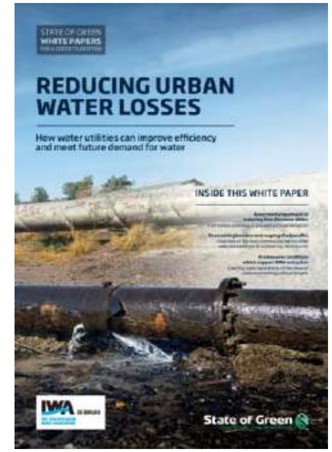
Achievements in the water cycle

Water Leakages / NRW in Water Distribution

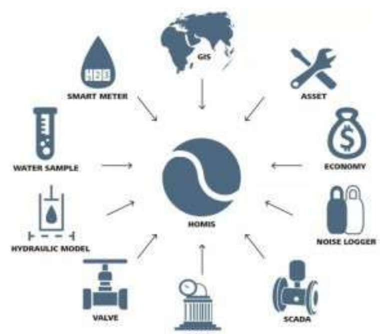
5. september 2022

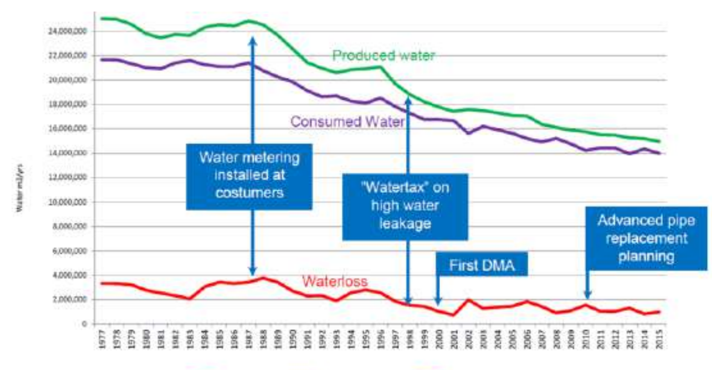
Two main achievements based on comprehensive Automatization: Water Leakage reduction (losses av 7%) and energy-efficient WWTPs



Pressure Zone Management – Highly improved operations and maintenance

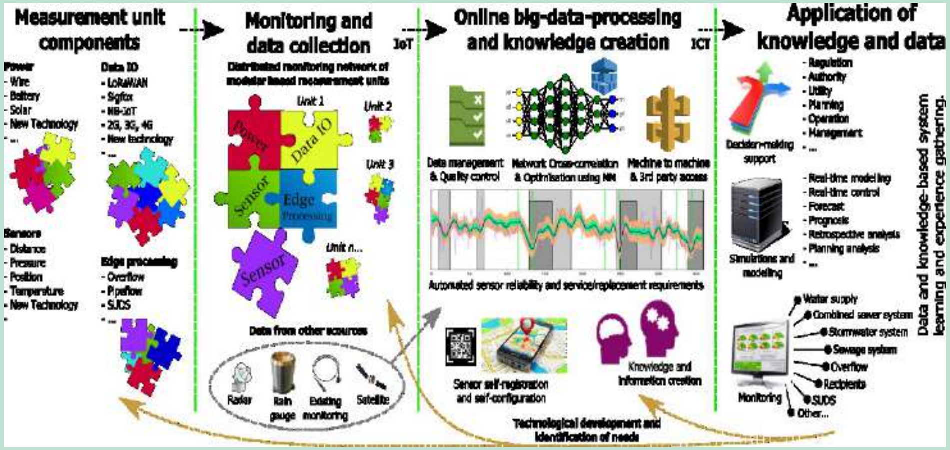
Leakman project – a showcase for water leakage reduction





OrEO

Cost-efficient Monitoring of Spill-overs and LAR-solutions with Smart Meters



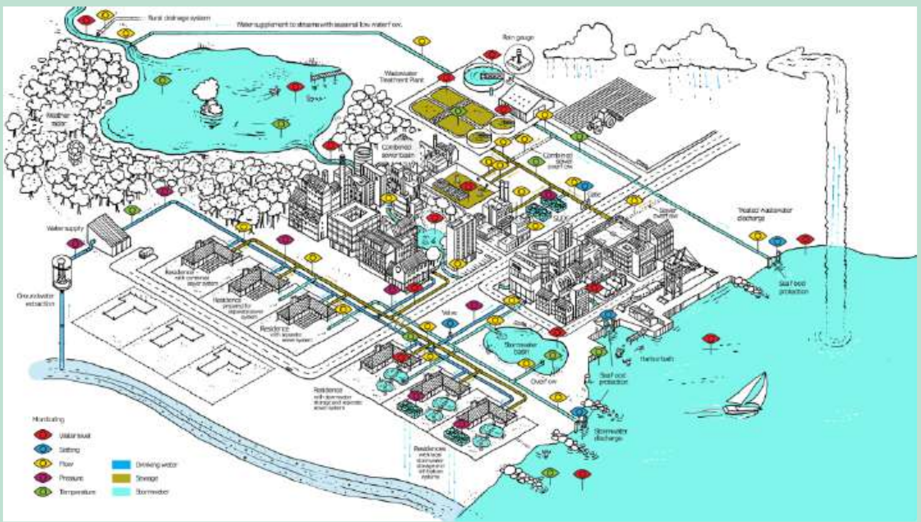
The Objective of the project was to develop a solution, which enables monitoring of spill-over constructions and LAR Solutions by use of Smart Meters. Data was connected wireless via IoT (Internet of Things)-Technology and online cloud-based IKT (Information- and Communication) Technologoy for realtime monitoring of the response of the infrastructure to various situations.

Partners: Informetics Aps, Aarhus Vand A/S, Aalborg Universitet, Montem A/S, Informetcs Aps.

Budget: Total 6.709.192 mio. kr., Contribution from MUDP: 4.198.241 mio. kr.
Period: 2018-2020

DONUT

Intelligent monitoring and management of the full water cycle



The aim of this project was to develop and commercialize a solution, which generates data from the entire water cycle in a cost-efficient manner and convert these data to information and knowledge, which utilities and authorities can use actively in the their decision support systems.

Partners: Aarhus Water Utility, Water Center South, Aalborg University, Montem A/S, Informetics Aps, Aarhus Municipality

Budget: Total 23,6 mio. kr. IFD: 14,6 mio. kr.
Period: 2018-2021

https://innovationsfonden.dk/da/presse/dansk-vandteknologi-i-front-med-intelligent-styring-og-overvaagning

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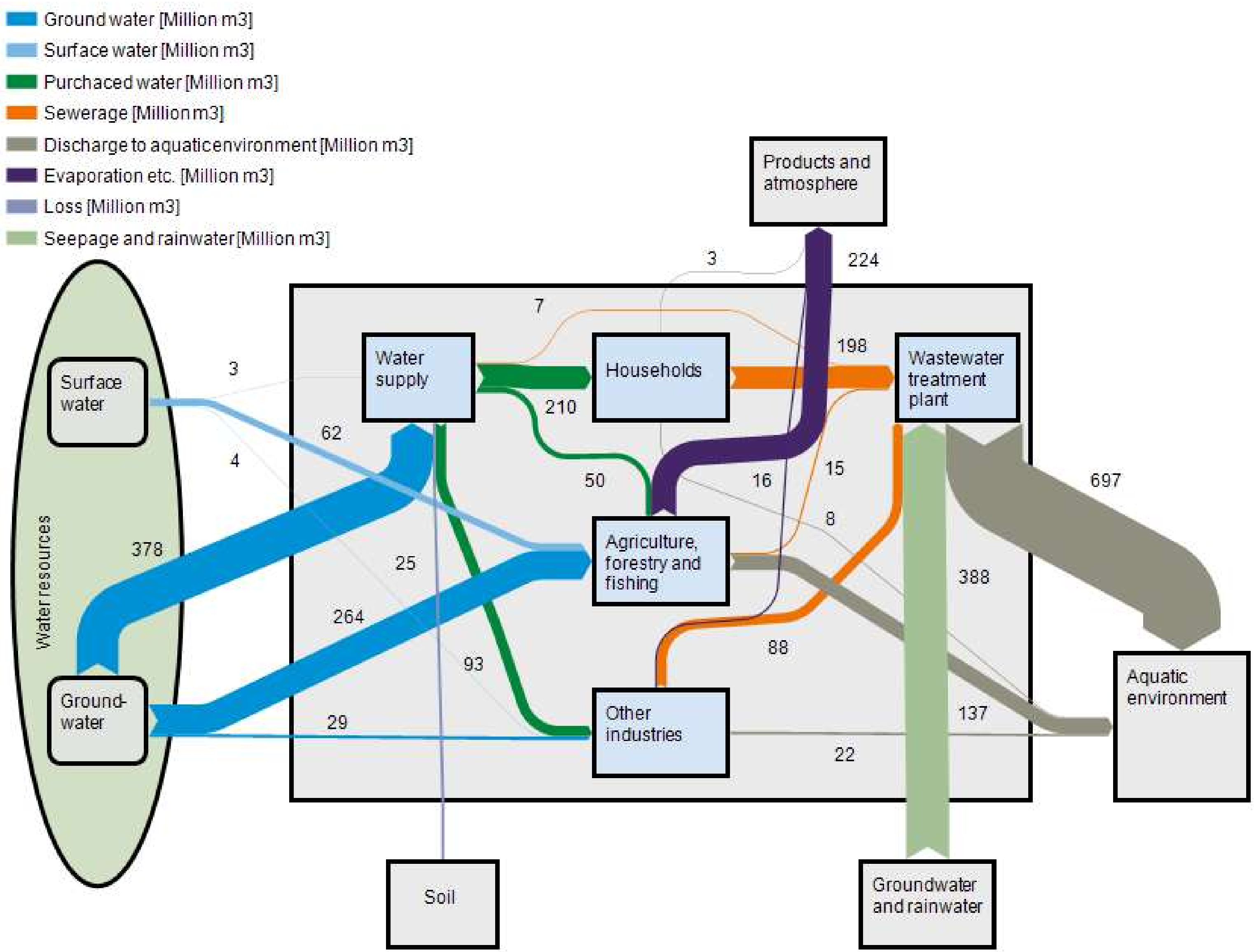
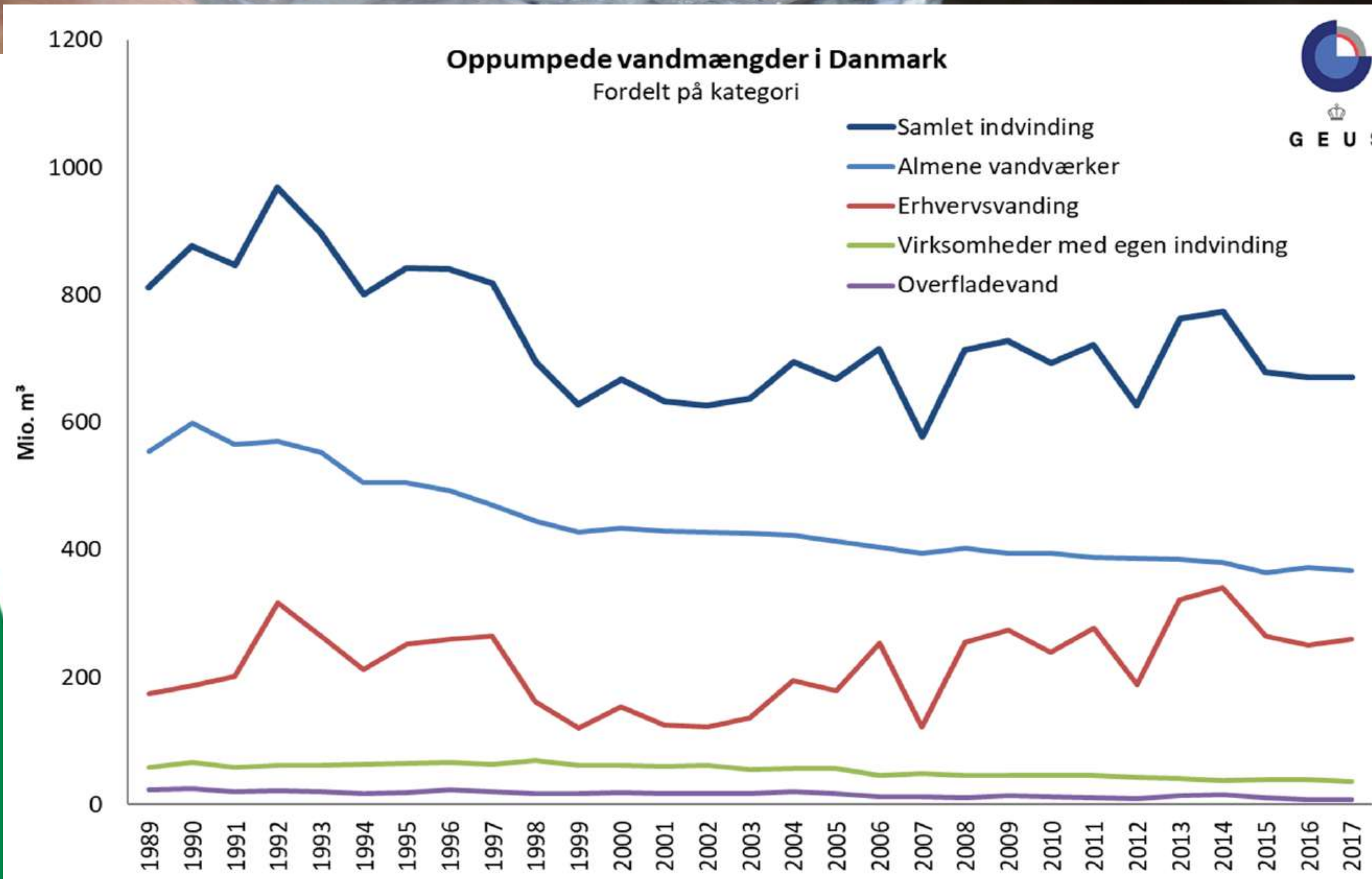
Achievements in the water cycle

Water Use Efficiency

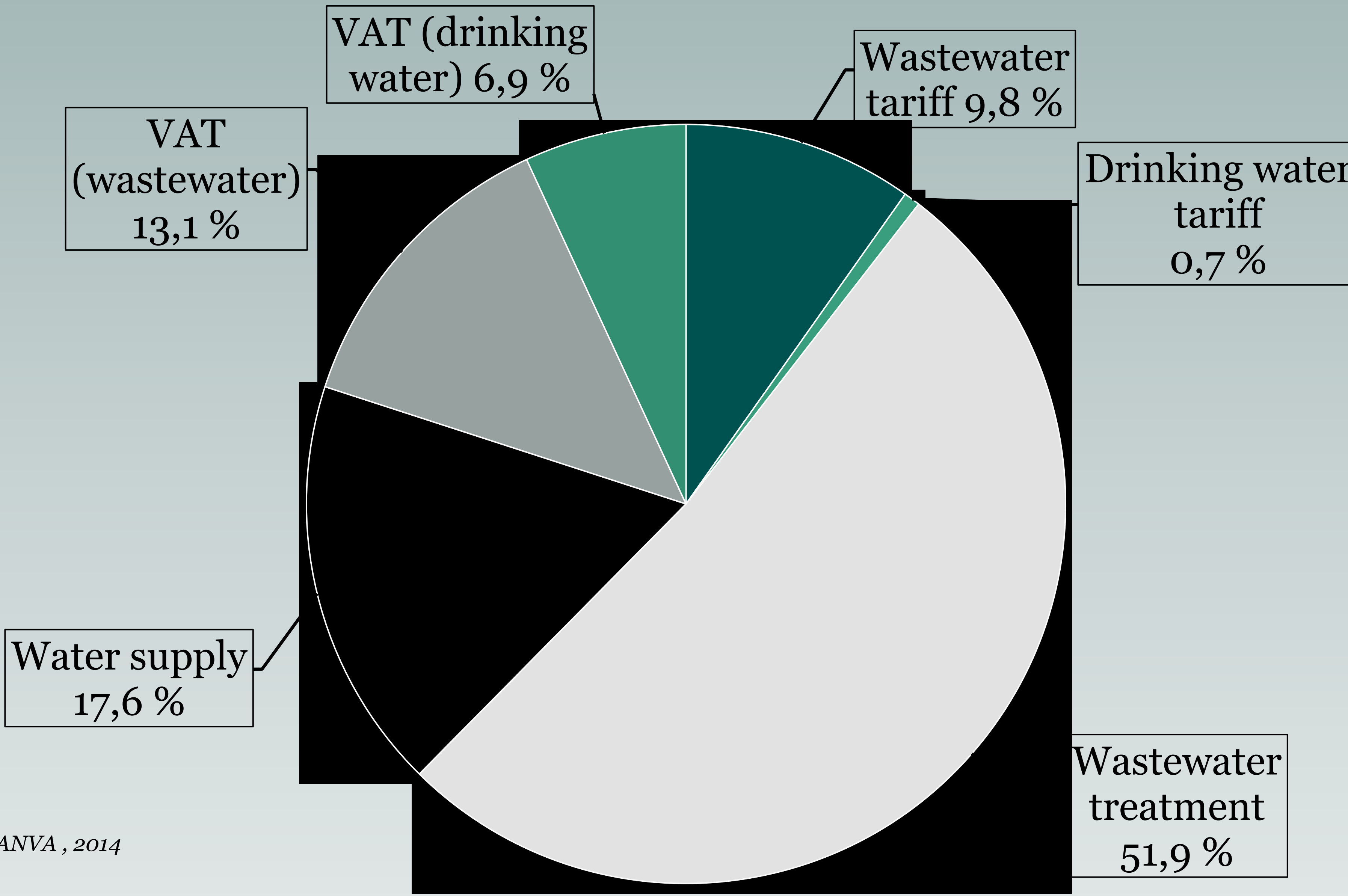
Water flows - 2016





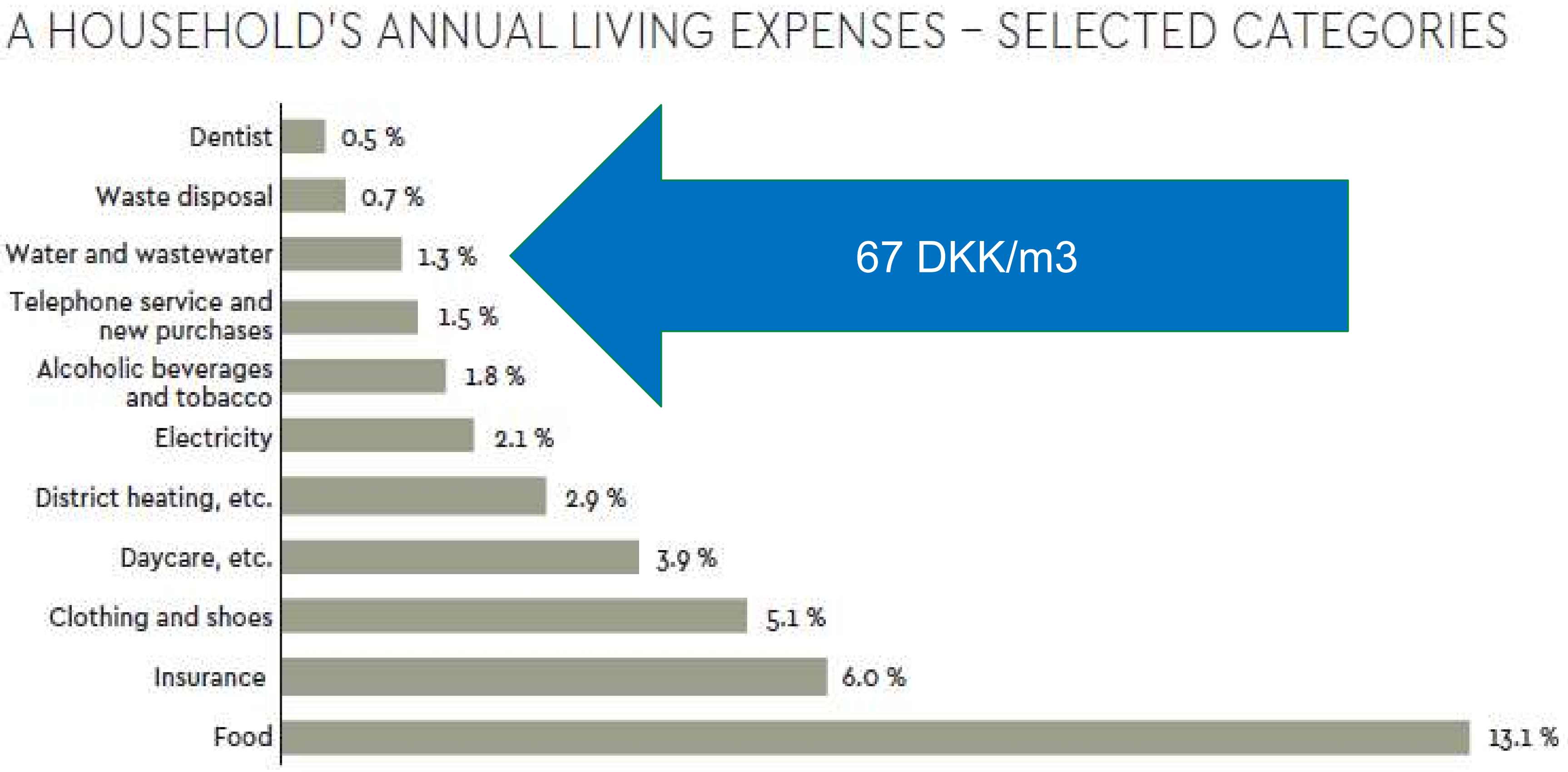
Reference: GEUS, 2019, Grundvandsovervågning 1989 - 2017

Composition of the water price

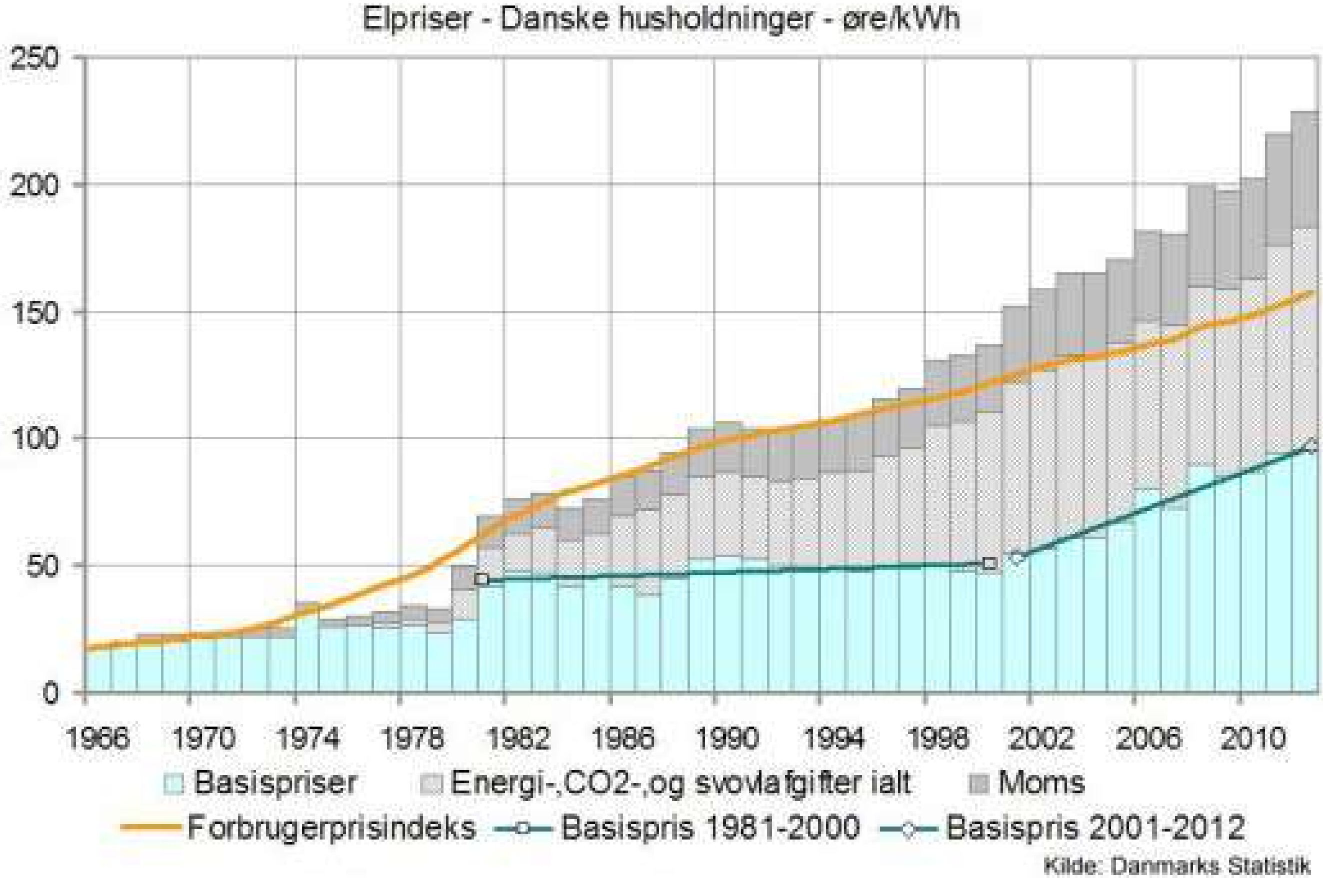


DANVA , 2014

Clean water comes at a price

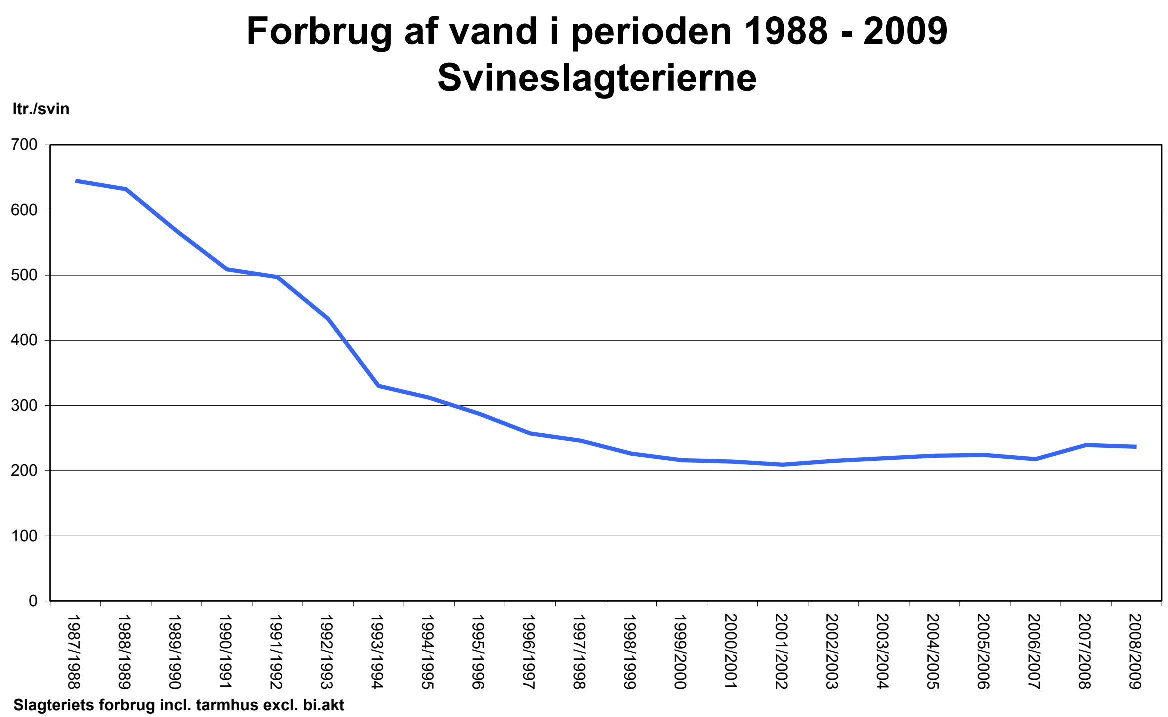


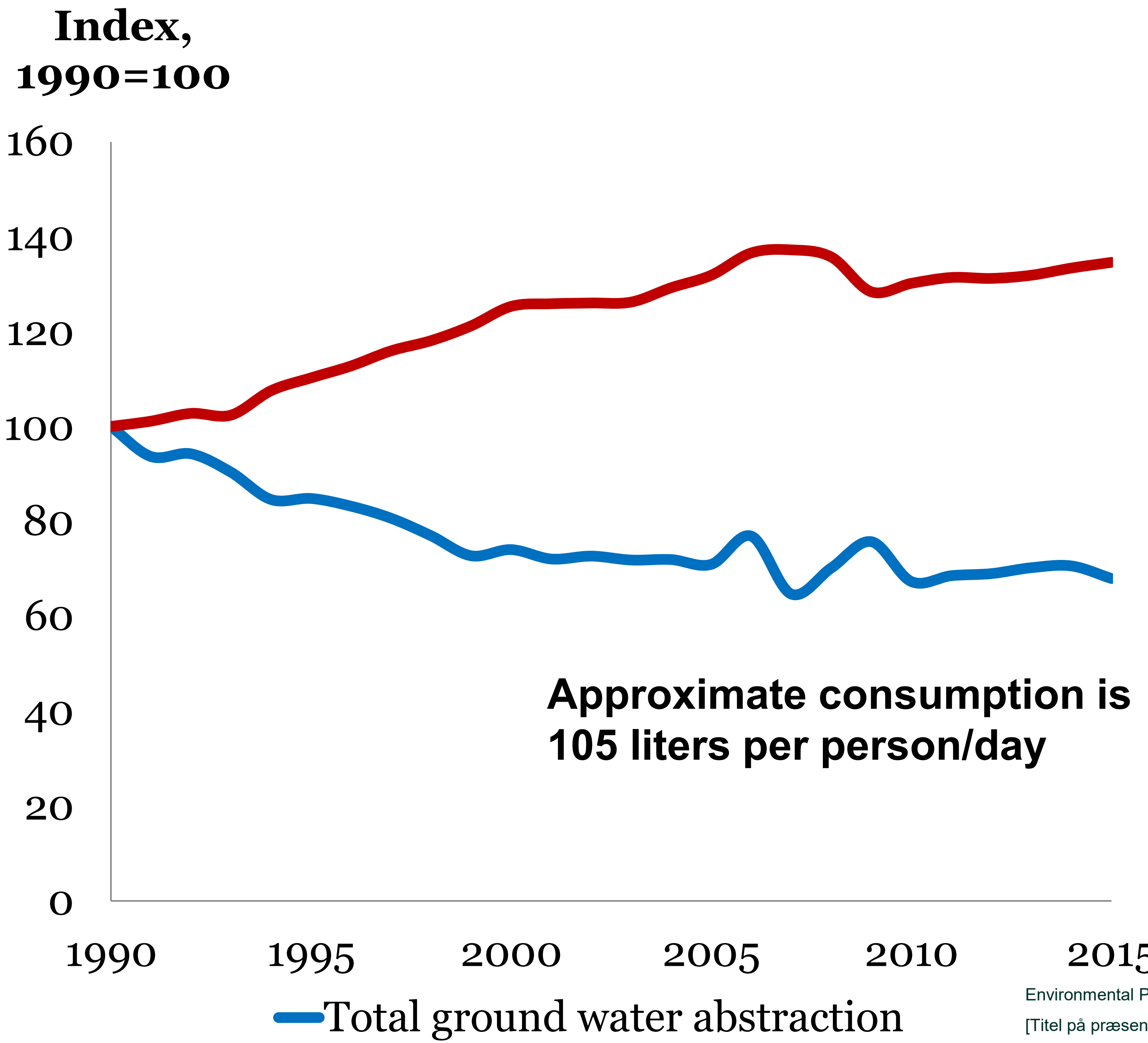
A key driver: energy prices



Water Consumption at Pig Slaughteries

Danish Ministry of the Environment




Index,
1990=100
160
140
120
100
80
60
40
20
0
1990
1995
2000
2005
2010
2015
Approximate consumption is
105 liters per person/day
Total ground water abstraction

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Achievements in the water cycle

Wastewater

5. september 2022

From WWTP’s to WRRF’s – the Danish case

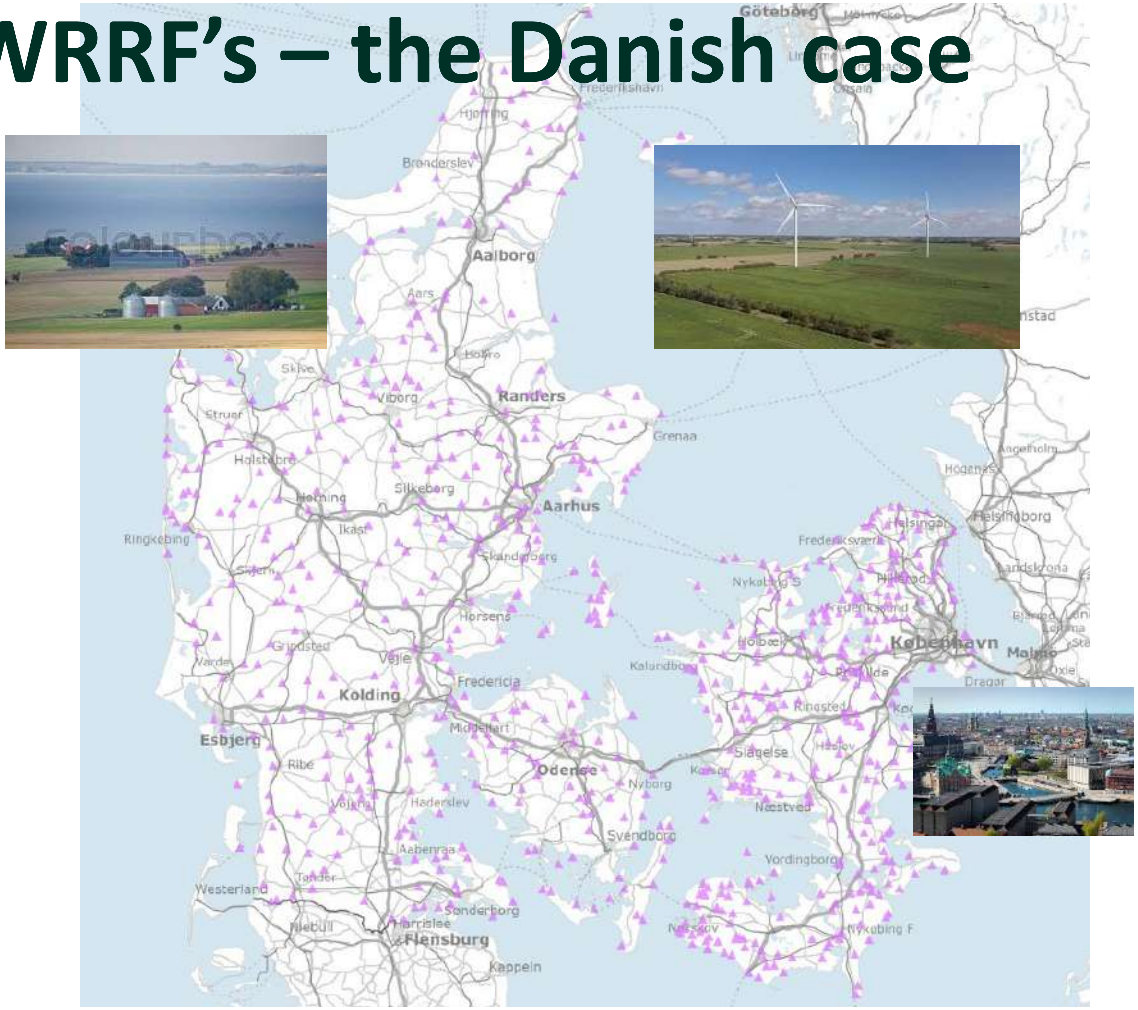
1989: 1.980 WWTP’s > 30 PE

2018: 634 WWTP’s > 30 PE
(746 plants in total)

Total WW discharges : 614 mill. m^3

35 largest WWTP treat 50 % of total wastewater nationally
Total discharges:
N: 3100 t
P: 300 t
Org. Matter: 2200 t.

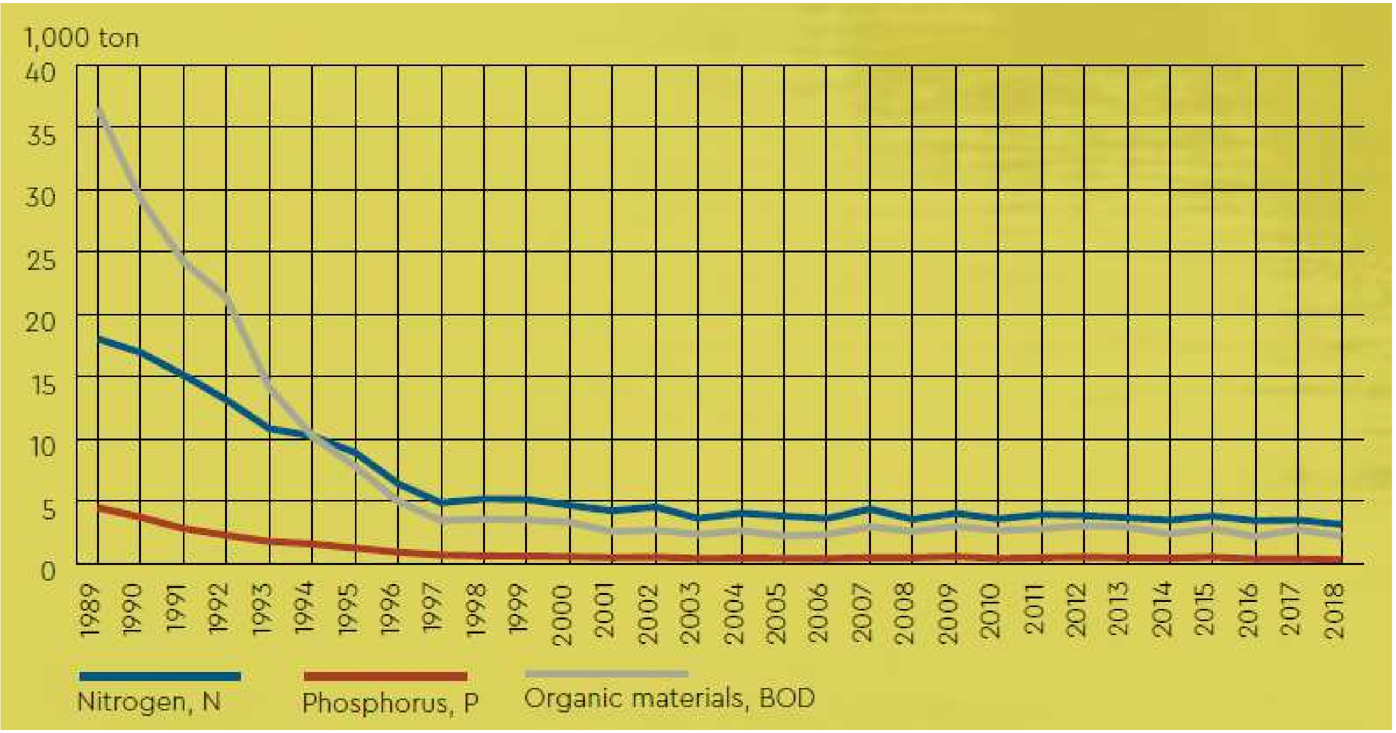
2020:
Avg. energy selfsufficiency rate: *70%*



Territory of Denmark: 16,580 sq miles (42,943 km2)
(1/10th of California)
Denmark 2020: 5,6 mio inhabitants

Late 1980's: <u>thresholds</u> on Nitrogen, Phosphorus, Org. matter.

Results: 80-90 % reduction in discharges



1990's : Levies on discharges (N, P, Org matter) and energy consumption

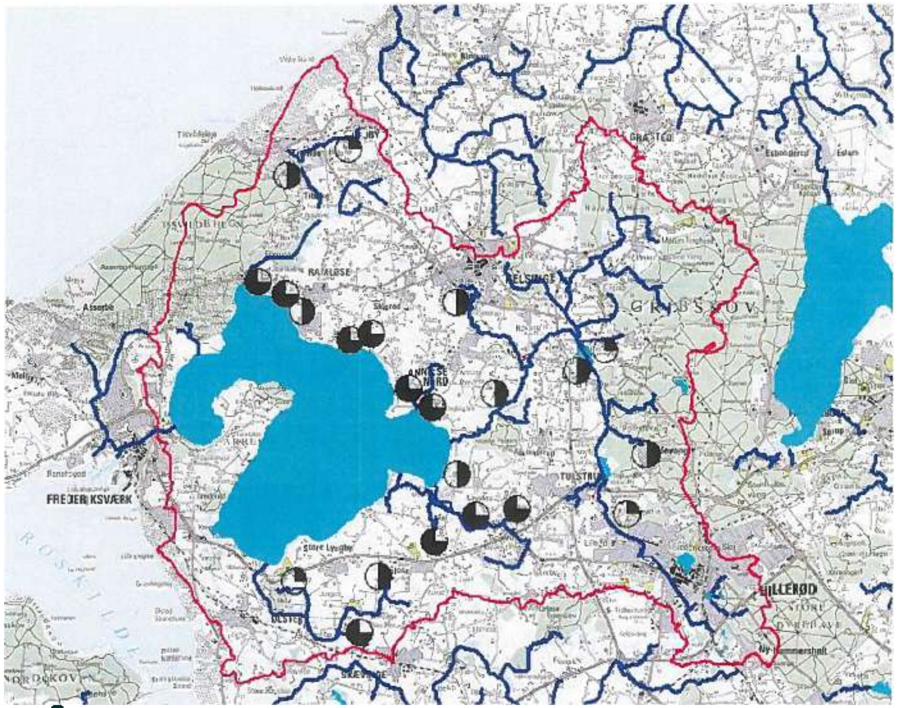
Results: 99+% WWTP's have biological treatment

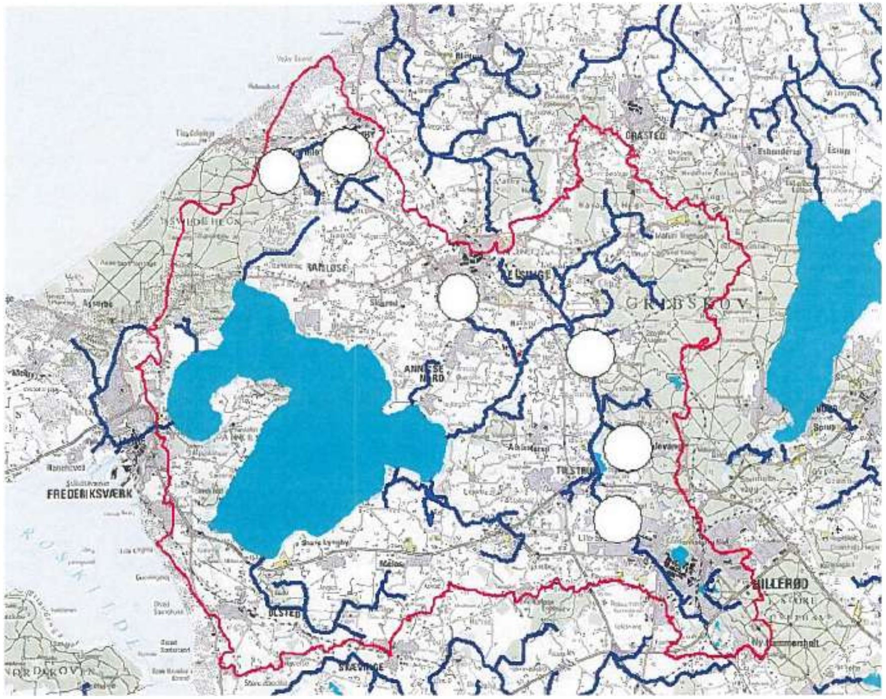
Focus on energy consumption throughout the waste water sector

3 Action Plans 1987-1992

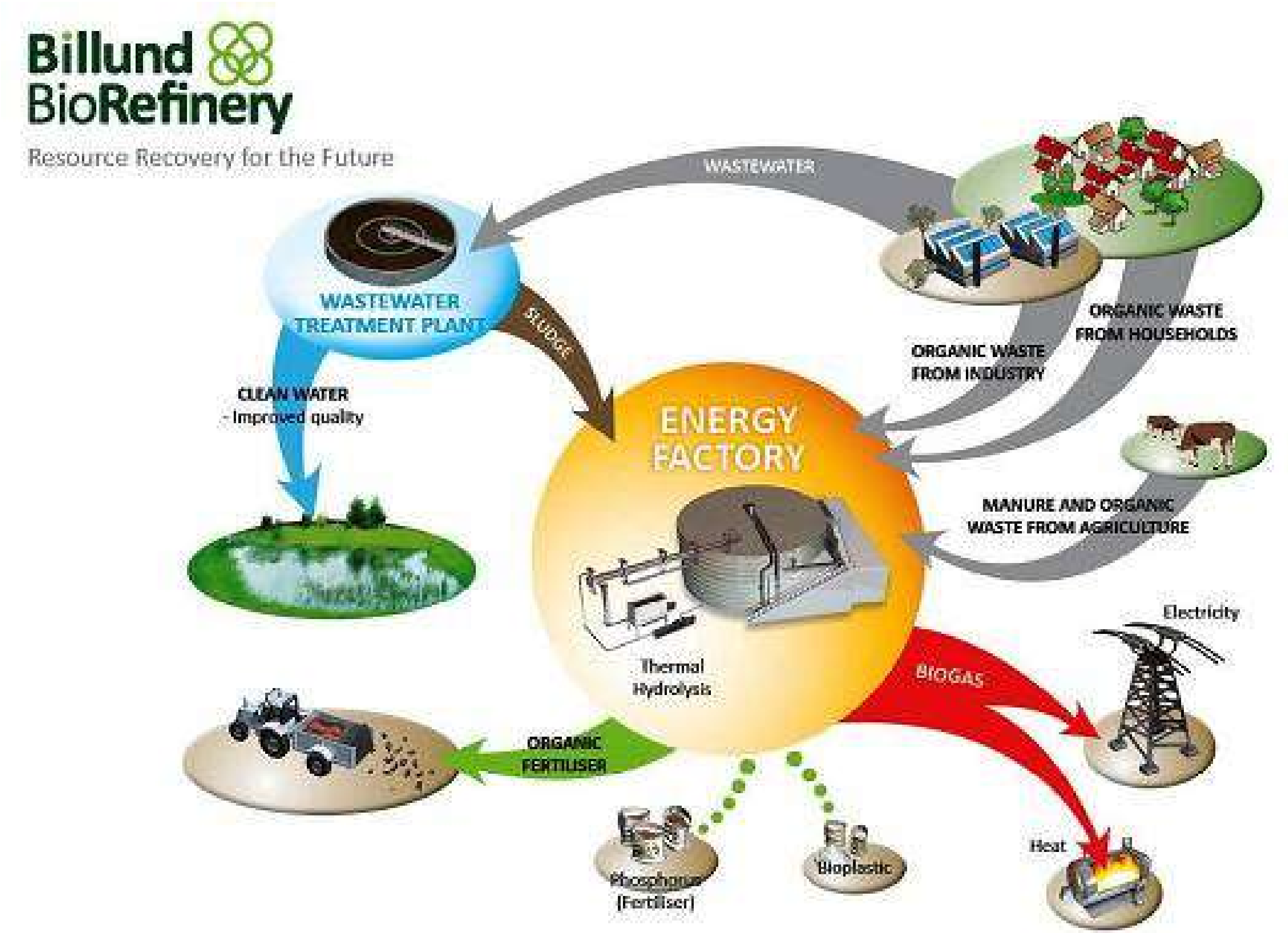
Substantial investments in WWTPs; Centralisation / Technical Consolidation; Biological treatment

Lake Arre catchment: From 20 to 6 WWTPs





From WWTPs to Energy Factories



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Achievements in the water cycle

Digitalization

5. september 2022

Digitalization – three distinct levels

Smart Water - Significant Opportunities and Potential for Better Results and Highly Improved Efficiency - Major Challenges

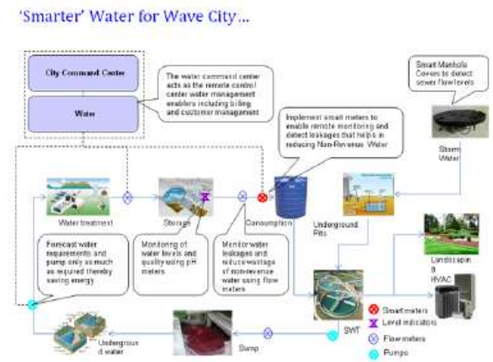
- **Increased Efficiency, Increased Speed, Improved Understanding, Better Performance, Better and more Precise Results**

- **Increased automation, improved analysis, AI solutions Improved Asset management, Field Staff Management Operations and Customer Services**

- **Foundation for Increased Effectiveness, more data for modelling, scenarios, planning, monitoring, evaluation,**

- **Leakage Reduction, Drinking Water Quality and Improving Health, Reducing pollution events**

- **Towards Integrated Solutions and Increased Effect; May lead to change of roles and responsibilities! Innovation based on partnerships.**



LOGIN REGISTER

bluefield RESEARCH

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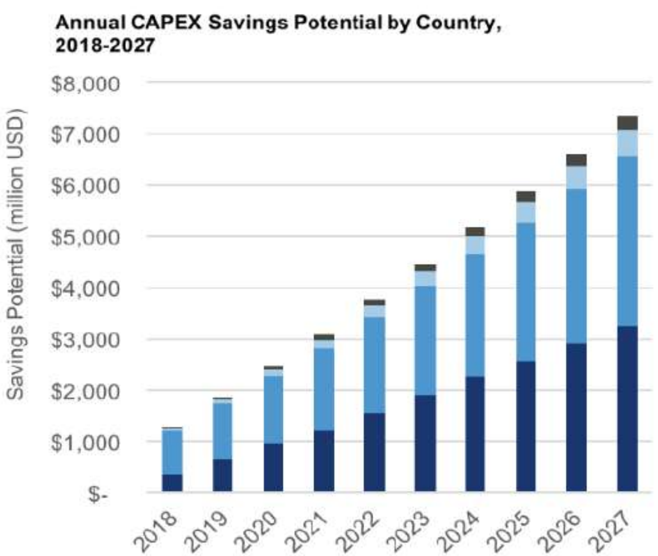
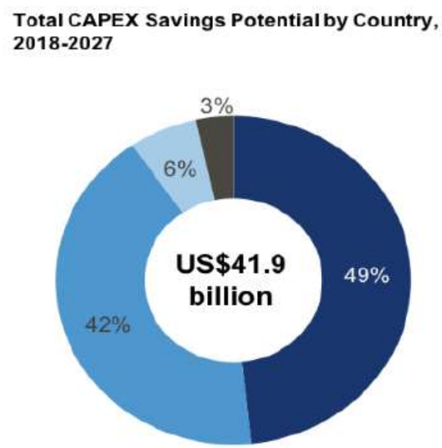
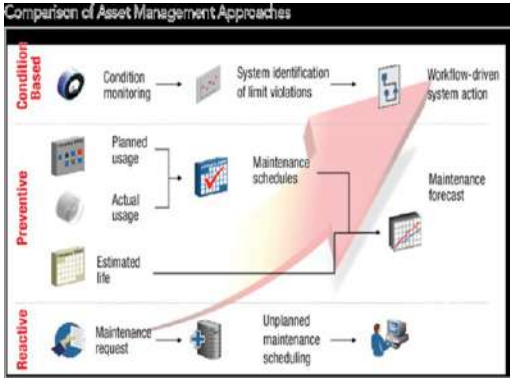
Utilities in the U.S., Canada, Australia, and Europe (representing 31 countries) currently manage US$2.9 trillion in water, wastewater and stormwater assets, which provide critical infrastructure services to over 822 million people, globally. Bluefield's forecasts indicate that advanced asset management solutions will save these utilities US$1.2 billion in annual CAPEX savings in 2018 and scale to US$7.3 billion in annual savings by 2027.

Exhibit: CAPEX Savings by Country, 2018-2027 (Annual and Total)





European Union - 28 | United States | Canada | Australia



Savings 0,3-0,7% of Assets Value

Source: Bluefield Research

arch.com/

Digitalization

Main phases of Digitalization in the Danish Water Sector:

*** Automatization of Proces Management at Utilities: significant results reg optimization of resources use**

*** Sector-wide dialogue reg Digitalization including utilities, business, research and authorities, led by Danish EPA: catalogue of 25 ideas for new initiatives**

*** A number of development projects, financed by Government Programs or Utilities/Companies own investments: new concepts and solutions reg Proces Management at Utilties and Industries and Environmental Quality of recipients, eg. Manmagement of Overflows**

*** Environmental Data Management setup: the Danish Environmental Portal**

*** Increased focus on Asset Management**

*** Recently, more focus on AI applications**

The Digitalization Value Chain – An entire Ecosystem

System Boundaries for data-generation
- Water-cycles
- Authorities
- Utilities
- Plants

Monitoring Equipment, drones of sufficient quality
- Sensors
- Drones
- Robots

Data Quality
- Compatible across silos
- Format, frequency, intensity
- Accessible

Tools, Tech Solutions
- Analysis
- Modelling
- Prognosis
- AI

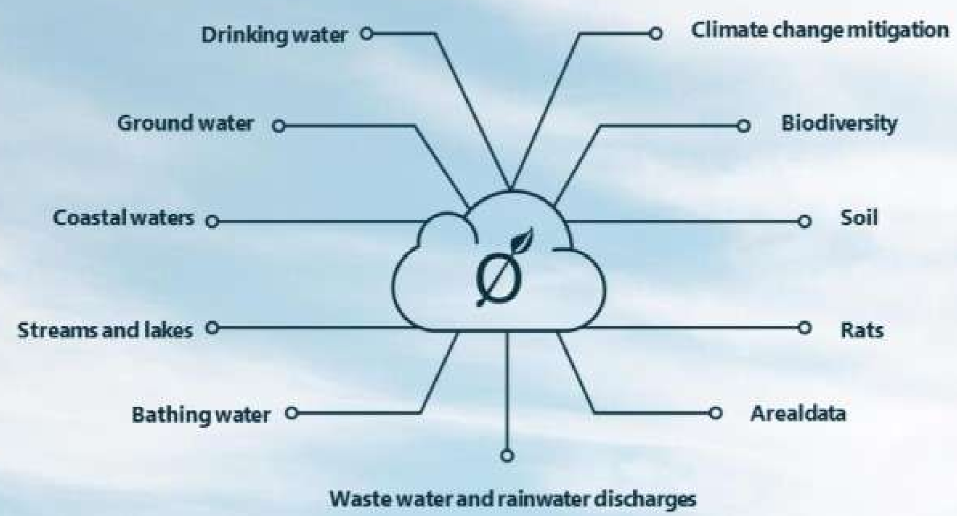
Beneficiaries
- ”The Challenge Owners”
- Digital Competences
- Financial Resources
- Costs Benefit Assessments

Framework Conditions
- Incentives
- Pricing; Water, Energy

System Boundaries
- Management
- Monitoring
- Planning
- Operational

The Environmental Portal -

Nationwide data on the natural environment – service to citizens, companies and regulators



150
organisations contributing data

4.000
persons producing data

Over 1 mio.
Updates of data yearly

5,7 mio.
yearly access by users

Availability of sensors – DRAFT

	WWTP	Sewer System	Surface Water	Drinking Water
Level	[green]	[green]	[green]	[green]
Flow	[green]	[green]	[green]	[green]
Precipitation	[green]	[green]	[green]	[green]
Temperature	[green]	[green]	[green]	[green]
Pressure	[green]	[green]	[green]	[green]
pH	[green]	[yellow]	[yellow]	[grey]
Conductivity	[green]	[yellow]	[yellow]	[grey]
Salinity	[green]	[yellow]	[yellow]	[grey]
Redox	[green]	[yellow]	[yellow]	[grey]
Dissolved Oxygen	[green]	[yellow]	[yellow]	[grey]
Tuebidity	[green]	[yellow]	[yellow]	[grey]
Dissolved Solids	[yellow]	[yellow]	[yellow]	[grey]

Mature sensors	[green]
Analyzers	[light blue]
Limited experience	[yellow]
Not available	[red]
Not relevant/mentioned	[grey]

Table 3: Current availability of sensors for physical and simple chemical parameters

	WWTP	Sewer System	Surface Water	Drinking Water
Level	[green]	[green]	[green]	[green]
Flow	[green]	[green]	[green]	[green]
Precipitation	[green]	[green]	[green]	[green]
Temperature	[green]	[green]	[green]	[green]
Pressure	[green]	[green]	[green]	[green]
pH	[green]	[green]	[green]	[grey]
Conductivity	[green]	[green]	[green]	[grey]
Salinity	[green]	[green]	[green]	[grey]
Redox	[green]	[green]	[green]	[grey]
Dissolved Oxygen	[green]	[green]	[green]	[grey]
Turbidity	[green]	[green]	[green]	[grey]
Dissolved Solids	[green]	[green]	[green]	[grey]

Mature sensors	[green]
Analyzers	[light blue]
Limited experience	[yellow]
Not available	[red]
Not relevant/mentioned	[grey]

Table 5: Physical and Simple Chemical Parameters - Probable Availability 3-8 Years from Now

Availability of sensors – DRAFT

	WWTP	Sewer System	Surface Water	Drinking Water
Ammonia	Mature sensors	Limited experience	Limited experience	Not relevant/mentioned
Nitrate	Mature sensors	Limited experience	Limited experience	Not relevant/mentioned
Chloride	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Sodium	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Calcium	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Phosphate	Analyzers	Not available	Not available	Not relevant/mentioned
Total-N	Not available	Not available	Not available	Not relevant/mentioned
Total-P	Not available	Not available	Not available	Not relevant/mentioned
Suspended solids	Analyzers	Not available	Not available	Not relevant/mentioned
Sludge blanket	Mature sensors	Not relevant/mentioned	Not relevant/mentioned	Not relevant/mentioned
H_2S	Limited experience	Not available	Not relevant/mentioned	Not relevant/mentioned
N_2O	Mature sensors	Not available	Not relevant/mentioned	Not relevant/mentioned
Methane	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
CO_2	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
BOD, COD, TOC	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
Chlorophyll a	Limited experience	Not relevant/mentioned	Limited experience	Not relevant/mentioned
E. coli	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
Phenols	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
Cyanide	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
Hydrocarbons	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
Heavy metals	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
PAH	Not available	Not available	Not available	Not available
Micro plastics	Not available	Not available	Not available	Not available

Mature sensors	(green)
Analyzers	(light blue)
Limited experience	(yellow)
Not available	(red)
Not relevant/mentioned	(grey)

Table 4: Current availability of sensors for Advanced Chemical and Biological Parameters

	WWTP	Sewer System	Surface Water	Drinking Water
Ammonia	Mature sensors	Mature sensors	Limited experience	Not relevant/mentioned
Nitrate	Mature sensors	Mature sensors	Limited experience	Not relevant/mentioned
Chloride	Mature sensors	Mature sensors	Limited experience	Not relevant/mentioned
Sodium	Mature sensors	Mature sensors	Limited experience	Not relevant/mentioned
Calcium	Mature sensors	Mature sensors	Limited experience	Not relevant/mentioned
Phosphate	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Suspended solids	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Sludge blanket	Mature sensors	Not relevant/mentioned	Not relevant/mentioned	Not relevant/mentioned
H_2S	Limited experience	Not available	Not relevant/mentioned	Not relevant/mentioned
N_2O	Mature sensors	Not available	Not relevant/mentioned	Not relevant/mentioned
Methane	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
CO_2	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
BOD, COD, TOC	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Chlorophyll a	Limited experience	Not relevant/mentioned	Limited experience	Not relevant/mentioned
E. coli	Limited experience	Limited experience	Limited experience	Limited experience
Phenols	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
Cyanide	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Hydrocarbons	Limited experience	Limited experience	Limited experience	Not relevant/mentioned
Heavy metals	Analyzers	Not available	Not relevant/mentioned	Not relevant/mentioned
PAH	Not available	Not available	Not available	Not available
Micro plastics	Not available	Not available	Not available	Not available

Mature sensors	(green)
Analyzers	(light blue)
Limited experience	(yellow)
Not available	(red)
Not relevant/mentioned	(grey)

Table 6: Advanced Chemical and Biological Parameters – Probable Availability 3-8 Years from Now

Ministry of Environment of Denmark
Environmental Protection Agency

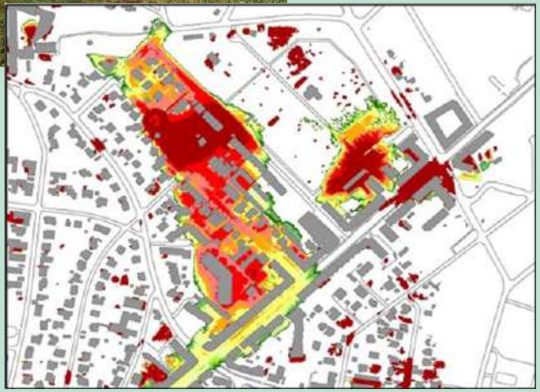
Achievements in the water cycle

Climate Change Adaptation

Photos: Colourbox

Water Smart Cities

Water Utilities co-operating on Water Management



Severe Cloudbursts causes the sewage system to send spill-overs to rivers, coastal areas and into the basements of buildings and houses. Development of new state-of-the-art water technology will give water utilties and public authorities a new tool for a more coherent planning and management of the water – whether caused by cloudbursts or floods.

Partners: DTU, DHI, Krüger A/S, Rambøll Danmark A/S, DMI, 3 Vand, Innovation og Udvikling, HOFOR, , AArhus Vand, Vandcenter Syd, BIOFOS, Forsikring & Pension

Budget: Total 28,3 mio. kr. IFD: 12,3 mio. kr.

Periode: 2016-2019

https://innovationsfonden.dk/da/case/smart-vandhaandtering-til-smarte-byer/

Ministry of Environment of Denmark
Environmental Protection Agency

2030 Look-out

5. september 2022

More challenges ahead?

- Contaminants in groundwater and surface water: pesticide residues , PFOS, etc.
- Micropollutants: pharmaceuticals, chemical residues in household waste water, antimicrobial resistance
- Extend digitalization to all utilities
- Increase benefit from AI application and advanced Digitalization
- Climate Change Adaptation

Looking Ahead – EU initiatives

EU Green Deal
Zero Emissions Action Plans

EU Taxonomy – implications for utilities
5.1. Construction, extension and operation of water collection, treatment and supply systems
5.2. Renewal of water collection, treatment and supply systems
5.3. Construction, extension and operation of waste water collection and treatment
5.4. Renewal of waste water collection and treatment

EU Horizon Europe partnership: Water4All

Thank you for listening !

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